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MEMORANDUM FOR DR. SEAMANS

This is in reply to your memorandum dated June 30, 1969, pertaining to the establishment of an Ad Hoc Group to review MOL hardware, technology and experience to insure that maximum national benefit is derived therefrom.

The Ad Hoc Group was established under the chairmanship of Dr. M. I. Yarymovych, and their report is transmitted herewith. The report is divided into two volumes. Volume I contains the summary and the conclusions, the MOL system development status at time of termination, the residuals and technology selected for special consideration and related planning considerations. Volume II contains the Appendixes which include supporting documentation and material reviewed by the Group.

I have reviewed the Ad Hoc Group's report and concur with their findings and recommendations, and I commend it to you for your approval of the recommended actions.

2 Attachments
1. Review of MOL Residuals, Vol I, (C)
2. Review of MOL Residuals, Vol II, (S)

Signed:
GRANT L. HANSEN
Assistant Secretary
Research and Development

WORKING PAPER

REVIEW OF MOL RESIDUALS

DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA
MCMXLVII

AUGUST 1, 1969

~~CONFIDENTIAL~~

REVIEW OF MOL RESIDUALS

Prepared by an Ad Hoc Group

for the Secretary of the U.S. Air Force

Volume I

Approved

M. I. YARYMOVYCH
Chairman

Washington, D.C.
August 1, 1969

~~CONFIDENTIAL~~ WORKING PAPER

REVIEW OF MOL RESIDUALS

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I. SUMMARY AND CONCLUSIONS

As directed by the Secretary of the Air Force, an Ad Hoc Group on MOL Residuals was organized to insure that maximum national benefit is realized from the MOL Program hardware, technology, and experience. In fulfilling its charter, the Group made a comprehensive review of the significant hardware, facilities, and technology available. The review included detailed presentations by the MOL Systems Office, the Space and Missiles Systems Organization, and the Aerospace Medical Division and stimulated a number of investigations of various areas by potential users.

Additionally, McDonnell Douglas Astronautics Corporation and General Electric Company presented to the Ad Hoc Group suggestions on possible uses of their developed hardware, technology, and experience.

Review and deliberations by the Group verified that the originally approved conceptual approach--that flight demonstrated hardware and proven technology be used to the maximum extent possible to achieve a highly reliable and operational system at the outset--was closely followed. The approach included the use of a modified Gemini reentry vehicle and space suit and proven space vehicle structural design and fabrication techniques. Modified or adapted Apollo subsystems and components and a modified Titan III booster for improved performance and man-rated safety were also used. Particularly close coordination and standardization between NASA and the Air Force was evident in the crew-related and fire-resistant materials areas.

In spite of the extensive utilization or adaptation of available hardware and technology, the MOL Program was a massive engineering undertaking to develop an efficient system useful for low-altitude, long-duration operations. A sizable portion of the engineering test hardware had been completed, and fabrication of flight articles had commenced.

All the significant MOL hardware, test and checkout equipment, facilities and technology were identified and the potential use to DoD and/or NASA was assessed. The disposition actions and plans of the MOL Program/Systems Office are generally concurred in by the Group. Furthermore, the plans insure that all possible beneficiaries of Government and industry are afforded an opportunity to review the residual inventories and assess their needs in accordance with the established priority although the beneficiary may not have been represented by membership on the Group.

Specifically, the following actions were underway and the Group concurs with their implementations:

1. The crew-related equipment which includes feeding systems, MOL suit development, and environmental control components have direct application to NASA manned programs. The feeding system contract is being transferred to NASA, and the waste management components and technologies are made available to NASA through the mutual contractor. The oxygen sensor components and the MOL development and training pressure suits will be transferred to NASA.

2. The Gemini Aerospace Ground Equipment was originally obtained from NASA and it will be returned to NASA as specified in the original agreement.

3. Space Launch Complex No. 6 will be "mothballed" and maintained in a "down-mode" for possible use on future programs. The MOL Support Facilities at Vandenberg will be reallocated to other users.

4. Air Force Satellite Control Facility's Advanced Data System and MOL-associated tasks were cancelled and a study to determine the use of the Advanced Satellite Test Center has been initiated.

5. The requirement for the Recovery Staging Base at Easter Island was cancelled.

6. The essential MOL development work that must be continued in other Air Force projects was associated with Titan IIIM. This involves design improvements and qualification tests that were slated for integration in other Titan III programs to improve payload capability and to preclude re-procuring of earlier obsolete configurations. The essential development effort has been transferred to the Titan III R&D program. Studies are presently underway to consider the most effective application of residual Titan IIIM test equipment.

A number of items were identified by the Group as requiring special consideration by the DoD and/or NASA. It is recommended that the following specific actions be taken:

1. The Air Force Systems Command (AFSC) and the Air Staff should evaluate the SAMSO study on use of the Titan III automatic checkout equipment (CAGE) and make recommendations to the Assistant Secretary of the Air Force for R&D (SAFRD) by September 1, 1969.

2. NASA should submit their recommendation on their use of simulators and checkout systems to SAFRD by September 1, 1969. Any conflict between the Air Force and NASA needs will be resolved by SAFRD.

3. All general purpose computers should be listed for inventory and disposition in accordance with Armed Services Procurement Regulations as planned; however, disposition of those computers associated with the simulators and checkout systems mentioned above should be held in abeyance until completion of the above studies.

4. The MOL fuel cell hardware should be transferred to the AF Aero Propulsion Laboratory.

5. The AF Rocket Propulsion Laboratory should have first priority on the Attitude Control Engines. The remaining engines and associated tankage and valving should be transferred to NASA, Langley Research Center.

6. AFSC and the Air Staff should investigate Air Force space and aeronautical systems need for the MOL 4 Pi Extended Performance flight computers and advise the appropriate Termination Contracting Officer. If not needed by the Air Force, the hardware may then be transferred to NASA.

7. The hardware for the Expandable Airlock Experiment for the Apollo Applications Program (D021) should be held in storage pending resolution of NASA's plans for the dry workshop. Inasmuch as the flight hardware is completed and NASA has expended most of the integration effort, it may be appropriate to continue this experiment. The Director of Laboratories should review this matter with the Air Staff and NASA. The Expandable Reentry Structure experiment (D022) should be cancelled.

8. In its charge to identify desirable MOL technology which might be continued, the Ad Hoc Group carefully reviewed the Biotechnology area. The Group concluded that in the future the difference between flight in manned spacecraft and high performance aircraft will become indistinguishable. Also, NASA relies heavily upon the Air Force Aerospace Medical Division (AMD), and it would be wasteful of national resources to establish a similar capability at NASA. Therefore, the Group recommends that continuation of a balanced activity in biotechnology is appropriate and desirable. In this context, for example, the Whole Body Exercise effort to improve crew conditioning techniques, which has been under development in-house by the AMD for MOL, should be continued because of its significant contribution to NASA and future Air Force programs. Also, the AFSC and NASA should jointly study the possibility of developing a value of man experiment in AAP to replace the data which would have been gained from MOL.

9. The Air Force Experiments for the NASA Apollo Applications Program, Human Mass Measuring Device (M-172 and M-074), should be continued as joint NASA/DoD efforts as presently negotiated and procured. The MOL Suit Donning and Sleep Station Evaluation (D019), and Alternate Restraints Evaluation (D020) experiments should be transferred to NASA by Manned Space Flight Experiment Board action.

10. NASA should be encouraged by SAFRD to continue development of the MOL suit. If NASA elects to continue the development effort, a limited number of Air Force personnel associated with the suit development should be detailed to support the NASA effort.

11. The desirable technology items related to MOL which might be continued as follow-on Exploratory or Advanced Development projects were identified. Important adaptations and technological developments evolved during the development phase of the MOL program and, it is considered highly desirable to have special papers or reports written in each area and provided to the scientific and engineering communities. Wide distribution would help insure that maximum national benefit is derived from MOL technologies. Because of the potential benefit and the small costs involved to provide the papers, the Group believes that the MOL Program Office should invite the respective contractors to prepare the reports and make publication possible after screening by the appropriate Air Force Laboratory.

Although the Group has attempted to assess all known needs, undoubtedly additional requirements exist, and the various Air Force elements should be encouraged to establish them with the appropriate Termination Contracting Officers at the contractors' plants.

II. INTRODUCTION

Cancellation of the Manned Orbiting Laboratory (MOL) Program was publicly announced by the Secretary of Defense on June 10, 1969. Simultaneously, in accord with the Secretary's direction for an orderly closeout of MOL activities, the Air Force issued termination, partial-termination, or stop-work notices, as appropriate, to MOL contractors. Review of various contractual efforts for possible application in other projects were initiated immediately by National Aeronautics and Space Administration (NASA) and Space and Missile Systems Organization (SAMSO) in conjunction with the MOL Systems Office.

On June 30, the Secretary of the Air Force (SECAF) directed the Assistant Secretary of the Air Force for Research and Development to establish an Ad Hoc Group of appropriate individuals to conduct a formal, comprehensive review of MOL residuals to insure that maximum national benefit was realized from MOL hardware, technology and experience. The objectives of the Group included the identification of all significant MOL Program residuals that might be useful to DOD and/or NASA and review of the disposition actions and plans and recommendations thereof. Also the objective included the identification and recommended courses of action for essential MOL work which must be carried on in other Air Force projects as well as desirable MOL technology which might be continued. The Group consisted not only of representatives from various Air Force organizations, but also had member representatives from the Office of the Secretary of Defense and the National Aeronautics and Space Administration. The Ad Hoc Group reviewed the status of all systems and major subsystems of the MOL Program. They also heard views of the major associate contractors regarding their suggestions on utilization of MOL Program residuals. Appendixes to this report include the directive from SECAF establishing the Ad Hoc Group, the composition of the Group and a summary of its activities.

From the outset of the MOL Program, it was fundamental that flight-demonstrated hardware and proven technology would be used to the maximum extent possible. The reason for that approach was to achieve a highly reliable and operational space test bed, so that primary emphasis could be focused on the basic MOL objectives, i.e., the determination of the extent of man's utility in space for military purposes, and the development of experimental hardware for both manned and unmanned defense space applications.

At the beginning of the review by the Ad Hoc Group, it became obvious to all concerned that the tangible residual benefits of the MOL Program, in terms of advanced technology and hardware directly applicable to other military and civilian undertakings, would be relatively modest when measured against the sizeable investment since engineering development was initiated.

The review by the Ad Hoc Group revealed that a sizeable percentage of the engineering test hardware had been completed, and fabrication of flight articles had commenced. In this regard, an unmeasurable but real benefit of the program is the expansion of manned spaceflight know-how across a broad segment of industry and Government.

The report is divided into three major sections. First, (Section III) is a summary of the MOL systems status at the time of termination. Secondly, subsystems and facilities reviewed for possible use other than routine disposition are documented in Section IV. This section also contains discussions on essential work that must be continued and ongoing or projected technology developments outside the MOL Program which might have had an application to future MOL growth versions.

The MOL Systems Office is in the process of carrying out termination procedures per applicable regulations. The Group did not consider it within its responsibility to modify or redirect the normal termination and disposition activities. It only attempted to review the total activity to assure that all elements were considered and to make recommendations to the MOL Systems Office as well as to potential users of MOL hardware and technology regarding disposition alternatives.

In considering future planning, the Group became concerned that cancellation of MOL might precipitate an extended withdrawal by the DoD from space-related activities. This subject is discussed in Section V of the report.

The Group did not review personnel reassignments or manpower positions because another Ad Hoc Group has addressed the subject.

III. MOL SYSTEM DEVELOPMENT STATUS SUMMARY AT TIME OF TERMINATION

A. MAJOR SYSTEM SEGMENTS

At termination on June 10, 1969, the MOL Development Program was well into the engineering development which had begun in late 1966. Every component and subsystem of the total MOL vehicle had been defined and designed in detail. All of the hardware components were in some stage of fabrication, and the initial development testing of many of them had been completed. In some instances long-lead hardware items, particularly in the ground support equipment category, had advanced into manufacturing and were scheduled for early delivery during CY 1969 and CY 1970. Construction of major facilities was scheduled for completion in mid-1969.

The estimated status of completion of all the significant hardware being developed within the MOL Program at the time of program termination is presented in summary regardless of current disposition or other utilization. A more detailed compilation of the significant hardware developments is contained in Volume II, Appendix E which consists of a number of briefings presented by the responsible MOL Systems Office development managers to the Ad Hoc Committee on July 10, 1969. Although portions of Appendix E differ in context and format, they contain, in summary, a complete and detailed presentation of the significant developments as evaluated at the time of program termination.

It should be noted that the stages of hardware development varied among MOL contractors depending on the maturity of hardware. For example, because the Gemini B was largely a direct adaptation of the NASA Gemini, its development status, except for one or two significant modifications, was largely complete; and the next step was initiation of all manufacturing.

The MOL System development was characterized by the division of the MOL vehicle into major segments managed by associate contractors.

Segment	Associate Contractor
Laboratory Module (LM)	McDonnell Douglas, Western Division Huntington Beach, Calif. (MDAC-WD)
Mission Module (MM)	General Electric Company (GE) King of Prussia, Pa.
Gemini B (GB)	McDonnell Douglas, Eastern Division St. Louis, Mo. (MDAC-ED)
Titan IIIM Booster (T-IIIM)	
(Vehicle System)	Martin Marietta Corporation (MMC) Denver, Colo.
(Liquid Engines)	Aerojet General Corporation (AGC) Azuza, Calif.
(Guidance)	AC Electronics Division (ACED) Milwaukee, Wisconsin
(Solid Rocket Motors)	United Technology Corporation (UTC) Sacramento, Calif.
Pressure Suit Assembly (PSA)	Hamilton Standard (HS) Hartford, Conn.
MOL Feeding System	Whirlpool (WP) St. Joseph, Michigan

B. COMPLETION STATUS

The following tables summarize the status of completion of the major MOL hardware developments at the time of termination. All estimates reflect normal percentage of the complete effort associated with the particular development. For a particular subsystem the percent completion is based on the amount expended up to termination and the total cost to carry that particular effort through the complete MOL Program cycle including flight.

MOL Segment	Contractor	Completion Status (Percent)
LABORATORY VEHICLE	MDAC-WD	
Subsystems		
Mission Module Structure		40
Laboratory Module Structure		38
Attitude Control and Translation		54
Environmental Control		40
Data Management		64
Instrumentation Displays and Consoles		21
Communications		83
Electrical Power		50
Crew Status Monitoring		21
Crew Station and Accommodations		21
Subcontracts/Subcontractor		
ACTS-SCE	Honeywell	55
Low and High Thrustor Assembly	Marquardt	61
Propellant Tank Assembly	Rocketdyne	40
Primary Power	Allis-Chalmers	15
Environmental Control	Hamilton Standard	57
Waste Management	Fairchild Hiller	53
Atmosphere Reactants Supply	AiResearch	40
Communications	Collins	70
Command Subsystem Group	Radiation	46
Pulse Code Mod Assembly	Radiation	66
Data Computation Subsystem	IBM	78
Monitor and Alarm	Radiation	63
TITAN IIIM		
Subsystem		
T-IIIM Booster	MMC	46
Liquid Engines	AGC	58
Guidance	ACE	37
Solid Rocket Motors	UTC	35

MOL Segment	Contractor	Completion Status (Percent)
GEMINI B	MDAC-ED	
Subsystem		
Guidance and Control		35
Environmental Control		55
Instrumentation		45
Voice and Tracking		45
Ejection Seat		75
Electrical		60
Propulsion		50
Pyrotechnic		55
Landing and Recovery		50
Crew Station		60
Reentry Module Structure		55
Adapter Structure		50
MISSION PAYLOAD	GE	
Subcontract/Subcontractor		
Low "G" Accelerometer	Bell	23
Visual Display Projector	Lear Seigler	42
Star Tracker	Kollsman	52
Computer Integrated Test Equipment (CITE)	GE	52
PRESSURE SUIT ASSEMBLY	Hamilton Standard	29
FEEDING SYSTEM	Whirlpool	68
SPACE LAUNCH COMPLEX #6	Corps of Engineers	92
MOL SUPPORT FACILITIES	Corps of Engineers	80

The MOL development program was supported by a mixture of government-owned and contractor-owned facilities. The government facilities were located at the AF Western Test Range and the AF Satellite Test Center at Sunnyvale, California. All of the facilities at the contractor locations were contractor owned. A detailed identification of all these facilities is provided in Appendix D.

IV. RESIDUALS AND TECHNOLOGY SELECTED FOR SPECIAL CONSIDERATION

During the review and evaluation of the complete MOL system development status, the group identified specific items of hardware and technology for which special consideration and requirements for exploitation are desired. Whereas it is recognized that all possible users were not represented, the members did, however, represent all of the likely beneficiaries of MOL residuals. The established MOL hardware-disposition plan and priorities insure distribution and listing of residual inventories to other possible beneficiaries as soon as the inventories become available. Forecast dates for individual contractor inventory disposition are contained in Appendix E.

There were a total of 21 individual items selected for special consideration. They are divided into hardware, facilities, and related technology. Each item is treated as a separate subject in a standard format covering the situation, rationale for proposed action, and proposed action. Below is a list of the items discussed.

1. Food and Feeding System
2. MOL Suit Development
3. Waste Management Subsystem
4. Two Gas Controller
5. Laboratory Module Simulator
6. Computer Integrated Test Equipment
7. Data Processing Equipment

8. Gemini Aerospace Ground Equipment
9. Fuel Cells
10. Attitude Control Engine
11. MOL Flight Computer
12. Mass Measuring Device
13. MOL Related Experiments Assigned to AAP
14. Titan IIIM Hardware and Development Effort
15. MOL Support Facilities
16. Space Launch Complex No. 6
17. Air Force Satellite Control Facility
18. Recovery Staging Base
19. Technological Achievements Suitable for Publication
20. MOL Crew Whole Body Exerciser
21. Expandable Structures

A. MOL HARDWARE

1. Food and Feeding System

Situation: The U.S. Air Force and NASA have been engaged in a joint program, directed toward development of in-flight food and food preparation and eating techniques for approximately six years. The MOL Program termination requires that NASA review the activity in in-flight food development which was sponsored at this time by the U.S. Air Force.

NASA has expressed willingness to assume contractual and technical management responsibilities of the MOL contract with Whirlpool Corporation, for one year, beginning July 31, 1969, (Option A). Any time during this year NASA may extend the contract beyond July 31, 1970, (Option B); and, at any further time, NASA may elect to contract for production (Option C).

Agreements were reached for the implementation of contractual transfer to NASA/MSC by July 31, 1969.

Rationale for Proposed Action: The Food and Feeding System is a joint effort with NASA, and the system is presently being used on Apollo.

Proposed Action: The Group concurs with the action to transfer the Whirlpool contract to NASA by July 31, 1969.

2. MOL Suit Development

Situation: Immediately following the announcement of cancellation of the MOL program, NASA requested that the Air Force continue the Hamilton-Standard contract on suit development through July 31, 1969, on a minimum expenditure basis. This action was taken to permit the contractor to incorporate a number of mandatory changes into suits nearing completion. Although the Air Force contract will not, by July 31, 1969, result in delivery of flight-qualified suits, approximately 13 training suits and a number of development suits and components will have been delivered.

Rationale for Proposed Action: NASA, because of unique requirements imposed by lunar-surface extra-vehicular activity, and other Apollo and Apollo Applications considerations, has a vigorous suit-development program underway at MSC. The MOL suit had unique mobility and self-donning features, however, which may be very useful for AAP. The Air Force depended heavily upon the MOL suit development for the advancement of suit technology, and in-house R&D had been reduced under pressure of a squeeze on resources. Cancellation of the MOL undercut the in-Air Force program. Although the Air Force closely cooperates with NASA in the area of suit development, it still will require the re-establishment of a vigorous in-house suit development program in order that it can support its high-altitude aircraft programs as well as maintaining a competence in space-suit technology. At least, as an interim measure, the Air Force should transfer MOL suits and suit personnel to NASA in order that the technology and experience levels will be maintained while the Air Force is re-establishing its in-laboratory program.

Proposed Action: The Air Force should re-establish its exploratory development program for space-suit technology. Initially, MOL training and development suits should be transferred to NASA, and NASA should continue development of the MOL suit. Air Force personnel to support this work should be detailed to NASA until an in-house program can be re-established to maintain capabilities for the future in this area.

3. Waste Management Subsystem

Situation: The Fairchild-Hiller Corporation has been under contract for major elements of the MOL Waste Management System. In mid-February, 1969, NASA, through the McDonnell Douglas Corporation, contracted with the same corporation for the adaptation of certain MOL system components and technology to satisfy the requirements of the Apollo Applications Program. The waste management subsystem is part of the Environmental Life Support System and the contract was terminated.

Rationale for Proposed Action: This system development is uniquely applicable to the NASA waste management system because of the inter-relationship of the Air Force and NASA efforts.

Proposed Action: The group concurs that all of the tooling and development and test components produced under the MOL contract should be transferred to NASA.

4. Two-Gas Controller

Situation: The basic method of controlling the atmospheric gas in NASA's Apollo Application Program (AAP) is very similar to that planned for MOL. Both systems sense total pressure and partial pressure of oxygen. The two systems vary in the hardware implementation of the control valving; MOL uses an electronic controller whereas AAP uses the flight proven Apollo cabin pressure regulator in conjunction with a solenoid valve. The contract for the two-gas controller was terminated.

Rationale for Proposed Action: Because of the similarity and the proven flight experience of most of the AAP components, there does not appear to be an advantage to consider the MOL two-gas controller hardware as a system for AAP. However, the MOL partial pressure sensors will aid in the testing and verification of the AAP system.

Proposed Action: The MOL partial pressure sensors should be transferred to NASA. The remaining components should be placed on inventory for disposition.

5. Laboratory Module Simulator

Situation: As a portion of their overall responsibility, McDonnell Douglas-Western Division has been under contract to develop a laboratory module simulator. Major elements of the simulator include a functioning representation of the laboratory module itself, extensive stimulus generating and recording peripheral equipment, and operating consoles. Although the system was directly applicable to the MOL program, much of the logic behind its development, and many of its subsystems and components, are applicable to a range of manned space systems. At the time of cancellation the simulator basic hardware was checked out and operational. Real-time support-system software was coded and checked out.

Rationale for Proposed Action: The most effective utilization of the government investment in the simulator will be realized if it can be adapted to another manned space-flight program. If it is not economically feasible to employ it in this application, disposition of individual components can be made separately, but the net return from the investment to date will be significantly reduced.

Proposed Action: The contractor should be requested to consider, with appropriate personnel within NASA, the possible use of the simulator in the NASA Manned Space Flight Program. This should be determined prior to September 1, 1969, to allow timely disposition of the associated computers if a requirement is not established.

<u>Rationale for Proposed Action</u>: CITE and ACE-S/C equipment was designed and produced by General Electric. The ACE design preceded the CITE design by a number of years; therefore, CITE represents a second generation of automatic check-out equipment and may have a direct undating application to the ACE equipment now in use and/or other NASA programs. Also, CITE, with its computers, may be desirable for use with Air Force programs within SAMSO.

<u>Proposed Action</u>: The group recommends that the NASA work with the Air Force termination officer to identify those specific items of hardware which can be used in the NASA program; and when the equipment is adequately dentified, these items should be transferred to the NASA if there are no Air Force requirements. Also, the group recommends that a study be conducted by SAMSO to determine possible uses of CITE as a system. The computers associated with CITE should not be dispositioned until the SAMSO study is completed by September 1, 1969.

6. Computer Integrated Test Equipment (CITE)

Situation: CITE basically consists of the following categories of items:

a. Computer System - SDS 9300 Computers, Associated Peripheral Equipment and Input/Output Devices

b. Command Link

c. Downlink Automatic Ground Equipment

d. PCM Acquisition System

e. Timing System

f. Display System

g. MOL/Ground Interface Equipment

A preliminary review by NASA has indicated that there are considerable benefits to be gained if certain technology, documentation, and hardware associated with CITE could be made available. The CITE Ground Test and Checkout Equipment could be of benefit in furthering the Manned Spacecraft Center (MSC) ground checkout and test goals of automating and reducing the number of test consoles and test personnel required for checkout operations.

It is possible that CITE modules and/or components have direct commonality features with the NASA Automatic Checkout Equipment-Spacecraft (ACE-S/C) systems, so that existing components could be utilized to support operational ACE Station. As soon as the Air Force can provide termination inventories and permit direct contact with the manufacturer, the value of the existing inventory to the NASA program can be more clearly defined.

7. Data Processing Equipment

Situation: The MOL surplus data processing equipment consists of a total of 17 computers as follows:

4 - SDS 9300	located at MDAC at Huntington Beach for use in the All Systems Test Equipment Group (ASTEG).
2 - SDS 9300	located at General Electric, Valley Forge, for use with Computerized Integrated Test Equipment (CITE).
1 - SDS 9300	located at General Electric, Daytona Beach, for use with CITE.
1 - SDS 930/2200	located at General Electric, Valley Forge, for use with the Mission Simulator.
1 - IBM 360/44	located at General Electric, Valley Forge, for use with the Mission Simulator.
1 - IBM 360/65	located at MDAC, Huntington Beach, for use with the Laboratory Module Simulator.
2 - Honeywell 24 1 -Honeywell 324	located at MDAC, St. Louis, for use with the Gemini B simulator.
4 - SDS Sigma 7	located at Martin Company, Denver, used with Computerized Aerospace Ground Equipment.

This equipment has not been listed on the inventory schedule. Meanwhile, a review is being conducted throughout SAMSO and the Air Force Laboratories to determine where it can best be used. Preliminary review indicates possible uses as follows:

a. IBM 360/30:

(1) By 949 SPO for Command and Control support.

b. IBM 360/65:

(1) By 949 SPO for software development.
(2) By Air Training Command for 949 training.
(3) By Aerospace as Government Furnished Equipment in lieu of presently leased IBM 360/65.

c. SDS 9300:

(1) By 949 SPO as driver for user display.
(2) By Aerospace as Government Furnished Equipment in lieu of presently leased SDS 930.

d. SDS Sigma 7:

(1) By Titan III SPO for continued support of Titan program.
(2) By 949 SPO to drive user displays.
(3) At MIT in support of advanced technology contracts.

e. IBM 360/44:

(1) By the 949 SPO in the switching center.

f. IBM 360 Model:

(1) By Air Force Avionics Laboratory in the Reconnaissance Central Facility in lieu of presently leased equipment.

Rationale for Proposed Action: The critical need for computers throughout the Air Force dictates that assignments of a computer must be based on usability, need, and capability criteria. The computers are associated with the automated checkout systems and simulators being considered as total systems elsewhere in this report. Total Air Force requirements, however, must be considered and the computers, as indicated in the discussion on disposition priorities, will be reported in accordance with Armed Services

Procurement Regulations (ASPR). Because the computers were procured on Air Force contract, the Air Force retains priority over other agencies for disposition purposes.

Proposed Action: The Group concurs that the computers should be listed on inventory schedule and dispositioned in accordance with ASPR; however, disposition should be held in abeyance pending completion of SAMSO review and review of needs for CAGE, CITE, and the simulators reported upon elsewhere in this report. Disposition of the computers should be initiated after September 1, 1969, if no use for the systems are determined.

8. Gemini Aerospace Ground Equipment (AGE)

Situation: With the inception of the Gemini B-MOL Program, an official agreement between NASA and the DoD on the "Procedure for Transfer of NASA Gemini equipment to the USAF for utilization on the Manned Orbiting Laboratory Program," was consummated July 15, 1966. The NASA, with its more limited need, was to obtain articles of AGE hardware on a loan basis and then return them to the Air Force for their ultimate use. The agreement also provided for return of the AGE to NASA when the MOL requirement had been satisfied. The development of the Airlock module for the NASA Apollo Applications Program used Gemini experience and hardware to the greatest extent practicable. Aerospace Ground Equipment (AGE) required for the Airlock was drawn from existing Gemini AGE inventory and represents about 80% of the hardware required for the Airlock module. Late in 1968, it became evident that sufficient quantities of certain items were not available to support manufacturing and forecast launch schedules of both programs. Subsequently, NASA and the Air Force had been working together to reduce the quantity of additional AGE articles needed to support both programs.

Rationale for Proposed Action: The NASA Airlock program has a continuing direct application for this equipment. Furthermore, the Air Force/NASA agreement provides for the return of the equipment to NASA.

Proposed Action: The Group concurs that the Gemini AGE equipment should be returned to NASA.

9. Fuel Cells

Situation: Allis Chalmers was developing a 2 kilowatt radiatively cooled fuel cell for the MOL and possibly for the Apollo Applications Program (AAP). The MOL Program was funding the engineering development of the fuel cell and NASA was funding the qualification testing. One fuel cell has been completed and most of the components exist for two more fuel cells. NASA requirement for fuel cells on AAP has been recently cancelled.

Rationale for Proposed Action: A proposed FY 70 Advanced Development Program for fuel-cell development was disapproved by AFSC because of budgetary considerations. Air Force Aero Propulsion Laboratory (AFAPL) FY 70 efforts in Exploratory Development are still programmed to proceed as planned because there are applications for fuel cells for unmanned satellites, hard-rock silos and remote-standby power. These efforts consist of component developments for high performance, high power density, and regenerative fuels. AFAPL is also working with other Air Force agencies on the possible deployment of a 400 watt fuel cell in another program.

Proposed Action: The Group concurs in the AFAPL request that the completed units and components be shipped to them for further study, test, and evaluation.

10. Attitude Control Engine

Situation: MOL attitude control engines of 22 and 100-lb. thrust were being adapted from NASA engines. Some thrusters are available as a result of the MOL termination. One 22-lb. thruster has already been shipped to the Air Force Rocket Propulsion Laboratory (AFRPL) as part of their request for four engines (2-22 lb. thrust and 2-100 lb. thrust).

The NASA Lewis Research Center will design, build, and test two complete flightweight space propulsion (research) modules. One module will use Hydrogen-Florine as primary propellants; the other, flox-methane. They hope to delineate all real spacecraft problems including interactions such as mutual freezing between primary and secondary propellants, or the effects of plume heating from the secondary propulsion. For secondary propulsion, current analyses indicate earth storable by propellant engines to be the most likely choice.

Rationale for Proposed Action: The engines and components are no longer required by the MOL Program, but can be used by the AFRPL to refine an in-house pulse-performance computer-simulation model of attitude control engines and to complete an in-house project to determine the effects of attitude-control engine-exhaust products on optical and radar windows. This latter program is 80% complete. The results of both these programs will be made available to NASA.

For direct use in the NASA program, they estimate the need for 8 to 12 each of the 22-lb. and 100-lb. thrust engines complete with tankage and feed systems if possible. However, four engines each would be of great assistance because additional thrusters could be purchased if these engines are selected after preliminary system interaction testing. Excess propellant valves could be used for some of the Viking simulation effort at JPL.

Proposed Action: The Group concurs with the transfer of required 22 and 100-lb. thruster and attitude control engines to AFRPL. The remaining engines and associated tankage and fuel systems should be transferred to NASA.

11. MOL Flight Computer

Situation: The IBM 4 Pi Extended Performance (EP) computer and its peripheral equipment (printers, keyboard, display unit, auxiliary memory unit and laboratory data adaptor unit) provided the integrated on-board data computation capability. The contract for the computer was terminated and inventory lists should be available in approximately 90 days.

Rationale for Proposed Action: Proposed uses for the MOL 4 Pi EP computer include the Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) and the On-board Checkout System (OCS). These systems are being developed by NASA for potential use in future space programs including the NASA dry workshop, space station, space base, lunar base, and space shuttle. The technology is also adaptable to other aerospace and aircraft programs.

The IBM 4 Pi EP computer is a vital part of the IMBLMS functional breadboard and will probably be part of the later versions. Prior to the MOL cancellation, the NASA Manned Spacecraft Center (MSC) had planned to borrow a 4 Pi computer for six months and then purchase one.

OCS is being developed to provide on-board checkout of long duration spacecraft subsystems and experiments. It will be capable of operation in automatic, semi-automatic and manual modes. The 4 Pi EP computer is utilized in the Martin Company flight packaged OCS development unit to be delivered to MSC for test and evaluation. One 4 Pi EP computer has already been purchased for this unit and another is desired to test multi-processing techniques with two computers.

Another potential use of the 4 Pi EP computer is to provide experience for the forthcoming Apollo Telescope Mount 4 Pi Tactical Computer (TC) used for attitude control in the Apollo Applications Program (AAP) dry workshop. Both computers are members of the same family and experience with one will be beneficial to use of the other.

In addition to the basic IBM 4 Pi computers and the associated software and documentation, available peripheral equipment such as the laboratory data adapter unit, keyboard, printer, display, system control panel, maintenance equipment, auxiliary memory unit, computer subsystem control are required.

The MOL 4 Pi computer is an extended performance model which may be useful and needed by Air Force space or aeronautical programs.

Proposed Action: The Group recommends that the Air Force Aeronautical Systems Division be made aware of the availability of the 4 Pi computer equipment, and the total Air Force requirement should be investigated by the Air Staff (AFRDC). The peripheral equipment should be transferred to NASA along with a 4 Pi computer if available after Air Force investigation.

12. Mass Measuring Device

Situation: The Aerospace Medical Division (AMD) of the Air Force Systems Command (AFSC) has designed and built a device for use by the MOL that will measure mass and mass changes within 1% accuracy. The device was designed to provide this capability over two ranges of masses, those from 1 gram to 1 kilogram and those from 1 kilogram to 100 kilograms. These devices represent a new invention by in-house scientists. Patent applications have been submitted.

Flight prototypes of both the small and human mass devices have been completed; laboratory tests, including zero gravity Keplerian flight tests, have been completed and have validated the design and anticipated accuracies.

Flight demonstration of the mass measuring devices has been proposed by AMD as an experiment for the NASA AAP. The experiments have been approved by NASA as M-172 Human Mass Measuring Device and M-074 Small Mass Measuring Device.

Subsequently, NASA proposed to use the AF experiment units for operational measurements over both ranges of mass during the AAP missions. As a result NASA and AMD re-negotiated the experimental protocol and plans for funding. Air Force participation in this experiment is being carried by the Air Force Exploratory Development Program in Aerospace Biotechnology. Flight hardware for these experiments is under procurement.

Rationale for Proposed Action: The availability of an accurate mass measurement system for measuring small masses and large masses permits the biologist to undertake an accurate in-flight energy and fluid balance program for the first time. Accurate tally of the amount that has been eaten and drunk by the crewmen can be established. Comparison of this data with accurate measured data of the diet makeup permits daily inflight assessment of energy intake. Measurement of the mass of urinary and solid waste output permits the establishment of the other side of fluid and energy balance only as long as fluid loss through sweating is controlled. The periodic measurement of total body mass will provide a cross-check of the accuracy of the daily intake-output assessment. Measurement of total body mass becomes essential in the flight assessment of any biomedical changes that might occur through severe sweating (i.e. suited operations, temporary loss of thermal control of the vehicle, etc.) or gastrointestinal upset (i.e. vomiting, diarrhea, etc.). It also provides essential check data for evaluating the effectiveness of any efforts at replacement of the fluids lost by the events above.

Proposed Action: The successful development and flight qualification of the mass measuring devices will provide important tools for the daily assessment of crew status during prolonged missions. The devices should be continued to completion of the experiments on AAP. The Air Force should continue the experimental and operational plans for flight of these mass measuring units as planned before MOL termination.

13. MOL-Related Experiments Assigned to AAP

Situation: Two MOL-related experiments have been under Air Force development to be flown in NASA AAP missions. The first, entitled Suit Donning and Sleep Station Evaluation (designated as D019 by NASA) was to permit evaluation of the techniques and time required for pressure-suit donning and for the evaluation of sleep restraints. The second, Alternate Restraints Evaluation, D020, was to evaluate various crew restraint devices designed for use in both operating and maintaining equipment. Testing was to include foot, leg, waist, pelvic and head restraints, MOL tools, task board and pressure suits. McDonnell Douglas-Western Division has been under contract for the development hardware has been produced. Manufacture of flight hardware has not been authorized.

Rationale for Proposed Action: Although the experiments were planned for direct support of MOL, the problems to be studied are common to all zero-g manned spacecraft. NASA has a number of complementary experimental activities underway for flight in AAP. It is appropriate, therefore, for DoD to withdraw the experiments from the NASA flight program, and to transfer the designs and development hardware produced under Air Force contract to NASA for possible incorporation into NASA experiments or flight systems.

Proposed Action: It is recommended that the DoD members of the NASA Manned Space Flight Experiment Board be instructed to withdraw the request for NASA to fly D019 and D020, and to transfer the experiment design and development hardware to NASA for their possible experimental or operational use.

14. Titan IIIM Hardware and Development Effort

Situation: The termination of the MOL Program and issuance of cancellation instructions to the Titan IIIM associate contractors seriously impacted the Titan III B, C, and D programs. Several developments under the Titan IIIM contracts were planned for and scheduled for integration into the Titan III B, C, and D production.

Contract Change Notices and RFP's have been issued to Titan III contractors to continue the essential development efforts under the appropriate Titan III B, C, and D contracts. Examples of this effort are: completion of design and fabrication of test equipment, test fixtures, and simulators for re-designed and improved subsystems, completion of Electromagnetic Interference (EMI) and qualification tests on common avionics components, completion of development of improved Stage II engine, Stage I battleship tests, continuing Titan IIIM initiated production of common items of hardware required for current and follow-on booster buys. The qualification tests of the Thrust Vector Control system will continue through three additional static firings of the Titan IIIM 7-segment SRM's. The termination of the Titan IIIM reduced the production base on the common guidance computer to the point that further purchases have become uneconomical. A competition will take place to develop and qualify a new guidance computer that will have a larger production base than just Titan III; e.g., computer used by Agena, NASA/Centaur and aircraft programs. Also, studies are underway to determine the most effective use of the residual technology and equipment such as Computerized Aerospace Ground Equipment (CAGE) for use on other Titan III programs.

Rationale for Proposed Action: Failure to complete the essential developments would result in even greater expense in terminating portions of current B, C, D program efforts, re-engineering and re-procuring to earlier configurations, and associated payload program schedule slippages. Also, payload design and weight constraints have, in many cases, been relaxed to take full advantage of expected improved launch vehicle capabilities. Additionally, the CAGE system, which incorporates Sigma 7 computers, represents an advancement in vehicle check out methods and employs a unique machine launguage and data compression technique which could be useful to the other Titan III programs. FY 70 and 71 funds are presently programmed for the updating/modernization of the Aerospace Ground Equipment (AGE) for Titan III at the Eastern Test Range. Residual Titan IIIM CAGE use is proposed.

Proposed Action: SAMSO has received authority to transfer the essential development efforts to the appropriate Titan III contracts for completion and the group supports the action. Also, the group concurs in the study efforts that are under way to consider possible application of the CAGE and residual hardware for use on other Titan III programs. However, a determination on the use of CAGE should be made by September 1, 1969, to allow timely disposition review of the computers in accordance with Armed Services Procurement Regulations should CAGE not be used as a system.

B. MOL FACILITIES

1. MOL Support Facilities

Situation: As a result of the MOL cancellation, three buildings designed as MOL support facilities at Vandenberg Air Force Base have become available for other use. The buildings are the Engineering and Operations Building (EOB), Operational Readiness Unit (ORU), and the Operational Training and Evaluation Facility (OTEF). These facilities are currently 80% complete and are usable structures which can be occupied with some outfitting of the interiors. SAMSO, based upon agreement between the 6595th ATW commander, the AFWTR commander, and the 1st Strategic Aerospace Division (SAC) commander has proposed to AFSC and Air Force that these facilities be taken over by resident organizations at Vandenberg.

Rationale for Proposed Action: This course of action has the following advantages:

a. Vandenberg AFB Headquarters is now scattered and poorly housed. The proposed move would allow the Headquarters activities to be properly consolidated under one roof in the area most appropriate to its function.

b. At the present time, AFWTR occupies a part of the 6595th ATW Headquarters building and, as a matter of fact, a large addition to this building is under construction for their use. Future plans call for construction of an additional technical building in this area for the AFWTR. Thus, the proposed move of AFWTR to the 6595th ATW Headquarters building does permit them to consolidate all of their activities in the area most appropriate to their needs.

c. Although the 6595th ATW is adequately accommodated in its present building, the new facilities will be suitable for their needs and should be done to accommodate a and b, above. Their relocation into the MOL facilities should also provide for a better interface with contractors and AFCMD.

Proposed Action: The Group concurs with the proposed re-allocation of these buildings as planned to the resident organizations at Vandenberg AFB.

2. Space Launch Complex No. 6 (SLC-6) Facilities

Situation: The SLC-6 includes the launch pad with Mobile Service and Umbilical towers; fuel and oxidizer facilities; AGE, Complex Support and Ready buildings; Launch Control Center; Solid Rocket Motor Inspection and Storage buildings; and small support buildings and utilities.

On the date of the MOL Program cancellation, the SLC-6 was approximately 92% complete. The remaining 8% of effort included primarily the requirement for the construction contractor to conduct acceptance and demonstration tests prior to Air Force acceptance at the beneficial occupancy data. The decision was made to complete the construction, demonstration testing and Air Force acceptance. The following phases such as AGE installation were cancelled. The facility will be maintained in a "down mode" caretaker status. The down mode status involves the minimum operation and maintenance of critical items that cannot be feasibly removed and stored. The detailed down mode maintenance plan is being prepared by the 6595th Aerospace Test Wing. The implementation of the plan is to be accomplished by a caretaker crew consisting of approximately four people from the 6595th ATW and supported by the 4392nd Civil Engineering Squadron (SAC).

Rationale for Proposed Action: It is the opinion of the group that the above plans will provide maximum protection of the Air Force investment and allow potential future use at a minimum cost and effort.

Proposed Actions: The Group concurs with the assignment of SLC-6 to SAMSO for possible use with current and/or future Titan III programs.

3. Air Force Satellite Control Facility

Situation: The termination of the MOL Program eliminated the requirement for the Advanced Data System and the MOL portion of the Advanced Satellite Test Center (ASTC). The ASTC is complete and the integral power plant is to be completed in September 1969. The current status is as follows:

a. Advanced Data System was terminated except for the Remote Tracking Site Tasks and delivery of Control and Display equipment which was 90% complete (Lockheed).

b. MOL software integration and computer program development was terminated (SDC).

c. MOL software development for Remote Tracking Sites was terminated (Mellonics).

d. Software modeling contract was terminated; the 360-67 Triplex computer and 360-67 Duplex computer leases were cancelled (IBM).

e. The CDC 6600 computer lease was cancelled and the associated operating system development was terminated (CDC).

Rationale for Proposed Action: The move of the existing satellite programs from the STC to the ASTC will allow cancellation of the approved support facility addition to STC. Consolidation of the software development test facilities now at Santa Monica and Santa Clara in the ASTC will provide for efficient and economical software support and facilitate the move of the satellite programs to the ASTC.

Proposed Action: The Group concurs with the actions that have been taken and the proposed move into the ASTC.

4. Recovery Staging Base

Situation: The MOL Program has negotiated for the use of the 6200 foot airfield at Easter Island as an recovery aircraft staging base in the event of a launch abort. The potential use of this airfield by the Air Force Western Test Range and/or NASA was considered. The airfield construction is completed.

Rationale for Proposed Action: NASA has indicated no requirement for recovery forces in this location and the airfield is not adequate for the Range instrumented C-135 aircraft use.

Proposed Action: No future action required.

C. RELATED TECHNOLOGY

1. Technological Achievements Suitable for Publication

Situation: Although no new technology was developed, important adaptations or unique techniques to existing technology evolved in several areas during the course of the MOL development program. Because of the particular technology or capability, the following list of items are presented for consideration as subjects for special papers to be published in order to provide wide distribution to the scientific and engineering communities. The production of these papers may require costs for preparation and, in some cases, only the compilation of test data. Each item should be reviewed and treated separately on its own merit and on its related application.

a. Cylindrical Structures

The MOL decision to use a waffle rather than a smooth cylindrical structure on a space vehicle should be of interest to the engineering/scientific community. It is believed that a 25% weight savings was realized when considering the strength-to-weight relationship. The Technique to achieve optimum design is unique, particularly in areas of combined multi-dimensional skin (MDAC-WD)

b. Bearing Technology

Unique application of bearing technology allowed reduction in ripple (noise) in slow moving ball bearings. (GE)

c. Torquer Technology

Reduction in noise (ripple, cogging, brush noise) in slow moving torquers. (GE)

d. Majority Vote Redundancy

A new method for continuous failure mode monitoring of three redundant electromechanical channels with automatic and instaneous selection of the most probable channel. The theory and hardware being tested have potential use on high reliability (man-rated) systems, either aircraft or space vehicles. (MMC)

e. Computerized Aerospace Ground Equipement (CAGE)

CAGE is automated control and checkout system which monitors, analyzes, displays, controls, and records data from any test article in real time. The CAGE system utilizes unique machine language and data compression techniques. The fully developed CAGE hardware has potential use in the pre-launch and in-flight portions of space programs, flight line verification of aircraft systems, and large environmental test programs. (MMC)

f. MOL Pressure Suit Assembly (PSA)

This pressure suit is unique in providing the best performance mobility available in US Aerospace technology today. (AMD)

g. Crew Conditioning Unit (CCU)

The CCU is a unique exercise device which the space crewman uses to quantitatively exercise selected body/muscle systems and to stablize cardiovascular deconditioning resulting from prolonged exposure to weightlessness. (AMD)

h. Manned Space Radiation Dosimetry

The Charged Particle Spectrometer (CPS) and the Active Biological Dosimeter (ABD) are a pair of unique instruments which provide a means of measuring space radiation and relating it to the dose received by the crewman in the spacecraft. The CPS can also provide data useful in the prediction of the solar events as they relate to mission programming. (AMD)

i. Mass Measurement Unit (MMU)

The MMU is a unique device developed to accurately measure the weight/mass of a man in the weightless state in order to evaluate his water balance relative to the effects of the flight environment and the quality of life support. A report on the MMU prototype has been published by AMD School of Aerospace Medicine. (AMD)

j. Monitor and Alarm Subsystem (MAS)

The MAS monitors those functions which have been determined critical either to the safety of the crew or to the completion of the mission. It provides an oral and visual alarm (warning or caution) output in event of an out of tolerance condition. The MAS accepts data inputs, and provides output which activates visual and oral alarm, caution and warning pronunciators, and automatic master circuits. (MDAC-WD)

Rationale for Proposed Action: The techniques involved in each of the preceeding areas should be carefully screened by the applicable Air Force laboratory to insure its usefulness and desirability to the scientific and engineering community.

Proposed Action: The Group recommends that the MOL Program Office in conjunction with the Director of Laboratories should take appropriate action to have the papers published.

2. MOL Crew Whole-Body Exerciser

Situation: The Aerospace Medical Division (AMD) of AFSC has designed in-house a crew exercising apparatus to be used by the MOL crew during flight. Proper use of the apparatus was expected to counter the physiological deconditioning of the men due to weightlessness during the mission. The design of the apparatus permits the flexible scheduling of sufficient daily physical exercise during flight in a manner that the men are maintained within acceptable medical and physiological bounds. This apparatus represents a new invention by in-house scientists.

The design of the MOL vehicle flight prototype of the apparatus was nearing completion at the contractor at termination of the program. Laboratory prototypes of the flight model were complete. Similar units used for collecting ground data during bed rest (weightless analogue) studies have been constructed and are under test at AMD. These units were to be used in the training of the crewmen.

The MOL Program and AMD proposed an experiment for testing the exerciser on the NASA AAP. The objectives of the experiment would test the adequacy of the engineering design, verify the crew interfaces with the apparatus, and provide a cross-check of the flight results with that seen during the ground studies. The NASA Aeromedical Scientific Advisory Group requested the MOL and AMD to undertake a more comprehensive study than the initial experimental prototype because the use of the exerciser, if shown to be adequate, offered great promise for the maintenance of crew conditioning during prolonged weightless flight. If the concept of whole-body exercise is demonstrated, NASA then could consider the approach for long termed conditioning of crewmen. They recommended, as a first step, the undertaking of scientific ground study to verify the Whole-Body Exercise concept as well as the demonstration that the exercise unit is capable of providing the exercise levels desired. The NASA committee's recommendations were accepted by MOL and AMD and the ground studies were underway in the USAF School of Aerospace Medicine at MOL termination.

Rationale for Proposed Action: Analysis of the physiological changes observed in space crews to date indicate that an adequate exercise program may provide the best single and the most versatile approach for maintaining crew conditioning to within adequate limits during prolonged weightless flight. Demonstration of the validity of this approach through both ground studies and flight offers to future programs an alternate to the provision of artificial gravity now expected to be needed for crews during long missions.

Proposed Action: This approach to crew conditioning and the associated hardware development are of such potential importance to future long termed manned space-flight that the following actions should be required:

a. Because this approach is an "in-house Air Force invention" and the NASA operations has expressed a degree of reservation on its use until proven, the Air Force should continue the laboratory studies to a point of confirming the adequacy of both the concept and the equipment.

b. After demonstration of the concept, the Air Force should undertake negotiations with NASA to either confirm the concept and equipment as an experiment or, as in the case of the mass measuring units, develop a joint program for flight testing and operational use of the concept and equipment.

c. To achieve a and b above, the program for "whole-body exercise" be incorporated into the Air Force Exploratory Development Program as soon as possible.

3. Expandable Structures

Situation: Expandable Airlock (D021) and Expandable Reentry Structure (D022) Experiments were approved in 1967 for testing on the NASA Saturn IVB Orbital Workshop under the assumption that expandable structures might find application on manned spacecraft which were follow-on to MOL. An Advanced Development Program on Expandable Structures was programmed for $1.5M in FY 70. Major emphasis was to be given to manned spacecraft applications.

FY 70 Exploratory Development Funds for the experiment are withheld. No FY 70 funds are apportioned for the Advanced Development Program.

Rationale for Proposed Action: With the termination of the MOL Program and the re-orientation of the NASA Orbital Workshop, no FY 70 Exploratory Development Funds should be expended until NASA's programs become firmer. The proposed Advanced Development Program was also tied in part to manned spaceflight applications. AFSC recommended, that no FY 70 funds be apportioned because of budget restrictions and relative priorities. The termination of MOL served only to reinforce this position.

Proposed Action: The Group concurs with the plan to withhold funds for D021 experiment until NASA's plans are firmer. Since the hardware is complete, the Director of Laboratories should explore with NASA the future of this experiment. The D022 experiment should be cancelled.

V. PLANNING CONSIDERATIONS

A. AEROSPACE BIOTECHNOLOGY

1. Background

The cancellation of the MOL Program eliminated the only DoD manned spaceflight program. The question arises as a result of this action as to whether the Air Force should continue or discontinue the development of space-related biotechnology for man and man-support systems.

Appendix F summarizes the AMD analysis of the impact of MOL cancellation on the program element "Aerospace Biotechnology." The major part of the RDT&E program carried out under this program element is done in the laboratories of the Aerospace Medical Division (AMD) of the Air Force Systems Command. The space-related efforts are an integral part of a program to develop the requirements for man to live and work in the wide spectrum of aerospace environments and to develop the necessary equipments and procedures to provide these requirements. This R&D program recognizes that man may need to operate a variety of vehicles in several types of hostile environments. In this regard, manned space operations is considered as a natural extension beyond conventional aeronautical operations. It is recognized that specific tailoring of the data and systems selection is necessary for each program to insure that the best solution for that military system is achieved.

Only a small number of specific MOL tasks were underway within the AMD laboratories. Most of the other space-related work was being carried within this program element and was of a more general nature. In most cases it is considered the next logical step in an evolving technology base. Thus the data were equally applicable to MOL or NASA programs.

Specific actions taken on this program element since MOL cancellation include: Deferral of 8.0 million out of a total of 21.0 million requested for this program element for FY 70; reduction of the total funds for this program element from 21.0 million to 19.0 million, the 2.0 million reduction was taken from the deferral area and results in only a 6.0 million deferral remaining; AFSC is carrying on discussions with NASA to redefine their areas of data need in light of the MOL cancellation, the identification of the areas of unique Air Force resources to provide these needs, and the re-evaluation of NASA's fiscal participation in these efforts.

That portion of the proposed FY 70 budget related to the development of technology applicable only to spaceflight was 1.47 million. The remainder of the requested 21.0 million for this program element was proposed for work to support man in all operational Air Force environments, included such areas as aircraft, missile launch control centers, spaceflight as well as research and development in military medicine.

The cancellation of the MOL Program, as announced, was based upon the current fiscal considerations and the fact that most of the current military space needs can be achieved by unmanned satellites. The discussion surrounding the cancellation noted that the DoD maintained an interest in manned space-flight and would continue to assess each new program on its own merit as to whether man had a role. It was recognized that in the interim the DoD must rely heavily upon NASA to collect data on the flight aspects of manned spaceflight.

2. NASA Cooperation on MOL

During the early phases of the MOL, the NASA and Air Force bioastronautics teams made every effort to gain maximum benefit from the NASA experience. However, the direct translation of NASA experience to the specifics of MOL operations proved quite difficult. In the basic sciences and life systems criteria areas, it was found that NASA data, although fully provided by NASA, did not permit direct program interpretation. The most valuable source of data for the military application was gained from the Air Force Laboratory scientists who had performed related studies in areas of mutual Air Force/NASA interests. These scientists were able to provide the detailed laboratory data and interpret their significance to the military circumstances proposed for MOL. Fortunately, most of the critical crew-related design areas had been under active study within the laboratories either for aircraft or combinations of aircraft and spacecraft applications. In many of the most critical areas, joint NASA/Air Force programs were underway. This arrangement had also been of benefit to NASA because the Air Force Laboratories contained unique facilities for making the complex environmental studies, and of more importance, had the multiple scientific and engineering disciplines needed to carry out the long-term studies for currently operating programs. Such a combination of facilities and associated staff to operate them is unavailable elsewhere. Key scientists from these laboratories were appointed as consultants and advisors to the MOL Program. The resulting familiarity with the MOL Program problems permitted them to evaluate and redesign their own laboratory efforts, thus both MOL and laboratories benefited from this working relationship.

A similar situation was found when the translation of medical operational aspects of NASA experience to the MOL Program were addressed. As a result a request was made by MOL, and accepted by NASA, to permit MOL bioastronautics personnel to work directly with the NASA operations during Gemini and Apollo flights. This proved to be highly satisfactory to both programs and the most adequate way of insuring meaningful exchange and training. Experience gained during NASA flights by the MOL personnel could then be interpreted and applied to the MOL specific problems.

3. Future Needs

The AMD Laboratories operate primarily as in-house laboratories. Thus, the major part of the funds represented in the "Aerospace Biotechnology" program element are used in direct support of this capability. A large portion of the remaining so-called contractual funds also are used to either augment the technical base of the in-house laboratory or to upgrade the capacity of the facilities. Marked reduction of funding or the establishment of a policy prohibiting these facilities to continue efforts covering the total scope of biotechnology, supporting the entire range of Air Force missions will stunt the capability of this set of facilities and its staff to maintain their pre-eminence in the field of biotechnology.

Since military pilots are urged to fly higher and faster, and modern military aircraft operate at the threshold of exo-atmospheric flight, it is prudent that the Air Force maintain its competence across the entire spectrum of biotechnology. If the Space Transportation System proceeds in the next few years, the special categorization of spaceflight versus airflight will cease to exist.

In accepting this point, the space-related biotechnology areas being carried under the "Aerospace Biotechnology" program element should be continued as active and vital efforts, and the Air Force should continue assigning selected bioastronautics personnel for tours with the NASA Manned Spaceflight in order that actual operational experience will be gained.

4. Experiment on Value of Man in Space

The plans to assess the value of man in the performance of military tasks, as planned for in the MOL 30-day missions, was terminated with the cancellation of the program. MOL's experimental activities and operations plan provided a unique opportunity to perform a controlled, statistically significant evaluation of man's role and contribution to a demanding series of mission-like tasks.

Analysis of the MOL experimental tasks developed the following unique factors: the crew would be tested to near maximum rates of performance in both the sensory and motor functions of man; the daily workload demanded sustaining this high-level integrated performance for sufficiently long periods to permit assessment of man's daily capacity to operate; the weekly repetitive orbital tracks and repetitiveness of the experimental tasks offered sequential weekly assessment of man's continued capacity to perform over the four-week mission.

The MOL crew assessment also had the major advantage in that it tested man as he performed realistic military operational type tasks rather than while he was performing synthetic laboratory tests. Thus, crew motivation and the desire to do a good job could be expected to be under control throughout the 30-day mission.

NASA has no equivalent experiment as planned for MOL. NASA, to do an experiment equivalent to the MOL effort, would have to create a similar dedicated approach containing a daily and repetitive weekly task load that would demand activities up to the near maximum capacity of man, and propose to fly the experiment over similar flight durations.

The arguments related to what the role of man in spaceflight should be have continued since before the first manned space program, Project Mercury. The data needed to scientifically and technically answer these reasonable questions have not been gained during the first decade of manned flight. Thus, each decision in spaceflight planning has used subjective or, at least, qualitative judgments to keep man in the system or exclude him. Performance of a man-value experiment would permit these judgments to be based finally upon scientific data and provide a base upon which man's role and capacities in future programs can be planned.

Therefore, the DoD and NASA should undertake the formal development of an experimental program to develop the data needed for addressing man's role and value in spaceflight. The experimental design must consider not only direct measurement of man's capabilities to perform tasks, but also provide a comparison of results of man alone, the machine alone and combinations of man-machine. The experimental design and plan for management must be made in a manner that will be suitable for submission to the NASA Manned Space Flight Experiments Board.

B. MILITARY SPACE PLANNING

The primary Air Force project-level planning activity for space and space related systems has been the Director of Development Plans (SMA), Space and Missile Systems Organization (SAMSO), AFSC. Within SAMSO the planning functions have been oriented toward unmanned high-altitude operations planning. For example the MOL Program Office accomplished all planning for the basic MOL, all growth applications for the MOL system and advanced missions in near earth orbit. In support of MOL a portion of the SAMSO advanced planning effort has been concentrated on synchronous-altitude space-station studies and space rescue/escape systems.

With the cancellation of MOL, a void in technical system oriented planning for manned and unmanned low-altitude space flight has been created.

With the phase-out of the MOL Program Office, SAMSO should be given the responsibility to examine on a continuing basis military space systems in near earth orbit and compare the utility of manned and unmanned systems for similar functions.

The Group supports the plan to expand the SAMSO function to include near earth-manned and unmanned mission planning as well as the current high-altitude unmanned efforts.

Associated with the augmentation of AFSC/SAMSO planning efforts toward manned military space flight, all echelons will continue emphasizing the establishment of long-range objectives, formulation of policies, guidance and procedures to exploit promising technology and to orient advanced development toward desired operational capabilities.

The Space Studies line item should be closely monitored and expanded if necessary to conduct analytical investigations, studies, and analyses leading to the derivation of operational requirements, development plans, and documentation to provide a sound basis for Air Force space technology and development activities.

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REVIEW OF CLASSIFIED MOL RESIDUALS

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CLASSIFIED MOL RESIDUALS

A. INTRODUCTION

Certain of the MOL residuals, which tend to be highly classified because of their direct interface with the primary mission, have potential application in other programs. Some such programs are in the reconnaissance/intelligence community while others are unclassified.

The purpose of this annex of the Review of MOL Residuals is to identify those items of equipment, discuss their possible applications and make recommendations where appropriate.

In the majority of instances, information relating to a specific application of this equipment is not adequate to support a meaningful recommendation as to disposition. In such cases, a delay in determining disposition, sufficient to permit a thorough analysis of the application, has been suggested. There are, however, within the activities concerned, sufficient technical management personnel with suitable clearance status to make the determinations recommended by the Ad Hoc Group. To this end, members of the Group have tasked their respective organizations to undertake the necessary studies. Responses with specific recommendations for disposition of the equipment have been requested by September 1, 1969. Implicit in this effort is the necessity that the funds required to utilize the equipment be understood and identified as part of the application recommendation.

The primary optics assembly of the MOL was excluded from consideration by the Ad Hoc Group on MOL Residuals.

Classified subsystems that have been considered for possible disposition are treated on an individual basis. Part of this consideration, of necessity, recognized that maximum utility of a piece of classified equipment might be realized only if the equipment could be used on an unclassified basis. While agreeing in principle, the Group recommends that the post MOL utility of a classified subsystem be determined within the appropriate security system. Then, if the application so warrants, a downgrading of the classification may be considered on a case by case basis.

Characteristic of each suggested application of the classified equipment has been that it envisioned the equipment essentially intact. Also, the need for time to conduct a fairly detailed study of the suggested application was common. In any event, it would appear reasonable to maintain this equipment in bonded storage until each proposed application could be thoroughly examined. Final disposition could then be made by the Secretary of the Air Force. The security classification of the equipment would be addressed at that time.

B. MIRROR POINTING AND TRACKING TECHNOLOGY

Technology developed in connection with the DORIAN pointing and tracking system, as described in Appendix C, while not fundamentally new, represents a significant engineering refinement which may be of value to other programs. Specifically, engineering data and development test hardware where available on the following should be made available for further study:

1. Torquers
2. Bearings
3. Shaft encoders
4. Computer derived drive signals
5. Mission data adapter unit

This technology has potential applicability to any highly precise, low noise pointing and tracking system.

C. IMAGE VELOCITY SENSOR

The Image Velocity Sensors in the DORIAN optical assembly as discussed in Appendix D were developed to provide an automatic rate killing input to the tracking system. At termination, developments by two manufacturers were judged equally capable of meeting the specified rate limit. This development, while representing a relatively modest portion of the program cost, proved to be one of the most trying technical undertakings in the entire effort. The technology developed has extensive application in bombing/navigation systems, missile homing system, aircraft reconnaissance systems and numerous other activities requiring precise identification/recognition characteristics.

Tracking systems for ground based optical or high powered laser tracking systems are particularly in need of such a device. Coupled with active vibration isolation systems, image velocity sensor systems could improve long-range, aircraft-based, oblique photography resolution by a factor of two to four.

Even if all other technical problems can be solved, practical laser weapons systems will require these velocity sensing, and pointing and tracking technologies. Appropriate steps should be taken to apprise a few selected individuals at the Air Force Weapons Laboratory of these technologies.

The image velocity sensors and test equipment technology should be considered by the Air Force Avionics Laboratory (AFAL) for possible manned aircraft applications. In particular the AFAL Dynamic Analysis Facility has an urgent need for test equipment to evaluate existing image velocity sensors which are now used in special access intelligence collection systems.

It is recommended that these Air Force Laboratories study the equipment technology. The hardware is not available for transfer.

D. BIMAT ON-BOARD FILM PROCESSOR

One of the current national reconnaissance and surveillance problems concerns near real time access, display and reaction. The Bimat on-board film processor as described in Appendix E might be an extremely useful piece of equipment on certain large aircraft. The processor might be transferred to AFAL for test and evaluation. AFAL investigation and recommendations in this regard are solicited.

E. VISUAL DISPLAY PROJECTOR

The Visual Display Projector system as described in Appendix F might be modified to augment current reconnaissance and intelligence data management devices for both airborne and ground based systems and could complement the Automatic Data Handling System. It also has potential application in NASA manned spaceflight programs for crew information storage and retrieval, flight plan display, maintenance procedure display and recreation. Proposals for its application should be solicited.

F. OPTICAL INSTRUMENTATION AND MOL EQUIPMENT

In many instances, equipment in this category developed for MOL has direct application to other optical reconnaissance systems and should be so employed. However, much of this instrumentation and equipment can also be used on the AFAL Dynamic Analysis Facility or in the AFAL Optical Science Laboratory in conjunction with their 100 inch collimator.

G. ACQUISITION AND TRACKING SCOPE AND MISSION SIMULATOR

A number of suggestions for useful application of the Acquisition and Tracking Scope (ATS) described in Appendix G, the Mission Development Simulator described in Appendix H and related equipment, software and documentation have resulted from the Group's review. The deliberations have included NASA use of the ATS as an experiment designed to measure the manned contribution to a pointing and tracking capability. Such an experiment, which could be part of the Earth Resources Program, would also anticipate use of the simulator for training and experiment development. There have also been suggestions that this equipment be considered for its applicability to aircraft reconnaissance photography and related training.

The simulator consists of a control console similar to the flight unit located in the MOL experiment module, a tracking telescope with the associated slide projector to simulate scenes as seen from space, a cue display on the console, together with the associated monitoring equipments, computers and software. One simulator was essentially completed at the GE Valley Forge facility.

The Air Force is vitally interested in the study of the man-machine interface but, at present, specific programs which can effectively and economically use the ATS or simulator have not been identified. Neither has NASA any missions where this unique man-machine interface has a direct application.

The astronomy missions in Apollo Applications Program (AAP) have a somewhat similar man-machine interface, with similar precision required for alignment, focusing, pointing, and operating, but without the continuing rapid sequences and judgment requirements that are associated with multiple moving targets passing under the spacecraft. The Earth Resources observation experiments envisaged for AAP, and later manned missions, may require equipments similar to the ATS, but the precision required is thought to be far less rigorous.

Although there appears to be no obvious direct application of the ATS in the NASA AAP, a good conceptual understanding of the ATS and the simulator would provide insight in identifying and articulating the role man can or should play in spaceflight.

There are several subsystems or elements of the ATS and the simulator that merit more detailed review by NASA and AFAL personnel.

1. The slide projector that simulated the ground scene as viewed through the ATS optics may have application in NASA simulators or in intelligence system training devices.

2. The cue display and the associated 16 mm film strip system may have application in AAP for simulations, conducting experiments, flight operations, or in-flight recreation. It may also have application in intelligence system data management.

3. The technology acquired in defining and developing the interface between man and optical system (ATS) would appear to be of value to any APP project or experiment involving man and optical devices.

A visit by suitably cleared NASA and AFAL personnel to the GE facility to obtain thorough briefings on the ATS, and the ATS simulator, will establish what interest there is in continuing any of the ATS related developments in technology, hardware, software or facilities.

Possible Air Force (AFAL) interest in some components of these items has been indicated earlier in this annex.

H. ARMS CONTROL OPTION

The up-coming arms control negotiations with the USSR may produce a situation wherein the U.S. would want to elect whether or not to exercise an inspection option. Such an inspection option might be comprised of the ATS with suitable recording equipment flown in an available manned space vehicle. Exercise of the option would entail over-flying the USSR to observe, perhaps openly, arms control or disarmament violations.

Should an open skies, above, say 50 miles, agreement result as part of a treaty with the USSR, the ATS might prove to be the quickest and least expensive way to exercise the right.

If the suggestions cited above prove to be of no value in bargaining with the Soviet Union, the only cost is bonded storage of the equipment until that determination is in hand. Routine disposition could then follow.

Retaining the equipment in storage for the present appears reasonable as there is as yet no firm requirement for the ATS or the Mission Simulator in other programs.

I. ASTRONOMY APPLICATION OF MOL/DORIAN OPTICS ASSEMBLY

In connection with the disposition of MOL hardware and technology, the Administrator of NASA posed a question regarding the applicability of the main optics assembly to astronomy missions. A cursory briefing on the subject was prepared and is summarized here.

To apply the DORIAN main optics as a stellar or solar telescope would require some fairly extensive modifications. These, however, would consist mainly of removing the tracking mirror assembly, the Ross Barrel and folding mirror and some of the forward section of the mission module. To then adapt the remaining mirror and optical barrel to a vehicle such as the NASA workshop or some other vehicle would require rather significant structural, pointing controls and environmental control development. A wide band-multi-spectral recording system would also need to be developed.

The performance of such an adaptation in relatively low earth orbit is estimated in the attached figures. Depending upon the capability of the recording device selected, resolution improvements of between 3 and 4 times over the best earth-based observatory appear possible.

Since the main optics system in MOL was not to be considered by the Ad Hoc Group for disposition, this discussion is included only for record.

J. CONCLUSIONS

Most of the classified MOL equipment that was considered for disposition requires further analysis prior to a decision. This is borne out by the absence of concrete, detailed proposals for direct application of the equipment. Consequently, further study by those interested agencies prior to making a firm proposal has been recommended. Such studies should be possible within the appropriate security system and initiating action has been taken. Responses from agencies indicated should be delivered to the Secretary of the Air Force by September 1, 1969. As a matter of record, the contractors' briefings are included in Appendix I.

APPENDIX A

ENABLING DOCUMENT

TOP SECRET

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DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE SECRETARY

June 30, 1969

MEMORANDUM FOR MR. HANSEN, SAFRD

Although I am aware of various efforts underway in the MOL Program and Systems Offices, the Air Staff, and NASA aimed at exploiting MOL residuals and/or carrying-on essential work, I nevertheless feel that a more formal, comprehensive review should also be undertaken to insure that maximum national benefit is realized from MOL hardware, technology, and experience.

What I have in mind is an Ad Hoc Group of appropriate individuals to accomplish the following:

o Identify all significant MOL hardware, test and checkout equipment, technology, etc., which might be useful to DOD and/or NASA. Review MOL Program/System Office disposition actions and plans in this regard and provide any necessary additional guidance.

o Identify any <u>essential</u> MOL work which <u>must</u> be continued in other AF projects. Review actions already taken, underway, or planned and provide any necessary guidance or direction to the appropriate AF agency.

o Identify <u>desirable</u> MOL technology which <u>might</u> be continued as follow-on Exploratory or Advanced Development projects, and provide any necessary guidance or direction to the appropriate AF agency.

o Prepare a report on all of the above as of August 1.

For composition of the Ad Hoc Group, I suggest Dr. Yarymovych as Chairman, with General Hedrick, General Gilbert, and appropriate representatives from MOL and SAMSO as members. Additionally, consideration should be given to

DORIAN

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the inclusion of NASA and DDR&E representatives as members of the group; as a minimum, an early and continuing liaison should be established with those agencies.

Although those elements of the DORIAN camera system that are applicable to an unmanned system and in the process of transfer to the National Reconnaissance Program are excluded from this review, the Ad Hoc Group should consider all man-unique aspects of the MOL camera system regardless of classification.

To facilitate its use, the report of the Ad Hoc Group should be a non-BYEMAN document and make no inference of any such material. BYEMAN-classified aspects of the MOL Program dealt with by the Group should be covered in a supplementary annex to the basic document.

Attached for your use, as appropriate, is an unclassified version of this memorandum.

Robert C. Seamans Jr.

ROBERT C. SEAMANS Jr.

Attachment
a/s

cc: SAFUS
AFCCS
AFSC (SCG)

APPENDIX B

COMMITTEE MEMBERS
AND
CLASSIFIED MINUTES

MEMBERS AD HOC GROUP TO REVIEW MOL RESIDUALS

Dr. Michael I. Yarymovych - SAFRD - Chairman

Brig. Gen. Raymond A. Gilbert - AFSC/SCT

Brig. Gen. Walter R. Hedrick, Jr. - AFRDS/Col. Raymond Nelsen

Brig. Gen. Louis L. Wilson - SAMSO

Mr. Howeard P. Barfield - DDR&E

Mr. Samuel H. Hubbard - SAFSL

Col. Stanley C. White - SAFSL

Lt. Col. Clements B. Merritt - SAFSL

Lt. Col. Larry Skantze - SAFSL-6

Lt. Col. Donald L. Steelman - SAFSL

Mr. William C. Schneider - NASA

Mr. Philip E. Culbertson - NASA

Mr. Myron W. Krueger - NASA

CLASSIFIED ADDENDUM

TO JULY 1, 1969, MEETING OF
THE AD HOC GROUP TO REVIEW MOL RESIDUALS

Reference is made to the unclassified minutes of the first meeting.

Following are classified areas discussed in the meeting.

1. There will be two reports - one will be a Byeman/DORIAN classified discussing those areas requiring this classification. The other report will be in the white - classified no higher than SECRET and it will not refer to the black documents in any way.

2. The DORIAN classified equipment can be reviewed and if the use was justifiable, the possibility of downgrading it would be considered.

3. The optical system and the Eastman Kodak facilities will not be discussed.

4. Attendees at the meeting were:

Dr. Michael I. Yarymovych - SAFRD - Chairman
Maj. Gen. James T. Stewart - SAFSL
Brig. Gen. Raymond A. Gilbert - AFSC/SCT
Brig. Gen. Louis L. Wilson - SAMSO
Col. Raymond Z. Nelsen - Alternate for Gen Hedrick - AFRDS
Col. Stanley C. White - SAFSL
Capt. Robert Geiger - SAFSS
Mr. Samuel H. Hubbard - SAFSL
Lt. Col. Larry Skantze - SAFSL-6
Lt. Col. Donald L. Steelman - SAFSL
Mr. William C. Schneider - NASA
Mr. Howard P. Barfield - DDR&E
Mr. Philip E. Culbertson - NASA
Mr. Myron W. Krueger - NASA

ADDENDUM TO 10-11 JULY MEETING OF
AD HOC GROUP TO REVIEW MOL RESIDUALS

Reference is made to the minutes of subject meeting. Following are specific areas discussed which must be separated because of security classification.

a. Bi Matt Processor

The technology of bi-matt processing is available in Air Force Laboratory in unclassified versions. If required, it can be obtained. Also, the Air Force laboratories are continuing to work on the bi-matt processing technology. The processor should not be mentioned in the non-Byeman report thereby disassociating it with MOL.

NASA indicated that they may consider on-board processing in follow-on (second generation) AAP for stellar application. An engineering unit is available at Eastman Kodak (EK) if they desire to review its operation.

It was suggested that the unit remain in storage at EK for a period of time and processor technology be followed through the Air Force Labs.

General Gilbert will write a short paragraph on the processor for the black supplement.

b. Acquisition & Tracking Scope (ATS)

NASA expressed an interest in the possibility of using it, or a version thereof, for earth resources and possibly lunar activity. Other uses are being investigated. Aerospace Corp. made studies and reports on use and capability of the ATS and these can be obtained if required.

A short paragraph on ATS will be provided by Mr. Schneider for space applications and General Gilbert will review for possible SR-71 use.

c. Image Velocity Sensor (IVS)

The Chairman stated that the IVS was not in perview of group and the fallout of IVS is applicable and being considered for other programs.

d. Startracker

Accuracy requirement is all that is new.

e. Low G Accelerator

Off-the-shelf type item.

f. Drive Subsystem (bearings)

Advanced technology provided low-speed smooth operation. Present bearing techniques were used and "honed" or improved to obtain smooth operation.

Other areas associated with the camera system, i.e., optics and special contractor facilities, were excluded from the scope of the review group per direction of Dr. Seamans.

DONALD L. STEELMAN
Lt. Colonel, USAF
SAFSLS

APPENDIX C

TRACKING MIRROR CONTROL SYSTEM

TRACKING MIRROR CONTROL SYSTEM

FUNCTION

To drive and control the Tracking Mirror (i.e., LOS) at prescribed rates and null accuracies.

TECHNICAL DESCRIPTION

Point and maintain during operation the optical line of sight within a cone of half angle .1 degree.

Slew and settle to the above pointing accuracy and a rate accuracy of $\pm 42\ \mu$rad/sec within $\frac{\Delta\theta}{6} + N$ where N is 4 under IVS control and 5 under crew rate nulling. In addition at N equal to 3 sec the line of sight rate accuracy must be less than $\pm 540\ \mu$rad/sec for open loop performance.

Components included are:

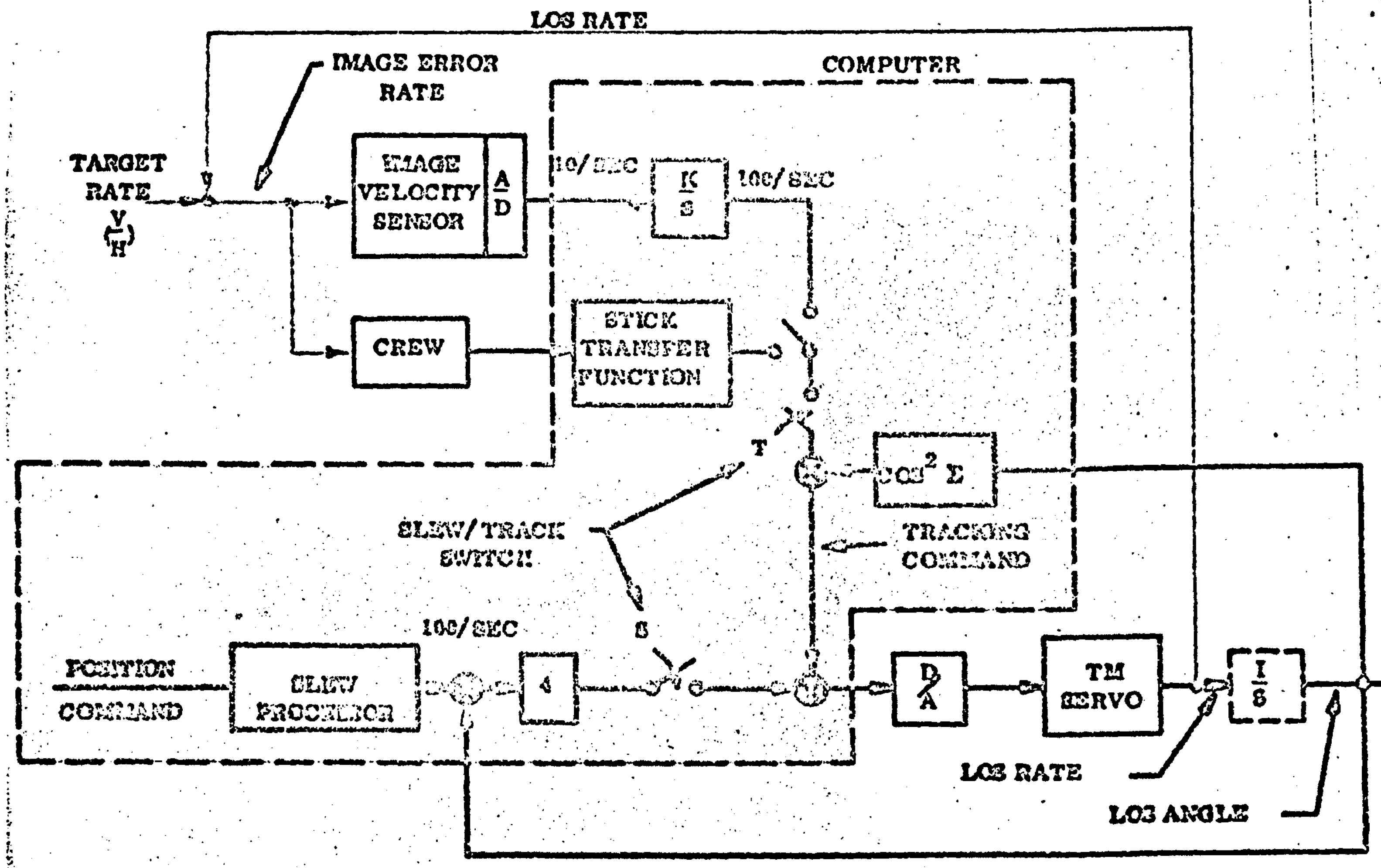
- Pitch and Roll Torquers
- Pitch and Roll Gyro's
- Drive Electronics
- Super Smooth Bearings (Pitch & Roll)
- Shaft Position Encoder
- Bearing Lubricant (F-50)

STATUS

Analysis and brass and bread board test results have shown the drive system, assuming an operable IVS, to meet or exceed specification. Studies have shown the open loop performance to be on the order of 100 μrad/sec. The drive loop responded properly to IVS feed-back signals. The IVS component is covered separately. One minor problem area was the pointing accuracy, worst case IVS operation allowed the pointing accuracy to drift out of specification.

% COMPLETE 40% - TOTAL PROGRAM   COST TO COMPLETE $9M 1st Unit
60% Complete

TRACKING MIRROR CONTROL SYSTEM



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APPENDIX D

IMAGE VELOCITY SENSOR (IVS)

IMAGE VELOCITY SENSOR (IVS)

FUNCTION

The IVS optically senses the velocity of image in two axes and provides the information to the Tracking Mirror control loop to null the image rate.

TECHNICAL DESCRIPTION

The IVS input is the center 2.8 inches of the overall 9-inch scene.

The IVS senses primarily in the visual (.4 - .9 millimicrons) range.

The IVS outputs:

(1) an x and y signal in analog form indicative of x and y velocity in the range of ± 0-600 μradians/sec or ± 0-.3 inches/sec at the image plane.

(2) a digital signal for each velocity channel indicating a lock-on status.

(3) a digital signal indicating operational readiness of unit to meet spec.

(4) a digital signal indicative of the status of the input energy.

STATUS

This component was subcontracted to two vendors. At termination these two units were undergoing competitive testing to determine which vendor would supply the flight models. Both vendors had problems under adverse input scene conditions; however, the Systems Office is confident that with further development either vendor could supply working units that would meet the specification.

% COMPLETE 70% - TOTAL PROGRAM COST TO COMPLETE $2.1M 1st Flt Unit 80% Complete

IMAGE VELOCITY SENSOR (IVS) TESTER

FUNCTION

To provide the tester for the IVS test program.

TECHNICAL DESCRIPTION

Simulates the orbital conditions with known pictures to simulate scene.

STATUS

Complete except for modifications to haze control to better control the input light levels.

APPENDIX E

BIMAT ON-BOARD FILM PROCESSOR

ON BOARD PROCESSOR

TYPE:	BIMAT, SO-111, 9.46 IN, WIDTH.
NOMINAL LOAD:	1270 FT.
CAPACITY:	1500 FT.
PROCESSOR RATE:	5 MIN/FRAME (REQ'D)
	5 INCHES/MINUTE (GOAL)
WEIGHT:	PROCESSOR - 195#
	BIMAT - 50#
POWER:	480 WATTS PEAK
	225 WATTS PROCESSING

ON BOARD PROCESSOR

TEST STATUS

EM - FUNCTIONAL TESTS - COMPLETED SATISFACTORILY

EM - ENVIRONMENTAL - COMPLETED SATISFACTORILY

QM - MECHANICAL COMPONENTS - ASSEMBLY COMPLETE

ELECTRICAL COMPONENTS - IN ASSEMBLY

ENGINEERING MODEL FUNCTIONAL TEST OBJECTIVES

VERIFY MECHANICAL FEATURES

PRELIMINARY EVALUATION OF PROCESSING QUALITY

EXAMINATION OF FILM/BIMAT DRYING

DETERMINE PERFORMANCE OF SALT PAD MOISTURE RESERVOIR

ESTABLISH FLOW PERFORMANCE OF DRYER SYSTEM

COMPARE PERFORMANCE WITH UTB & TB FILMS

COMPARE PROCESSOR OVERALL PERFORMANCE IN AIR & He/O_2 - GAS

EVALUATE ELECTRICAL CONTROL & MONITORING CIRCUITRY

RESULTS FROM EM FUNCTIONAL TESTS

TEST	RESULTS
FILM/BIMAT TRACKING	OK
FILM/BIMAT WEB TENSION CONTROL	OK
FILM/BIMAT TRANSPORT RATE	OK
THREADUP OPERATIONS	OK
FILM/BIMAT LAMINATION & DELAMINATION	OK
FILM/BIMAT DRYING	OK
FLOW PERFORMANCE OF DRYING SYSTEM	OK
PROCESSING QUALITY (NO CONTROLLED SENSITOMETRY)	OK
PERFORMANCE IN AIR & $He/^{0}2$ GAS	OK
SALT PAD SYSTEM PERFORMANCE	OK
ELECTRICAL DISPLAY AND INSTRUMENTATION OUTPUTS	OK
ELECTRICAL POWER CONSUMPTION	OK
MANUAL & AUTOMATIC OPERATION/FUNCTION PROCEDURES	OK

ENVIRONMENTAL VERIFICATION TEST OBJECTIVE

TO SIMULATE MISSION PARAMETERS:

GAS	AIR @ 14.7 PSIA, He/O_2 & OXYGEN @ 5.0 PSIA
THERMAL BOUNDARY	60° F TO 110° F
COOLANT	SOURCE "A" 34° - 43° F PLUS SINE EXCURSION TO 55° F SOURCE "B" 63° ± 3° F PLUS SINE EXCURSION TO 80° F
VOLTAGE RANGE	22 - 31 VOLTS
TIME LINE	6 DAY PRE-GO PLUS 30 DAY OPERATION
OPERATION SEQUENCE	MANUAL/AUTOMATIC PER PRIME PROCEDURE
MATERIALS	SINGLE ROLL BIMAT, SINGLE SALT PAD ASSEMBLY
	MULTIPLE FILM ROLLS (50'/BATCH & 1200' TOTAL)
	CONTROLLED PHOTO SENSITOMETRY
	UTB & TB FILM
ORIENTATION	3 AXES

TEST GROUPING

1-6 DAY PRE-GO STANDBY (AIR @ 14.7 PSIA)

8-PROCESSING (AIR @ 14.7 PSIA)

13-PROCESSING (He/O_2 -GAS @ 5.0 PSIA)

1-PROCESSING (OXYGEN @ 5.0 PSIA) PLUS OVERNIGHT STORAGE

RESULTS FROM ENVIRONMENTAL VERIFICATION TESTING

BIMAT FILM KEEPING	OK
PROCESSING FILM QUALITY & SENSITOMETRY	OK
FILM DRYNESS ($\leqq$ 50% RH EQUILIBRIUM)	OK
BIMAT DRYING	OK
SALT PAD SYSTEM MOISTURE CAPACITY & MASS TRANSFER	OK
MECHANICAL PERFORMANCE (FILM MOTION SENSING EXCLUDED)	OK
PROCESSOR PERFORMANCE SENSITIVITY TO ORIENTATION	OK

CONCLUSIONS FROM EM PROCESSOR TESTING

1. PROCESSOR PERFORMANCE REQUIREMENTS ARE MET UNDER EXTREMES OF TEMPERATURE, COOLANT, VOLTAGE & GAS CONDITIONS

2. MOISTURE MANAGEMENT SATISFACTION

3. VAPOR CONCENTRATION OF DEA IN PROCESSOR IS ACCEPTABLE

4. SENSITOMETRY SATISFACTORY

5. ELECTRICAL/MECHANICAL FUNCTION SATISFACTORY

6. ADDITIONAL O_2 TESTING REQUIRED

7. VIBRATION, ACCELERATION AND PRESSURE PROFILE TESTING NOT STARTED

MOL Segment	Prime Contractor	Completion Status (Percent)
PHOTOGRAPHIC SEGMENT	EK	
Subcontract/Subcontractor		
Processor (negotiated)	EK	70%
MISSION PAYLOAD (negotiated)	GE	
Subcontract/Subcontractor		
Acquisition Track Scope/ITEK		60%
Image Velocity Sensor	Goodyear*	95%
	Hycon*	95%

*Goodyear and Hycon were developing in separate prototypes. Figures are based on those prototypes only.

APPENDIX F

VISUAL DISPLAY PROJECTOR

VISUAL DISPLAY PROJECTOR

FUNCTION

The visual display projector presents to the crewmen high resolution pictues of the scene prior to the target pass which aids in locating targets in the acquisition tracking scope field-of-view. A secondary function is to provide maintenance or instructional material to the crew.

TECHNICAL DESCRIPTION

The visual display projector has the capability of displaying any cue frame in a cue frame library of 32,752 frames. The frames are stored in eight film modules, each containing 4,094 frames. Each frame is identified by a binary code which is printed on the film.

During target pass operations, cues are called up by airborne digital computer commands. Each cue frame called up is held for a fixed duration and then released to permit the visual display projector to retrieve the next cue. The operation is planned so that a cue is being retrieved during the periods when the crewman is viewing a scene in the acquisition tracking scope. The cue is displayed during the slew period (perhaps with some overlap into the track period). The cue is released automatically if the crew votes on the target while it is still being displayed. The crew can retain a cue frame beyond the planned release time by rotating the magnification control stick in a clockwise direction.

During prepass briefing periods, the airborne digital computer automatically commands each frame retrieval as in the target pass operation.

However, cues can also be called up and released manually by operating the manual controls located on the visual display control panel. Cue frames are called up manually by dialing the desired frame number, in octal form, on the manual selector control.

A six-character alpha-numeric display is included on the visual display projector to project cue words relating to each target. This information is stored in the airborne digital computer.

STATUS

The design is 85% complete and the first unit is 40%.

APPENDIX G

ACQUISITION TRACKING SCOPE

ACQUISITION TRACKING SCOPE

The acquisition telescopes function was to permit the crewman to view ground targets.

TECHNICAL DESCRIPTION:

The resolving power of the acquisition optics shall be high enough to enable an observer with vision of AFM 160-1 Flying Class I to resolve a 3-bar target of alternating 1.65 feet wide white and black bars. The real FOV shall be at least 4.0° at minimum magnification and at least 1° at one-half maximum magnification. The minimum magnification shall be $16x \pm 2x$; the maximum magnification shall be $127x+5x-3x$. The slew capability of the ATS scanner shall be : $T = \frac{\Delta\theta}{30} + 1$, where $\Delta\theta$ is the line-of-sight angle (in degrees) between the current target and the subsequent target at the start of slew.

STATUS OF HARDWARE/TECHNOLOGY:

1. ATS Drive Electronics: Detailed drawings for the modules comprising the drive electronics were 80% released. Engineering units of many of the modules had been fabricated and tested, but not as a complete subsystem.

2. ATS Scanner: The scanner mechanical design was 80-90% complete. The engineering model was in fabrication and near completion.

3. Telescope: Optical design was complete in 1967. Optical bench tests completed in May 1969 had confirmed the design (at least on-axis performance). Internal mechanism designs, power changer, zoom, were quite crude and would have required extensive redesign.

While much detailed design has been completed on the ATS, many aspects of the design had not satisfactorily completed PDR. These items are specifically:

A. Thermal Design

B. Sun Shutter

C. Installation Alignment

D. Internal Telescope Mechanisms.

ESTIMATE TO COMPLETE

Cost to complete design, development, qualification, acceptance testing of one Acquisition Tracking Scope would be approximately 0.50 Million (just for the telescope). This task is ≈80% complete. The complete subsystem; i.e., gyros, shaft position encoders, etc; would be 4.0 Million. This task is ≈60% complete.

APPENDIX H

SIMULATION PROGRAM

SIMULATION

Technical description and status of MOL Mission Module Simulation Activities:

The purpose of the Mission Module Simulation Program was to develop and validate MOL payload operating concepts, timelines, and procedures; to develop and validate flight computer programs; and to train the flight crew and flight controllers. Three simulators were planned to meet these objectives, as follows:

a. Elemental Development Simulator (EDS). This simulator was operated during 1968, primarily for validation of cockpit configuration. The optical displays were driven by 70 mm motion picture projectors. Optical quality was of marginal quality to perform advanced flight crew simulations. The EDS completed operation and was dismantled in September 1968.

b. Mission Development Simulator (MDS).

(1) This simulator is a modified and improved version of the EDS. Located at the GE plant in Valley Forge, it was to continue the engineering development and mission validation tasks. The optical displays of the ATS and visual optics are provided by a series of slide viewing subsystems (SVS) which projected images from 9-inch square glass slides. The images are modified by zoom lenses, anamorphic lenses, and derotation prisms to provide to the flight crewman scenes of the earth as seen through his displays from the spacecraft. All operating controls and displays are simulated to allow realistic target acquisition, weather avoidance, intelligence activity detection, rate nulling, and tracking, as well as contingency mode operation. The MDS contained a computer complex consisting of an IBM 360-44 digital computer, a SDS/Beckman 930/2200 hybrid

Addendum 1 to the NASA Report for Simulation

STATUS OF SIMULATION PROGRAM

1. Elemental Development Simulator (EDS). The EDS completed operation in September 1968 and has been torn down.

2. Mission Development Simulator (MDS). The Phase Zero configuration MDS (single cockpit) was scheduled for operation July 1969 and was, therefore, virtually complete. The final Phase 3 configuration MDS, complete with five slide viewing subsystems, Airborne Digital Computer and both crew stations, was scheduled for initial operation during early 1970. Hardware fabrication was essentially complete, but approximately 50% of the computer software remains to be developed.

3. Mission Module Simulation Equipment (MMSE). The MMSE design was to be patterned after the Phase 3 MDS. The MMSE was in the early design stage, and virtually no fabrication had been accomplished.

ESTIMATED COST TO COMPLETE PHASE 0 AS DESCRIBED IN PARAGRAPH 2 ABOVE

It is estimated that approximately $250,000 and 6 to 10 weeks of time would be required to bring the Phase 0 MDS to full operational status. It could then be operated for a cost of about $1.5 Million per year. Phase 0 was approximately 95% complete.

computer, and an actual IBM 4 pi flight computer, containing airborne software. An instructor/operator station, which includes television monitors of flight crew visual displays, is also included, as well as all necessary power conditioning and signal conditioning and switching equipment.

(2) The initial single cockpit phase of the MDS was due to be completed in July 1969. The final two-crewman configuration was scheduled for completion during early 1970.

c. Mission Module Simulation Equipment (MMSE). This simulator was to be used at Vandenberg AFB for training. It was similar in configuration to the MDS, except it was designed to interface with the MDAC furnished Laboratory Module Simulation Equipment for integrated orbiting vehicle training. The MMSE was in the early design stage.

APPENDIX I

CONTRACTORS' BRIEFINGS

On 24 July 1969 the General Electric Company recommended several actions to the MOL Disposition Board to assist that Board in applying MOL hardware experience and technology to other Government programs. This paper summarizes the classified portion of this presentation and the major recommendations.

1. The Acquisition Telescope System is a high performance system combining high quality optics with precise pointing capability. The system includes the telescope pointing, zoom, and de-rotation servos and the computer subsystem necessary to drive the servos.

   The potential applications of the Acquisition Subsystem have been identified for Apollo and the Apollo Applications Program as an experiment in: lunar site determinations, surface observations or record from lunar orbit, earth resources observation and record, adjunct to stellar, solar and planetary astronomy, [redacted] ocean surveillance.

   General Electric recommends clearances for a limited number of NASA people and a funded study, supported by NASA and DoD, for the definition of an unclassified experimental flight program using the Acquisition Telescope Subsystem.

2. The MOL Mission Development Simulator has been completed to the extent of providing an operating capability for a single crewman with high quality flexible optics and controls which permit quantitative determinations of performance by man and equipment in electro-optical and command/control systems. In addition to direct eye piece observation, the Simulator has a video pick-up which is used as an input to a Video Console Simulator. The Video Console Simulator is currently being used to study command/control and read-out aspects of an unmanned direct read-out reconnaissance satellite system.

Potential applications, manned or read-out, include Apollo Telescope Mount simulation; landmark positioning and associated studies of autonomous navigation; earth resources performance evaluation; reconnaissance, surveillance, target location control and bandwidth studies; ocean surveillance studies and ASW studies; [redacted] and astronomy.

General Electric recommends continued USAF space and aircraft investigations in the simulator. General Electric also recommends clearance for appropriate NASA people on the earth resources and ATM programs with funded operation of the simulator during an experimental investigation to determine the applicability of the simulator to these programs and the NASA interests.

3. The MOL Program developed an integrated software capability at General Electric with unique capabilities to produce and integrate both space borne and ground control and telemetry reducing software. The control philosophy of MOL was different from that of other manned space programs in that the system was organized to interface man with the on-board computer in such a manner as to relieve man of routine tasks and optimize his capability to exercise judgment and discrimination in mission performance. The future NASA missions in Apollo applications and space station are in this direction and, in this instance, approximate those of MOL. The application of the control philosophy developed in MOL can be a significant economy to NASA.

General Electric recommends that a limited number of NASA personnel be cleared in order that the applicability and value of this software experience and philosophy missions can be determined and transferred to NASA.

4. General Electric recommended potential applications of the Image Velocity Sensor in automatic, precise, optical tracking of targets - terrestrial, lunar, planetary, satellite or booster during powered flight. It recommended potential applications of the attitude reference system for autonomous navigation in space flight when ground tracking is not available or not sufficiently accurate, and in any other application where precise, automatic pointing of optical sensors, lasers, communication antennas or radar antennas is required. It recommended applications of the gimbal drive system, or the technology, wherever ultra precise control along with rapid and smooth target tracking is required for optical sensors, radar and communication antennas or lasers. In this last category, General Electric specifically recommends that USAF

study funding be expended to transfer this technology to aircraft or weapons applications.

5. General Electric recommended the following administrative actions be approved at the earliest opportunity:

a) Relief from provisions of message [redacted] 2117 to permit free discussion and application activity on all MOL technology, experience, and hardware except that protected by Dorian classification.

b) Approval to contact Dorian cleared government officials to discuss applications without specific prior approval.

c) Approval to use the simulator, IVS tester and other equipment to demonstrate MOL technology and hardware.

d) Approval to propose use of MOL hardware and equipment as GFE.

e) Retention of MOL simulator, IVS tester and computers with peripheral equipment by excluding from mandatory screening and inventory procedures under termination pending definition of applications.

f) Agreement to grant limited number of Dorian clearances to individuals as identified by NASA members of the Board and as necessary to develop the applications.

In our judgment, the program we have recommended will realize the most immediate utilization of paid-for hardware and technology in other programs. It can quantify and upgrade, or accelerate, man's role in the NASA manned spacecraft programs. It can serve as a continuing and effective research tool in the investigation of advanced manned military space systems which may be undertaken in space by ourselves or others.

PRESENTATION TO AD HOC COMMITTEE FOR MOL PROGRAM DISPOSITION

24 JULY 1969

GENERAL ELECTRIC COMPANY

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BRIEFING OUTLINE

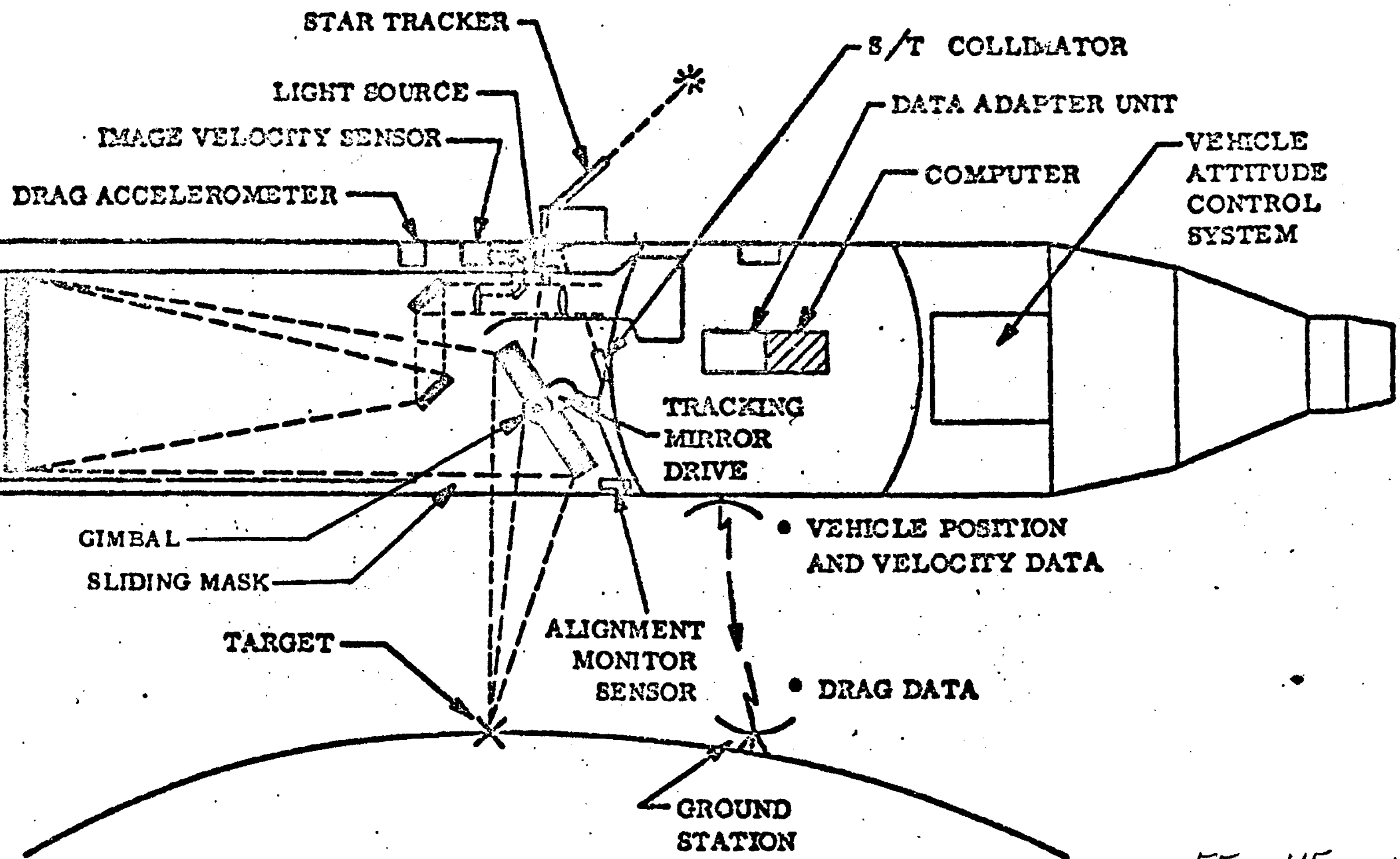
INTRODUCTION & GE MOL PROGRAM OVERVIEW	M. MALKIN
ACQUISITION & TRACKING SYSTEM	R. BARCHET
MOL MISSION SIMULATOR	T. HAIG
COMPUTER INTEGRATED TEST EQUIPMENT & SOFTWARE	J. ARMSTRONG
SUBSYSTEMS & TECHNOLOGIES	R. BARCHET
SUMMARY OF APPLICATIONS & RECOMMENDATIONS	R. PASSMAN

SPECIFIC GE ROLE

MISSION SYSTEM OPERATION

- PROVIDE MISSION MODULE HARDWARE/SOFTWARE TO:
  - POINT OPTICAL SYSTEM AT GROUND/SPACE TARGET
  - STABILIZE TARGET IMAGE IN CAMERA TO LIMIT PHOTOGRAPHIC SMEAR
  - ON-BOARD COMPUTER SOFTWARE
- INTEGRATE FLIGHT CREW INTO MISSION OPERATION
  - LABORATORY MODULE MISSION CONSOLES
  - ACQUISITION TRACKING SYSTEM
- PROVIDE GROUND MISSION SIMULATION EQUIPMENTS/OPERATION/ TRAINING
- PROVIDE SUPPORTING AEROSPACE GROUND EQUIPMENT
  - COMPUTER INTEGRATED TEST EQUIPMENT
  - HANDLING EQUIPMENT
  - SPECIAL TEST EQUIPMENT
- PROVIDE MISSION/ON-ORBIT OPERATIONS PLANNING/SUPPORT

POINTING AND TRACKING OPERATION



- ACQUISITION & TRACKING SYSTEM
- MOL MISSION SIMULATOR
- COMPUTER INTEGRATED TEST EQUIPMENT
- SOFTWARE
- SUBSYSTEMS
- TECHNOLOGY
- APPLICATIONS & RECOMMENDATIONS

ACQUISITION & TRACKING SYSTEM

MOL APPLICATIONS - ACQUISITION AND TRACKING SYSTEM

- WEATHER EVALUATION AND TARGET ASSESSMENT PRIOR TO COMMITMENT OF MAIN OPTICS
- TARGET CENTERING AND RATE NULLING FOR MAXIMUM RESOLUTION
- BORESIGHTING OF MAIN OPTICS/CAMERA - BACK-UP RATE NULLING
- TARGET ACQUISITION, CENTERING AND RATE NULLING FOR [redacted]

POTENTIAL ACQUISITION AND TRACKING SYSTEM APPLICATIONS

NASA APPLICATIONS

- LUNAR ORBIT OPERATIONS (MANNED)
  - HIGH RESOLUTION SURFACE OBSERVATIONS
  - LANDING SITE POSITION DETERMINATION
- PLANTETARY FLY-BY/ORBIT OPERATIONS (MANNED OR AUTOMATIC)
  - LANDING SITE SELECTION/POSITION DETERMINATION
  - METEOROLOGY/GEODESY
- EARTH ORBIT OPERATIONS (MANNED)
  - EARTH RESOURCES - RELATED EXPERIMENTS
  - AUTONOMOUS NAVIGATION EXPERIMENTS
  - METEOROLOGY EXPERIMENTS
  - OCEANOGRAPHY EXPERIMENTS
  - PLANETARY/STELLAR OBSERVATION SUPPORT

POTENTIAL ACQUISITION AND TRACKING SYSTEM APPLICATIONS (CONT)

USAF EXPERIMENTS (MANNED AND AUTOMATIC)

- RECONNAISSANCE
- SURVEILLANCE
- [redacted]

NAVY EXPERIMENTS (MANNED AND AUTOMATIC)

- OCEAN SURVEILLANCE
- OCEANOGRAPHY

(MOL SIMULATOR WOULD BE USED TO SUPPORT APPLICATIONS ACTIVITY)

MAJOR ELEMENTS - ACQUISITION AND TRACKING SYSTEM

ITEM	SUPPLIER	WEIGHT
• TELESCOPE	ITEK (SC)	88
• SCANNER/PROTECTIVE COVER	ITEK (SC)	124
• CONTROL STICKS (MAGNIFICATION & RATE)	GE	5
• CONTROL/DISPLAY ELECTRONICS	GE	77
• AIRBORNE DIGITAL COMPUTER**	(IBM)	(94)**
• COMPUTER INTERFACE UNITS	GE	14
• SOFTWARE	GE	
• SYSTEM INSTALLATION/CREW STATION*	GE	47*
• VISUAL DISPLAY PROJECTOR (VDP)**	LEAR-SIEGLER (SC)	23**
• VDP AUXILIARY UNITS/INSTALLATION**	GE	28**

*CONFIGURATION PECULIAR
**APPLICATION PECULIAR

ACQUISITION AND TRACKING SYSTEM STATUS

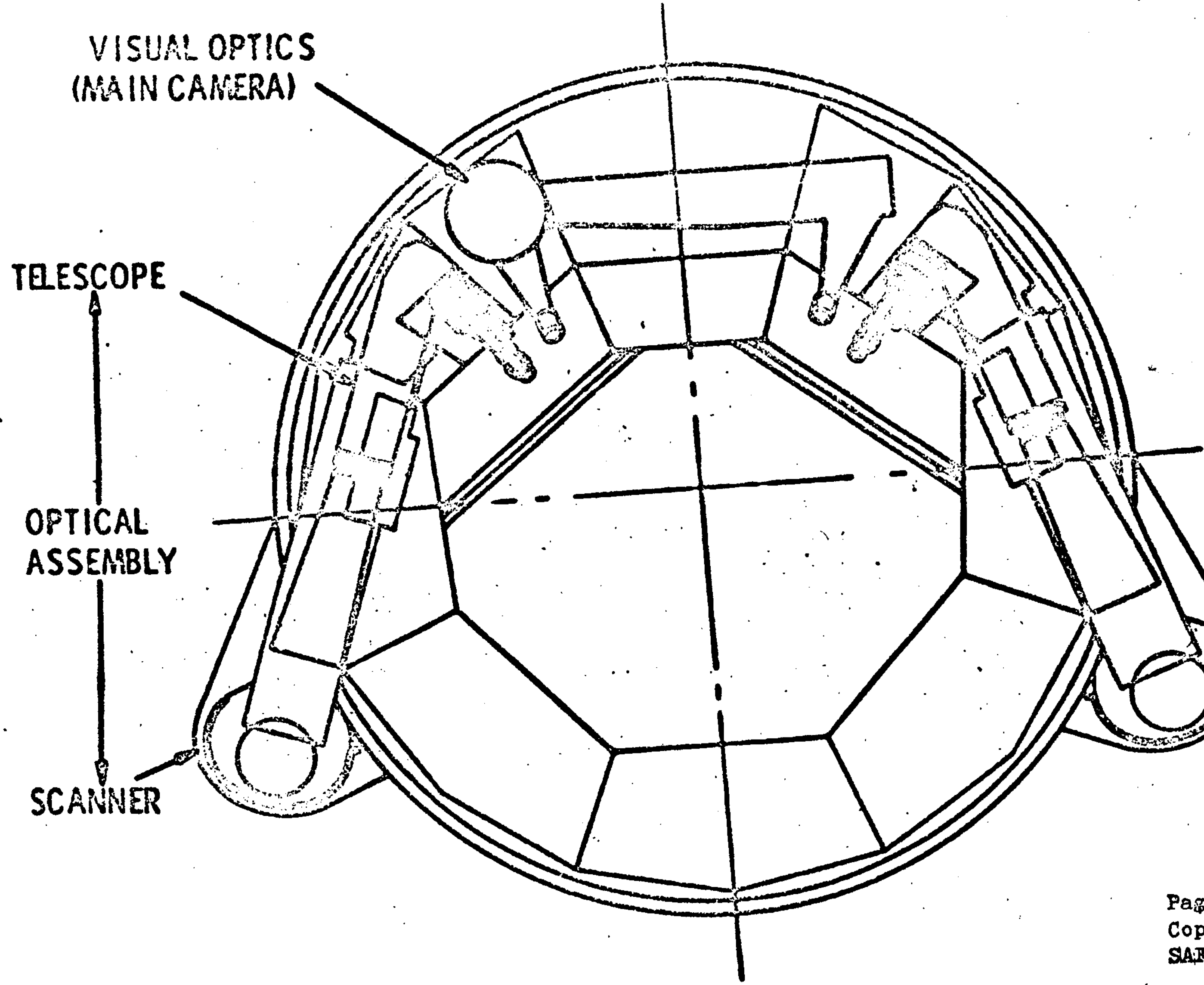
TELESCOPE/SCANNER
- DESIGN COMPLETE
- OPTICAL SYSTEM BENCH TESTING COMPLETE
- PROTOTYPE ASSEMBLY 90% COMPLETE
- PERFORMANCE VERIFIED BY TESTING
- COMPONENT TESTING COMPLETE

CONTROL STICKS
- DESIGN COMPLETE
- PROTOTYPE FABRICATION 80% COMPLETE
- COMPONENT TESTING COMPLETE

CONTROL ELECTRONICS
- DESIGN 95% COMPLETE
- BREADBOARD TESTING COMPLETE
- PROTOTYPE ASSEMBLY 50% COMPLETE

VISUAL DISPLAY PROJECTOR
- DESIGN COMPLETE
- PROTOTYPE UNIT 90% COMPLETE
- COMPONENT TESTING COMPLETE
- ENGINEERING DEMONSTRATION UNIT COMPLETE
- SYSTEM PERFORMANCE VERIFIED BY TESTING

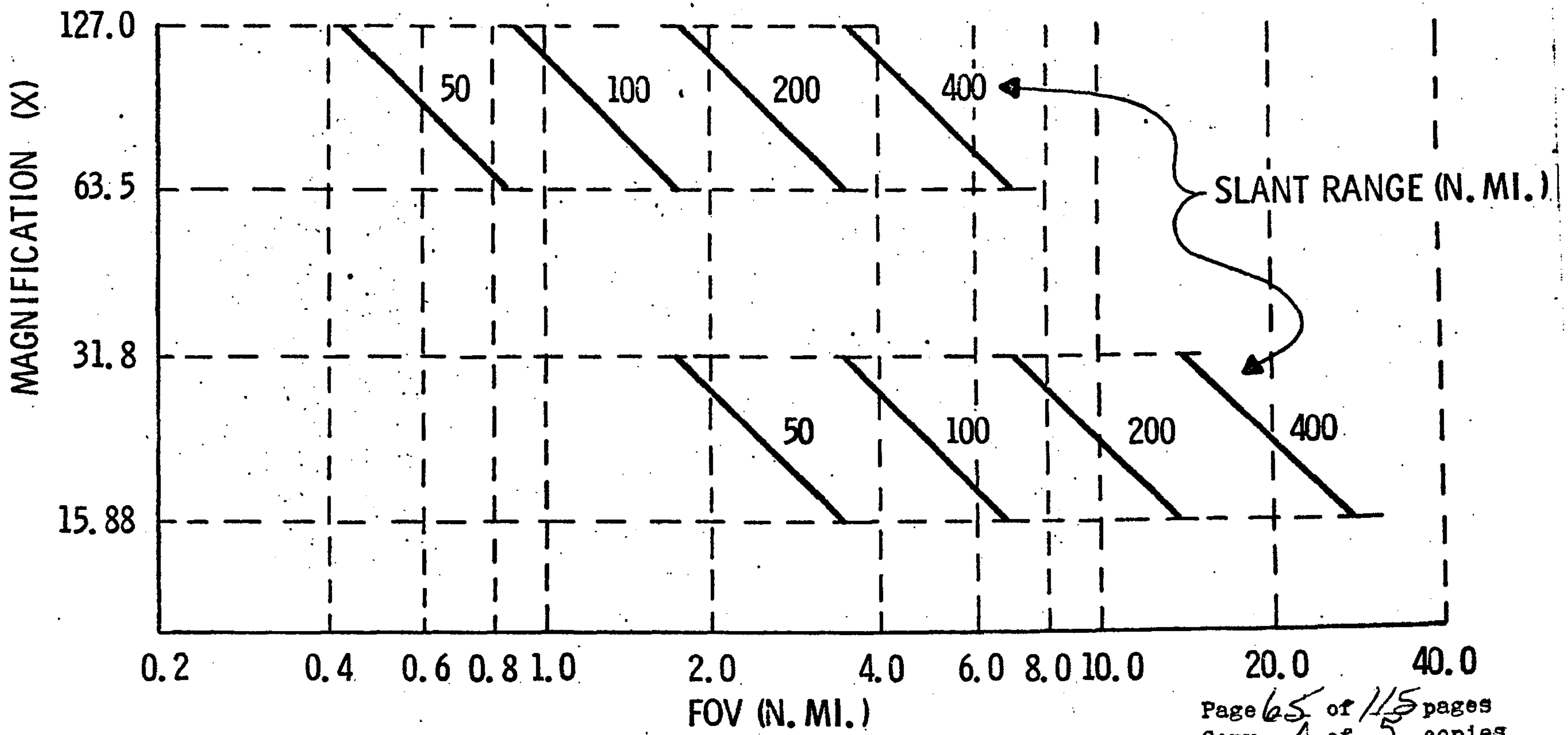
MISCELLANEOUS
- ACCEPTANCE TEST EQUIPMENT DESIGN 75% COMPLETE
- GYRO DESIGN, PROTOTYPE ASSEMBLY, AND TESTING COMPLETE


VISUAL OPTICS
(MAIN CAMERA)
TELESCOPE
OPTICAL
ASSEMBLY
SCANNER

ACQUISITION AND TRACKING SYSTEM CHARACTERISTICS

SCAN FIELD	$+70^0 \rightarrow -40^0$ PITCH $\pm 45^0$ ROLL
MAXIMUM GIMBAL RATE	50^0/SEC
MAGNIFICATION	15.88 X → 31.8X (CONTINUOUS ZOOM) 63.5 X → 127X (CONTINUOUS ZOOM)
FOV	$4.4^0 \rightarrow 2.2^0$; $1.0^0 \rightarrow 0.5^0$
APERTURE	10 IN.
EXIT PUPIL	2 → 4 MM
DEROTATION	PECHAN PRISM
FOCAL LENGTH	73 IN.
FILTERS	UP TO 3 (PLUS CLEAR)
OTHER FEATURES	- TWO-POSITION PROTECTIVE COVER - MANUAL OVERRIDES - SUN VIEWING PROTECTION (BLANKING SHUTTER)

FIELD-OF-VIEW VS MAGNIFICATION



SYSTEM VISUAL RESOLUTION (FT/LP)

SLANT RANGE (N. MI.) →	50	100	200	400
MAGNIFICATION				
15.88X	9.6	19.2	38.4	76.8
31.8X	4.9	9.8	19.6	39.2
63.5X	2.8	5.6	11.2	22.4
127X	1.6	3.2	6.4	12.8

CONDITIONS

- ON-AXIS
- 2:1 CONTRAST RATIO } AT APERTURE
- $>$ 560 FT LAMBERTS } AT APERTURE
- $<$ 0.5 ARC SEC JITTER (P-P)

ATS/CREW COMBINATION CAN OBSERVE ANY SMITHSONIAN-CATALOGED STAR (M = +9).

TV SYSTEM RESOLUTION (FT/LP)

SLANT RANGE (N.MI.) →	50	100	200	400
MAGNIFICATION				
- LOW RANGE	11.9	23.8	47.6	95.2
- HIGH RANGE	3.9	7.8	15.6	31.2

CONDITIONS

- ON-AXIS
- 2:1 CONTRAST RATIO } AT APERTURE
- >560 FT LAMBERTS } AT APERTURE
- 60μ RAD/SEC SMEAR
- FPS VIDICON CAMERA
- 2250 LINE SYSTEM (HELICAL SCAN)

SYSTEM PHOTOGRAPHIC RESOLUTION (FT/LP)

SLANT RANGE (N.MI.) →	50	100	200	400
MAGNIFICATION				
- LOW RANGE	4.4	8.8	17.6	35.2
- HIGH RANGE	1.2	2.4	4.8	9.6

CONDITIONS

- ON-AXIS
- 2:1 CONTRAST RATIO } AT APERTURE
- > 560 FT LAMBERTS } AT APERTURE
- 60 μ RAD/SEC SMEAR
- TYPE 3404 FILM

MOL MISSION SIMULATOR

MOL MISSION SIMULATOR IS A FLEXIBLE HIGH PRECISION TOOL FOR OBTAINING QUANTITATIVE DATA FOR ELECTRO-OPTICAL AND COMMAND/CONTROL SYSTEMS

- MAN'S ROLE AND PERFORMANCE
- EQUIPMENT PERFORMANCE TO AID MAN
  - RESOLUTION
  - DYNAMIC RESPONSE
  - IMAGE CORRECTION

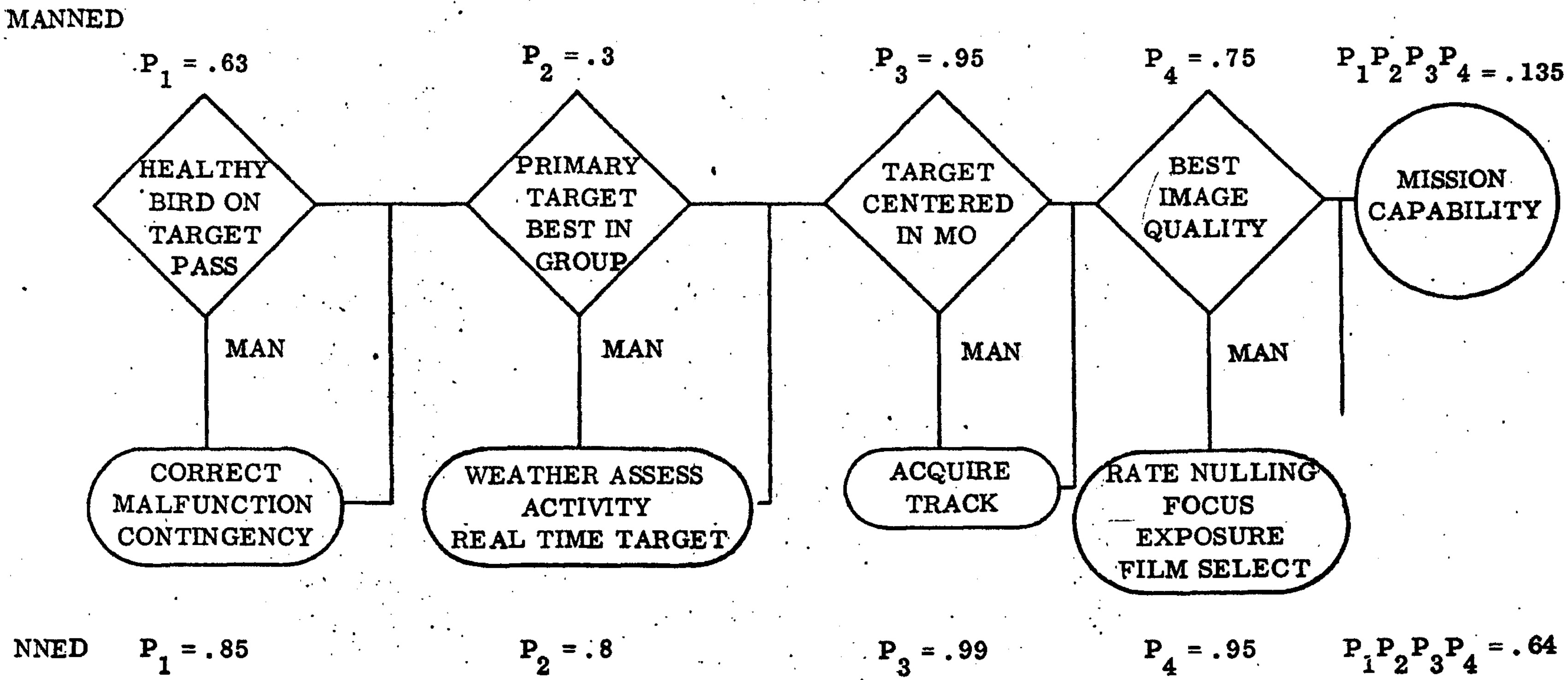
POTENTIAL APPLICATIONS (MANNED OR READOUT)

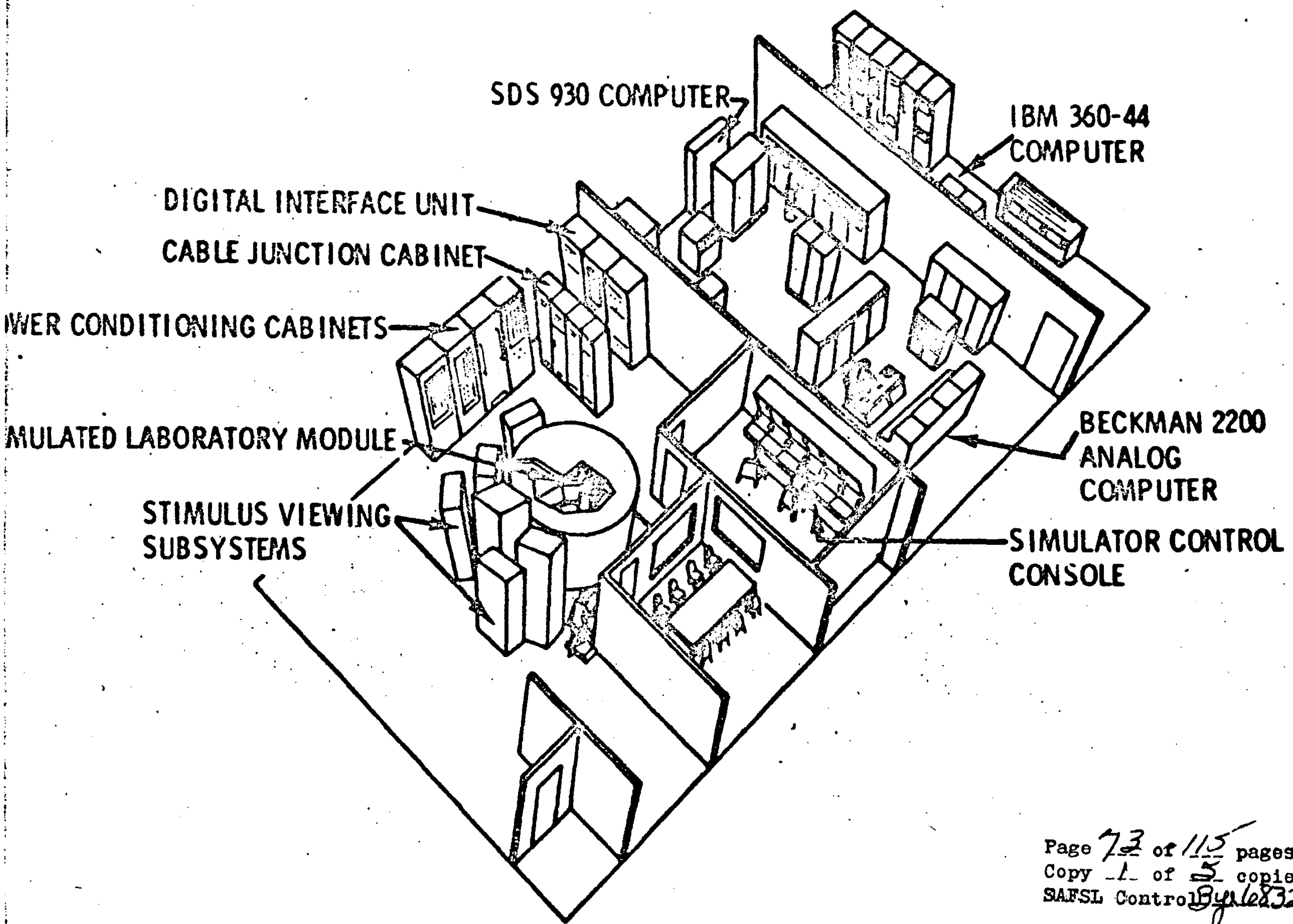
- NAVY ASW STUDIES
- NAVY OCEAN SURVEILLANCE STUDIES
- APOLLO TELESCOPE MOUNT SIMULATOR
- LAND MARK TRACKING AND NAVIGATION STUDIES
- RECONNAISSANCE, SURVEILLANCE & TARGET LOCATION STUDIES
- EARTH RESOURCES PERFORMANCE EVALUATION
- [redacted]
  - ASTRONOMY
  - [redacted]

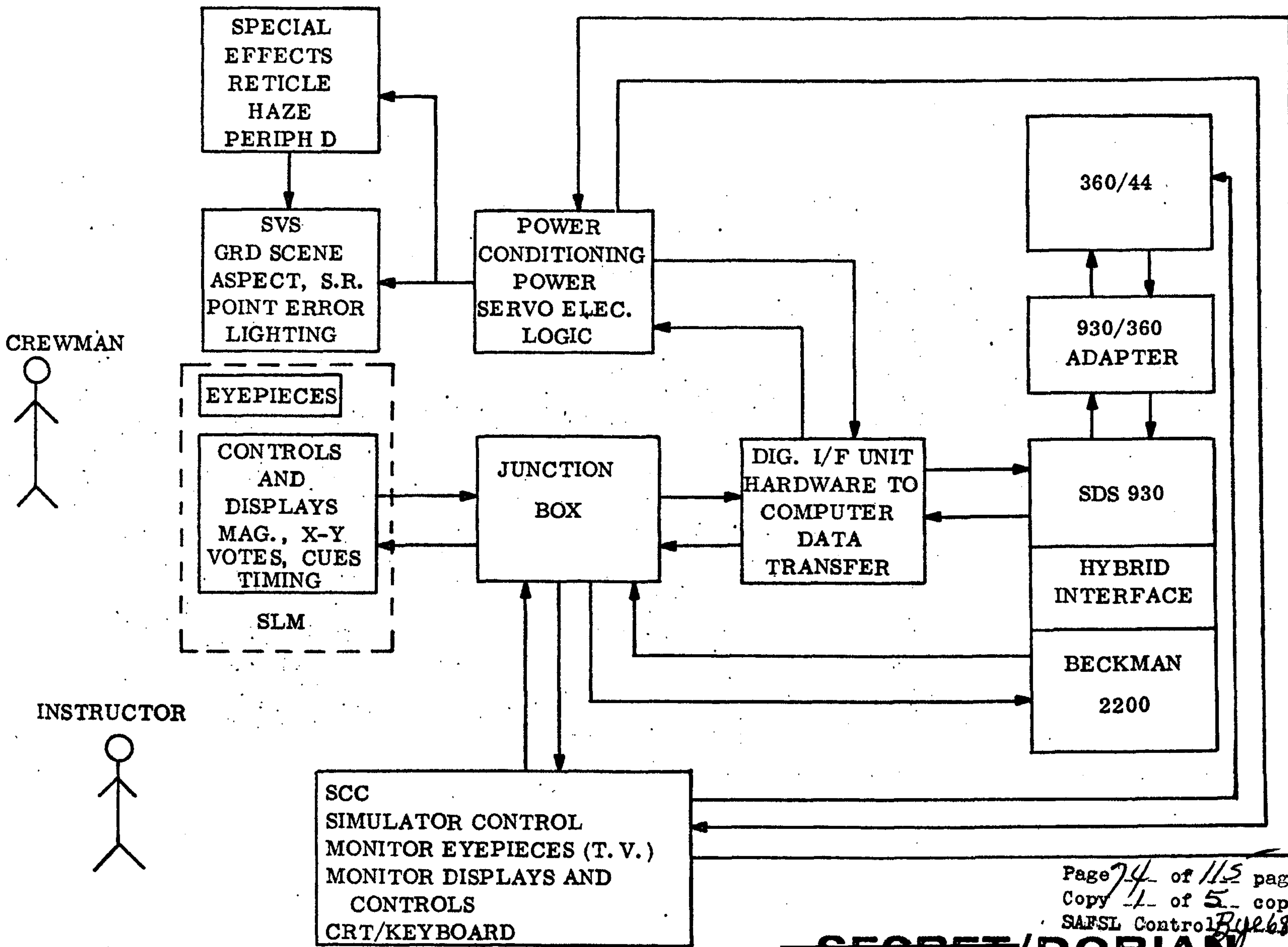
MISSION OPTIMIZATION

- REQUIRED FOR MANNED AND UNMANNED FLIGHTS
- BASIC DESIGN DEVELOPMENT
  - CONSOLES AND DISPLAYS
  - CREW OPERATIONS
- MISSION DEVELOPMENT
  - PRE-PASS PREPARATION
  - TARGET PASS SEQUENCE OF EVENTS
  - MISSION TIME LINES
  - COMMAND AND CONTROL, ON BOARD COMPUTER SOFTWARE
  - INTEGRATION OF MISSION OPERATION AND FLIGHT HARDWARE
- TRAINER DESIGN

MAN'S ROLE - DEVELOPED AND EVALUATED IN THE MISSION SIMULATOR




SDS 930 COMPUTER
IBM 360-44 COMPUTER
DIGITAL INTERFACE UNIT
CABLE JUNCTION CABINET
WER CONDITIONING CABINETS
MULATED LABORATORY MODULE
STIMULUS VIEWING SUBSYSTEMS
BECKMAN 2200 ANALOG COMPUTER
SIMULATOR CONTROL CONSOLE

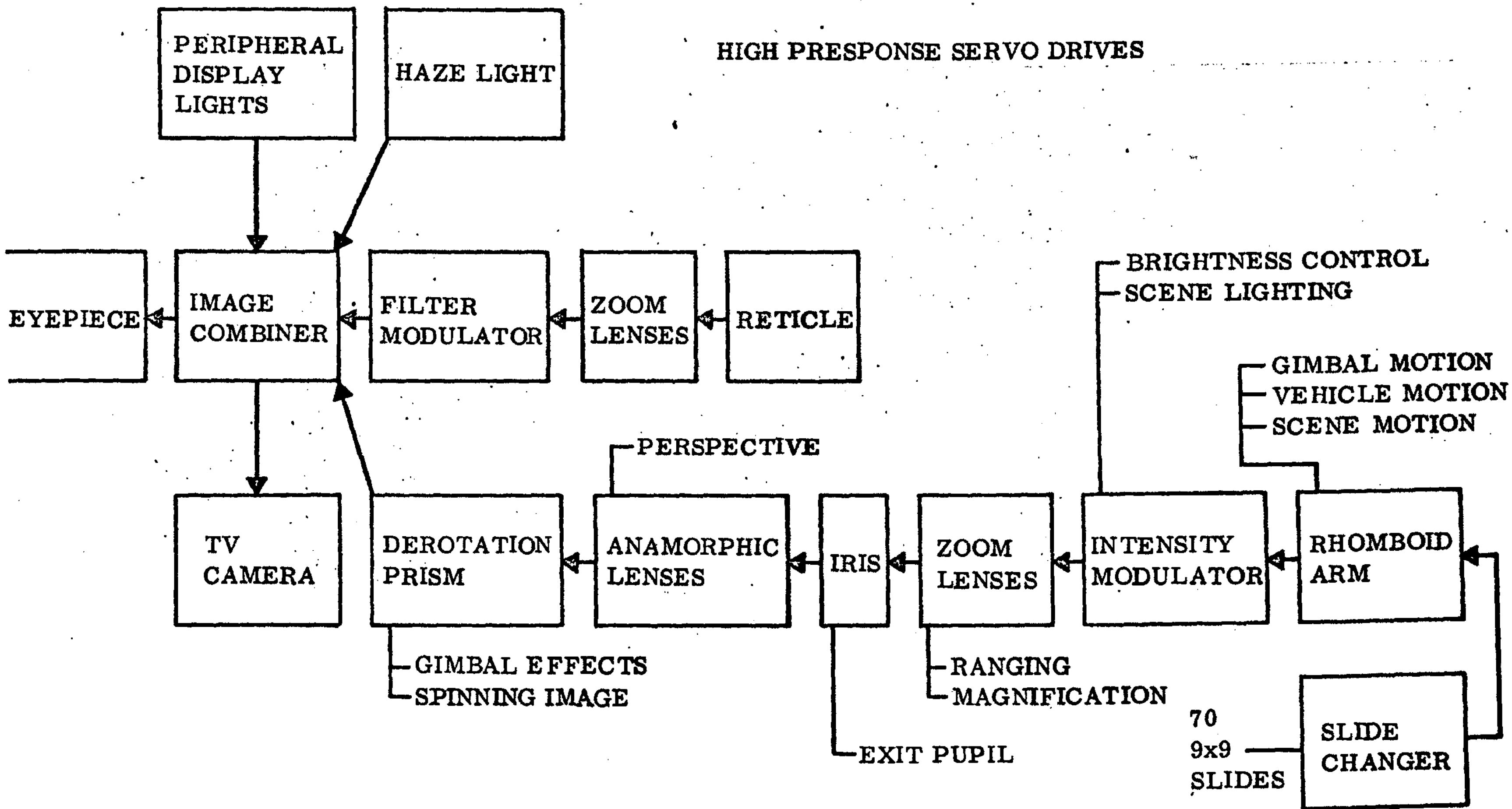

SPECIAL
EFFECTS
RETICLE
HAZE
PERIPH D
SVS
GRD SCENE
ASPECT, S.R.
POINT ERROR
LIGHTING
POWER
CONDITIONING
POWER
SERVO ELEC.
LOGIC
360/44
930/360
ADAPTER
CREWMAN
EYEPIECES
CONTROLS
AND
DISPLAYS
MAG., X-Y
VOTES, CUES
TIMING
SLM
JUNCTION
BOX
DIG. I/F UNIT
HARDWARE TO
COMPUTER
DATA
TRANSFER
SDS 930
HYBRID
INTERFACE
BECKMAN
2200
INSTRUCTOR
SCC
SIMULATOR CONTROL
MONITOR EYEPIECES (T.V.)
MONITOR DISPLAYS AND
CONTROLS
CRT/KEYBOARD

OPTICAL SYSTEM

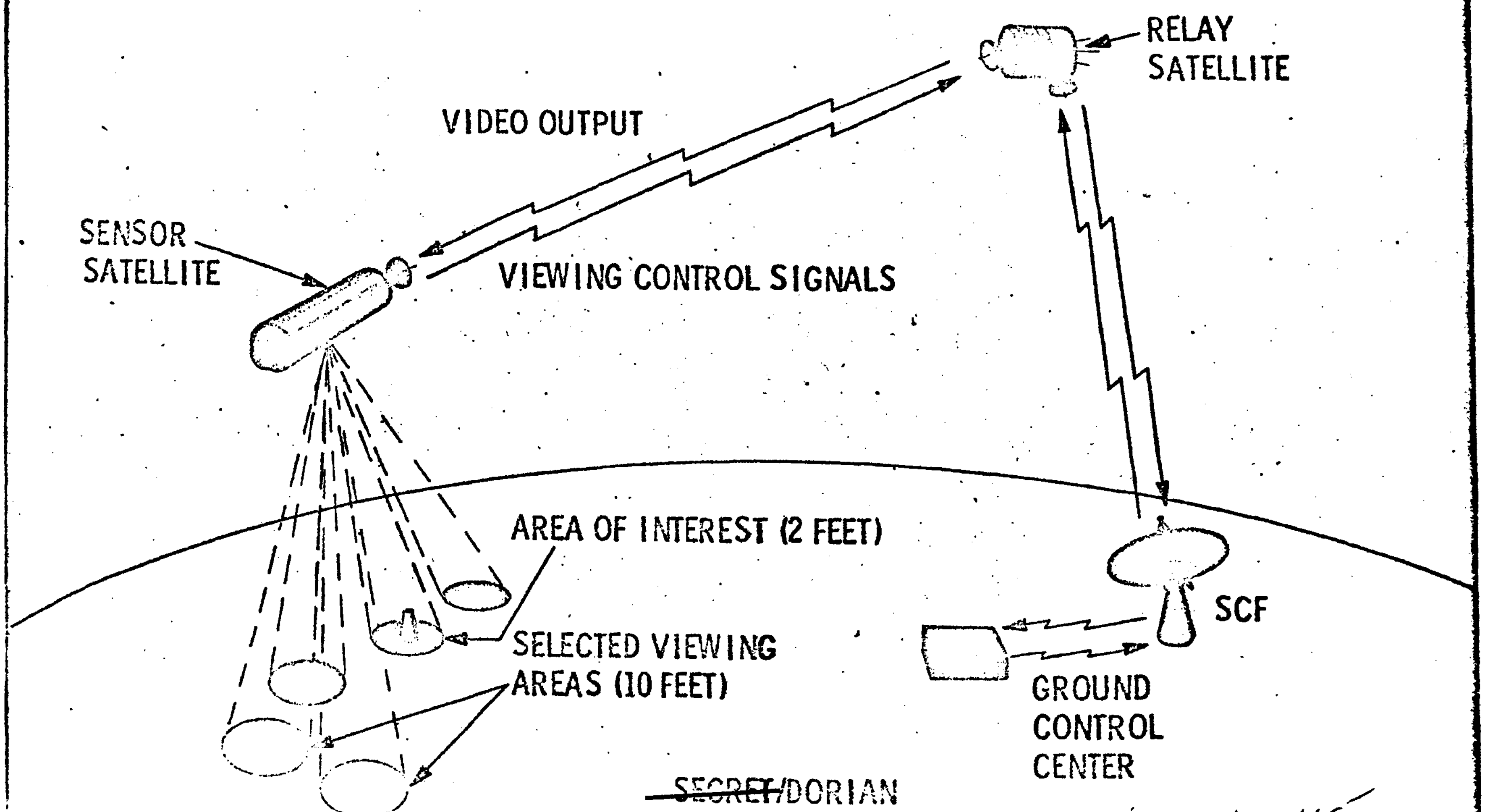
HIGH RESOLUTION (80 LP/MM AT 2:1 CONTRAST RATIO)

FIELD OF VIEW - 60°

HIGH PRESPONSE SERVO DRIVES

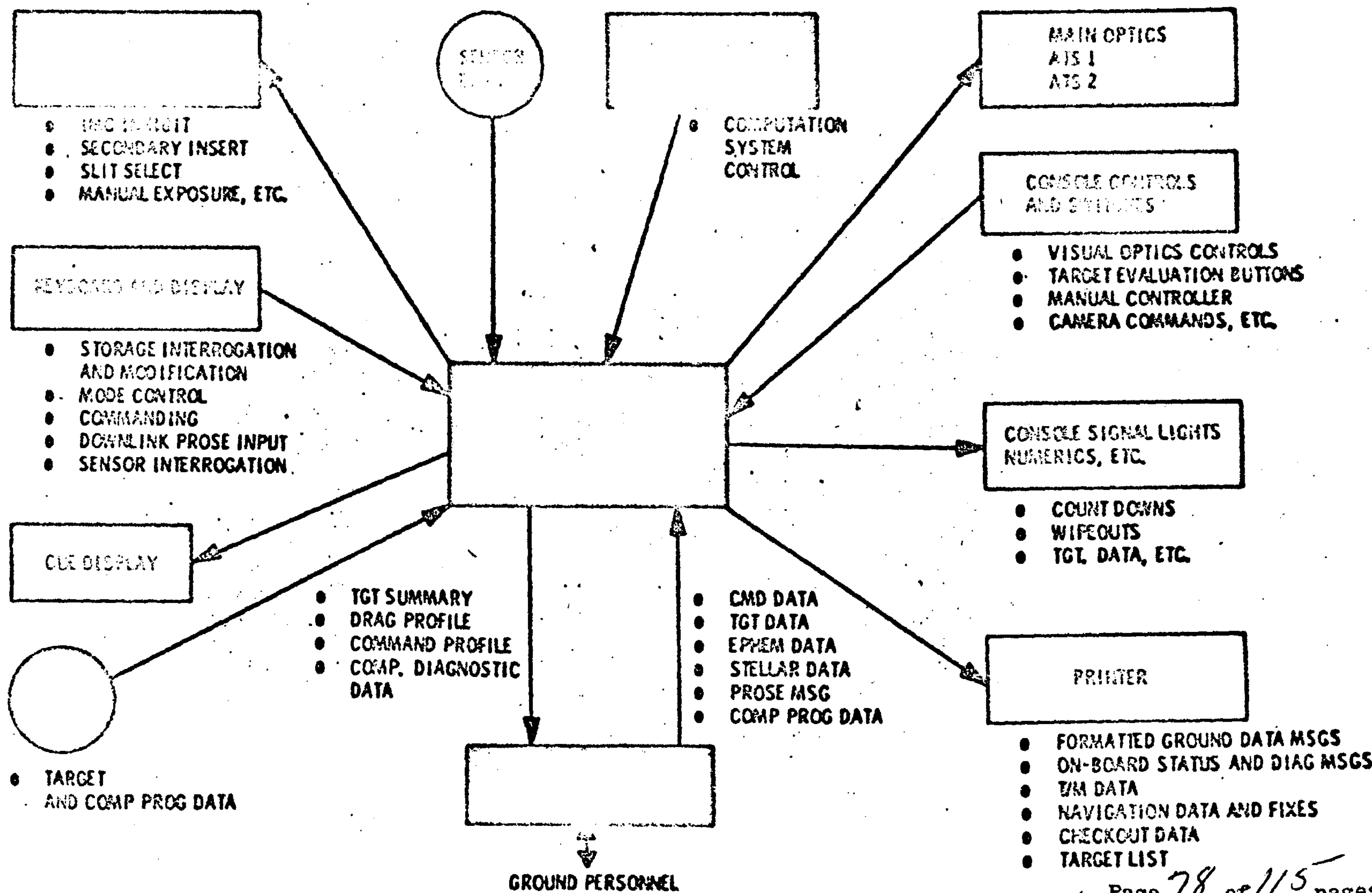


SYSTEM CONCEPT



MOL SOFTWARE

CREW/SOFTWARE INTERFACE



- SUBSYSTEMS
- TECHNOLOGY

MOL APPLICATION OF IMAGE VELOCITY SENSOR SYSTEM

- AUTOMATIC REDUCTION OF IMAGE RATE DURING TARGET TRACKING FROM 600 μRAD/SEC TO 10 μRAD/SEC (0.3 IN./SEC TO 0.005 IN./SEC)*

  [$\frac{1}{16}$ OF THE ANGULAR RATE OF AN HOUR-HAND]

  *WITH [redacted] FL OPTICS

POTENTIAL IMAGE VELOCITY SENSOR SYSTEM APPLICATIONS

- ULTRA-PRECISE, AUTOMATIC VELOCITY (RATE) MEASUREMENT AND/OR CONTROL VIA OPTICAL MEANS:
  - AUTOMATIC, PRECISE, OPTICAL TRACKING OF TERRESTRIAL, LUNAR, PLANETARY TARGETS
  - AUTOMATIC, PRECISE, OPTICAL TRACKING OF SATELLITES OR BOOSTERS DURING POWERED FLIGHT

IMAGE VELOCITY SENSOR SYSTEM HARDWARE STATUS

IMAGE VELOCITY SENSORS

- HYCON
  - FLIGHT DESIGN 60% COMPLETE
  - COMPONENT TESTING 50% COMPLETE
  - PROTOTYPE ASSEMBLY COMPLETE
  - PROTOTYPE TESTING COMPLETE
  - PERFORMANCE VERIFIED BY TESTING
- GOODYEAR
  - FLIGHT DESIGN 80% COMPLETE
  - COMPONENT TESTING 70% COMPLETE
  - PROTOTYPE ASSEMBLY COMPLETE
  - PROTOTYPE TESTING COMPLETE
  - PERFORMANCE VERIFIED BY TESTING

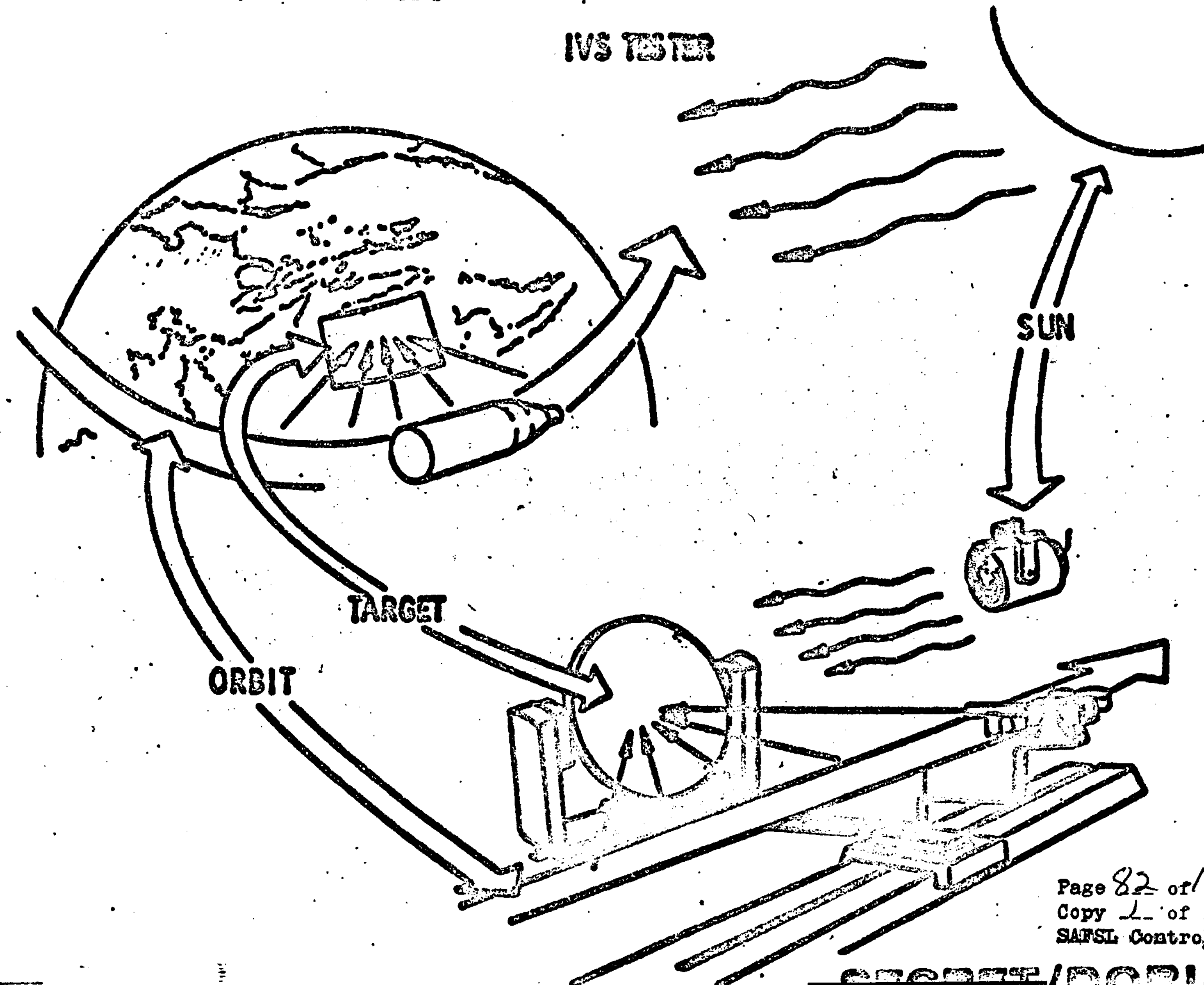
BENCH TESTER

- COMPLETE - USED IN GE/IVS TEST PROGRAM

ORBITAL IMAGE DYNAMICS SIMULATOR (BETA TESTER)

- COMPLETE - USED IN GE/IVS TEST PROGRAM

IVS TESTER



MOL APPLICATION - ATTITUDE REFERENCE SYSTEM

- PRECISE DETERMINATION OF TRACKING MIRROR ATTITUDE WITH RESPECT TO STELLAR REFERENCE
  - REDUCED OPTICAL POINTING ERROR DUE TO ATTITUDE ERRORS ALONE FROM 0.5^{0} TO 0.03^{0}
  - DECREASED TARGET - MISS PROBABILITY FROM 32% TO 0.01%

POTENTIAL ATTITUDE REFERENCE SYSTEM APPLICATIONS

- PRECISE KNOWLEDGE OF COMPONENT/ASSEMBLY ATTITUDE RELATIONSHIP TO A STELLAR REFERENCE FRAME
  - PRECISE, AUTOMATIC POINTING OF OPTICAL SENSORS, LASERS, COMMUNICATION ANTENNAS, RADAR ANTENNAS
  - AUTONOMOUS NAVIGATION DURING PERIODS WHEN GROUND TRACKING IS NOT AVAILABLE OR IS INSUFFICIENTLY ACCURATE

MOL APPLICATION - GIMBAL DRIVE SYSTEMS

- PRECISE CONTROL OF THE MAIN AND ATS TRACKING MIRRORS TO PRODUCE RAPID AND SMOOTH TARGET TRACKING

POTENTIAL GIMBAL DRIVE SYSTEM APPLICATIONS

- ULTRA-PRECISE CONTROL OF OPTICAL SENSORS, RADAR AND COMMUNICATION ANTENNAS, AND LASERS

APPLICATIONS & RECOMMENDATIONS

USE OF ACQUISITION SUBSYSTEM* ON APOLLO/APOLLO APPLICATIONS PROGRAM

- NASA APPLICATION IN
  - LUNAR OPERATIONS
  - EARTH RESOURCES
  - PLANETARY FLY-BY
  - AUTONOMOUS NAVIGATION
- NAVY EXPERIMENTS
  - OCEAN SURVEILLANCE
- USAF EXPERIMENTS
  - RECONNAISSANCE
  - SURVEILLANCE

* MOL SIMULATOR WOULD BE USED TO SUPPORT APPLICATION

USE OF MOL MISSION SIMULATOR FOR ADVANCED MANNED SYSTEM INVESTIGATIONS

- APOLLO TELESCOPE MOUNT SIMULATOR DEVELOPMENT
- AAP/LEO REMOTE SENSING EXPERIMENTS
- SPACE STATION & SHUTTLE DEVELOPMENT
- REAL-TIME READOUT/CONTROL SYSTEM CONCEPTS
- NON-SPACE APPLICATIONS (ASW, AIR TRAFFIC, ETC)

RECOMMENDATIONS

1. NASA AND DOD VISITS TO GE VALLEY FORGE FOR DISCUSSIONS AND DEMONSTRATIONS

2. COOPERATIVE (DOD/NASA/GE) DEFINITION OF PROGRAMS USING ACQUISITION & TRACKING SYSTEM, THE SIMULATOR AND CITE

3. AS OTHER PROGRAM REQUIREMENTS DEVELOP, DECLASSIFICATION OF ELEMENTS OF THE ACQUISITION & TRACKING SYSTEM, THE SIMULATOR AND CITE

URGENT ADMINISTRATIVE RECOMMENDATIONS

1. RELIEF FROM PROVISIONS OF MESSAGE [redacted] 2117 TO PERMIT FREE DISCUSSION AND SALES ACTIVITY ON ALL MOL TECHNOLOGY, EXPERIENCE, AND HARDWARE EXCEPT THAT PROTECTED BY DORIAN CLASSIFICATION

2. APPROVAL TO CONTACT DORIAN CLEARED GOVERNMENT OFFICIALS TO DISCUSS APPLICATIONS WITHOUT SPECIFIC PRIOR APPROVAL

3. APPROVAL TO USE THE SIMULATOR, IVS TESTER AND OTHER EQUIPMENT TO DEMONSTRATE MOL TECHNOLOGY AND HARDWARE

4. APPROVAL TO PROPOSE USE OF MOL HARDWARE AND EQUIPMENT AS GFE

5. RETENTION OF MOL SIMULATOR, IVS TESTER AND COMPUTERS WITH PERIPHERAL EQUIPMENT BY EXCLUDING FROM MANDATORY SCREENING AND INVENTORY PROCEDURES UNDER TERMINATION PENDING DEFINITION OF APPLICATIONS

6. AGREEMENT TO GRANT LIMITED NUMBER OF DORIAN CLEARANCES NECESSARY TO DEVELOP APPLICATIONS

D

SCIENTIFIC VALUE OF MOL ASTRONOMY

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D ~~SECRET~~

V2020-5

WHY SPACE ASTRONOMY?

- BETTER 'SEEING'
- EXTENDED SPECTRUM
- REDUCED NIGHT-SKY RADIATION
- UNIVERSAL VIEWPOINT
- IMPROVED OPTICAL FIGURE

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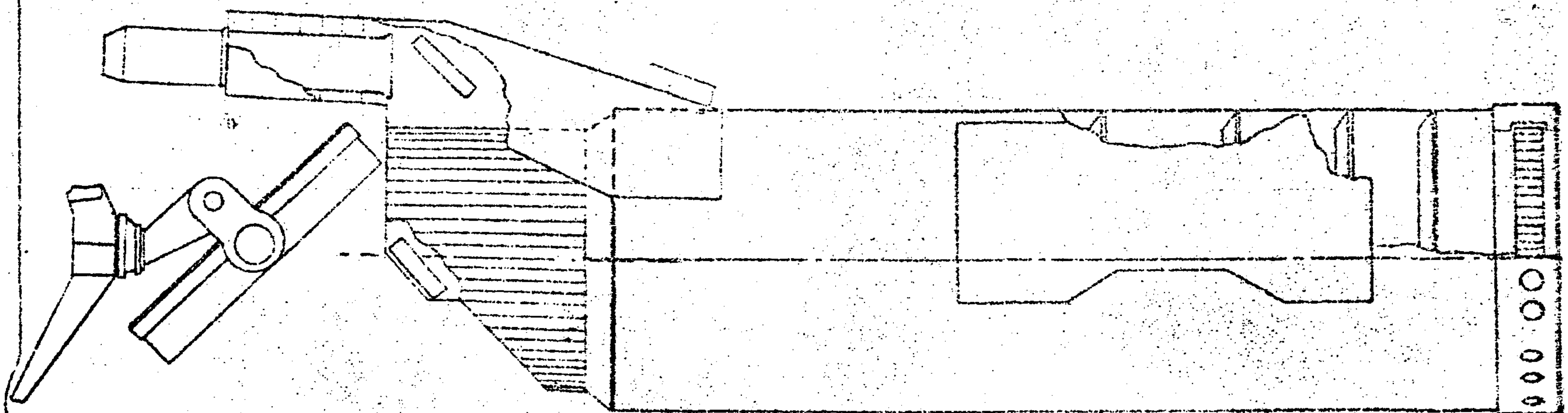
COPY 2

CONFIGURATION CHANGES



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HANDLE VIA BYEMAN
CONTROL SYSTEM ONLY

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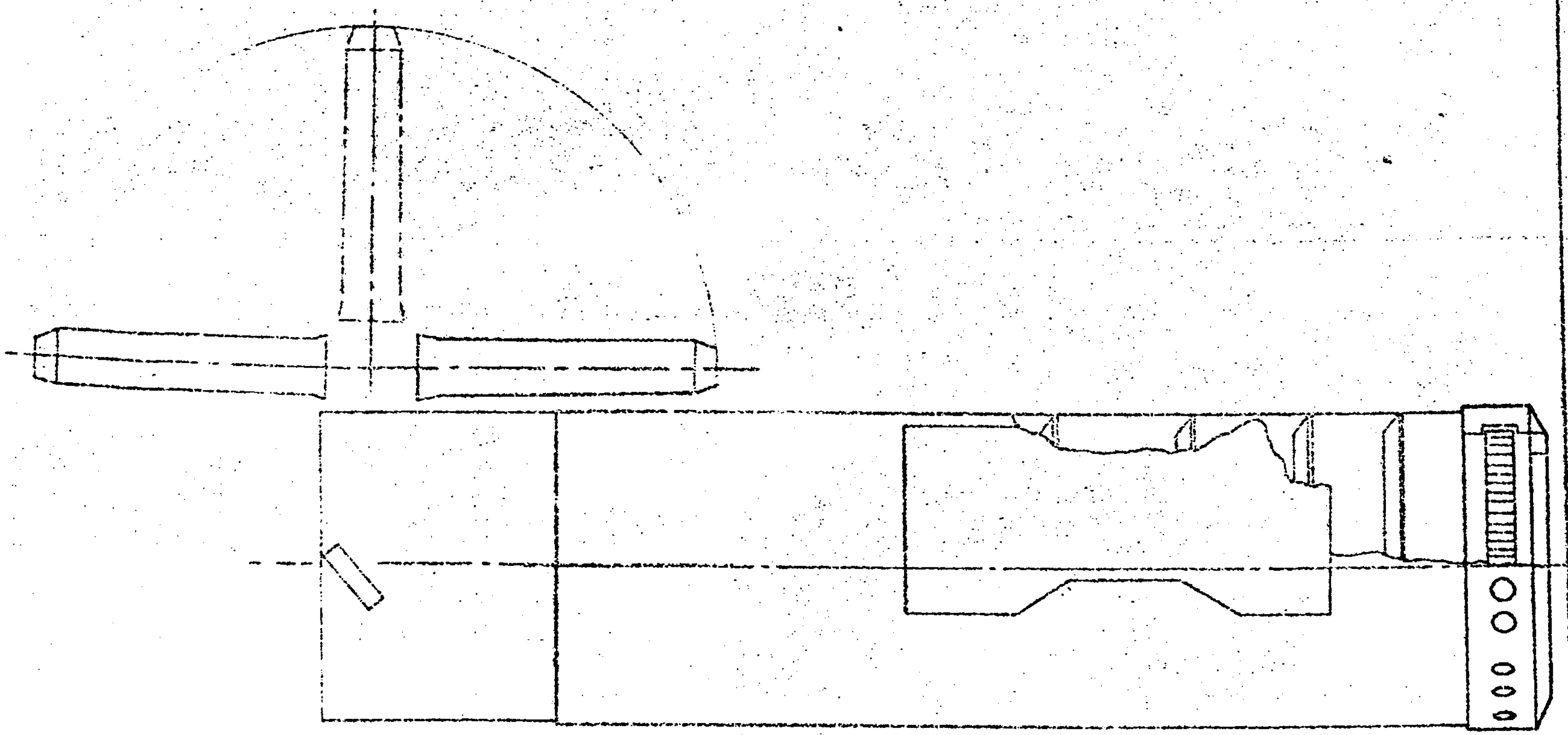
[redacted]

CONFIGURATION CHANGES



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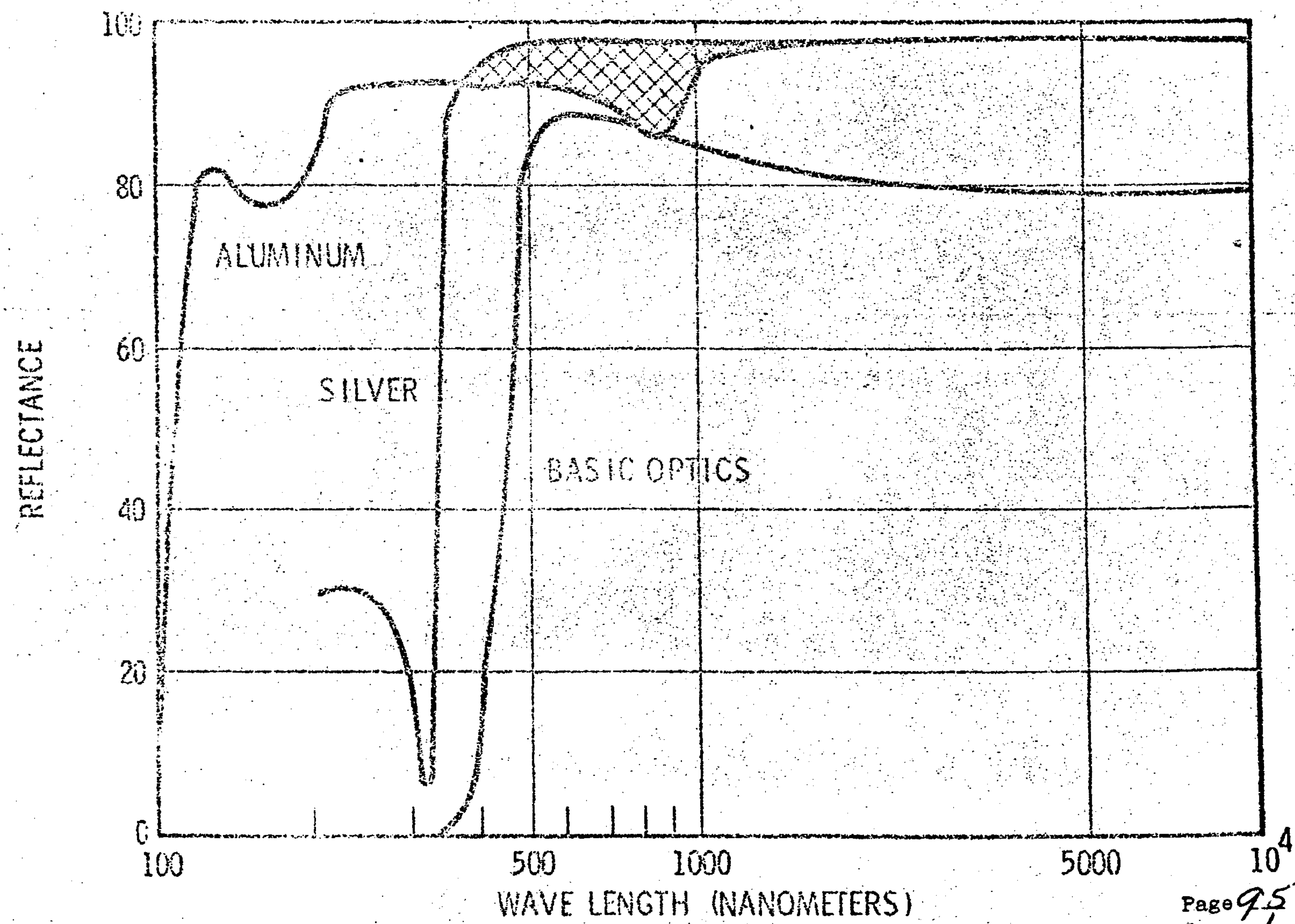
REFLECTANCE OF ALUMINUM VS SILVER



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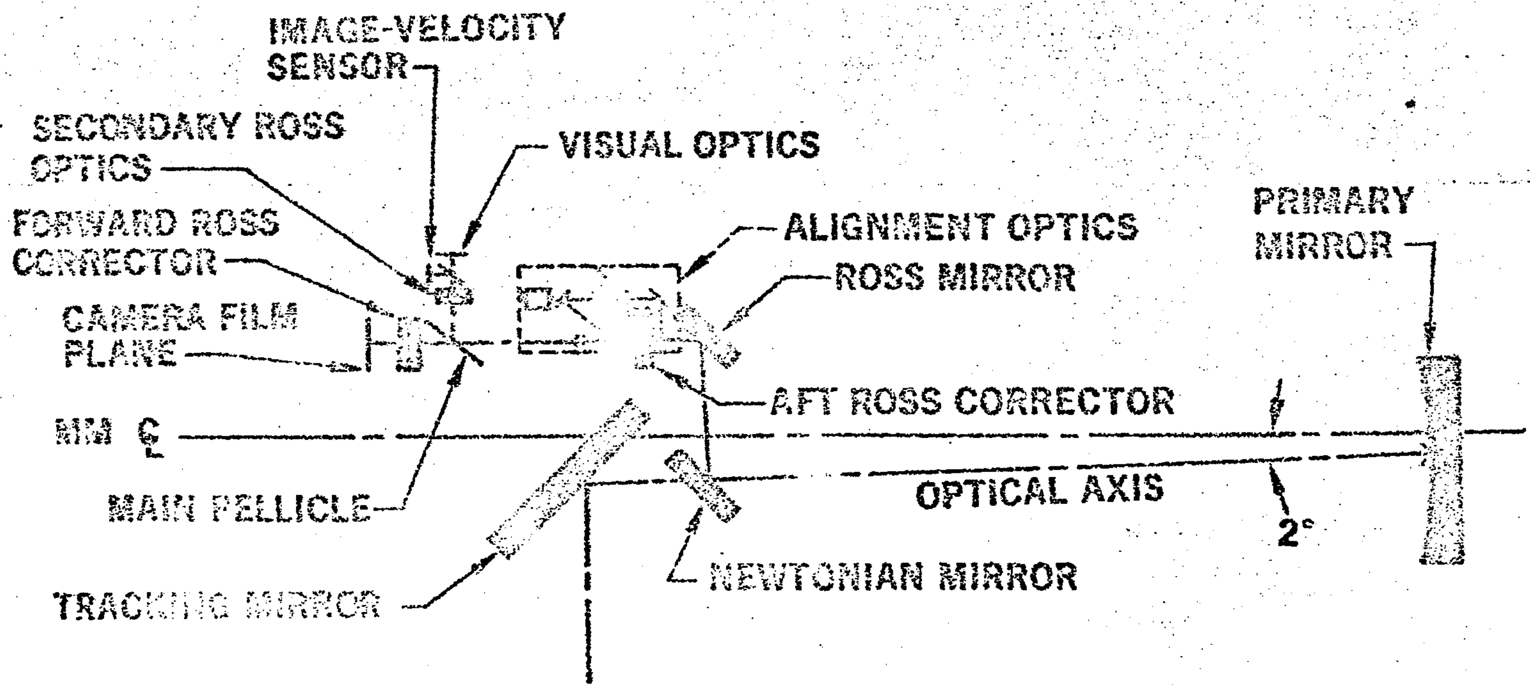
COPY 2

MOL/DORIAN OPTICAL CONFIGURATION



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HANDLE VIA BYEMAN
CONTROL SYSTEM ONLY

~~SECRET~~

OPTIONAL ASTRONOMY COMPONENTS

- CAMERAS AND INSTRUMENTATION
- INSTRUMENT AIRLOCK ON WORKSHOP
- PASSIVE TELESCOPE COOLING
- SECONDARY OPTICS
- OPTICAL STABILIZATION

STELLAR OBSERVATIONS

- RESOLUTION OF CLOSE BINARY STARS
- UV SPECTROPHOTOMETRY OF O AND B TYPE STARS
- UV SPECTROSCOPY OF NEBULAE
- HIGH RESOLUTION RADIOMETRY OF IR SOURCES
- DOPPLER SHIFT IN O AND B TYPE STARS
- UV LUMINOSITY-SENSITIVE LINES IN O AND B STARS
- SEARCH FOR INTERSTELLAR H_2
- UV POLARIMETRY FOR INTERSTELLAR DUST
- COLOR PHOTOGRAPHY OF ALL SOURCES

NRO APPROVED FOR RELEASE 1 JULY 2015

/DORIAN

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COPY 2

SURFACE RESOLUTION

OBJECT	DIAMETER (ARC SEC)	OBJECT DIA (NM)	DIST (A.U.)	IMAGE SIZE (mm)	RESOLUTION (NM) DORIAN	RESOLUTION (NM) EARTH (0".5)
MERCURY	12.7	2600	0.52	0.79	29	105
VENUS	64.5	6600	0.27	3.98	15	54
MARS	25.1	3650	0.37	1.55	21	75
ASTEROIDS	- -	1-420	1.3-2.3	- -	70-125	250-450
JUPITER	50.0	75,500	3.93	3.08	216	780
SATURN	20.6	63,500	8.00	1.27	415	1480
URANUS	4.2	25,500	17.27	0.26	910	3200
NEPTUNE	2.4	24,000	28.75	0.15	1500	5400
PLUTO	0.6	5,000 ?	38.0	0.04	2000	7100
SUN	1950 (32' 25")	750,000	1.0	120.0	55	195
MOON	1867 (31' 07")	1880	- -	115.0	0.143 (870FT)	0.5 (3000 FT)

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CONTROL SYSTEM ONLY

~~SECRET~~/DORIAN

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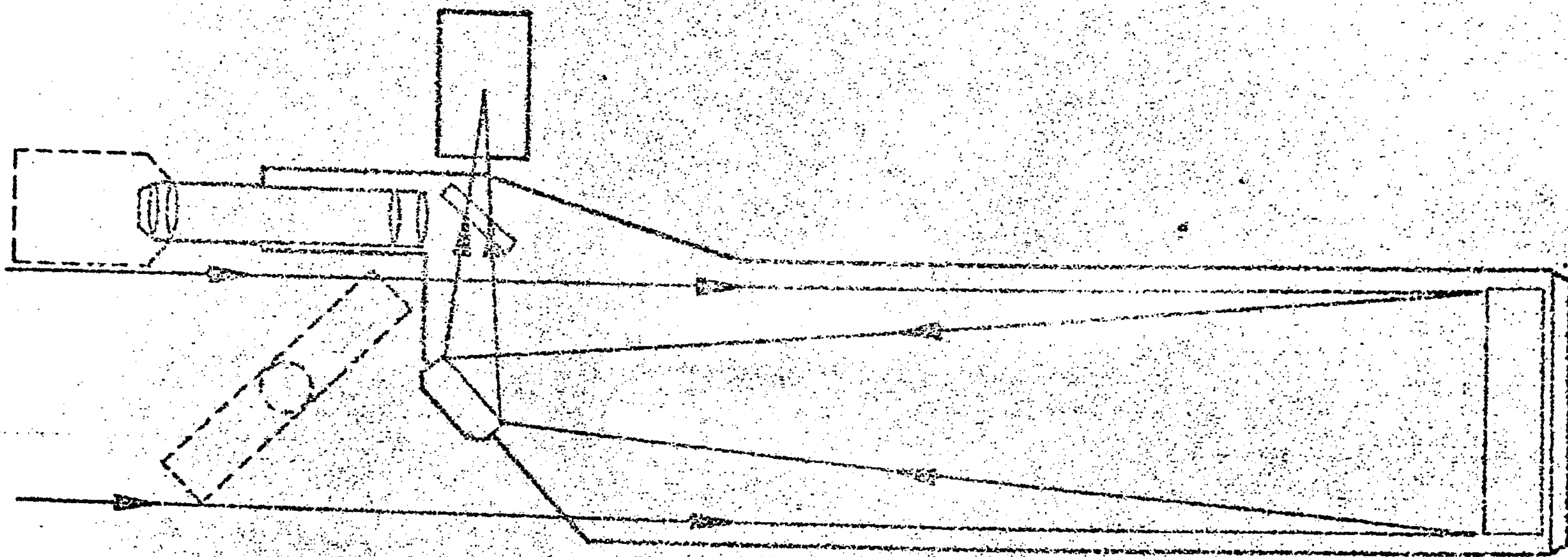
OPTICAL PATH ALTERNATIVES



NEWTONIAN FOCUS

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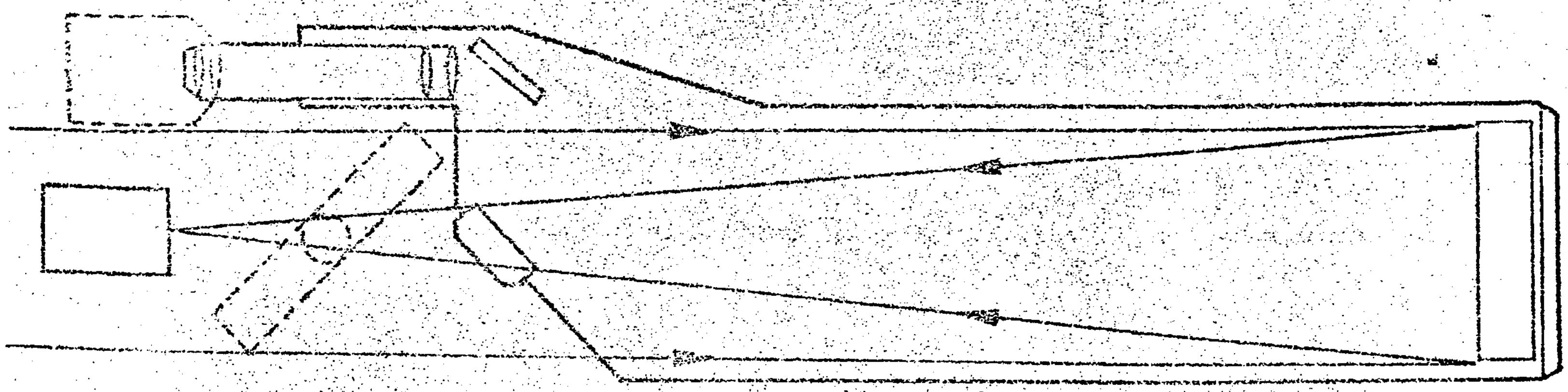
OPTICAL PATH ALTERNATIVES



PRIME FOCUS

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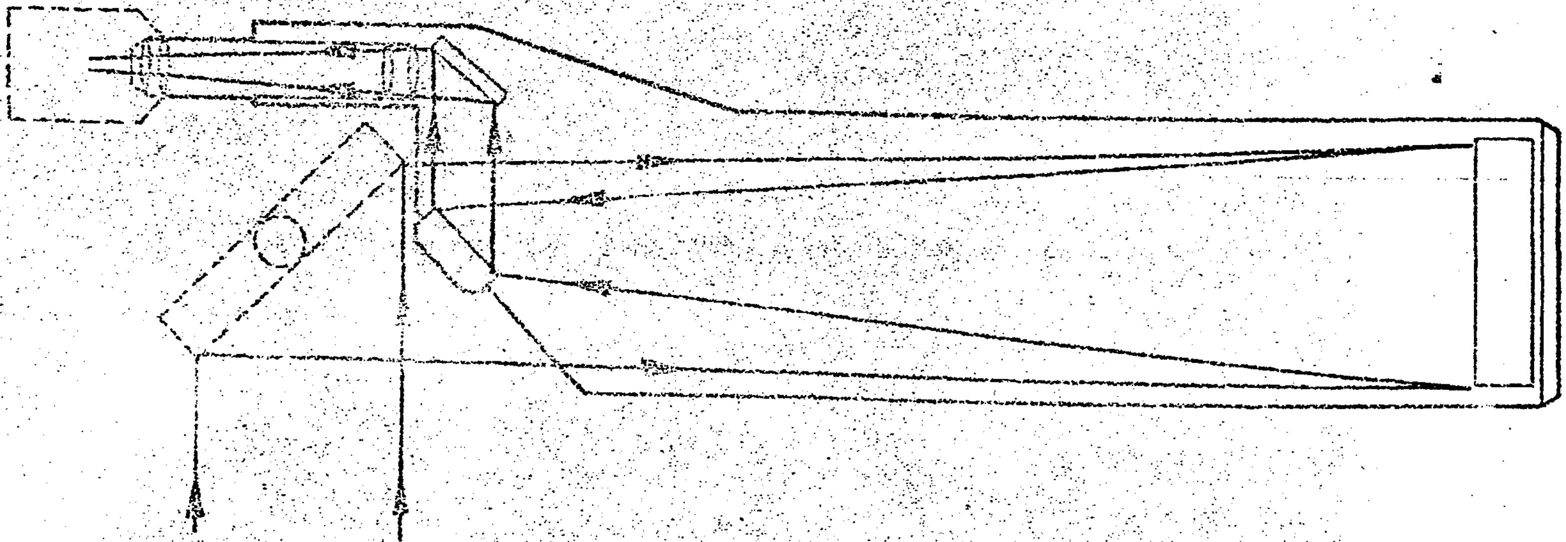

DORIAN SYSTEM

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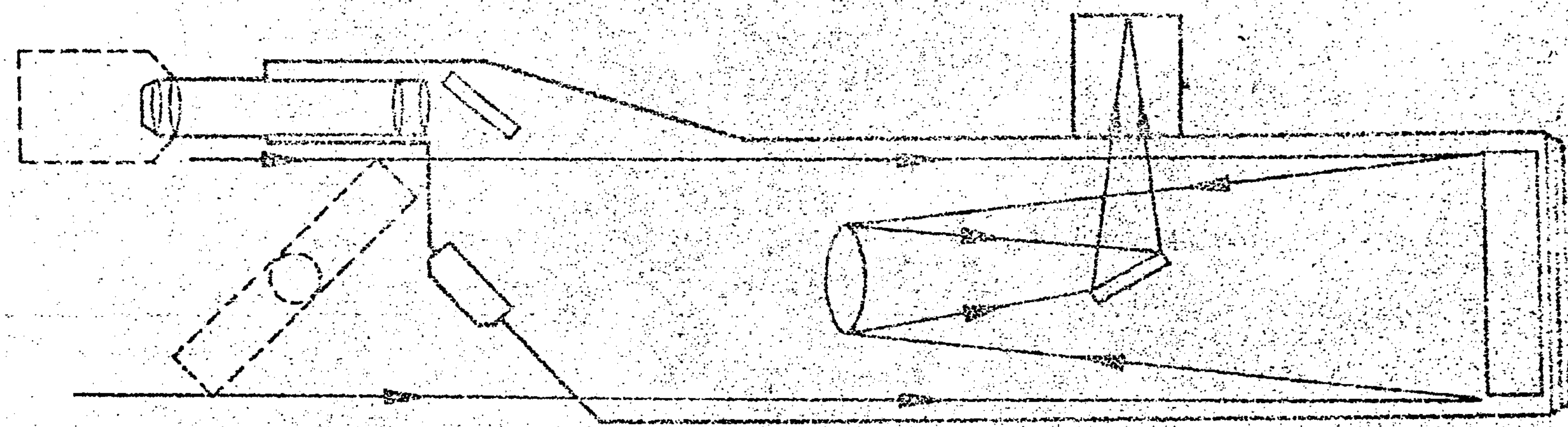

COUDE' FOCUS

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USE OF COMPONENTS

OPTICAL ASSEMBLY

LENS ASSEMBLY

PRIMARY MIRROR, DIAGONAL MIRROR, ROSS CORRECTOR, ALIGNMENT ASSEMBLY, COMPOSITE TUBE

THERMAL CONTROL - HEATERS, HEATER CONTROLLERS, INSULATION

ELECTRICAL CONTROL

INSTRUMENTATION

PRIMARY MIRROR LAUNCH - LOCK ASSEMBLY

COA UNIBAL MOUNT STRUCTURE

[redacted]

PLUS: MANUFACTURING AND TEST FACILITIES

RED FOIL

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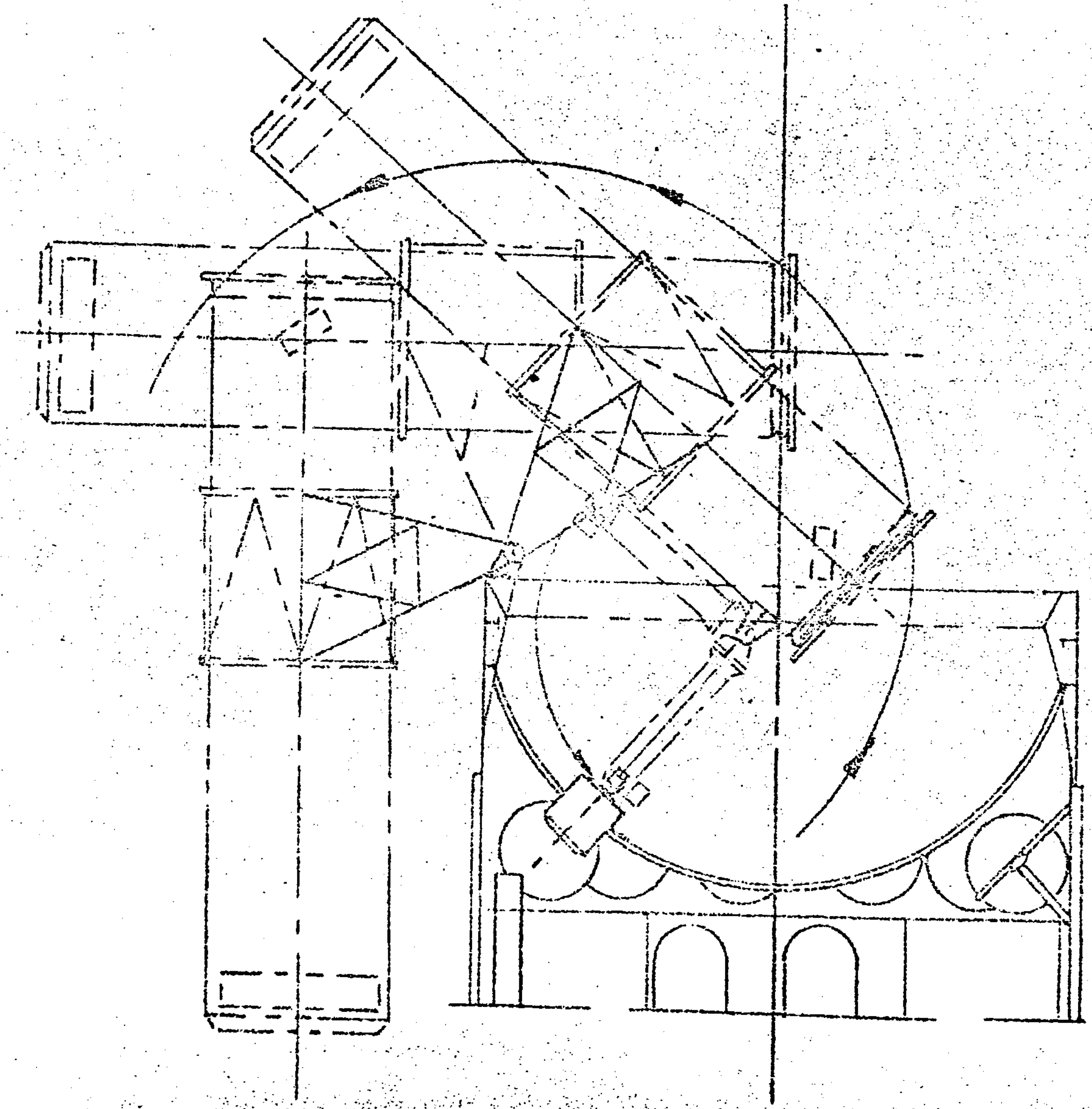
WORKSHOP AFT MOUNTING



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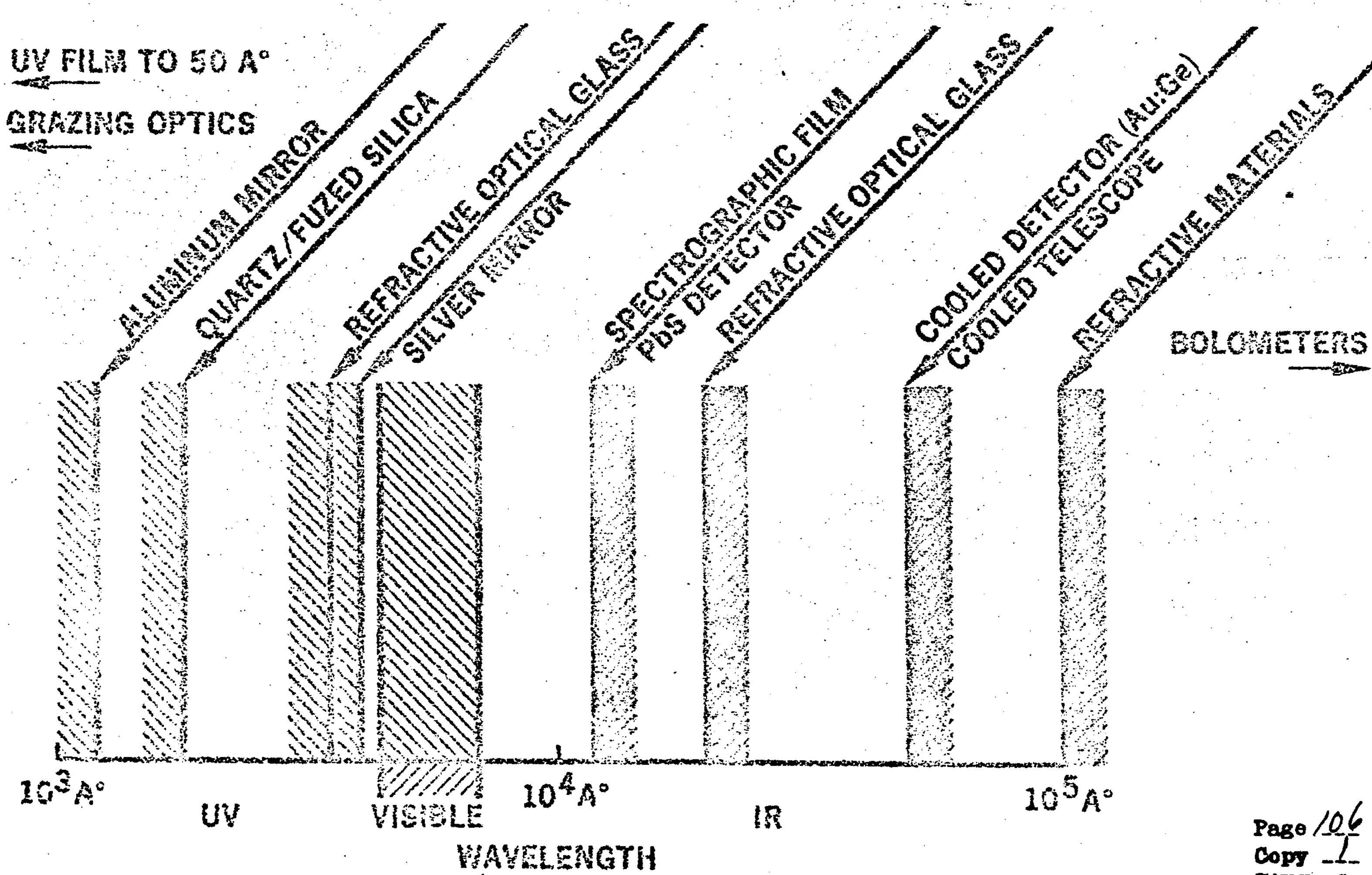
V2021-1

SPECTRAL INSTRUMENTATION



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DORIAN MOL ASTRONOMY
PERFORMANCE

- OPTICS ———— 70" DIA [redacted]
- RESOLUTION ———— [redacted]
- FIELD OF VIEW ———— 1.08°
- TRANSMISSION ———— 400 TO 1000 + NANOMETERS
- EXPOSURE RANGE ———— 0.0025 TO 0.080 SECONDS
- STABILIZATION ———— [redacted]/SEC
- RECORD ———— CHOICE OF FILMS
- OBSERVATION TIME ———— 3 CONSECUTIVE REVS/DAY

DORIAN

DORIAN MOL ASTRONOMY
PERFORMANCE

NEW ASTRONOMY PERFORMANCE

- OPTICS ——— 70" DIA [redacted]
  DOUBLE LIGHT GATHERING POWER
- RESOLUTION ——— [redacted]
  IMPROVED - LESS OPTICAL ELEMENTS
- FIELD OF VIEW ——— 1.05° REDUCED
  LARGE F.O.V. NOT REQUIRED
- TRANSMISSION ——— 400 TO 1000 + NANOMETERS
  GREAT INCREASE 100 TO 6000 NM
- EXPOSURE RANGE ——— 0.0025 TO 0.080 SECONDS
  AS REQUIRED NO LIMIT
- STABILIZATION ——— [redacted]/SEC
  GREAT IMPROVEMENT
- RECORD ——— CHOICE OF FILMS
  WIDE CHOICE OF INSTRUMENTS
- OBSERVATION TIME ——— 3 CONSECUTIVE REVS/DAY
  ESSENTIALLY UNLIMITED

REQUIRED ASTRONOMY COMPONENTS

- TELESCOPE MOUNT
- TRACKING SYSTEM
- FOCUS/ALIGNMENT SYSTEM
- SUNSHADE
- MIRROR COATING

~~SECRET~~

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MARS OBSERVATIONS

- ATMOSPHERIC CIRCULATION PATTERNS
- WIND VELOCITIES AND DURATIONS
- SEASONAL CHANGES
- DIURNAL VARIATIONS
- IMPROVED CARTOGRAPHY
- GEOLOGICAL STRUCTURE

	MOL	EARTH
RESOLUTION	21	75

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JUPITER OBSERVATIONS

- CIRCULATION OF ZONES AND BELTS
- VERTICAL STRUCTURE OF ATMOSPHERE
- DYNAMICS OF RED SPOT
- CIRCULATION AROUND RED SPOT
- EVIDENCE OF 'TAYLOR COLUMN'
- SURFACE DETAILS OF SATELLITES

	MOL	EARTH
RESOLUTION	216	780

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SATURN OBSERVATIONS

- ATMOSPHERIC CIRCULATION
- COLOR OF CLOUDS
- 'SURFACE' DETAILS
- STRUCTURE OF RINGS
- RESOLUTION OF NATURAL SATELLITES
- ATMOSPHERE ON TITAN
- POLAR FLATTENING

	MOL	EARTH
RESOLUTION	415	1480

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PLANETARY OBSERVATIONS

- HIGH RESOLUTION CHARTS OF MARS
- SYNOPTIC TIME LAPSE METEOROLOGY ALL PLANETS
- CIRCULATION PATTERNS ON MARS, JUPITER
- HIGH RESOLUTION IMAGES OF DISTANT PLANETS
- DETAILS OF NATURAL SATELLITES
- DETAILS OF COMETS COMPOSITION, STRUCTURE
- COMPOSITION OF PLANETARY ATMOSPHERE AND SURFACE
- ASTEROID SHAPES, SIZE, ORBITS, COMPOSITION
- COLOR PHOTOGRAPHY ALL OBJECTS

SOLAR OBSERVATIONS

- HIGH RESOLUTION TIME LAPSE OF SOLAR ACTIVITIES
- FILTERGRAMS OF CHROMOSPHERIC STRUCTURE
- IR AND WHITE LIGHT OBSERVATION OF OUTER CORONA

FUTURE ACTION

- DETERMINE STATUS OF EXISTING COMPONENTS
- PREPARE PROGRESSIVE MODIFICATION/COST ANALYSIS
- DEFINE OBSERVATIONAL OBJECTIVES
- EVALUATE ALTERNATE MODES OF USE
- SELECT/DESIGN REQUIRED INSTRUMENTS
- INTEGRATE TELESCOPE ON WORKSHOP/VEHICLE
- SUPPORT OPERATIONAL PROGRAM
- EVALUATE ALTERNATE OPTICAL CONFIGURATIONS

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