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ESMRO
STUDY PROGRAM

FINAL REPORT

Volume III
Experiment Missions

Prepared for

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER

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BALL BROTHERS RESEARCH CORPORATION
SUBSIDIARY OF BALL BROTHERS COMPANY INCORPORATED
BOULDER, COLORADO

EXPERIMENTS FOR SATELLITE AND MATERIAL RECOVERY FROM ORBIT

STUDY PROGRAM

F67-05

FINAL REPORT

VOLUME III
EXPERIMENT MISSIONS

Prepared for

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

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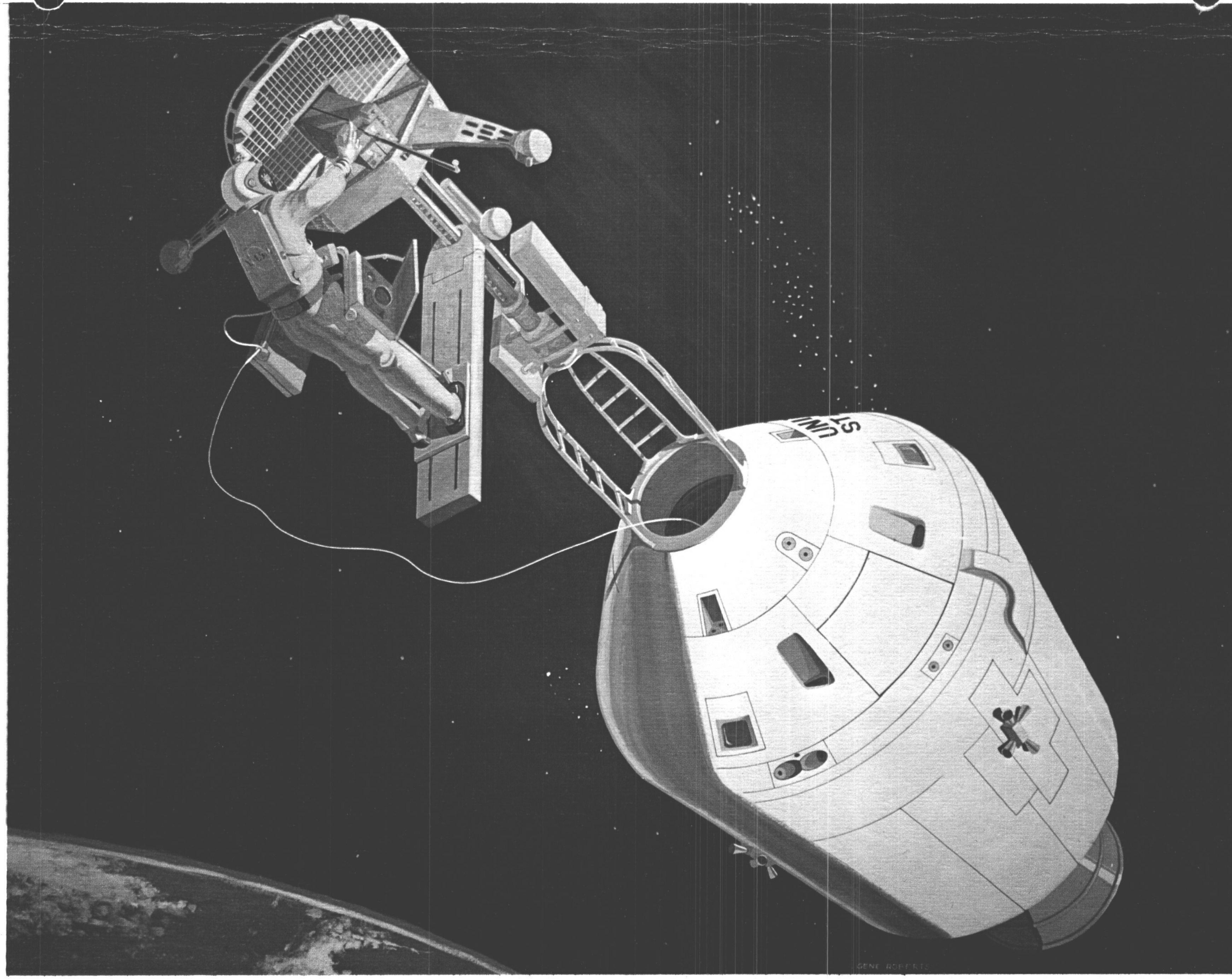

SATELLITE CAPTURE WORK PLATFORM / APOLLO

BALL BROTHERS RESEARCH CORPORATION

B B R C

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B B R C

ESMRO
MISSION 1
(NASA FORM 1138 DATA)

APOLLO EARTH ORBITAL SCIENTIFIC EXPERIMENT PROPOSAL

TITLE OF EXPERIMENT

Mission 1

OSO Capture and Material Retrieval

NAME OF INVESTIGATOR

(1) Ball Brothers Research Corporation, Boulder, Colorado

(2) Emerson Electric Company of St. Louis, St. Louis, Missouri

NAME OF SPONSORING INSTITUTION

Co-sponsors:

(1) George C. Marshall Space Flight Center/OMSF

(2) Goddard Space Flight Center/OSSA

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1. TITLE OF EXPERIMENT

Mission 1 - OSO Capture and Material Recovery

DATE OF SUBMISSION

1 March 1967

(For Headquarters use only.)

DATE RECEIVED BY SM

2. SPONSOR

NAME OF SPONSORING INSTITUTION

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1. PURPOSE AND OBJECTIVE OF THE EXPERIMENT

This experiment is the first of a series of three experiment missions, evolutionary in complexity, the purposes of which are developing techniques and hardware requirements for rendezvous, capture, inspection, recovery of equipment and experiments; replenishing expended supplies; and refurbishing of satellites in orbit.

Specific objectives to be accomplished are:

- Rendezvous with a noncooperative satellite
- Capture of a noncooperative spin stabilized satellite
- Conduct of useful EVA work tasks

The conduct of useful EVA work tasks will:

- Advance the EVA state-of-the-art knowledge
- Enhance the scientific knowledge of the space environment effects on materials
- Establish the techniques for improving a satellite's operation or extending its useful lifetime

The specific purposes of this experiment, Mission 1—OSO capture and material recovery—are to be rendezvous with and capture an OSO satellite, and conduct useful EVA work on the captured satellite. Since this mission will be the first of three experiment missions, emphasis will be on satisfying the objectives of rendezvous, capture and release. Significant experiment tasks are also presented in the area of EVA useful work tasks with respect to satellite inspection and material retrieval.

(Attach additional sheets if necessary, identifying items by number.)

The Gemini Program has contributed significantly to the state-of-the-art of rendezvous with a cooperative satellite, docking with a cooperative satellite and conducting limited EVA useful work. Tabulated below is a record of the manned Gemini missions where orbit changing, rendezvous, Agena docking and extravehicular activity were successfully conducted.

Table 1-1
GEMINI FLIGHT RECORD (No. 1)

Gemini	Rendezvous	Agena Docking	EVA
Gemini III	X[a]		
Gemini IV			X
Gemini V			
Gemini VI	X		
Gemini VII			
Gemini VIII	X	X	X
Gemini IX	X		X
Gemini X	X	X	X
Gemini XI	X	X	X
Gemini XII	X	X	X

[a] Orbit change only

Rendezvous. Problems of rendezvous involve the preflight phase, orbit transfer and correction, and acquisition and terminal guidance. In the Gemini Program, the problems involved in the preflight phase of establishing the "launch window" were minimized by the launching of the two boost vehicles with precise time phasing, thereby simplifying the inflight operations and the time spent in the rendezvous attempt. A simultaneous countdown of both launch vehicles was conducted; the target vehicle was launched first, its orbit was precisely established by ground tracking, and then the manned chase vehicle was launched into relatively the same orbit. The manned vehicle launch was deliberately delayed from a liftoff which would provide a perfect phase match, but it avoided a spacecraft phase lead condition that would require target vehicle maneuvering or extremely long catch-up maneuvering. Normally, no manned spacecraft maneuvering took place during the first orbit in order to check out the onboard radar system and to determine an accurate orbit position for the manned spacecraft by ground tracking. Spacecraft maneuvering was then accomplished to maximize the support from the ground tracking network, and to provide the greatest tolerance to onboard failure of the spacecraft radar and inertial guidance system

Acquisition of the target vehicle was accomplished between 200 to 250 nm distance using onboard radar. The spacecraft radar was then used to track the target vehicle until visual sightings were made. On Gemini flights XI and XII, the onboard radar malfunctioned before visual sighting occurred, and the use of radar for closed-loop rendezvous was abandoned. The astronauts utilized the spacecraft inertial guidance system and calculated their bearings to bring them to station keeping with the target vehicle as scheduled with very reasonable fuel expended and thereby demonstrated passive rendezvous capability.

Agena Docking. Docking the Gemini with the Agena can be considered as a cooperative docking system since the Agena was controlled in attitude stabilization, and utilized visual docking aids such as lights and a docking bar. Except for a post-docking malfunction on the Gemini VIII mission, all of the Gemini docking missions were rated as very successful.

Extra Vehicular Activity. Some form of EVA was conducted on six Gemini missions as indicated in Table 1-1. Although each mission recorded success in varying degrees, each mission substantiated that EVA can be conducted. The mission that was most successful toward proving EVA capability, especially toward useful EVA tasks similar to this proposed experiment, was Gemini XII. On that mission, astronaut Major Edwin E. Aldrin, Jr. proved that with adequate preflight training, EVA support equipment and tools, and adequate rest periods, man can successfully conduct a variety of EVA useful work tasks and skills.

It is improtant to point out that in the functions of rendezvous and docking, the Gemini program utilized "cooperative" procedures and systems in conducting rendezvous and docking with the Gemini spacecraft and Agena target vehicle. However, it is also important to point out that with the use of these cooperative procedures and systems, the state-of-the-art technology was advanced such that open loop rendezvous was successfully accomplished on Gemini's X, XI, and XII; consequently, the astronauts believe they can maneuver and dock with any target vehicle that is independently stabilized. (Reference the close maneuvering that took place between Gemini VI and VII after rendezvous was accomplished.)

3. SPECIFY PARAMETERS TO BE MEASURED INCLUDING NUMERICAL VALUES EXPECTED AND OUTLINE THE RESEARCH PROGRAM:

The experiments conducted on this mission present a blend of engineering and scientific investigation, with some items measured during the conduct of experiment, and others (the majority) to be measured, analyzed and evaluated during post-flight analysis. The following table gives a composite of the experiments proposed to be conducted for Mission 1 with the expected information to be gained.

Table 1-2

MISSION 1 EXPERIMENT TASKS AND RESULTS

Experiment	Inflight Determination	Post-Flight Determination
Precapture Inspection		
• Radiation	Go/no-go (determined safe levels present for EVA)	
• OSO dynamics	Go/no-go (determined OSO spin rate, 10-40 rpm)	Compare with ground predictions
• Photography		Precapture damage evaluation
Capture operations		
• Photography		Precapture configurations evaluation 1) Dynamic characteristics 2) Capture operations
Post-capture inspection and preparation		
• Photography		Before and after damage evaluation
• EVA monitoring photography		1) Evaluation of EVA astronaut operations. 2) Correlate space EVA operations with training simulation operations.
• Radiation Measurement	Go/no-go decision (Dual experiment to provide for instantaneous radiation doses and long term dose rate exposure)	Accumulative dose rate
• Mechanical damage	1) Evaluation of physical damage 2) Determination of cold-welding effects	

(Attach additional sheets if necessary, identifying items by number.)

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3. Specify parameters to be measured including numerical values expected and outline the research program (Cont.)

Table 1-2 (Cont.)

Experiment	Inflight Analysis	Post-Flight Analysis
Material Retrieval		
• NRL Occulting Disk		Phenomenon of whisker growth. (Study of the molecular behavior of metals and alloys after long term exposure to space environment)
• Fine eye assembly		1) Solar cell lens surface degradation 2) Knife edge reticle degradation
• HCO instrument		1) Cause of failure of high voltage electronics upon turn-on. 2) Surface damage of highly polished surfaces due to micro meteorite impacts and their sputtering. 3) Browning or yellowing discolorations of optics which decrease transmissivity as a function of wavelength. 4) Shifts in index of refraction 5) New or enhanced absorption bands. 6) Devitrification which crystallographically and physically alters glass structure and renders glass nonhomogeneous and increases absorptivity. 7) Contamination due to sputtering and outgassing of other materials on the satellite, and photo-polymerization of condensed films.
• Ames emissivity plate		Determine the extent of polymeric damage as a result of long term exposure to space vacuum and radiation.

3. Specify parameters to be measured including numerical values expected and outline the research program (Cont.)

Table 1-2 (Cont.)

Experiment	Inflight Analysis	Post-Flight Analysis
• Right hand solar panel		1) Surface degradation effects 2) Transient effects 3) Semiconductor degradation due to local changes in crystal lattice
• Univ. of Minn. zodical light telescopes		Same as HCO Instrument items 2-7. (Comparative information can be gained between this experiment since HCO is located in the sail structure which is pointed at the sun during orbit day, and the Univ. of Minn. telescopes are located in the spinning wheel section.)
• GSFC-UV azimuth indexer		1) Evaluation of mechanism operating efficiency in space environment 2) Evaluation of bearing and friction wear in space environment
• Univ. of N. Mex. foil covers		Determination of micrometeorite bombardment
Release		
• OSO dynamics	Determine OSO spin rate	
• Photography		Post release damage evaluation

4. PRESENT AN ANALYSIS OF THE PERFORMANCE OF THE PROPOSED EXPERIMENT *(e.g., dynamic range, signal to noise ratio, etc.)*

Refer to Part I, paragraphs 3 and 6, for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

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5. DISCUSS THE METHOD OR POSSIBLE METHODS FOR THE ANALYSIS AND INTERPRETATION OF THE DATA *(e.g., the statistical validity)*

Refer to Part I, paragraphs 3 and 6, for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

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6. DESCRIBE THE EXPERIMENTAL PROCEDURE TAKING INTO CONSIDERATION THE ENVIRONMENT AND ORBITAL CHARACTERISTICS OF THE SPACECRAFT. INCLUDE ANY CONSTRAINTS ON SPACECRAFT ATTITUDE, POINTING ACCURACY, AND STABILITY. EXPLAIN WHY THE ASTRONAUT IS NECESSARY TO THE PERFORMANCE OF THIS EXPERIMENT. DESCRIBE IN DETAIL OPERATIONS PERFORMED BY THE ASTRONAUT AND TIME CONSUMED DURING EACH OPERATION. *(Include length of time the spacecraft must hold a given attitude.)*

The mission operations consist of the following functional steps:

- Rendezvous maneuvers
- Capture mechanism docking
- Precapture inspection
- Capture operations
- Post-capture inspection and preparation
- Material retrieval
- Refurbishment
- Stowage of materials
- Release and capture mechanism jettison
- Post-release inspection

Experiment tasks have been established for each of these functional operations which are discussed in considerable detail in paragraph 6.3, Volume II (the technical report). The information presented herein summarizes and supplements the information presented in the technical report. A Mission 1 Time Line Summary is presented in Table 1-3.

Since one of the primary objectives of this experiment mission is to advance extra vehicular capability and state of the art technology, the man-machine interface during the conduct of this experiment mission is paramount. The improtance and role of the astronaut in the conduct of the experiments for the capture of the OSO satellite and the retrieval of material and equipment is defined in the descriptions of each experiment task.

6.1 CAPTURE MECHANISM DOCKING: The objective of this mission support operations task is to dock the Apollo Command Service Module (CSM) with the OSO satellite capture mechanism in order to capture the OSO satellite, and conduct the useful work experiments for material recovery.

(Attach additional sheets if necessary, identifying items by number.)

Table 1-3

MISSION 1 TIME LINE SUMMARY

Operation/Event	Experiment Priority	EVA (Min)	IVA (Min)	Accrued Mission Time (EVA + IVA) (Min)
I Rendezvous Operations				
CSM/CWP Docking	MSO		25	25
CSM Orbit Transfer	MSO		44	69
Close Rendezvous Maneuvers	MSO		9	78
Night Time Station Keeping	MSO		31	109
Circumnavigation	MSO		6	115
Pre-Capture Inspection	MSO		60	175
Night Time Station Keeping	MSO		31	206
OSO Capture Maneuvers	MSO		6	212
Sub Total			212	
II Work Session No. 1				
Start EVA-Egress Fwd Hatch	MSO	5	5	222
Prepare Equipment and OSO Inspection	MSO	27	27	276
Astronaut Rest Period		5		281
Mount EVA Cameras	P	3	3	287
Expr. Preparation and Radiation Meas.	MSO	36		323
Satellite Centering	MSO	21		344
Astronaut Rest Period		6		350
Wheel Power Bus Removal	MSO	7		357
Mech. Freedom and Damage Evaluation Photos	P	26		383
Removal Coronagraph Occul. Disk and Photos	S	14		397
Astronaut Rest Period		6		403
Removal Control Sun Sensor Assembly and Photos	P	19		422
Astronaut Rest Period		6		428
Stow Exprs.-Return to CM	M	47	47	522
Sub Total		228	82	
III Astronaut 8 Hour Rest Period				1002
IV Work Session No. 2				
Start EVA-Egress Fwd Hatch	MSO	5	5	1012
Prepare Equip. Reposition Platform	MSO	27	27	1066
Remove Ames Emissivity Plate and Photos	P	26		1092
Astronaut Rest Period		6		1098
Remove Zodiacal Light Telescope and Photos	S	22		1120
Astronaut Rest Period		5		1125
Remove R.H. Solar Panel and Photos*	P	120		1245
Astronaut Rest Period		8		1253
Stow Exprs. Return to CM	M	47	47	1347
Sub Total		266	79	
V Astronaut 8 Hour Rest Period				1827
VI Work Session No. 3				
Start EVA-Egress Fwd Hatch	MSO	5	5	1837
Prepare Equip. Reposition Platform	P	27	27	1891
Remove HCO Expr. and Photos*	P	111		2002
Remove Gamma-Ray Telescope Foils and Photos	S	36		2038
Astronaut Rest Period		6		2044
Remove U.V. Azimuth Indexer and Photos	S	34		2078
Replenish Pitch Gas	S	25	8	2111
Prepare Expr. Stowage Containers	MSO	8		2119
Astronaut Rest Period		5		2124
Stow Exprs. Return to CM	MSO	47	47	2218
Sub Total		304	87	
VII Release Operations	MSO		23	2241
Mission 1 Totals		798	483	

NOTES:

*With Astronaut Rest Periods as Applicable

MSO - Mission Support Operation, P - Primary Objective, S - Secondary Objective

6.1.1 Task Description: Task operations for the pilot astronaut are as follows:

(1) Separate the CSM from the S-IVB.

(2) Orient the CSM center line (head on) with the capture mechanism docking collar.

(3) Dock the CSM with the capture mechanism docking collar.

(4) Pull the OSO satellite capture mechanism clear of the S-IVB.

6.1.2 Spacecraft Constraints: Specific spacecraft constraints for conducting the docking operation will be determined as a part of AAP mission integration studies.

6.1.3 Astronaut Operations: This operation will be similar to the Apollo operation of docking the CSM with the LEM. Detail procedures for accomplishing this docking operation will be determined as a part of AAP mission integration studies. A time of 25 minutes has been allocated for conducting this operation. This time allocation has been incorporated into the time line summary for Mission 1. (See Table 1-3.)

6.2 RENDEZVOUS MANEUVERS: The objective of this mission support operations task is to maneuver the Apollo CSM in an orbit transfer operation from the nominal AAP orbit to the nominal OSO orbit, in order to rendezvous with and capture the OSO satellite.

6.2.1 Task Description: Task operations for the pilot astronaut are as follows:

(1) Perform CSM orbit transfer.

(2) Perform terminal guidance with the OSO satellite.

(3) Perform station keeping.

6.2.2 Spacecraft Constraints: Constraints affecting the CSM spacecraft in the conduct of this experiment mission are presented below for the three task descriptions cited.

CSM Orbit Transfer:

(1) The Apollo launch window necessary to conduct the ESMRO mission can be as much as 175 minutes

(2) The CSM will be launched into an orbit inclination of 32.85 degrees.

(3) Orbit transfer of the CSM will initiate from the nominally circular orbit of 370 km (200 nm) altitude.

(4) The parameters of the OSO satellite orbit will be

- Apogee: 626 km (340 nm)
- Perigee: 549 (297 nm)
- Inclination: 32.85 deg
- Period: 96.5 min

(5) The amount of SPS engine propellent assumed available for CSM orbit transfer and rendezvous with the OSO, will be equivalent to a ΔV of 762 mps (2500 fps).

(6) Previous to transfer, the OSO orbit will be determined by ground radar and fed into a ground based computer for analyzing and comparing with the CSM orbit during transfer maneuvers.

(7) During transfer, the CSM will be in contact with ground based tracking stations. The CSM trajectory will be compared with the necessary transfer trajectory and corrective measures will be taken. The transfer itself will be initiated after ground based computers analyze the comparitive positions of OSO and the CSM and calculate the best trajectory for accomplishing the transfer.

Terminal Guidance:

- The positional errors of the CSM will be known to ±150 meters (±490 feet) in cross range and radial, and ±300 meters (±980 feet) in longitude.

- The positional errors of the OSO will be known to within the following accuracies:

Longitude	±1.6 km (0.87 nm)
Cross range	±0.5 km (0.27 nm)
Radial	±0.5 km (0.27 nm)

- Terminal rendezvous with the OSO will occur during the down phase of the OSO orbit with the CSM approaching the OSO from below and ahead.

Delta Velocity Requirements: ΔV requirements for the rendezvous maneuvering phase are presented in Table 1-4. ΔV for precapture and post-nuclear close-in maneuvers have been included for additional information.

Table 1-4

RENDEZVOUS ΔV REQUIREMENTS

Rendezvous Operation	ΔV (mps)	ΔV (fps)
Launch window	67	220
Orbit Transfer	300	984
Terminal closure	24	79
Close-in Maneuvers - Precapture	7.6	25
Close-in Maneuvers - Post-Release	7.6	25
	406	1333

6.2.3 Astronaut Operations: The orbit transfer and terminal guidance maneuvers will be similar to the rendezvous maneuvers conducted during the Gemini program. Detail procedures for accomplishing these maneuvers will be determined as a part of AAP mission integration studies. A time of 44 minutes has been estimated for conduct of the operation. The times for conducting the station keeping operations have been incorporated into the time line summary for Mission 1. (See Table 1-3).

6.3 Precapture Inspection: Prior to capture of the OSO satellite, pre-capture inspection will be required to assure that it is safe to proceed with the capture operations of the mission.

6.3.1 Task Description: Task operations of the IVA astronaut are as follows:

- Determine OSO dynamics
- Conduct documentation photography

6.3.2 Spacecraft Constraints:

- These inspection tasks will be conducted during the circumnavigation station keeping from within the Command Module spacecraft.

- The OSO must not be contaminated by the RCS engine gases during the circumnavigation maneuvering and station keeping.

6.3.3 Astronaut Operations: These precapture inspection operations will be conducted as described in detail in paragraphs 6.3.3.1, 6.3.3.2, and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs.

- OSO Radiation - This experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. A hand held, directional spectrometer will be used to obtain quantitative and qualitative radiation data. An IVA astronaut will take the data through a spacecraft window and ascertain that the OSO radiation levels are within prescribed limits.

- OSO Dynamics - This experiment task will be performed from within the Command Module during daytime circumnavigation of the OSO. Using a visual aid and a stop watch, the IVA astronaut will determine the OSO spin rate and ascertain that it is within acceptable limit to proceed with the capture operations.

- Photography - This experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. Using still and motion picture cameras, the IVA astronaut will take documentary pictures to record the precapture condition and dynamics of the OSO.

Estimated times for these tasks have been included in the Time Line Summary, Table 1-3.

6.4 CAPTURE OPERATIONS: Capture of the OSO satellite will be one of the major objectives of Mission 1. Capture of the OSO will be necessary to perform the useful work experiments. On Mission 1, this operation will prove out the capture mechanism system.

6.4.1 Task Description: Task operations of the pilot and IVA astronauts are as follows:

- Closure maneuvers and OSO capture
- Documentation photography

6.4.2 Spacecraft Constraints: The spacecraft constraints for documentation photography has been discussed in paragraph 6.3.2 above. Spacecraft constraints associated with the capture operations are as follows:

(1) Precapture OSO radiation levels must be within acceptable limits.

(2) The CSM spacecraft must not be damaged.

(3) Capture will be accomplished with an active non-cooperative OSO satellite.

(4) The OSO satellite must not be damaged.

(5) The OSO satellite must not be contaminated by RCS engine gas during capture maneuver operations.

(6) During capture maneuvers operations, the longitudinal axis of the CSM must be aligned to the OSO spin axis within ±TBD* degree in pitch, ±TBD degree yaw and ±TBD degree in roll.

*TBD = to be determined.

(7) The CSM limit cycle rates will not exceed ±0.05 deg/sec in pitch/yaw, and roll.

(8) The CSM dead band limit will not exceed ±1/2 degree in pitch/yaw/roll.

(9) The differential velocity between the CSM and OSO during capture shall not exceed 1 fps.

(10) The capture operation will not exceed 15 minutes during the daylight portion of the orbit.

6.4.3 Astronaut Operations: These capture operations will be conducted as described in detail in paragraphs 6.3.4.1 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Closure Maneuvers and OSO Capture - This experiment taks will be performed from within the Command Module. The CM will be maneuvered so as to approach the OSO from underneath along the satellite spin axis. Prior to capture, the CWP attachment head must be spun up to approximately match the OSO spin rate. At the time of capture, the velocity differential between the CSM/CWP and OSO should be approximately one fps. The CSM/CWP should be maneuvered so that the attachment head encircles the OSO mounting flange. After capture, the OSO is despin on astronaut command by the CWP.

- Documentation Photography - This experiment task is performed by an IVA astronaut during closure maneuvers and OSO capture. Motion pictures will be taken during closure and OSO capture pictorially to document that operation..

Estimated times for these tasks have been included in the Time Line Summary, Table 1-3.

6.5 POST-CAPTURE INSPECTION: After capture of the OSO satellite, continued inspection and experiment preparation will be performed for the conduct of the useful work experiments.

6.5.1 Task Description: Task operations of the IVA and EVA astronauts are as follows:

- Experiment preparation and radiation monitoring
- OSO centering in the capture mechanism
- OSO wheel power bus removal
- Evaluation of mechanical freedom and damage
- Documentary observations and photography

6.5.2 Spacecraft Constraints: The constraints imposed are as follows:

(1) The IVA astronaut must monitor the EVA astronaut all times while he is conducting EVA useful work.

(2) The OSO must not be contaminated by the RCS engine gases during orbit keeping.

(3) The EVA astronaut must exercise caution not to contaminate any of the experiments schedules for removal.

6.5.3 Astronaut Operations: These post-capture inspection operations will be conducted as described in detail in paragraphs 6.3.5.1, 6.3.5.2, 6.3.5.3, 6.3.5.4, and 6.3.5.5 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Experiment Preparation and Radiation Monitoring - During this experiment task, the EVA astronaut will egress from the CSM, erect the CWP into its useful work position, position himself and his support equipment on the CWP, and measure the OSO radiation levels as a backup to the measurements made from within the Command Module.

(2) OSO Satellite Centering - This experiment task is performed by the EVA astronaut. First, the centering mechanism is unlatched so that it can be fastened to the OSO mating flange. Then, the adhesive bond (or yoke arms) is released, and the centering mechanism is activated with a power tool to position the OSO on the center of the attachment head. The OSO is then in position for useful work and subsequent release.

(3) OSO Wheel Power Bus Removal - This experiment task is performed by the EVA astronaut to assure that all OSO power has been interrupted before conducting useful work on the satellite. This is accomplished by removing a special external connector plug that was installed prior to launching the OSO. The plug is replaced upon conclusion of the useful work tasks.

(4) Mechanical Freedom and Damage Evaluation - This experiment task is performd by the EVA astronaut. The mechanical freedom evaluation consists of manually rotating the OSO sail with respect to the wheel and the pointed instruments with respect to the sail to determine if cold welding has occurred. The EVA astronaut will inspect

the OSO surfaces and parts for damage and photograph anything noticed.

(5) Documentation photography - This experiment task is performed by the EVA astronaut after capture operations have been completed and during useful work tasks. As a minimum, before and after pictures will be taken for each experiment task conducted. This task will be intermittently performed during the entire useful work phase of the mission.

Estimated times for these tasks have been included in the Time Line Summary, Table 1-3.

6.6 MATERIAL RETRIEVAL: The conduct of useful EVA work and the return of materials will be two of the major objectives of Mission 1. On Mission 1, the primary useful work objective will be the retrieval of materials and equipment for return to earth for post-flight analysis. The conduct of useful work on Mission 1 will prove out man's capabilities in space, along with proving out the use of the work platform and EVA tools.

6.6.1 Task Description: Task operations of the EVA and IVA astronauts during the conduct of material retrieval experiments are as follows:

- Retrieval of NRL coronagraph occulting disk
- Retrieval of control sensor assembly
- Retrieval of right hand solar panel
- Retrieval of Harvard College Observatory ultraviolet spectrometer instrument.
- Retrieval of Ames emissivity plate

- Retrieval of University zodiacal light telescopes.
- Retrieval of GSFC ultraviolet spectrometer azimuth indexer
- Retrieval of University of New Mexico high energy gamma ray telescope foil covers
- EVA documentation photography
- Replenish pitch gas supply
- Experiment container stowage preparation
- Return of EVA astronaut and materials to the Command Module

6.6.2 Spacecraft Constraints: The necessary constraints are:

(1) The EVA astronaut must monitor the EVA astronaut at all times while he is conducting EVA useful work.

(2) The OSO must not be containimated by RCS engine gases during orbit keeping.

(3) The EVA astronaut must exercise caution not to contaminate any of the experiments scheduled for removal.

6.6.3 Astronaut Operations: These useful work operations will be conducted as described in detail in paragraphs 6.3.6.1, 6.3.6.2, 6.3.6.4, 6.3.6.5, 6.3.6.6, 6.3.6.7, 6.3.6.8, 6.3.6.9, 6.3.6.10, 6.3.7.1 and 6.3.8 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Retrieval of NRL Occulting Disk - This experiment

task is performed by the EVA astronaut. The disk is fastened to the end of a boom and should be easily removed.

(2) Retrieval of Control Sensor Assembly - This experiment task is conducted by the EVA astronaut and must be performed prior to removal of the HCO experiment. The assembly is located on the front end of the HCO experiment and is fastened by three screws.

(3) Retrieval of Right Hand Solar Panel - This experiment is performed by the EVA astronaut and must be performed prior to removal of the HCO experiment. Utilizing a screw locating template, the astronaut core drills around the 21 screws holding the solar panel. When this is completed, the array can be wedged away from the sail structure, exposing the connecting wire bundles. These are then cut and the panel is removed from the satellite.

(4) Retrieval of HCO Experiment - This experiment task is performed by the EVA astronaut after retrieval of the control sensor assembly and right hand solar panel. To accomplish this task, it is necessary to remove several small assemblies that protrude from the main portion of the experiment, clip all connecting wiring, remove three mounting screws, pry the instrument off a stub shaft, and slide the experiment out of the OSO elevation gimbal.

(5) Retrieval of Ames Emissivity Plate - This experiment task is performed by the EVA astronaut. The plate is fastened to the OSO wheel with eight screws. After

removing these, the astronaut clips the connecting wire bundle.

(6) Retrieval of U. of Minn. Telescope - This experiment task is performed by the EVA astronaut. The telescope assembly is fastened with five screws to the rim panel of the OSO wheel. After removing these screws, the telescope assembly can be slipped out of the OSO wheel.

(7) Retrieval of GSFC Azimuth Indexer - This experiment task is performed by the EVA astronaut. The azimuth indexer is attached to the bottom of the GSFC experiment with three screws. Accessiblity to these screws in from the underside of the OSO wheel. After removing these screws, the assembly can be pulled from the wheel and held while the connecting wire bundle is cut by the astronaut.

(8) Retrieval of U. of New Mexico Foils - This experiment is conducted by the EVA astronaut. The foil covers are fastened with a flange to the instrument telescope that protrudes through the OSO wheel rim panel. The foils and flange are released by removing eleven screws.

(9) EVA Photography - This experiment task is performed by both the EVA and IVA astronauts. The IVA astronaut will take time sequenced motion pictures of the EVA astronaut during egress and erection of the work platform and during stowing of the work platform and ingress to the CM. The EVA astronaut will take time sequence motion pictures of EVA experiment tasks, using a remote camera positioned on the work platform.

(10) Replenishment of Pitch Gas - This experiment task is performed by both the EVA and IVA astronauts. The EVA

astronaut attaches the gas supply line to pitch gas line check valve located on the OSO sail assembly. He then completes any required EVA tasks, including storage of the work platform, return of containers to the CM, etc. and then ingress to the CM. When CM is pressurized, the IVA then remotely commands the commencement of the filling operation. When it is completed, he remotely commands the gas line to disconnect from the OSO.

(11) Experiment Container Stowage Preparation - This experiment task is performed by the EVA astronaut. All containers that are to be placed in the Command Module for return to earth will be pressurized with inert gas. The astronaut will use the low pressure gas supply on the CWP to perform this operation. Each container will be filled to a prescribed pressure.

(12) Container stowage and EVA astronaut return - This experiment task is conducted by both the EVA and IVA astronauts. The EVA astronaut will attach transfer tethers to each container and then release the containers from the CWP. The astronaut will then move to the egress/ingress structure where he will pass the containers to the IVA astronaut. When all the containers are inside the CM, the EVA astronaut will secure the work platform in its stowed position, unhook the power umbilical and ingress to the CM. The IVA will stow the contains within the CM. The forward hatch will be secured, and the CM will be pressurized. Estimated times for these tasks have been included in the Time Line Summary, Table 1-3.

6.7 RELEASE: AFter the conduct of the useful work operations, release of the capture mechanism must be accomplished to permit the CSM to intitiate re-entry maneuvers.

6.7.1 Task Description: The task operations of the IVA astronauts during the conduct of the release operation is as follows:

- Satellite release and capture mechanism jettison

6.7.2 Spacecraft Constraints: The major constraint imposed is:

- All stowed items must be adequately packaged and secured to withstand the Apollo Command Module re-entry loads.

6.7.3 Astronaut Operations: The release operation will be conducted as described in detail in paragraph 6.3.9 of Volume II. Estimated time for the IVA astronauts to conduct the release of the satellite and capture mechanism jettison will be typical of the Apollo/LEM docking operations and is included in the Time Line Summary, Table 1-3. A brief description of these tasks is presented in the following paragraph:

(1) Satellite Release and Capture Mechanism Jettison - This experiment task will be performed by the IVA astronaut. Utilizing a remote command console, the astronaut will spin up the OSO to about six rpm. Then the CWP attachment head will be released from the OSO to a safe distance. When well clear of the OSO, jettison the CWP by releasing its docking collar, and fire the RCS thrusters to back the CSM away.

6.8 POST-RELEASE INSPECTION: After release of the OSO satellite, post-release inspection will be required to document the OSO condition and spin characteristics.

6.8.1 Task Description: Task Operations of the IVA astronaut are as follows:

(1) Determine OSO dynamics.

(2) Conduct documentation photography.

6.8.2 Spacecraft Constraints: The constraints imposed are:

(1) These inspection tasks will be conducted after release of the OSO satellite from within the Command Module.

(2) The OSO must not be contaminated by the RCS engine gases during the station keeping maneuvers.

6.8.3 Astronaut Operations: These post-release inspection operations will be conducted as described in detail in paragraphs 6.3.3.2 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) OSO Dynamics - The experiment task is the same as the pre-capture activities described earlier in this section.

(2) Photography - This experiment task is the same as the pre-capture activity described earlier in this section.

Estimated times for these tasks have been included in the Time Line Summary, Table 1-3.

6.9 TIME LINE ANALYSIS: A detail time line analysis has been prepared for ESMRO Mission 1 and is included as Figure 1-1.

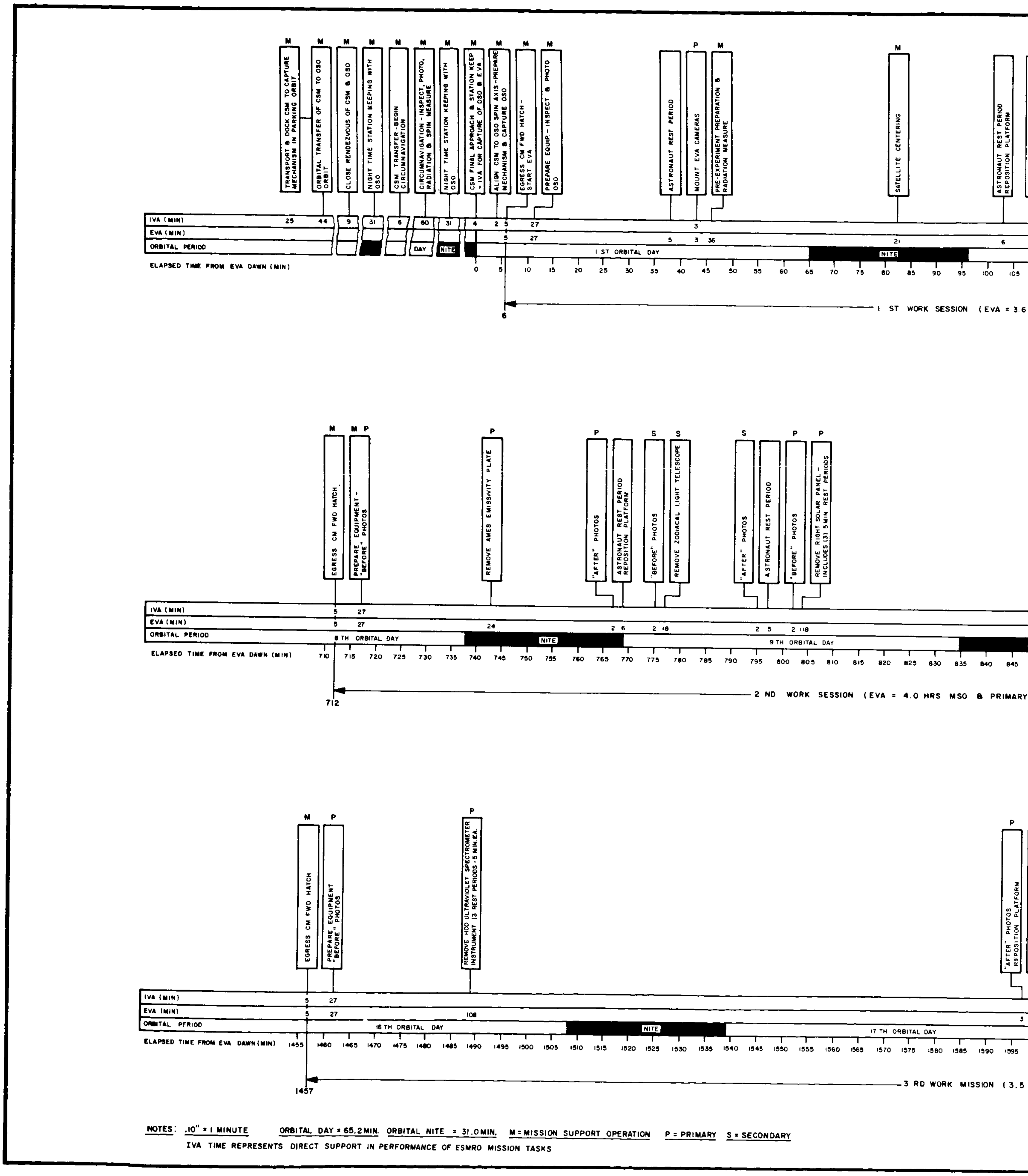
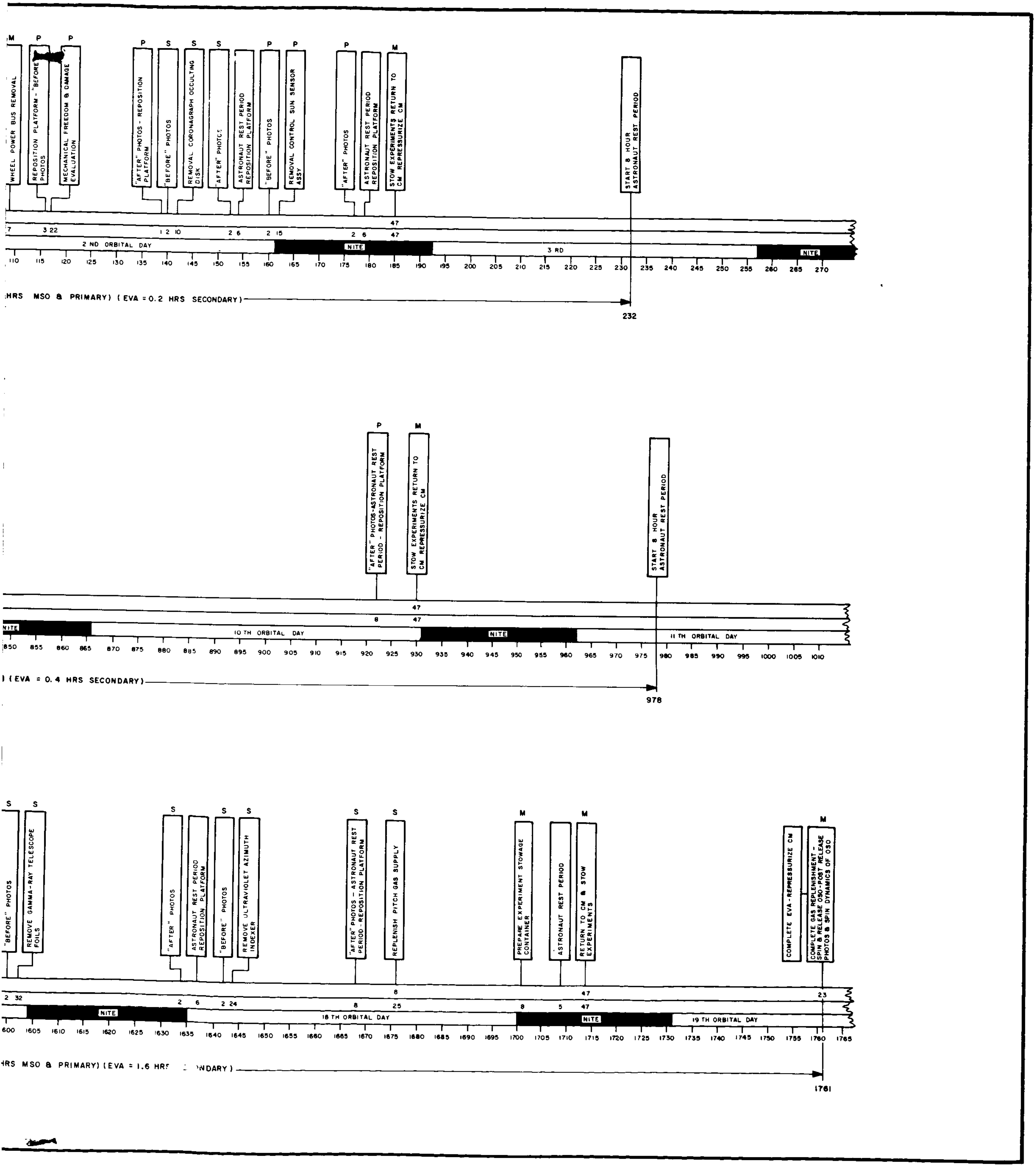


Fig. 1-1 Mission 1 T



ime Line Analysis

- A docking simulator which provides capability of simulating a free spinning OSO.

Experiment Preparation and Container Return. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of transferring out to the work platform and returning with experiment containers. These tasks will require:

- Familiarization with the CSM/forward hatch/tethers/work platform mockup; without a suit, in a 1 g environment.

- Familiarization and practice with the CSM/forward hatch/tethers/work platform mockup, with a pressurized suit at 3.7 psig, in a neutral buoyancy environment.

Useful Work. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of conducting useful work on the OSO. The EVA astronaut will require:

- Familiarization with the OSO mockup without a suit, in a 1 g environment

- Familiarization and practice with the OSO and work platform mockup, in a pressurized suit, at 3.7 psig, in a 1 g environment

- Neutral buoyancy EVA simulation of useful work activities for training and time line evaluation

- Use and practice with the EVA tools for the aforementioned training requirements

7. ASTRONAUT TIME REQUIREMENT SYNOPSIS		
PREFLIGHT TIME	IN-FLIGHT TIME	POSTFLIGHT TIME
Normal Training	See Table 1-3	Normal de-briefing

8. DESCRIBE THE PREFLIGHT AND POSTFLIGHT REQUIREMENTS ON THE ASTRONAUT

In order to conduct this complicated experiment mission, the AAP astronauts must be familiar with and have proficiency in several skills and operations. Preflight training requirements for this experiment mission are given below for each functional task:

Rendezvous. The pilot astronaut must become proficient in maneuvering the CSM spacecraft for making orbit transfers and completing terminal guidance. These tasks will require practice and training on:

- A rendezvous simulator
- Visual acquisition simulator for the OSO satellite

Inspection. Inspection tasks will require the IVA astronaut to become proficient with:

- A directional spectrometer and dosimeter
- Visual determination of OSO dynamics
- Operation with a 70 mm Maurer still camera and a 16 mm Maurer sequential camera.

Docking, Capture, and Release. These functional tasks will require the pilot astronaut to become proficient with maneuvering the CSM spacecraft during the docking with the capture mechanism, and capture and release of the OSO satellite. These tasks will require practice and training on:

- A spacecraft docking simulation device similar to the CSM/LEM operations

(Attach additional sheets if necessary, identifying items by numbers.)

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A variety of post flight facilities will be required to support the Mission 1 OSO capture and material retrieval experiment. The facilities required are as follows:

Photographic. Photographic facilities will be required to develop colored still and sequence pictures taken during:

- Precapture inspection (still and sequence)
- Capture operations (sequence)
- Post-capture inspection (still)
- EVA useful work (sequence)
- Release operations (sequence)

Sanborne Recorder. A Sanborne recorder or equivalent will be required to play back radiation monitoring data obtained from the directional spectrometer instrument measurements.

Vacuum Laboratory. A vacuum laboratory(s) will be required for the post-flight analysis of material and equipment returned to earth for the following experiments:

- Retrieval of HCO instrument
- Retrieval of Ames emissivity plate
- Retrieval of right half solar panel
- Retrieval of control sensor assembly
- Retrieval of U. of Minn. zodiacal light telescopes

(Attach additional sheets if necessary, identifying items by number.)

Clean Room Laboratory. A clean room laboratory(s) will be required for the post-flight analysis of material and equipment returned to earth for the following experiments:

- Retrieval of HCO instrument
- Retrieval of NRL occulting disk
- Retrieval of control sensor assembly
- Retrieval of U. of Minn. zodiacal light telescopes
- Retrieval of U. of N. Mex. foil covers
- Retrieval of GSFC azimuth indexer

In conjunction with the facilities cited above, engineering evaluation of the subject and materials will be required.

ENGINEERING INFORMATION AND PROGRAM PLAN - PART II

1. DESCRIPTION OF EQUIPMENT *(Sketch major assemblies in Item 5.)*

The equipment required to conduct this experiment mission has been categorized as follows:

- Adaptive tools
- Common tools
- Special equipment
- Common equipment

A listing of these tools and equipment is presented in Table 1-5. A conceptual picture of the Capture Work Platform is illustrated in the frontispiece and in Fig. 1-2.

(Attach additional sheets if necessary, identifying items by number.)

2. DESCRIBE SPACECRAFT MODIFICATIONS REQUIRED FOR ACCOMODATION OF EQUIPMENT. INDICATE PREFERRED MOUNTING CONFIGURATION HERE OR IN ITEM 5

See page 1-40.

(Attach additional sheets if necessary, identifying items by number.)

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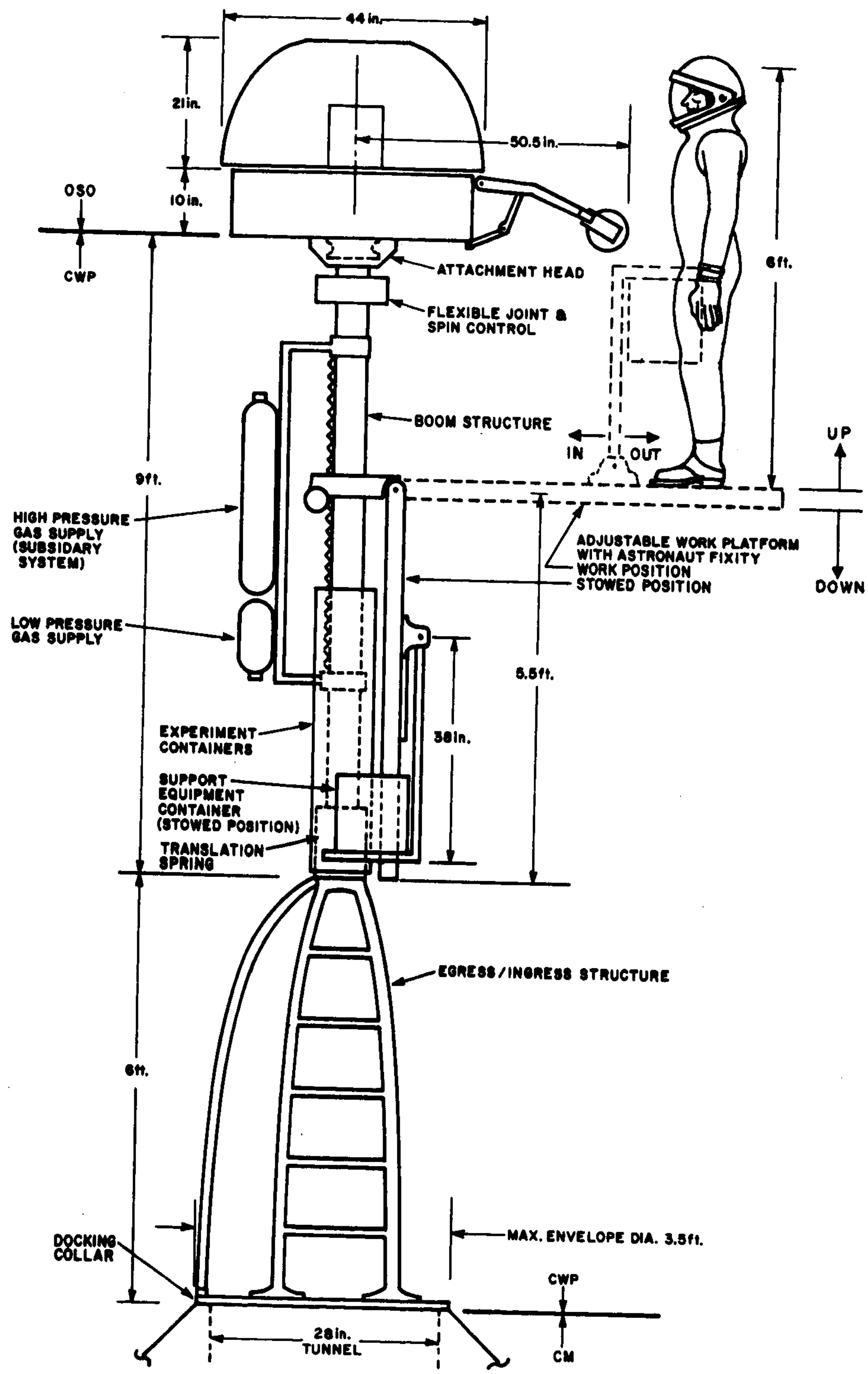

Fig. 1-2 Capture Work Platform Conceptual Configuration

Table 1-5

TOOLS AND EQUIPMENT FOR ESMRO MISSION 1

ADAPTIVE TOOLS

- Allen head driving tool
- High torque driving tool
- Phillips head driving tool
- Slot head driving tool
- Right angle button head driving tool
- Solar cell core drill
- Solar panel core drill
- Gas containing cap drive tool
- Screw head removal tool

COMMON TOOLS

- Power tool with adaptive head
- Power tool ratchet handle
- Pry bar with tether
- Variable angle wedge with tether
- Wire bundle cutter with tether
- Flex print cutter with tether
- Solar panel special wire bundle cutter with tether
- Long blade wire cutter with tether
- Bolt cutter with tether
- Connector removal tool
- Reel tether with clamp
- Short tether
- Equipment transfer tether
- Sail lock
- Pointed instrument elevaton frame lock

SPECIAL EQUIPMENT

- NRL occulting disk rigid tether
- Solar panel short tether

Table 1-5 (Cont.)

- HCO instrument short tether
- Solar cell protective covers
- Solar panel template and protective cover
- HCO ion trap protective cover
- Ames emissivity plate protective cover
- U. of Minn. telscope lens protective cover
- U. of N. Mex. foil protective cover
- Dosimeter (portable)
- Directional spectrometer
- Stop watch and visual aid
- High pressure nitrogen supply system (Remote astronaut operation)
  - Command controller (hand held in CM)
  - Gas attach fitting (remote operation)
  - Quick disconnect coupling (remote operation)
  - Check valve fitting tool
- Maurer 16 mm sequential camera, model 308 (2)
- General purpose 70 mm Maurer still camera

COMMON EQUIPMENT

- Capture work platform system
- - Boom (with compression spring)
- - Attachment head (with release capability)
  - Flexible joint and spin mechanism (remote operation)
  - Docking collar and egress/ingress structure
  - Adjustable work platform (with astronaut fixity)
  - Experiment containers
  - Support equipment containers (tool box)
  - Battery power supply
  - Electrical umbilical to CM
  - Artificial illumination (with portable light)
  - Low pressure inert gas supply system
  - Mounting apparatus for remote camera operation

1. Description of Equipment (Cont.)

Table 1-5 (Cont.)

- Command console (portable inside CM)
- Film storage containers
- General purpose vacuum container
- Inert gas pressurized container(s) necessary to accommodate
  - NRL occulting disk
  - Control sensor assembly
  - Right hand solar panel
  - HCO instrument with R.P.T. assembly
  - HCO Decoder
  - Ames emissivity plate
  - U. of Minn. telescopes
  - GSFC-UV azimuth indexer
  - U. of New Mex. foil filters

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2. Describe spacecraft modifications required for accomodation of equipment. Indicate preferred mounting configuration here or in item 5

No CSM spacecraft design modifications are anticipated; however, certain Apollo program support equipment will be required to conduct this experiment, some of which will interface with ESMRO equipment. These support items, and the respective Apollo/ESMRO equipment interfaces are as follows:

(a) Apollo Saturn I-B Launch Vehicle

(b) Apollo Command Service Module

- With docking system
- CM storage space (ascent and descent)
- EVA communications link
- Tape recording of astronauts voice annotation
- Electrical power and signals

2. Spacecraft Modification of Equipment (Cont.)

(c) Spacecraft Lunar Module Adapter (SLA)

- Storage for the ESMRO Capture Work Platform during boost phase

(d) IVA astronaut

(e) EVA astronaut with life support equipment

(f) Procedural transmission link between CSM and EVA astronaut

(g) Procedural transmission link between CSM and ground (MCC)

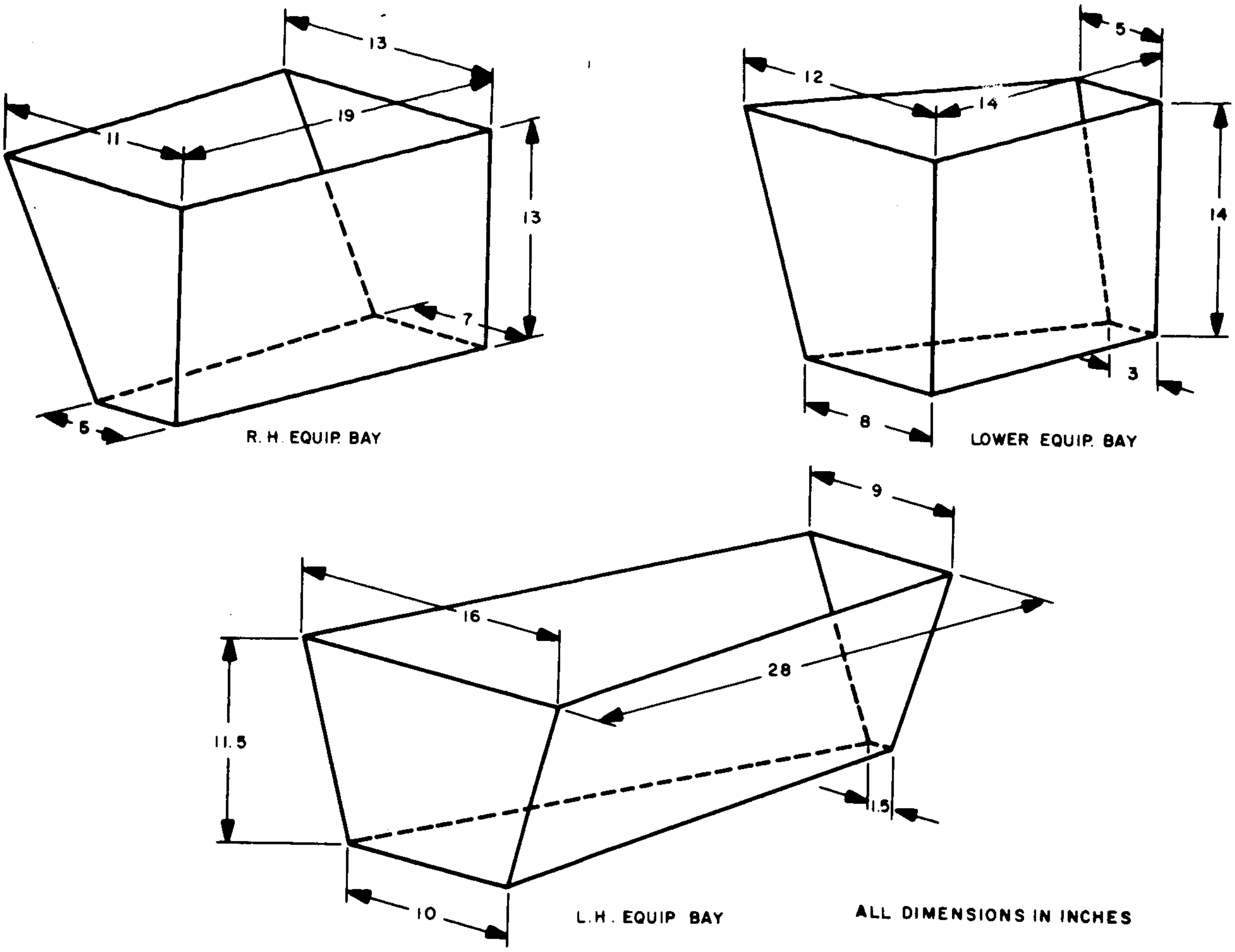
(h) Communications link with ground tracking stations

2.1 APOLLO SATURN I-B LAUNCH VEHICLE AND COMMAND SERVICE MODULE: The ESMRO experiment mission is proposed to be conducted as a part of the Apollo Applications Program and would utilize an Apollo Saturn I-B launch vehicle Command Service Module (CSM).

2.1.1 The conduct of the ESMRO experiment mission will require that the Command Module be equipped with the CSM/LEM docking mechanism. This docking mechanism will be used to dock the CSM with the OSO satellite capture mechanism.

2.1.2 Storage space in the Command Module will be required for returning retrieved materials and equipment from the OSO satellite and exposed film to the earth for post-flight evaluation. Possible CM storage areas are given in Fig. 1-3. A detail analysis and investigation must be completed to determine the optimum size(s) of storage container(s) necessary to package the selected items for retrieval and still be compatible with CM storage space.

2.1.3 The conduct of the ESMRO experiment mission proposes an electrical power and signal interface with the CSM. This interface will involve a power umbilical connected within the Command Module and run out to the CWP through the forward hatch. An electrical signal interface can be otained utilizing the electrical signal



Area	Volume (cu. ft.)
Food Compartment (Lower Equipment Bay)	1.0
Food Compartment (L. H. Equipment Bay)	1.7
Food Compartment (R. H. Equipment Bay)	0.9
LIOH Cannisters Area	4.5
Isleway (under center couch)	3.0
	11.1

(1) Reference BBRC ATM Study Program Final Report, dated 1 Apr 1966

Fig. 1-3 Possible CM Storage Areas (1)

connector in the CSM/LEM docking adapter. Utilizat on of these two electrical hookups may require wiring modifications or changes within the Command Module which will require investigating. The total power required will not exceed 2 kilo watt hours. (See Item 6, Part II.)

2.1.4 The conduct of the ESMRO experiment mission requires the use of a control console from within the (CM). This console is small and portable, and should not present any significant interface problems. The unit can be designed to fit, or make use of spare panel space on the astronauts controls and display console, or it could be a self contained portable unit which the astronaut could operate and then stow. This item needs to be investigated in more detail to determine its optimum configuration.

2.1.5 A voice communications link between the astronauts inside the Command Module and the EVA astronaut will be required. It is understood, that this capability will exist for the Apollo Applications Program.

2.1.6 Tape recordings of the astronauts voice annotations will be required during the conduct of IVA and EVA experiment tasks. It is understood, that this capability will exist for the Apollo Applications Program.

2.2 Spacecraft Lunar Module Adapter (SLA) - In the conduct of this experiment, it is proposed to store the ESMRO Capture Work Platform (CWP) in the SLA during the Saturn launch and boost phase. The outside envelope dimensions of the folded Capture Work Platform are illustrated in Fig. 1-2.

2.3 INTRA-VEHICULAR ASTRONAUT: The services of an astronaut inside the Command Module will be required for both monitoring the EVA astronaut at all times he (the EVA astronaut) is outside of the CM, and for performing specific functions on many of the proposed ESMRO experiment tasks. Please refer to Section 6 of Volume II, (Mission 1 program plan), and Part I, paragraph 6, of this NASA

Form 1138 for detail IVA tasks and time requirements.

2.4 EXTRA VEHICULAR ASTRONAUT: The services of an astronaut working outside the Command Module will be required for conducting many of the proposed ESMRO experiment tasks. Please refer to Section 6 of Volume II, Mission 1 Experiment tasks, and Part I, paragraph 6 of this NASA Form 1138 for detail EVA tasks and time requirements.

2.5 CSM AND EVA ASTRONAUT PROCEDURAL TRANSMISSION: In order to conduct the Mission 1 EVA ESMRO experiment tasks, a procedural transmission between the monitoring astronaut inside the CSM and the EVA astronaut will be required. The transmission will utilize the CSM/EVA astronaut voice communication link. Procedural documentation must be generated for each experiment task selected for Mission 1.

2.6 CSM AND MCC PROCEDURAL TRANSMISSION: In order to conduct many of the Mission 1 ESMRO experiment tasks, a procedural transmission between the CSM and the Manned Spacecraft Control Center will be required. These transmissions will utilize the Manned Space Flight Network (MSFN). Procedural documentation must be generated for each experiment task selected for Mission 1 requiring CSM/MCC procedural transmissions.

2.7 GROUND TRACKING STATIONS COMMUNICATIONS: During the rendezvous phase of the mission, communications between the ground tracking stations and the CSM will be required to provide orbit information on both the CSM and the OSO satellite to up-date the CSM inertial guidance. This communications link will interface with the CSM/MCC procedural transmission link. Procedural documentation must be generated as required to support the rendezvous phase of Mission 1.

3. WEIGHT		4. VOLUME	
TOTAL WEIGHT:	750 lb	TOTAL VOLUME:	130 cu ft
WEIGHT OF SEPARATE ASSEMBLIES (If any)		VOLUME OF SEPARATE ASSEMBLIES (If any)	
ASSEMBLY #1 CWP System	500 lb	ASSEMBLY #1 CWP System	115 cu ft
ASSEMBLY #2 Experiment Containers	200 lb	ASSEMBLY #2 Experiment Containers	10 cu ft
ASSEMBLY #3 Miscellaneous	50 lb	ASSEMBLY #3 Miscellaneous	2.5 cu ft

5. ENVELOPE *(Sketch each assembly (Designate 1, 2 or 3) indicate nominal and limiting values of each major dimension.)*

Assembly No. 1 (Capture Work Platform System). From Part II, Fig. 1-2, an overall envelope space has been determined for the OSO Capture Work Platform System in the stowed configuration. This space envelope has been estimated to be within a cylindrical shape that is less than 3 1/2 feet in diameter, and 15 feet long.

Assembly No. 2 (Experiment Containers). Initial evaluation of the requirements for experiment containers establishes a need for four containers. Estimates regarding the contents, size, and weight of each container when full are presented in Table 1-6. These numbers must be regarded as preliminary. A detail analysis and investigation must be completed to determine the optimum size(s) of storage containers necessary to package the selected items for retrieval and still be compatible with available Command Module storage space.

Assembly No. 3 (Miscellaneous). Covered in this group, are equipment items such as the general purpose container, the radiation instruments, cameras and film. A volume of 2.5 cubic feet has been estimated for these items. Similarly, a detail analysis and investigation must be completed to determine the optimum size(s) of storage container(s) necessary to stow the selected items for return to earth and still be compatible with available Command Module storage space.

(Attach additional sheets if necessary, identifying items by number.)

Table 1-6

SPACE ENVELOPES FOR EXPERIMENT CONTAINERS (No. 1)

Container	Max. Dim. (in.) h x w x l	Volume (cu ft)
Container No. 1		
• HCO insturment	15 x 6 x 40	
• Control sensor assembly	4 x 4 x 4	
• NRL occulting disk	2 x 1 x 4	
• Container No. 1	20 x 10 x 42	2.78
Container No. 2		
• R. H. solar panel	22 x 22 x 2	
• Container No. 2	24 x 24 x 4	1.34
Container No. 3		
• Ames emissivity plate	6 x 1 x 6	
• HCO decoder	7 x 3 x 7	
• Container No. 3	15 x 6 x 15	0.78
Container No. 4		
• U. of Minn. telescopes	12 x 4 x 12	
• GSFC-UV azimuth indexer	8 x 1 x 7	
• U. of New Mex. foil covers	7 x 1 x 7	
• Container No. 4	24 x 8 x 18	2.00

6.

POWER			
TOTAL POWER:	STANDBY	AVERAGE	MAXIMUM 1740 watt hr

POWER CONSUMED BY SEPARATE ASSEMBLIES			
ASSEMBLY #1	STANDBY	AVERAGE	MAXIMUM 140 watt hr
ASSEMBLY #2	STANDBY	AVERAGE	MAXIMUM 1200 watt hr
ASSEMBLY #3	STANDBY	AVERAGE	MAXIMUM 400 watt hr

IF POWER CONSUMPTION IS NOT CONSTANT, INDICATE POWER PROFILES BELOW:

The subsystems of the capture mechanism system and other items which will utilize electrical power are listed below in Table 1-7 with estimates concerning their power profile.

(Attach additional sheets if necessary, identifying items by number.)

7.

THERMAL CONSTRAINTS		
OPERATING TEMPERATURE LIMITS OF EACH ASSEMBLY		
ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C
STORAGE TEMPERATURE LIMITS OF EACH ASSEMBLY		
ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C

OTHER THERMAL CONSTRAINTS

None

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6. If power consumption is not constant, indicate power profiles below (Cont.)

Table 1-7

POWER REQUIREMENTS (No. 1)

Subsystem/Item	Watts	On-Time Hours	Kilowatt Hours	Remarks
Assembly No. 1				
Wheel torque and lock	20	1	20	CWP Battery Power
-Despin and spin-up				
-Wheel turn operation				
Attachment head	100	0.2	20	CM power peak load is estimated not to exceed 250 watts
-Adhesive release				
Work platform	100	1	100	
-Up and down operation				
-In and out operation				
-Erect and stow operation				
Assembly No. 2				
Artificial illumination	100	12	1200	
Assembly No. 2				
Power tool operation	75	4	300	
Camera operation	10	10	100	

8. OTHER ENVIRONMENTAL CONSTRAINTS *(List any remaining constraints such as preferred or prohibited orientation of assemblies with respect to direction of maximum vibration and acceleration, susceptibility to RFI, etc.)*

- OSO contamination due to RCS engines
- OSO contamination due to suit exhaust and outgassing
- Radiation levels must not exceed prescribed levels

(Attach additional sheets if necessary, identifying items by number.)

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9.

TELEMETRY

	OUTPUT 1	OUTPUT 2	OUTPUT 3	OUTPUT 4
FUNCTION				
MUST MEASUREMENT BE CONTINUOUS				
MINIMUM NUMBER OF SAMPLES PER SECOND				
ACCURACY OF MEASUREMENT				
MAXIMUM BIT RATE *(Digital only)*				
MINIMUM FREQUENCY RESPONSE *(Analog only)*				

ADDITIONAL INFORMATION

There is no requirement for the utilization of the Apollo CSM telemetry system during the conduct of Mission 1 experiment tasks.

(Attach additional sheets if necessary, identifying items by number.)

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10. **DEVELOPMENTAL PROGRAM** (1)

ITEM	WHERE PERFORMED	BEGINNING DATE	COMPLETION DATE
PRELIMINARY ELECTRICAL DESIGN		8/1/67 (1) or 1 month ARC(2)	1/1/68 or 6 months ARC
PRELIMINARY MECHANICAL DESIGN		7/1/67 or ARC	11/1/67 or 4 months ARC
PRELIMINARY MOCK UP FABRICATION		10/1/67 or 3 monthsARC	1/1/68 or 6 months ARC
FINAL ELECTRICAL DESIGN		1/1/68 or 6 months ARC	5/1/68 or 12 months ARC
FINAL MECHANICAL DESIGN		1/1/68 or 6 months ARC	7/1/68 or 12 months ARC
EXACT MECHANICAL MOCK UP CONSTRUCTION		5/1/68 or 10 months ARC	7/15/68 or 12½ mon. ARC
PROTOTYPE FABRICATION		9/1/68 or 14 months ARC	1/1/69 or 18 months ARC
PROTOTYPE ENVIRONMENTAL TEST		1/1/69 or 18 months ARC	3/1/69 or 20 months ARC
FLIGHT UNIT FABRICATION		12/1/69 or 17 months ARC	4/1/69 or 21 months ARC
FLIGHT UNIT ENVIRONMENTAL TEST		4/1/69 or 21 months ARC	5/1/69 or 22 months ARC
FLIGHT SPARE FABRICATION		3/1/69 or 20 months ARC	6/1/69 or 23 months ARC
FLIGHT SPARE ENVIRONMENTAL TEST		6/1/69 or 23 months ARC	7/1/69 or 24 months ARC

(1) All dates are figured from an assumed contract start of 1 Jul 1967.
(2) ARC means "after receipt of contract".

The above program schedule information, along with additional details is presented in graphic form in Fig. 1-4. All dates in that schedule are also shown as months after a contract go-ahead of 1 Jul 1967, and a continuous development program has been assumed. A launch six months after delivery of the first flight model is shown.

While the actual hardware system is composed of many items, it has been treated in the schedule as a single unit since design, fabrication and test of the various items would proceed in parallel with one another.

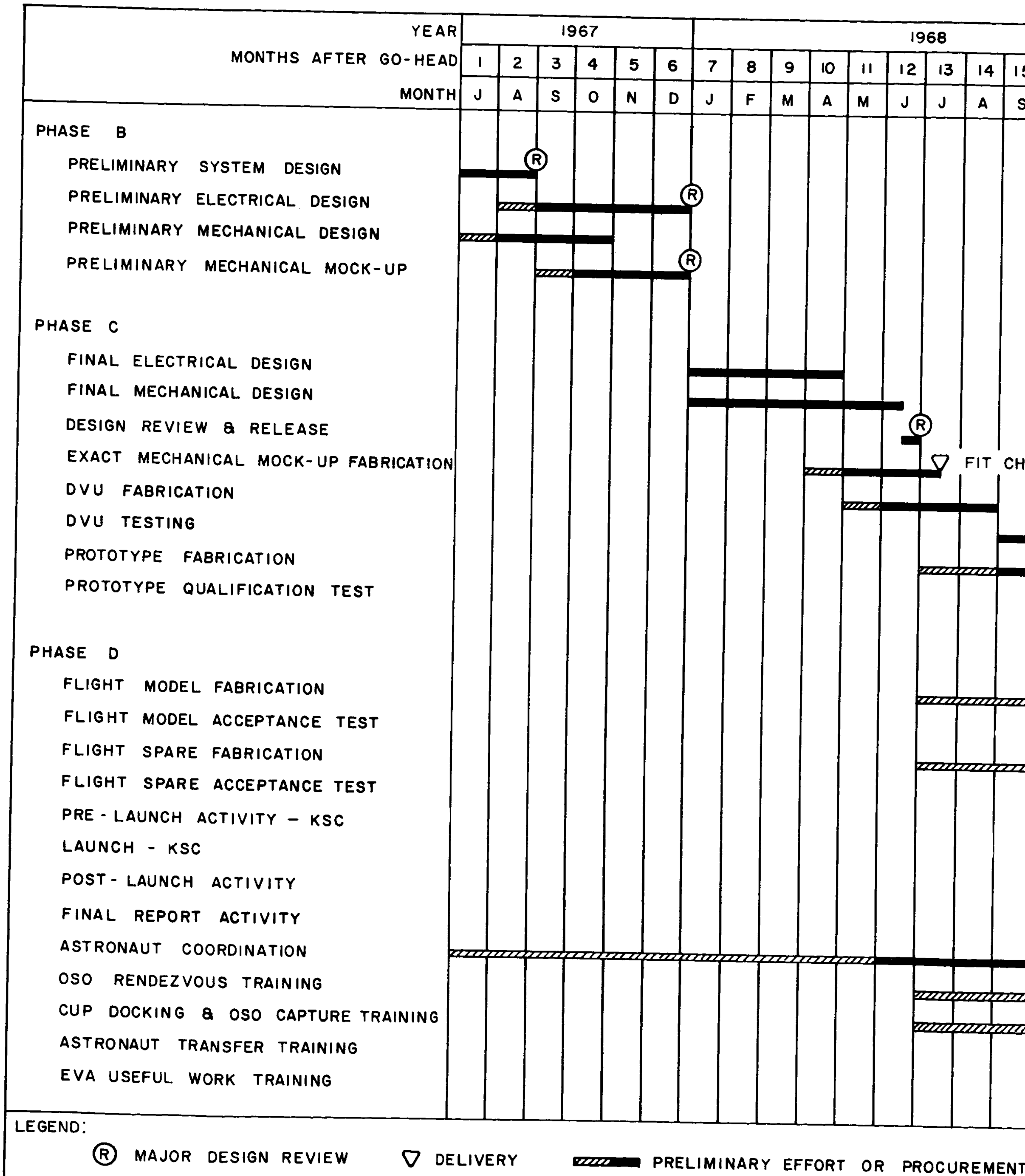
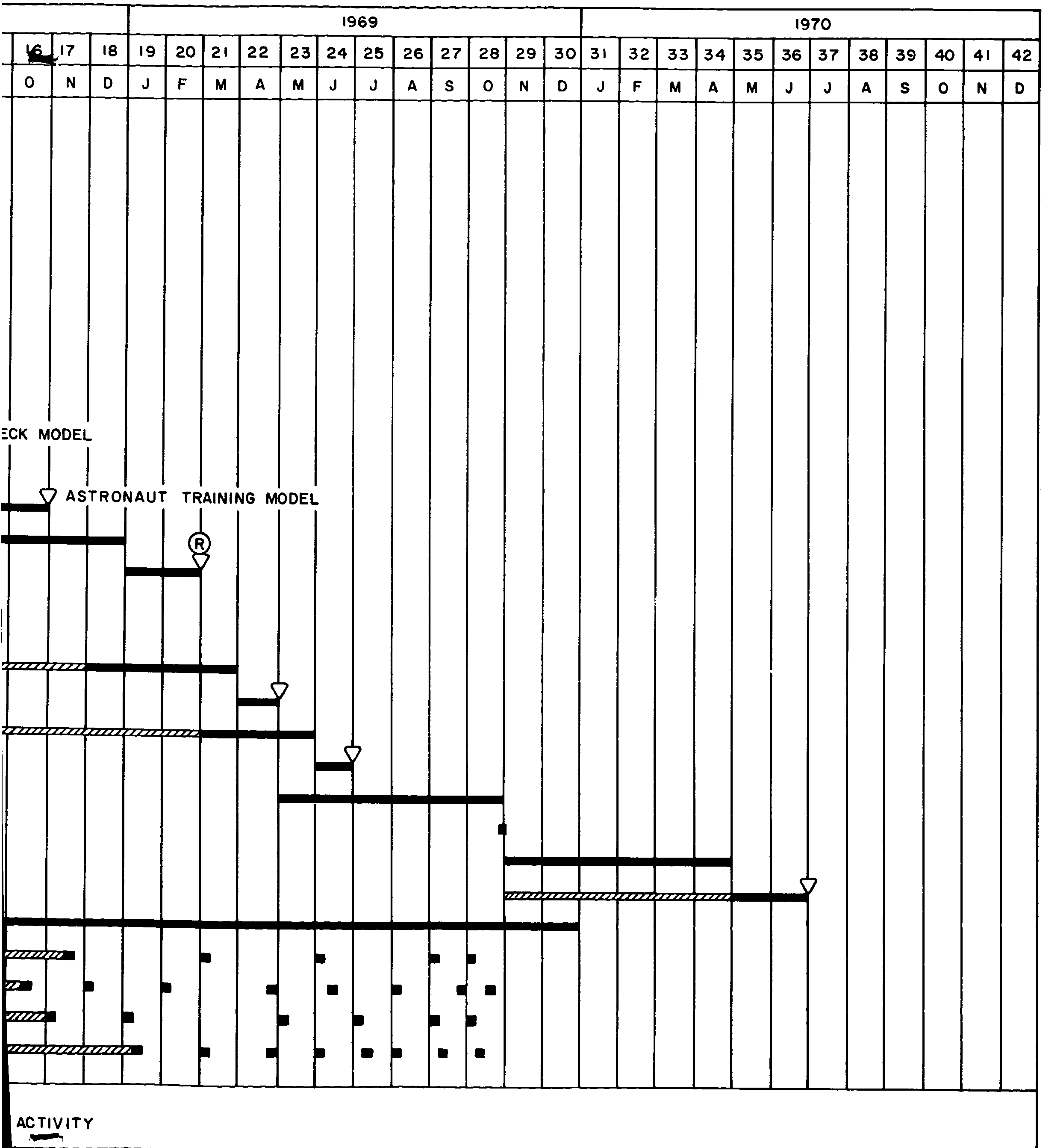

YEAR
1967
1968
MONTHS AFTER GO-HEAD
1 2 3 4 5 6 7 8 9 10 11 12 13 14
MONTH
J A S O N D J F M A M J J A S
PHASE B
PRELIMINARY SYSTEM DESIGN
PRELIMINARY ELECTRICAL DESIGN
PRELIMINARY MECHANICAL DESIGN
PRELIMINARY MECHANICAL MOCK-UP
PHASE C
FINAL ELECTRICAL DESIGN
FINAL MECHANICAL DESIGN
DESIGN REVIEW & RELEASE
EXACT MECHANICAL MOCK-UP FABRICATION
FIT CH
DVU FABRICATION
DVU TESTING
PROTOTYPE FABRICATION
PROTOTYPE QUALIFICATION TEST
PHASE D
FLIGHT MODEL FABRICATION
FLIGHT MODEL ACCEPTANCE TEST
FLIGHT SPARE FABRICATION
FLIGHT SPARE ACCEPTANCE TEST
PRE-LAUNCH ACTIVITY – KSC
LAUNCH - KSC
POST-LAUNCH ACTIVITY
FINAL REPORT ACTIVITY
ASTRONAUT COORDINATION
OSO RENDEZVOUS TRAINING
CUP DOCKING & OSO CAPTURE TRAINING
ASTRONAUT TRANSFER TRAINING
EVA USEFUL WORK TRAINING
LEGEND:
R MAJOR DESIGN REVIEW
DELIVERY
PRELIMINARY EFFORT OR PROCUREMENT

Fig. 1-4 Miss



ion 1 Schedule

The exact mechanical mockup is to be used as an Apollo fit check model, a structural test model and in neutral bouyancy astronaut training exercises. A design verification unit (DVU) has been included in the schedule and this model will be utilized in the following ways:

(1) Pre-prototype Production Model - Fabricated from pre-release engineering drawings, the DVU will serve as a production test model. Any problems arising during fabrication can be resolved and the necessary corrections incorporated prior to prototype fabrication. This shortens prototype production time and generally results in a better prototype model.

(2) Engineering Model for System Tests - The DVU will be the first complete flight unit configuration model available for system engineering tests. Results of these tests, performed prior to completion of prototype fabrication, can be used as a basis for changes to that model prior to its completion. Again, this results in a better prototype model. The additional system testing performed on the DVU gives greater confidence that the prototype will pass its qualification tests and also cuts down on the amount of preliminary testing required on the prototype prior to commencing qualification tests.

(3) Astronaut Training Model - Upon completion of DVU system testing, the model is then available for use as an astronaut trainer. The complexity of the tasks to be performed by the astronauts make this a very desirable addition to the program. With an OSO mockup, an Apollo trainer, various simulators, the exact mechanical mockup and this model, all phases of the mission can be duplicated for training purposes.

10.1 ASTRONAUT COORDINATION AND TRAINING: Since the astronaut is a dominent part of the CWP system, heavy emphasis will be placed on coordination with the astronaut office and the astronaut training program. As shown in Fig. 1-4, coordination activity will commence at program inception and continue through to the completion of post flight activity. Astronaut training effort will commence with the completion of final design and will be conducted in the following four major areas:

- OSO rendezvous
- CWP docking and OSO capture
- Astronaut transfer
- EVA useful work

In addition to astronaut coordination and training support, personnel will participate in prelaunch, launch, flight and post-flight activity.

MANAGEMENT PLAN - PART III

(For Headquarters use only.)
DATE RECEIVED BY SM

TITLE OF EXPERIMENT

Mission 1 - OSO Capture and Material Recovery

SPONSORING INSTITUTION	ADDRESS
Co-sponsors: George C. Marshall Space Flight Center/OMSF	Huntsville, Alabama 35812
Goddard Space Flight Center/OSSA	Greenbelt, Maryland 20771

1. RESPONSIBILITIES

INDIVIDUAL	NAME	ADDRESS
A. RESPONSIBLE ADMINISTRATOR	Mr. G. von Tiesenhausen R-AS-VO	NASA-MSFC Huntsville, Alabama 35812
B. PRINCIPAL INVESTIGATOR	Advanced Systems Office	NASA-MSFC Huntsville, Alabama 35812
C. CO-INVESTIGATOR(S)		
	Dr. L. Werner	OMSF-MT-E, Washington, D.C.
	Mr. R. Halpern	OSSA-SGH, Washington, D.C.
	Mr. D. C. Cramblit	NASA-MSFC-R-AS-VO, Huntsville, Alabama 35812
	Mr. W. H. Stafford	NASA-MSFC R-AS-VO, Huntsville, Alabama 35812
	Mr. J. Walls	NASA-GSFC OSO Program Greenbelt, Maryland 20771

D. PRINCIPAL INVESTIGATOR'S ROLE IN RELATION TO THIS EXPERIMENT

Overall program direction and coordination with both the AAP and OSO Program.

E. RESPONSIBILITIES OF OTHER KEY PERSONS

To be determined

(Attach additional sheets if necessary, identifying items by number.)

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2.

BUDGETARY COST BREAKDOWN

Attach a sheet (or sheets) giving the costs of the experiment for which NASA support will be required, in the following format, and in the detail specified. Separate cost breakdowns should be submitted for the three phases of experiment funding shown in Item 3, "Quarterly Funding Requirements".

ITEM	AMOUNT
DIRECT LABOR *(Separate by Labor Category; Rate per hour or man-month; Personnel involved, what they will do, etc.)*	$
MANUFACTURING BURDEN *(Overhead)* RATE (%) *(Flight experiments normally will be supported by contracts rather than grants.)*	
MATERIALS *(Total)* *(Bill of Material, including estimated cost of each major item.)*	
SUBCONTRACTS *(List those over $25,000)* *(Specify the vendor if possible, and the basis for the estimated cost.)*	
SPECIAL EQUIPMENT *(Total)* *(List of lab equipment, proposed uses, and estimated cost.)*	
TRAVEL *(Estimated number of individual trips, destinations, and costs.)*	
ANY OTHER ITEMS *(Total)* *(Explain in detail similar to the above.)*	
TOTAL COSTS	$
GENERAL AND ADMINISTRATIVE RATE ( )	$
TOTAL ESTIMATED COST	$ 6,580,000*

Experimenters who request to conduct the proposed experiment as an extension of an existing grant or contract, should list the grant or contract number and the name and address of the NASA technical monitor below.

GRANT OR CONTRACT NO.	NAME AND ADDRESS OF NASA TECHNICAL MONITOR

*See attached Cost Breakdown (Table 1-8).

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Table 1-8

MISSION 1 COST BREAKDOWN (BUDGETARY)

Phase B - includes preliminary design and mockup	$ 380,000
Phase C - includes detail design, detail mockup, design verification unit (DVU), prototype and prototype qualification	3,500,000
Phase D - includes flight model and spare fabrication and acceptance test, astronaut training and launch support	2,500,000
OSO - includes OSO modifications, OSO refurbishment parts and OSO training models	200,000
Program Total	$6,580,000

3. QUARTERLY FUNDING REQUIREMENTS (DOLLARS IN THOUSANDS)

MISSION 1 (BUDGETARY)

Flight Model Delivery (June 1969) · Launch (Dec 1969) · Final Report (June 1970)

Program Phases \ Quarters Ending	Sept 1967	Dec 1967	Mar 1968	June 1968	Sept 1968	Dec 1968	Mar 1969	June 1969	Sept 1969	Dec 1969	Mar 1970	June 1970	Totals
Phase B	160	220											380
Phase C			500	750	1,000	800	450						3,500
Phase D					100	300	600	800	200	200	100	200	2,500
OSO					50	100	50						200
Totals	160	220	500	750	1,150	1,200	1,100	800	200	200	100	200	6,580

SECTION 2

MISSION 2

BBRC

MISSION 2
(NASA FORM 1138 DATA)

APOLLO EARTH ORBITAL SCIENTIFIC EXPERIMENT PROPOSAL

TITLE OF EXPERIMENT

Mission 2
OSO Capture and Refurbishment

NAME OF INVESTIGATOR

(1) Ball Brothers Research Corporation, Boulder, Colo.
(2) Emerson Electric Company of St. Louis, St Louis, Mo.

NAME OF SPONSORING INSTITUTION

Co-sponsors:

(1) George C. Marshall Space Flight Center/OMSF
(2) Goddard Space Flight Center/OSSA

NASA FORM 1138 AUG 64

1. PURPOSE AND OBJECTIVE OF THE EXPERIMENT

This experiment is the second of a series of three experiment missions, evolutionary in complexity, for the purpose of developing techniques and hardware requirements for rendezvous, capture, inspection, recovery of equipment and experiments, replenishment of expended supplies, and refurbishment of satellites in orbit.

Specific objectives to be accomplished are:

- Rendezvous with a noncooperative satellite
- Capture of a noncooperative spin stabilized satellite
- Conduct of useful EVA work tasks

The conduct of useful EVA work tasks will:

- Advance the EVA state-of-the-art knowledge
- Enhance the scientific knowledge of the space environment effects on materials
- Improve the satellite operation or extend its useful lifetime

The specific purposes of this experiment, Mission 2-OSO capture and refurbishment, are to rendezvous with and capture an OSO satellite and to conduct useful EVA work on the captured satellite. Since this mission will be the second of three experiment missions, emphasis will be on satisfying the objectives of accomplishing useful EVA work. Significant experiment tasks presented in the area of EVA useful work, will be directed toward satellite refurbishment.

(Attach additional sheets if necessary, identifying items by number.)

1. TITLE OF EXPERIMENT

Mission 2 – OSO Capture and Refurbishment

DATE OF SUBMISSION

1 March 1967

(For Headquarters use only.)

DATE RECEIVED BY SM

2. SPONSOR

NAME OF SPONSORING INSTITUTION

George C. Marshall Space Flight Center/Goddard Space Flight Center

ADDRESS

Huntsville, Alabama, 35812 / Greenbelt, Maryland 20771

TELEPHONE

(205) 876-0226 MSFC
(301) 982-5701 GSFC

NAME OF PRINCIPAL ADMINISTRATOR RESPONSIBLE FOR EXPERIMENT

Mr. G. von Tiesenhausen, MSFC (R-AS-VO), Mr. L. Hogarth, GSFC (OSO Program)

3. INVESTIGATORS

NAME OF PRINCIPAL INVESTIGATOR

George C. Marshall Space Flight Center - Advanced System Office

ADDRESS

Huntsville, Alabama 35812

TELEPHONE

(205) 876-0226

NAMES OF OTHER INVESTIGATORS	ADDRESS	TELEPHONE
Dr. L. Werner	OMSF-MT-E Washington, D.C. 20546	(202) 962-3582
Mr. R. Halpern	OSSA-SGH Washington, D.C. 20546	(202) 962-0157
Mr. D. C. Cramblit	MSFC-R-AS-VO Huntsville, Alabama 35812	(205) 876-9680
Mr. W. H. Stafford	MSFC-R-AS-VO Huntsville, Alabama 35812	(205) 876-0159
Mr. J. Walls	GSFC-OSO Project Greenbelt, Maryland 20771	(301) 982-5701
Mr. R. E. Hathaway	Ball Brothers Research Corp. Boulder, Colorado 80302	(303) 444-5300 Ext. 481
Mr. J. A. Campbell	Emerson Electric of St. Louis St. Louis, Missouri 63136	(314) 261-1800

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The Gemini Program has contributed significantly to the state-of-the-art of rendezvous with a cooperative satellite, docking with a cooperative satellite, and conducting limited EVA useful work. Tabulated below is a record of the manned Gemini missions where orbit changing, rendezvous, Agena docking and extravehicular activity was successfully conducted.

Table 2-1
GEMINI FLIGHT RECORD (No. 2)

Gemini	Rendezvous	Agena Docking	EVA
Gemini III	X (a)		
Gemini IV			X
Gemini V			
Gemini VI	X		
Gemini VII			
Gemini VIII	X	X	X
Gemini IX	X		X
Gemini X	X	X	X
Gemini XI	X	X	X
Gemini XII	X	X	X

(a) Orbit change only

Rendezvous. Problems of rendezvous involve the preflight phase, orbit transfer and correction, and acquisition and terminal guidance. In the Gemini Program, the problems involved in the preflight phase of establishing the "launch window" were minimized by the launching of the two boost vehicles with precise time phasing and thereby simplifying the inflight operations and the time spent in the rendezvous attempt. A simultaneous countdown of both launch vehicles was conducted; the target vehicle was launched first, its orbit was precisely established by ground tracking, and then the manned chase vehicle was launched into relatively the same orbit. The manned vehicle launch was deliberately delayed from a liftoff which would provide a perfect phase match, but it avoided a spacecraft phase lead condition that would require target vehicle maneuvering or extremely long catch-up maneuvering. Normally, manned spacecraft maneuvering took place during the first orbit in order to check out the onboard radar system and to determine an accurate orbit position for the manned spacecraft by ground tracking. Spacecraft maneuvering was then accomplished to maximize the support from the ground tracking network, and provide the greatest tolerance to onboard failure of the spacecraft radar and inertial guidance system.

Acquisition of the target vehicle was accomplished between 200 to 250 nm distance using onboard radar. The spacecraft radar was then used to track the target vehicle until visual sightings were made. On Gemini flights XI and XII, the onboard radar malfunctioned before visual sighting occurred, and the use of radar for closed-loop rendezvous was abandoned. The astronauts utilized the spacecraft inertial guidance system and calculated their bearings to bring them to station keeping with the target vehicle as scheduled with very reasonable fuel expended and thereby demonstrated passive rendezvous capability.

Agena Docking. Docking the Gemini with the Agena can be considered as a cooperative docking system since the Agena was controlled in attitude stabilization, and utilized visual docking aids such as lights and a docking bar. Except for a post-docking malfunction on the Gemini VIII mission, all of the Gemini docking missions were rated as very successful.

Extra Vehicular Activity. Some form of EVA was conducted on six Gemini missions as indicated in Table 2-1. Although each mission recorded success in varying degrees, each mission substantiated that EVA can be conducted. The mission that was most successful toward proving EVA capability, especially toward useful EVA tasks similar to this proposed experiment, was Gemini XII. On that mission, astronaut Major Edwin E. Aldrin, Jr. proved that with adequate preflight training, EVA support equipment and tools, and adequate rest periods, man can successfully conduct a variety of EVA useful work tasks and skills.

It is important to point out that in the functions of rendezvous and docking, the Gemini program utilized "cooperative" procedures and systems in conducting rendezvous and docking with the Gemini spacecraft and Agena target vehicle. However, it is also important to point out that with the use of these cooperative procedures and systems, the state-of-the-art technology was advanced such that open loop rendezvous was successfully accomplished on Gemini's X, XI, and XII; consequently, the astronauts believe they can maneuver and dock with any target vehicle that is independently stabilized. (Reference the close maneuvering that took place between Gemini VI and VII after rendezvous was accomplished.)

3. SPECIFY PARAMETERS TO BE MEASURED INCLUDING NUMERICAL VALUES EXPECTED AND OUTLINE THE RESEARCH PROGRAM:

The experiments conducted on this mission present a blend of engineering and scientific investigation. As previously stated, the primary objectives are placed on conducting refurbishment EVA experiments. The following table gives a composite of the experiments proposed to be conducted for Mission 2 with the expected information to be gained.

Table 2-2

MISSION 2 EXPERIMENT TASKS AND RESULTS

Experiment	Inflight Determination	Post-Flight Determination
Precapture inspection		
• Radiation	Go/no-go (determined safe levels present for EVA)	
• OSO dynamics	Go/no-go (determined OSO spin rate, 10-40 rpm)	Compare with ground predictions
• Photography		Precapture damage evaluation
Capture Operations		Precapture configuration evaluation
• Photography		1) Dynamic characteristics 2) Capture operations
Post-capture inspection and preparation		
• Photography		Before and after damage evaluation
• Radiation	Go/no-go decision (dual experiment to provide for instantaneous radiation doses and long term dose rate exposure)	Accumulative dose rate
• Mechanical damage	1) Evaluation of physical damage 2) Determination of coldwelding effects	

(Attach additional sheets if necessary, identifying items by number.)

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3. Specify Parameters to be Measured Including Numerical Values and Outline the Research Program (Cont.)

Table 2-2 (Cont.)

Experiment	Inflight Determination	Post-Flight Determination
Refurbishment		
• Pitch gas supply	Adequacy of EVA procedures and technology	Extended operational life of OSO
• Spin gas supply	Same	Same
• Battery power supply	Same	Same
• Solar array panels	Same	Same
• Tape recorders	Same	Same
• Elevation locking system	1) Adequacy of EVA procedures and technology 2) Correct satellite malfunction	
• Stabilization magnets	Adequacy of EVA procedures and technology	Improve OSO performance
• Magnetometer calibration	Evaluation of checkout procedures	Bias error induced in magnetometer readings
• EVA monitoring photography		1) Evaluation of EVA astronaut operations 2) Correlate space EVA operations with training simulation operations
• OSO automatic operations	Evaluation of checkout procedures	Extend operational life of OSO
Release		
• OSO dynamics	Determine OSO spin rate	
• Photography		Post-release damage evaluation

4. PRESENT AN ANALYSIS OF THE PERFORMANCE OF THE PROPOSED EXPERIMENT *(e.g., dynamic range, signal to noise ratio, etc.)*

Refer to Part I, paragraphs 3 and 6, for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

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5. DISCUSS THE METHOD OR POSSIBLE METHODS FOR THE ANALYSIS AND INTERPRETATION OF THE DATA *(e.g., the statistical validity)*

Refer to Part I, paragraphs 3 and 6, for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

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6. DESCRIBE THE EXPERIMENTAL PROCEDURE TAKING INTO CONSIDERATION THE ENVIRONMENT AND ORBITAL CHARACTERISTICS OF THE SPACECRAFT. INCLUDE ANY CONSTRAINTS ON SPACECRAFT ATTITUDE, POINTING ACCURACY, AND STABILITY. EXPLAIN WHY THE ASTRONAUT IS NECESSARY TO THE PERFORMANCE OF THIS EXPERIMENT. DESCRIBE IN DETAIL OPERATIONS PERFORMED BY THE ASTRONAUT AND TIME CONSUMED DURING EACH OPERATION. *(Include length of time the spacecraft must hold a given attitude.)*

The mission operations consist of the following functional steps:

- Capture mechanism docking
- Rendezvous maneuvers
- Precapture inspection
- Capture operations
- Post-capture inspection and preparation
- Refurbishment and checkout
- Stowage of materials
- Release and capture mechanism jettison
- Post-release inspection

Experiment tasks have been established for each of these functional operations which are discussed in considerable detail in paragraph 7.3 Volume II (the technical report). The information presented herein summarizes and supplements the information presented in the technical report. A Mission 2 Time Line Summary is presented in Table 2-3.

Since one of the primary objectives of this experiment mission is to advance extra vehicular capability and state-of-the-art technology, the man-machine interface during the conduct of this experiment mission is paramount. The importance and role of the astronaut in the conduct of the experiments for the capture of the OSO satellite and the conduct of refurbishment and checkout tasks is defined in the descriptions of each experiment task.

(Attach additional sheets if necessary, identifying items by number.)

6. The Experimental Procedure (Cont.)

Table 2-3

MISSION 2 TIME LINE SUMMARY

Operation/Event	Experiment Priority	EVA (Min)	IVA (Min)	Accrued Mission Time (EVA + IVA) (Min)
I Rendezvous Operations				
CSM/CWP Docking	MSO		25	25
CSM Orbit Transfer	MSO		44	69
Close Rendezvous Maneuvers	MSO		9	78
Night Time Station Keeping	MSO		31	109
Circumnavigation	MSO		6	115
Pre-Capture Inspection	MSO		60	175
Night Time Station Keeping	MSO		31	206
OSO Capture Maneuvers	MSO		6	212
Sub Total			212	
II Work Session No. 1				
Start EVA-Egress Fwd Hatch	MSO	5	5	222
Prepare Equip. & OSO Inspection	MSO	27	27	276
Astronaut Rest Period		5		281
Mount EVA Cameras	P	3	3	287
Expr. Preparation & Radiation Meas.	MSO	36		323
Astronaut Rest Period		6		329
Satellite Centering	MSO	21		350
Power Bus Removal & Umbilical Connect	MSO	12		362
Astronaut Rest Period		6		368
Mech. Freedom & Damage Evaluation & Photos	P	32		400
Read Magnetometer	S		32	432
Add Stabilization Magnets	S	21		453
Astronaut Rest Period		6		
Stow Equip.-Return to CM	MSO	47	47	553
Sub Total		227	114	
III Astronaut 8 Hr. Rest Period				1033
IV Work Session No. 2				
Start EVA-Egress Fwd Hatch	MSO	5	5	1043
Prepare Equip. Reposition Platform	MSO	27	27	1097
Astronaut Rest Period		5		1102
Add Tape Recorders & Photos*	P	80	15	1197
Astronaut Rest Period		6		1203
Correct Nutation Damper Lock	P	25	15	1243
Astronaut Rest Period		6		1249
Add Solar Array Panel & Photos	P	39	15	1303
Astronaut Rest Period		6		1309
Stow Equip.-Return to CM	MSO	47	47	1403
Sub Total		246	124	
V Astronaut 8 Hr. Rest Period				1883
VI Work Session No. 3				
Start EVA-Egress Fwd Hatch	MSO	5	5	1893
Prepare Equip. Repositon Platform	MSO	27	27	1947
Correct Arm Locking System and Photos*	P	105	15	2067
Astronaut Rest Period		6		2073
Add Batteries & Photos*	P	74	15	2162
Astronaut Rest Period		6		2168
Replenish Pitch Gas	P	25	8	2201
Replenish Spin Gas	P	16	8	2225
Astronaut Rest Period		6		2231
Stow Equip.-Return to CM	MSO	47	47	2325
Sub Total		317	125	
VII Release Operations	MSO		36	2361
Mission 2 Totals		790	611	

NOTES:

*With Astronaut Rest Periods as Applicable

MSO - Mission Support Operation, P - Primary Objective, S - Secondary Objective

6.1 CAPTURE MECHANISM DOCKING: The objective of this mission support operations task is to dock the Apollo Command Service Module (CSM) with the OSO satellite capture mechanism in order to capture the OSO satellite and to conduct the useful work experiments for satellite refurbishment.

6.1.1 Task Description: Task operations for the pilot astronaut are as follows:

(1) Separate the CSM from the Saturn IVB.

(2) Orient the CSM center line (head on) with the capture mechanism docking collar.

(3) Dock the CSM with the capture mechanism docking collar.

(4) Pull the OSO satellite capture mechanism clear of the S-IVB.

6.1.2 Spacecraft Constraints: Specific spacecraft constraints for conducting the docking operation will be determined as a part of AAP mission integration studies.

6.1.3 Astronaut Operations: This operation will be similar to the Apollo operation of docking the CSM with the LEM. Detail procedures for accomplishing this docking operation will be determined as a part of AAP mission integration studies. A time of 25 minutes has been allocated for conducting this operation. This time allocation has been incorporated into the time line analysis for Mission 2. (See Table 2-3.)

6.2 RENDEZVOUS MANEUVERS: The objective of this mission support operations task is to maneuver the Apollo CSM in an orbit transfer operation from the nominal AAP orbit to the nominal OSO orbit, in order to rendezvous with and capture the OSO satellite.

6.2.1 Task Description: Task operations for the pilot astronaut are as follows:

(1) Perform CSM orbit transfer.

(2) Perform terminal guidance with the OSO satellite.

(3) Perform station keeping.

6.2.2 Spacecraft Constraints: Constraints affecting the CSM spacecraft in the conduct of this experiment mission are presented below for the three task descriptions cited.

CSM Orbit Transfer:

(1) The Apollo launch window necessary to conduct the ESMRO mission can be as much as 175 minutes.

(2) The CSM will be launched into an orbit inclination compatable with the OSO orbit.

(3) Orbit transfer of the CSM will initiate from the nominally circular orbit of 370 (200 nm) altitude.

(4) The nominal parameters of the OSO satellite orbit will be:

Circular orbit:	555 ± 92 km (300 ± 50 nm)
Inclination:	33 ± 3 deg
Period:	96 min

(5) The amount of OSO engine propellant assumed available for CSM orbit transfer and rendezvous with the OSO, will be equivalent to a ΔV of 762 mps (2500 fps).

(6) Previous to transfer, the OSO orbit will be determined by ground radar and fed into a ground based computer for analyzing and comparing with the CSM orbit during transfer maneuvers.

(7) During transfer, the CSM will be in contact with ground based tracking stations. The CSM trajectory will be compared with the necessary transfer trajectory, and corrective measures will be taken. The transfer itself will be initiated after ground based computers analyze the comparative positions of OSO and the CSM and calculate the best trajectory for accomplishing the transfer.

Terminal Guidance:

(1) The positional errors of the CSM will be known to ±150 meters (±490 feet) in cross range and radial, and ±300 meters (±980 feet) in longitude.

(2) The positional errors of the OSO will be known to within the following accuracies:

Longitude:	±1.6 km (0.87 nm)
Cross Range:	±0.5 km (0.27 nm)
Radial:	±0.5 km (0.27 nm)

(3) Terminal rendezvous with the OSO will occur during the dawn phase of the OSO orbit with the CSM approaching the OSO from below and ahead.

Delta Velocity Requirements: ΔV requirements for the rendezvous maneuvering phase are presented in Table 2-4. The ΔV for precapture and post-release close-in maneuvers have been included for additional information.

6.2.3 Astronaut Operations: The orbit transfer and terminal guidance maneuvers will be similar to the rendezvous maneuvers conducted during the Gemini program. Detail procedures for accomplishing these maneuvers will be determined as a part of AAP mission integration studies. A time of 44 minutes has been estimated for conduct of the operation. The times for conducting the station keeping operations have been incorporated into the time line summary for Mission 2. (See Table 2-3.)

Table 2-4

RENDEZVOUS ΔV REQUIREMENTS (No. 4)

Rendezvous Operation	ΔV (mps)	ΔV (fps)
Launch window	67	220
Orbit transfer	300	984
Terminal closure	24	79
Close-in maneuvers, Precapture	7.6	25
Close-in maneuvers, Post-release	7.6	25
TOTAL	406	1333

6.3 PRECAPTURE INSPECTION: Prior to capture of the OSO satellite, precapture inspection will be required to assure that it is safe to proceed with the capture operations of the mission.

6.3.1 Task Description: Task operations of the IVA astronaut are as follows:

(1) Determine precapture OSO radioactive radiation levels.

(2) Determine OSO dynamics.

(3) Conduct documentation photography.

6.3.2 Spacecraft Constraints:

(1) These inspection tasks will be conducted from inside the Command Module spacecraft during the circum-navigation station keeping.

(2) The OSO must not be contaminated by the RCS engine

gases during the circumnavigation maneuvering and station keeping.

6.3.3 Astronaut Operations: These precapture inspection operations will be conducted as described in detail in paragraphs 6.3.3.1, 6.3.3.2, and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) OSO Radiation - This experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. A hand held, directional spectrometer will be used to obtain quantitative and qualitative radiation data. An IVA astronaut will take the data through a spacecraft window and ascertain that the OSO radiation levels are within prescribed limits.

(2) OSO Dynamics - This experiment task will be performed from within the Command Module during daytime circumnavigation of the OSO. Using a visual aid and a stop watch, the IVA astronaut will determine the OSO spin rate and ascertain that it is within acceptable limits to proceed with the capture operations.

(3) Photography - This experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. Using still and motion picture cameras, the IVA astronaut will still take documentary pictures to record the precapture condition and dynamics of the OSO.

Estimated times for these tasks have been included in the Time Line Summary, Table 2-3.

6.4 CAPTURE OPERATIONS: Capture of the OSO satellite will be a mission support operation of Mission 2. Capture of the OSO will be necessary to perform the useful work experiments.

6.4.1 Task Description: Task operations of the pilot and IVA astronauts are as follows:

- Closure maneuvers and OSO capture
- Documentation photography

6.4.2 Spacecraft Constraints: The spacecraft constraints for documentation photography have been discussed in paragraph 6.3.2 above. Spacecraft constraints associated with the capture operations are as follows:

(1) Precapture OSO radiation levels must be within acceptable limits.

(2) The CSM spacecraft must not be damaged.

(3) Capture will be accomplished with an active non-cooperative OSO satellite.

(4) The OSO satellite must not be damaged.

(5) The OSO satellite must not be contaminated by RCS engine gas during capture maneuver operations.

(6) During capture maneuver operations, the longitudinal axis of the CSM must be aligned to the OSO spin axis within ±TBD* degrees in pitch, ±TBD degrees yaw and ±TBD degrees in roll.

(7) The CSM limit cycle rates will not exceed ±0.05 deg/sec in pitch/yaw, and roll.

(8) The CSM dead band limit will not exceed ±1/2 degree in pitch/yaw/roll.

*TBD = To be determined

(9) The differential velocity between the CSM and OSO during capture shall not exceed 1 fps.

(10) The capture operation will not exceed 15 minutes during the daylight portion of the orbit.

6.4.3 Astronaut Operations: These capture operations will be conducted as described in detail in paragraphs 6.3.4.1 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Closure Maneuvers and OSO Capture - This experiment task will be performed from within the Command Module. The CM will be maneuvered so as to approach the OSO from underneath along the satellite spin axis. Prior to capture, the CWP attachment head must be spun up to approximately match the OSO spin rate. At the time of capture, the velocity differential between the CSM/CWP and OSO should be approximately 1 fps. The CSM/CWP should be maneuvered so that the attachment head encircles the OSO mounting flange. After capture, the OSO is despun on astronaut command by the CWP.

(2) Documentation Photography - This experiment task is performed by an IVA astronaut during closure maneuvers and OSO capture. Motion pictures will be taken during closure and OSO capture to pictorially document that operation.

Estimated times for these tasks have been included in the Time Line Summary Table 2-3.

6.5 POST-CAPTURE INSPECTION: After capture of the OSO satellite continued inspection and experiment preparation will be performed for the conduct of the useful work experiments.

6.5.1 Task Description: Task operations of the IVA and EVA astronauts are as follows:

- Experiment preparation and radiation monitoring
- OSO centering in the capture mechanism
- OSO wheel power bus removal
- Evaluation of mechanical freedom and damage
- Documentary observations and photography

6.5.2 Spacecraft Constraints: The constraints imposed are the following:

(1) IVA astronaut must monitor the EVA astronaut at all times while he is conducting EVA useful work.

(2) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±TBD degrees in pitch, ±TBD degrees yaw, and ±TBD degrees roll.

(3) The OSO must not be contaminated by the RCS engine gases during orbit keeping.

(4) The EVA astronaut must exercise caution not to contaminate any of the experiments scheduled for removal.

6.5.3 Astronaut Operations: These post-capture inspection operations will be conducted as described in detail in paragraphs 6.3.5.1, 6.3.5.2, 7.3.5.3, 7.3.5.4 and 7.3.5.5 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Experiment Preparation and Radiation Monitoring - During this experiment task, the EVA astronaut will egress from the CSM, erect the CWP into its useful work position, position himself and his support equipment on the CWP, and measure the OSO radiation levels as a backup to the measurements made from within the Command Module.

(2) OSO Satellite Centering - This experiment task is performed by the EVA astronaut. First the centering mechanism is unlatched so that it can fasten to the OSO mating flange. Then the adhesive band (or yoke arms) is released, and the centering mechanism is activated with a power tool to position the OSO on the center of the attachment hand. The OSO is then in position for useful work and subsequent release.

(3) OSO Wheel Power Bus Removal - This experiment task is performed by the EVA astronaut to assure that all OSO power has been interrupted before conducting useful work on the satellite. This is accomplished by removing a special external corrector plug that was installed prior to launching the OSO. This plug is replaced upon conclusion of the useful work tasks.

(4) Mechanical Freedom and Damage Evaluation - This experiment task is performed by the EVA astronaut. The mechanical freedom evaluation consists of manually rotating the OSO sail with respect to the wheel and the pointed instruments with respect to the sail to determine if cold welding has occurred. The EVA astronaut will inspect the OSO surfaces and parts for damage and photograph anything noted.

(5) Documentation Photography - This experiment task is performed by the EVA astronaut after capture operations have been completed and during useful work tasks. As a minimum, before and after pictures will be taken for each experiment task conducted. This task will be intermittently performed during the entire useful work phase of the mission.

Estimated times for these tasks have been included in the Time Line Summary, Table 2-3.

6.6 REFURBISHMENT: The conduct of useful EVA work will be the major objective of Mission 2. On Mission 2, the primary useful work objective will be to refurbish the OSO satellite. The conduct of useful work will prove out man's capability of performing maintenance and repair work in space.

6.6.1 Task Description: Task operations of the EVA and IVA astronauts during the conduct of refurbishment experiments are as follows:

- Replenishment of pitch gas supply
- Replenishment of spin gas supply
- Addition of a new battery power supply
- Addition of a new solar array panel
- Addition of new tape recorders
- Maintenance of nutation damper locking system
- Addition of stabilization magnets
- Calibration of the magnetometer
- EVA documentation photography

- Return OSO to automatic operation
- Return of EVA astronaut and materials to the Command Module.

6.6.2 Spacecraft Constraints:

(1) The IVA astronaut must monitor the EVA astronaut at all times while he is conducting EVA useful work.

(2) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±TBD degrees in pitch, ±TBD degrees yaw, and ±TBD degrees roll.

(3) The OSO must not be contaminated by the RCS engine gases during orbit keeping.

(4) The EVA astronaut must exercise caution not to contaminate any of the experiments scheduled for removal.

6.6.3 Astronaut Operations: These useful work operations will be conducted as described in detail in paragraphs 7.3.7.1, 7.3.7.2, 7.3.7.3, 7.3.7.4, 7.3.7.5, 7.3.7.6, 7.3.7.7, 7.3.7.8, 7.2.7.10, 6.3.6.9, 7.3.7.11 and 7.3.8 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Replenishment of Pitch Gas - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut attaches the gas supply line to pitch gas line check valve located on the OSO sail assembly. He then completes any required EVA tasks, including storage of the work platform, return of containers to the CM, etc. and then egress to the CM. When the CM is pressurized, the IVA astronaut then remotely commands the commencement of the filling

operation. When it is completed, he remotely commands the gas line to disconnect from the OSO.

(2) Replenish Spin Gas Supply - This experiment task is conducted in the same manner as the pitch gas replenishment experiment. The spin gas line check valve is located on the rim panel of wheel compartment No. 4.

(3) Addition of a new Battery Power Supply - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut positions and fastens one battery pack to each of three OSO lifting lugs located on the rim of the wheel structure. The batteries are then electrically connected together and to the power console test connector on the bottom of the wheel structure. The IVA astronaut then checks out the OSO power system with the Apollo onboard checkout system (OCS).

(4) Addition of a new Solar Array Panel - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut positions and secures a new solar array to the sail structure. Using connectors available on the back of the sail, he then hooks up the new panel. The IVA astronaut then checks out the OSO power system with the Apollo OCS.

(5) Addition of new Tape Recorders - This experiment task is conducted by both the EVA and IVA astronauts. The EVA astronaut will position and secure two tape recorders to two of the OSO wheel lifting lugs. A ballast weight will be secured to the third lug. The two recorders will be electrically connected to the OSO system umbilical connector. The IVA astronaut will then checkout the tape recorders with the Apollo OCS.

(6) Maintenance of Nutation Damper Locking System - The experiment task will be conducted by the EVA astronaut. In the event that a nutation damper pin squib did not fire after launch of the OSO, the EVA astronaut can connect a power lead from the CWP and provide sufficient power to fire the squib.

(7) Addition of Stabilization Magnets - This experiment task is conducted by the EVA astronaut. Two permanent magnets are to be fastened to the back of the sail structure. These magnets will aid the function of the OSO electromagnetic coil that is used to counteract the interaction between the OSO and the earth's magnetic field.

(8) Calibration of the Magnetometer - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut will rotate the sail to six different specific positions. For each position the IVA astronaut will take a magnetometer reading and a simultaneous inertial reference reading from the CM inertial guidance system. This information will be relayed to ground stations for evaluation.

(9) EVA Photography - This experiment task is performed by both the EVA and IVA astronauts. The IVA astronaut will take time sequenced motion pictures of the EVA astronaut during egress and erection of the work platform and during stowing of the work platform and then egress to the CM. The EVA astronaut will take time sequence motion pictures of EVA experiment tasks using a remote camera positioned on the work platform.

(10) Return OSO to Automatic Operation - This experiment task is performed by the EVA astronaut. The

astronaut replaces the special external connector play removed at the beginning of the useful work experiment tasks.

(11) Experiment Container Storage Preparation - This experiment task is performed by the EVA astronaut. All containers that are to be placed in the Command Module for return to earth will be pressurized with inert gas. The astronaut will use the low pressure gas supply on the CWP to perform this operation. Each container will be filled to a prescribed pressure.

(12) Container Storage and EVA Astronaut Return - This experiment task is conducted by both the EVA and IVA astronauts. The EVA astronaut will attach transfer tethers to each container and then release the containers from the CWP. The astronaut will then move to the egress/ingress structure where he will pass the containers to the IVA astronaut. When all the containers are inside the CM, the EVA astronaut will secure the work platform in its stowed position, unhook the power umbilical and ingress to the CM. The IVA astronaut will stow the containers within the CM. The forward hatch will be secured and the CM will be pressurized.

Estimated times for these tasks have been included in the Time Line Summary, Table 2-3.

6.7 RELEASE: After the conduct of the useful work operations, release of the capture mechanism must be accomplished to permit the CSM to initiate re-entry maneuvers.

6.7.1 Task Description: Task operations of the IVA astronauts during the conduct of the release operation are as follows:

- Satellite release and capture mechanism jettison

6.7.2 Spacecraft Constraints: The constraints imposed are the following:

(1) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±60 degrees in pitch, and with a roll rate of 10 degrees per hour.

(2) The OSO must not be contaminated by the RCS engine gases during release operations.

(3) All stowed items must be adequately packaged and secured to withstand the Apollo Command Module re-entry loads.

6.7.3 Astronaut Operations: The release operation will be conducted as described in detail in paragraph 6.3.9 of Volume II. Estimated time for the IVA astronauts to conduct the release of the satellite and capture mechanism jettison will be typical of the Apollo/LEM docking operations and is included in the Time Line Summary. See Table 2-3. A brief description of these tasks is presented in the following paragraph:

(1) Satellite Release and Capture Mechanism Jettison - This experiment task will be performed by the IVA astronaut. Utilizing a remote command console, the astronaut will spin up the OSO to about six rpm. Then the CWP attachment head will be released from the OSO. Using RCS thrusters, the CSM will slowly back away from the OSO to a safe distance. When well clear of the OSO, jettison the CWP by releasing its docking collar and firing the RCS thruster to back the CSM away.

6.8 POST-RELEASE INSPECTION: After release of the OSO satellite, post-release inspection will be required to document the OSO condition and spin characteristics.

6.8.1 Task Description: Task Operations of the IVA astronaut are as follows:

(1) Determine OSO dynamics

(2) Conduct documentation photography

6.8.2 Spacecraft Constraints: The constraints imposed are the following:

(1) These inspection tasks will be conducted after release of the OSO satellite from within the Command Module.

(2) The OSO must not be contaminated by the RCS engine gases during the station keeping maneuvers.

6.8.3 Astronaut Operations: These post-release inspection operations will be conducted as described in detail in paragraphs 6.3.3.2 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) OSO Dynamics - This experiment task is the same as the precapture activities described earlier in this section.

(2) Photography - This experiment task is the same as the precapture activity described earlier in this section.

Estimated times for these tasks have been included in the Time Line Summary, Table 2-3.

6.9 TIME LINE ANALYSIS: A detail time line analysis has been prepared for ESMRO Mission 2 and is included as Fig. 2-1.

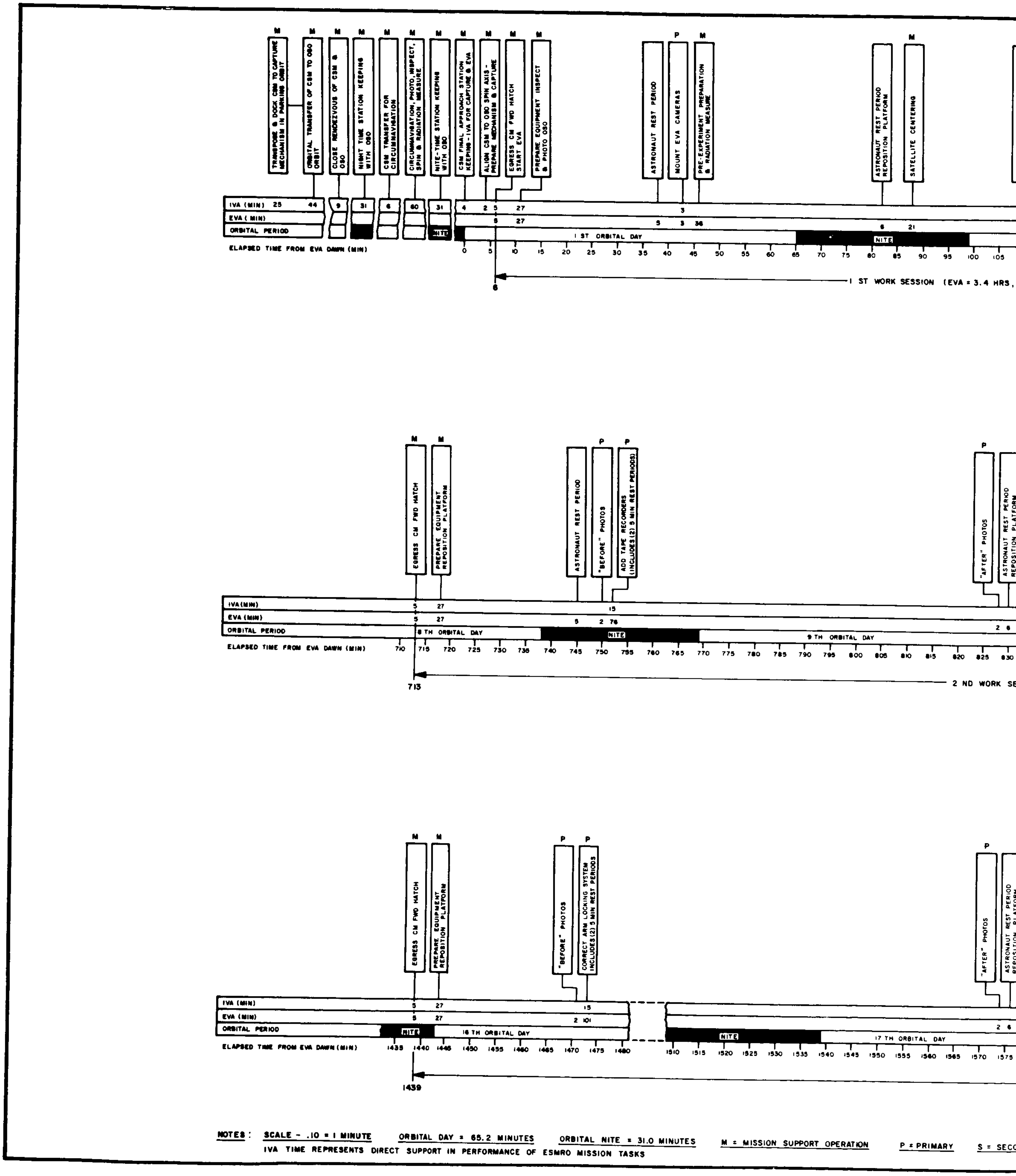
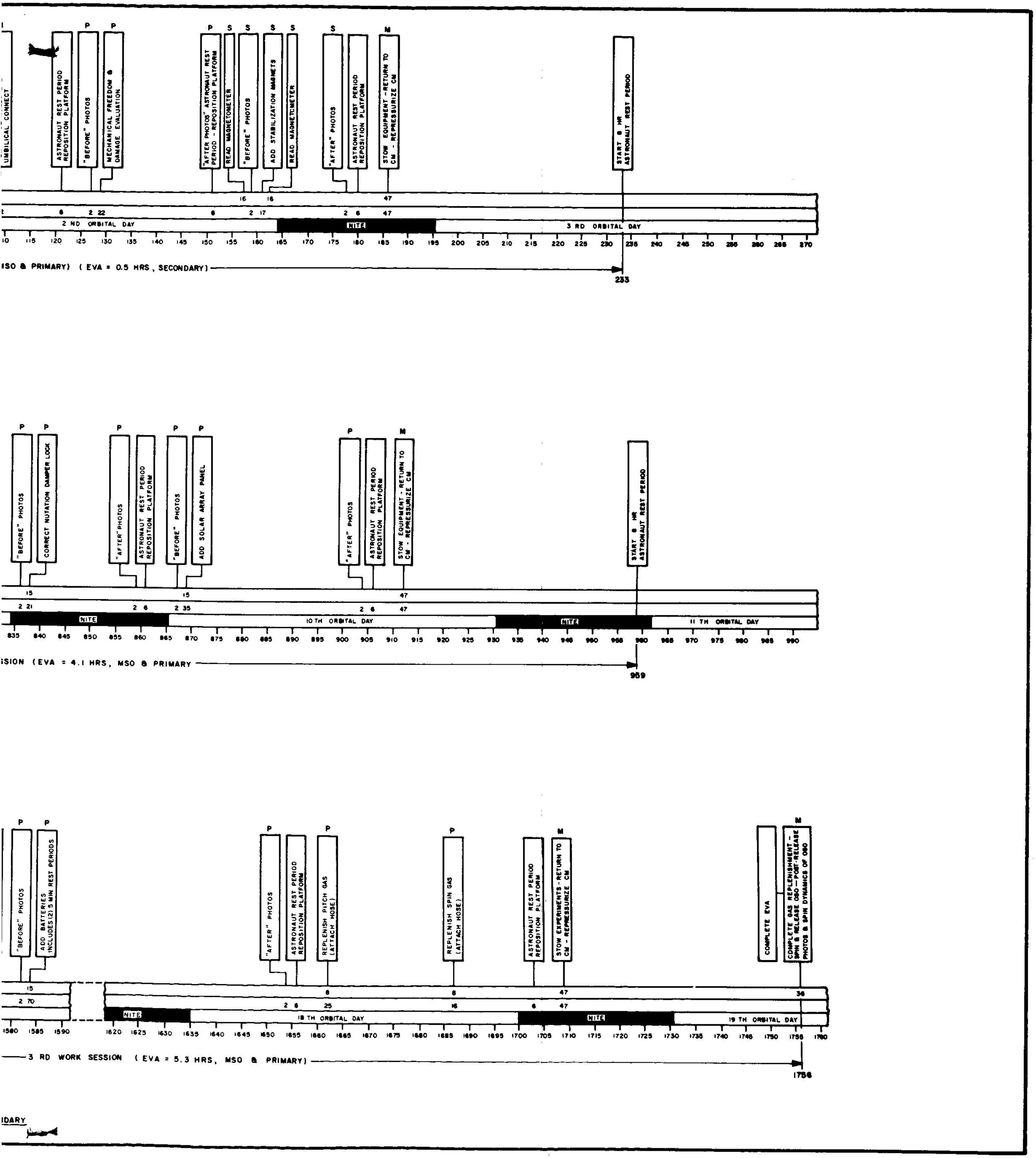


Fig. 2-1 Mission 2 T



me Line Analysis

7. ASTRONAUT TIME REQUIREMENT SYNOPSIS

PREFLIGHT TIME	IN-FLIGHT TIME	POSTFLIGHT TIME
Normal Training	See Table 2-3	Normal Training

8. DESCRIBE THE PREFLIGHT AND POSTFLIGHT REQUIREMENTS ON THE ASTRONAUT

In order to conduct this complicated experiment mission, the AAP astronauts will have to be familiar with and have proficiency in several skills and operations. Preflight training requirements for this experiment mission are given below for each functional task in the following paragraphs.

Rendezvous. The pilot astronaut must become proficient in maneuvering the CSM spacecraft for making orbit transfers and completing terminal guidance. These tasks will require practice and training on:

- A rendezvous simulator
- Visual acquisition simulator for the OSO satellite

Inspection. Inspection tasks will require the IVA astronaut to become proficient with:

- A directional spectrometer and dosimeter
- Visual determination of OSO dynamics
- Operation with a 70 mm Maurer still camera and a 16 mm Maurer sequential camera.

Docking, Capture, and Release. These functional tasks will require the pilot astronaut to become proficient with maneuvering the CSM spacecraft during the docking with the capture mechanism, and capture and release of the OSO satellite. These tasks will require practice and training on:

- A spacecraft docking simulation device similar to the CSM/LEM operations

(Attach additional sheets if necessary, identifying items by numbers.)

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8. Describe the Preflight and Post-flight Requirements on the Astronaut (Cont.)

- A docking simulator which provides capability of simulating a free spinning OSO

<u>Experiment Preparation and Container Return</u>. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of transferring out to the work platform and returning with equipment containers. These tasks will require:

- Familiarization with the CSM/forward hatch/tethers/work platform mockup, without a suit in a 1 g environment

- Familiarization and practice with the CSM/forward hatch/tethers/work platform mockup, with a pressurized suit at 3.7 psig in a neutral buoyancy environment

<u>EVA Useful Work</u>. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of conducting useful work on the OSO. The EVA astronaut will require:

- Familiarization with the OSO mockup without a suit in a 1 g environment

- Familiarization and practice with the OSO and work platform mockup with a pressurized suit at 3.7 psig in a 1 g environment

- Neutral buoyancy EVA simulation of useful work activities for training and time line evaluation

- Use and practice with the EVA tools for the training requirements above

9. DISCUSS PREFLIGHT AND RECOVERY FACILITIES REQUIRED AND DATA HANDLING PROCEDURES

A variety of post-flight facilities will be required to support the Mission 2 OSO capture and refurbishment experiment. The facilities required are discussed in the following paragraphs.

Photographic. Photographic facilities will be required to develop colored still and sequence pictures taken during:

- Precapture inspection (still and sequence)
- Capture operations (sequence)
- Post-capture inspection (still)
- EVA useful work (sequence)
- Release operations (sequence)

Sanborne Recorder. A Sanborne recorder or its equivalent will be required to play back radiation monitoring data obtained from the directional spectrometer instrument measurements.

Digital Computer Facility. A digital computer facility will be required to reduce the magnetometer calibration data.

(Attach additional sheets if necessary, identifying items by number.)

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ENGINEERING INFORMATION AND PROGRAM PLAN - PART II

1. DESCRIPTION OF EQUIPMENT *(Sketch major assemblies in Item 5.)*

The equipment required to conduct this experiment mission has been categorized as follows:

- Adaptive tools
- Common tools
- Special equipment
- Common equipment

A listing of these tools and equipment is presented in Table 2-5. A conceptual picture of the Capture Work Platform System is illustrated in the frontispiece and in Fig. 2-2.

(Attach additional sheets if necessary, identifying items by number.)

2. DESCRIBE SPACECRAFT MODIFICATIONS REQUIRED FOR ACCOMODATION OF EQUIPMENT. INDICATE PREFERRED MOUNTING CONFIGURATION HERE OR IN ITEM 5

See page 2-39.

(Attach additional sheets if necessary, identifying items by number.)

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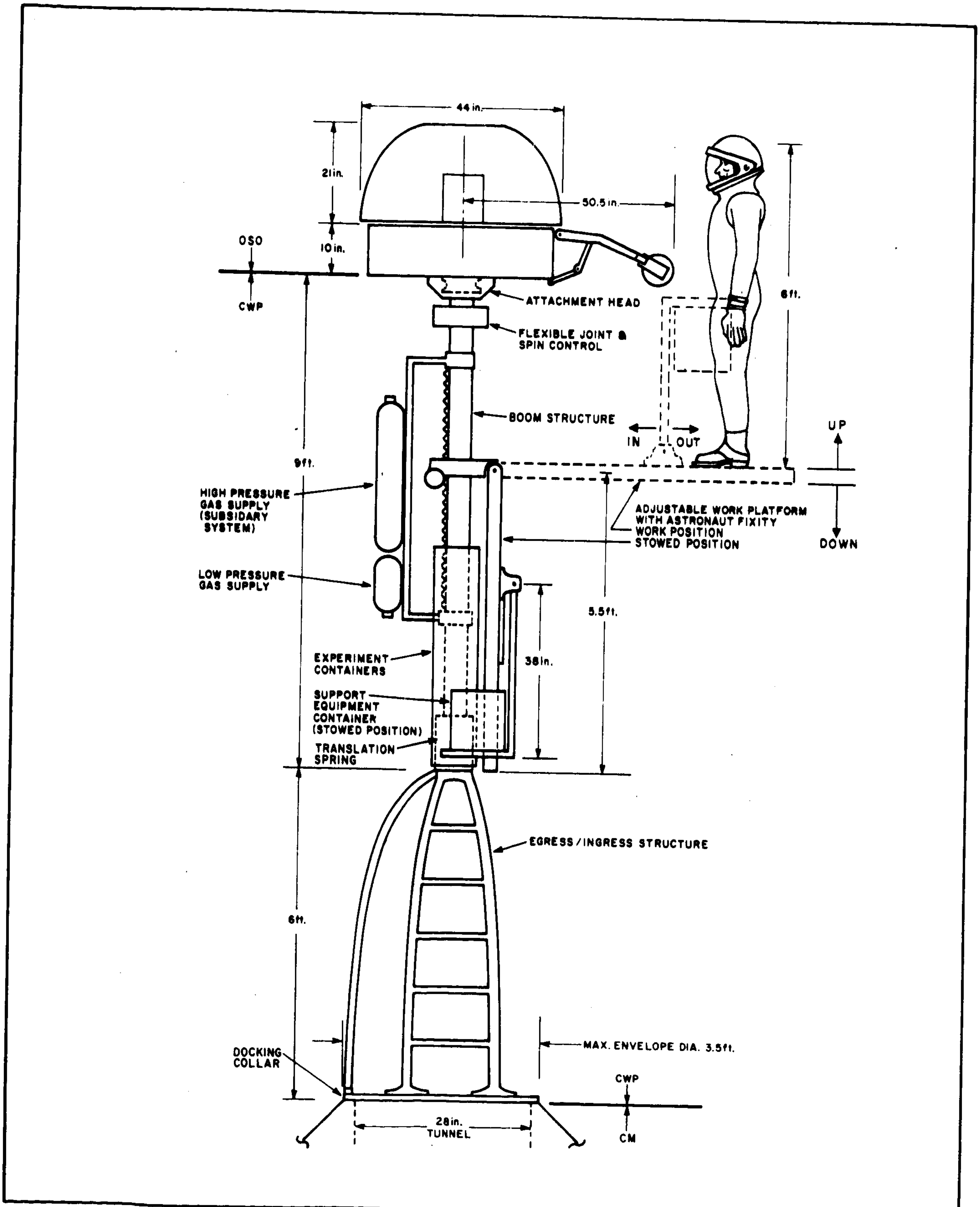


Fig. 2-2 Capture Work Platform Conceptual Configuration

Table 2-5

TOOLS AND EQUIPMENT FOR ESMRO MISSION 2

ADAPTIVE TOOLS

- Allen head driving tool
- High torque driving tool
- Phillips head driving tool
- Slot head driving tool
- Gas containing cap drive tool

COMMON TOOLS

- Power tool with adaptive head
- Power tool ratchet handle
- Pry bar with tether
- Variable angle wedge with tether
- Wire bundle cutter with tether
- Long blade wire cutter with tether
- Connector removal tool with tether
- Reel tether with clamp
- Short tether
- Equipment transfer tethers
- Sail lock
- Pointed instruments elevation frame lock

SPECIAL EQUIPMENT

- Dosimeter (portable)
- Directional spectrometer
- Stop watch and visual aid
- High pressure nitrogen supply system (remote operation)
  - Command controller (hand held)
  - Gas attach fitting (remote operation)
  - Quick disconnect coupling
  - Check valve fitting tool

Table 2-5 (Cont.)

- Maurer 16 mm sequential camera, Model 308 (2)
- General purpose 70 mm Maurer still camera
- Three battery packs with cable harness and attachment screws
  - Battery pack storage container
- Solar array panels with electrical harness connectors and attachment clamps
  - Solar array protective container
- Lens and solar cell protective covers
- Two tape recorders with cable harness and attachment screws
- One ballast (tape recorder simulation) with attachment screws
  - Tape recorder and ballast storage container
- Set of permanent magnets (2) with locking clamp
  - Permanent magnet storage container

COMMON EQUIPMENT

- Capture Work Platform System
  - Boom (with compression springs)
  - Attachment head (with release capability)
  - Flexible joint and spin mechanism (remote operation)
  - Docking collar and egress/ingress structure
  - Adjustable work platform (with astronaut fixity)
  - Support equipment containers (tool box)
  - Electrical umbilical to CM
  - Artificial illumination (with portable light)
  - Low pressure inert gas supply system
  - Battery power supply
  - Mounting apparatus for remote camera operation
  - Command console (portable, inside CM)
- Film storage containers
- General purpose vacuum container

2. Describe spacecraft modifications required for accommodation of equipment. Indicate preferred mounting configuration here or in item 5.

No CSM spacecraft design modifications are anticipated; however, certain Apollo program support equipment will be required to conduct this experiment, some of which will interface with ESMRO equipment. These support items, and the respective Apollo/ESMRO equipment interfaces, are as follows:

- Apollo Saturn I-B Launch Vehicle
- Apollo Command Service Module
  - a. With docking system
  - b. CM storage space (ascent and descent)
  - c. EVA communications link
  - d. Tape recording of astronauts voice annotation
  - e. Electrical power and signals
  - f. Inertial guidance
  - g. CM telemetry
  - h. Onboard checkout system (OCS)
- Spacecraft Lunar Module Adapter (SLA)
  - a. Storage for the ESMRO Capture Work Platform during boost phase
- IVA astronaut
- EVA astronaut with life support equipment (e.g. life support tether, mechanical tether, etc.)

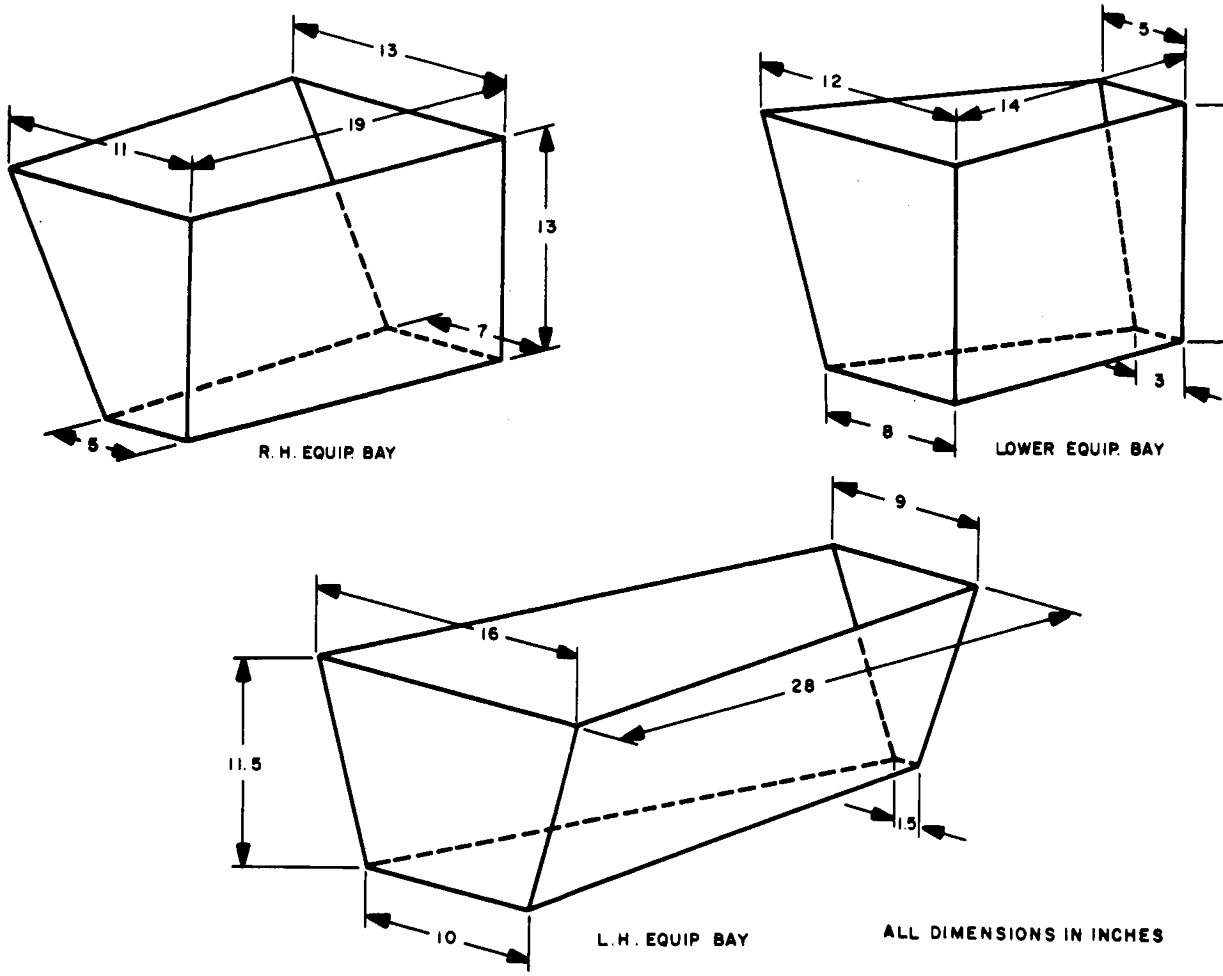
- Procedural transmission link between CSM and EVA astronaut
- Procedural transmission link between CSM and ground (MCC)
- Communications link with ground tracking stations
- CSM ground telemetry link

2.1 APOLLO SATURN I-B LAUNCH VEHICLE AND COMMAND SERVICE MODULE - The ESMRO experiment mission is proposed to be conducted as a part of the Apollo Applications Program and would utilize an Apollo Saturn I-B Launch Vehicle and Command Service Module (CSM).

2.1.1 The conduct of the ESMRO experiment mission will require that the Command Module be equipped with the CSM/LEM docking mechanism. This docking mechanism will be used to dock the CSM with the OSO satellite capture mechanism.

2.1.2 Storage space in the Command Module will be required for returning equipment and exposed film to the earth for post-flight evaluation. Possible CM storage areas are given in Fig. 2-3. A detail analysis and investigation must be complete to determine the optimum size(s) of storage container(s) necessary to package the selected items for retrieval and still be compatible with CM storage space.

2.1.3 The conduct of the ESMRO experiment mission proposes an electrical power and signal interface with the CSM. This interface will involve a power umbilical connected within the Command Module and run out to the CWP through the forward hatch. An electrical signal interface can be obtained utilizing the electrical signal connector in the CSM/LEM docking adapter. Utilization of these two electrical hookups may require wiring modifications or changes within the Command Module which will require investigating. The total power required will not exceed 2 kilowatt hours. (See Item 6, Part II.)



Area	Volume (cu. ft.)
Food Compartment (Lower Equipment Bay)	1.0
Food Compartment (L. H. Equipment Bay)	1.7
Food Compartment (R. H. Equipment Bay)	0.9
LIOH Cannisters Area	4.5
Isleway (under center couch)	3.0
	11.1

(1) Reference BBRC ATM Study Program Final Report, dated 1 Apr 1966

Fig. 2-3 Possible CM Storage Areas (1)

2.1.4 The conduct of the ESMRO experiment mission requires the use of a control console from within the (CM). This console is small and portable, and should not present any significant interface problems. The unit can be designed either to fit, or to make use of spare panel space on the astronauts controls and display console; it could also be a self-contained portable unit which the astronaut could operate and then stow. This item needs to be investigated in more detail to determine its optimum configuration.

2.1.5 A voice communications link between the astronauts inside the Command Module and the EVA astronaut will be required. It is understood, that this capability will exist for the Apollo Applications Program.

2.1.6 Tape recordings of the astronauts voice annotations will be required during the conduct of IVA and EVA experiment tasks. It is understood, that this capability will exist for the Apollo Applications Program.

2.1.7 Reference data from the Command Module inertial guidance system will be required in conjunction with performing rendezvous with the OSO, and the magnetometer calibration experiment. (See Sections 3. and paragraph 7.3.7.10 of Volume II.)

2.1.8 A telemetry interface with the Command Module data system will be required in conjunction with performing the magnetometer calibration experiment and to return the OSO to automatic operation. (See paragraphs 7.3.7.10 and 7.3.7.11 of Volume II.)

2.1.9 Interface with the Apollo CSM onboard checkout system (OCS) will be required in conjunction with performing the following experiments: battery power supply, solar array panels, tape recorders and return of OSO to automatic operation. (See paragraphs 7.3.7.3, 7.3.7.4, 7.3.7.5 and 7.3.7.11 of Volume II.)

2.2 SPACECRAFT LUNAR MODULE ADAPTER (SLA): In the conduct of this experiment, it is proposed to store the ESMRO Capture Work Platform

(CWP) in the SLA during the Saturn launch and boost phase. The outside envelope dimension of the folded capture work platform are illustrated in Fig. 2-2.

2.3 INTRA VEHICULAR ASTRONAUT: The services of an astronaut inside the Command Module will be required for both monitoring the EVA astronaut at all times he (the EVA astronaut) is outside of the CM and also for performing specific functions on many of the proposed ESMRO experiment tasks. Please refer to Section 7 of Volume II, (Mission 2 Program Plan), and Part I, paragraph 7, of this NASA Form 1138 for detail IVA tasks and time requirements.

2.4 EXTRA VEHICULAR ASTRONAUT: The services of an astronaut working outside the Command Module will be required for conducting many of the proposed ESMRO experiment tasks. Please refer to Section 7 of Volume II, Mission 2 experiment tasks, and Part I, paragraph 7, of this NASA Form 1138 for detail EVA tasks and time requirements.

2.5 CSM AND EVA ASTRONAUT PROCEDURAL TRANSMISSION: In order to conduct the Mission 2 EVA ESMRO experiment tasks, a procedural transmission between the monitoring astronaut inside the CSM and the EVA astronaut will be required. The transmission will utilize the CSM/EVA astronaut voice communication link. Procedural documentation must be generated for each experiment task selected for Mission 2.

2.6 CSM AND MCC PROCEDURAL TRANSMISSION: In order to conduct many of the Mission 2 ESMRO experiment tasks, a procedural transmission between the CSM and the Manned Spacecraft Control Center will be required. These transmissions will utilize the Manned Space Flight Network (MSFN). Procedural documentation must be generated for each experiment task selected for Mission 2 requiring CSM/MCC procedural transmissions..

2.7 GROUND TRACKING STATIONS COMMUNICATIONS: During the rendezvous phase of the mission, communications between the ground tracking stations and the CSM will be required to provide orbit information on both the CSM and the OSO satellite to up-date the CSM inertial guidance. This communications link will interface with the CSM/MCC procedural transmission link. Procedural documentation must be generated as required to support the rendezvous phase of Mission 2.

3. WEIGHT		4. VOLUME	
TOTAL WEIGHT:	750 lb	TOTAL VOLUME:	125 cu ft
WEIGHT OF SEPARATE ASSEMBLIES (If any)		VOLUME OF SEPARATE ASSEMBLIES (If any)	
ASSEMBLY #1 CWP	500 lb	ASSEMBLY #1 CWP	115 cu ft
ASSEMBLY #2 Equipment Containers	200 lb	ASSEMBLY #2 Equipment Containers	5 cu ft
ASSEMBLY #3 Miscellaneous	50 lb	ASSEMBLY #3 Miscellaneous	2.5 cu ft

5. ENVELOPE *(Sketch each assembly (Designate 1, 2 or 3) indicate nominal and limiting values of each major dimension.)*

Assembly No. 1 (Capture Work Platform System). From Part II, Fig. 2-2, an overall envelope space has been determined for the OSO Capture Work Platform system in the stowed configuration. This space envelope has been estimated to be within a cylindrical shape that is less than 3-1/2 feet in diameter and 15 feet long.

Assembly No. 2 (Special Equipment Containers). Four special equipment containers will be required as specified in paragraph 1, Part II under Special Equipment. Estimates regarding the contents, and size, of each container are presented in Table 2-6. These numbers must be regarded as preliminary. A detail analysis and investigation must be completed to determine the optimum size(s) of storage containers necessary to package the selected items for retrieval and still be compatible with available Command Module storage space.

Assembly No. 3 (Miscellaneous). Covered in this group, are equipment items such as the general purpose container, the radiation instruments, cameras and film. A volume of 2.5 cubic feet has been estimated for these items. Similarly, a detail analysis and investigation must be completed to determine the optimum size(s) of storage container(s) necessary to stow the selected items for return to earth and still be compatible with available Command Module storage space.

(Attach additional sheets if necessary, identifying items by number.)

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Table 2-6

SPACE ENVELOPES FOR EQUIPMENT CONTAINERS (No. 2)

		Max. Dim. (in.) h x w x l	Volume (cu ft)
Container No. 1		22 x 6 x 12	0.92
•	Battery packs (3)	6 x 4 x 10	
Container No. 2		24 x 24 x 6	2.00
•	Solar array panels (2)	22 x 22 x 2	
Container No. 3		8 x 16 x 12	0.89
•	Tape recorders (2)	6 x 4 x 10	
•	Ballast (1)	6 x 4 x 10	
Container No. 4		2 x 4 x 6	0.03
•	Permanent magnets (2)	1 x 2 x 4	

6.

POWER

TOTAL POWER:	STANDBY	AVERAGE	MAXIMUM 1740 watt hr

POWER CONSUMED BY SEPARATE ASSEMBLIES

ASSEMBLY #1	STANDBY	AVERAGE	MAXIMUM 140 watt hr
ASSEMBLY #2	STANDBY	AVERAGE	MAXIMUM 1200 watt hr
ASSEMBLY #3	STANDBY	AVERAGE	MAXIMUM 400 watt hr

IF POWER CONSUMPTION IS NOT CONSTANT, INDICATE POWER PROFILES BELOW:

The subsystems of the capture mechanism system, and other items which will utilize electrical power, are listed below in Table 2-7 with estimates concerning their power profile.

(Attach additional sheets if necessary, identifying items by number.)

7.

THERMAL CONSTRAINTS

OPERATING TEMPERATURE LIMITS OF EACH ASSEMBLY

ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C

STORAGE TEMPERATURE LIMITS OF EACH ASSEMBLY

ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C

OTHER THERMAL CONSTRAINTS

The CSM spacecraft must maintain the OSO pitch axis perpendicular to the solar vector ±60 degrees, and maintain a roll rate of 10 degrees per hour.

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6. If Power Consumption is not Constant, Indicate Power Profiles Below

Table 2-7

POWER REQUIREMENTS

Subsystem/Item	Watts	On-Time Hours	Kilowatt Hours	Remarks
Assembly No. 1 Wheel torque and lock -Despin and spin-up -Wheel turn operation	20	1	20	CWP Battery Power
Attachment head -Adhesive release	100	0.2	20	CM Power Peak load is estimated not to exceed 250 w (applies to all items from Attachment head through Camera operation)
Work platform -Up and down operation -In and out operation -Erect and stow operation	100	1	100	
Assembly No. 2 Artificial illumination	100	12	1200	
Assembly No. 2 Power tool operation	75	4	300	
Camera operation	10	10	100	

8. OTHER ENVIRONMENTAL CONSTRAINTS *(List any remaining constraints such as preferred or prohibited orientation of assemblies with respect to direction of maximum vibration and acceleration, susceptibility to RFI, etc.)*

- OSO contamination due to RCS engines
- OSO contamination due to suit exhaust and outgassing
- Radiation levels must not exceed prescribed levels

(Attach additional sheets if necessary, identifying items by number.)

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9.

TELEMETRY

	OUTPUT 1	OUTPUT 2	OUTPUT 3	OUTPUT 4
FUNCTION				
MUST MEASUREMENT BE CONTINUOUS				
MINIMUM NUMBER OF SAMPLES PER SECOND				
ACCURACY OF MEASUREMENT				
MAXIMUM BIT RATE *(Digital only)*				
MINIMUM FREQUENCY RESPONSE *(Analog only)*				

ADDITIONAL INFORMATION

A telemetry interface with the Command Module data system will be required in conjunction with performing the magnetometer calibration experiment and returning the OSO to automatic operation. (See paragraphs 7.3.7.10 and 7.3.7.11 of Volume II.)

The OSO telemetry format output is in the Manchester digital code. The transmitted bit rate is 800 bits per second; it has 8 bit words to a frame with 32 frames. The OSO has three 48 channel submultiplexers. The digital voltage output will be 0 ± 0.5 volts for a zero bit and 3.2 ± 0.5 volts for a one bit.

(Attach additional sheets if necessary, identifying items by number.)

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10. **DEVELOPMENTAL PROGRAM** (1)

ITEM	WHERE PERFORMED	BEGINNING DATE	COMPLETION DATE
PRELIMINARY ELECTRICAL DESIGN as required		8/1/68(2) or 13 month ARC	1/1/69 or 18 months ARC
PRELIMINARY MECHANICAL DESIGN as required		7/1/68 or 12 month ARC	11/1/68 or 16 months ARC
PRELIMINARY MOCK UP FABRICATION as required		10/1/68 or 15 month ARC	1/1/69 or 18 months ARC
FINAL ELECTRICAL DESIGN as required		1/1/69 or 18 month ARC	5/1/69 or 24 months ARC
FINAL MECHANICAL DESIGN as required		1/1/69 or 18 month ARC	7/1/69 or 24 months ARC
EXACT MECHANICAL MOCK UP CONSTRUCTION as required		5/1/69 or 22 month ARC	7/15/69 or 24-1/2 monARC
PROTOTYPE FABRICATION as required		9/1/69 or 26 month ARC	1/1/69 or 30 months ARC
PROTOTYPE ENVIRONMENTAL TEST		1/1/70 or 30 month ARC	3/1/70 or 32 months ARC
FLIGHT UNIT FABRICATION		12/1/69 or 29 month ARC	4/1/70 or 33 months ARC
FLIGHT UNIT ENVIRONMENTAL TEST		4/1/69 or 33 month ARC	5/1/70 or 34 months ARC
FLIGHT SPARE FABRICATION as required		3/1/70 or 32 month ARC	6/1/70 or 23 months ARC
FLIGHT SPARE ENVIRONMENTAL TEST as required		6/1/70 or 35 month ARC	7/1/70 or 36 months ARC

(1) All dates are figured from an assumed contract start of 1 Jul 1967.

(2) ARC means "After receipt of contract".

The above program schedule information, along with additional details is presented in graphic form in Fig. 2-4. All dates in that schedule are also shown as months after a contract go-ahead of 1 Jul 1967, and a continuous development program has been assumed. A launch six months after delivery of the first flight model is shown. While the actual hardware system is composed of many items, it has been treated in the schedule as a single unit since design, fabrication and test of the various items would proceed in parallel with one another.

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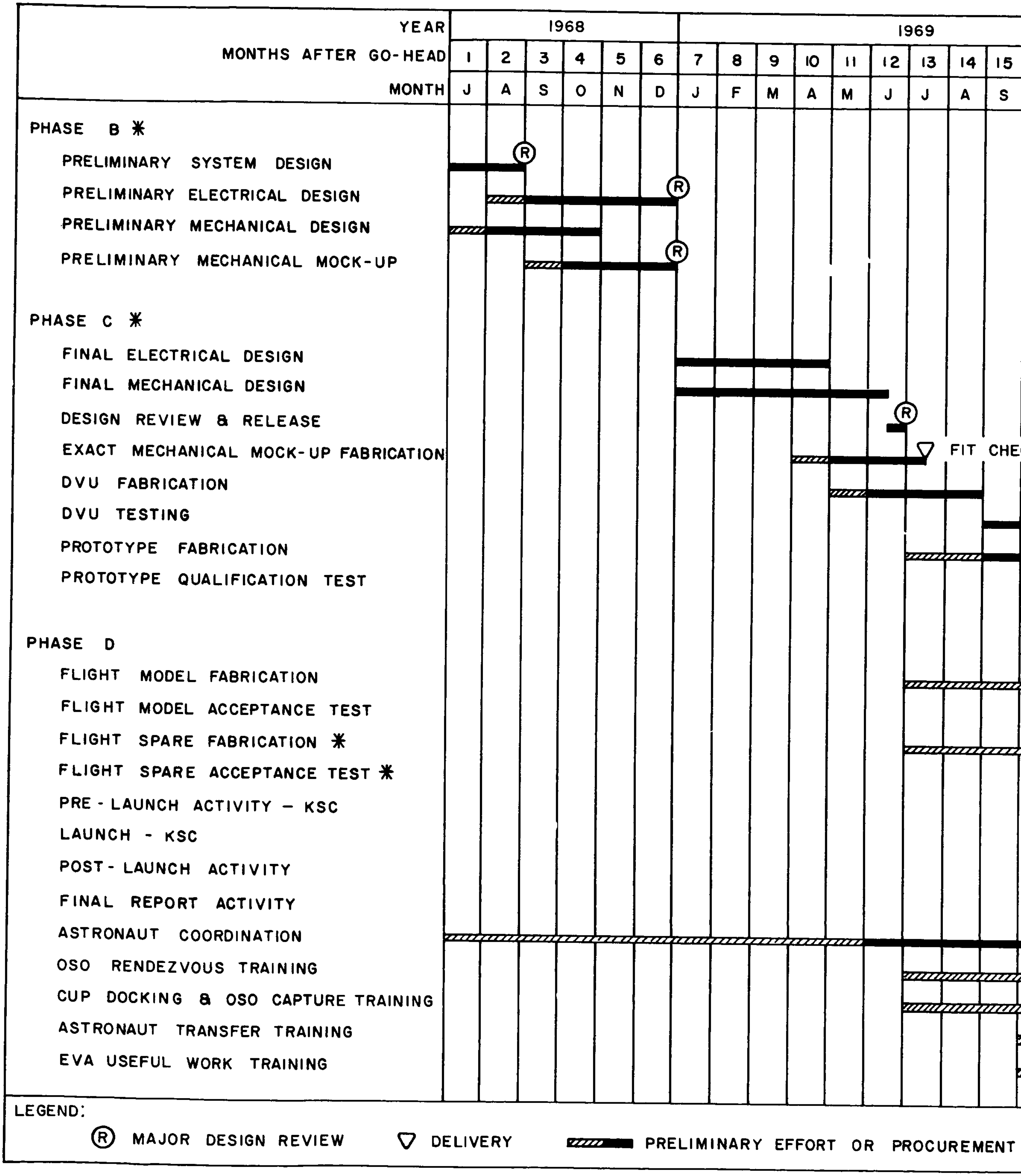
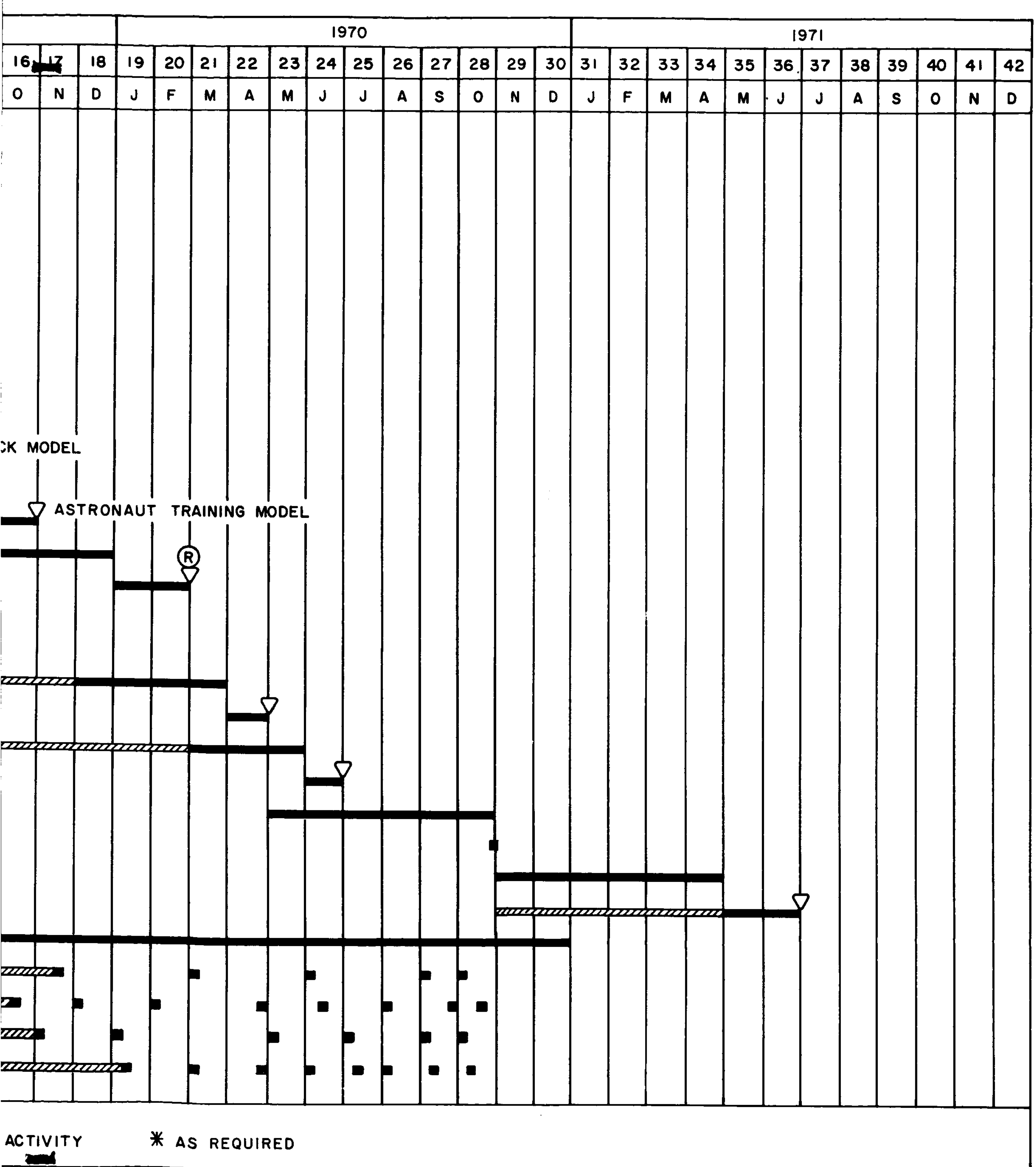


YEAR
1968
1969
MONTHS AFTER GO-HEAD
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MONTH
J A S O N D J F M A M J J A S
PHASE B *
PRELIMINARY SYSTEM DESIGN
PRELIMINARY ELECTRICAL DESIGN
PRELIMINARY MECHANICAL DESIGN
PRELIMINARY MECHANICAL MOCK-UP
PHASE C *
FINAL ELECTRICAL DESIGN
FINAL MECHANICAL DESIGN
DESIGN REVIEW & RELEASE
EXACT MECHANICAL MOCK-UP FABRICATION
FIT CHE
DVU FABRICATION
DVU TESTING
PROTOTYPE FABRICATION
PROTOTYPE QUALIFICATION TEST
PHASE D
FLIGHT MODEL FABRICATION
FLIGHT MODEL ACCEPTANCE TEST
FLIGHT SPARE FABRICATION *
FLIGHT SPARE ACCEPTANCE TEST *
PRE - LAUNCH ACTIVITY — KSC
LAUNCH - KSC
POST - LAUNCH ACTIVITY
FINAL REPORT ACTIVITY
ASTRONAUT COORDINATION
OSO RENDEZVOUS TRAINING
CUP DOCKING & OSO CAPTURE TRAINING
ASTRONAUT TRANSFER TRAINING
EVA USEFUL WORK TRAINING
LEGEND:
(R) MAJOR DESIGN REVIEW
▽ DELIVERY
PRELIMINARY EFFORT OR PROCUREMENT

Fig. 2-4 Miss



ion 2 Schedule

[redacted]

The exact mechanical mockup is to be used as an Apollo fit check model, a structural test model and in neutral buoyancy astronaut training exercises. A design verification unit (DVU) has been included in the schedule, and this model will be utilized in the following ways:

(1) Pre-prototype Production Model - Fabricated from prerelease engineering drawings, the DVU will serve as a production test model. Any problems arising during fabrication can be resolved and the necessary corrections incorporated prior to prototype fabrication. This shortens prototype production time and generally results in a better prototype model.

(2) Engineering Model for System Tests - The DVU will be the first complete flight unit configuration model available for system engineering tests. Results of these tests, performed prior to completion of prototype fabrication, can be used as a basis for changes to that model prior to its completion. Again this results in a better prototype model. The additional system testing performed on the DVU gives greater confidence that the prototype will pass its qualification tests and also cuts down on the amount of preliminary testing required on the prototype prior to commencing qualification tests.

(3) Astronaut Training Model - Upon completion of DVU system testing, the model is then available for use as an astronaut trainer. The complexity of the tasks to be performed by the astronauts make this a very desirable addition to the program. With an OSO mockup, an Apollo trainer, various simulators, the exact mechanical mockup and this model, all phases of the mission can be duplicated for training purposes.

10.1 ASTRONAUT COORDINATION AND TRAINING: Since the astronaut is a dominant part of the CWP system, heavy emphasis will be placed on coordination with the astronaut office and the astronaut training program. As shown in Fig. 2-3, coordination activity will commence at program inception and continue through to the completion of post flight activity. Astronaut training effort will commence with the completion of final design and will be conducted in the following four major areas:

- OSO rendezvous
- CWP docking and OSO capture
- Astronaut transfer
- EVA useful work

In addition to astronaut coordination and training support, BBRC and EE personnel will participate in prelaunch, launch, flight, and post-flight activity.

MANAGEMENT PLAN - PART III

(For Headquarters use only.)
DATE RECEIVED BY SM

TITLE OF EXPERIMENT

Mission 2 - OSO Capture and Refurbishment

SPONSORING INSTITUTION	ADDRESS
Co-sponsors: George C. Marshall Space Flight Center/OMSF	Huntsville, Alabama 35812
Goddard Space Flight Center/OSSA	Greenbelt, Maryland 20771

1. RESPONSIBILITIES

INDIVIDUAL	NAME	ADDRESS
A. RESPONSIBLE ADMINISTRATOR	Mr. G. von Tiesenhausen R-AS-VO	NASA-MSFC Huntsville, Alabama 35812
B. PRINCIPAL INVESTIGATOR	Advanced Systems Office	NASA-MSFC Huntsville, Alabama 35812
C. CO-INVESTIGATOR(S)		
	Dr. L. Werner	OMSF-MT-E, Washington, D.C.
	Mr. R. Halpern	OSSA-SGH, Washington, D.C.
	Mr. D. C. Cramblit	NASA-MSFC-R-AS-VO, Huntsville, Alabama 35812
	Mr. W. H. Stafford	NASA-MSFC-R-AS-VO, Huntsville, Alabama 35812
	Mr. J. Walls	NASA-GSFC OSO Program Greenbelt, Maryland 20771

D. PRINCIPAL INVESTIGATOR'S ROLE IN RELATION TO THIS EXPERIMENT

Overall Program Direction and Coordination with both the AAP and OSO Program

E. RESPONSIBILITIES OF OTHER KEY PERSONS

To be determined

(Attach additional sheets if necessary, identifying items by number.)

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2.

BUDGETARY - COST BREAKDOWN

Attach a sheet (or sheets) giving the costs of the experiment for which NASA support will be required, in the following format, and in the detail specified. Separate cost breakdowns should be submitted for the three phases of experiment funding shown in Item 3, "Quarterly Funding Requirements".

ITEM	AMOUNT
DIRECT LABOR *(Separate by Labor Category; Rate per hour or man-month; Personnel involved, what they will do, etc.)*	$
MANUFACTURING BURDEN *(Overhead)* RATE (%) *(Flight experiments normally will be supported by contracts rather than grants.)*	
MATERIALS *(Total) (Bill of Material, including estimated cost of each major item.)*	
SUBCONTRACTS *(List those over $25,000) (Specify the vendor if possible, and the basis for the estimated cost.)*	
SPECIAL EQUIPMENT *(Total) (List of lab equipment, proposed uses, and estimated cost.)*	
TRAVEL *(Estimated number of individual trips, destinations, and costs.)*	
ANY OTHER ITEMS *(Total) (Explain in detail similar to the above.)*	
TOTAL COSTS	$
GENERAL AND ADMINISTRATIVE RATE ( )	$
TOTAL ESTIMATED COST	$ 2,620,000*

Experimenters who request to conduct the proposed experiment as an extension of an existing grant or contract, should list the grant or contract number and the name and address of the NASA technical monitor below.

GRANT OR CONTRACT NO.	NAME AND ADDRESS OF NASA TECHNICAL MONITOR

*See attached Cost Breakdown (Table 2-8)

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2. Cost Breakdown (Cont.)

Table 2-8

MISSION 2 COST BREAKDOWN (BUDGETARY)

Phase B - includes preliminary design and mockup, as required for changes from Mission 1 design.	$	130,000
Phase C - includes detail design, detail mockup, design verification unit (DVU), prototype and prototype qualification, as required for changes from Mission 1 design.		460,000
Phase D - includes flight model and astronaut training and launch support		1,680,000
OSO - includes OSO modifications, OSO refurbishment parts and OSO training models		350,000
Program Total	$	2,620,000

3. Quarterly Funding Requirements (Dollars in Thousands)

MISSION 2 (BUDGETARY)

Milestones: Flight Model Delivery (June 1970); Launch (Dec 1970); Final Report (after June 1971)

Program Phases \ Quarters Ending	Sept 1968	Dec 1968	Mar 1969	June 1969	Sept 1969	Dec 1969	Mar 1970	June 1970	Sept 1970	Dec 1970	Mar 1971	June 1971	Totals
Phase B	60	70											130
Phase C			80	100	120	100	60						460
Phase D					80	300	500	300	150	150	50	150	1,680
OSO		50	100	50	50	50	50						350
Totals	60	120	180	150	250	450	610	300	150	150	50	150	2,620

SECTION 3

MISSION 3

BBRC

MISSION 3
(NASA FORM 1138 DATA)

APOLLO EARTH ORBITAL SCIENTIFIC EXPERIMENT PROPOSAL

TITLE OF EXPERIMENT

Mission 3

OSO Capture, Refurbishment and Checkout

NAME OF INVESTIGATOR

(1) Ball Brothers Research Corporation, Boulder, Colorado

(2) Emerson Electric Company of St. Louis, St. Louis, Missouri

NAME OF SPONSORING INSTITUTION

Co-sponsors:

(1) George C. Marshall Space Flight Center/OMSF

(2) Goddard Space Flight Center/OSSA

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1. TITLE OF EXPERIMENT

Mission 3 - OSO Capture, Refurbishment and Checkout

DATE OF SUBMISSION

1 March 67

(For Headquarters use only.)

DATE RECEIVED BY SM

2. **SPONSOR**

NAME OF SPONSORING INSTITUTION

George C. Marshall Space Flight Center/Goddard Space Flight Center

ADDRESS

Huntsville, Alabama, 35812/Greenbelt Maryland 20771

TELEPHONE

(205) 876-0226 MSFC
(301) 982-5701 GSFC

NAME OF PRINCIPAL ADMINISTRATOR RESPONSIBLE FOR EXPERIMENT

Mr. G. von Tiesenhausen, MSFC (R-AS-VO), Mr. L. Hogarth, GSFC (OSO Program)

3. **INVESTIGATORS**

NAME OF PRINCIPAL INVESTIGATOR

George C. Marshall Space Flight Center - Advanced System Office

ADDRESS

Huntsville, Alabama 35812

TELEPHONE

(205) 876-0226

NAMES OF OTHER INVESTIGATORS	ADDRESS	TELEPHONE
Dr. L. Werner	OMSF-MT-E Washington, D.C. 20546	(202) 962-3582
Mr. R. Halpern	OSSA-SGH Washington, D.C. 20546	(202) 962-0157
Mr. D. C. Cramblit	MSFC-R-AS-VO Huntsville, Alabama 35812	(205) 876-9680
Mr. W. H. Stafford	MSFC-R-AS-VO Huntsville, Alabama 35812	(205) 876-0159
Mr. J. Walls	GSFC-OSO Project Greenbelt, Maryland 20771	(301) 982-5701
Mr. R. E. Hathaway	Ball Brothers Research Corp. Boulder, Colorado 80302	(303) 444-5300 Ex. 481
Mr. J. A. Campbell	Emerson Electric of St. Louis St. Louis, Missouri 63136	(314) 261-1800

NASA FORM 1138 AUG 64

SCIENTIFIC INFORMATION AND PROGRAM PLAN - PART I

1. PURPOSE AND OBJECTIVE OF THE EXPERIMENT

This experiment is the last of a series of three experiment missions, evolutionary in complexity, for the purpose of developing techniques and hardware requirements for rendezvous, capture, inspection, recovery of equipment and experiments, replenishment of expended supplies, and refurbishment of satellites in orbit.

Specific objectives to be accomplished are:

- Rendezvous with a noncooperative satellite
- Capture of a noncooperative spin stabilized satellite
- Conduct of useful EVA work tasks

The conduct of useful EVA work tasks will:

- Advance the EVA state-of-the-art knowledge
- Enhance the scientific knowledge of the space environment effects on materials
- Improve the satellite operation or extend its useful lifetime

The specific purposes of this experiment, Mission 3, OSO capture, refurbishment and checkout, are to rendezvous with and capture an OSO satellite, and conduct useful EVA work on the captured satellite. Since this mission will be the third of three experiment missions, emphasis will be on advancing the objectives of accomplishing useful EVA work. Significant experiment tasks presented in the area of EVA useful work tasks, will be directed toward satellite refurbishment and checkout.

(Attach additional sheets if necessary, identifying items by number.)

The Gemini Program has contributed significantly to the state-of-the-art of rendezvous with a cooperative satellite, docking with a cooperative satellite, and conducting limited EVA useful work. Tabulated below is a record of the manned Gemini missions where orbit changing, rendezvous, Agena docking and extravehicular activity was successfully conducted.

Table 3-1

GEMINI FLIGHT RECORD (No. 3)

Gemini	Rendezvous	Agena Docking	EVA
Gemini III	X[a]		
Gemini IV			X
Gemini V			
Gemini VI	X		
Gemini VII			
Gemini VIII	X	X	X
Gemini IX	X		X
Gemini X	X	X	X
Gemini XI	X	X	X
Gemini XII	X	X	X

[a]Orbit change only

Rendezvous. Problems of rendezvous involve the preflight phase, orbit transfer and correction, and acquisition and terminal guidance. In the Gemini Program, the problems involved in the preflight phase of establishing the "launch window" were minimized by the launching of the two boost vehicles with precise time phasing and thereby simplifying the in-flight operations and the time spent in the rendezvous attempt. A simultaneous countdown of both launch vehicles was conducted; the target vehicle was launched first, its orbit was precisely established by ground tracking, and then the manned chase vehicle was launched into relatively the same orbit. The manned vehicle launch was deliberately delayed from a lift-off which would provide a perfect phase match, but avoided a spacecraft phase lead condition that would require target vehicle maneuvering or extremely long catchup maneuvering. Normally, no manned spacecraft maneuvering took place during the first orbit in order to check out the onboard radar system and to determine an accurate orbit position for the manned spacecraft by ground tracking. Spacecraft maneuvering was then accomplished to maximize the support from the ground tracking network and to provide the greatest tolerance to onboard failure of the spacecraft radar and inertial guidance system.

Acquisition of the target vehicle was accomplished between 200 to 250 nm distance using onboard radar. The spacecraft radar was then used to track the target vehicle until visual sighting occurred and the use of radar for closed-loop rendezvous was abandoned. The astronauts utilized the spacecraft inertial guidance system and calculated their bearings to bring them to station keeping with the target vehicle as scheduled with very reasonable fuel expended and thereby demonstrated passive rendezvous capability.

Agena Docking. Docking the Gemini with the Agena can be considered as a cooperative docking system since the Agena was controlled in attitude stabilization, and utilized visual docking aids such as lights and a docking bar. Except for a post-docking malfunction on the Gemini VIII mission, all of the Gemini docking missions were rated as very successful.

Extra Vehicular Activity. Some form of EVA was conducted on six Gemini missions as indicated in Table 3-1. Although each mission recorded success in varying degrees, each mission substantiated that EVA can be conducted. The mission that was most successful toward proving EVA capability, especially toward useful EVA tasks similar to this proposed experiment, was Gemini XII. On that mission, astronaut Major Edwin E. Aldrin, Jr. proved that with adequate preflight training, EVA support equipment and tools, and adequate rest periods, man can successfully conduct a variety of EVA useful work tasks and skills.

It is important to point out that in the functions of rendezvous and docking, the Gemini program utilized "cooperative" procedures and systems in conducting rendezvous and docking with the Gemini spacecraft and Agena target vehicle. However, it is also important to point out, that with the use of these cooperative procedures and systems, the state-of-the-art technology was advanced such that open loop rendezvous was successfully accomplished on Gemini's X, XI, and XII; consequently, the astronauts believe they can maneuver and dock with any target vehicle that is independently stabilized. (Reference the close maneuvering that took place between Gemini VI and VII after rendezvous was accomplished.)

3. SPECIFY PARAMETERS TO BE MEASURED INCLUDING NUMERICAL VALUES EXPECTED AND OUTLINE THE RESEARCH PROGRAM:

The experiments conducted on this mission present a blend of engineering and scientific investigation. As previously stated, the primary objectives are placed on conducting refurbishment EVA experiments and in-orbit satellite checkout. The following table gives a composite of the experiments proposed to be conducted for Mission 3 with the expected information to be gained.

Table 3-2

MISSION 3 EXPERIMENT TASKS AND RESULTS

Experiment	Inflight Determination	Post-Flight Determination
Precapture inspection		
• Radiation	Go/no-go (determined safe levels present for EVA)	
• OSO dynamics	(Determined OSO spin rate, 10-40 rpm)	Compare with ground predictions
• Photography		Precapture damage evaluation Precapture configuration evaluation
Capture operations		
• Photography		1) Dynamic characteristics 2) Capture operations
Post-capture inspection and preparation		
• Photography		Before and after damage evaluation
• Radiation	Go/no-go decision (dual experiment to provide for instantaneous radiation doses and long term dose rate exposure.)	Accumulative dose rate
• Mechanical damage	1) Evaluation of physical damage 2) Determination of cold-welding effects	
• High resolution photography		Surface erosion, contamination and micrometeorite effects

(Attach additional sheets if necessary, identifying items by number.)

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3. Specify parameters to be measured including numerical values and outline the research program (Cont.)

Table 3-2 (Cont.)

Experiment	Inflight Determination	Post-Flight Determination
• Emissivity measurements		Emissivity changes to material surfaces
Refurbishment and Checkout		
• Pitch gas supply	Adequacy of EVA procedures and technology	Extend operational life of OSO
• Spin gas supply	Same	Same
• Battery power supply	Same	Same
• Solar array panels	Same	Same
• Tape recorders	Same	Same
• Pointing control electronics	1) Adequacy of EVA procedures and technology 2) Correct experiment malfunction	Same
• Experiment optics or sensors	1) Adequacy of EVA procedures and technology 2) Correct experiment malfunction	Same
• Elevation locking system	1) Adequacy of EVA procedures and technology 2) Correct satellite malfunction	Same
• Arm locking system	1) Adequacy of EVA procedures and technology 2) Correct satellite malfunction	Same
• Stabilization magnets	Adequacy of EVA procedures and technology	Improve OSO performance
• Stabilization torquing coils	Adequacy of EVA procedures and technology	Improve OSO performance
• Magnetometer calibration	Evaluation of checkout procedures	Bias error induced in magnetometer readings
• EVA monitoring photography		1) Evaluation of EVA astronaut operations 2) Correlate space EVA operations with training simulation operations

3. Specify parameters to be measured including numerical values and outline the research program (Cont.)

Table 3-2 (Cont.)

Experiment	Inflight Determination	Post-Flight Determination
• OSO automatic operations	Evaluation of checkout procedures	Extend operational life of OSO
Material Retrieval		
• Control sensor assembly		1) Solar cell lens surface degradation 2) Knife edge reticle degradation
• Experiment optics or sensors		1) Surface degradation
Release		
• OSO dynamics	Determine OSO spin rate	
• Photography		Post-release damage evaluation

4. PRESENT AN ANALYSIS OF THE PERFORMANCE OF THE PROPOSED EXPERIMENT *(e.g., dynamic range, signal to noise ratio, etc.)*

Refer to Part I, paragraphs 3 and 6 for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

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5. DISCUSS THE METHOD OR POSSIBLE METHODS FOR THE ANALYSIS AND INTERPRETATION OF THE DATA *(e.g., the statistical validity)*

Refer to Part I, paragraphs 3 and 6 for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

NASA FORM 1138a AUG 64

5. DISCUSS THE METHOD OR POSSIBLE METHODS FOR THE ANALYSIS AND INTERPRETATION OF THE DATA *(e.g., the statistical validity)*

Refer to Part I, paragraphs 3 and 6 for information relevant to this subject.

(Attach additional sheets if necessary, identifying items by number.)

NASA FORM 1138a AUG 64

6. DESCRIBE THE EXPERIMENTAL PROCEDURE TAKING INTO CONSIDERATION THE ENVIRONMENT AND ORBITAL CHARACTERISTICS OF THE SPACECRAFT. INCLUDE ANY CONSTRAINTS ON SPACECRAFT ATTITUDE, POINTING ACCURACY, AND STABILITY. EXPLAIN WHY THE ASTRONAUT IS NECESSARY TO THE PERFORMANCE OF THIS EXPERIMENT. DESCRIBE IN DETAIL OPERATIONS PERFORMED BY THE ASTRONAUT AND TIME CONSUMED DURING EACH OPERATION. *(Include length of time the spacecraft must hold a given attitude.)*

The mission operations consist of the following functional steps:

- Capture mechanism docking
- Rendezvous maneuvers
- Precapture inspection
- Capture operations
- Post-capture inspection and preparation
- Refurbishment and checkout
- Material retrieval
- Stowage of materials
- Release and capture mechanism jettison
- Post-release inspection

Experiment tasks have been established for each of these functional operations which are discussed in considerable detail in paragraph 8.3, Volume II (the technical report). The information presented herein summarizes and supplements the information presented in the technical report. A Mission 3 Time Line Summary is presented in Table 3-3.

Since one of the primary objectives of this experiment mission is to advance extra vehicular capability and state-of-the-art technology, the man-machine interface during the conduct of this experiment mission is paramount. The importance and role of the astronaut in the conduct of the experiments for the capture of the OSO satellite and the conduct of refurbishment and checkout tasks is defined in the descriptions of each experiment task.

6.1 CAPTURE MECHANISM DOCKING: The objective of this mission support operations task is to dock the Apollo Command Service Module (CSM) with the OSO satellite capture mechanism in order to capture the OSO satellite and to conduct the useful work experiments for satellite refurbishment and checkout.

(Attach additional sheets if necessary, identifying items by number.)

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Table 3-3

MISSION 3 TIME LINE SUMMARY

Operation/Event	Experiment Priority	EVA (Min)	IVA (Min)	Accrued Mission Time (EVA + IVA) (Min)
I Rendezvous Operations				
CSM/CWP Docking	MSO		25	25
CSM Orbit Transfer	MSO		44	69
Close Rendezvous Maneuvers	MSO		9	78
Night Time Station Keeping	MSO		31	109
Circumnavigation	MSO		6	115
Pre-Capture Inspection	MSO		60	175
Night Time Station Keeping	MSO		31	206
OSO Capture Maneuvers	MSO		6	212
Sub Total			212	
II Work Session No. 1				
Start EVA-Egress Fwd Hatch	MSO	5	5	222
Prepare Equipment and OSO Inspection	MSO	27	27	276
Astronaut Rest Period		5		281
Mount EVA Cameras	P	3	3	287
Expr. Preparation and Radiation Meas.	MSO	36		323
Astronaut Rest Period		6		329
Satellite Centering	MSO	21		350
Power Bus Removal and Umbilical Connect	MSO	12		362
Astronaut Rest Period		6		368
Mech. Freedom and Damage Evaluation and Photos	P	32		400
Replace Expr. Optics/Sensors and Photos	S	24	15	739
Astronaut Rest Period		6		445
Replace Control Sensor Assembly and Photos	S	32	15	492
Astronaut Rest Period		6		498
Stow Equip.-Return to CM	MSO	47	47	592
Sub Total		268	112	
III Astronaut 8 Hour Rest Period				1072
IV Work Session No. 2				
Start EVA-Egress Fwd Hatch	MSO	5	5	1082
Prepare Equip. Reposition Platform	MSO	27	27	1136
Astronaut Rest Period		5		1141
High Resolution Photography*	S	76		1217
Astronaut Rest Period		5		1222
Satellite Emissivity Meas.*	S	50		1272
Astronaut Rest Period		5		1277
Correct Nutation Damper Lock and Photos	P	25		1302
Astronaut Rest Period		6		1308
Add Solar Panel and Photos	P	39	15	1362
Astronaut Rest Period		6		1368
Stow Equip.-Return to CM	MSO	47	47	1462
Sub Total		296	94	
V Astronaut 8 Hour Rest Period				1942
VI Work Session No. 3				
Start EVA-Egress Fwd Hatch	MSO	5	5	1952
Prepare Equip. Reposition Platform	MSO	27	27	2006
Read Magnetometer	S		16	2022
Add Stabilization Elec/Mag. Coils and Photos	S	22		2044
Astronaut Rest Period		6		2050
Correct Arm Locking System and Photos*	P	105		2155
Astronaut Rest Period		6		2161
Add Batteries and Photos*	P	74	15	2250
Stow Equip.-Return to CM	MSO	47	47	2344
Sub Total		292	110	
VII Astronaut 8 Hour Rest Period				2824
VIII Work Session No. 4				
Start EVA-Egress Fwd Hatch	MSO	5	5	2834
Prepare Equip. Reposition Platform	MSO	27	27	2888
Add Tape Recorders and Photos*	P	80	15	2983
Astronaut Rest Period		6		2989
Replace Pointing Control Elec. and Photos	P	24	15	3028
Astronaut Rest Period		6		3034
Replenish Pitch Gas Supply	P	25	8	3067
Replenish Spin Gas Supply	P	15	8	3090
Astronaut Rest Period		5		3095
Stow Equip.-Return to CM	MSO	47	47	3189
Sub Total		240	125	
IX Release Operations	MSO		36	3225
Mission 3 Totals		1096	689	

NOTES:

*With Astronaut Rest Periods as Applicable

MSO - Mission Support Operation, P - Primary Objective, S - Secondary Objective

6.1.1 Task Description: Task operations for the pilot astronaut are as follows:

(1) Separate the CSM from the Saturn IVB.

(2) Orient the CSM center line (head on) with the capture mechanism docking collar.

(3) Dock the CSM with the capture mechanism docking collar.

(4) Pull the OSO satellite capture mechanism clear of the S-IVB

6.1.2 Spacecraft Constraints: Specific spacecraft constraints for conducting the docking operation will be determined as a part of AAP mission integration studies.

6.1.3 Astronaut Operations: This operation will be similar to the Apollo operation of docking the CSM with the LEM. Detail procedures for accomplishing this docking operation will be determined as a part of AAP mission integration studies. A time of 25 minutes has been allocated for conducting this operation. This time allocation has been incorporated into the time line summary for Mission 3. (See Table 3-3.)

6.2 RENDEZVOUS MANEUVERS: The objective of this mission support operations task is to maneuver the Apollo CSM in an orbit transfer operation from the nominal AAP orbit to the nominal OSO orbit, in order to rendezvous with and capture the OSO satellite.

6.2.1 Task Description: Task operatons for the pilot astronaut are as follows:

(1) Perform CSM orbit transfer.

(2) Perform terminal guidance with the OSO satellite.

(3) Perform station keeping.

6.2.2 Spacecraft Constraints: Constraints affecting the CSM spacecraft in the conduct of this experiment mission are presented below for the three task descriptions cited.

CSM Orbit Transfer:

(1) The Apollo launch window necessary to conduct the ESMRO mission can be as much as 175 minutes.

(2) The CSM will be launched into an orbit inclination compatable with the OSO orbit.

(3) Orbit transfer of the CSM will initiate from the nominally circular orbit of 370 km (200 nm) altitude.

(4) The nominal parameters of the OSO satellite orbit will be

Circular orbit:	555 ± 92 km (300 ± 50 nm)
Inclination:	33 ± 3 deg
Period:	96 min

(5) The amount of SPS engine propellant assumed available for CSM orbit transfer and rendezvous with the OSO will be equivalent to a ΔV of 762 amps (2500 fps).

(6) During transfer, the CSM will be in contact with ground based tracking stations. The CSM trajectory will be compared with the necessary transfer trajectory and corrective measures will be taken. The transfer itself will be initiated after ground based

computers analyze the comparative positions of OSO and the CSM and calculate the best trajectory for accomplishing the transfer.

Terminal Guidance:

(1) The positional errors of the CSM will be known to ±150 meters (±490 feet) in cross-range and radial, and ±300 meters (±980 feet) in longitude.

(2) The positional errors of the OSO will be known to within the following accuracies:

Longitude:	±1.6 km (0.87 nm)
Cross range:	±0.5 km (0.27 nm)
Radial:	±0.5 km (0.27)nm)

(3) Terminal rendezvous with the OSO will occur during the dawn phase of the OSO orbit with the CSM approaching the OSO from below and ahead.

Delta Velocity Requirements: ΔV requirements for the rendezvous maneuvering phase are presented in Table 3-4. ΔV for precapture and post-release close-in maneuvers have been included for additional information.

Table 3-4
RENDEZVOUS ΔV REQUIREMENTS (No. 3)

Rendezvous Operation		ΔV (mps)	ΔV (fps)
Launch window		67	220
Orbit transfer		300	984
Terminal closure		24	79
Close-in maneuvers	Precapture	7.6	25
Close-in maneuvers	Post-release	7.6	25
	TOTAL	406	1333

6.2.3 Astronaut Operations: The orbit transfer and terminal guidance maneuvers will be similar to the rendezvous maneuvers conducted during the Gemini program. Detail procedures for accomplishing these maneuvers will be determined as a part of AAP mission integration studies. A time of 44 minutes has been estimated for conduct of the operation. This and the times for conducting the station keeping operations have been incorporated into the Time Line Summary for Mission 3 (See Table 3-3).

6.3 PRECAPTURE INSPECTION: Prior to capture of the OSO satellite, precapture inspection will be required to assure that it is safe to proceed with the capture operations of the mission.

6.3.1 Task Description: Task operations of the IVA astronaut are as follows:

(1) Determine precapture OSO radioactive radiation levels.

(2) Determine OSO dynamics.

(3) Conduct documentation photography.

6.3.2 Spacecraft Constraints: The constraints imposed are the following:

(1) These inspection tasks will be conducted during the circumnavigation station keeping from within the Command Module spacecraft.

(2) The OSO must not be contaminated by the RCS engine gases during the circumnavigation maneuvering and station keeping.

6.3.3 Astronaut Operations: These precapture inspection operations will be conducted as described in detail in paragraphs 6.3.3.1, 6.3.3.2, and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs.

(1) OSO Radiation - The experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. A hand held, directional spectrometer will be used to obtain quantitative and qualitative radiation data. The IVA astronaut will take the data through a spacecraft window and ascertain that the OSO radiation levels are within prescribed limits.

(2) OSO Dynamics - This experiment task will be performed from within the Command Module during daytime circumnavigation of the OSO. Using a visual aid and a stop watch, the IVA astronaut will determine the OSO spin rate and ascertain that it is within acceptable limits to proceed with the capure operaitons.

(3) Photography - This experiment task will be conducted from within the Command Module during daytime circumnavigation of the OSO. Using still and motion picture cameras, the IVA astronaut will take documentary pictures to record the precapture condition and dynamics of the OSO.

Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.4 CAPTURE OPERATIONS: Capture of the OSO satellite will be a mission support operation of Mission 3. Capture of the OSO will be necessary to perform the useful work experiments.

6.4.1 Task Description: Task operations of the pilot and IVA astronauts are as follows:

- Closure maneuvers and OSO capture
- Documentation photography

6.4.2 Spacecraft Constraints: The spacecraft constraints for documentation photography have already been discussed in paragraph 6.3.2. Spacecraft constraints associated with the capture operations are as follows:

(1) Precapture OSO radiation levels must be within acceptable limits.

(2) The CSM spacecraft must not be damaged.

(3) Capture will be accomplished with an active noncooperative OSO satellite.

(4) The OSO satellite must not be damaged.

(5) The OSO satellite must not be contaminated by RCS engine gas during capture maneuver operations.

(6) During capture maneuver operations, the longitudinal axis of the CSM must be aligned to the OSO spin axis within ±TBD* degrees in pitch, ±TBD degrees yaw and ±TBD degrees in roll.

(7) The CSM limit cycle rates will not exceed ±0.05 deg/sec in pitch/yaw, and roll.

*TBD = To be determined.

(8) The CSM dead band limit will not exceed ±1/2 degrees in pitch/yaw/roll.

(9) The differential velocity between the CSM and OSO during capture shall not exceed 1 fps.

(10) The capture operation will not exceed 15 minutes during the daylight portion of the orbit.

6.4.3 Astronaut Operations: These capture operations will be conducted as described in paragraphs 6.3.4.1 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs:

(1) Closure Maneuvers and OSO Capture - This experiment task will be performed from within the Command Module. The CM will be maneuvered so as to approach the OSO from underneath along the satellite spin axis. Prior to capture, the CWP attachment head must be spun up to approximately match the OSO spin rate. At the time of capture, the velocity differential between the CSM/CWP and OSO should be approximately one fps. The CSM/CWP should be maneuvered so that the attachment head encircles the OSO mounting flange. After capture, the OSO is despun on astronaut command by the CWP.

(2) Documentation Photography - This experiment task is performed by an IVA astronaut during closure maneuvers and OSO capture. Motion pictures will be taken during closure and OSO capture to pictorially document that operation.

Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.5 POST CAPTURE INSPECTION: After capture of the OSO satellite, continued inspection and experiment preparation will be performed for the conduct of the useful work experiments.

6.5.1 Task Description: Task operations of the IVA and EVA astronauts are as follows:

- Experiment preparaton and radiation monitoring
- OSO centering in the capture mechanism
- OSO wheel power bus removal
- Evaluation of mechanical freedom and damage
- Documentary observations and photography
- High resolution photography
- Satellite emissivity measurements

6.5.2 Spacecraft Constraints: The constraints imposed are the following:

(1) The IVA astronaut must monitor the EVA astronaut at all times while he is conducting EVA useful work.

(2) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±TBD degrees in pitch, ±TBD degrees yaw, and ±TBD degrees roll.

(3) The OSO must not be contaminated by the RCS engine gases during orbit keeping.

(4) The EVA astronaut must exercise caution not to contaminate any of the experiments scheduled for removal.

6.5.3 Astronaut Operations: These post-capture inspection operations will be conducted as described in detail in paragraphs 6.3.5.1, 6.3.5.2, 7.3.5.3, 6.3.5.4, and 7.3.5.5., 8.3.5.6, and 8.3.5.7 of Volume II. A brief description of these tasks is presetned in the following paragraphs.

(1) Experiment Preparation and Radiation Monitoring - During this experiment task, the EVA astronaut will egress from the CSM, erect the CWP into its useful work position, position himself and his support equipment in the CWP, and measure the OSO radiation levels as a backup to the measurements made form within the Command Module.

(2) OSO Satellite Centering - This experiment task is performed by the EVA astronaut. First the centering mechanism is unlatched so that it can fastened to the OSO mating flange. Then the adhesive bond (or yoke arms) is released and the centering mechanism is activated with a power tool to position the OSO on the center of the attachment head. The OSO is then in position for useful work and subsequent release.

(3) OSO Wheel Power Bus Removal - This experiment task is performed by the EVA astronaut to assure that all OSO power has been interrupted before conducting useful work on the satellite. This is accomplished by removing a special external connector plug that was installed prior to launching the OSO. This plug is replaced upon conclusion of the useful work tasks.

(4) Mechanical Freedom and Damage Evaluation - This experiment task is performed by the EVA astronaut. The mechanical freedom evaluation consists of manually rotating the OSO sail with respect to the wheel and the pointed instruments with respect to the sail to determine if cold welding has occurred. The EVA astronaut will inspect the OSO surfaces and parts for damage and photograph anything noted.

(5) Documentation Photography - This experiment task is performed by the EVA astronaut after capture operations have been completed and during useful work tasks. As a minimum, before and after pictures will be taken for each experiment task conducted. This task will be intermittently performed during the entire useful work phase of the mission.

(6) High Resolution Photography - This experiment task is performed by the EVA astronaut. The astronaut will photograph preselected surfaces on the OSO satellite with a special high resolution camera, camera mount and hood, and an artificial light source. These photos will later be compared with prelaunch pictures taken of the OSO under identical conditions.

(7) Satellite Emissivity Measurements - The experiment task will be conducted by the EVA astronaut who will make emissivity measurements of preselected areas on the OSO with a spectroreflectometer. The data will be compared with that taken prior to launching the OSO.

Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.6 REFURBISHMENT AND CHECKOUT: The conduct of useful EVA work will be the major objective of Mission 3. On Mission 3, the primary useful work objective will be to refurbish and checkout the OSO satellite. The conduct of useful work will demonstrate man's capability of performing maintenance, repair, and checkout work in space.

6.6.1 Task Description: Task operations of the EVA and IVA astronauts during the conduct of refurbishment and checkout experiments are as follows:

- Replenishment of pitch gas supply
- Replenishment of spin gas supply
- Addition of a new battery power supply
- Addition of a new solar array panels
- Addition of new tape recorders
- Replacement of pointing control electronics
- Replacement of control sensor assembly
- Replacement of experiment optics or sensors
- Maintenance of nutation damper locking system
- Maintenance of arm locking system
- Addition of stabilization magnets
- Addition of stabilization torquing coils

- Calibration of the magnetometer
- EVA documentation photography
- Return OSO to automatic operation
- Return of EVA astronaut and materials to the Command Module

6.6.2 Spacecraft Constraints: The constraints imposed are the following:

(1) The IVA astronaut must monitor the EVA astronaut at all times while he is conducting EVA useful work.

(2) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±TBD degrees in pitch, ±TBD degrees yaw, and ±TBD degrees roll.

(3) The OSO must not be contaminated by RCS engine gases during orbit keeping.

(4) The EVA astronaut must exercise caution not to contaminate any of the experiments scheduled for removal.

6.6.3 Astronaut Operations: These useful work operations will be conducted as described in detail in paragraphs 7.3.7.1, 7.3.7.2, 7.3.7.3, 7.3.7.4, 7.3.7.5, 8.3.7.1, 8.3.7.2, 8.3.7.3, 7.3.7.6, 7.3.7.7, 7.3.7.8, 8.3.7.9, 7.3.7.10, 6.3.6.9, 7.3.7.11 and 8.3.8, Volume II. A brief description of these tasks is presented in the following paragraphs.

(1) Replenishment of Pitch Gas - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut attaches the gas supply line to a pitch gas

line check valve located on the OSO sail assembly. He then completes any required EVA task, including stowage of the work platform, return of containers to the CM, etc., and then ingresses to the CM. When the CM is pressurized, the IVA astronaut remotely commands the commencement of the filling operation. When it is completed, he remotely commands the gas line to disconnect from the OSO.

(2) Replenish Spin Gas Supply - This experiment task is conducted in the same manner as the pitch gas replenishment experiment. The spin gas line check valve is located in the rim panel of wheel compartment No. 4.

(3) Addition of a New Battery Power Supply - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut positions and fastens one battery pack to each of three OSO lifting lugs located on the rim of the wheel structure. The batteries are then electrically connected together and to the power console test connector on the bottom of the wheel structure. The IVA astronaut then checks out the OSO power system with the Apollo onboard checkout system (OCS).

(4) Addition of a New Solar Array Panel - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut positions and secures a new solar array to the sail structure. Using connectors available on the back of th sail, he then hooks up the new panel. The IVA astronaut next checks out the OSO power system with the Apollo OCS.

(5) Addition of Tape Recorders - This experiment task is conducted by both the EVA and IVA astronaut. The EVA astronaut will position and secure two tape recorders to two of the OSO wheel lifting lugs. A ballast weight will be secured to the third lug. The two recorders will be electrically connected to the OSO system umbilical connector. The IVA astronaut will then check out the tape recorders with the Apollo OCS.

(6) Replacement of Pointing Control Electronics - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut will open the pointing control electronics assembly located on the sail. After removing a preselected board, he replaces it with a new board. The IVA astronaut checks out the pointing control electronics utilizing the Apollo OCS.

(7) Replacement of Control Sensor Assembly - This experiment task is conducted by the EVA astronaut. The astronaut takes off the existing sensor assembly by removing the three attachment screws. The new unit is then attached in the same position.

(8) Replacement of Experiment Optics or Sensors - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut removes a predetermined instrument optic or sensor assembly and replaces it with a new unit. The IVA astronaut checks out the instrument utilizing the Apollo OCS.

(9) Maintenance of Nutation Damper Locking System - This experiment task will be conducted by the EVA

astronaut. In the event that a nutation damper pin squib did not fire after launch of the OSO, the EVA astronaut can connect a power lead from the CWP and provide sufficient power to fire the squib.

(10) Maintenance of Arm Locking System - This experiment task is the same as the nutation damper locking system except that it applies to the three OSO arms.

(11) Addition of Stabilization Magnets - This experiment task is conducted by the EVA astronaut. Two permanent magnets are to be fastened to the back of the sail structure. This magnets will aid the function of the OSO electromagnetic coil that is used to counteract the interaction between the OSO and the earth's magnetic field.

(12) Addition of Stabilization Torquing Coils - This experiment task is performed by the EVA astronaut. The astronaut positions and fastens an electromatnetic coil to the back of the OSO sail structure. The coil is connected electrically to the sail umbilical.

(13) Calibration of the Magnetometer - This experiment task is performed by both the EVA and IVA astronauts. The EVA astronaut will rotate the sail to six different specific positions. For each position the IVA astronaut will take a magnetometer reading and a simultaneous inertial reference reading from the inertial guidance system. This information will be relayed to ground stations for evaluation.

(14) EVA Photography - This experiment task is performed by both the EVA and IVA astronauts. The IVA astronaut will take time sequenced motion pictures of the EVA astronaut during egress and erection of the work platform and during stowing of the work platform and ingress to the CM. The EVA astronaut will take time sequence motion pictures of EVA experiment tasks using a remote camera positioned on the work platform.

(15) Return OSO to Automatic Operation - This experiment task is performed by the EVA astronaut. The astronaut replaces the special external connector plug removed at the beginning of the useful work experiment tasks.

(16) Experiment Container Stowage Preparation - This experiment task is performed by the EVA astronaut. All containers that are to be placed in the Command Module for return to earth will be pressurized with inert gas. The astronaut will use the low pressure gas supply on the CWP to perform this operation. Each container will be filled to a prescribed pressure.

(17) Container Stowage and EVA Astronaut Return - This experiment task is conducted by both the EVA and IVA astronauts. The EVA astronaut will attach transfer tethers to each container and then release the containers from the CWP. The astronaut will then move to the egress/ingress structure where he will pass the containers to the IVA astronaut. When all the containers are inside the CM, the EVA astronaut will secure the work platform in its stowed position, unhook the power umbilical, and ingress to the CM. The IVA astronaut will stow the containers within the CM. The forward hatch will be secured, and the CM will be pressurized.

Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.7 MATERIAL RETRIEVAL: Material retrieval will be conducted as a secondary objective of Mission 3, and will be accomplished only for those experiments where replacement tasks are accomplished.

6.7.1 Task Description: Task operations of the EVA astronaut during the conduct of retrieval operations are as follows:

- Retrieval of control sensor assembly
- Retrieval of experiment optics or sensors

6.7.2 Spacecraft Constraints: The constraints imposed are the following:

(1) The IVA astronaut must monitor the EVA astronaut at all times while he is conducting useful work.

(2) The CSM spacecraft will control the OSO attitude relative to the solar vector to within ±60 degrees in pitch, and a roll rate of at least 10 degrees per hour.

(3) The OSO must not be contaminated by the RCS engine gases during orbit keeping.

(4) The EVA astronaut must exercise caution not to contaminate any of the components scheduled for removal.

6.7.3 Astronaut Operations - These useful work operations will be conducted as described in detail in paragraphs 8.3.7.2 and 8.3.7.3 of Volume II. The EVA stronaut will plan the two assemblies being returned in special experiment containers. Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.8 RELEASE: After the conduct of the useful work operations, release of the capture mechanism must be accomplished to permit the CSM to intitiate re-entry maneuvers.

6.8.1 Task Descriptions: Task operations of the IVA astronauts during the conduct of the release operations are as follows:

- Satellite release and capture mechanism jettison

6.8.2 Spacecraft Constraints: The constraints imposed are the following:

(1) The CSM spacecraft will control the OSO attitude relative to the solar vector to within 60 degrees in pitch, and with a roll rate of 10 degrees per hour.

(2) The OSO must not be contaminated by the RCS engine gases during release operations.

(3) All stowed items must be adequately packaged and secured to withstand the Apollo Command Module re-entry loads.

6.8.3 Astronaut Operations: The release operation will be conducted as described in detail in paragraph 6.3.9 of Volume II. Estimated times for the IVA astronauts to conduct the release of the satellite and capture mechanism jettison will be typical of the Apollo/LEM docking operation and is included in the Time Line Summary, Table 3-3. A brief description of these tasks is presented in the following paragraph.

(1) Satellite Release and Capture Mechanism Jettison - This experiment task will be performed by the IVA astronaut. Utilizing a remote command console, the astronaut will spin up the OSO to about six rpm. Then the CWP attachment head will be released from the OSO. Using RCS thrusters, the CSM will slowly back away from the OSO to a safe distance. When well clear of the OSO, the CWP is jettisoned by releasing its docking collar and firing the RCS thrusters to back the CSM away.

6.9 POST RELEASE INSPECTION: After release of the OSO satellite, post-release inspection will be required to document the OSO condition and spin characteristics.

6.9.1 Task Description: Task operations of the IVA astronaut are as follows:

- Determination OSO dynamics
- Documentation photography

6.9.2 Spacecraft Constraints: The constraints imposed are the following:

(1) These inspection tasks will be conducted after release of the OSO satellite from within the Command Module.

(2) The OSO must not be contaminated by the RCS engine gases during the station keeping maneuvers.

6.9.3 Astronaut Operations: These post-release inspection operations will be conducted as described in detail in paragraphs 6.3.3.2 and 6.3.3.3 of Volume II. A brief description of these tasks is presented in the following paragraphs.

(1) OSO Dynamics - This experiment task is the same as the precapture activities described earlier in this section.

(2) Photography - This experiment task is the same as the precapture activity described earlier in this section.

Estimated times for these tasks have been included in the Time Line Summary, Table 3-3.

6.10 TIME LINE ANALYSIS: A detailed time line analysis has been prepared for ESMRO Mission 3 and is included as Figure 3-1.

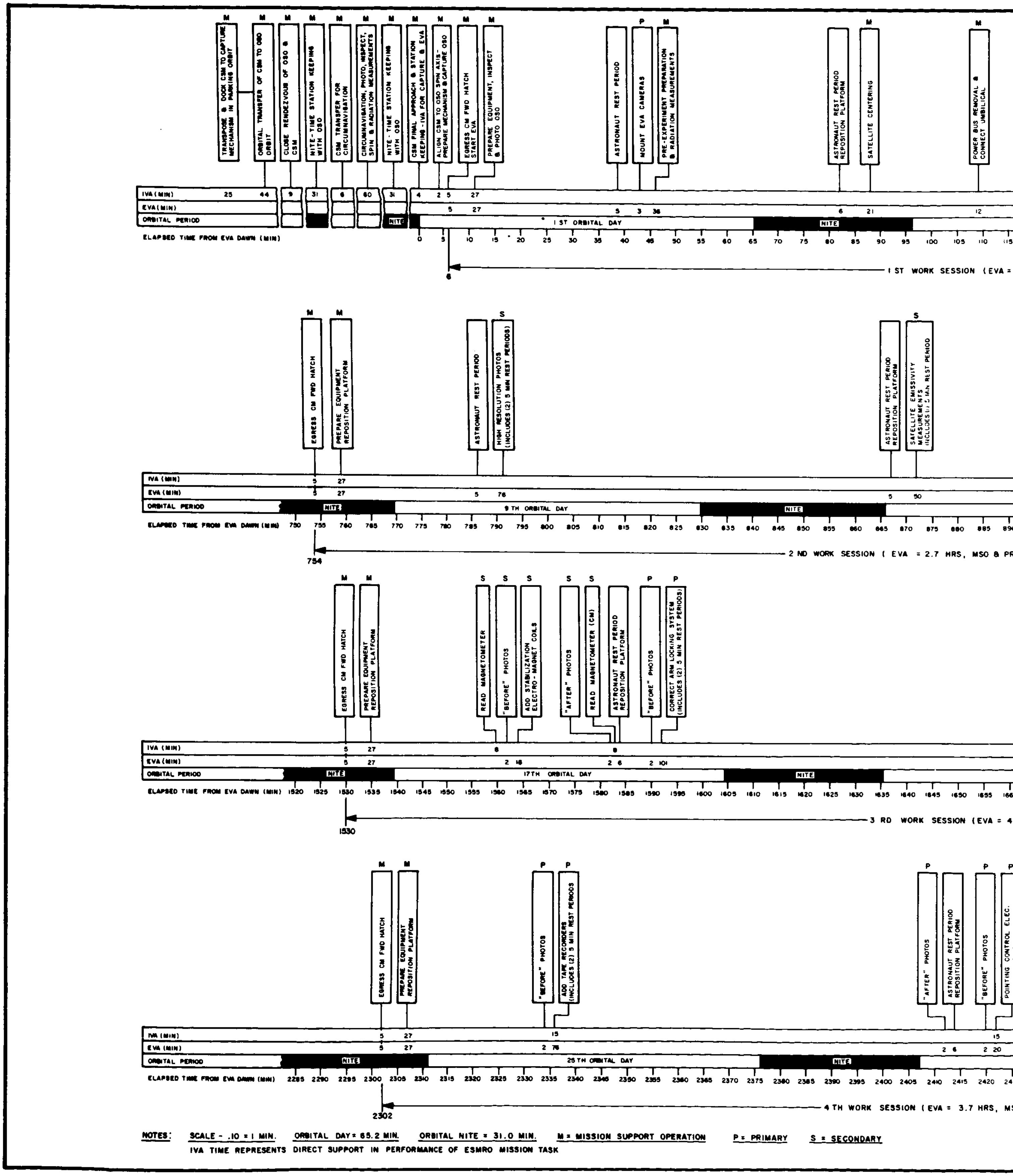
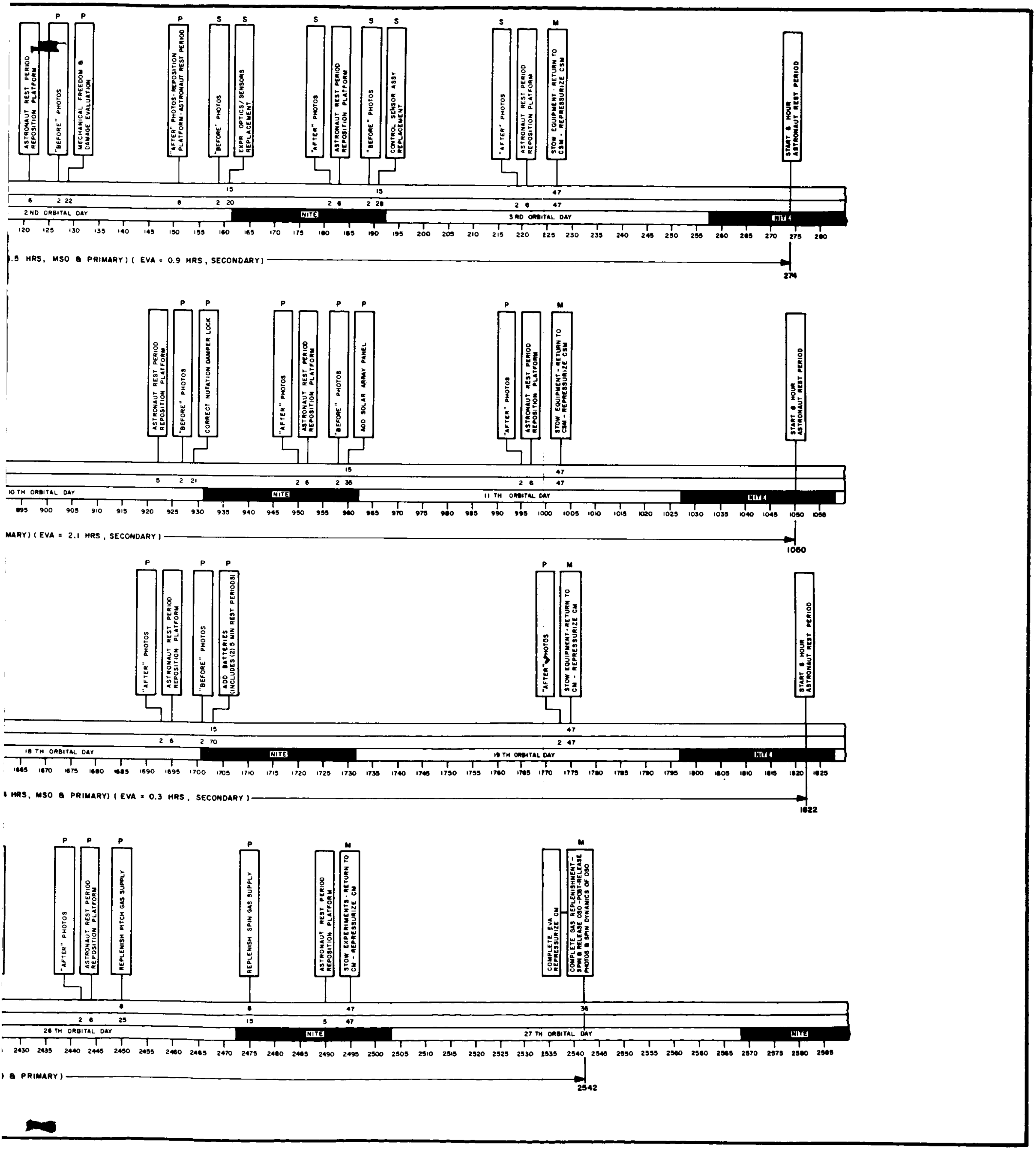


Fig. 3-1 Mission 3 T



ime Line Analysis

7. ASTRONAUT TIME REQUIREMENT SYNOPSIS		
PREFLIGHT TIME	IN-FLIGHT TIME	POSTFLIGHT TIME
Normal Training	See Table 3-3	Normal de-briefing

8. DESCRIBE THE PREFLIGHT AND POSTFLIGHT REQUIREMENTS ON THE ASTRONAUT

In order to conduct this complicated experiment mission, the AAP astronauts will have to be familiar with and have proficiency in several skills and operations. Preflight training requirements for this experiment mission are given below for each functional task:

Rendezvous. The pilot astronaut must become proficient in maneuvering the CSM spacecraft for making orbit transfers and completing terminal guidance. These tasks will require practice and training on:

- A rendezvous simulator
- Visual acquisition simulator for the OSO satellite

Inspection. Inspection tasks will require the IVA astronaut to become proficient with:

- A dierctional spectrometer and dosimeter
- Visual determination of OSO dynamics
- Operation with a 70 mm Maurer still camera and a 16 mm Maurer sequential camera.

Docking, Capture, and Release. These functional tasks will require the pilot astronaut to become proficient with maneuvering the CSM spacecraft during the docking with the capture mechansim, and capture and release of the OSO satellite. These tasks will require practice and training on:

- A spacecraft docking simulation device similar to the CSM/LEM operations.

(Attach additional sheets if necessary, identifying items by numbers.)

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- A docking simulator which provides capability of a free spinning OSO

Experiment Preparation and Container Return. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of transferring out to the work platform and returning with equipment containers. These tasks will require:

- Familiarization with the CSM/forward hatch/tethers/work platform mockup, without a suit in a 1 g environment.

- Familiarization and practice with the CSM/forward hatch/tethers/work platform mockup, with a pressurized suit at 3.7 psig in a neutral buoyancy environment.

EVA Useful Work. These functional tasks will require the EVA and IVA astronauts to become familiar with the procedural requirements of conducting useful work on the OSO. The EVA astronaut will require:

- Familiarization with the OSO mockup without a suit in a 1 g environment

- Familiarization and practice with the OSO and work platform mockup with a pressurized suit at 3.7 psig in a 1 g environment

- Neutral buoyancy EVA simulation of useful work activities for training and time line evaluation

- Use and practice with the EVA tools for the training requirements above

9. DISCUSS PREFLIGHT AND RECOVERY FACILITIES REQUIRED AND DATA HANDLING PROCEDURES

A variety of post-flight facilities will be required to support the Mission 3 OSO capture, refurbishment and checkout experiment. The facilities required are as follows:

Photographic - Photographic facilities will be required to develop colored still and sequence pictures taken during

- Precapture inspection (still and sequence)
- Capture operations (sequence)
- Post-capture inspection (still)
- EVA useful work (sequence)
- Release operations (sequence)

Sanborne Recorder. A Sanborne recorder or equivalent will be required to play back radiation monitoring data obtained from the directional spectrometer instrument measurements.

Digital Computer Facility. A digital computer facility will be required for the postflight analysis of material and equipment returned to earth for the following experiments:

- Retrieval of control sensor assembly
- Retrieval of experiment optics or sensors

(Attach additional sheets if necessary, identifying items by number.)

1. DESCRIPTION OF EQUIPMENT *(Sketch major assemblies in Item 5.)*

The equipment required to conduct this experiment mission has been categorized as follows:

- Adaptive tools
- Common tools
- Special equipment
- Common equipment

A listing of these tools and equipment is presented in Table 3-5. A conceptual picture of the Capture Work Platform system is illustrated in the frontispiece and Fig. 3-2.

(Attach additional sheets if necessary, identifying items by number.)

2. DESCRIBE SPACECRAFT MODIFICATIONS REQUIRED FOR ACCOMODATION OF EQUIPMENT. INDICATE PREFERRED MOUNTING CONFIGURATION HERE OR IN ITEM 5

See page 3-44.

(Attach additional sheets if necessary, identifying items by number.)

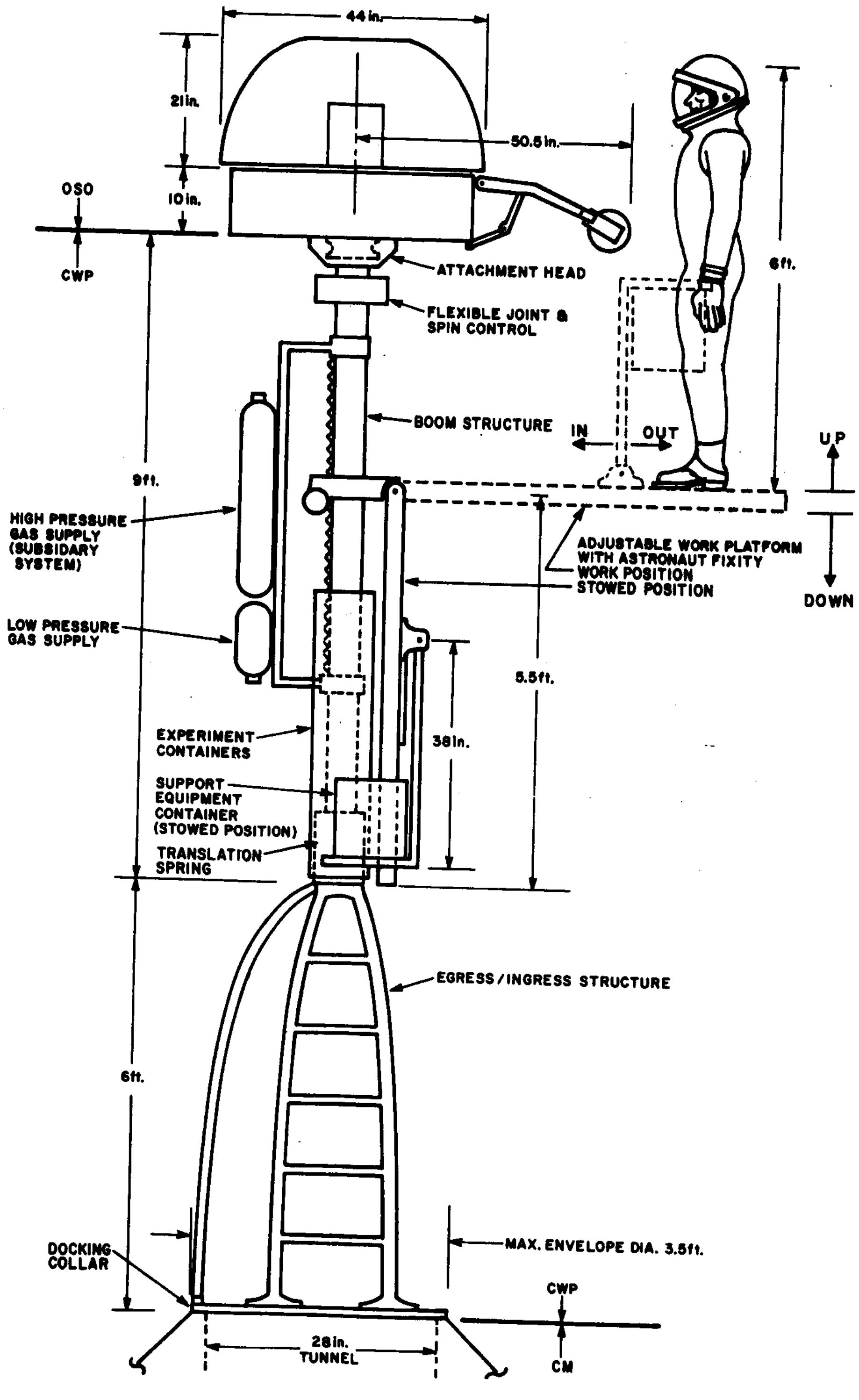


Fig. 3-2 Capture [illegible] Platform Conceptual Configuration

1. Description of Equipment (Cont.)

Table 3-5

TOOLS AND EQUIPMENT FOR ESMRO MISSION 3

ADAPTIVE TOOLS

- Allen head driving tool
- High torque driving tool
- Phillips head driving tool
- Slot head driving tool
- Gas containing cap drive tool
-

COMMON TOOLS

- Power tool with adaptive head
- Power tool ratchet handle
- Pry bar with tether
- Variable angle wedge with tether
- Wire bundle cutter with tether
- Latch release tool
- Printed circuit board removal tool
- Optic/sensor removal tool
- Long blade wire cutter with tether
- Connector removal tool with tether
- Reel tether with clamp
- Short tether
- Equipment transfer tethers
- Sail lock
- Pointed instruments elevation frame lock

SPECIAL EQUIPMENT

- Dosimeter (portable)
- Directional spectormeter
- Stop watch and visual aid

1. Description of Equipment (Cont.)

Table 3-5 (Cont.)

- High pressure nitorgen supply system (remote operation)
  - -Command controller (hand held)
  - -Gas attach fitting (remote operation)
  - -Quick disconnect coupling
  - -Check valve fitting tool
- Camera with high resolution lens and artificial illumination
- Maurer 16 mm sequential camera, Model 308 (2)
- General purpose 70 mm Maurer still camera
- Three battery packs with cable harness and attachment screws
  - -Battery pack storage container
- Solar array panels with electrical harness connectors and attachment clamps
  - -Solar array protective container
- Lens and solar cell protective covers
- Two tape recorders with cable harness and attachment screws
- One ballast (tape recorder simulation) with attachment screws
  - -Tape recorder and ballast storage container
- Set of permanent magnets (2) with locking clamp
  - -Permanent magnet storage container
- Torquing coil with electric harness and clamps
  - -Torquing coil storage container
- Spectroreflectometer with holding fixture
  - -Template container
- Printed circuit board for control system electronics
  - -Storage container
- Experiment replacement optics or sensors
  - -Storage container

COMMON EQUIPMENT

- Capture Work Platform System
  - -Boom (with compression spring)
  - -Attachment head (with release capability)
  - -Flexible joint and spin mechanism (remote operation)
  - -Docking collar and egress/ingress structure
  - -Adjustable work platform (with astronaut fixity)
  - -Support equipment containers (tool box)
  - -Electrical umbilical to CM
  - -Artificial illumination (with protable light)
  - -Low pressure inert gas supply system
  - -Battery power supply
  - -Mounting apparatus for remote camera operation
  - -Command console (portable inside CM)
- Film storage containers
- General purpose vacuum container

2. Describe spacecraft modifications required for accommodation of equipment. Indicate preferred mounting configuration here or in item 5.

No CSM spacecraft design modifications are anticipated; however, certain Apollo program support equipment will be required to conduct this experiment, some of which will interface with ESMRO equipment. These support items, and the respective Apollo/ESMRO equipment interfaces are as follows:

- Apollo Saturn I-B launch vehicle
- Apollo Command Service Moduel
    - a. With docking system
    - b. CM storage space (ascent and descent)
    - c. EVA communications link
    - d. Tape recording of astronauts voice annotation
    - e. Electrical power and signals
    - f. Inertial guidance
    - g. CM telemetry
    - h. On-board checkout system (OCS)
- Spacecraft Lunar Module adapter (SLA)
    - i. Storage for the ESMRO Capture Work Platform during boost phase
- IVA astronaut
- EVA astronaut with life support equipment (e.g. life support tether, mechanical tether, etc.)

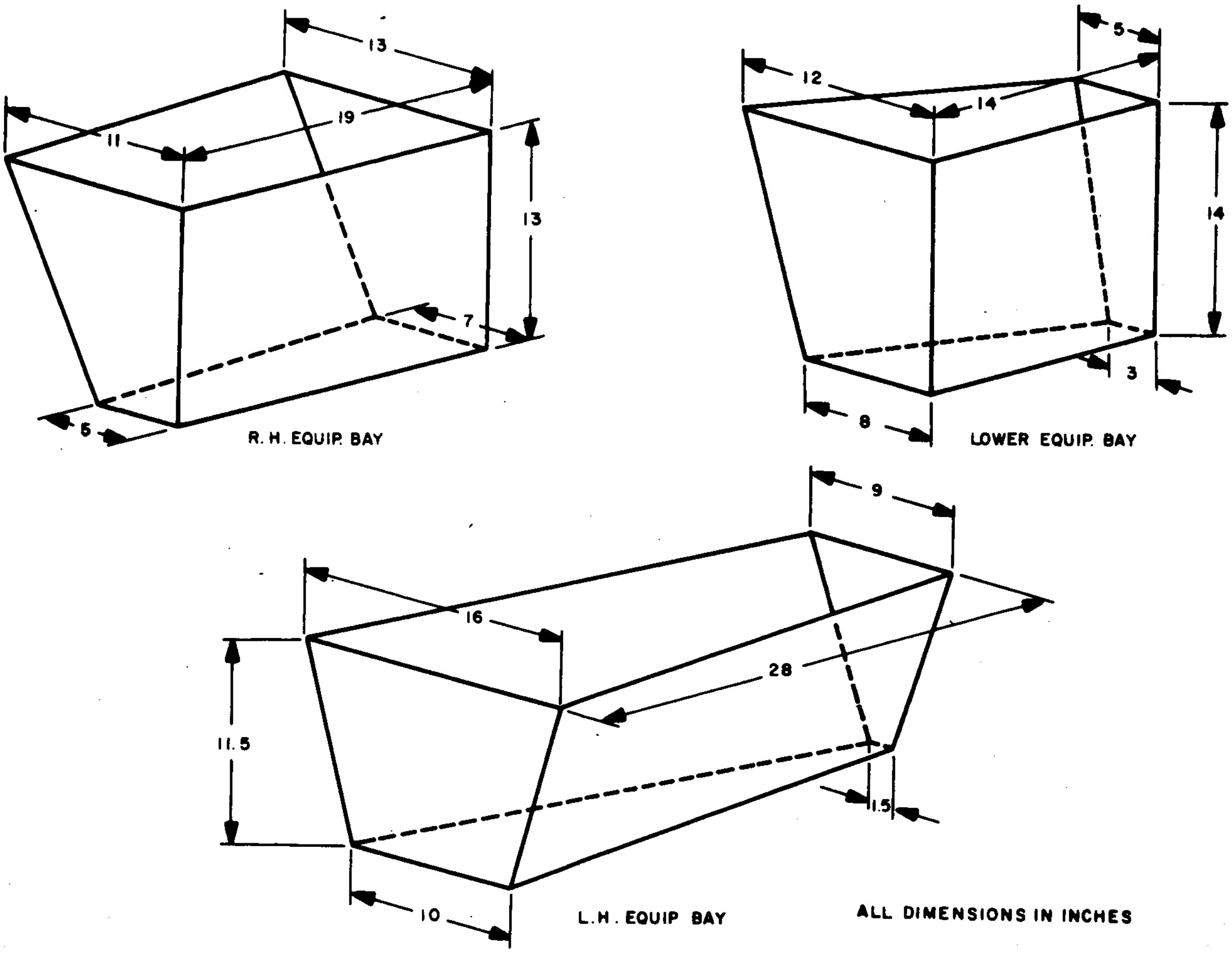
- Procedural transmission link between CSM and EVA astronaut
- Procedural transmisssion link between CSM and ground (MCC)
- Communications link with ground tracking stations
- CSM ground telemetry link

2.1 APOLLO SATURN I-B LAUNCH VEHICLE AND COMMAND SERVICE MODULE: The ESMRO experiment mission is proposed to be conducted as a part of the Apollo Applications Program and would utilize an Appllo Saturn I-B launch vehicle and Command Service Module (CSM).

2.1.1 The conduct of the ESMRO experiment mission will require that the Command Module be equipped with the CSM/LEM docking mechanisms. This docking mechansism will be used to dock the CSM with the OSO satellite capture mechanism.

2.1.2 Storage space in the Command Module will be required for returning equipment and exposed film to the earth for post-flight evaluation. Possible CM stowage areas are given in Fig. 3-3. A detail analysis and investigation must be complete to determine the optimum size(s) of storage container(s) necessary to package the selected items for retrieval and still be compatible with CM storage space.

2.1.2 The conduct of the ESMRO experiment mission proposes an electrical power and signal interface with the CSM. This interface will involve a power umbilical connected within the Command Module and run



Area	Volume (cu. ft.)
Food Compartment (Lower Equipment Bay)	1.0
Food Compartment (L. H. Equipment Bay)	1.7
Food Compartment (R. H. Equipment Bay)	0.9
LIOH Cannisters Area	4.5
Isleway (under center couch)	3.0
	11.1

(1) Reference BBRC ATM Study Program Final Report, dated 1 Apr 1966

Fig. 3-3 Possible CM Storage Areas

out to the CWP through the forward hatch. An electrical signal interface can be obtained utilizing the electrical signal connector in the CSM/LEM docking adapter. Utilization of these two electrical hookups may require wiring modifications or changes within the Command Module which will require investigating. The total power required will not exceed 2 kilo watt hours. (See item 6, Part II.)

2.1.4 The conduct of the ESMRO experiment mission requires the use of a control console from within the (CM). This console is small and portable; it should not present any significant interface problems. The unit can be designed to fit, or make use of, spare panel space on the astronauts controls and display console, or it could be a self-contained portable unit which the astronaut could operate and then stow. This item needs to be investigated in more detail to determine its optimum configuration.

2.1.5 A voice communications link between the astronauts inside the Command Module and the EVA astronaut will be required. It is understood that this capability will exist for the Apollo Applications Program.

2.1.6 Tape recordings of the astronauts voice annotations will be required during the conduct of IVA and EVA experiment tasks. It is understood that this capability will exist for the Apollo Applications Program.

2.1.7 Reference data from the Command Module Inertial Guidance System will be required in conjunction with performing rendezvous with the OSO and the magnetometer calibration experiment. (See 3 and paragraph 7.3.7.10 of Volume II.)

2.1.8 A telemetry interface with the Command Module data system will be required in conjunction with performing the magnetometer calibration experiment, and returning the OSO to automatic operation. (See paragraphs 7.3.7.10 and 7.3.7.11 of Volume II.

2.1.9 Interface with the Apollo CSM on-board checkout system (OCS) will be required in conjunction with performing the following experiments: battery power supply, solar array panels, tape recorders and return of OSO to automatic operation. (See paragraphs 7.3.7.3, 7.3.7.4, 7.3.7.5 and 7.3.7.11 of Volume II.)

2.2 SPACECRAFT LUNAR MODULE ADAPTER (SLA): In the conduct of this experiment, it is proposed to store the ESMRO Capture Work Platform (CWP) in the SLA during the Saturn launch and boost phase. The outside envelope dimension of the folded Capture Work Platform are illustrated in Fig. 3-3.

2.3 INTRA VEHICULAR ASTRONAUT: The services of an astronaut inside the Command Module will be required both for monitoring the EVA astronaut at all times he (the EVA astronaut) is outside of the CM and for performing specific functions onlmany of the proposed experiment tasks. Please refer to Section 8 of Volume II (Mission 3 Experiment Tasks) and Part I, paragraph 7, of this NASA Form 1138 for detail IVA tasks and time requirements.

2.4 EXTRA VEHICULAR ASTRONAUT: The services of an astronaut working outside the Command Module will be required for conducting many of the proposed ESMRO experiment tasks. Please refer to Section 8 of Volume II, Mission Experiment Tasks and Part I, paragraph 7, of this NASA Form 1138 for detail EVA tasks and time requirements.

2.5 CSM AND EVA ASTRONAUT PROCEDURAL TRANSMISSION: In order to conduct the Mission EVA ESMRO experiment tasks, a procedural transmission between the monitoring astronaut inside the CSM and the EVA astronaut will be required. The transmission will utilize the CSM/EVA astronaut voice communication link. Procedural documentation must be generated for each experiment task selected for Mission 3.

2.6 CSM AND MCC PROCEDURAL TRANSMISSION: In order to conduct many of the Mission 3 ESMRO experiment tasks, a procedural transmission between the CSM and the Manned Spacecraft Control Center will be required. These transmissions will utilize the manned space flight network (MSFN). Procedural documentation must be generated for each experiment task selected for Mission 3 requiring CSM/MCC procedural transmissions.

2.7 GROUND TRACKING STATIONS COMMUNICATIONS: During the rendezvous phase of the mission, communications between the ground tracking stations, and the CSM will be required to provide orbit information on both the CSM and the OSO satellite in order to up-date the CSM inertial guidance. This communications link will interface with the CSM/MCC procedural transmission link. Procedural documentation must be generated as required to support the rendezvous phase of Mission 3.

3. WEIGHT		4. VOLUME	
TOTAL WEIGHT:	750 lb	TOTAL VOLUME:	125 cu ft
WEIGHT OF SEPARATE ASSEMBLIES *(If any)*		VOLUME OF SEPARATE ASSEMBLIES *(If any)*	
ASSEMBLY #1 CWP System	500 lb	ASSEMBLY #1 CWP System	115 cu ft
ASSEMBLY #2 Equipment Containers	200 lb	ASSEMBLY #2 Equipment Containers	5 cu ft
ASSEMBLY #3 Miscellaneous	50 lb	ASSEMBLY #3 Miscellaneous	2.5 cu ft

5. **ENVELOPE** *(Sketch each assembly (Designate 1, 2 or 3) indicate nominal and limiting values of each major dimension.)*

Assembly No. 1 (Capture Work Platform System). From Part II, Fig. 3-2, an overall envelope space has been determined for the OSO Capture Work Platform system in the stowed configuration. This space envelope has been estimated to be within a cylindrical shape that is less than 3-1/2 feet in diameter, and 15 feet long.

Assembly No. 2 (Special Equipment Containers). Special equipment containers will be required as specified in paragraph 1, Part II, under Special Equipment. Estimates regarding the contents, and size, of each container are presented in Table 3-6. These numbers must be regarded as preliminary. A detail analysis and investigation must be completed. to determine the optimum size(s) of storage containers necessary to package the selected items for retrieval and still be compatible with available Command Module storage space.

Assembly No. 3 (Miscellaneous). Covered in this group are equipment items such as the general purpose container, the radiation instruments, and cameras and film. A volume of 2.5 cubic feet has been estimated for these items. Similarly, a detail analysis and investigation must be completed to determine the optimum size(s) of storage container(s) necessary to stow the selected items for return to earth and still be compatible with available Command Module storage space.

(Attach additional sheets if necessary, identifying items by number.)

Table 3-6

SPACE ENVELOPES FOR SPECIAL EXPERIMENT CONTAINERS (No. 3)

Container	Max. Dim. (in.) h x w x l	Volume (cu ft)
Container No. 1	22 x 6 x 12	0.92
• Battery packs (3)	6 x 4 x 10	
Container No. 2	24 x 24 x 6	2.0
• Solar array panels (2)	22 x 22 x 2	
Container No. 3	8 x 16 x 12	0.89
• Tape recorders (2)	6 x 4 x 10	
• Ballast (1)	6 x 4 x 10	
Container No. 4	8 x 10 x 6	0.28
• Permanent magnets (2)	1 x 2 x 4	
• Torquing coil	6 x 6 x 2	
Container No. 5	8 x 8 x 6	0.22
• Control system electronics PCB	6 x 6 x 1	
• Experiment optics/sensors	6 x 6 x 4	
Container No. 6	14 x 14 x 2	0.23
• Spectroreflectometer template	12 x 12 x 1	

6.

POWER

TOTAL POWER:	STANDBY	AVERAGE	MAXIMUM 1740 watt hr
POWER CONSUMED BY SEPARATE ASSEMBLIES			
ASSEMBLY #1	STANDBY	AVERAGE	MAXIMUM 140 watt hr
ASSEMBLY #2	STANDBY	AVERAGE	MAXIMUM 1200 watt hr
ASSEMBLY #3	STANDBY	AVERAGE	MAXIMUM 400 watt hr

IF POWER CONSUMPTION IS NOT CONSTANT, INDICATE POWER PROFILES BELOW:

The subsystems of the capture mechanism system, and other items which will utilize electrical power are listed below in Table 3-7 with estimates concerning their power profile.

(Attach additional sheets if necessary, identifying items by number.)

7.

THERMAL CONSTRAINTS

OPERATING TEMPERATURE LIMITS OF EACH ASSEMBLY		
ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C
STORAGE TEMPERATURE LIMITS OF EACH ASSEMBLY		
ASSEMBLY #1	MINIMUM °C	MAXIMUM °C
ASSEMBLY #2	MINIMUM °C	MAXIMUM °C
ASSEMBLY #3	MINIMUM °C	MAXIMUM °C

OTHER THERMAL CONSTRAINTS

The CSM spacecraft must maintain the OSO pitch axis perpendicular to the solar vector ±60 degrees, and maintain a roll rate of 10 degrees per hour.

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6. If power consumption is not constant, indicate power profiles below. (Cont.)

Table 3-7

POWER REQUIREMENTS (No. 3)

Subsystem/Item	Watts	On-Time Hours	Kilowatt Hours	Remarks
Assembly No. 1 Wheel torque and lock -Despin and spin-up -Wheel turn operation	20	1	20	CWP battery power
Attachment head -Adhesive release	100	0.2	20	CM power peak load is estimated not to exceed 250 w (applies to all items from Attachment head through Camera operation)
Work platform -Up and down operation -In and out operation -Erect and stow operation,	100	1	100	
Assembly No. 2 Artificial illumination	100	12	1200	
Assembly No. 2 Power tool operation	75	4	300	
Camera operation	10	10	100	

8. **OTHER ENVIRONMENTAL CONSTRAINTS** ***(List any remaining constraints such as preferred or prohibited orientation of assemblies with respect to direction of maximum vibration and acceleration, susceptibility to RFI, etc.)***

- OSO contamination due to RCS engines
- OSO contamination due to suit exhaust and outgassing
- Radiation levels must not exceed prescribed levels

(Attach additional sheets if necessary, identifying items by number.)

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9.

TELEMETRY	OUTPUT 1	OUTPUT 2	OUTPUT 3	OUTPUT 4
FUNCTION				
MUST MEASUREMENT BE CONTINUOUS				
MINIMUM NUMBER OF SAMPLES PER SECOND				
ACCURACY OF MEASUREMENT				
MAXIMUM BIT RATE *(Digital only)*				
MINIMUM FREQUENCY RESPONSE *(Analog only)*				

ADDITIONAL INFORMATION

A telemetry interface with the Command Module data system will be required in conjunction with performing the magnetometer calibration experiment and returning the OSO to automatic operation. (See paragraphs 7.3.7.10 and 7.3.7.11 of Volume II.)

The OSO telemetry format output is in the Manchester digital code. The transmitted bit rate is 800 bits per second, with 8 bit words to a frame with 32 frames. The OSO has three 48 channel submultiplexers. The digital voltage output will be 0 ± 0.5 volts for a zero bit and 3.2 ± 0.5 volts for a one bit.

(Attach additional sheets if necessary, identifying items by number.)

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10. DEVELOPMENTAL PROGRAM(1)

ITEM	WHERE PERFORMED	BEGINNING DATE	COMPLETION DATE
PRELIMINARY ELECTRICAL DESIGN as required		8/1/69(2) or 25 month ARC	1/1/70 or 30 month ARC
PRELIMINARY MECHANICAL DESIGN as required		7/1/69 or 24 month ARC	11/1/69 or 28 month ARC
PRELIMINARY MOCK UP FABRICATION as required		10/1/69 or 27 month ARC	1/1/70 or 30 month ARC
FINAL ELECTRICAL DESIGN as required		1/1/70 or 30 month ARC	5/1/70 or 36 month ARC
FINAL MECHANICAL DESIGN as required		1/1/70 or 30 month ARC	7/1/70 or 36 month ARC
EXACT MECHANICAL MOCK UP CONSTRUCTION as required		5/1/70 or 34 month ARC	7/15/70 or 36-1/2 monARC
PROTOTYPE FABRICATION as required		9/1/70 or 38 month ARC	1/1/71 or 42 month ARC
PROTOTYPE ENVIRONMENTAL TEST as required		1/1/71 or 42 month ARC	3/1/71 or 44 month ARC
FLIGHT UNIT FABRICATION		12/1/70 or 41 month ARC	4/1/71 or 45 month ARC
FLIGHT UNIT ENVIRONMENTAL TEST		4/1/71 or 45 month ARC	5/1/71 or 46 month ARC
FLIGHT SPARE FABRICATION as required		3/1/71 or 44 month ARC	6/1/71 or 47 month ARC
FLIGHT SPARE ENVIRONMENTAL TEST as required		6/1/71 or 47 month ARC	7/1/71 or 48 month ARC

(1) All dates are figured from an assumed contract start of 1 Jul 1967.

(2) ARC means "after receipt of contract".

The above program schedule information, along with additional details is presented in graphic form in Fig. 3-4. All dates on that schedule are shown as months after a contract go-ahead of 1 Jul 1967, and a continuous development program has been assumed. A launch six months after delivery of the flight model is shown. All design prototype and flight space activity will be associated only with new items for this experiment mission. While the actual hardware system is composed of many items, it has been treated in the schedule as a single unit since design, fabrication and test of the various items would proceed in parallel with one another.

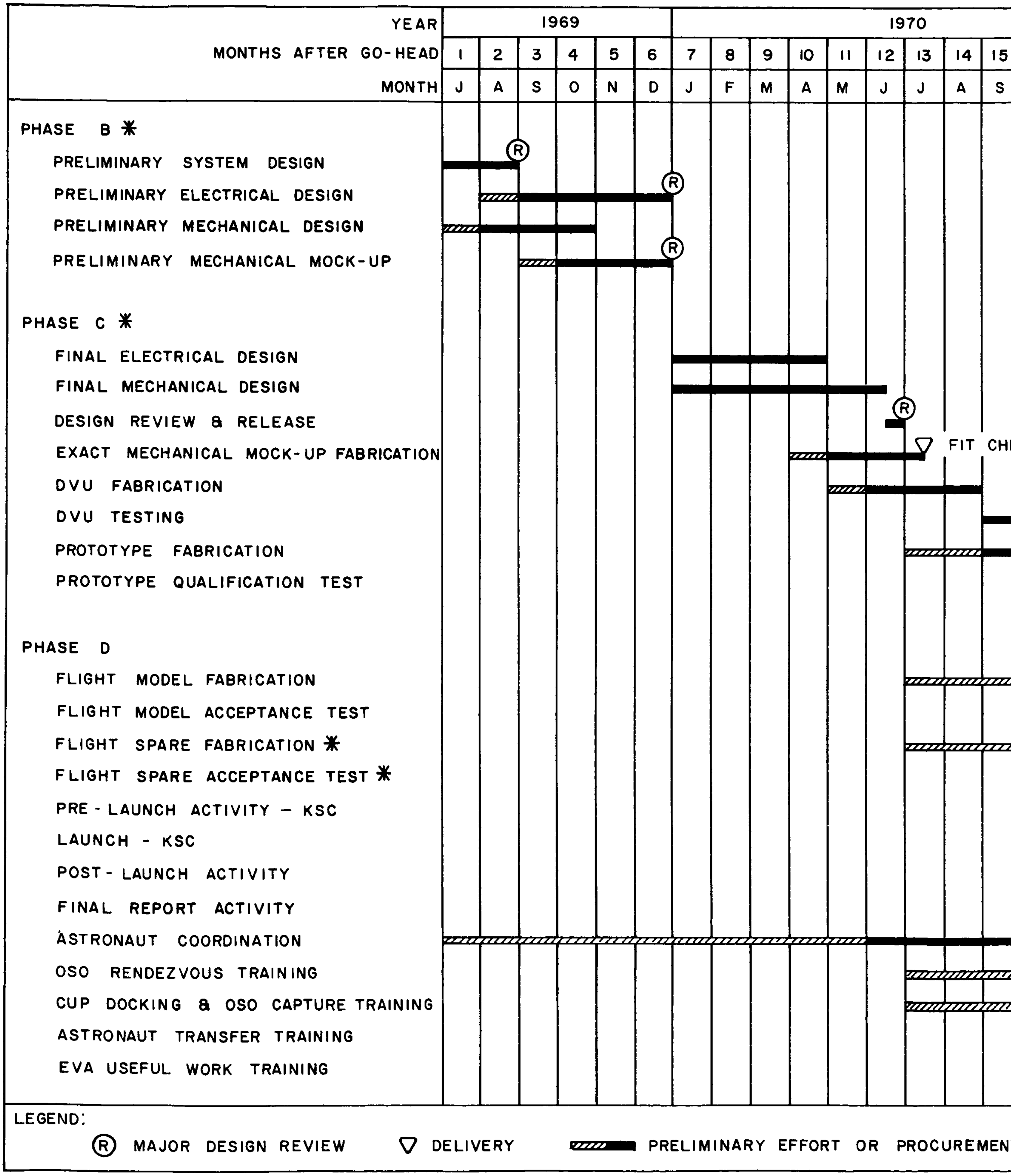
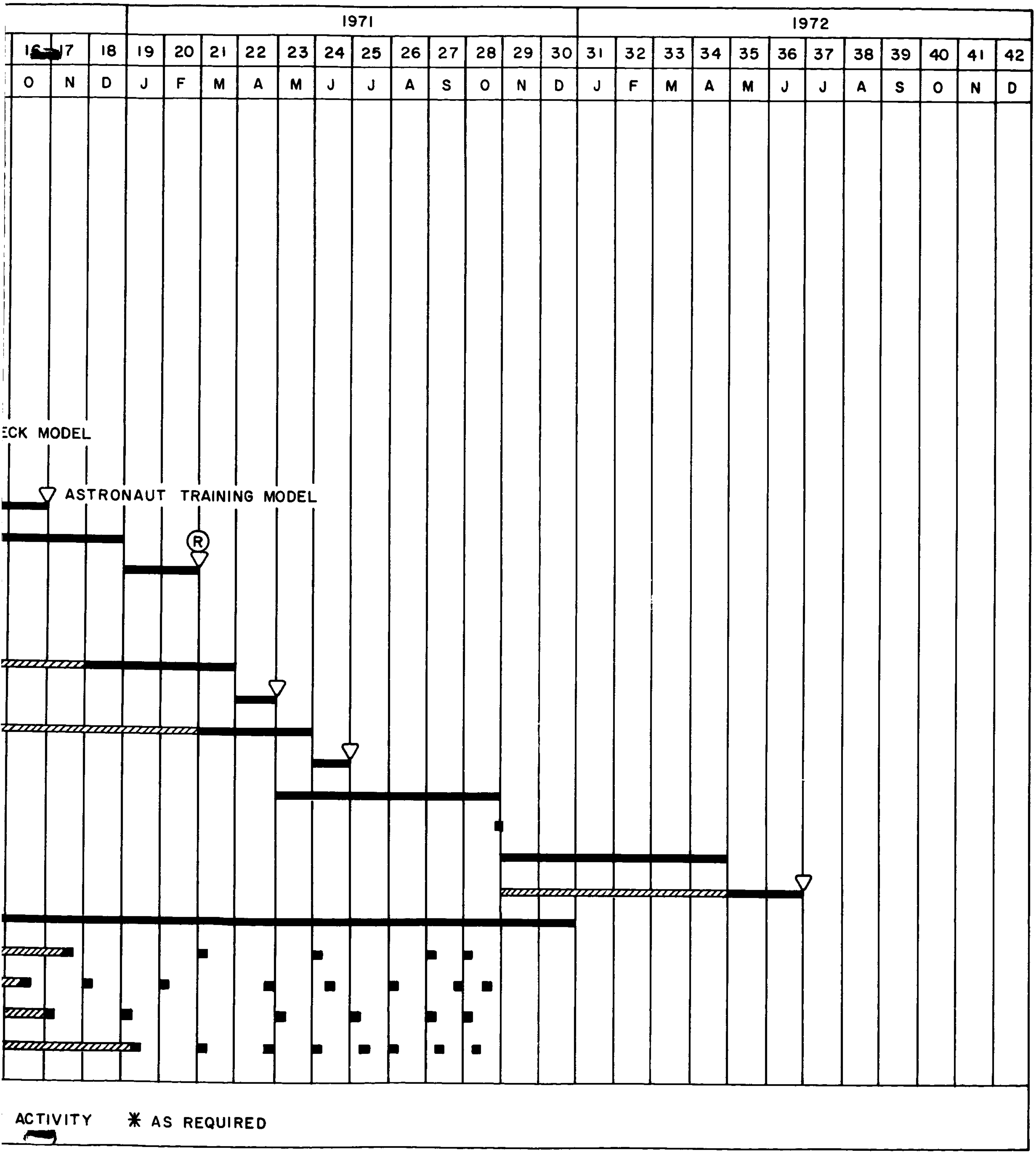

YEAR
1969
1970
MONTHS AFTER GO-HEAD
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MONTH
J A S O N D J F M A M J J A S
PHASE B ✱
PRELIMINARY SYSTEM DESIGN
PRELIMINARY ELECTRICAL DESIGN
PRELIMINARY MECHANICAL DESIGN
PRELIMINARY MECHANICAL MOCK-UP
PHASE C ✱
FINAL ELECTRICAL DESIGN
FINAL MECHANICAL DESIGN
DESIGN REVIEW & RELEASE
EXACT MECHANICAL MOCK-UP FABRICATION
FIT CH
DVU FABRICATION
DVU TESTING
PROTOTYPE FABRICATION
PROTOTYPE QUALIFICATION TEST
PHASE D
FLIGHT MODEL FABRICATION
FLIGHT MODEL ACCEPTANCE TEST
FLIGHT SPARE FABRICATION ✱
FLIGHT SPARE ACCEPTANCE TEST ✱
PRE - LAUNCH ACTIVITY — KSC
LAUNCH - KSC
POST - LAUNCH ACTIVITY
FINAL REPORT ACTIVITY
ASTRONAUT COORDINATION
OSO RENDEZVOUS TRAINING
CUP DOCKING & OSO CAPTURE TRAINING
ASTRONAUT TRANSFER TRAINING
EVA USEFUL WORK TRAINING
LEGEND:
Ⓡ MAJOR DESIGN REVIEW
▽ DELIVERY
PRELIMINARY EFFORT OR PROCUREMEN

Fig. 3-4 M



ssion 3 Schedule

[redacted]

The exact mechanical mockup is to be used as an Apollo fit check model and as a structural test model in netural buoyancy astronaut training exercises. A design verification unit (DVU) has been included in the schedule and this model will be utilized in the following ways:

(1) Pre-prototype Production Model - Fabricated from prerelease engineering drawings, the DVU will serve as a production test model. Any problems arising during fabrication can be resolved and the necessary corrections incorporated prior to prototype fabrication. This shortens prototype production time and generally results in a better prototype model.

(2) Engineering Model for System Tests - The DVU will be the first complete flight unit configuration model available for system engineering tests. Results of these tests, performed prior to completion of prototype fabrication, can be used as a basis for changes to that model prior to its completion. Again, this results in a better prototype model. The additional system testing performed on the DVU gives greater confidence that the prototype will pass its qualification tests and also cuts down on the amount of preliminary testing required on the prototype prior to commencing qualification tests.

(3) Astronaut Training Model - Upon completion of DVU system testing, the model is then available for use as an astronaut trainer. The complexity of the tasks to be performed by the astronauts make this a very desirable addition to the program. With an OSO mockup, an Apollo trainer, various simulators, the exact mechanical mockup and this model, all phases of the mission can be duplicated for training purposes.

10.1 ASTRONAUT COORDINATION AND TRAINING: Since the astronaut is a dominant part of the CWP system, heavy emphasis will be placed on coordination with the astronaut office and the astronaut training program. As shown in Fig. 3-4, coordination activity will commence at program inception and continue through to the completion of post-flight activity. Astronaut training effort will commence with the completion of final design and will be conducted in the following four major areas:

- OSO rendezvous
- CWP docking and OSO capture
- Astronaut transfer
- EVA useful work

In addition to astronaut coordination and training support, BBRC and EE personnel will participate in prelaunch, launch, flight and post-flight activity.

MANAGEMENT PLAN - PART III

(For Headquarters use only.)
DATE RECEIVED BY SM

TITLE OF EXPERIMENT

Mission 3 - OSO Capture, Refurbishment, and Checkout

SPONSORING INSTITUTION	ADDRESS
Co-sponsors: George C. Marshall Space Flight Center/OMSF	Huntsville, Alabama 35812
Goddard Space Flight Center/OSSA	Greenbelt, Maryland 20771

1. RESPONSIBILITIES

INDIVIDUAL	NAME	ADDRESS
A. RESPONSIBLE ADMINISTRATOR	Mr. G. von Tiesenhausen R-AS-VO	NASA-MSFC Huntsville, Alabama 35812
B. PRINCIPAL INVESTIGATOR	Advanced Systems Office	NASA-MSFC Huntsville, Alabama 35812
C. CO-INVESTIGATOR(S)		
	Dr. L. Werner	OMSF-MT-E, Washington, D.C.
	Mr. R. Halpern	OSSA-SGH, Washington, D.C.
	Mr. D.C. Cramblit	NASA-MSFC R-AS-VO, Huntsville, Alabama 35812
	Mr. W.H. Stafford	NASA-MSFC R-AS-VO, Huntsville, Alabama 35812
	Mr. J. Walls	NASA-GSFC OSO Program Greenbelt, Maryland 20771

D. PRINCIPAL INVESTIGATOR'S ROLE IN RELATION TO THIS EXPERIMENT

Overall Program Direction and Coordination with both the AAP and OSO Program

E. RESPONSIBILITIES OF OTHER KEY PERSONS

To be determined

(Attach additional sheets if necessary, identifying items by number.)

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2.

COST BREAKDOWN

Attach a sheet (or sheets) giving the costs of the experiment for which NASA support will be required, in the following format, and in the detail specified. Separate cost breakdowns should be submitted for the three phases of experiment funding shown in Item 3, "Quarterly Funding Requirements".

ITEM	AMOUNT
DIRECT LABOR *(Separate by Labor Category; Rate per hour or man-month; Personnel involved, what they will do, etc.)*	$
MANUFACTURING BURDEN *(Overhead)* RATE (%) *(Flight experiments normally will be supported by contracts rather than grants.)*	
MATERIALS *(Total) (Bill of Material, including estimated cost of each major item.)*	
SUBCONTRACTS *(List those over $25,000) (Specify the vendor if possible, and the basis for the estimated cost.)*	
SPECIAL EQUIPMENT *(Total) (List of lab equipment, proposed uses, and estimated cost.)*	
TRAVEL *(Estimated number of individual trips, destinations, and costs.)*	
ANY OTHER ITEMS *(Total) (Explain in detail similar to the above.)*	
TOTAL COSTS	$
GENERAL AND ADMINISTRATIVE RATE ( )	$
TOTAL ESTIMATED COST	$ 2,890,000*

Experimenters who request to conduct the proposed experiment as an extension of an existing grant or contract, should list the grant or contract number and the name and address of the NASA technical monitor below.

GRANT OR CONTRACT NO.	NAME AND ADDRESS OF NASA TECHNICAL MONITOR

*See attached Cost Breakdown, Table 3-8

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2. Cost Breakdown (Cont.)

Table 3-8

MISSION 3 COST BREAKDOWN (BUDGETARY)

Phase		Cost
Phase B - includes preliminary design and mockup, as required for changes from Mission 1 and 2 designs	$	130,000
Phase C - includes detail design, detail mockup, design verification unit (DVU), prototype and prototype qualifications, as required for changes from Mission 1 and 2 designs		460,000
Phase D - includes flight model and astronaut training and launch support		1,800,000
OSO - includes OSO modifications, OSO refurbishment parts and OSO training models		500,000
Program Total	$	2,890,000

3. Quarterly Funding Requirements (Dollars in Thousands)

MISSION 3 (BUDGETARY)

Program Phases \ Quarters Ending	Sept 1969	Dec 1969	Mar 1970	June 1970	Sept 1970	Dec 1970	Mar 1971	June 1971 (Flight Model Delivery)	Sept 1971	Dec 1971 (Launch)	Mar 1972	June 1972	Totals (Final Report)
Phase B	60	70											130
Phase C			80	100	120	100	60						460
Phase D					100	350	550	300	150	150	50	150	1,800
OSO		100	200	50	50	50	50						500
Totals	60	170	280	150	270	500	660	300	150	150	50	150	2,890