NRO APPROVED FOR
[redacted]1 JULY 2015

COMPLETED

~~SECRET~~

NRL Memorandum Report 1507

Copy No. 2[illegible] of 25 Copies

MANNED ORBITAL LABORATORY TECHNICAL PANEL

FIRST PRELIMINARY REPORT (U)

DR. W. C. HALL, CHAIRMAN

17 March 1964

Exempt from Distribution to Defense Documentation Center in Accordance with DOD Instruction 5100.38.

U. S. NAVAL RESEARCH LABORATORY
Washington, D.C.

1st half 64

~~SECRET~~
Excluded from automatic downgrading and declassification.

6403772

CONTENTS

APPENDIX A

Copies of Recommended Experiments
as Submitted to Manned Orbital Laboratory Technical Panel

~~SECRET~~

CONTENTS (CONT'D)

APPENDIX B

~~SECRET~~

LIST OF FIGURES

LIST OF TABLES

REFERENCES

(a) BUWEPS Secret ltr RT-11:RFS Ser 00316 of 7 Feb 1964, Subj: Technical Panel for Manned Orbital Laboratory Experiments; formation of

(b) NRL Conf ltr 7000-9:WCH:jsk of 3 Mar 1964, Subj: Minutes of Meeting of Manned Orbital Laboratory Technical Panel 27-28 Feb 1964 (U)

(c) INS "STARLIGHT Study Summary Report - Volume I" of Sep 1962

SECURITY

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or revelation of its contents in any manner to an unauthorized person is prohibited by law.

NRL Memo Rpt 1507
17 March 1964

~~SECRET~~

MANNED ORBITAL LABORATORY TECHNICAL PANEL

FIRST PRELIMINARY REPORT

Section I

Introduction

The Secretary of Defense has recently announced a manned space project which has been designated the Manned Orbital Laboratory (MOL). The Air Force is to manage this project. The MOL program is to have a twofold purpose; basically it is intended to assess man's utility and ability to perform a military mission in space; secondarily, it will include those military experiments which can make best use of the MOL vehicle and which at the same time can be accommodated. Since the National Aeronautics and Space Administration may also enter into the program, other than military experiments may be carried. The MOL program presents an excellent opportunity for the Navy to investigate and establish man's usefulness in space in the performance of naval missions. The investigations of the MOL program are intended to test or check only those components or parts of a military system which require the presence of man in space to determine the potential usefulness of the complete military system which could follow.

At present the MOL program stands in need of justification within the Department of Defense in order to obtain the necessary approvals for the preparation of a complete technical development plan as a first step in getting the program under way.

In order to prepare the Navy's plan for MOL experiments, by reference (a) the Bureau of Naval Weapons established a MOL Technical Panel composed of members from each bureau, the Office of Naval Research, the Institute of Naval Studies, and such other naval field activities or laboratories as were interested in or capable of making a contribution. The Naval Research Laboratory was requested to act as host activity and to designate the Panel chairman. The function of the Panel was to generate in detail a series of space experiment proposals suitable for flights on the MOL. A summary report recommending an array of experiments and supported by preliminary cost estimates, development schedules, experiment plans, and recommended sponsors for each experiment (a Navy laboratory or a contractor) was to be submitted to the Bureau of Naval Weapons for approval and ensuing action to assign specific follow-on responsibility and for funding support.

The first meeting of the MOL Technical Panel took place on 27-28 February 1964 at the Naval Research Laboratory under the chairmanship of Dr. W. C. Hall of the NRL. Minutes of this meeting have been provided to all participants (reference [b]). Those in attendance at this meeting as members of the MOL Technical Panel are listed in reference (b).

While further meetings of the MOL Technical Panel will be needed to complete the assignment of the Panel, the urgent time schedule now being followed in the development of the MOL program makes it advisable to submit a preliminary report at the present time. This preliminary report will discuss in some detail the concept for experiments bearing upon the Navy missions and provide all information that is available at the present time. It will also list briefly some of the more important work yet remaining to be done. The text of the report has not been circulated to Panel members for concurrence, again owing to lack of time, and hence represents the opinions and work of only a small number of the whole Panel. For this report, therefore, the Chairman alone must accept responsibility.

The guidelines provided by the Navy for the MOL Technical Panel were simply the following: that ocean surveillance, anti-submarine warfare, and command and control missions were to be given primary emphasis.

There were several approaches which could be followed by the Technical Panel in performing its mission. It could proceed logically to develop a series of experiments based upon concepts of the Navy mission to provide global coverage of the oceans; thus the Navy is required to maintain global surveillance over surface shipping. Similarly it needs surveillance over the globe for submarine activity. For both purposes it needs all-weather orbital sensors capable of detecting the presence of and classifying ocean going ships and submarines. In each case the same barrier to progress is reached, namely, the inability of the present state of the art to provide sensors in spacecraft capable of obtaining the necessary information for full performance of the mission.

A second approach being followed by the Space Systems Division of the United States Air Force is to study thoroughly all suggested experiments which can be performed in the following general areas: (1) reconnaissance and surveillance; (2) other missions - including [redacted] satellite survivability; satellite logistics, maintenance, and repair; and finally satellite orbital command posts; (3) bio-astronautics; and (4) general tests or general science.

The approach chosen by the MOL Technical Panel is a variation of the second approach. Thus the MOL Panel chose to consider those military missions which are now possible considering the state of the art, and of interest to the Navy. Each possible experiment needs to be reviewed critically to determine whether it involves man in an essential manner; it needs to be reviewed to determine whether it is of unique Navy interest; it needs to be reviewed to determine whether it is being done now by unmanned satellites. Table 1 presents a number of astronautic missions possible in the time period of 1968-1970 and of interest to the Navy. Opposite each of the astronautic missions there listed may be found an appropriate comment.

Table 1

Astronautic Missions of Naval Interest

Ocean Surveillance	The SAMOS Program of the AF has been active since 1961.
Command and Control	The STARLIGHT Report recommended space-oriented command ships.
General Science	NASA has OSO, OGO, OAO, and Explorer programs under way.
Communications	TELSTAR, RELAY, SYNCOM, LOFTI, COMSAT Programs, etc., are now under way.
Electronic Countermeasures	Of general interest to all Services.
ELINT	--
[redacted]	[redacted]
Meteorology	Present major programs are TIROS, NIMBUS, and the Operational Weather Satellite.
Navigation	TRANSIT and the ADVANCED TRANSIT programs are under way.
Bio-astronautics	NASA has a series of six bio-satellites planned.

(Continued on next page)

(Continued from previous page)

Orbital Defense	The DYNASOAR Program has been cancelled for reasons of economy.
Naval Ocean Data Satellites	NASA has a program for data collection satellites under preliminary study.
Precision Delivery Satellites	No Navy mission is now foreseen.
Logistics, Maintenance, and Repair of Satellites	--
Geodesy	The ANNA Program exists to fill this requirement.
Anti-submarine Warfare	The state of the art is not sufficiently far advanced.

* * *

The MOL Technical Panel received in all 89 experiment proposals, or topic ideas, for Navy astronautic systems. The Panel assumed that astronautics was to be regarded purely as a technology which could be used to improve the capability of the Navy to operate globally and maintain control of the seas. With this assumption, it arrived at the grouping given in Appendix B for these 89 experiments, and shown by Figure 1. It will be seen that the two groups receiving the greatest attention from the MOL Technical Panel members are those of Ocean Surveillance and General Science.

~~CONFIDENTIAL~~

MOL TECHNICAL PANEL

COMPOSITION – NAVAL ACTIVITIES–17

RESULTS –	EXPERIMENTS
OCEAN SURVEILLANCE –	26
COMMAND & CONTROL –	2
GENERAL SCIENCE –	34
COMMUNICATIONS –	3
ELINT –	4
[redacted]	5
BIO–ASTRONAUTICS –	14
GEODESY –	1
	89

Figure 1

~~CONFIDENTIAL~~

Section II

Ocean Surveillance

In view of the obvious importance of ocean surveillance to Navy missions a separate study group consisting of Panel representatives from the Institute of Naval Studies, the Applied Physics Laboratory, the Naval Air Development Center, the Naval Research Laboratory, the Naval Photographic Interpretation Center, and the Bureau of Naval Weapons met at the NRL to develop further this topic. The problem in ocean surveillance is to survey ships, harbors, and ocean lanes. It is necessary to detect and classify all vessels found in either harbors or ocean lanes. The problem is complicated by the fact that the oceans are vast, that the targets are continually on the move, and that good data must be obtained to be useful. Tardy, incomplete, and inaccurate data is of little value. It is obvious that an astronautic system cannot supply the total requirement but only supplement other means of maintaining ocean surveillance. It is probably true that the Navy's problem is not the same as that of the AF or the Army. Thus, the Navy's problem revolves around keeping track of ships on a global basis. The targets are relatively large but continually on the move. Hence, the naval requirement seems to be for a system of nominal resolution and very wide coverage.

Any consideration of the problem of ocean surveillance must begin with an understanding of the state of the art for the available sensors. Table II gives in summary form the most essential information with respect to each possible sensor. Some changes may be required in the final selections. It may be necessary, for example, that an optical system be procured having a 96"-focal-length lens, rather than the 48"-focal-length lens given in the table, to secure the desired resolution of 12' and permit at the same time some degradation of performance of the camera while in the spacecraft. The best choice for radar is similarly unsettled at the present time. Two possible choices are given: one with a rotating antenna system and one without. Note that the radar system with the non-rotating antenna leaves large gaps in the coverage of the earth below the spacecraft. See Figure 2 for coverage obtained with the simple non-rotating antenna proposed.

The concept for ocean surveillance developed by the sub-panel is as follows: there must be advanced detection of all shipping targets followed by classification by the astronaut, appropriate data processing, and read-out by ground stations.

To perform the function of detection in advance of the satellite the most promising sensors seemed to be radar, television, and infrared - in that order. It is desired that this advance detection take place

Table 2

OCEAN SURVEILLANCE
STATE OF THE ART, SENSORS

RADAR	[redacted]
OPTICAL	CA–101, 12′RES., PROCESSOR, 100 1/MM 12″APERTURE, 48″FL
TV	100′RES 24″F.L. F2 F4 LIGHTED SHIPS AT NIGHT, STARLIGHT
I R	[redacted]
I FF	L BAND – 1 DW PEAK – 10W AVER. MILITARY SHIPS – INTERROGATION – CODING 10′ DISH OR – 5′ DISH, DIRECTIONAL
ELINT	HF THRU VHF, LARGELY AVAILABLE
BEACON	UHF, PULSED, NON–MILITARY FRIENDLY VESSELS

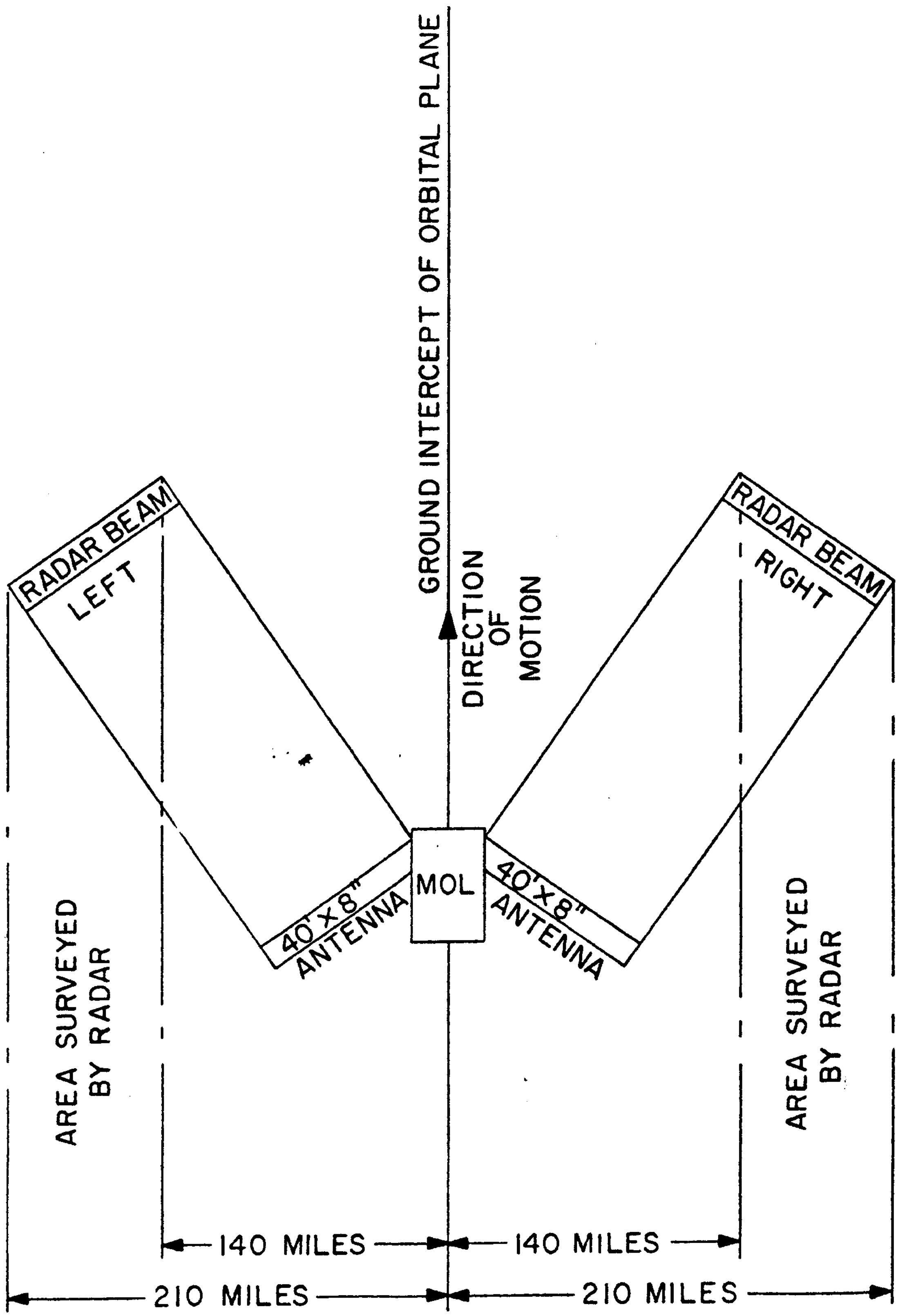


Figure 2 - Coverage obtained with simple non-rotating radar antenna of Table 2

as long as one minute in advance of the time when the spacecraft is over the target on the earth. At the orbital rate of travel of the spacecraft this corresponds to 250 miles; thus the detection range for the broadly scanning sensor systems should be approximately 250 miles in advance of the spacecraft. All-weather radar systems having this capability can be devised. Television and infrared systems can provide initial detection under favorable conditions where the weather is clear or clouds are only thin or broken. It is recognized that optical systems can also perform this function when the weather is clear or when clouds are thin and broken; but optical systems of high-resolution, particularly, are not as well adapted for automatic searching of large areas as is radar.

After the target has been detected the next step involves classification. Here, provided the weather is clear, a set of binoculars having variable magnification and directed by the astronaut to the coordinates indicated by the advance detection means would be used to find the target. If desired, then, through servo controls, the high-resolution camera can be caused to photograph automatically the target under examination by the astronaut. The pictures would be used for detailed study on a deferred basis. If the weather is not favorable, then the astronaut must depend upon other systems to determine friend from stranger. The directivity of an IFF-type interrogating device operating from the radar antenna or a separate 5-foot dish mounted on MOL is good enough to separate ship from ship under most conditions. The ELINT also can provide from coarse to good resolution and separate "friend" from "stranger." The same is true with respect to ultra-high-frequency beacons carried by friendly merchant shipping or aircraft.

The third part of the ocean surveillance concept is that automatic position determination must be provided to the astronaut. This should record automatically the coordinates of any target selected by the astronaut. Such a system can be devised depending upon ephemeris data carried within the orbiting capsule, a gyro-stabilized platform and means for relating the position of the classification device or camera with respect to the MOL vehicle attitude. There must be storage of all classification information provided by the astronaut. It may involve no more than operation of push buttons. There must be capability for command read-out of all data stored at such times as when the MOL capsule is over a friendly ground station desiring such information. Finally, there must be means within the data processing for instructed search to be initiated by ground command and acted upon by the astronaut. The command for instructed search given by the ground stations may be stored automatically for delivery to the astronaut at the proper time in orbit.

AM

ble 2

The astronaut may at times be saturated by targets; therefore, data processing techniques must be employed to reduce this problem. Automation must be provided wherever possible. High-resolution film must be used to record the nature and position of selected visible shipping and harbors and their contents for later study and classification by the astronaut. Provisions for directed search and classification aids are needed to limit demands made upon the astronaut. The several factors involved in the concept of the integration of the hardware for this experiment are shown in Figure 3.

Figure 4 provides a view of the MOL astronaut engaged in ocean surveillance using his search or detection equipment to illuminate areas some 250 miles in advance for detection purposes and using his optical and other systems for inspection of targets detected.

Three situations have been devised to illustrate the usefulness of ocean surveillance capabilities which can be provided the Navy by a manned astronautic system. Figure 5 is the layout for the first situation which illustrates the problem of ocean surveillance with respect to Cuba. There it is required that an unfriendly country be kept under surveillance to determine its shipping both in ocean lanes and in harbors, and the departure ports as well as the terminal ports. In the performance of this mission the astronaut provides the following contributions: (1) he can be selective and look only for certain kinds of shipping; (2) he can concentrate on certain areas and spend the whole of the time he is in the area of a fixed target (e.g., Havana - approximately two minutes) in surveillance of that target alone; (3) he can filter out a target from a low contrast or noisy background; (4) he can give rapid response to a command for search, the time required, if his orbit is over the target, being less than the orbital period; (5) he can make optimum choice of the sensors to be used; (6) he can optimize performance of the system by providing necessary adjustments; (7) he can improve reliability; (8) he can enhance accuracy. One further point in favor of man is that our capacity as a nation to orbit increasing payload, thus enabling man and his necessary environment to be included, seems likely to improve at a faster rate in the next ten years than is our capacity to orbit reliable, sophisticated systems able to replace man.

Situation 2 shown in Figure 6 depicts a condition existing when directed search is to be instituted by ground command. In this case an area of the Sulu Sea is known to contain four ships in the locations marked in red in the diagram. It is also thought to contain two ships in the general location shown in blue on the diagram. The problem is to identify these unknown targets and provide their location. The instructions to the astronaut can be stored in the data processing equipment of the vehicle from any ground station over which

OCEAN SURVEILLANCE-CONCEPT

ADVANCE DETECTION – 1 MIN., 250 MI.

- RADAR – ALL WEATHER
- TV – DAY OR NIGHT – CLEAR OR THIN BROKEN CLOUDS
- I R – DAY OR NIGHT – CLEAR OR THIN BROKEN CLOUDS
- OPTICAL – DAY

CLASSIFICATION –

- OPTICAL – ZOOM BINOCULARS – SLAVED CAMERA FILMS FOR DEFERRED OR DETAILED STUDY
- I FF – FRIEND OR STRANGER – DIRECTIVITY GOOD
- ELINT – COARSE TO GOOD RESOLUTION, FRIEND OR STRANGER
- BEACON – FRIEND OR STRANGER

DATA PROCESSING –

- AUTOMATIC POSITION DETERMINATION
- CLASSIFICATION STORAGE – MANNED INPUT
- COMMAND READ–OUT
- INSTRUCTED SEARCH STORAGE

TARGETS, SATURATION BY –

- AUTOMATION – DATA STORAGE
- DIRECTED SEARCH
- PROCESSED FILMS
- CLASSIFICATION AIDS

Figure 3

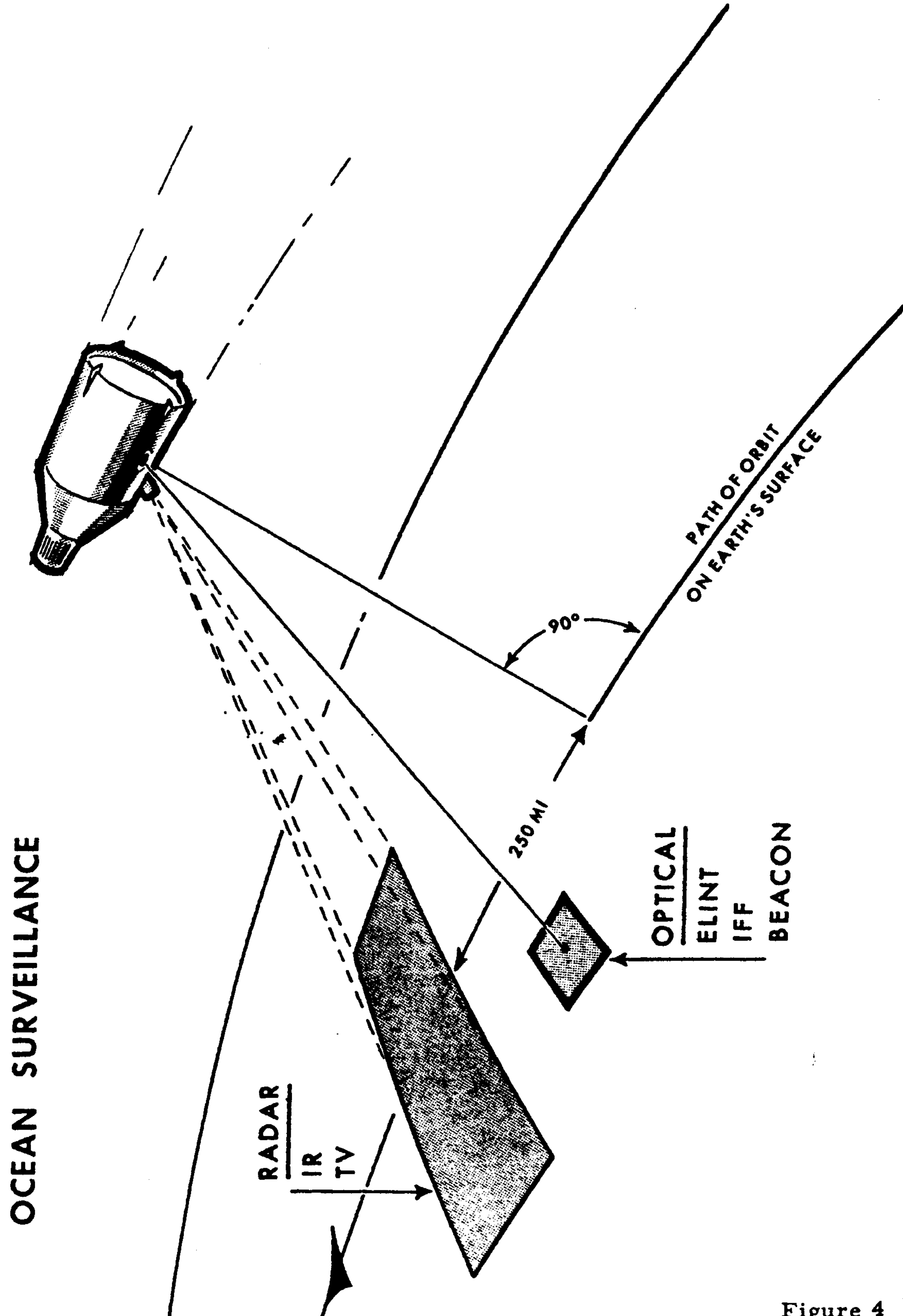
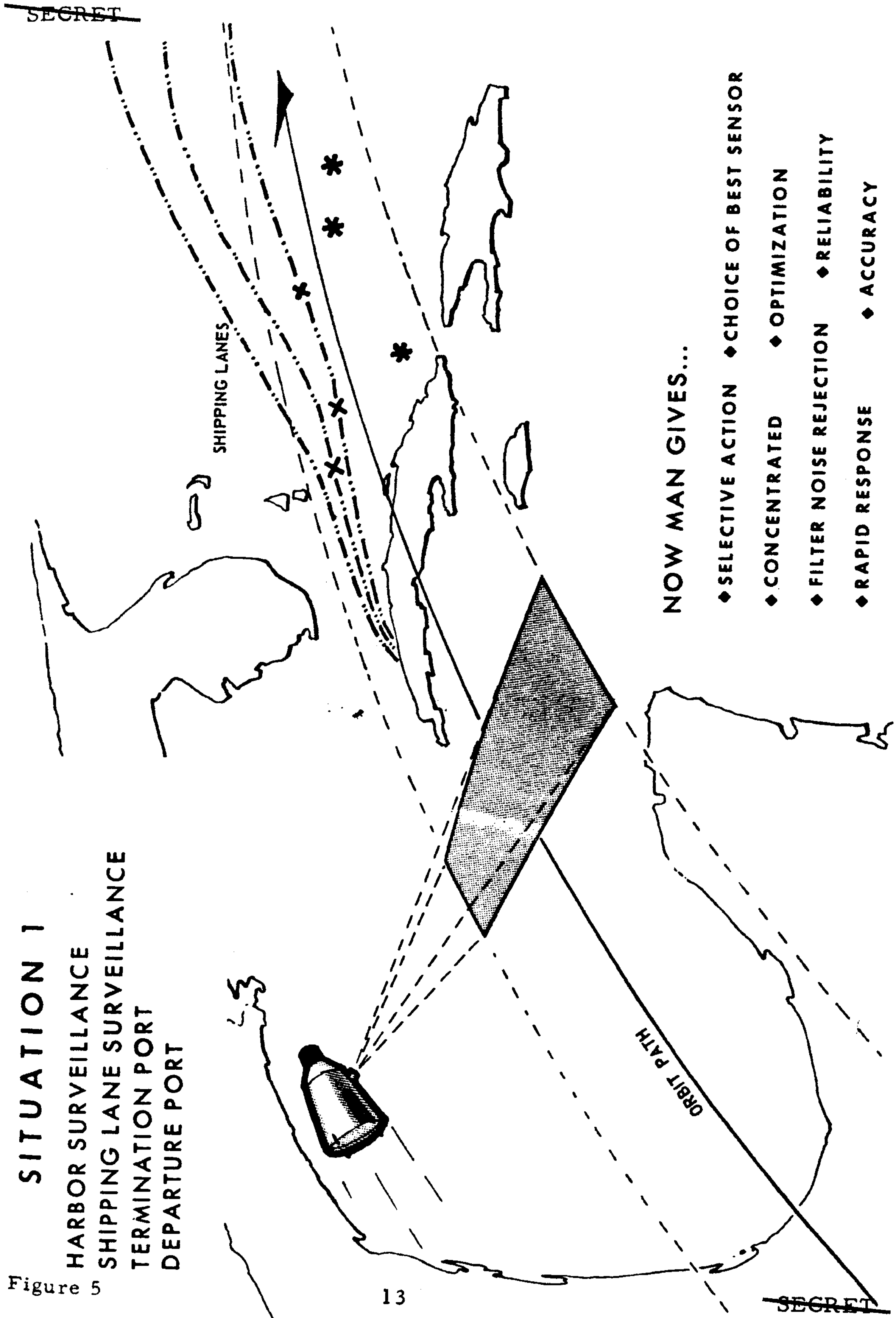

OCEAN SURVEILLANCE
PATH OF ORBIT
ON EARTH'S SURFACE
90°
250 MI
OPTICAL
ELINT
IFF
BEACON
RADAR
IR
TV

Figure 4

~~SECRET~~



ıre 4
~~ƆRET~~

Figure 5

~~SECRET~~

~~SECRET~~

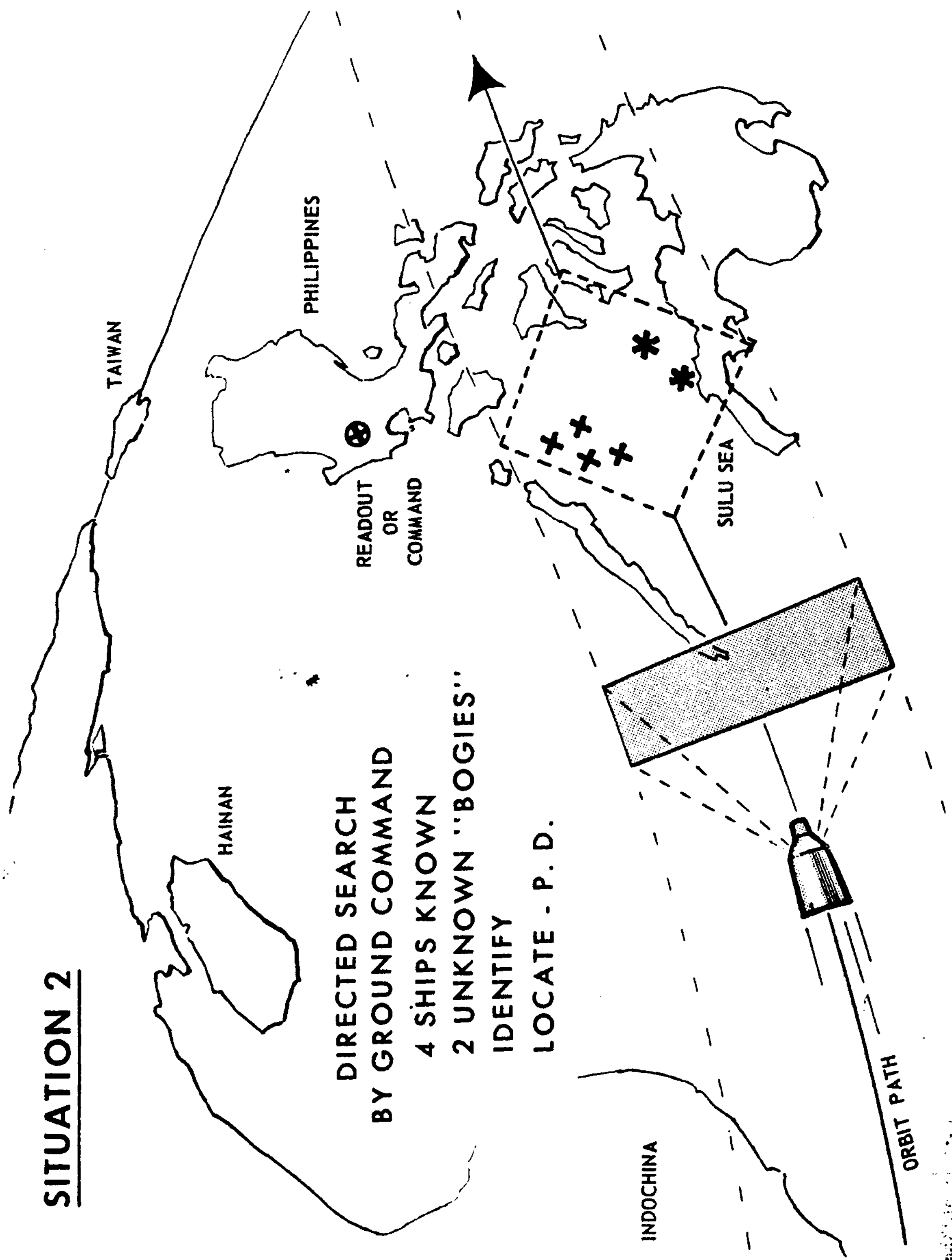


Figure 6

~~SECRET~~

the astronaut passes. At the appropriate time the astronaut will be given signals from his data storage to inspect the area outlined by the dotted lines. If he is able to use the optical systems he is likely to obtain ready classification of the targets. If he is forced to use all-weather sensors then he can determine whether the unknown targets are captured by his sensors, whether they are friends or strangers, and their positions. If he is able to detect no target but can see the surface areas whose coordinates are given he has provided information which may help to determine whether or not the unknown targets are submarines.

Situation 3 is depicted in figure 7. Here the problem is to determine the trend in world shipping as a portent for some future operation of an unfriendly power. The need is to inspect something like twenty ports around the world, e.g., to catalog and count the ships in ports and in lanes to these ports. The illustration chosen is that of a northern port where certain lanes may be ice-closed. With optical equipment in suitable weather the astronaut can survey with high resolution the harbors and the approaches to the harbors and classify shipping in these areas. He can also determine which shipping lanes are open and which are closed by ice. If weather is unfavorable he can count ships which are in the lanes using equipment such as radar, IFF, ELINT, and beacons. At night, in favorable weather, he may obtain a shipping count through the television system. Here again man gives selectivity or the ability to look for only certain kinds of information; he gives the ability to concentrate on certain areas; he gives the capability for optimizing all sensors used; he gives rapid response; and he can correlate and filter data. In short, he provides more accurate, more reliable data.

In Appendix A may be found a more complete development of the Ocean Surveillance Mission for MOL. Following a meeting of the subpanel on Ocean Surveillance, Dr. R. A. Summers of INS and Dr. Roscoe Bartlett of APL jointly prepared a report on the over-all concept. This is found in Appendix A as Item 1, "MOL An Investigation in Multi-Sensor Military Surveillance," APL. A report on the use of optical sensors was prepared by [redacted] of NPIC (Item 2). This is supplemented by other material previously prepared at NPIC and NADC on the problem of ocean surveillance by optical sensors (Items 3 and 4). The radar sensor was studied by Mr. Irving Page of NRL (Item 6). Mr. William Lee of NADC had submitted before the time of the Panel meeting a proposal for surveillance by television (Item 7). This has not yet been modified to incorporate the concept of advance scanning ahead of the MOL vehicle. NADC also submitted early a proposal for infrared mapping (Item 8). This, too, has not been modified to incorporate forward scan. Mr. Samuel Hubbard of the Bureau of Naval Weapons studied the question of surveillance by ELINT and

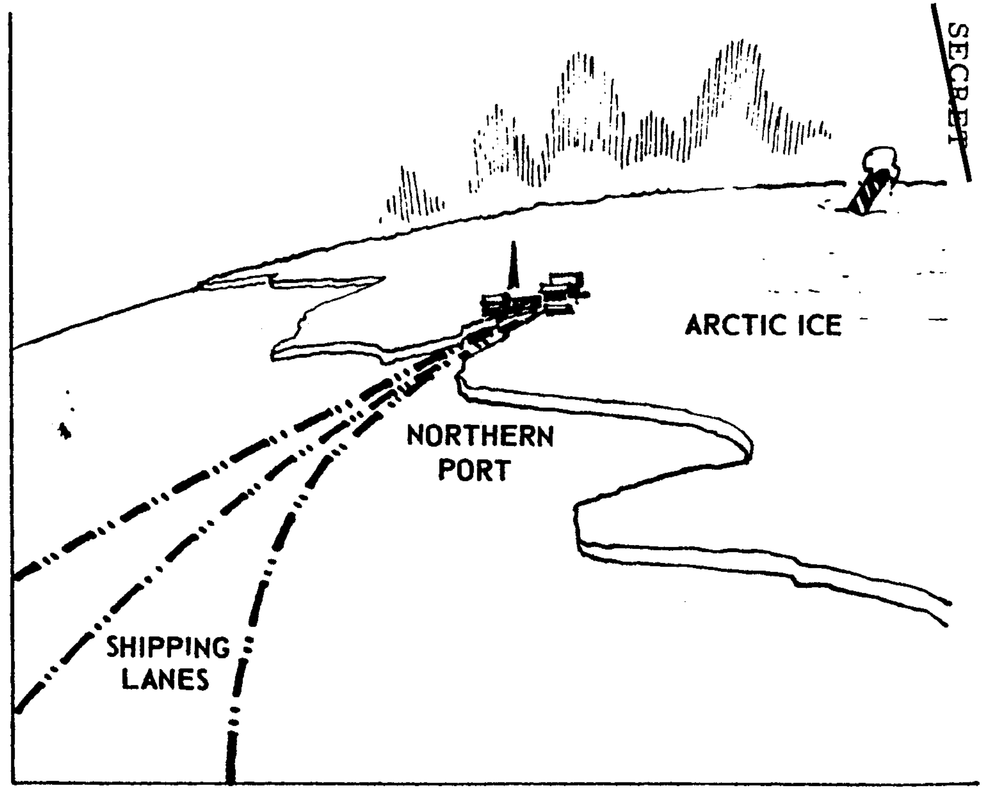
ORBIT PATH

ure 6

CRET

~~SECRET~~

SITUATION 3



PROBLEM . . .

- WORLD SHIPPING NEED TO INSPECT 20 PORTS
- CATALOGUE AND COUNT SHIPS IN PORT
- SHIPS IN LANES TO THESE PORTS

OPTICAL . . .

HI RES HARBORS AND APPROACHES, RADAR, TV-IR-LO RES HARBORS AND APPROACHES, OPEN LANES, ICE CLOSURES, IFF, ELINT, BEACONS, CLASSIFICATION, APPROACHES

MAN GIVES . . .

SELECTIVITY-CONCENTRATION, FILTERED, CORRELATED, RAPID, OPTIMIZED, RELIABILITY, ACCURATE DATA

Figure 7
~~SECRET~~

~~SECRET~~

Table 3

OCEAN SURVEILLANCE

ITEM	SPONSOR	65 COST	TOTAL
RADAR	NRL NMÇ NADC	$1.5M	$10M
OPTICAL	NPIC–APEL	$0.5M	$7M
TV	NADC	$0.15	$2M
IR	NADC NOTC (C.L.)	$0.25	$2.5M
ELINT	BUWEPS NRL	$0.10	$9.25M
IFF	NRL	$0.05	$0.25M
BEACON	NADC	$0.05	$0.25M
INTEGRATION	APL INS NRL	$0.15	$8M
		$3M	$40M

~~SECRET~~

submitted an experiment (Item 9). The use of IFF for sensors was looked into quickly by Mr. C. V. Parker of NRL (Item 10). A very brief proposal for a beacon experiment was submitted by NADC (Item 11). On the urgent time scale followed in the preparation of this report little more could be done to reduce inconsistencies and provide a complete definition of the integrated plan for the Ocean Surveillance experiment.

Table 3 is a preliminary estimate of the total cost to fund an ocean surveillance experiment on means for satisfying the naval mission requirements. In summary, it is a system utilizing radar, optical, television, infrared, ELINT, IFF, and beacon-type sensors. None of these sensors alone can do the job. All of these sensors used intelligently together can obtain great amounts of valuable information.

An estimate of the over-all weight of hardware for the ocean surveillance experiment is included in Table 4.

Table 4

Weight Estimates for Ocean Surveillance Experiments

Component	Weight
Integration and Data Processing	350 lb
Radar	1,500 lb
Optical Sensors	800 lb
Television	150 lb
Infrared	150 lb
IFF	25 lb
ELINT	200 lb
Beacon	25 lb
	3,200 lb *

*This is a preliminary estimate only. Weight for primary power and gyro-stabilization is not included.

* * *

There are a number of elements of the proposed ocean surveillance system which require further study. For example, it is necessary to determine whether the radar antenna can be a rotating one as is

oked
)-
tle
ient.
ion
li-
r-

preferred or whether it must be fixed to avoid disturbing the optical system. Secondly, it is necessary to determine whether the radar antenna can provide the multiple usage capability required by the IFF, the ELINT, the beacon, and the radar systems. It may be necessary to provide a second antenna (perhaps a 5-foot aperture dish) for use by the IFF, the ELINT, and the beacon systems to classify the targets. Thirdly, it is necessary to determine how the optical cameras can be made adequately directive. (It is considered that an essential element of this system is that the camera should be quite flexible in its ability to be trained upon any point on the earth within 250 miles or so of the astronaut.) A fourth question has to do with the need for a camera of focal length of 98". (The 48"-focal-length camera will give the required resolution only if it is operating at its maximum effectiveness. To allow for some degradation of performance it may be necessary to use 98"-focal-length optics.) The camera aperture may need to be increased from 12 to 18 inches. Schedules are yet to be determined. Much more accurate cost data are required. The many interfaces between the various sensors must be thoroughly examined and properly related one to another. Also, it is necessary to determine the cost in effectiveness which will ensue to the over-all experiment if certain portions must be omitted for one reason or another.

Section III

Command and Control

In the specific area of Command and Control the Technical Panel received no experiment proposals of note. This is an unsatisfactory situation because there is a problem which exists in this area. The STARLIGHT Study (reference [c]) in particular recommended that the Navy develop space-oriented command ships. The obvious technical requirements for command and control posts, whether in space or on shipboard, include data sensors and processors, means for communication, means for presentation of information, and means for storage and response to direction and command. The hardware already envisioned for the MOL vehicle to perform the Navy ocean surveillance mission can take care of surveillance, data processing, and communication functions envisaged for the command and control function, and therefore will support the Command and Control mission. However, no suggestions with respect to specific experiments in command and control are provided herein. It is suggested that sponsors be sought within the Navy to develop a suitable command and control experiment.

p-

ponse
OL

ged

Section IV

Communications

There is much work under way on unmanned space communication experiments. There is still a place for special experiments, however. The Navy has a wide interest in global communications, hence the Technical Panel accepted a communications experiment proposing further work in VLF, ELF, and HF areas. This experiment will check out the efficiency of global communication to a spacecraft on the opposite side of the earth from a ground station using VLF. It proposes further to measure antenna impedances and propagation characteristics within the frequency ranges listed. Man can be very useful in tuning and adjusting the equipment to optimize the performance of the experiment and enhance its reliability and accuracy. Figure 8 provides a summary of the factors involved in a communication experiment. Sponsors for the proposed experiment include the NRL and NADC. A proposal prepared by NRL (Item 12) as a part of the LOFTI program is included in Appendix A.

COMMUNICATIONS VLF,ELF,HF

PROBLEM	GLOBAL COMMUNICATIONS ANTENNA IMPEDANCE PROPAGATION CHARACTERISTICS
MAN	TUNES ADJUSTS OPERATES CONTROLS ATTITUDE OPTIMIZES
SPONSOR	NRL NADC

COST	65	TOTAL
	$0.6M	$2.0M

Figure 8

~~SECRET~~

Section V

[redacted]

~~SECRET~~

COST

65 TOTAL

$0.6M $2.0M

gure 8

~~NTIAL~~

~~SECRET~~

[redacted]

[redacted]

Figure 9

~~SECRET~~

Section VI

ELINT

In the area of the ELINT mission man can provide selectivity to examine signals which appear to be of most interest; he can filter out noise; he can provide better accuracy, and better reliability; and he can provide correlation of data in-put with respect to other information. Furthermore, the manned astronautic vehicle is the only manned vehicle now available for passage over foreign territory. It therefore enables the development of capability for selective, tactical, ELINT analysis which appears to be promising during the 1968-1970 period. This is particularly so in view of the fact that man's capability to launch larger payloads is presently increasing faster than is his capability to launch highly reliable adequately sophisticated unmanned systems to obtain some kinds of information which is desired. At least four Navy laboratories could be selected as sponsors for a selective, tactical ELINT analysis project. These include the NRL, the NADC, the NMC, and the NOL (White Oak). Costs of the hardware needed for performing the experiment are included in the estimates for the ocean surveillance system; however, some additional funding may be required to cover costs of the sponsoring activity for this particular experimental area. A summary of the factors considered in the ELINT problem is given in Figure 10. Mr. Samuel Hubbard, BUWEPS, has prepared a study of the ELINT problem, Appendix A, Item 15.

re 9
~~RET~~

ELINT

PROBLEM

SECURITY – SEPARATE APPROACHES
MAN GIVES SELECTIVITY, NOISE REJECTION,
ENHANCED ACCURACY,
RELIABILITY, CORRELATION
PASSAGE OVER FOREIGN TERRITORY

SELECTIVE, TACTICAL ELINT ANALYSIS

NADC, NMC, NRL, NOL(WO) COST INCLUDED

Figure 10

~~SECRET~~

Section VII

Bio-astronautics

In the mission area of Bio-astronautics there are several factors to be considered. In the first place NASA has planned the launching of a series of at least six 1,000-pound bio-satellites. These are to be orbited for periods extending from 3 to 30 days. It is also to be remembered that the directives for the MOL program state that work in the area of bio-astronautics is not to be overdone. Hence, the Panel considered that only those experiments should be considered for naval participation in which the Navy can make some unique contribution or has some special reason for performing the experiment.

The summary included in Figure 11 shows that only three experiments were selected in the bio-astronautics area. The first one of these (see Appendix A, Item 16) is an extension of Project ARGUS in which the Navy has been making at the Naval Medical Research Institute an extended study of the capabilities of man to exist in small parties of from 2 to 15 in number for extended periods of time in deeply submerged vehicles which are completely cut off from mankind. In such a vehicle man encounters many environmental conditions which are like those in space. Therefore, it is considered that the Navy can make a considerable contribution to the national effort by relating and extending its ARGUS studies to the MOL system. In the case of the remaining two experiments on nuclear radiation monitors proposed by the Naval Radiological Defense Laboratory (see Appendix A, Items 17 and 18), it is considered advisable that these be included in the MOL vehicle because NRDL has certain advisory responsibilities to DOD which require it to obtain first-hand information on the space environment encountered by man. Also, in the case of the heavy-particle dosimeter experiment proposed by NRDL (Item 17, Appendix A) recovery of records is necessary for further study.

ıre 10

~~SECRET~~

~~NTIAL~~

BIOASTRONAUTICS

PROBLEM FACTORS –

NASA BIO SATELLITES
MOL – "NOT TO BE OVERDONE"
SPECIAL EXPERIMENTS ONLY

EXPERIMENT	SPONSOR	65 COST	TOTAL
PROJ. ARGUS EXPT. IMPORTANT NAVY CONTRIBUTION	NMRI	\$0.2M	\$2.25M
NUCLEAR RADIATION MONITOR DOD ADVISORY RESPONSIBILITIES	NRDL	\$.025M	\$0.10M
HEAVY PARTICLE DOSIMETER RECOVERY NEEDED	NRDL	\$0.075M	\$0.90M
	TOTAL	\$0.3M	\$3.25M

Figure 11

Section VIII

General Science

The Navy has much capability in the area of General Science, and consequently the Panel had many experiments to review. Those ultimately selected are thought to have potential military value. Considered first were experiments that are related to the MOL vehicle and deal with space and plasma physics. For example, the proposal of the NRL to study plasma surrounding the MOL vehicle by scatter of RF energy is indluded (Appendix A, Item 19). Similarly, the proposal to study by the use of probe techniques the density and temperature of electrons within this plasma was included (Appendix A, Item 20). The far-UV orthicon (Appendix A, Item 14) was included because of its military mission interest, its need for manned operation, and the inherent value of background information with respect to UV radiation in near-earth space vehicles. The airglow horizon photography (Appendix A, Item 21) was selected as being of value because the airglow is a major phenomena encountered by any optical sensor operating near the earth, and horizon sensors are of considerable interest.

Of long-range interest is the cosmic radiation coming in to earth and its direction of origin. This would be studied in one of the experiments recommended (Appendix A, Item 22). Also, of interest is information on the white light corona about the sun and possible sky surveillance of the area near the sun (Appendix A, Item 23). The airglow spectroscopy made possible in the MOL vehicle is also considered to be a valuable experiment (Appendix A, Item 24). Finally, photography of the solar planets and of the geology of the earth using the camera planned for ocean surveillance from the MOL vehicle is worthwhile. (It is true, however, that the camera proposed will be only marginally effective for use in photography of the planets.)

A much more complete study of the Navy proposals in General Science has been prepared by Dr. William Faust of NRL (Appendix A, Item 25).

GENERAL SCIENCE

MILITARY INTEREST (CAN USE MOL VEHICLE)

I MOL ORIENTED – SPACE & PLASMA PHYSICS 65 COST–TOTAL

		65 COST	TOTAL
SCATTER	NRL	$.95	$1.5M
ELECTRON D&T	NRL	$.20	$1.6
FAR UV ORTHICON	NRL	INCLUDED	
AIRGLOW HORIZON PHOTOGRAPHY	NRL	$.20	$1.5M
		$0.45	$4.6M

Figure 12

12

GENERAL SCIENCE

II LONG RANGE MILITARY INTEREST

COSMIC RADIATION	NRL	$.05	$0.75M
WHITE LIGHT CORONA, AND SKY SURVEILLANCE	* NRL	$.20	$1.5M
AIRGLOW SPECTROSCOPY	NRL	INCLUDED	

III GENERAL SCIENTIFIC INTEREST

PHOTO SOLAR PLANETS	NOTS	?	
PHOTO GEOLOGY EARTH	NOTS	?	
		$0.25	$2.25M

Figure 13

Section IX

Summary

A preliminary report of the MOL Technical Panel has been prepared for submission to the Bureau of Naval Weapons as requested. In all, the Panel received eighty-nine proposals or ideas for experiments. From these were selected those experiments to be proposed for the MOL program. The number of experiments submitted in each area, the number recommended for support by the Navy, and the preliminary estimates of costs for these experiments are given in Table 5.

Major interfaces between these experiments exist on data management, structural arrangements, vehicle stabilization and control, position determination, communications, etc. These require further study.

The experiments proposed are within the state of the art and can be orbited in the 1968-1970 time period. They are also well within the payload capability of the MOL vehicle.

Inclusion in the MOL program of experiments described here and intended to study means for improving the performance of naval missions is highly recommended.

Table 5

Over-all Summary of Experiments Recommended for MOL

Mission Area	Experiments: Reviewed	Experiments: Recommended	Costs (Millions): FY '65	Costs (Millions): Total
✓ Ocean Surveillance	26	1 (8 parts)	$2.75	$39.25
Command and Control	2		?	?
✓ Communications S-1	3	1	0.60	2.0
[redacted]	5	2	1.50	7.0
ELINT	4	1 0	Included(?)	Included(?)
Bio-astronautics	14	3 2 S-20 S-21	0.30	3.25
General Science	35	10 9 S-22	0.70	6.85
	89		$6.00M*	$59.00M*

*Preliminary estimates only. Not for budget purposes.

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

ted.

ro-
n
ne

on-

nd

Appendix A

COPIES OF RECOMMENDED EXPERIMENTS
AS SUBMITTED TO MANNED ORBITAL LABORATORY
TECHNICAL PANEL

MOL,

AN INVESTIGATION

IN MULTI-SENSOR

MILITARY SURVEILLANCE

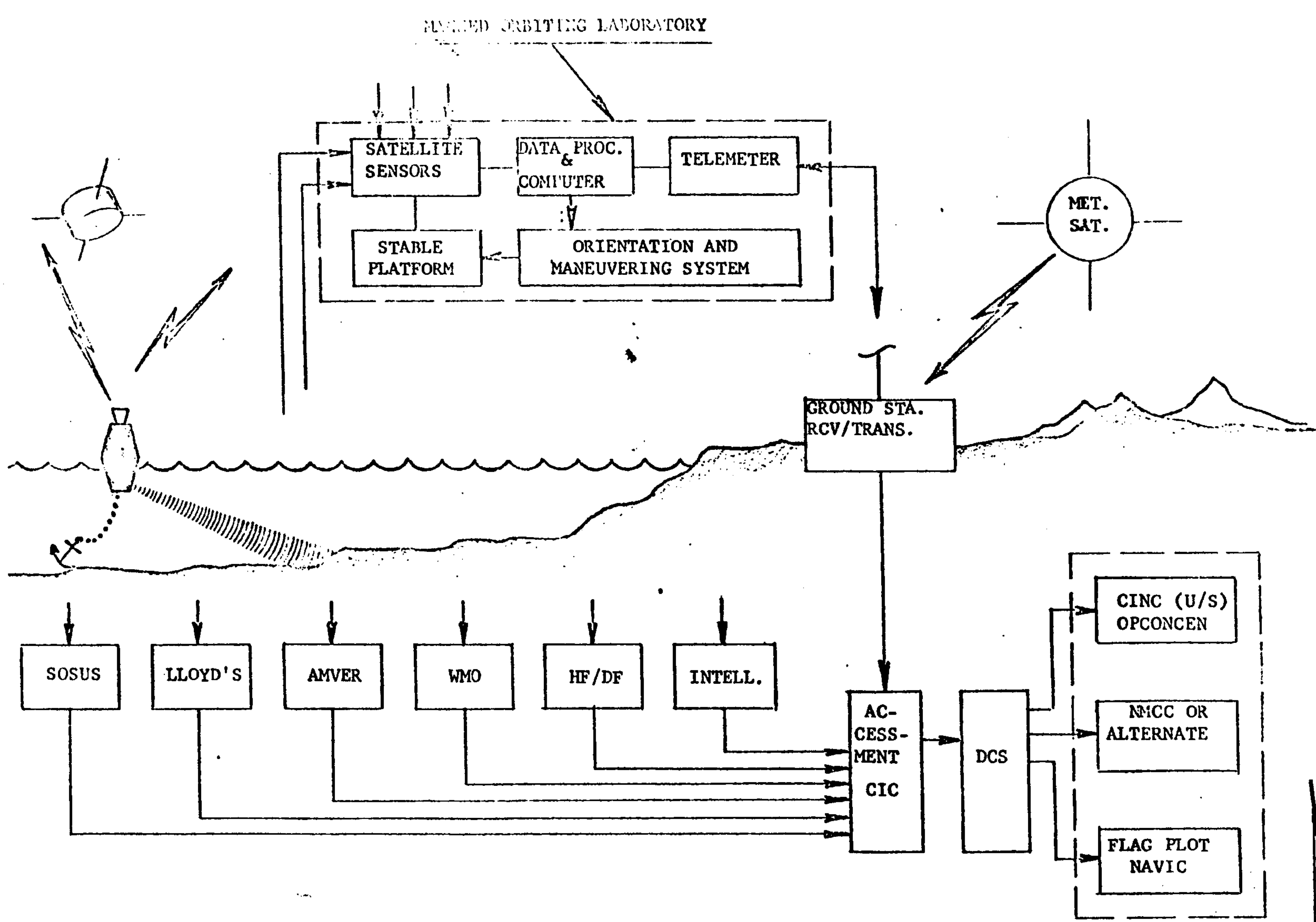
(Title Confidential)

P-13

S-11

Excluded from automatic
downgrading and declassification.

~~SECRET~~



MANNED OCEAN SURVEILLANCE SATELLITE SYSTEM

~~SECRET~~

A. INTRODUCTION

There are a number of sensors which might be used in satellite reconnaissance and surveillance. In many applications the sensors could be operated from an unmanned satellite and the information telemetered for ground interpretation and use. There are obvious limitations to such unmanned systems. The problem, then, for MOL is to provide an overall system in a manned satellite which in terms of economy and usefulness is superior to the use of a collection of unmanned systems. It is envisioned that this system should complement and not supplant other ground and aircraft surveillance systems now in use (Frontispiece). Study may show, however, that some of the data acquisition and interpretation techniques now employed might be better accomplished with a manned space station. The intent in the following presentation is not to define the ultimate or even the prototype manned military space station but rather to define an experimental Manned Orbital Laboratory which will be used for conduct of those experiments necessary for a definition of the prototype manned military space station.

The most obvious use of a manned military space station is the surveillance of the earth for targets of military interest. This surveillance requires at least two separate procedures; acquisition and identification. To scan a meaningful percentage of the possible earth surface viewable from the satellite will require relatively low resolution devices. Once a potential target is acquired by one or more of the scan sensors it must then be fixed by the high resolution sensors for identification. To accomplish this fix, of course, will require either that the high resolution sensors be slaved to the low resolution sensors or that the coordinate position of the potential target be known from the acquisition by the scan sensors and the identification sensors be trained to the directed position. The method used will depend on whether one astronaut accomplishes both surveillance and identification or whether the two tasks are accomplished separately by a two man team. To accomplish identification it may be useful to provide a target image memory, as by photography for instance.

Even should one man perform both surveillance and search, it will yet be necessary to provide a capability for target coordinate position determination so that meaningful use can be made of the acquisition and identification data. To accomplish this will require the possession of at least two and perhaps three types of information. It will certainly be necessary to know precisely the orbital parameter This can be accomplished by tracking and orbit prediction and storage of the predicted orbital parameters aboard the spacecraft. In additio it will be necessary to know the inertial coordinates of the sensors. This might be accomplished by tying the sensors directly to an inertia platform where inertial coordinates are obtained from tracking known reference objects (stars, sun, horizon, etc.) orbital data and computations. It may, however, be necessary to physically separate the sensors from the inertial platform so that the inertial orientation of the spacecraft would be determined from one or more of the means for inertial coordinate reference location and the pointing angle of the sensors with the spacecraft also provided for computer use. The computer would define the scan center in earth based map coordinates from the stored orbital parameters referenced against the inertial platform.

In addition, the information will be maximally useful to the astronaut by providing a visual display of the earth based coordinate position of the target either continually or on command. The computer, of course, would have such information continually availabl on a real time basis.

The essential information must on command be telemetered to the ground. To reduce the telemetry requirements it might be well to do some initial data processing aboard the spacecraft.

It is, of course, impossible at this time to define the desired military space station configuration. The experiments conducted on MOL should provide the necessary information for the detailed definition of the prototype military space station.

B. ORBIT

To provide more uniform coverage if the swath width does not give contiguous coverage at the equator, the period of the orbit should be chosen so that it is not near an exact submultiple of the earth's rotation period. In the range of altitudes considered (125-250 n.m.) there is one synchronous period of 96 minutes correspondong to a mean orbital altitude of about 185 miles. Most uniform coverage will be obtained with orbital altitudes either near the minimum 125 n.m. or the maximum 250 n.m.

Since this first Laboratory experiment is not the operational system, it is not desired that complete contiguous coverage be obtained in each 24 hour period.

Further since the results obtained at a given altitude are easily scaled for another altitude, it will be expedient to choose the lowest orbit which will meet the task testing needs. This would seem to obviously dictate the range of 120 to 150 miles.

C. SENSORS

1. Acquisition

The purpose of the sensors is to present to the man as much information of the earth's surface as possible, limited both by the ability of the instrumentation available and the ability of the man to assimilate these data. The sensors should include a small low resolution radar whose purpose is to locate the larger objects on the ocean, especially under cloudy conditions. Without cloud cover the most effective instrumentation will be visual.

It is expected that a significant part of the target acquisition phase may be accomplished with the naked eye. However, there may be some advantage in having a low-powered binoculars at about three times magnification to assist in this process. There may be some merit in extending the spectral range of sensitivity of the observer by having an infrared sensitive viewing device. For the dark side of the earth a sensitive television camera or image intensifier may provide useful data.

The acquisition process in a dense target region will be enhanced if the observer has an ability to check off the targets in turn. In addition to a cursor which he may present in superposition to the scene which he uses to center on each target to store its location in the memory, when so located there should appear a superposed marker provided from the computer and memory which will stay locked on that target's geographic coordinates independent of the motion of the telescope. His attention is thus more easily directed to the remaining targets and his speed will be significantly improved.

There is another kind of visual signal which might be useful. If the ground CIC is interested in certain ships, or suspects certain locations, or can produce predicted locations of interesting objects, then this information can be inserted in the memory through the ground command station. The observers can evaluate and update these targets. This mode of operation may be the only practical way to perform the land surveillance, with two observers using separate high power telescopes to provide the necessary resolution. For both

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

land and ocean surveillance telescopes pointing position is slaved to the computer and programmed through the priority queues.

2. Classification and Identification

Identification instrumentation will be primarily a high magnification optic system. Assuming that the acquisition process has identified the location of objects, the only limitation on magnification used will be governed by the ability to mount and launch a large optical system.

The ocean identification problem can probably be solved quite adequately with an optical aperture of about 8" giving a resolution of about 12 ft. with a slant range of 700 miles (see Figure 1). If a higher resolution were desired to make the device useful for observation of ground targets, for instance, a [redacted] When one considers the problem of slewing speeds the very great problem of providing a mounting platform sufficiently free of vibration, larger aperture optical devices become unattractive for these early experimental missions. Even a 24" telescope may impose overly stringent engineering requirements. In addition to direct visual identification processes, there may be advantages to photographing certain regions to be identified later. This may be especially important in regions of the North Atlantic where the traffic density is high. Both of these visual and photographic processes may be augmented by extending their spectral sensitivity at least to the near infrared.

Under cloud cover some additional information may be gained from direction finding, spectral, and time pattern measurements of electromagnetic radiations from ships. The EM frequency spectrum extending from 100 kc to 100 kmc might be continuously monitored by panoramic receivers. Continuous recording of the receiver outputs on multitrack magnetic tape should be provided in addition to visual display. An alarm system would indicate to the operator which parts of the spectrum show unusual activity or when selected frequencies become active.

These receivers would normally be connected to omnidirectional antennas. Provision should be made for direction finding by changing over to fixed spaced antennas at the lower frequencies and rotating directional antennas at the higher frequencies.

The receivers should also have provision for more sensitive examination of specific parts of the spectrum, with alternative demodulation, display, and recording facilities to permit detailed analysis of the signal structure, identification of purpose of the transmission, and possibly decoding.

To cover the spectrum from 100 kc to 100 kmc would require about 10 receivers; the total weight including displays, recording, etc., might be about 200 lbs. The weight of 10 omni-antennas and 10 direction-finding antennas might run to about 100 pounds. The power consumption should not exceed 200 watts.

3. Minimal Optics for Ocean Surveillance

At an orbital altitude of 150 n.m. a good eye will have a resolution of about 200 ft. at the nadir (see Figure 1). If the

SECRET

[redacted]

FIGURE 1

SECRET

maximum field coverage is $\pm 45^{o}$ from this, the maximum slant range is about 200 n.m. and the eye resolution drops to about 300 ft.

The complete swath is then 300 n.m. in width and at the orbital speed of about 4 n.m/sec. the area scan rate is 1200 n.m.^{2}/sec. This is equivalent to a square patch of about 35 n.m. on a side, which presents a field of view of about 13^{o} on a side. If this patch is magnified in a low power wide field telescope (about the practical limit) the magnification will be 4.5 This calculation presumes that this telescope (or binocular) is mechanically scanned to dwell on this patch area effectively for one second, and that the preset program of scanning provides complete coverage of the full swath without significant overlap or holes.

With a 4.5 magnification the resolution at slant rang becomes about 70 ft. which tends to enhance the ability to acquire even small ships.

In fact this resolution may allow the acquisition operation to include a coarse identification. This will be especial useful in a high target density region since the coarse identificati can then be used to provide a priority selection in the targest-to-b identified queues.

The acquisition operation is envisaged as a pointing operation.. The observer superposes a reticule image on the scene and moves it into coincidence with the object and then operates a button which stores this targets' geographic coordinate in a memory. This operation may include very brief identification symbology (e.g. big, fast, SE course).

The identification phase may best be done as a separ operation. The memory store feeds the objects to be identified to second observer on his command. He has a higher power telescope wi resolution capabilities to meet his needs. If the resolution required on the scene is 12 ft. at the oblique view then this may be met with a telescope aperture of about 2.5 inches. The eyepiece choice which preserves best light will then give a magnification of 25 so that the field of view is 60/25 or about 2.4° which corresponds to approximately 50 K ft. at a slant range of 200 n.m. This field of view is more than sufficient to give good centering of the potential target.

The job of the identification process is one which will profit from well disciplined training. The observer must be well conditioned so that the recognition process in the required output terminology is automatic and fast. It is envisioned that he controls centering to provide more accurate coordinate measures and then without removing his eyes from the scene taps keys (as in a stenotype) to characterize the target. When this is complete, he then signals for the next target in the waiting list and repeats.

Acoustic signals from the computer can alert this observer to the need for greater speed when the queue length starts to build up too fast, but at the saturation density of the man there should be deletions from the queue to preserve only the more important targets as programmed by size, location, position with respect to the satellite, or best viewing region.

D. COORDINATE TRANSFORMATION AND PRESENTATION

The information obtained from the several sensors is only complete if the position of the object can be defined as well. It would interrupt the human and decrease his effectiveness in continuing his search if he had to perform a complicated task of manipulation or computation in order to name the position of each interesting object he sees. Rather, this coordinate measurement job should be accomplished by automatic means so that as he centers his optics on an object, a push of a button will provide the coordinates of that object.

The implementation of this scheme will require that a platform on the vehicle be oriented in a coordinate system. The most accurate reference will be an array of star trackers. It will be sufficient to have two approximately orthogonal stars being tracked simultaneously. Because these may, in the course of time, be shadowed by the earth or moon, or blinded by sunlight, earth-shine or moonshine, there will need be about 6 star trackers. It would be wise for reasons or reliability to provide some alternate references. These may include, horizon trackers, sun tracker, moon tracker, X, Y, Z magnetometers, drift sight, gyro compass, RF array referenced to ground station (Cubic Corp.). The pointing direction of the telescope with respect to this inertial platform needs to be known and if time and orbital parameters are known, the complete geometric relations are defined. To complete the system, a real-time digital computer can correlate these data to provide the desired coordinate information. This, of course, can be done for each of several telescopes that may be in use.

This computer is the heart of the system. It should be able to provide the present satellite position coordinates from orbital elements or from interpolation of an ephemeris provided from the ground. Then, referenced against the inertial platform, it must solve some simple geometry to define the scene center in earth based map coordinates. This would seem to require a modest unit of possibly a cubic foot volume.

It would be useful to the crew to provide a direct analogue display of satellite position with respect to a globe of the earth. The data necessary would be available from the computer.

E. DATA OUTPUT AND COMMUNICATIONS

Communications of several types will be required in the MOL program. Obviously there must be means by which the astronauts discuss problems related to their well being and logistics with appropriate earth surface station. It will also be necessary to relay particular information resulting from the surveillance operations and other technical experiments carried aboard. It is desired here to discuss the apparent requirement of the latter and more particularly those involving ocean surveillance.

In order to transmit information gathered over a period of time from perhaps as many as two orbital passes it would appear to be mandatory to provide a storage capability and to encode the information in digital or similar manner. Retrieval of the stored information should be accomplished by ground command and rapid readout capability. It should not be a requirement that the astronaut be responsible for initiating such transmissions of information. It may be desirable to also continuously transmit such information in real time for use by friendly vessels and stations to gain an appreciation of the immediate local scene. Voice communication should be reserved for indicating changes in the operating modes and procedures which are of interest from the system planning standpoint.

Communications between the astronaut operations relative to target surveillance should be in the form of symbolic visual displays to the greatest extent possible. These should be either superimposed on the field of view of the device being used or conveniently located at the side so as to require the minimum of eye motion. It will likely be necessary to supplement this with voice communication, but it would appear desirable to minimize this in any way possible since it is relatively inefficient and should be reserved for unplanned and/or emergency procedures.

F. EXPERIMENTAL PLANNING

1. Flexibility

One purpose of the MOL flights will be to discover the most effective ways to conduct the mission and to this end it will be necessary to try various approaches to the problem. Some of these various methods can be determined ahead of time and planned for, but it will be most likely that some new approach requiring a new arrangement of the instrumentation may arise after launch and there needs, therefore, to be a sort of a building block approach to the whole instrumentation arrangement so that the instruments may be used in various combinations.

Parts of acquisition and identification tasks will be assisted by what amounts to automatic programming provided by the computer. It is obvious, then, that we may need to reprogram this automatic control as the task organization changes. Since the essence of this whole experiment is to optimize the task performance of the man--machine system we may need to change the nature of the data presentation to the man's sensors. Some of this can be planned, but again, the man may need to "rebuild" parts of this instrumentatio

2. Objectives

Ground based simulation experiments can lead to variou combinations of operational methods to be experimented with. There are two distinctly different methods obvious at this writing which ma need to be exploited. One method of organizing, the task may be to have the astronaut cover assigned sub-track swaths independent of each other, and another task organization may be to assign one man to provide the acquisition function, designating in geographic coordinates the potential targets, as his sole job. The second man would then examine these designated positions in turn with greater magnification to perform the identification. The efficiency of the whole operation can be improved if we have more detailed measures o the tasks involved.

Analogous to the time and motion study we need to gather data about many kinds of tasks. In the acquisition we will need to know the precision of target coordinate measure. We need to know the statistical measure of the ability to locate and identify various kind of targets with varying illumination, sea state, etc., conditions. Related to these tasks is the question of symbolization or language that needs to be used to efficiently and concisely compile the results of the acquisition and identification.

In general, there will be limitations in behavior of both the instrumentation and the man. A sensible system will only arise from a measure of these parameters in orbit. The task of this satellite system will have to be performed under the environmental conditions that are found to exist. For instance, there will be a certain number of ships that must be located on a given pass. They are there. The illumination may vary from high contrast to low contrast and cannot be changed. The pressure to have complete, or nearly complete, coverage requires that a large area be searched in a given time.

The sun may be in a favorable location or it may not. The sea state will vary in many ways. When it is smooth enough, ships wakes may stand out clearly. The most perturbing thing will be intermittent cloud cover. Some of these problems can be simulated in a ground experiment. In fact, it will be essential to try to be as realistic as possible in this preliminary ground experiment. Many of the questions which we are unable to answer at the present will be answered through these preliminary experiments.

G. SPACECRAFT ORGANIZATION

1. Characteristics and Stabilization

The nature of the equipment and their use dictate some features of spacecraft design. It is assumed that the general launch configuration of the MOL will be determined by mating requirements with the Titan III booster and the modified Gemini capsule. The suggested orbital configuration briefly described here then would be erected after injection into orbit.

It seems clear that the spacecraft should always present the same face to the earth to avoid excessive complication in equipment design. Since high resolution sensors will demand a very stable platform to optimize observation and recognition, it would be desirable to provide the overall spacecraft with as high a moment of inertia as possible about each axis of rotation. In addition to keeping the same face of the satellite facing the earth it would also be desirable to know the alignment of the major satellite axis with the orbital path. Many of these requirements can be simply achieved with a gravity gradient stabilized satellite asymmetrical about the Z axis. This would assure one face of the satellite to continually face the earth, would align the major axis of the satellite body orthogonal to the Z axis in the plane of the orbit, would markedly increase the moments of inertia, thus providing a more stable platform and would much reduce the weight and power penalty required for stabilization as compared to an active system.

It may also be attractive to make use of active systems to act as vernier devices to correct for small perturbations to the angular rate of the spacecraft. A combination of rate sensing and the controlled ejection of by-products of the life support system may provide an inexpensive scheme for accomplishing this. Active systems, including inertia wheels could, of course, be used for spacecraft alignment for deorbiting and other special maneuver by simply overriding the gravity gradient torques.

2. Power Supply

Power generating and storing equipment must be designed on the basis of the complete MOL requirements. It would appear that high level of reliability and flexibility should be guide lines in the power system design. While it is not felt desirable to specify the particular method of energy conversion at this point, consideration of use of features of the life support system may be found to be attractive.

The requirements of the electronic devices associated with the ocean surveillance experiment may approach a value of 10 kilowatts peak and perhaps 2 kilowatts average. This, combined with the balance of the MOL power needs would suggest the use of fuel cells or rotating machinery, for a mission of a few weeks duration. For an extended mission consideration may be given to a nuclear power source. An independent low level, emergency back up power source will, of course, be a requirement.

H. GROUND STATIONS

While it is possible that certain information of interest to the ocean surveillance experiment may be transmitted to the network of ground stations deployed about the earth for monitoring the astronauts' well being, the majority of information of interest to the ocean surveillance experiment should be relayed to one or two ground stations equipped primarily for that purpose. Such a station(s) should have the ability to command the rapid read out storage device aboard MOL, to reduce and/or distribute such information in the desired manner and to inject any orders in the form of a coded message into the spacecraft. The latter could include a request for observation of targets of known geographical position during subsequent orbital passes. These stations must also have a voice communication capability so as to receive and transmit information of a non-routine or unplanned nature.

As was mentioned in a previous section, it may be desirable to continuously transmit information in real time to furnish friendly users an appreciation of the local scene on an immediate basis. If this is desired, a receiving and data reduction device of a somewhat simpler character than that at the primary station would be provided. Such an instrument may be practical for reasonable sized vessels and aircraft having special interests. No transmitting ability would appear to be required for such an installation.

I. CONCLUSION

To physiologically support man in space for protracted periods of time will be extremely expensive and the expense will be further increased by his psychologic support demanding short duty cycle and long terrestrial furloughs. A manned military mission is justified, then, only when the objectives can be met more economically and in a more timely fashion than they could with unmanned systems. One must inquire, therefore, for those functions whose performance by the human represents a degree of excellence presumably not attainable competitively by unmanned systems. The unique human power of inquisition, observation, synthetic appraisal, judgment based on a learned art as well as on objective parameters, the dynamic range of the human sensors and the data correlation and rejection capability of the human brain offer an overall system performance that does not appear to be attainable with unmanned systems. For vision alone, for instance, the telemetry of the necessary fidelity would require a telemetry capability an order of magnitude greater than that projected as being available in the next five years. When color vision requirements are added the telemetry task increases twofold. Earth reconnaissance and surveillance, particularly over the ocean, may well be accomplished in a superior fashion by a manned military space station as compared to unmanned systems. The MOL series of experiments should provide the necessary information for making a definitive analysis of the relative effectiveness and economies.

APPENDIX A

MOL STABILIZATION SYSTEM

After an appraisal of competative systems it appears that there would be considerable advantage in providing the MOL with gravity gradient attitude stabilization.

A conceptual scheme for a boom/vehicle arrangement is shown in Figure 1. A 200 foot long extendible boom of approximately 4 inch diameter would be used with an end mass of approximately 320 lbs. Most of the 320 lbs. could be in the form of a damper possibly of the type that has recently been used by the General Electric Company on an NRL satellite. The boom would have 3 or 4 layers of 15 mil thick beryllium copper tubing. Booms of this type have already been developed for spacecraft applications by the DeHavilland Aircraft of Canada, Ltd. If we take a set of coordinate axes for the spacecraft such that the X axis is in the direction of motion of the spacecraft, the Z axis is along the extendible boom, and the Y axis direction is taken to form an orthogonal set, then for this configuration the approximate moments of inertia will be given as follows:

$$I_x = 40{,}000 \text{ slug-feet}^2$$

$$I_y = 50{,}000 \text{ slug-feet}^2$$

$$I_z = 10{,}000 \text{ slug-feet}^2$$

These moments of inertia are sufficient to give an adequately large restoring torque under the forces of the earth's gravity gradient. Furthermore, by having $I_x \neq I_y >> I_z$ we not only get a restoring torque in the vertical direction, but we get an additional torque which will cause the long axis of the spacecraft to be aligned in the plane of the orbit. The magnitude of the maximum torque in the vertical direction is 0.72 inch lbs. The magnitude of the torque controlling yaw motion of the satellite is .06 inch lbs. These should be appreciably larger than any other perturbing force on the satellite, with the possible exception of aerodynamic forces which could be made to supplement these restoring torques.

One problem that might be encountered is due to motions of the men within the MOL. A fair approximation for a 150 lb. man is that he has a moment of inertia about his center of gravity of 20 slug-feet^2. Should the man do a maneuver in which he turned 180 degrees, the ratio of his moment of inertia to the spacecraft's moment of inertia is so small that this would cause a motion of the spacecraft of something less than 0.1 degree.

It would probably be advisable to provide the MOL with some cold gas jet system for additional attitude control. However, the provision of 3 axis gravity gradient stabilization system would drastically reduce the demands on the cold gas jet attitude control devices.

The telescope for ground surveillance must however be mounted on a gyro stabilized platform. This is because even a 0.1 degree rotation of the spacecraft will cause an apparent motion of something being observed on the earth surface that is well beyond the resolution that is desired for this system.

men
a
d the
ment
would

ld
n of
the

on a
of the
n the
his

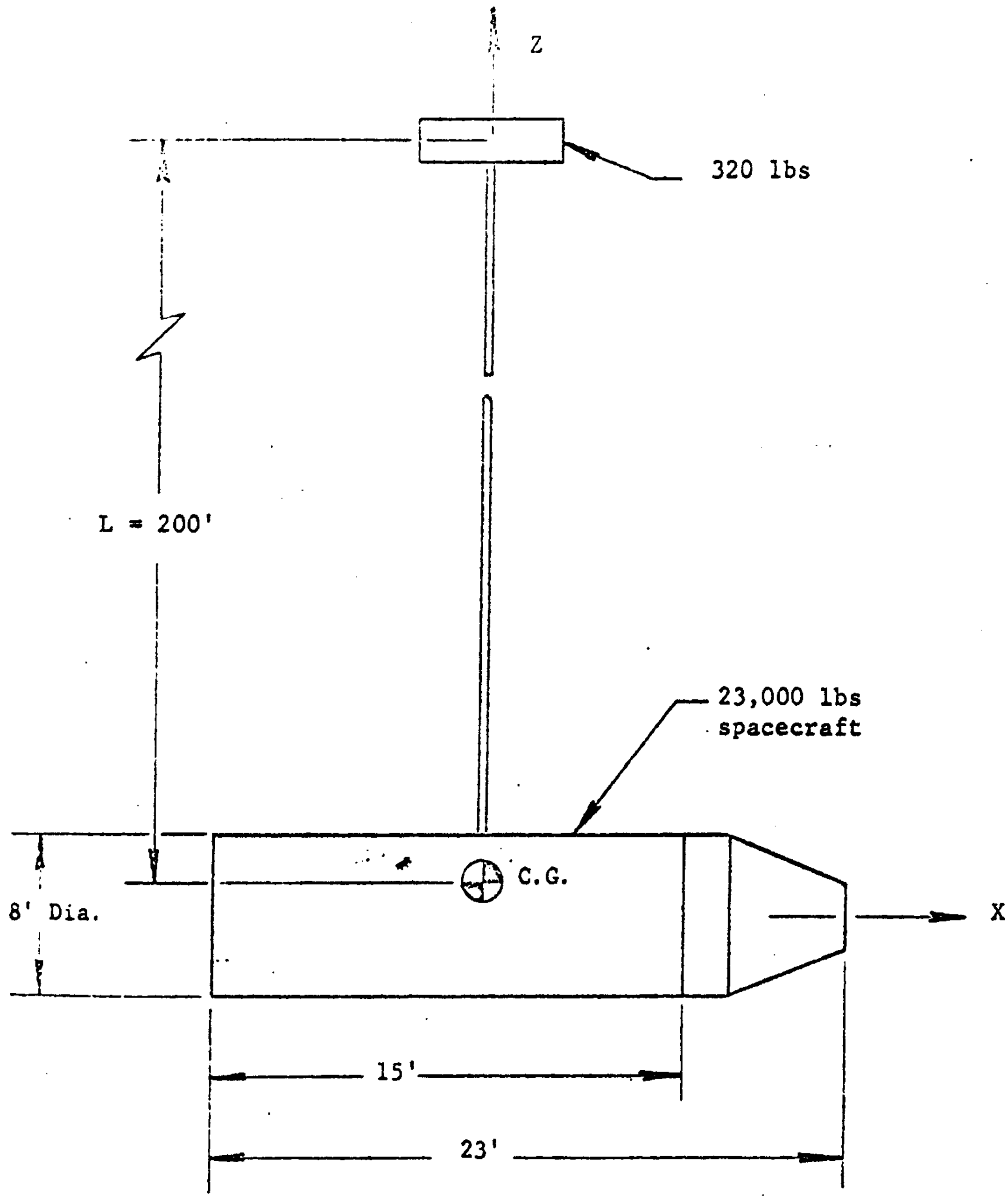


FIGURE 1

CONCEPTUAL SCHEME FOR A BOOM/VEHICLE ARRANGEMENT

I_x = 40,000 slug-ft

I_y = 50,000 slug-ft

I_z = 10,000 slug-ft

APPENDIX B

APPLICATIONS OF THE CORNUCOPIA CONCEPT TO MOL

Cornucopia is the name given to a novel concept for extending the utility of storable rocket propellants to include life support and other essential services in the space environment. Initial feasibility studies, heretofore unreported in the literature, have recently been conducted by The Johns Hopkins University, Applied Physics Laboratory under the sponsorship of the U. S. Bureau of Naval Weapons. The potential applications to MOL appear particularly attractive.

Most of the presently contemplated manned space missions involve some impulsive maneuvers by the inhabited vehicle, typically calling for the variable impulse and multiple restart capabilities of liquid chemcial rockets. This could apply to the initial MOL, which may require small thrust producers for attitude control or station keeping purposes. It will certainly apply to follow-on missions that call for rendezvous, docking, and other maneuvers associated with periodic re-supply and crew transfer. It appears that such missions will call for earth-storable propellants and a two-gas cabin atmosphere, but might not justify a fully regenerative life support system or a nuclear power source. Such cases represent a considerable quantity and variety of vital fluids, including the liquid bi-propellants, potable water, atmospheric oxygen and nitrogen, any necessary coolants, and whatever reactants might be needed for electrical power generation. This tends to create a formidable over-storage problem, since the supply of each separately stored fluid must include some individually determined margin for uncertainty or emergency reserve. Also, the inherent inefficiencies of multiple tankage incur additional penalties in hardware weight, volume and complexity. Clearly, a substantial consolidation of on-board fluid storage requirements can pay off handsomely in terms of system performance and habitability.

An extremely promising approach involves the use of hydrazine and hydrogen peroxide as a storable bi-propellant combination. Equally promising in certain applications is the hydrazine/nitrogen tetroxide system. The suitability and attractiveness of these liquids for space propulsion and attitude control is well documented, but more exciting is the abundance of potentially useful products from their oxidizer-rich combustion in a gas generator. Always present are interestingly large quantities of potable water, plus gaseous oxygen and nitrogen in virtually any desired proportion, depending on the selected mixture ratio. The released heat and kinetic energy are available for electrical power generation, thermal management, and a variety of mechanical functions. Figure 1 illustrates the foregoing in a representative block diagram, while Figures 2 through 5 plot the basic chemical and thermochemical relationships from which estimates of performance in specific areas may be derived.

Figure 6 schematically depicts one scheme for the generation and control of a two-gas cabin atmosphere in zero gravity, while Figures 7 and 8 indicate the mixture ratios required to maintain various atmospheric compositions under widely varying conditions of overboard leakage. Figure 9 presents the corresponding requirements for total reactant flow rate. Figures 10 and 11 similarly plot the generation rates of by-product water and thermal energy. A possible side process of thermal management is suggested in Figure 12 and Figure 13 illustrates a method of extracting electrical power via turbomachinery. The tabulated data in Figures 14 and 15, coupled with a fair assurance of subsequent shifting equilibria, attest to physiologically acceptable concentrations of combustion-generated impurities.

Particularly worthwhile in the MOL application would be the substantial atmospheric flush rates that accompany power generation. These high rates would effectively solve the otherwise critical problem of contaminant build-up at no extra cost in weight or complexity. They would also provide a free source of additional low thrust (from the expelled atmosphere) that could conveniently be directed for attitude control or station keeping purposes.

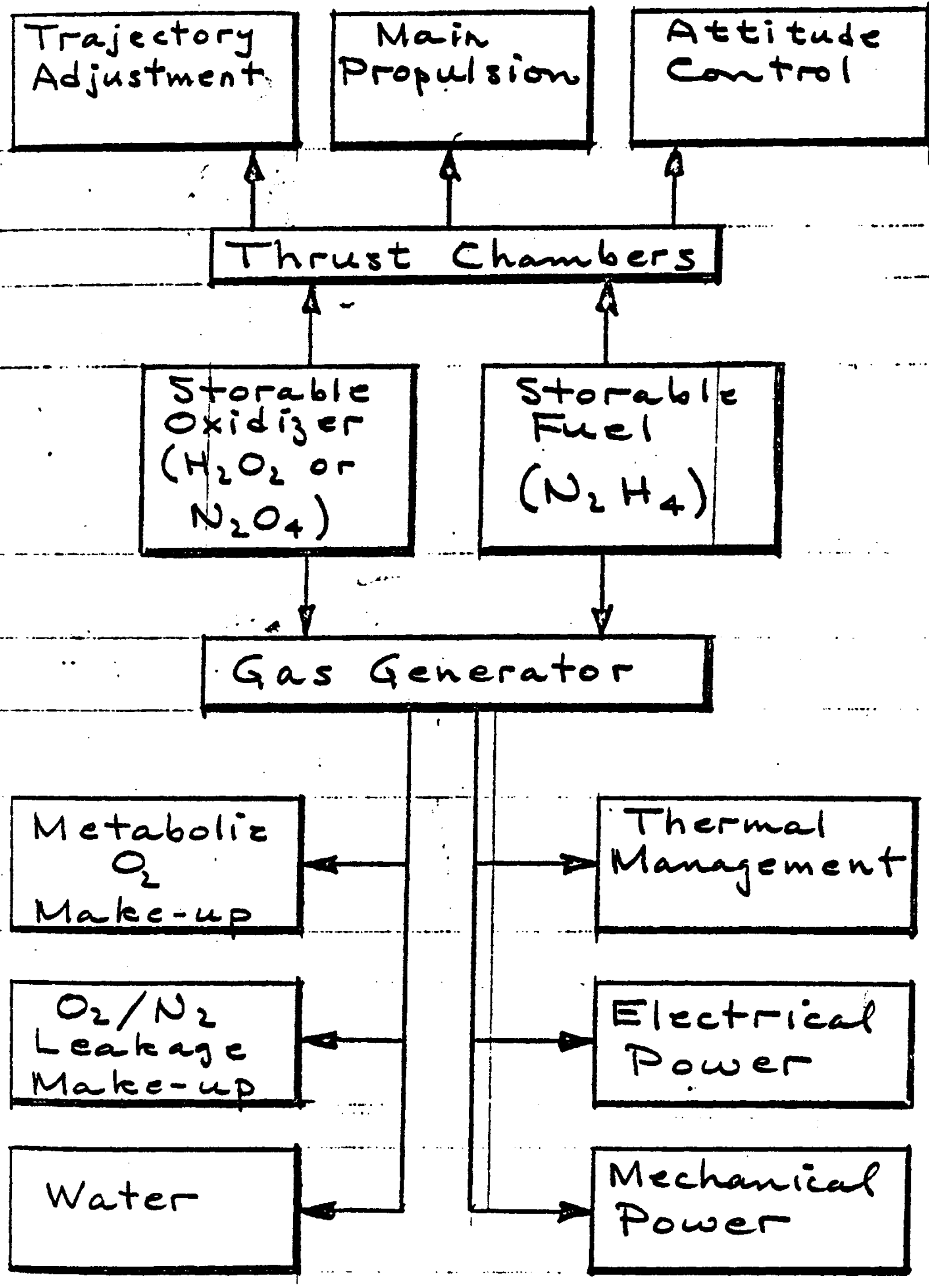
Another intriguing opportunity involves the integration of space station fluid usage with that of the shuttle vehicle. It appears quite reasonable and attractive to visualize the unburned reserve propellants aboard each arriving shuttle as usable supplies for station operation, and vice versa.

It is therefore suggested that the Cornucopia concept be introduced into the MOL program, first as a passenger experiment, and perhaps later as an integral element of the space system.

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Fig. 1

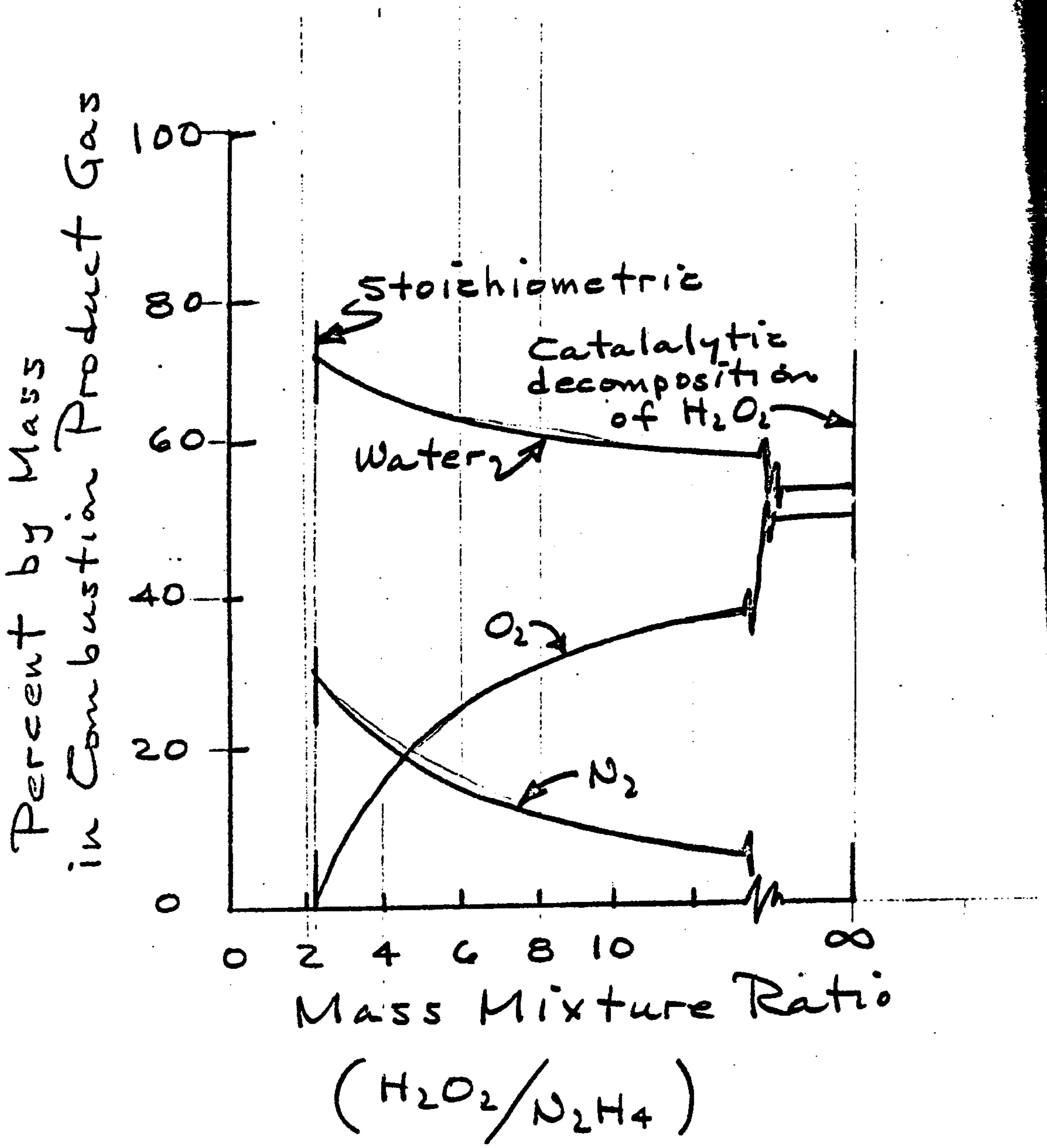
Cornucopia
Representative Block Diagram



The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia Fig.

Principal Products of Hydrogen Peroxide / Hydrazine Reaction



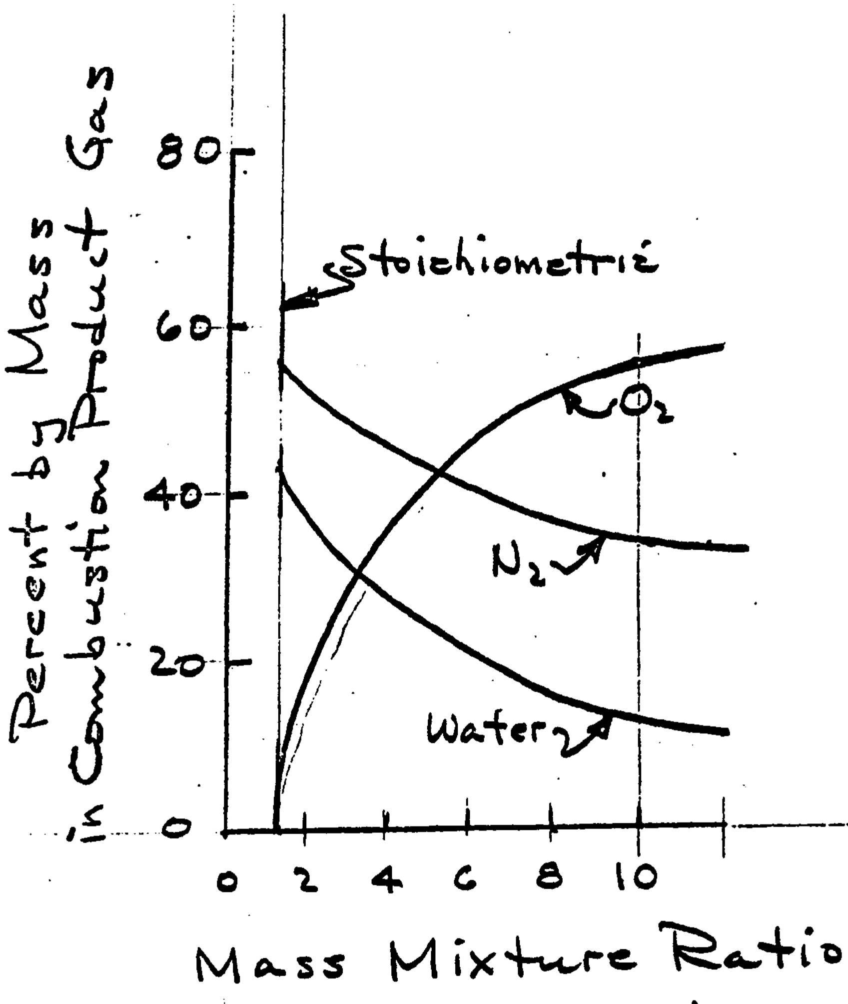
g. 2

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia

Fig. 3

Principal Products of Nitrogen Tetroxide/Hydrazine Reaction

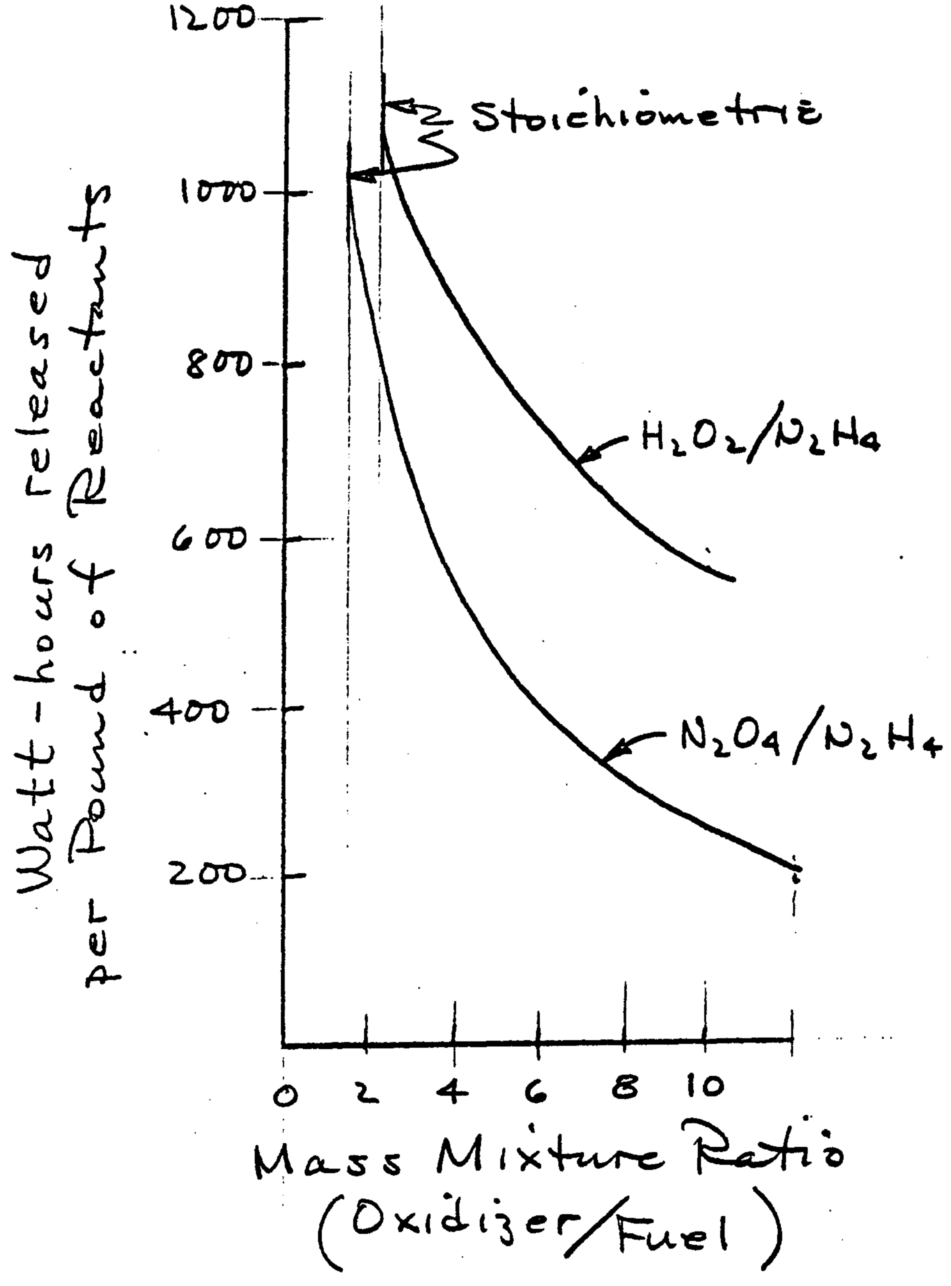


The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia

Fig.

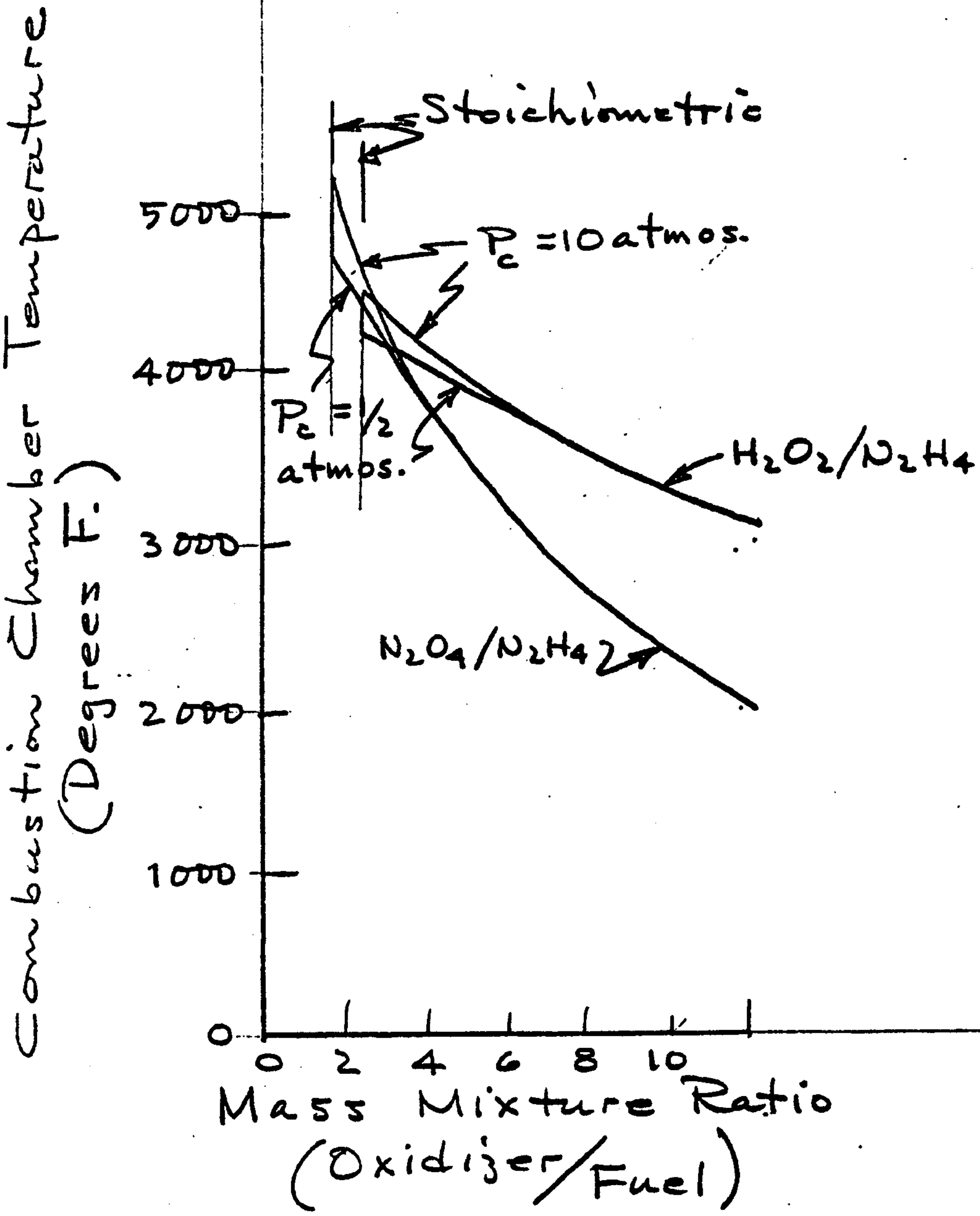
Total Energy Production



The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Fig. 5

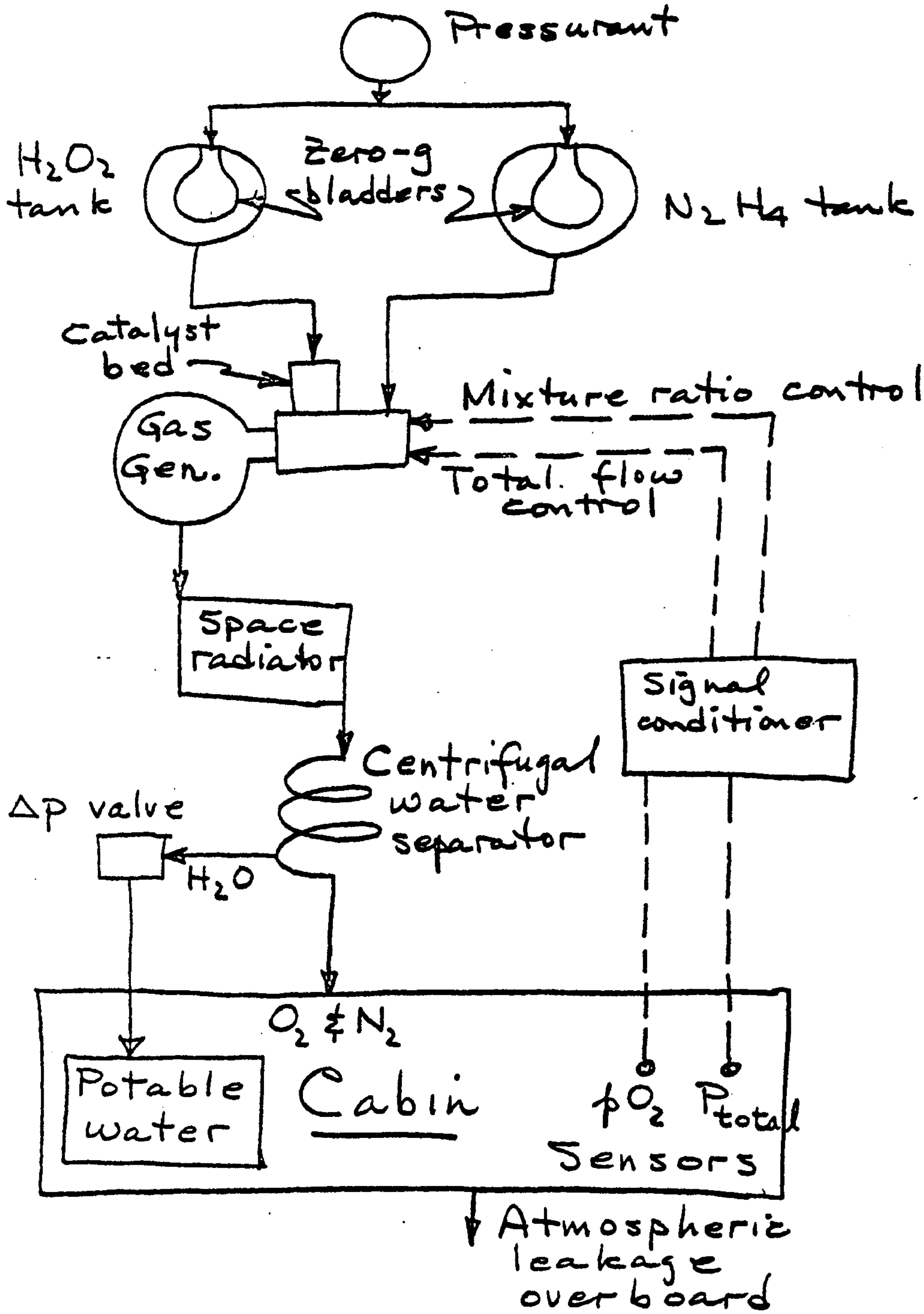
Cornucopia Reaction Temperatures



The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia Fig. 6

Representative Two Gas Atmosphere Control System



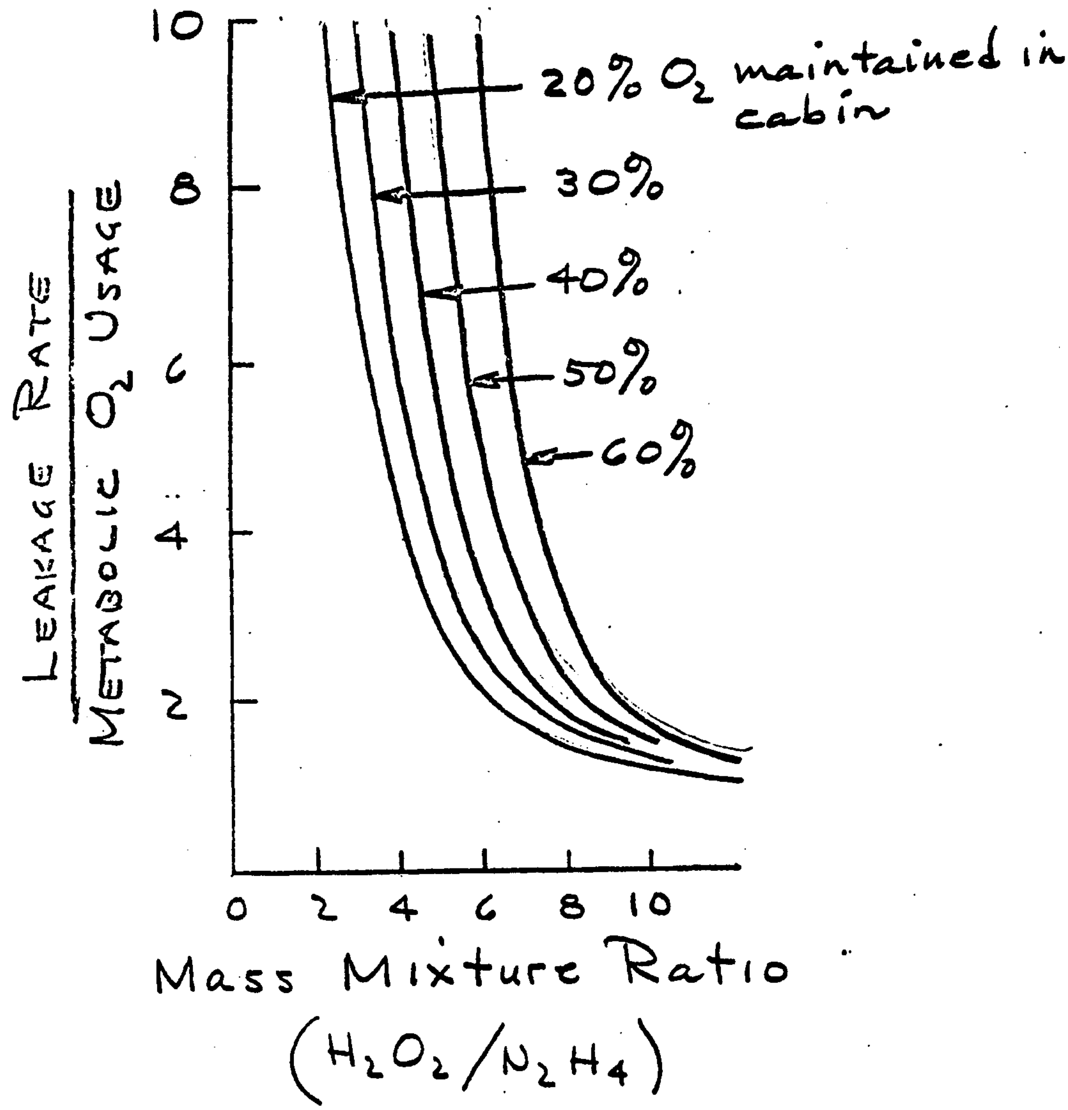
6

The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Fig 7

Cornucopia

Atmosphere Replenishment from Hydrogen Peroxide/Hydrazine Reation

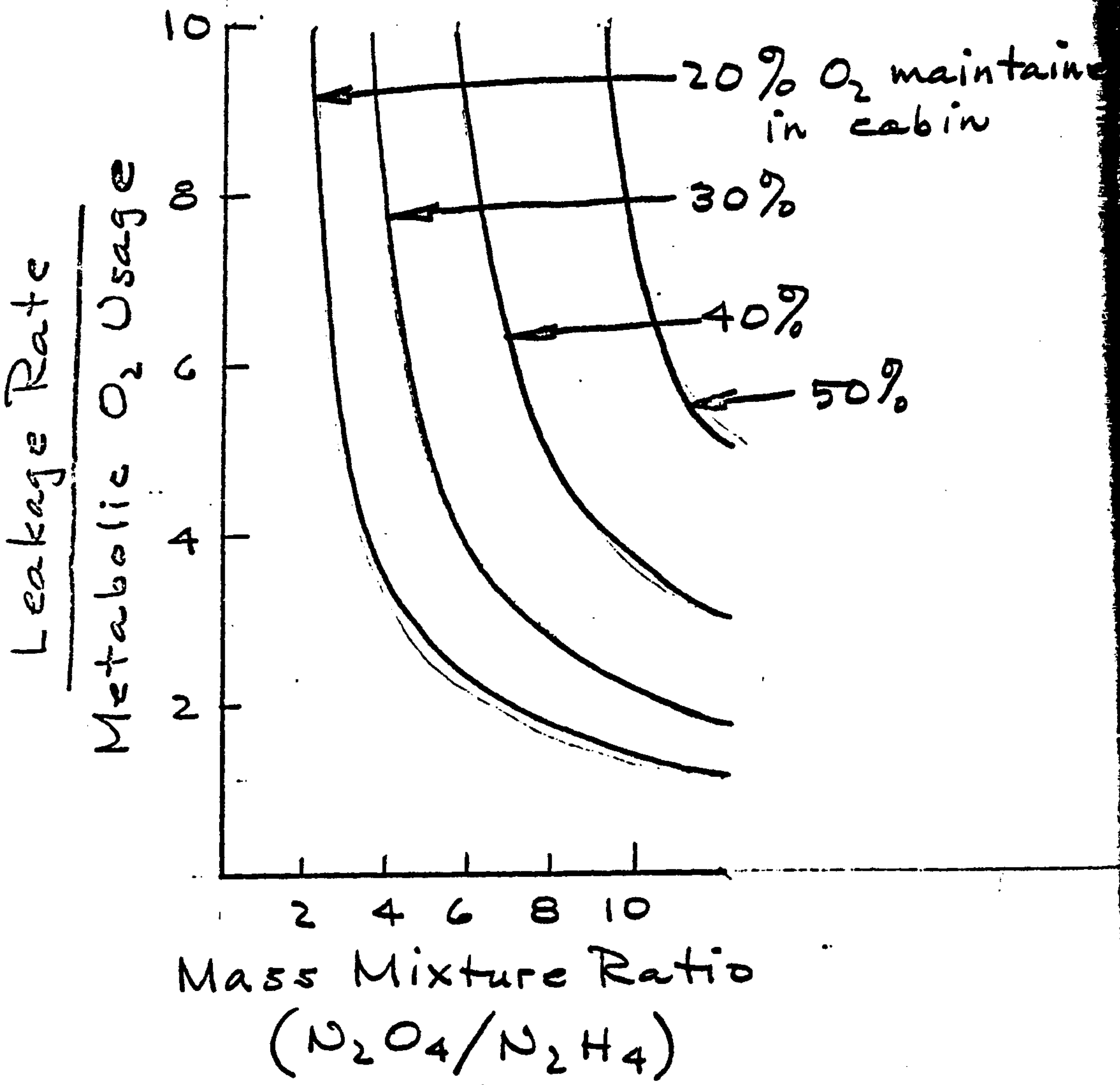


The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Fig 8

Cornucopia

Atmosphere Replenishment from Nitrogen Tetroxide/Hydrazine React



3

Johns Hopkins University
PHYSICS LABORATORY
Silver Spring, Maryland

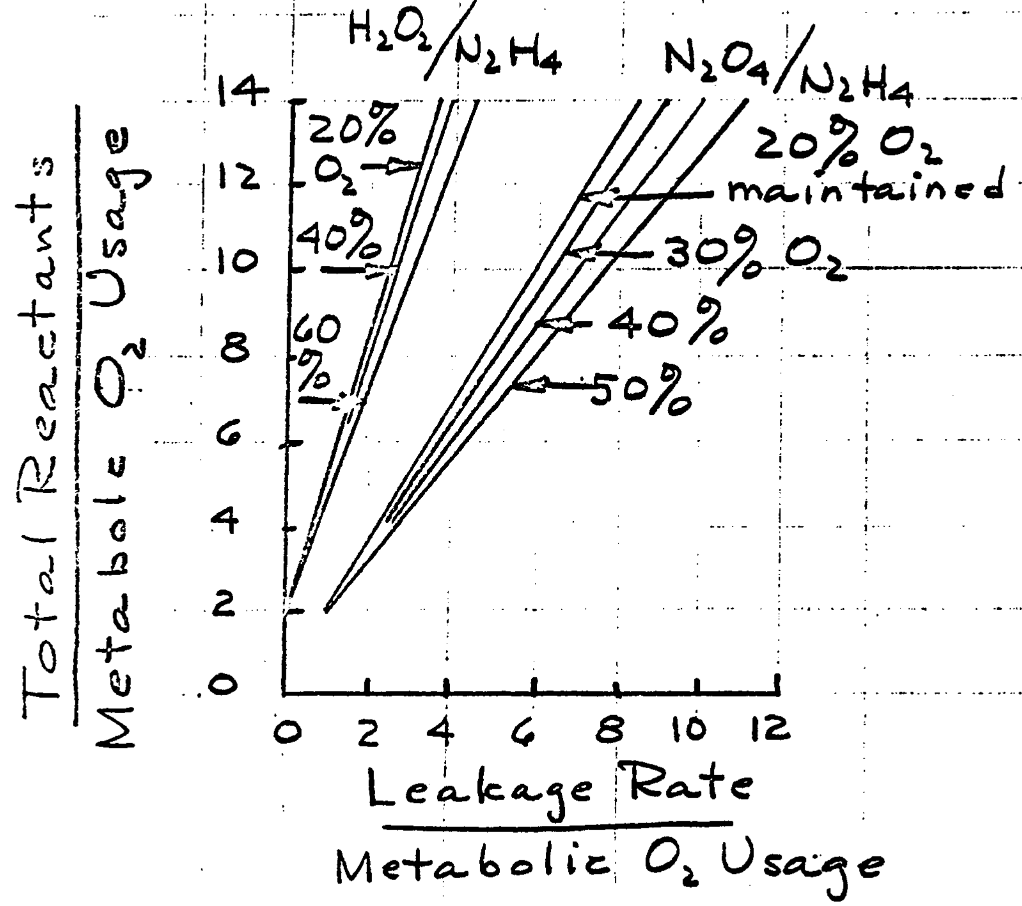
Cornucopia

Fig. 9

Total Reactant Mass Flow
for Atomosphere Replenishment

.cti

taine

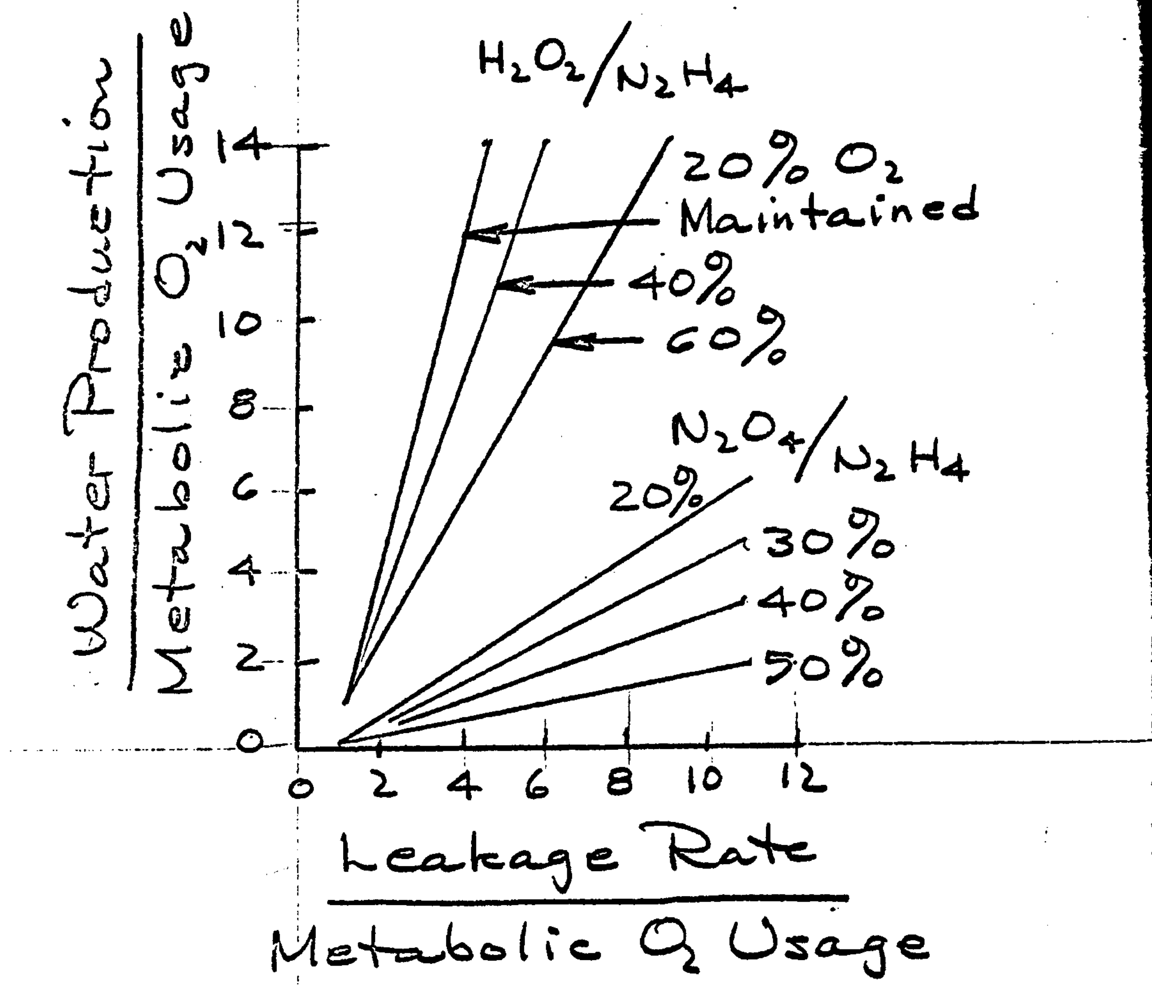


The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia

Fig. 10

Water Produced by Atmosphere Replenishment Process



ig. 10

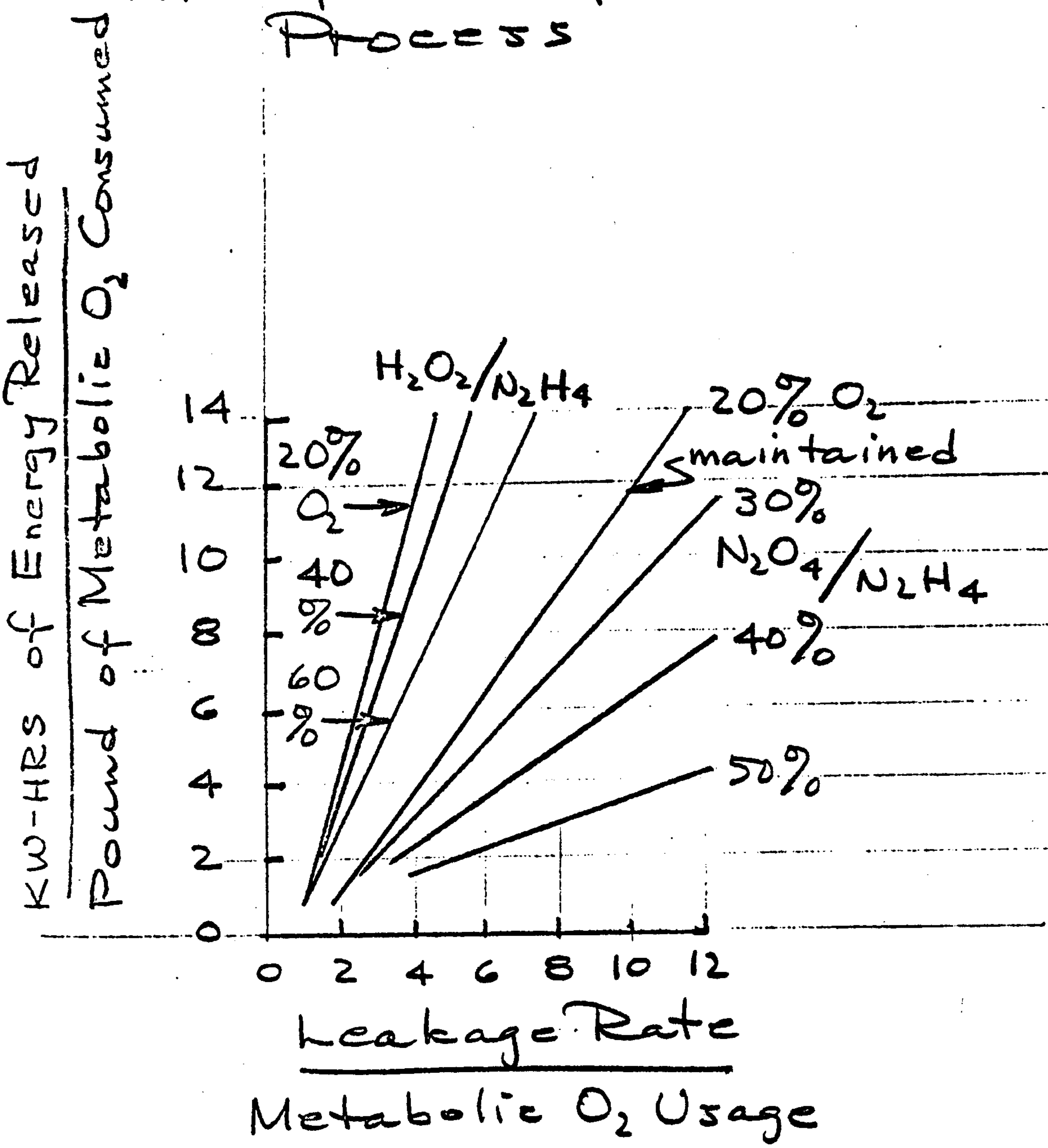
Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

cess

Cornucopia

Fig. 11

Energy Released by Atmosphere Replenishment Process

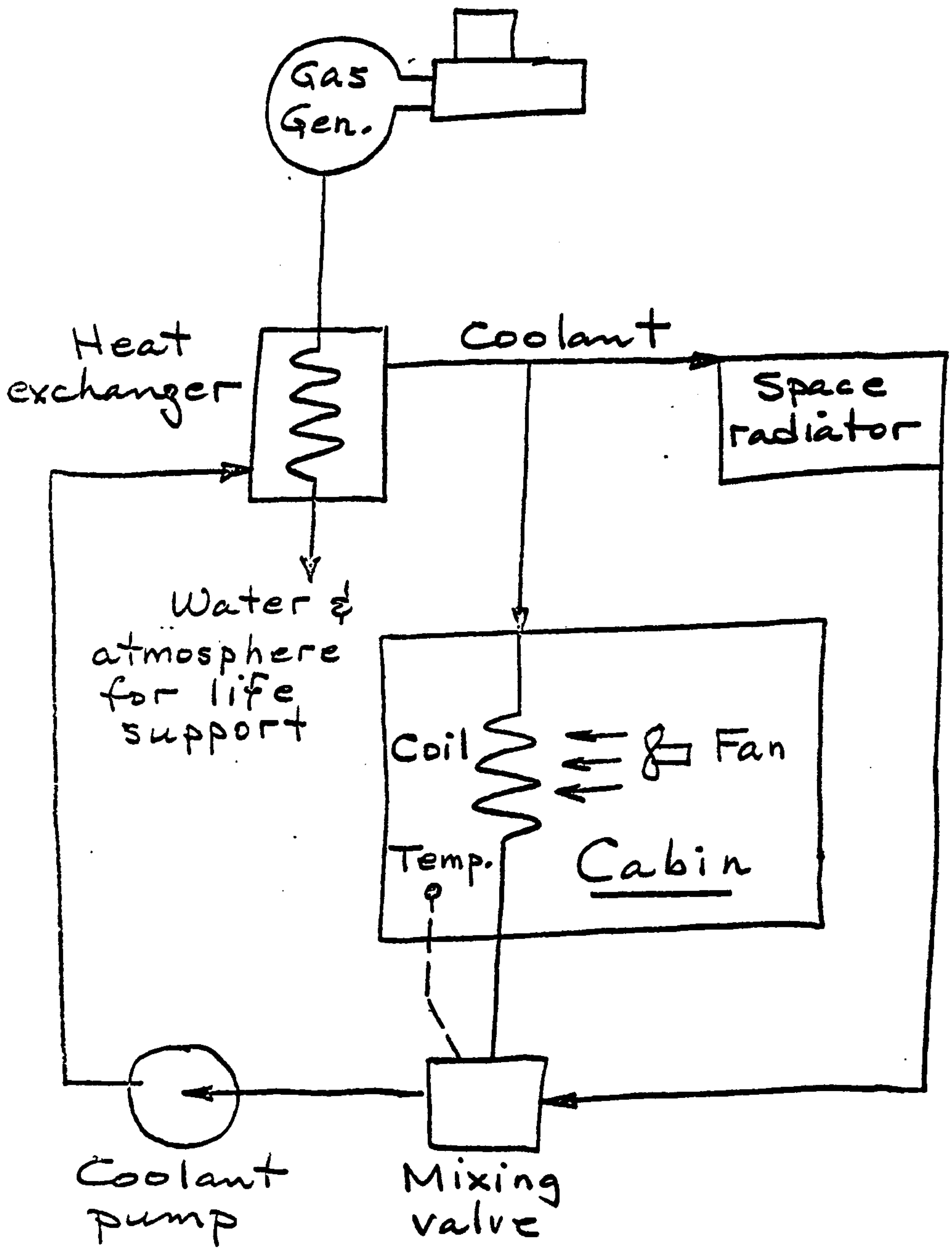


The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Silver Spring, Maryland

Cornucopia

Fig. 1

Representative Cabin Temperature Control System

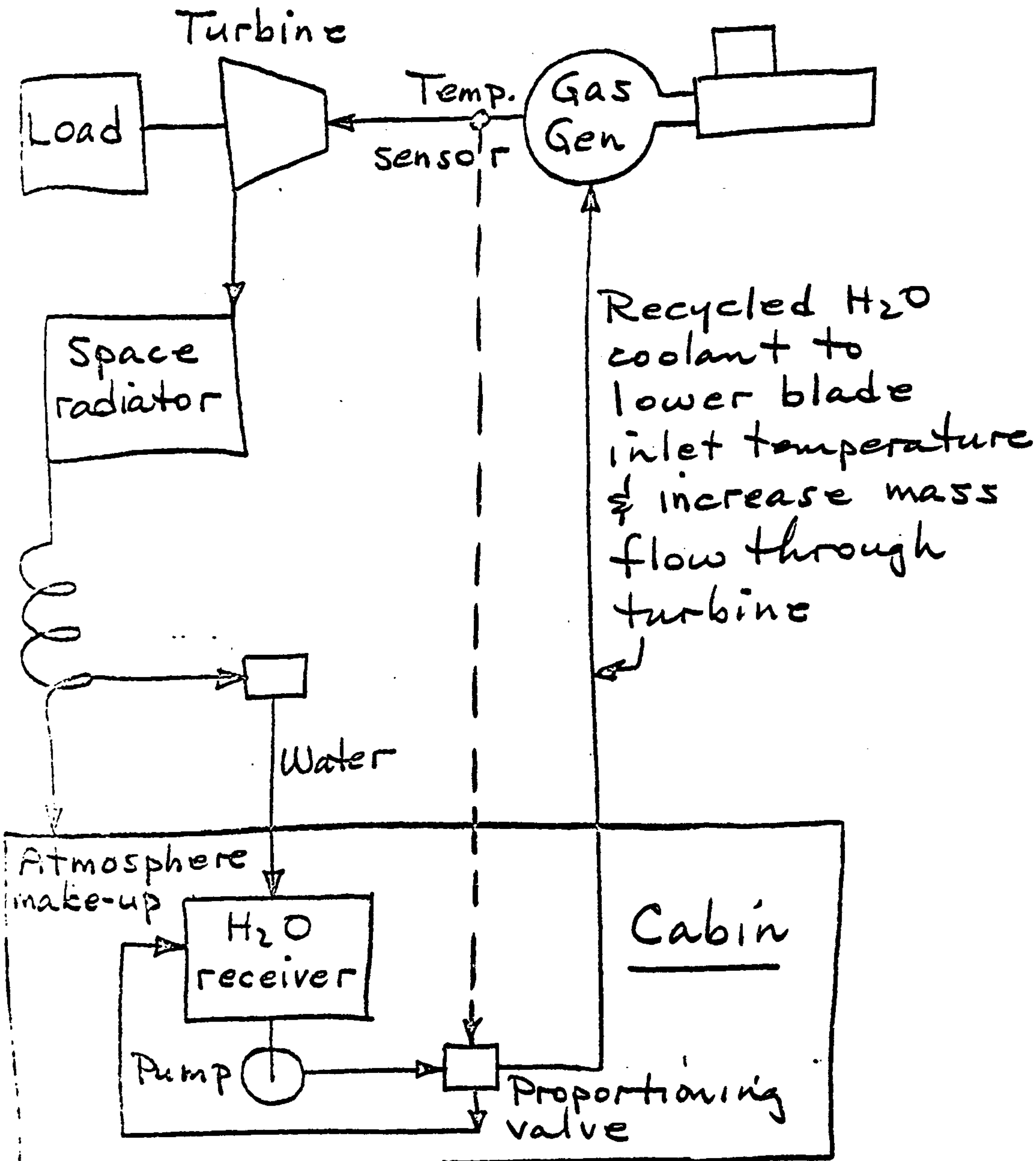


2

The Johns Hopkins University
Applied Physics Laboratory
Silver Spring, Maryland

Fig. 13

Cornucopia
Representative Power Generation System



Temporary Products of Hydrogen Peroxide/Hydrazine Reaction

Oxidizer/fuel Mixture Ratio (mol)	Oxidizer/fuel Mixture Ratio (mass)	Combustor Pressure (atm)	Concentration in Combustor (parts per million by mass): H	O	N	OH	H_2N	NH_3	NH	NO	NO_2	H_2
2	2.12	0.5	752	4250	0	32050	0	0	15	7170	0	6778
		1.0	625	3580	0	30400	0	0	15	7380	0	6308
		2.0	512	2960	0	28600	0	0	15	7550	0	5828
		5.0	384	2240	0	25900	0	0	15	7680	0	5184
		10.0	302	1775	0	23700	0	0	15	7680	0	4692
4	4.25	0.5	86	2650	0	21300	0	0	0	7910	0	862
		1.0	61	2110	0	19400	0	0	0	8280	0	688
		2.0	42	1680	0	17500	0	0	0	8580	0	548
		5.0	25	1200	0	15100	0	0	0	8970	0	392
		10.0	17	928	0	13400	0	0	0	9200	46	302
6	6.38	0.5	13	880	0	10100	0	0	0	5130	0	192
		1.0	8	672	0	8900	0	0	0	5250	0	146
		2.0	5	495	0	7750	0	0	0	5360	0	108
		5.0	3	336	0	6440	0	0	0	5490	46	72
		10.0	2	240	0	5510	0	0	0	5550	46	54
8	8.50	0.5	3	320	0	5200	0	0	0	3330	0	58
		1.0	2	240	0	4500	0	0	0	3390	0	44
		2.0	1	176	0	3860	0	0	0	3420	0	32
		5.0	1	112	0	3130	0	0	0	3480	0	20
		10.0	0	80	0	2670	0	0	0	3510	46	14
10	10.62	0.5	1	144	0	3000	0	0	0	2310	0	22
		1.0	0	96	0	2570	0	0	0	2340	0	16
		2.0	0	64	0	2180	0	0	0	2340	0	12
		5.0	0	48	0	1750	0	0	0	2370	0	8
		10.0	0	32	0	1480	0	0	0	2370	46	6

Figure 14

Figure 14

[illegible] Products of Nitrogen Tetroxide/Hydrazine Reaction

Oxidizer/fuel Mixture Ratio (mol)	(mass)	Combustor Pressure (atm)	Concentration in Combustor (parts per million by mass) H	O	N	OH	H_2N	NH_3	NH	NO	NO_2	H_2
0.5	2.88	0.5	1743	10440	0	41900	0	0	45	14280	0	8124
		1.0	1519	9180	0	41000	0	0	45	15050	0	7808
		2.0	1306	7950	0	39700	0	0	60	15750	0	7450
		5.0	1054	6450	0	37700	0	0	75	16550	0	6942
		10.0	879	5400	0	35800	0	0	90	17000	0	6526
1.0	4.30	0.5	252	9400	0	30550	0	0	0	22530	0	984
		1.0	194	7950	0	29000	0	0	0	24050	46	842
		2.0	145	6610	0	27150	0	0	0	25450	46	706
		5.0	96	5070	0	24550	0	0	0	27250	46	546
		10.0	68	4060	0	22450	0	0	0	28450	92	440
2.0	5.76	0.5	3	656	0	4290	0	0	0	10290	0	24
		1.0	2	480	0	3690	0	0	0	10400	46	18
		2.0	1	352	0	3195	0	0	0	10540	46	12
		5.0	1	224	0	2600	0	0	0	10700	92	8
		10.0	0	160	0	2210	0	0	0	10760	92	6
3.0	8.60	0.5	0	16	0	425	0	0	0	3210	0	0
		1.0	0	16	0	357	0	0	0	3210	46	0
		2.0	0	16	0	289	0	0	0	3210	46	0
		5.0	0	0	0	238	0	0	0	3240	46	0
		10.0	0	0	0	204	0	0	0	3240	92	0
4.0	11.50	0.5	0	0	0	51	0	0	0	1020	0	0
		1.0	0	0	0	34	0	0	0	1020	0	0
		2.0	0	0	0	34	0	0	0	1020	46	0
		5.0	0	0	0	17	0	0	0	1020	46	0
		10.0	0	0	0	17	0	0	0	1020	46	0

Figure 15

3 March 1964

MEMORANDUM

From: M. Douglas, NPIC
To: Dr. W. C. Hall, NRL

Subj: Comments on MOL Ocean Surveillance

1. Target Search.

The astronaut should be provided with high quality binoculars or a telescope for target search. This viewer should have a continuously vari (zoom) magnification capability to assist the astronaut in target evaluat once detection is achieved. The viewer and aerial camera should be coord ("slaved"), so that the optical axis of each continuously tracks the same location on the ground. This would insure that photography of a selected target is obtained when the camera is activated by the astronaut.

The astronaut should be assisted in target search by one or more senso such as radar or IR, which would provide advance warning and acquisition o targets of opportunity on the sea surface. The optical system, on command the astronaut, could be guided "on target" by the electronic sensor(s).

2. Aerial Camera.

The camera selected for the MOL experiments, as a result of the great altitude (150 n.mi.), will of necessity be of the long focal length type. N focal length shorter than 48", producing a nadir scale of 1:228,000, would b acceptable. To improve the photo interpretation capability a longer focal length would be highly desirable, and may prove to be essential.

The system resolution of the camera must be of the highest order possible, with 100 lines/mm representing a minimum in-flight goal, rather than a static bench test rating of a lens. This stringent requirement is necessitated by the small image sizes of most naval vessels on satellite photography; for example, a destroyer imaged on 96" focal length photography at the nadir would have length-width dimensions of only .00368 X .00036 feet.

Associated factors, such as image motion, must be carefully considered to prevent the introduction of serious degradation effects on the film imagery.

3. Aerial Processor.

The aerial processor is the final link in the MOL photographic system. In terms of photographic interpretation it is equally as important as the camera, since high quality imagery achieved by the camera can be drastically degraded during the processing stage. The aerial processor ultimately selected for the MOL should have a proven resolution capability of 100 lines/mm or greater.

4. Summary Statement.

It is realized that the camera and processor requirements as stated previously are severe. It must be recognized, however, that the photo interpretation requirements for ship surveillance are equally severe. Insufficient scale or image quality could quite easily result in a total lack of even a minimal P.I. capability with respect to shipping in the MOL. For other categories of Naval interest, such as ports and coastal conditions, the photographic requirements are much less stringent and useful information could be obtained with less sophisticated camera systems. These latter categories, by virtue of their large size and fixed position, present a greatly simplified reconnaissance problem.

The present state-of-the-art in aerial reconnaissance is deemed adequate for the development of an MOL photographic system suitable for Navy requirements.

Melvin Douglas
MELVIN DOUGLAS

(If we can assist in any further way, please let us know.)

Code: 81
File : 3900

PROPOSAL FOR A PHOTO INTERPRETATION EXPERIMENT TO BE CONDUCTED IN A ONE-MAN GEMINI SATELLITE

1. BACKGROUND.

Unmanned orbiting and deep space vehicles (TIROS, MARINER, RANGER, etc) have demonstrated a capability for gross aerial surveillance and reconnaissance. It is reasonable to assume that in the not too distant future improvement in the transmission system will permit the scanning, transmissi[on] and reconstitution of high quality images. However, it is felt that these images will not be able to match the resolution of modern film emulsions fo[r] many years to come; even with the benefit of spectacular advances.

Further, it can be assumed that by proper programming, a reconnaissance satellite could obtain and transmit intelligence of a given target at a given time. Advance programming, however, does not readily solve the proble[m] of "targets of opportunity." In addition, programming cannot readily solve the problem of selectivity - that is "hold" or "cancel" coverage of target areas which are obscured by weather. Human judgement may also prove valuabl[e] in descriminating areas of significance vice general coverage which would result in large quantities of sensor records, of which only a relatively small amount would be of real value.

In view of the above, it appears that it may be desirable to test the capabilities of a man in the space vehicle. If he can adequately interpret and analyze high quality sensor records and report his finding to earth, it may prove a valuable step in determining to what degree human judgement is required "on scene" in a space vehicle or whether equal value can be obtained by decisions made on earth from unmanned sensors. Further, it will provide interim investigations into real time operations until high-resolution, high-quality transmission of sensor records becomes a reality.

2. DESCRIPTION OF PROPOSED GEMINI TEST PROGRAM.

The two-man GEMINI capsule, with photographic equipment substituted for one man, would be utilized for testing the ability of an astronaut to conduct visual search, visual target analysis, and photographic reconnaissance functions in space. The astronaut, with the aid of optical devices, would seek out and study targets of Naval interest such as shipping and coastal activities, as well land targets of interest. To maintain control in the test program, certain pre-selected targets and areas would be assigned the astronaut as well as targets of opportunity, thus permitting a more definitive evaluation of human performance with respect to known object characteristics. Once objects of significance were visually acquired, the astronaut would activate a high quality reconnaissance camera under his direct control and obtain photographic coverage. Equipment for in-flight processing and viewing of the film would be provided to permit in-flight interpretation. The information obtained from the photography could then be transmitted to the cognizant ground station through standard radio communication channels, or could be acquired in written form upon recovery of the capsule. This information would be compared with that obtained from analysis of the photography at NAVPIC, and from known data on the pre-selected targets. The results of the test program would indicate:

a. The value of in-flight human judgement in a space surveillance system.

b. The capabilities and limitations of optically-aided visual search and target analysis.

c. The level of information obtainable from in-flight photographic interpretation, when compared with ground analysis at NAVPIC.

d. The relative merits of visual vs. photographic surveillance.

e. The value of real time intelligence reporting.

3. RECONNAISSANCE CONSIDERATIONS.

a. Objects of Intelligence Interest.

Ocean surveillance, or more specifically the location, identification, and course of ships is of obvious concern to the Navy. Since both manned and unmanned satellite surveillance systems for ship reconnaissance are being considered by the Navy for possible development, the performance of the GEMINI astronaut would provide guidance for future planning in this realm. An astronaut, with the aid of high quality optical viewing devices, should be capable of detecting shipping of varying categories and photographing vessels of interest. The typical dimensions of some U. S. Naval vessel classes are given in Table I and will be referred to in a later paragraph. It should be noted that ship's wake is a valuable detection aid in most cases and will be of special significance in detecting ships of small size.

Coastal targets, such as ports, by their nature are geographically fixed and present no great problem to surveillance from space. Pattern analysis, not possible with individual objects such as ships, will assist the astronaut in his study of coastal facilities.

The successful detection and analysis of land targets of intelligence interest (new missile sites, for example) will be dependent upon the usual reconnaissance factors: size, shape, contrast, degree of concealment, associated clues (smoke, road networks, etc.) and others. Interruptions in the predominant land use or vegetative patterns will serve to direct the astronaut's attention to locales of possible military activity.

TABLE I

TYPICAL U.S.N. SHIP DIMENSIONS (FEET)

	Overall Length	Overall Wid
CVA(N)	1100	252
CVA	1039-47	252
CGN	721	73
CA	716	75
CL	610	66
DD	418	45
SSBN	410	33
SSN	278	31
SS	312	27

b. Basic Data

The proposed GEMINI capsule will operate at an orbital altitude of 150 nautical miles. Table II presents some pertinent photographic data with respect to surveillance from this altitude. (Scale data are for center of format and are approximate for high tilts).

TABLE II

PHOTO DATA FOR 150 N.M. ORBITAL ALTITUDE

CAMERA TILT ANGLE	SLANT RANGE(N.M)[1]	ARC DISTANCE(N.M.)[2]	12" FOCAL LENGTH X SCALE[3]	12" FOCAL LENGTH Y SCALE[4]
0°	150	0	1:912,030	-
30°	174.5	87.3	1:1,060,995	1:1,216,037
60°	322.8	279.8	1:1,962,688	1:3,648,111
$73^{\circ}22'27''$ (Apparent horizon)	1026.6	997.6	1:6,241,933	-

24" FOCAL LENGTH X SCALE	24" FOCAL LENGTH Y SCALE
1:456,015	-
1:530,498	1:608,014
1:981,344	1:1,824,060
1:3,120,966	-

[1]Distance from camera to intersection of optical axis with surface of earth.
[2]Distance from ground nadir to above intersection.
[3]Scale parallel to horizon.
[4]Scale perpendicular to horizon.

The area of coverage of a photograph is dependent upon photographic format, focal length, camera altitude and attitude in space. Table III provides ground distance data with respect to the principal parallel (x axis) of a photograph of zero swing (70mm format).

TABLE III

GROUND DISTANCE (N.M.) REPRESENTED BY PHOTO PRINCIPAL PARALLEL

Tilt Angle	12" F.L.	24" F.L.
0°	28.1	14.1
30°	32.7	16.4
60°	(Approx.) 60.5	(Approx.) 30.3

Table IV indicates the image sizes of ship classes to be expected on photography of zero tilt at an altitude of 150 nautical miles. While it appears that these images would not be normally visible to the naked eye, it is anticipated that at least the larger ones should be detectable through high quality optical aids. A high quality camera system should provide image sizes which are adequate for photo interpretation. (See paragraph 3d.)

TABLE IV

IMAGE SIZE

	12" F.L.				24" F.L.			
	Feet		Inches		Feet		Inches	
	Length	Width	Length	Width	Length	Width	Length	Width
CVA(N)	.00121	.00028	.01452	.00336	.00241	.00055	.02892	.00660
CVA	.00114	.00028	.01368	.00336	.00228	.00055	.02736	.00660
CGN	.00079	.00008	.00948	.00096	.00158	.00016	.01896	.00192
CA	.00079	.00008	.00948	.00096	.00157	.00016	.01884	.00192
CL	.00067	.00007	.00804	.00084	.00134	.00014	.01608	.00168
DD	.00046	.00005	.00552	.00060	.00092	.00009	.01104	.00108
SSGN	.00045	.00004	.00540	.00048	.00089	.00007	.01068	.00084
SSN	.00031	.00004	.00372	.00048	.00061	.00007	.00732	.00084
SS	.00034	.00003	.00408	.00036	.00068	.00006	.00816	.00072

c. Visual Factors.

The limit of resolution (visual acuity) of the human eye has been the object of study for years. Most of the data available are the result of tests performed in the laboratory under controlled conditions of contrast, target luminance, etc. It has been found that the resolution of the eye is dependent upon both physical and physiological factors. In addition, the nature of the target being viewed has significance in the resolution level obtained. Point source targets indicate a normal eye resolution limit of 30 seconds of arc, whereas line targets produce a resolution limit of about 1-2 minutes of arc. Very low target luminance or contrast values significantly reduce the visual acuity of the eye. One goal of the GEMINI test program will be to investigate the visual acuity of the human eye with respect to viewing the earth from a position in near space. Because of the small viewing scale, the astronaut will be assisted by an optical telescope or binoculars.

d. Photographic Factors.

The small photographic image size of Naval vessels (Table IV), even of large aircraft carriers, indicates the need for a high resolution photographic system of adequate focal length. A focal length of 24" is suitable for the proposed GEMINI test program, provided that sufficient resolution is maintained in the camera and processing components to overcome the small photographic scales. The use of a 12" focal length, although increasing ground coverage and reducing image motion problems, would severely restrict the quantity of information obtained from the photography. This ground coverage gain with 12" photography is not significant since the astronaut will be directing the camera towards specific objects or locales, rather than attempting broad area coverage.

To obtain adequate photographic imagery, the camera system components utilized in the GEMINI capsule should be selected with care. Film emulsion, camera optics, and image motion compensation are among the many factors to be considered. For example, no film emulsion of less resolution than Panatomic-X Aerial Film would be desirable in the proposed test program. This film has a low contrast static resolution capability of 65 lines per millimeter. Several 24" aerial reconnaissance lenses (Table V) are currently "on-the-shelf" or Navy test items and could be considered for the GEMINI program. Static resolutions with SO213 film are in the AWAR range of 80-100 lines per millimeter. The marriage of lens cone and camera, with IMC magazine, would require approximately three months and could be accomplished at the Aeronautical Photographic Experimental Laboratory, NADC Johnsville, Pa. The weight of the camera system and associated components would be compatible with the removal of one astronaut.

Equipment for processing the exposed negatives would be installed in the GEMINI capsule to enable the astronaut to perform photo interpretation in space. This equipment should be compact, reliable, compatible with the capsule environment, and capable of maintaining good image detail. Various methods exist for in-flight processing of aerial negatives. One non-liquid method developed by Kodak provides a processed negative and positive in 15-20 minutes and retains a resolution of 50 lines per millimeter on Plus-X film. Each in-flight processor would be evaluated in detail, prior to final selection for inclusion in the GEMINI system, to assure that the previously stated requirements were met.

Extensive flight testing of various Naval camera systems at Edwards Air Force Base in 1960 indicated that system resolutions of 55 lines per millimeter were attainable at that time with certain 70mm cameras. If this resolution were achieved by the proposed 24" GEMINI system, each line of resolution would represent 27 feet on the ground at zero tilt. Research has revealed that even at a ground resolution level of 50 feet, photo interpreters are able to identify ships, storage tanks, buildings, runways, etc., and that some useful information may be obtained at still poorer ground resolution levels. Provided adequate film scale and resolution, the photography obtained in the GEMINI capsule should be suitable for the level of interpretation required for the test program. (In future systems, more sophisticated equipment could be used than that envisioned for the GEMINI capsule.)

e. In-flight Photographic Interpretation.

Sufficient photo interpretation equipment would be provided the astronaut to permit in-flight analysis of the processed photography. This equipment consists of a few direct viewing optical devices and other miscellaneous tools. The photo interpretation equipment is highly compact, light weight, and necessitates only a minimal expenditure of capsule space. A skeletal set of P.I. tools could consist of one variable magnification viewer (pocket size), a small 12" X 12" light table (one inch deep), film marker, pencil, .001 and .5mm scale and paper pad for notes. Since it is not reasonable to expect the astronaut to perform detailed metrical operations in this test program, no photogrammetric devices would be required.

Training of the astronaut for the photo interpretation phase of the mission would be accomplished at NAVPIC. The training would include interpretation techniques with small scale photography and reporting procedures applicable to the test program.

4. COST FACTOR.

APEL estimate - very roughly - $30,000 (labor and parts)

NAVPIC estimate - very roughly - $10,000 (training and equipment)

TABLE V

24" LENSES

	Weight (with cone)	Dimensions	Resolution*	Remarks
Eastman Kodak f4.0	30-35 lbs.	25" length, 8" diameter	AWAR 86 1/mm (S0213)	Can be made in 24"f.l., 9-12 mos. for delivery.
Perkin Elmer Aspheric f8.0	40 lbs.	25" length, 8" diameter	AWAR 501/mm (PLUS X)	Curved focal plane required.
Photronics Catadioptric f4.0	65 lbs.	72" length, 12" diameter	Anticipate 80-100 1/mm(S0213)	To be tested shortly.
Pacific Optical Refractor f8.0	24 lbs.	28" length, 7" diameter	AWAR 1001/mm (S0213)	Extreme temperature sensitivity problem.

*Area Weighted Average Resolution. A single average value for the resolution over the entire negative rather than in one specific area.

PHOTOGRAPHIC OCEAN SURVEILLANCE TEST PROGRAM

TEST OBJECTIVE

To assess the capability of a high resolution photographic reconnaissance system to perform surveillance over ocean and coastal areas. Determine optimum sensitized materials required as well as shielding in the environment of a manned space vehicle. Determine by test the optimum method for accomplishment of the final phase of test which will be the addition of a photographic transmission system with readout stations on shipboard and ground areas. A ground resolution of 12 feet, from 200 miles is considered to be realistic at present for the photographic system.

II. IMPORTANCE OF TEST

To achieve the maximum resolution potential of reconnaissance equipment installed in space vehicles for surveillance of terrestrial, lunar and possibly other planetary bodies is one of the major objectives. In addition, it is planned to obtain valid data on the suitability of equipment provided and to determine possible further design changes which may be required. It will permit assessment of the performance of various films when used in the space environment and provide guidance for possible changes which may be required in respect to preparation of the sensitized materials i.e. emulsion characteristics, spectral sensitivity and etc. Also, tests of in-flight processing methods would be performed with film exposed in the laboratory using resolution targets as the quality determinant and processing half of the film on the ground and half in the space vehicle. An optimum in-flight processing method would be determined using wet methods as well as a sandwich (semi-dry) method such as Eastman Kodak Bimat or any other method which has been found to possess a high resolution potential.

III. DESCRIPTION OF THE EXPERIMENT

The experiment would be divided into a Phase I and a Phase II effort. Phase I would be ready for installation within 18 months after funding. The tests involved in this phase could be accomplished in one or two flights depending on the availability of astronaut time to devote to the required tasks.

a. Configuration of Test Items

PHASE I

(1) A high acuity 4½" x 4½" format camera equipped with a 48 inch focal length f/4 lens capable of resolving 100 lines/mm.

Downgraded at 3 year intervals; Declassified after 12 years.

IAL

Such a camera, which lacks some of the additional design features considered necessary, has been proposed but not yet developed by Chicago Aerial Industries and is designated as the CA-101. However, certain changes would be required in the focal plane shutter mechanism within the camera body as well as a larger camera body to eliminate any possible vignetting by a lens of 48 inch focal length. In addition, changes to the basic CA-101 camera concept are required to provide for film flattening using compressed air (Note: very little air is required) provided by a pressurized air container. The camera itself is not pressurized and the air vents to the ambient atmosphere within the vehicle after each exposure. The camera is equipped with a rotatable mirror permitting an extended transverse field of view. Dependent upon altitude, total angular coverage desired, and forward overlap consideration, transverse coverage of 35° could be provided by sequential pulse panning the camera through seven positions. The 48 inch focal length lens covers 5° on the 4½" x 4½" format. Magazines of 500 feet, 250 feet and 100 feet film capacity are intended for use in test of various types of film. The lens is partially patterned after one currently under development for the U. S. Navy by Fairchild Camera and Instrument Corporation, West Coast Division. See enclosure (2).

(2) Concurrently with the above described test for Phase I, it is intended to perform numerous sensitometric tests on various types of films both inside and outside of the space vehicle using containers capable of providing shielding against radiation and pressure environment. Simultaneous monitoring of inside and external environment will be made at specified intervals. The containers for film will be designed by the Aeronautical Photographic Experimental Laboratory (APEL) and fabricated either in prototype shop or under contract.

(3) The two in-flight processing test equipments will be either designed and fabricated by APEL or contracted for if the workload should prove to be excessive during period when equipment has to be produced. As previously noted, the in-flight processing tests could be performed on the first flight depending on the limitations imposed on the astronaut by operating the various other test equipments installed in the space vehicle.

PHASE II

(1) In this phase the photographic transmission system is to be added to the camera. A new airborne scanner is currently under development for a 4½" x 4½" format camera system which is due to be delivered to APEL in 1964. This system will be tested in the A3D-2P aircraft, and will provide data useful in ascertaining the required design changes to upgrade the resolution of the system for space application. The in-flight processor being developed by CBS for this system could also be assessed for possible suitability in a space environment. It is anticipated that the current designs and prototypes for other in-flight processors will serve as an essential background to the designs for this application.

(2) Specific equipments to be developed for Phase II.

(a) High resolution scanner to be completed during 1966-1967.

(b) Airborne transmitter to be completed during 1966-1967.

(c) Ground and shipboard receivers to be completed during 1966-1967.

b. Test Support Equipment Required

No requirement for special test equipment other than that already available is foreseen at the time of this writing.

c. Test Procedure

(1) Man's role is estimated to be the following:

(a) Maintain record of films used and perform visual observation at selected times when recordings are being made.

(b) Record status of environment within and outside of vehicle as tests are being conducted.

(c) Perform assigned tasks required in the determination of optimum in-flight processing methods for space usage. Obtain operating data and observe performance results.

(d) In the final phase, when the photographic transmission is used, voice communication with ground and shipboard stations will be required to advise on transmission start and finish times.

(e) Although the test procedures performed by astronaut will be well within his technical competence, voice communication with stations will be required to advise him on possible minor difficulties which may arise.

d. Category of Experiment

Category b is perhaps most applicable to these experiments. Except for optical port for camera lens, availability of voice communication, provision for storage of special film containers outside the vehicle, and antenna requirement in last phase of test of the photographic transmission system, it is not expected that the equipment for this experiment would affect the design characteristics of the MOL.

e. Cost is estimated as follows:

(1) Phase I

(a)	4½" x 4½" High Acuity Camera Development	$250,000
(b)	Controls for Camera	10,000
(c)	Spare Magazines for Camera	15,000
(d)	Cost of 48 Inch f/4 Catadioptric Lens (Fairchild)	80,000
(e)	Camera Equipment Installations	20,000
(f)	Camera Port	15,000
(g)	Subtotal for Camera Equipment and Installation	390,000
(h)	Subtotal for Cost of Film Sensitivity Experiment	20,000
(i)	Subtotal for Cost of In-Flight Processing Experiment	60,000
(j)	Cost of Contract Labor Involved in Performing Installation for Items (h) and (i)	20,000
	Total of (g), (h), (i) and (j)	$490,000

(2) Phase II

(a) Specifications for the transmission system will be prepared upon completion of the 4½" x 4½" format line scan system, which it is estimated will be evaluated in the latter part of 1964. It should be funded early in 1965, but at this point only a very broad estimate can be made relative to development cost of the transmission equipment which will consist of the following:

One each - Scanner and Processor
One each - Transmitter
Two each - Ground Stations

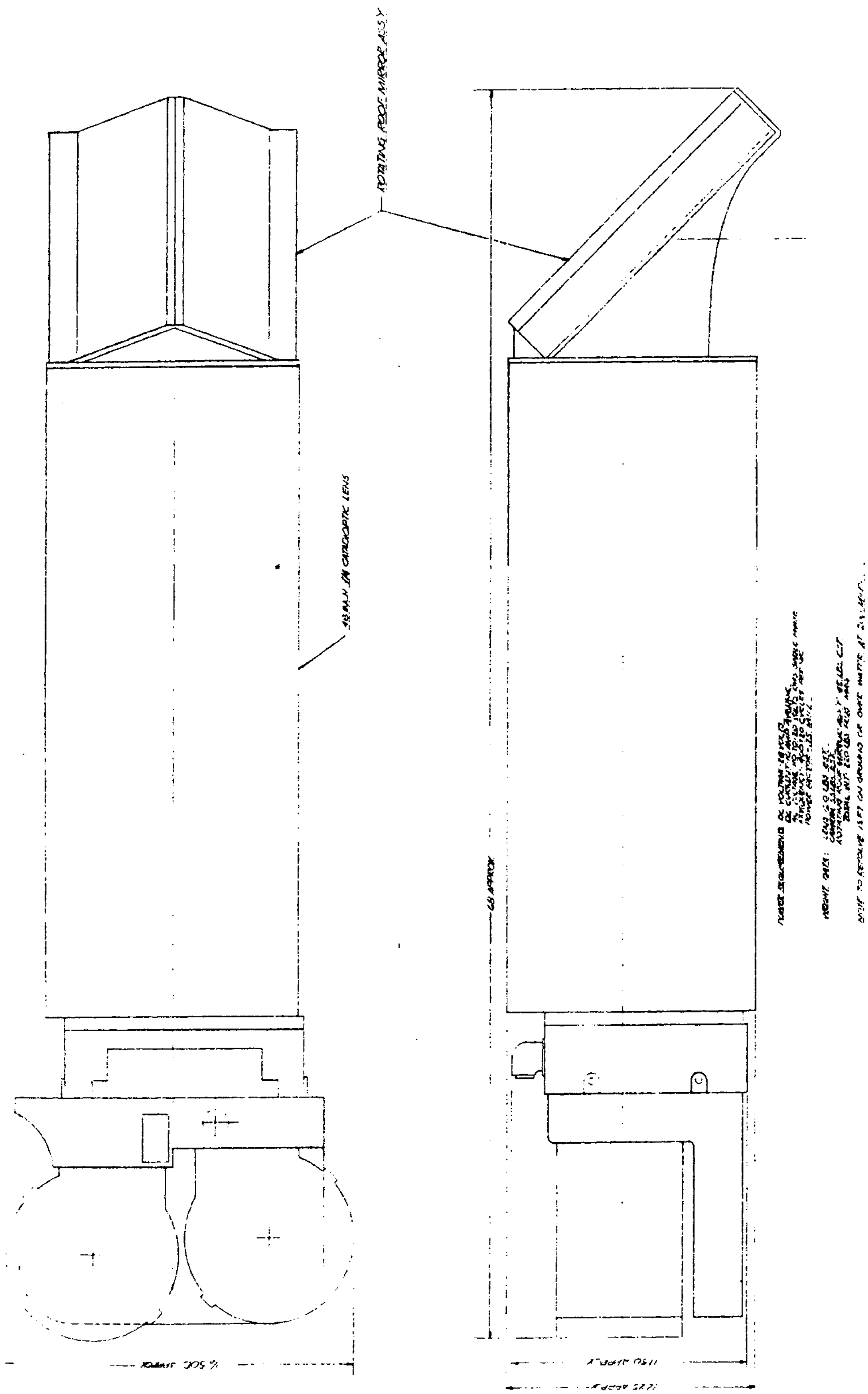
(b) Rough Estimate $950,000

Total of (1) and (2) = $490,000 + 950,000 = $1,440,000

NOTE: Detailed technical data on the requirements, configuration and installation of the photographic transmission system will be forwarded shortly. Substantial savings may be possible prior to the initiation of Phase II if it is found that current developments being made for the photographic transmission system are found to be applicable to the space program. In addition, small savings may also be possible by using available film magazines for Phase I.

Question: is the scanner required to be in manned vehicle. If this is not, then cost = $½ M
x 4
$2.0 M

$1.5 M
x 2
3.0 M cost of equip
x 2
6.0 M cost of equip plus integration


ROTATING ROOF MIRROR ASSY
CATADIOPTIC LENS

Title of Experiment: Optical Surveillance Sensor Experiment

I. Test Objective

The objective of this experiment will be to determine the capacity and capability of the combination of a man and a semi-automatic recording optical surveillance sensor.

II. Importance of the Test

This test is required to determine the utility of a man as an integral portion of a single or multisensor surveillance system. The space environment will be required to provide a complete test and since man is required for the test, MOL is the appropriate test vehicle.

III. Description of the Experiment

The experiment will consist of a series of tests to determine the handling rates for automatic and manual sensor operation including target selection and rejection; to determine the effects of manual operation on sensor requirements such as field of view, pointing accuracies, resolution requirements, etc.; to determine the capability of man for data correlation by detailed observation in conjunction with an automatic gross area surveillance sensor. The problems which may be encountered are weather restrictions, excessive target rates, fatigue, etc.

c. Test Procedure

The tests envisioned will be a series of comparative tests to provide a basis for comparing the performance of the manned system with the automatic system and determine the limits on the parameters of interest. This can be accomplished by using suceeding passes over the same areas or parallel systems of manual and automatic sensors. The determination of the effects of incorporating a man in the system on the sensor requirement will be determined by varying the operating parameters of the sensors to define the effective limits in both manual and automatic modes on the same or similar targets.

Man is an integral part of the sensor system to be tested. He will be utilized as an intelligent sensor and as a technician for the comparative test against which his performance will be measured.

d. Category of Experiment

This experiment will be category a. It will require at least openings for the optics and antennae, sensor stabilization, and support equipment.

e. Cost (in thousands)

	Prior	FY 65	FY 66	FY 1967	FY 68	FY 69
Engineering & Development		500	750	1000	500	500
Integration & Installation			500	1000		
Age			200	300	200	700
Simulators/Trainers				200		
Data Reduction					300	500
Equipment Work		-	-	-	-	-
Travel		10	15	15	20	20
PCP in Process		510	1465	2515	1020	1720

510
1465
2515
1020
1720
7230

~~CONFIDENTIAL~~

5307-125:IHP:lac

TO : Code 7000 DATE: 6 March 1964

FROM : Code 5307

SUBJECT: MOL Forward Looking Radar

1. The Radar Division has looked at several types of radar in the frequency range of 300 to 10,000 Mc which will provide a forward looking capability and be able to detect ship size targets. Without discussing reasons at this time it has been decided that the frequency range of 1000 to 10,000 Mc is likely to be the best compromise from the standpoint of reasonable antenna sizes and reasonable power requirements. Because of complexity, weight, and resolution limitations, electronic scanning techniques were eliminated from consideration. The remaining two methods are (a) Rotating antenna providing 360° coverage in a range band of 200 to 300 miles projected ground range, and (b) Two fixed beams canted at ±45° from the projected ground path, providing 2-70 mile wide ground swaths of coverage 140 to 210 mile coverage each side of the path. System (a) gives complete coverage of a 600 mile wide swath, with 40 to 60 seconds alerting time on targets in the forward quadrant. System (b) has a hole in the coverage so that only targets offset from the path will be detected, and the alerting time is about 30-40 seconds on those targets within the coverage area.

2. Both of the above methods could be instrumented at any frequency in the microwave region. Weather and sea clutter considerations somewhat favor the low end of the region, but antenna size would favor the high end. The

~~CONFIDENTIAL~~

following summary sheets will list the parameters of a type (a) system at 1500 Mc and at 3000 Mc and one type (b) system at 10,000 Mc. It is apparent that size, weight and power requirements are not greatly different, and if a rotating antenna is practical its advantages in coverage and target observation time are very significant.

I. H. Page

I. H. PAGE
Consultant
Radar Division

TABLE 1

Type (a) System -- 360° Scanning Antenna

Frequency - 1500 Mc	3000 Mc
Antenna - 30' X 5'	15' X 2.5'
Horizontal beamwidth - 1.5°	1.5°
Vertical beamwidth - 10°	10°
Gain - $\frac{41 + 24}{2}$ = 32.5 db	32.5 db
Rotation rate - 1 rps	1 rps
Power - 50 kw peak	1 Mw peak
200 w average	1 kw average
Transmitter - VA131B TWT	VA87 klystron
Pulse rate - 720 per second	240 per second
RF sequenced through 3 frequencies	single frequency
Pulse length - 5 μsecs	5 μsecs
Pulse compression to .1 μsec	.05 μsec
Hits per scan - 3	1
Number of scans/target - 20	20
Modulation - grid	plate
Display - modified PPI - pulse stretched	modified PPI - pulse stretched
Range on 100 M^2 target - 285 nautical miles	350 nautical miles
Mean clutter return - 40 M^2 equivalent	40 M^2 equivalent
Slant range - 220-310	220-310
Weight and power - 650# - 3 kw	1130# - 6 kw

TABLE 2

Type (b) System -- Fixed Antennas

Frequency - 10,000 Mc

Antenna - 40' x 8" - 2 required

Beamwidths - .2° x 9° - depressed 30° - offset 45°

Gain - 42 db

Observation time - .25 seconds

Number of hits - $\frac{80}{4} = 20$

Peak power - 50 kw - 2 required

Average power - 100 watts - 2 required

Compressed pulse - .1 μsec

Transmitted pulse - 10 μsec

Range on 100 M^2 target - 350 nautical miles

Spot size - 50' x 1 mile = 300,000 square feet = 30,000 square meters

ranges

Equivalent mean sea clutter area ≈ 30 square meters

Swath coverage ≈ 140-210 miles each side, about 150 miles ahead of vehicle.

Almost impossible to cover center path

TABLE 3

Type (a) -- Rotating Antennas

	1500 Mc		3000 Mc	
	Weight	Power	Weight	Power
Antenna	100 lbs		50 lbs	
Transmitter	90		365	
Power supply	100	1.85 kw	200	4.0 kw
Modulator	50	.2	100	1.0
Receiver	25	.2	25	.2
Frequency generator	25	.2	25	.2
Pulse compressor	25	.1	25	.1
Display	50	.2	50	.2
Drive motor	25	.2	15	.1
Packaging	100		200	
Miscellaneous	50		75	
	640 lbs	2.95 kw	1,130 lbs	5.8 kw

TABLE 4

Type (b) -- Fixed Antennas

	Unit weight	Number required	Weight	Power
Antennas	50 lbs	2	100 lbs	
Transmitter	90	1	90	
Power supply	100	1	100	1.85 kw
Modulator	50	1	50	.2
Receiver	25	2	50	.4
Frequency generator	25	1	25	.2
Pulse compressor	25	2	50	.2
Display	50	1	50	.2
Packaging	100	1	100	
Miscellaneous	50		50	
			665 lbs	3.05 kw

~~CONFIDENTIAL~~

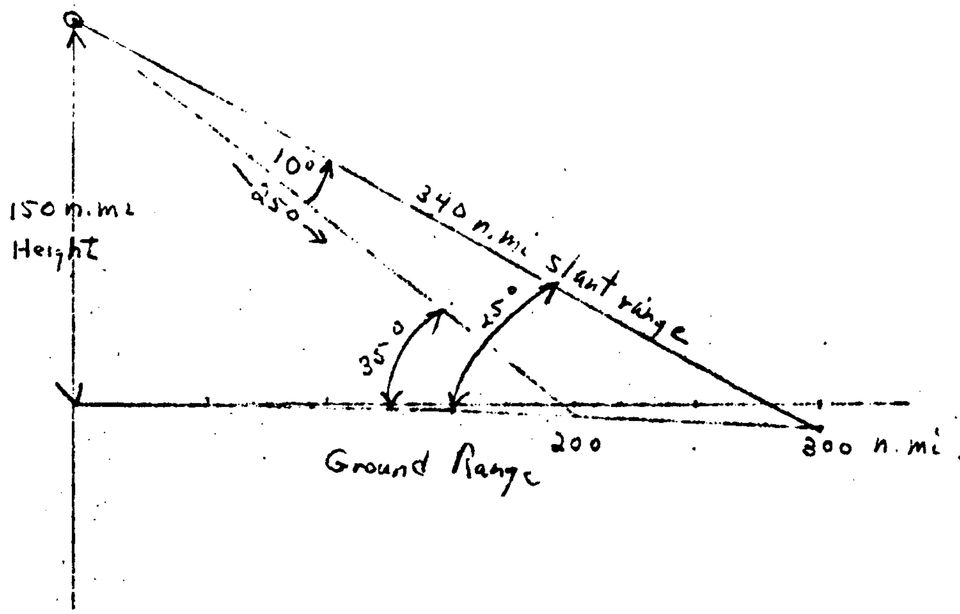


Fig. 1 - Geometry

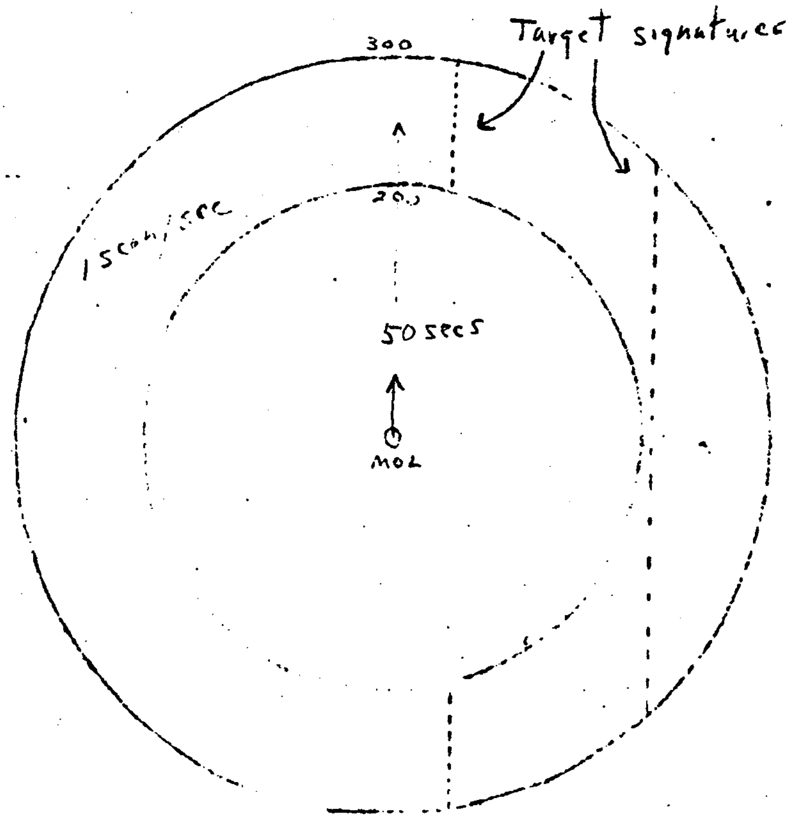


Fig. 2 - PPI Display with Memory

~~CONFIDENTIAL~~

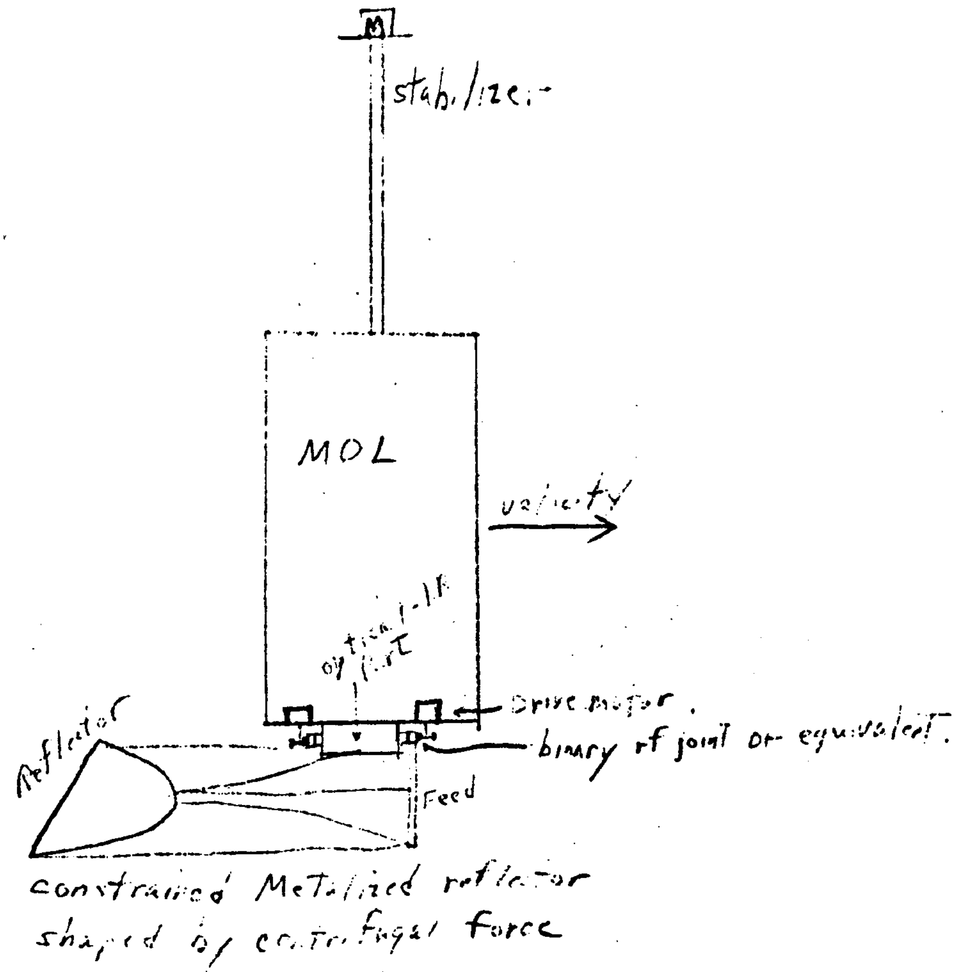


Fig. 3 - Side View -- Type (a) System

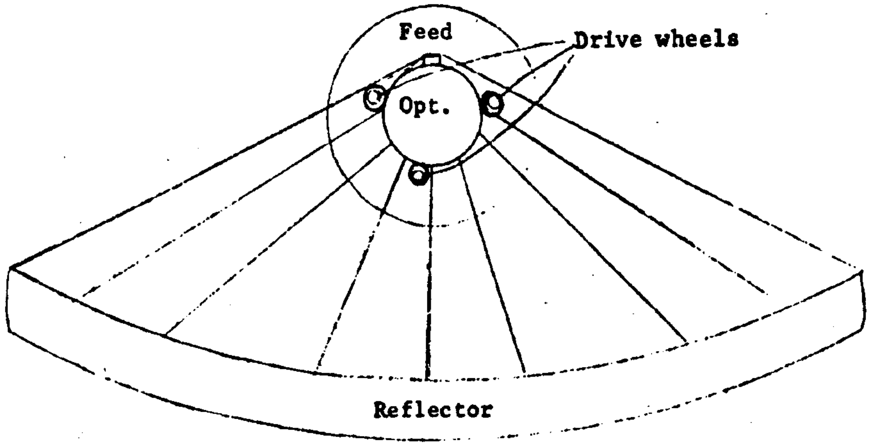


Fig. 4 - Bottom View -- Type (a) System

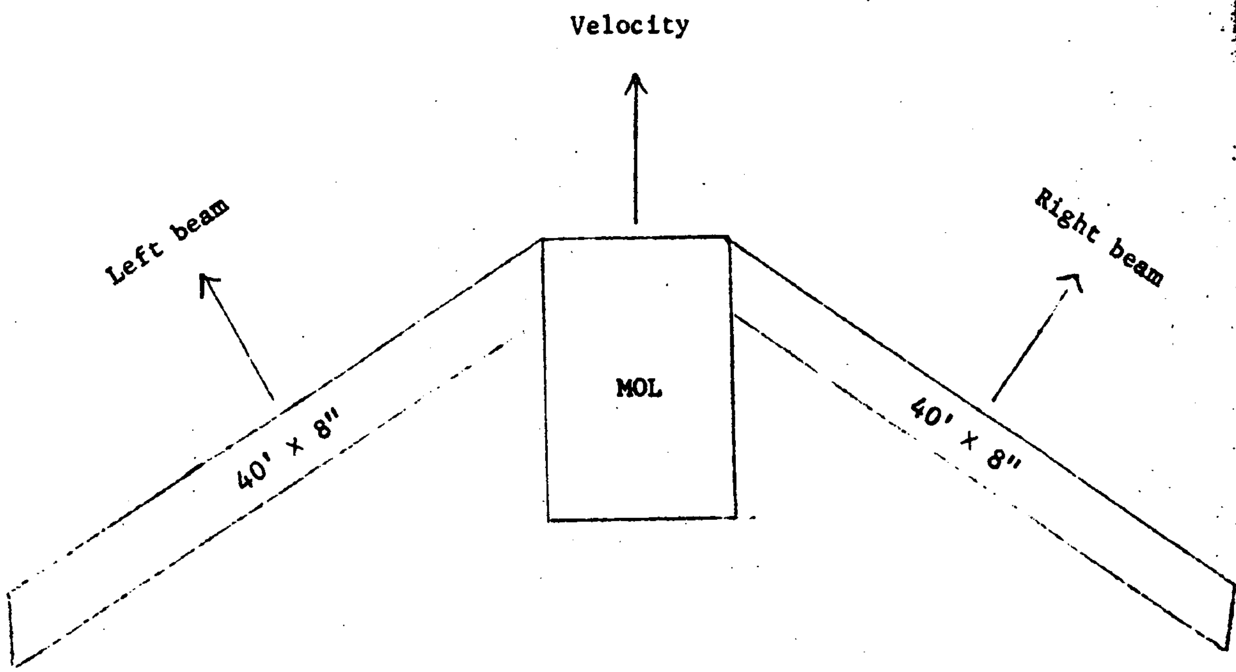


Fig. 5 - Top View -- Type (b) System

~~CONFIDENTIAL~~

AWM
20 Feb 1964

TITLE OF EXPERIMENT. Global Television Surveillance

TEST OBJECTIVE. The ultimate objective is the development of a high data rate television global surveillance system for the night side of the earth. The investigation will establish the possibility of detecting, classifying and identifying from satellites surface ships and surfaced submarines by their own lights or wakes, ambient illumination ranging from starlight to full moonlight, with and without searchlighting by a laser beam. Other objectives include the inferring of the approximate sea surface condition and the experimental determination of the size of the surface object that can be resolved. Meteorological data such as cloud cover would be available for comparison with information from weather satellites Tiros and Nimbus.

Favorable results in the investigation will make possible the systematic development of a global surveillance system, both visual and film recorded.

IMPORTANCE OF THE TEST. The test is needed to make visual and film recording measurements, to establish optimum ranges of parameters and to determine the merits of a potential surveillance system.

The tests should be conducted in MOL because the presence of a man is required in the following: optimization of adjustments to equipment, modifications in the experiment, selection of scenes viewed, proper orientation of the satellite including image motion compensation and visual comparison with the permanent film record, with and without laser searchlighting. MOL will make available suitable payload and power for the proper prosecution of the proposed experiment. In addition, the astronauts can analyze, collate and interpret the sensor data from selected areas of interest in a minimum time. This test will help assess man's ability and utility as part of a visual and film recording global surveillance system, particularly on the dark side of the earth.

It is necessary for the Navy to learn the possible nature and form some estimate of the effectiveness of satellite surveillance units of potential enemy countries. Such information would be the basis for the development of suitable countermeasures.

DESCRIPTION OF THE EXPERIMENT. Using the monitor of the low light level television coupled with the proper optical system (estimated focal length 24 in.), the astronauts will determine how well they can detect the presence of and identify lighted ships at locations known to them on the dark side of the earth, ambient scene illumination ranging from starlight to full moonlight. Throughout the experiment the ship's spatial orientation,

~~CONFIDENTIAL~~

attitude rates, velocity, altitude, location, time etc., will be recorded. The experiment will be performed with various levels of laser searchlight illumination. Photographic film records will be made of the scenes viewed. The detection system will be properly adjusted and its performance optimized during the course of these tests. The experiment will be repeated using as targets the high contrast wakes of unlighted ships and the ships themselves under laser beam illumination. Having obtained experience with the detection system, the astronauts will continue the experiment into the search and surveillance potential phase. They may orient the satellite, vary searchlight intensity, focus the system, photograph the scens, observe it visually, communicate with ground stations etc., as the like to learn what they can about unspecified targets below them. From the film record and the astronauts' description of what they observed under a wide range of conditions and knowing the type and location of targets on the earth under the orbital path, it will be possible to determine whether the detection system is adequate and the best course to be pursued in improving the crude and unsystematic surveillance procedure.

a. Configuration of Test Items

	Estimated Vol.(in.^{3})	Estimated Wt.(lbs.)
(1) TV Camera	800	40
(2) Camera Control Unit	1064	25
(3) Viewing Monitor	348	5
(4) Recording Monitor and Photo Camera Unit	230	10
(5) Monitor Electronics and Equipment Control Unit	200	20
(6) Experiment Control Panel	12	1
(7) Laser Searchlight	500	30

b. Test Support Equipment Required

Not known at present.

c. Test Procedure

(1) The man will turn on the detection system, adjust it for optimum performance, adjust searchlight illumination level, record scenes of interest, observe these scenes visually and simultaneously, evaluate, interpret and note what is observed. The man will orient the spacecraft and compensate for image motion as required.

(2) and (3). See the DESCRIPTION OF THE EXPERIMENT.

d. Category of Experiment

Category b

e. Cost

	FY65	FY66	FY67	FY68	FY69	TOTAL
(1) Engineering & Development	50K	100K	600K	100K	50K	900K
(2) Installation	25K	50K	300K	25K	25K	425K
(3) Ground Support		25K	100K	50K	25K	200K
	75	175	1000	175	TOTAL	1525K

f. Schedule

Hardware ready for test January 1967.

PARTICIPATING GOVERNMENT AGENCY. U. S. Naval Air Development Center.

ADDITIONAL REQUIREMENTS. Security classification: CONFIDENTIAL

Additional information will be furnished when experiment is more thoroughly planned.

U. S. NAVAL AIR DEVELOPMENT CENTER
ANTI-SUBMARINE WARFARE LABORATORY
JOHNSVILLE, PENNSYLVANIA

AW-42
12 Nov 196

Proposal for Experiment N-10

LOW LIGHT LEVEL TELEVISION FOR PROJECT GEMINI

INTRODUCTION

The primary purpose of the experiment is to investigate the possibility of detecting from satellites the presence of surface ships by their own lights or wakes, ambient illumination ranging from full moon to starlight. Secondary goals include the inferring of the approximate sea surface condition and the experimental determination of the surface object size the system can resolve. A television monitor will be provided for visual observation while a separate monitor will be employed to obtain a photographic record for detailed post-flight analysis.

"Detect the presence of" is the phrase employed to emphasize that the television system, with its comparatively short focal length lens, is not expected to resolve even the largest ships in the sense that details can be seen. Rather, the energy from the various sources of light associated with ship targets will be processed to provide immediate detection capability for the astronaut without requiring his dark adaptation. The best resolution compatible with a sufficiently high detection capability will be the goal in the design of the system.

The experiments should indicate the effectiveness of a low light level viewing system as a visual aid for the astronaut. For example, yaw maneuvers using cloud references on very dark nights may be carried out. The identification of ground characteristics, such as small islands, should also be made easier, especially at low light levels where non-dark adapted viewing is of little value. A study of the photographs taken during the controlled experiments will help determine the merits of a low light level system for general target recognition.

The detection of surface ships has military implications, since the experiment may reveal whether the nighttime movements of our own fleet can be regularly monitored by others using comparable means. Still another area of value is the possible application of a similar system for examining the dark side of the moon where the atmosphere and airglow are absent; information obtained from the earth orbit experiment would be useful.

It is intended to make a three way comparison by obtaining the opinions of one astronaut viewing the monitor, of the other astronaut viewing the same scene directly, and comparing these with the photographic record. The men aboard Gemini will also be able to select targets of opportunity, control the attitude of the spacecraft, and even provide almost complete image motion compensation which will be useful in evaluating the system's capabilities.

The experiments presented would be conducted best in a manned spacecraft. Where the astronaut is part of the experiment or performs some selective function, there is no alternative to a manned vehicle. The astronaut, in addition, contributes valuable flexibility which may be required if changes in the experiments are necessitated because unexpected or unpredicted situations arise at launch or during orbit.

DESCRIPTION OF EXPERIMENT

A. DETECTION OF SHIPS AND SHIP WAKES

1. Lighted Ships. Ship lights will raise the illumination level on certain areas of the ship to relatively high values, 10^{-1} to better than one foot candle, compared to the ambient light, 10^{-2} to 10^{-4} foot candles for full moon and no moon respectively. The low light level system will then be used to take advantage of this high concentration of light energy against the essentially black ocean background that will constitute most of the monitor presentation. Immediate detection of the bright "blip" representing the lighted ship should be possible with no need to dark adapt.

2. Ship Wakes. In a calm sea, the wake of a ship may present a long, high contrast ribbon of highlights because of moonlight reflecting and glinting off the disturbed water. The light emanating from the wake path may be expected to show up on a photographic negative obtained from a monitor different from the less coherent variations of light produced by the undisturbed sea. The experiment will also show whether the length of the wake will permit in-flight detection on the monitor screen because of continuity effects. In addition to length, the changing water slopes within the wake should give rise to a scintillation effect. Whether this will aid in real time detection can also be learned during the experiment.

3. Unlighted Ships. The focal length of the camera lens in relation to the orbital altitude, along with other considerations, makes detection of unlighted ships very unlikely, especially if there is little or no wake. In general, the calmer the sea, the more likely is it that the ship can be detected if it is possible to do so at all, because then the ship itself stands out in maximum contrast with the water. The experiment may give some answers in terms of the ambient light level, ship size, and sea condition.

B. OTHER SHIP EXPERIMENTS

1. Flare and Smoke Tests. Recovery ships will display lights, release flares, and generate smoke for observation on the monitor. Some flare tests will be possible even through light cloud cover.

2. Dye Marker Tests. The astronaut can determine the effectiveness of the system in revealing the extended image of a dye marker in terms of ambie[illegible] light level, and size of the marker. Such markers may be useable as fixed reference points on a calm ocean, and thus aid in attitude control for other experiments.

C. COARSE DETERMINATION OF SEA CONDITION

Photographs of the sea will be made over rough and calm areas. It may be possible to infer that the sea was very rough, rough, or very calm by analyzing the density noise variations over an adequate number of photographs taken from the monitor. The experiment will also determine whether the scintillation effect is pronounced enough to make in-flight observations possible.

D. DETERMINATION OF SYSTEM RESOLUTION

Overland photographs will be made at various light levels and ground haze conditions to determine the resolution capability of the low light level system. Some of these photographs should be made using Image Motion Compensation which could be supplied by the astronaut. In all cases, the attitude and rotation rates of the capsule should be known.

TECHNICAL DISCUSSION

A. OPERATIONAL DESCRIPTION

As discussed previously, the TV system will be used to detect the presence of ships at sea. This will require that ships be positioned as nearly as possible directly under the flight path of the satellite.

It is planned that the experiments be performed during orbits when the spacecraft will fly over these ships on the dark side of the earth.

1. Proposed Targets

a. Specific targets

TABLE I

Experiment Number	Length of Experiment	Targets	Conditions
1	15 sec	ships and islands	1) no tracking of targets 2) dark side of earth
2	1.5 min	ships and islands	1) tracking of targets 2) dark side of earth
3a (same orbit)	1.5 min	ships and islands	1) tracking of targets 2) dark side of earth
3b (same orbit)	3.0 min	targets of opportunity	1) select targets for tracking 2) dark side of earth
4a (same orbit)	4.0 min	calm and rough sea conditions	1) no tracking 2) light side of earth
4b (same orbit)	4.0 min	calm and rough sea conditions	1) no tracking 2) dark side of earth
5a (same orbit)	4.0 min	land masses	1) select targets for tracking 2) light side of earth
5b (same orbit)	4.0 min	land masses	1) select targets for tracking 2) dark side of earth

(1) ships in the recovery area

(2) tracking network ships

(3) island tracking stations

(4) the sea under varying conditions

(5) land masses (mountain ranges, rivers, cities, etc.)

b. Targets of opportunity - any visual targets over land or water both on the dark and light side of the earth.

2. Experimental Orbits

Five orbits will be required for the N-10 experiments which are distributed as follows:

a. Three for the detection of recovery and tracking ships and island tracking stations.

b. One for the detection study of sea conditions.

c. One for the detection of land targets.

The astronauts will participate in each experiment. They will

a. Energize the experiment equipment

b. Maneuver the space capsule

c. Select and track targets

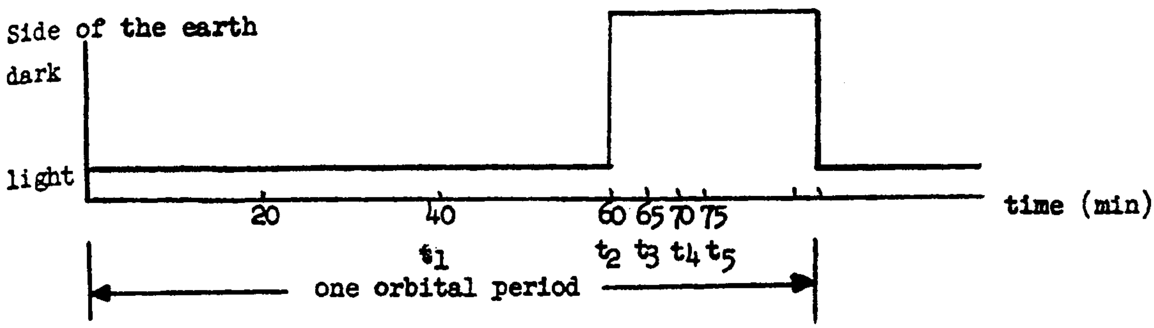
d. Record visual observations.

Detailed instructions, more specific than those supplied in previous briefing, will be required. They will be conveyed by voice communication with the project monitor via the tracking network.

3. Sequence of Events in Experiment

The number assigned to each experiment is for identification in this proposal. Prior to launch, modified numbers will be assigned relating the experiments to their occurrence in the flight plan. Table I presents characteristics of the experiments.

The following time diagram for the duration of an experiment illustrates a typical sequence of events.



t_1 - a. turn on inertial platform providing a 30-minute warm-up period prior to start of the experiment

t_2 - a. turn on experiment equipment providing a 5-minute warm-up period

b. maneuver space capsule into position required for the experiment and attain attitude stabilization or control

t_3 - a. final adjustment of TV system prior to start of the experiment

t_4 - a. start of the experiment

t_5 - a. end of the experiment

The time sequence plotted in the diagram will vary according to the location of the desired targets in the earth light and dark side cycle. The astronauts' participation time will be approximately 15 minutes for experiments 1, 2 and 3 and 20 minutes for experiments 4 and 5.

Table II lists the experiments giving astronaut participation, spacecraft maneuvers, equipment required and the function of the tracking network.

4. <u>Data</u>

A camera is used to photograph the output of the recording monitor. The photographic data rate and number of photographs to be taken are shown in Table III.

TABLE II

Experiment Number	Spacecraft Position	Astronaut Participation	Equipment Required	Recovery Area and Tracking Network Participation
1	1) looking down 2) attitude stabilized	1) visual comparison by both astronauts 2) record observations	1) inertial platform 2) TV system 3) recording camera	1) voice commands 2) visual aids 3) record attitude and rate data 4) location of ships
2	1) looking down 2) attitude control	1) visual comparisons 2) record observations 3) track target	"	"
3	"	1) visual comparisons 2) record observations 3) track target 4) after 1.5 min. track targets of opportunity	"	"
4	"	1) track targets of opportunity	"	"
5	"	"	"	"

TABLE III

Experiment	Photographic Data Rate	Number of Photos
1	15 sec at 20 photos/sec	300
2	1.5 min at 1 photo/sec	90
3a	1.5 min at 1 photo/sec	90
3b	3.0 min at 1 photo/sec	180
4a	4.0 min at 1 photo/sec	240
4b	4.0 min at 1 photo/sec	240
5a	4.0 min at 1 photo/sec	240
5b	4.0 min at 1 photo/sec	240

The reduction of the photographic data requires that for each experiment the following satellite information be recorded by the tracking network stations.

a. Pitch, roll and yaw attitude

b. Pitch, roll and yaw rates

c. Linear velocity

d. Altitude

e. Special position

f. Time.

The analysis of photographs, tracking network data and the astronauts' visual observations during the experiment and in debriefing will be the basis for determining the success of the N-10 experiment.

5. <u>NASA Tracking Network Rôle</u>

In addition to providing the data required for photographic correlation, NASA must provide information on the locations of the recovery area and tracking ships. The TV system camera has a maximum 55-mile diameter field of view at the surface of the earth. The ship targets will have to be positioned within this field to insure target acquisition. The ships will employ detection enhancement aids such as lights, smoke and dye markers.

The tracking network will provide the communication link required for the performance of the experiment and will record on tape the astronauts' observations with the unaided eye and by the TV system.

6. Astronauts' Role

In each experiment, the spacecraft must be pointed vertically down and maintained in this attitude with the best precision possible. In experiments 2, 3, 4 and 5, the astronauts will track specified targets or targets of opportunity.

Both astronauts must participate in the N-10 experiment to make possible comparisons between the unaided eye, the TV aided eye, and the photographic records. The astronaut viewing the scene unaided will attempt to become dark adapted over a specified period prior to the start of the experiment. Post-flight laboratory experiments can determine the degree of dark adaptation acquired by the astronaut for each experiment.

The observers will be required to voice record the time of target acquisition, relative headings, and duration of tracking. A grid pattern placed over the face of the presentation monitor will aid the astronaut in estimating these variables.

7. Controls

It is intended that the operation of the experiment equipment be essentially automatic. The variables controlled automatically include the following:

a. Dynamic light range

b. Sensitivity

c. Camera frame rate

d. Camera record time.

The astronaut will control the brightness level of the presentation monitor and select the TV camera field of view by means of a zoom lens. The adjustable field of view will aid in target acquisition and in target tracking.

B. SYSTEM INFORMATION

1. Major Components

The major equipment components are the TV camera, the camera control unit, the presentation monitor, the recording monitor, the photographic camera, and the experiment control console.

a. TV Camera

The TV camera consists of a zoom lens, a single stage image intensifier, and an image orthicon sensor.

b. Camera Control Unit

The camera control unit provides the synchronizing circuits, video amplifiers, dynamic light range control circuits, and the camera power supplies.

c. Presentation Monitor

The presentation monitor is a 5-inch diameter CRT and high voltage power supply.

d. Recording Monitor

The recording monitor is a 1-inch diameter CRT and high voltage power supply.

e. Photographic Camera

The photographic camera is of special design for obtaining programmed sequential photographs. It is capable of recording time and exposure settings on the film.

f. Experiment Control Console

The experiment control console contains the video amplifier, synchronizing circuits, and the experiment control circuits.

2. System Design Characteristics

The system performance, electrical requirements, and physical configuration are based on commercially available low light level components. The final selection of experiment equipment will depend on investigations of the performance capabilities of developmental equipment and on some basic laboratory experiments.

The possibility of detecting the presence of ships under low light conditions is the basis for the specification of system performance. The essential characteristics to be considered are

a. Scene brightness level

b. Scene contrast

c. System static resolution for low light conditions

d. System dynamic resolution for low light conditions

e. System dynamic light range control

f. Photographic recording.

The electrical requirements for the experiment equipment are as follows:

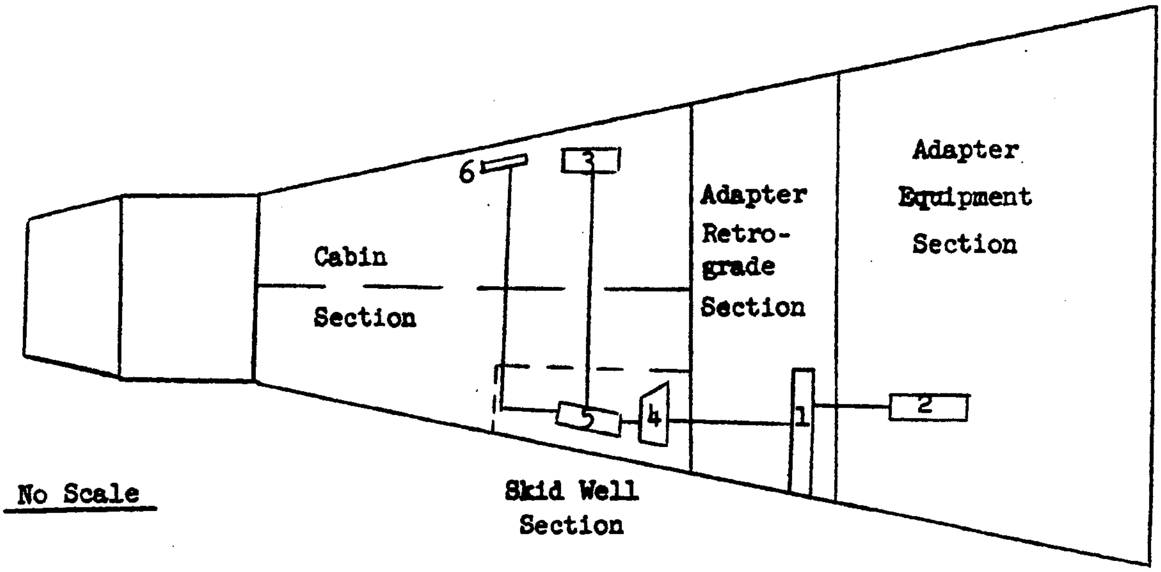
a. Standby (warm-up time)
5-minute warm-up period for filament of the image orthicon and monitor CRT's.
1.5 amps at 6 V $\approx$ 10 watts, a total of 25 minutes at 10 watts.

b. Average (operating)
45 minutes at 110 watts.

The proposed physical arrangement, weight, dimensions, and volume of the experiment equipment are shown in figure 1. These estimates are preliminary.

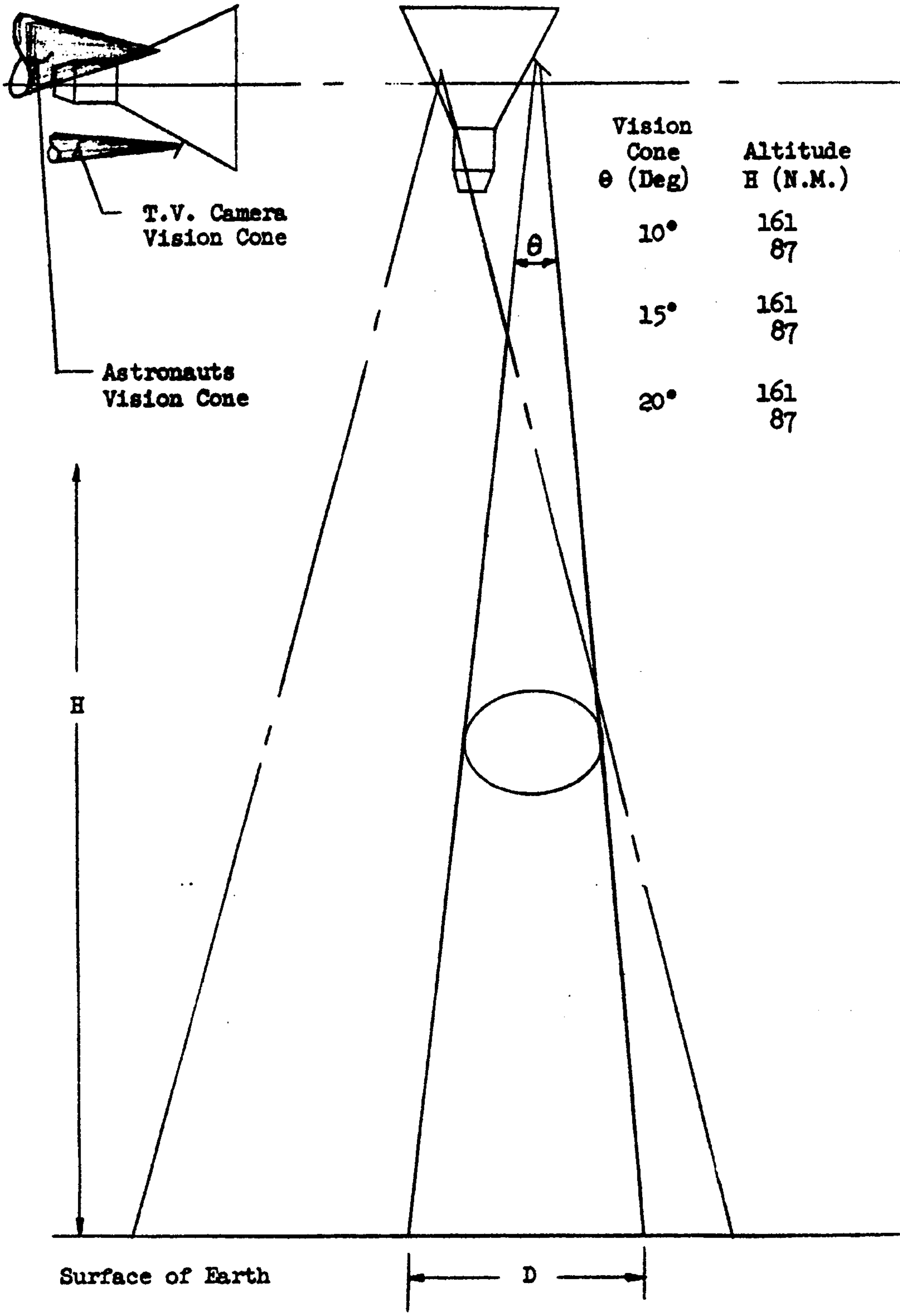
Fig. # . Schematic of Functional Equipment Location

Exp. N-10



No Scale

Item	Component	Dimensions (in)	Volume (in)^3	Weight (lbs)
1.	T.V. Camera	5 dia. x 28	550	30
2.	T.V. Camera Control Unit	7 x 8 x 19	1064	25
3.	Viewing Monitor	5 1/2 x 5 1/2 x 11 1/2	348	5
4.	Recording Monitor & Photo Camera Unit		231	10
5.	Monitor Electronics & Equipment Control Unit		200	20
6.	Experiment Control Panel		12	1
			2405	91

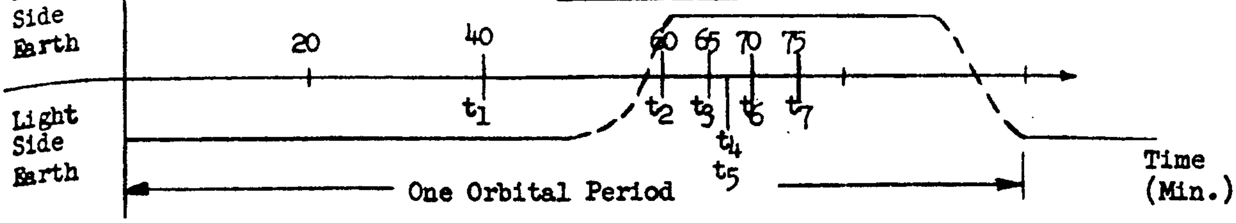


Vision Cone θ (Deg)	Altitude H (N.M.)	Earth Fiel of View D (Miles)
10°	161	32
	87	17
15°	161	49
	87	26
20°	161	65
	87	35

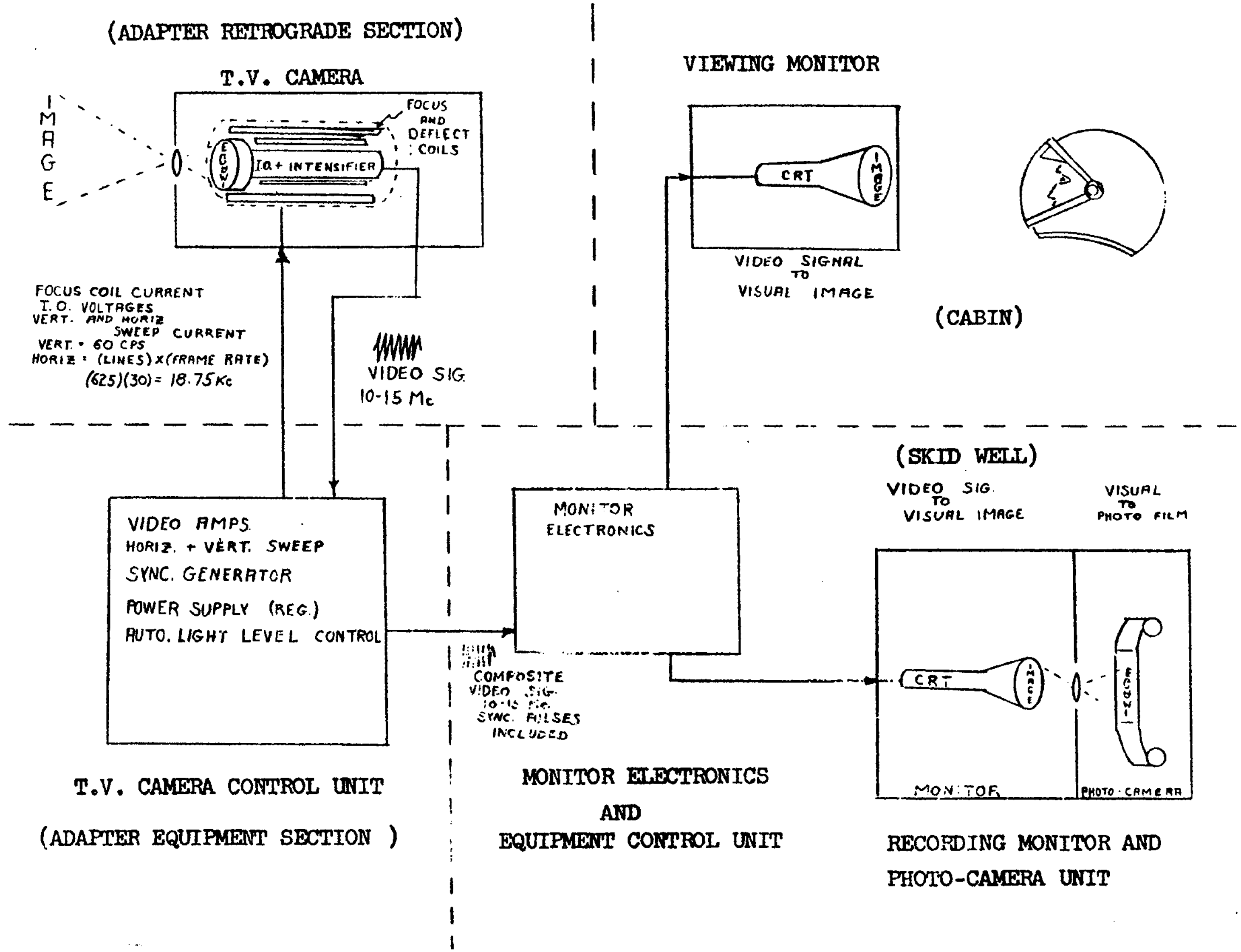
Figure . T.V. Camera's Earth Field of View

Typical Experiment Time Diagram-Sequence of Events

Time Diagram

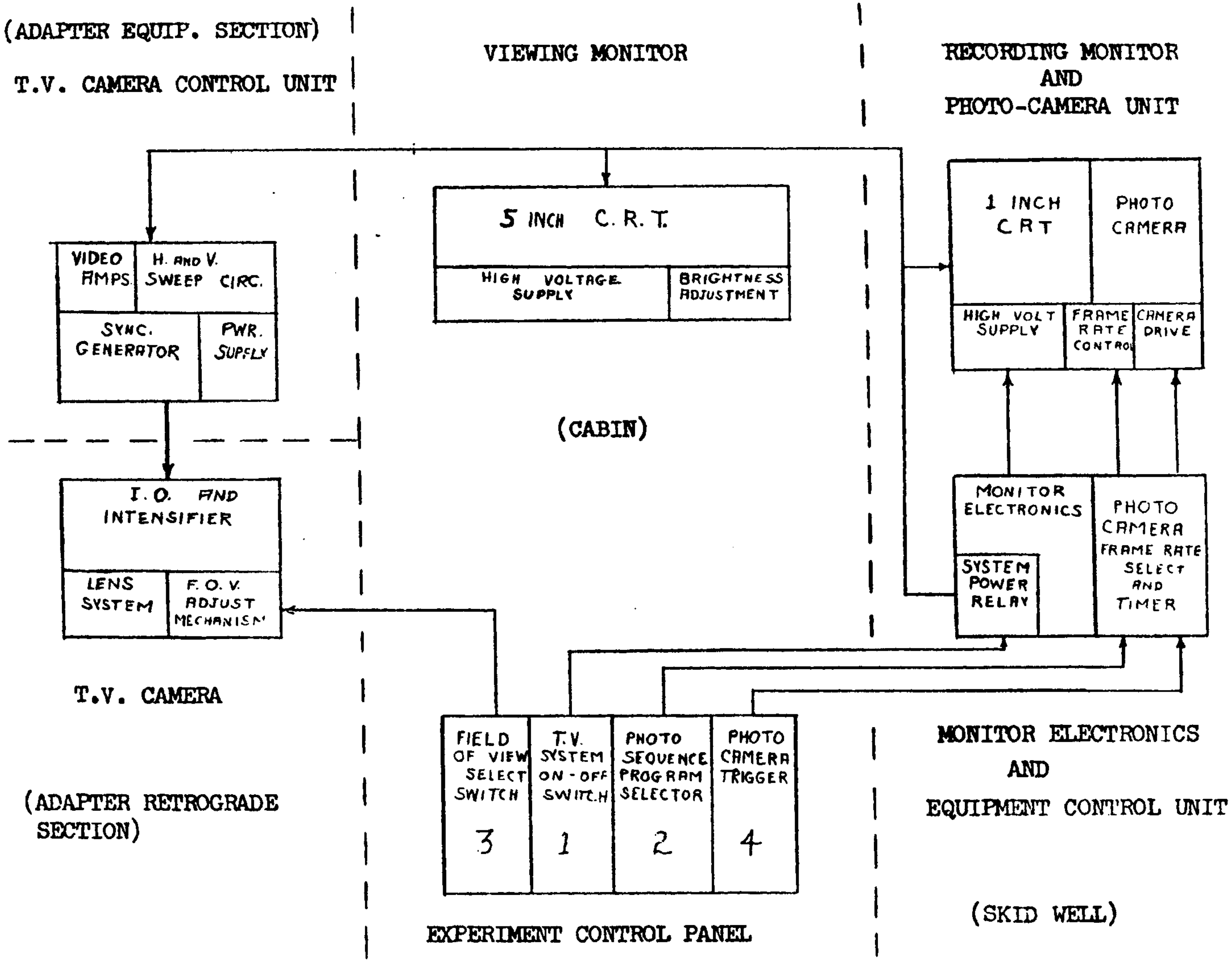


Time	Sequence of Events
t_1	Turn on Inertial Platform (Provide 30 min. warm-up period)
t_2	1. Turn on Experiment Equipment (Switch #1) Provides 5 min. warm-up period a. Monitor Electronics and Equipment Control Unit - Standby b. T.V. Camera Control Unit - Standby c. T.V. Camera Filaments d. Viewing Monitor Filaments e. Recording Monitor Filaments 2. Maneuver Space Capsule into position required for experiment and attain stabilization and control.
t_3	1. Automatic switching on of all experiment equipment except Recording-Photo Camera. 2. Adjust Viewing Monitor brightness prior to start of experiment.
t_4	Select desired experiment (Switch #2)
t_5	Select Field of View (Switch #3)
t_6	Start of experiment (Switch #4) - Recording Photo Camera Operation
t_7	End of experiment - Automatic Photo Camera stop a. Turn off Switch #1 b. Turn off Inertial Platform



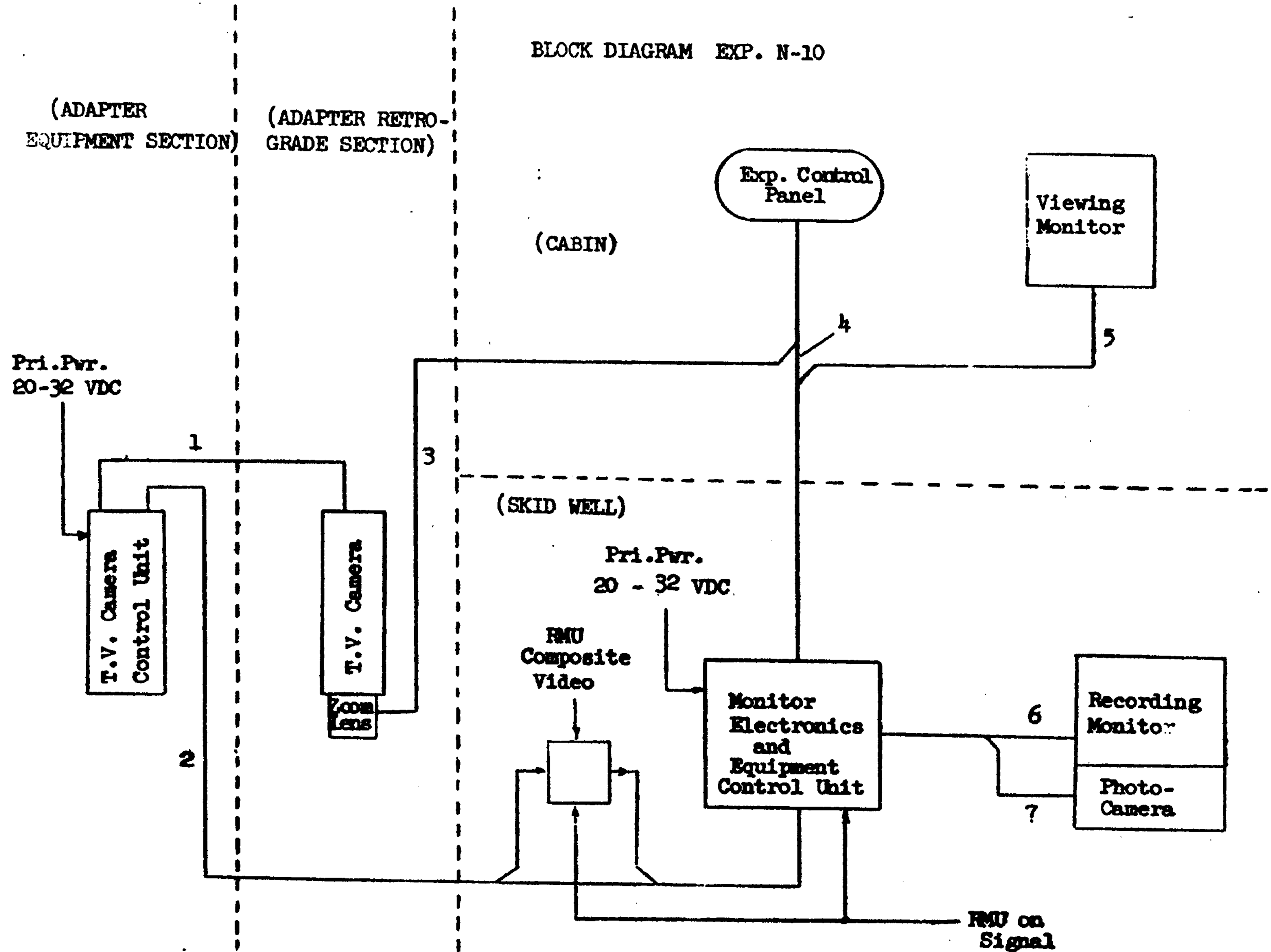
SIGNAL PATHS EXP. N-10

SIGNAL PATHS EXP. N-10



FUNCTIONAL CONTROL DIAGRAM EXP. N-10

BLOCK DIAGRAM EXP. N-10



TELEMETRY REQUIREMENTS

The following information should be telemetered to ground stations:

1. Time marker indicating photo-camera start and stop times (photo-camera).

2. Iris setting (TV camera).

3. Neutral density filter setting (TV camera).

4. Ambient light level (measured by a separate photo-sensor) (camera control unit).

5. The integrated video output of the camera and camera control unit. This will give rise to a D.C. level indicating the presence of or lack of video signal at the camera output and the camera control unit output.

AGE TEST POINTS

A. TV Camera

1. video output (coax)

B. TV Camera Control Unit

1.	I.O. vertical sweep current	(shielded)
2.	I.O. horizontal sweep current	"
3.	vertical sweep signal to monitors	"
4.	horizontal sweep signal to monitors	"
5.	video output signal (video + blanking)	(coax)

C. Monitor Electronics and Equipment Control Unit

1.	video to viewing monitor	(coax)
2.	video to recording monitor	"
3.	viewing CRT vertical sweep current	(shielded)
4.	viewing CRT horizontal sweep current	"
5.	recording CRT vertical sweep current	"
6.	recording CRT horizontal sweep current	"

POWER, SIZE AND WEIGHT ESTIMATES
NASA/DOD EXPERIMENT N-10

Unit #	Description	Power Dissipated (watts)	Size (in.)	Volume ($in.^3$)	Weigh (lb.)
1	TV Camera	23	5 Dia. x 28	550	33
2	Camera Control Unit	77	7 x 8 x 19	1060	18.
3	Viewing Monitor	8	5 1/2 x 5 1/2 x 12	363	8
4	Recording Monitor & Photographic Camera	31	MAC L/O - 019934C	349	13.5
5	Monitor Electronics & Equipment Control Unit	36	MAC L/O - 019933B	300	10.0
	TOTAL	175	-	2622	83.0

NOTES:

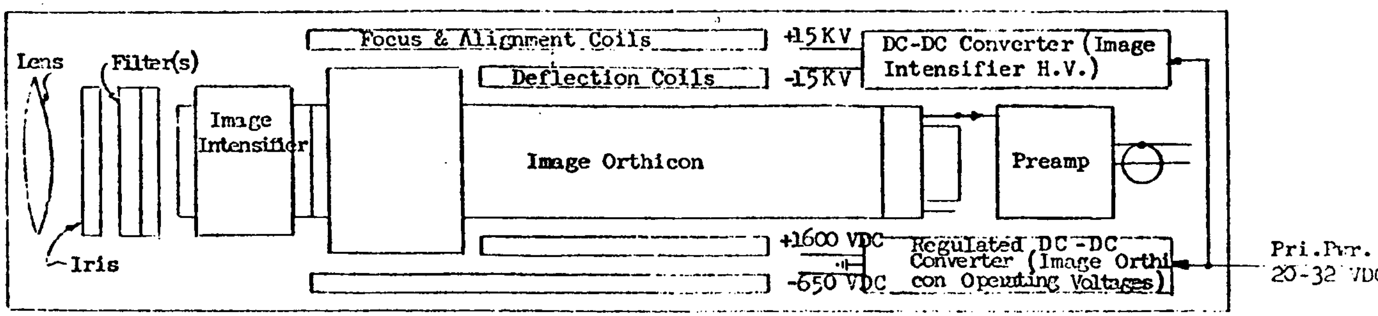
1. These values are for a 3" Image Orthicon System.

2. Weights of Units include electronics, internal mounting structures and boxes.

3. Weights do not include external wiring or external mounting provisions.

4. Cold plate weights are not included in the above weights.

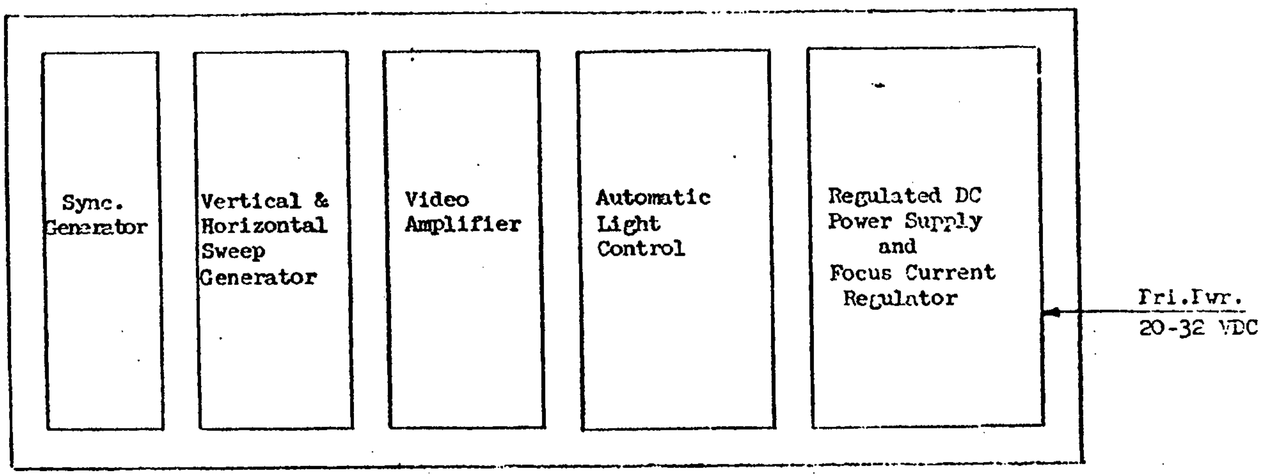
TV CAMERA - Unit #1



I.O. Adjustment Controls
Align "A" (with reversal switch)
Align "B" (with reversal switch)
Beam Focus (G-4)
Photo Cathode
Accelerator
Decelerator (G-5)
Persuader (G-3)

Power Dissipated (Watts)	23
Dimensions (In.)	5 Dia. x 28 L
Volume (In.^{3})	550
Total Unit Weight (Lb.)	33

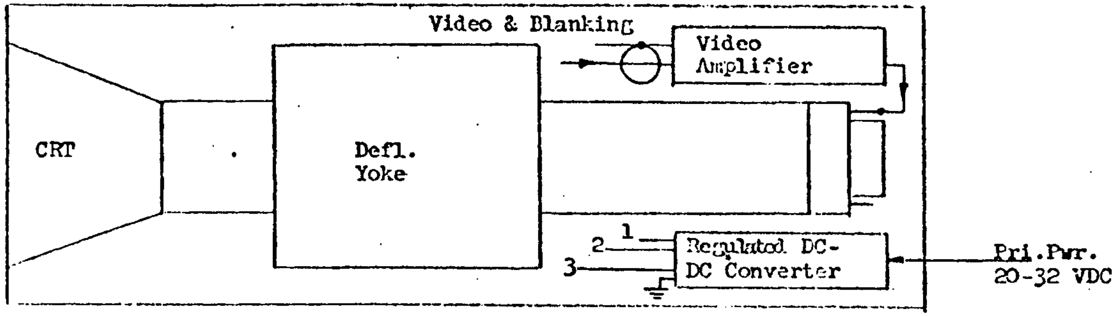
TV CAMERA CONTROL UNIT - Unit #2



Power Dissipated (Watts)	77
Dimensions (In.)	7 x 8 x 19
Volume ($In.^3$)	1060
Electronics & Components Wt. (Lb.)	12.5
Structural Weight (Lb.)	6.0
Total Unit Weight (Lb.)	18.5

Total Unit Weight (Lb.)	18.5

VIEWING MONITOR - Unit #3

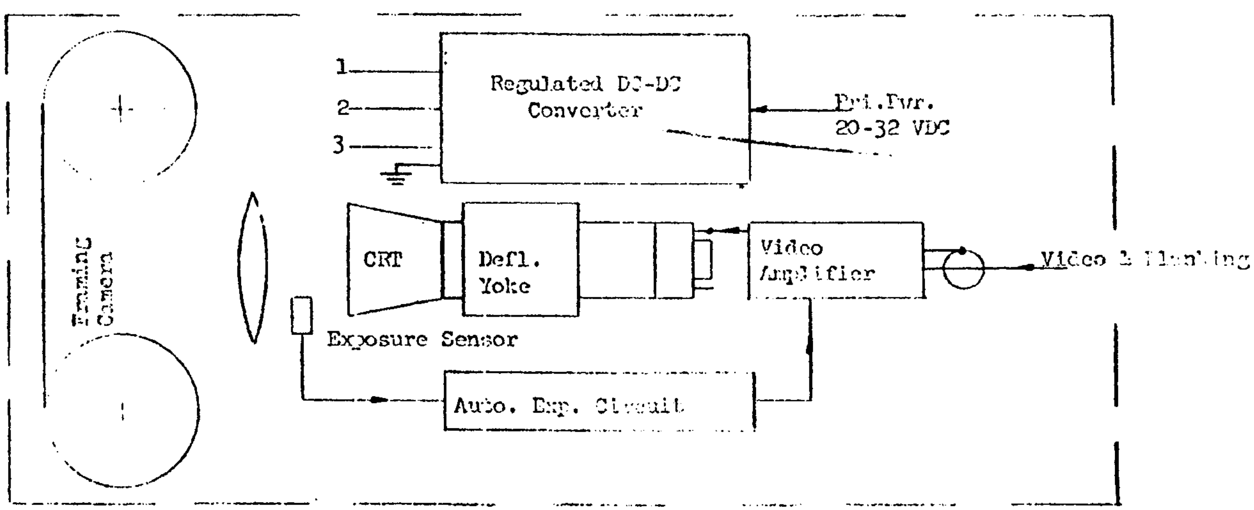


1. CRT Anode Voltage - 10-15 KV DC
2. CRT Focus Voltage - 1-5 KV DC
3. CRT Accel. Potentials - 300-600 V DC

External Controls
CRT Brightness
Camera Start Switch

Power Dissipated (Watts)	8
Dimensions (In.)	5.5 x 5.5 x 12
Volume (In.^{3})	363
Electronics & Components Wt. (Lb.)	4.5
Structural Weight (Lb.)	3.5
Total Unit Weight (Lb.)	8.0

RECORDING MONITOR AND FRAMING CAMERA - Unit [illegible]

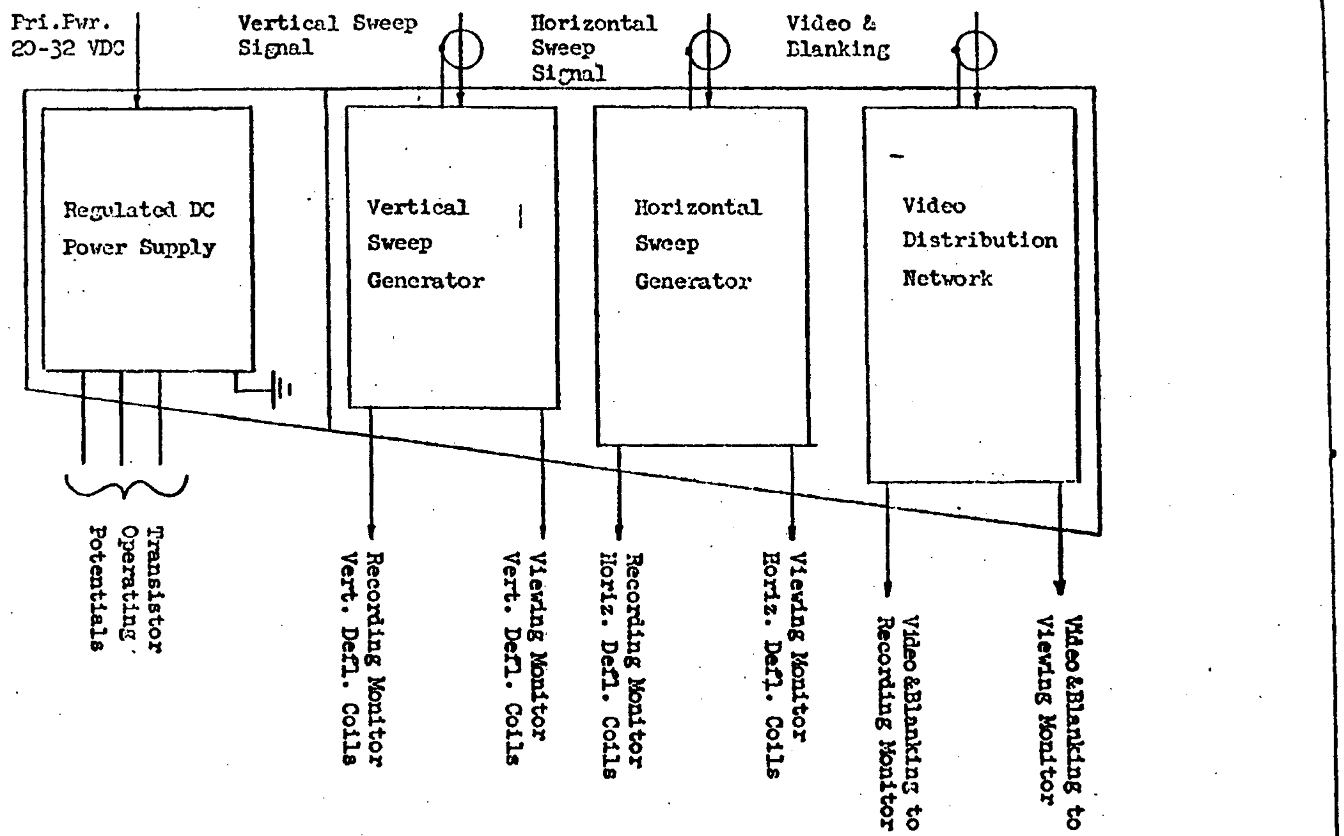


1. CRT Anode - 11 KV
2. CRT Focusing Grid - 1.5 KV
3. CRT Accel. Potentials - 150-800 V DC

Power Dissipated (Watts)	31
Dimensions (In.)	MAC L/C -01992MC
Volume (In.^{3})	349
Electronics & Components Wt. (Lb.)	9.0
Structural Weight (Lb.)	4.5
Total Unit Weight (Lb.)	13.5

Total Unit Weight (Lb.)	13.5

MONITOR ELECTRONICS & EQUIPMENT CONTROL UNIT - Unit #5



Power Dissipated (Watts)	36
Dimensions (In.)	MAC L/O -019933B
Volume (In.^{3})	300
Electronics & Components Wt.(Lb.)	6.0
Structural Weight (Lb.)	4.0
Total Unit Weight (Lb.)	10.0

~~CONFIDENTIAL~~

AHM
17 Feb 1964

TITLE OF EXPERIMENT. Infrared Mapping

TEST OBJECTIVE. The purpose of this experiment is to survey ocean and terrestrial features by infrared techniques.

IMPORTANCE OF THE TEST. Since targets observed with infrared radiation will be seen with self-emitted radiation, infrared mapping is particularly of interest on the dark side of the earth. Data will be useful in determining the optimum combinations of infrared, electro-optical photographic, DF/ELINT microwave radiometry, active radar and other sensors for sea surveillance. Experience with airborne passive infrared mapping sets has demonstrated their application to oceanography, meteorology and geology. Thermal pictures of the sea surface reveal the structure of ocean currents, presence of oceanic "cold fronts," and the presence of icebergs. In the field of meteorology, cloud distributions can be mapped both day and night for use in weather predictions. Dynamics of cloud formation can be studied because accumulations of atmospheric water vapor associated with nascent and evanescent clouds can be recorded by operating the set in a spectral range corresponding to one of the water absorption bands. In the science of geology, thermal pictures recorded over land masses could provide information on geologic structures by revealing their relative heating and cooling rates over the diurnal cycle. The imminence of volcanic eruptions might be inferred from observations of "hot spots" on the earth's surface. In general, it appears that a wealth of information about the earth could be learned by viewing it by its infrared incandescence. Experience with airborne infrared mapping devices has indicated that unexpected information is often obtained when objects are viewed in this different light.

DESCRIPTION OF THE EXPERIMENT. The astronaut would orient the spacecraft to see the selected areas of observation. He would adjust controls for optimum seeing conditions. With the equipment contemplated it would be possible to map an area approximately 700 miles in width and resolve objects separated by about 1100 feet from an observation platform 200 miles away. This means that features such as rivers, valleys, lakes, cities, mountains, coastlines, oceans, ocean currents, weather fronts, icebergs, and any other object whose temperature differs from its surroundings by an appreciable portion of a degree should become visible to the infrared scanner. The form of these objects would become clear. By passing over the area at successive times he could observe movements of clouds, storms, ocean currents, etc.

~~CONFIDENTIAL~~

a. Configuration of Test Items

(1) Scanner 40 pounds

(2) Rapid Processor Readout Device 40 pounds

(3) Recording Monitor 20 pounds

b. Test Support Equipment Required

Not known at present.

c. Test Procedure

The astronaut would compare information from rapid processed map with visual information. His comments would be recorded for later comparison with recorded data. It is expected that recordings of the same scene taken at successive intervals would show progress of storms, clouds, sea currents, icebergs, etc. Approximately four hours of information taken over one week duration would be necessary. Services of the astronaut for this period are recommended.

d. Category of Experiment

Category b

e. Cost

	FY65	FY66	FY67	FY68	FY69	TOTAL
(1) Engineering & Development	100K	600K	100K	50K	50K	900K
(2) Installation	100K	100K	600K	50K	50K	900K
(3) Ground Support	50K	50K	200K	200K	50K	550K
				TOTAL COST		2350K

f. Schedule

Hardware ready for test January 1967.

PARTICIPATING GOVERNMENT AGENCY. U. S. Naval Air Development Center.

ADDITIONAL REQUIREMENTS. Security - Equipment - CONFIDENTIAL
Data - CONFIDENTIAL

Additional information will be furnished when experiment is more thoroughly planned.

U. S. NAVAL AIR DEVELOPMENT CENTER
ANTI-SUBMARINE WARFARE LABORATORY
JOHNSVILLE, PENNSYLVANIA

AW-411
13 Dec 1963

~~C O N F I D E N T I A L~~

TECHNICAL MEMORANDUM ADC-AW-411:PMM

Subj: WEPTASK RT 7045001/2021/F019-05-02, Passive infrared mapping set for use in Gemini satellite; feasibility study of

Ref: (a) General Electric Co. Radiation Calculator
(b) Rand Corp. Conf Report "Fundamentals of Infrared for Military Applications (U)" of 31 Mar 1956
(c) General Electric Co. Advanced Electronics Center Report R57ELC15, "A Procedure for Calculation of Atmospheric Transmission of Infrared," of 1 May 1957
(d) NASA Technical Note NASA TN D-1850, "The Infrared Horizon of the Planet Earth," of Sep 1963

Encl: (1) NAVAIRDEVCEN Conf Conceptual Drawing of Gemini Infrared Mapping Set of 12 Oct 1963

I. INTRODUCTION

Considerable interest exists in the possibility of placing a passive, high resolution, infrared mapping set in a Gemini satellite scheduled for a two-day orbital flight during December 1965. It has been proposed that such a device would yield information of value to the Navy on the locations and movements of ships and in the broad scientific fields of oceanography and meteorology. It has also been proposed that the pictures generated by an infrared mapping set would provide visual aid to the astronauts both day and night. The purpose of this memorandum is to consider the feasibility of including an infrared mapping set in the complement of Gemini instruments. The items to be discussed are (1) areas of application, (2) system design considerations, (3) system design parameters, (4) results to be expected, (5) conclusions, and (6) recommendations.

II. AREAS OF APPLICATION

The type of infrared mapping set under consideration would be sensitive to radiation in the [redacted] portion of the electromagnetic spectrum. Since all bodies radiate infrared energy at rates proportional to the fourth power of their temperatures and since the wavelength at which maximum radiation from objects on the surface of the earth is emitted occurs within this band, an infrared mapping set can provide thermal pictures of the surface of the earth at night. Since solar radiation incident upon the earth also

~~C O N F I D E N T I A L~~

includes radiation in the [redacted] band, those portions of the earth viewed during hours of daylight will be seen through the joint agency of reflected solar radiation and self-emitted radiation.

Experience with airborne passive infrared mapping sets has demonstrated their application to oceanography, meteorology, and geology. Thermal pictures of the sea surface reveal the structure of ocean currents, presence of oceanic "cold fronts," and the presence of icebergs. In the field of meteorology, cloud distributions can be mapped both day and night for use in weather predictions. Dynamics of cloud formation can be studied because accumulations of atmospheric water vapor associated with nascent and evanescent clouds can be recorded by operating the set in a spectral range corresponding to one of the water vapor absorption bands. In the science of geology, thermal pictures recorded over land masses could provide information on geologic structures by revealing their relative heating and cooling rates over the diurnal cycle. The imminence of volcanic eruptions might be inferred from observations of "hot spots" on the earth's surface. In general, it appears that a wealth of information about the earth could be learned by viewing it by its infrared incandescence. Experience with airborne infrared mapping devices has indicated that unexpected information is often obtained when objects are viewed in this different light.

III. SYSTEM DESIGN CONSIDERATIONS

A. In the design of the infrared mapping set the following will be assumed:

Altitude of satellite (h)	150 nautical miles
Radius of earth (R_E)	3.50×10^3 nautical miles
Angle between equatorial plane of earth and the satellite's orbital plane	28.5^o
Tangential speed of earth at equator (v_E)	903 knots
Circular orbit for satellite of radius ($R = R_E + h$)	3.65×10^3 nautical miles

~~CONFIDENTIAL~~

Subj: WEPTASK RT 7045001/2021/F019-05-02, Passive infrared mapping set for use in Gemini satellite; feasibility study of

B. Orbital period of satellite

$$T = 3.16 \times 10^{-10} \sqrt{R^3} \quad \text{(for T in seconds and R in cm)}$$

$$= 5.50 \times 10^3 \text{ sec}$$

$$= 91.8 \text{ min}$$

$$= 1.53 \text{ hr.}$$

C. Circumference of orbit

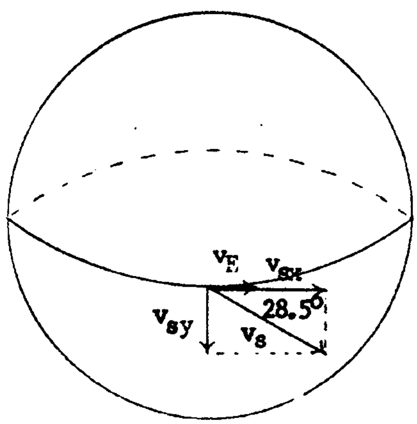
$$C = 2\pi \times 3.65 \times 10^3 = 22.9 \times 10^3 \text{ nautical miles.}$$

D. Orbital speed

$$v_s = C/T = 22.9 \times 10^3/1.53 = 15.0 \times 10^3 \text{ knots.}$$

E. Speed of satellite relative to the earth at the equator (v)

$$v = \left|\vec{v}_s - \vec{v}_E\right|$$



$$\vec{v}_s \begin{cases} v_{sx} = v_s \cos 28.5^\circ = 15.0 \times 0.879 \times 10^3 \\ \quad = 13.2 \times 10^3 \text{ knots} \\ v_{sy} = v_s \sin 28.5^\circ = 15.0 \times 0.477 \times 10^3 \\ \quad = 7.16 \times 10^3 \text{ knots} \end{cases}$$

$$v_{Ex} = v_E = 903 \text{ knots}$$

$$v_{Ey} = 0$$

$$v = \sqrt{(13.2 \times 10^3 - 903)^2 + (7.16 \times 10^3)^2} = 14.2 \times 10^3 \text{ knots.}$$

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

Subj: WEPTASK RT 7045001/2021/F019-05-02, Passive infrared mapping set for use in Gemini satellite; feasibility study of

F. Angular velocity of a target point on the surface of the earth relative to the satellite

$$v/h = \frac{14.2 \times 10^3 \text{ n mi/hr}}{1.50 \times 10^2 \text{ n mi} \times 3.6 \times 10^3 \text{ sec/hr}} = 2.63 \times 10^{-2} \text{ rad/sec}$$

$$= 26.3 \text{ milliradians/sec.}$$

G. It is desirable that the mapping set not scan from horizon-to-horizon insofar as the abrupt difference in the level of radiation from the earth and from the void beyond would exceed the dynamic range of the sensitive system under consideration. In addition, the information gained from viewing targets near the horizon would have negligible value because of loss of system spatial resolution associated with viewing targets at a glancing angle. A total scan angle of 120° is considered optimum; this will provide a sweep width of 550 nautical miles on the surface of the earth.

IV. SYSTEM DESIGN PARAMETERS

Enclosure (1) illustrates the design concept of the type of infrared mapping set under consideration. The set consists of two units: a scanner and a printer. Its design is an extension of that employed successfully in several generations of passive airborne infrared mapping sets used by the NAVAIRDEVCEN; there are no radical departures from present designs and all of the requirements of the system are within the present state of the art.

[redacted]

Since system noise equivalent temperature difference (a measure of system sensitivity) improves with increased detector aperture but system spatial resolution deteriorates with increased detector aperture, it is apparent that the choice of aperture diameter is a matter of compromise. In the event that

~~CONFIDENTIAL~~

it is decided at some later date to shift the compromise point selected to one that would yield either higher sensitivity or higher resolution, this can be accomplished readily by changing the detector aperture diameter.

The detector is maintained at a proper operating temperature of approximately 27°K by thermal contact with a reservoir of liquid neon stored in an altitude-independent, attitude-independent, metal dewar container of about 0.7-liter capacity. The dewar will be equipped with blow-off valves that maintain a constant absolute pressure of slightly more than one atmosphere over the liquid neon. The design of these valves must be such that only gaseous neon may pass through them. Provision must also be made in the dewar for maintaining thermal contact between the liquid neon and the detector in a gravity-free environment. The innermost wall of the dewar will be constructed of a good thermal conductor such as copper. In addition, a bladder made of material that will remain flexible at low temperature will be incorporated in the dewar; this bladder, which will be attached to the end of the dewar remote from the detector, will be inflated by the boiled-off neon gas and will force the remaining liquid neon to remain in contact with the base of the detector element. The capacity of the dewar will be adequate for three to four days of operation from the time of filling it with liquid neon.

The scanning mirror will rotate at the rate of 50 revolutions per second and will cause the projected image of the detector aperture to scan repeatedly across the terrain below with a locus consisting of a series of parallel lines perpendicular to the direction of travel of the spacecraft. Scanning in the forward direction is provided by the forward motion of the vehicle. Radiation is accepted only during those portions of the scan cycle that the detector is viewing the terrain within $\pm 60^\circ$ of the vertical. The number of one-milliradian resolution elements per scan will be

$$120 \text{ degrees/scan} \times 17.45 \text{ resolution elements/degree} = 2094 \text{ resolution elements/scan.}$$

For complete coverage of the terrain to be scanned, the minimum rate of scan must be

$$\frac{v/h \text{ (rad/sec)}}{\Delta\theta \text{ (rad)}} = \frac{26.3 \times 10^{-3} \text{ rad/sec}}{1 \times 10^{-3} \text{ rad}} = 26.3 \text{ scans/second.}$$

Since photoconductive infrared detectors generate electrical noise whose amplitude is greatest at low audio frequencies, it is desirable to scan at a rate greater than 26.3 scans/second so that the bulk of the signal information will occur at high audio frequencies. A rate of 50 scans/second appears reasonable. Accordingly, the duration of the active portion of each scan will be

$$\frac{120^\circ}{360^\circ} \times \frac{1}{50} \text{ sec} = \frac{1}{150} \text{ second.}$$

The required electrical bandwidth Δf of the system will be

$$\Delta f = 1/2 \times (\text{number of resolution elements per second})$$

$$= 1/2 \times \frac{\text{2094 resolution elements/scan}}{\text{1/150 sec/scan}} = 157 \times 10^3 \text{ cycles/second.}$$

The effective bandwidth Δf_{eff} for computing system noise will be approximately one-half the electrical bandwidth Δf because of noise averaging in the recording medium due to partial overlap on successive scans.

The electrical signal generated in the detector is amplified and applied to the intensity control grid of a high resolution cathode ray tube. The electron beam of the cathode ray tube is line-scanned in synchronism with the scanning mirror and the resulting intensity modulated line is focused on a strip of continuously moving 35 millimeter photographic film which advances at a rate of 2.57 feet/hour. The film, when developed, will yield a continuous-tone picture of the terrain under surveillance. The resolution characteristics of the type of cathode ray tube and of the size of the film selected are consistent with the one-milliradian resolution of the scanner. The 150-foot supply of film is adequate for more than two-days' continuous recording.

V. RESULTS TO BE EXPECTED

A change in the radiant power ΔP (watt) impinging on a photoconductive infrared detector of sensitive area a (cm^2) produces an electrical output having a signal-to-noise ratio S/N (dimensionless) given by

$$S/N = D^*_{av} \text{ (cm cps}^{\frac{1}{2}}\text{/watt)} \times \Delta P \text{ (watt)} \times a^{-\frac{1}{2}} \text{ (cm}^{-1}) \times (\Delta f_{eff})^{-\frac{1}{2}} \text{ (cps}^{-\frac{1}{2}}) \qquad \text{(Eq 1)}$$

where D^*_{av} is the average detectivity (a figure of merit) of the detector material over the spectral range of interest and Δf_{eff} is the effective electrical bandwidth over which signal and noise are being measured. Application of this equation involves the following considerations: (1) the emission of radiant power from the target, (2) the transmission of this power through the atmosphere, (3) the interception of a small fraction of this radiant power by a satellite-borne optical system, and (4) the conversion of this radiant power to an electrical signal by the detector and the subsequent amplification and recording of the signal. Each of these considerations will be discussed in turn. In the calculations that follow it is assumed that the targets considered behave as blackbody radiators and that the scanner optical system is 100% efficient.

The change in spectral radiant emittance of a blackbody accompanying a change in its temperature can be determined by differentiating the Planck radiation equation with respect to temperature. A graph of the resulting function was obtained by use of reference (a) and is plotted in figure 1. A reference temperature of 15°C was chosen. This graph shows that, in the spectral range of interest, a target temperature change of 1K° produces an average change in the power radiated per square centimeter of approximately 43 microwatts per micron interval of wavelength.

For clear sky conditions, the principal atmospheric attenuators of infrared radiation are water vapor, carbon dioxide and ozone. Reference (b) gives average values for the concentration of atmospheric water vapor as a function of altitude over eastern United States. These were plotted in figure 2. The area under the curve of figure 2 was determined and used to compute the total amount of precipitable water vapor in a vertical column through the atmosphere. The number obtained (36.3 mm of water) was increased by about 40% to allow for the higher values of absolute humidity to be expected in the tropics and a round number of 50 mm of precipitable water vapor was used in the transmission calculations. Figure 3 is a graph of the percent transmission of infrared radiation in the wavelength range of interest through 50 mm of precipitable water vapor. Reference (c) was used in making the determination.

Figure 4 is a graph of the percent transmission of infrared radiation in the wavelength range of interest through an equivalent sea level path of 5 kilometers of carbon dioxide. These transmission values were determined from data given in reference (c). The equivalence of the vertical path through the entire atmosphere to a sea level path of 5 kilometers was concluded from both references (b) and (c).

The concentration of ozone in the atmosphere is a function of altitude, latitude, time of the year, and weather conditions (references (c) and (d)). Typically, the ozone layer exhibits a maximum concentration at an altitude in the range of 20 to 30 kilometers. The model atmosphere graph of reference

(c) giving ozone concentration as a function of altitude was integrated to determine a representative quantity of 2.44 mm of ozone (at standard temperature and pressure) in a vertical column through the atmosphere. The percent transmission of infrared radiation through 2.44 mm of ozone was then determined by further use of reference (c) and was plotted as a function of wavelength in figure 5.

The net transmission of infrared radiation in a vertical path through the atmosphere as a function of wavelength was obtained by a point-by-point multiplication of the graphs given in figures 3, 4 and 5 and is plotted in figure 6. An average transmission over the spectral range of 7.7 to 13.5 microns of 39% was obtained from this curve.

The net change in spectral radiant emittance of a blackbody per Kelvin degree change in temperature transmitted vertically through the atmosphere was obtained by a point-by-point multiplication of the curves of figures 1 and 6 and is plotted in figure 7. The integral of the function plotted in figure 7 over the wavelength range of 7.7 to 13.6 microns is represented by the symbol L in the following discussion and has the value $95.8 \times 10^{-6} \frac{\text{watt}}{\text{cm}^2\,\text{K}^\circ}$.

The incremental change in radiant power ΔP (watt) incident on the infrared detector element for an incremental change in extended area target ~~temperature~~ ΔT can be derived in terms of quantities defined in figure 8. The target area from which radiation is accepted

$$A = \omega h^2 = \frac{a\,h^2}{F^2} = \frac{\pi (d/2)^2\, h^2}{F^2} .$$

The solid angle subtended at the target by the collecting optics

$$\Omega = \frac{\pi (D/2)^2}{h^2} .$$

The fraction of the power radiated normal to the target surface per steradian of solid angle Ω is $1/\pi$. Accordingly

$$\Delta P = 1/\pi \; L\, A\, \Omega\, \Delta T = \frac{L\, \pi d^2\, h^2\, \pi D^2\; \Delta T}{\pi\; 4\, F^2\;\; 4\, h^2} = \frac{\pi\, D^2\, d^2\, L\, \Delta T}{16\;\; F^2} . \qquad \text{(Eq 2)}$$

Subj: WEPTASK RT 7045001/2021/F019-05-02, Passive infrared mapping set for use in Gemini satellite; feasibility study of

The effective bandwidth Δf_{eff} of the system for noise considerations can be expressed in terms of the total time the radiation from a target is intercepted. For purposes of computation, consider the case in which the projected image of the detector on the target plane is congruent with the target. Then the total dwell time per picture element (including overlap on successive scans) is

$$\tau = \frac{\omega\, h^2}{2\pi\, h \cdot v} = \frac{\omega h}{2\pi v}$$

where v is the speed of the spacecraft. The effective bandwidth

$$\Delta f_{eff} = \frac{1}{2\tau} = \frac{\pi v}{\omega h} = \frac{\pi 4 F^2 v}{\pi d^2 h} = \frac{4 F^2}{d^2} \frac{v}{h} . \qquad \text{(Eq 3)}$$

If equations 2 and 3 are substituted into equation 1, the following is obtained:

$$S/N = \frac{\pi^{\frac{1}{2}} D^2 d^2 D^*_{av} L \Delta T}{16 \; F^3 (v/h)^{\frac{1}{2}}} .$$

If S/N is set equal to unity then ΔT equals the noise-equivalent temperature difference ΔT_N and

$$\Delta T_N = \frac{16 \; F^3 (v/h)^{\frac{1}{2}}}{\pi^{\frac{1}{2}} D^2 d^2 D^*_{av} L} .$$

For the system proposed:

$F = 15.24$ cm	$D^*_{av} = 8 \times 10^9$ cm cps$^{\frac{1}{2}}$/watt ✓
$D = 8.25$ cm	$L = 95.8 \times 10^{-6}$ watt/cm^2 K^o
$d = 1.524 \times 10^{-2}$ cm	$v/h = 2.63 \times 10^{-2}$ rad/sec.

Therefore $\Delta T_N = 0.43$ K^o. This means that a target whose size is equal to that of one resolution element (that is, the projected image of the detector) will yield a signal equal to the noise level of the system provided its temperature differs from that of the surround by 0.43 K°.

The image of the detector element projected on the earth will have, in general, the shape of an ellipse whose major and minor axes will vary as functions of the angle of incidence. For vertical incidence the ellipse will reduce to a circle of 910-foot diameter; for an angle of incidence of 60° with respect to the vertical its approximate major and minor axes will be 3640 feet and 1820 feet. Since the minimum signal-to-noise ratio required for reliable detection of single resolution element targets is of the order of two to three, targets in the above size ranges will be detected at night if they exhibit temperature contrasts of the order of one degree or more.

In general, but within limits, the minimum signal-to-noise ratio required for reliable target detection with a mapping set varies inversely as the square root of the area of the target, provided the target is larger than the resolution element. If the target is smaller than the resolution element, the magnitude of the signal is proportional to the ratio of the area of the target to the area of the resolution element.

One can calculate the minimum temperature contrast between target and background required for reliable detection at night as a function of target size. Such a set of values has been computed for the proposed infrared surveillance set and has been plotted as a graph in figure 9, which essentially summarizes the foregoing calculations.

In daytime use the set would perform largely by reflected solar radiation and the pictures obtained would appear much like those taken with conventional cameras. If a target does not behave as a blackbody radiator, that is, if it is reflective, its apparent temperature will be some intermediate value between its true temperature and the effective temperature of the sky it reflects. In this manner, highly reflective objects at the same temperature as their non-reflective surroundings may appear to be more than 100 K° cooler than their surroundings and thereby yield intense signals.

VI. CONCLUSIONS

From figure 9 and from available information obtained with airborne infrared radiometers and mapping sets, it is concluded that meaningful information in the areas of application (oceanography, meteorology, and geology) discussed in part II could be obtained by orbiting a passive infrared mapping device of high sensitivity and high resolution, particularly if the device could be operated continuously over the duration of many orbits such that many areas of the earth might be imaged at various times during the diurnal cycle.

Since the proper objects of geology, oceanography, and meteorology (i.e. land, sea, and air) are the environments in which military operations take place, it is likely that information of indirect military value would flow from conducting this experiment. Cities would be recognizable from their street grid patterns. Paved runways of large airfields would also be recognizable. The sites of near-surface nuclear explosions and of missile launchings may be detectable and identifiable for short periods of time after the events. Information on the clandestine nighttime establishment of large military bases and airfields may be obtainable with the orbiting infrared mapping set. Large ships such as aircraft carriers would yield detectable signals provided their decks differ in temperature from the water by at least four to five degrees; however, these signals would appear on the pictures as point targets which would not be identifiable. Small ships and wakes would not be detectable.

The relevance of this experiment to <u>manned</u> space flight would be limited. The infrared mapping set would probably not provide the earth-orbiting astronaut with information of value in his mission that he would not already possess with greater precision (such as his geographical location). Conversely, it is not the type of experiment that can be done only in <u>manned</u> space flight (such as human biological and psychological experiments). However, since it is desired ultimately to land men on the moon and on other planets, it may be desirable to have thermal pictures of the earth for comparison with thermal pictures of these other bodies before a manned extra-terrestrial landing is attempted.

It is concluded, therefore, that an orbiting passive infrared mapping set (1) would be of keen scientific interest in several fields providing it could be operated for extended periods, (2) would have indirect military value, and (3) would have limited relevance to manned space flight.

VI. RECOMMENDATIONS

It is recommended that consideration be given to placing a passive infrared mapping set in a gravity-gradient-stabilized, unmanned, earth-orbiting satellite for scientific exploratory purposes. The device recommended would have a useful life of the order of one month and it would telemeter its vide[o] data to earth receiving stations. It is recommended that such work be done on a time scale that would permit an orderly approach to the objectives sought and well-considered means for circumventing the many problems anticipated so that an acceptable probability of successful operation would be attained.

l
et for
e.
y (i.e.,
take
flow
heir
recog-
launch-
er the
rge
ared
table
at
e
ps
limited.
g
already
Con-
nned
.
n
rth
anned
ping
ing
litary
e infra-
iting
d would
ts video
e done
es
antic-
d be
~~TIAL~~

AW-411

~~CONFIDENTIAL~~

Subj: WEPTASK RT 7045001/2021/F019-05-02, Passive infrared mapping set for use in Gemini satellite; feasibility study of

It is not recommended that a passive infrared mapping set be included in the complement of Gemini instrumentation.

Paul M. Moser
PAUL M. MOSER

~~CONFIDENTIAL~~

13 Dec 1963

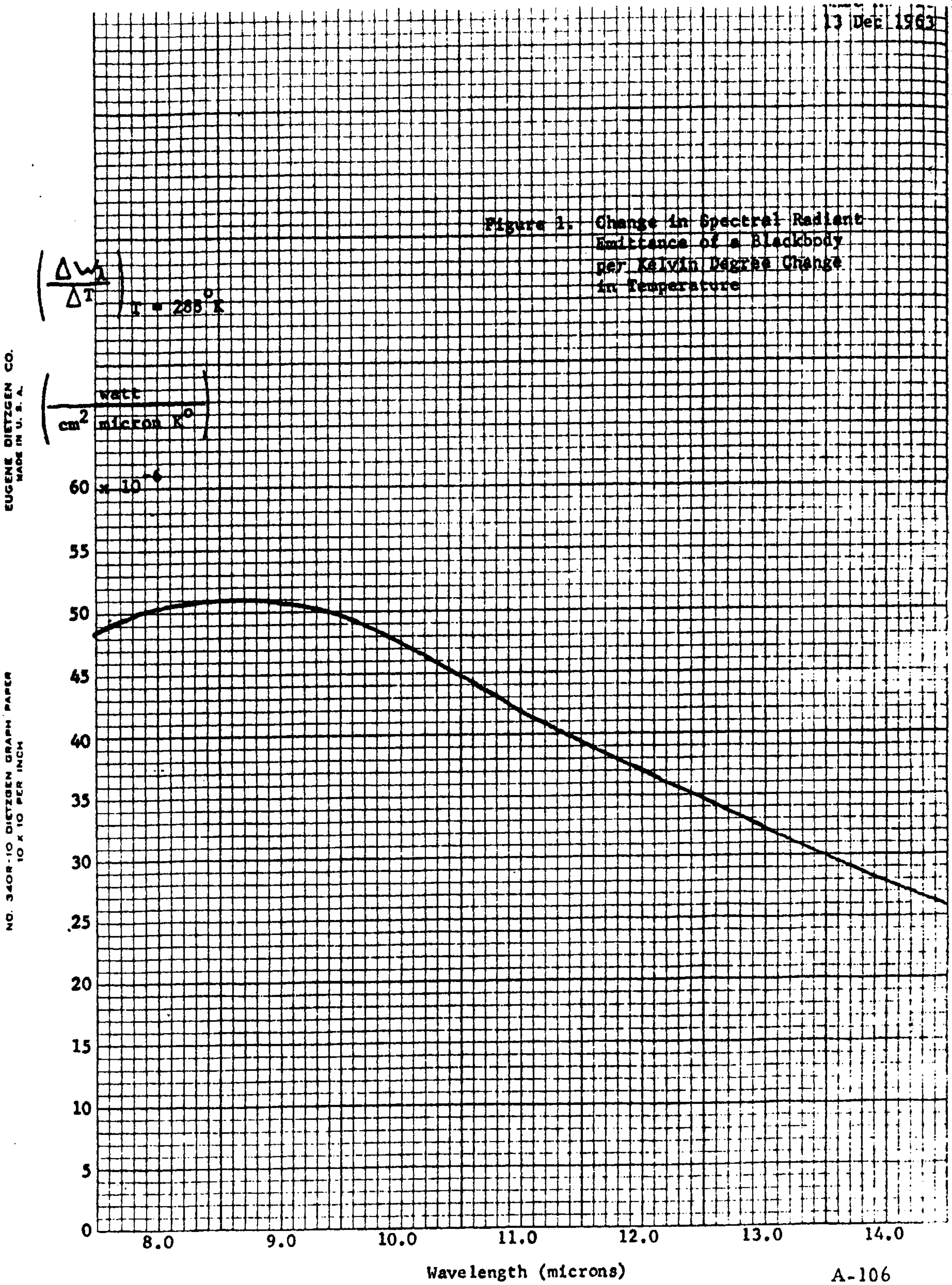


Figure 1. Change in Spectral Radiant Emittance of a Blackbody per Kelvin Degree Change in Temperature

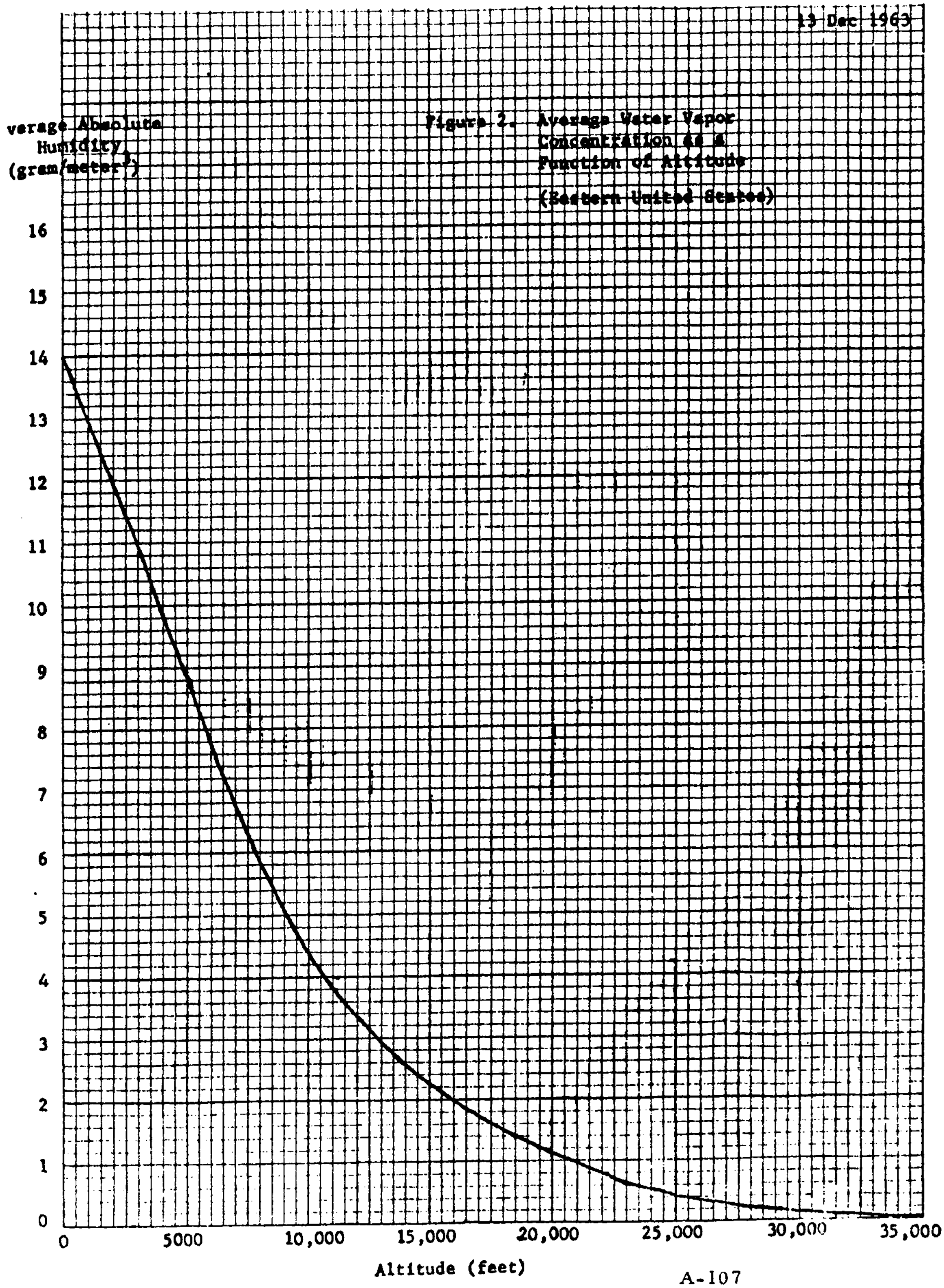


Figure 2. Average Water Vapor Concentration as a Function of Altitude

(Eastern United States)

13 Dec 195

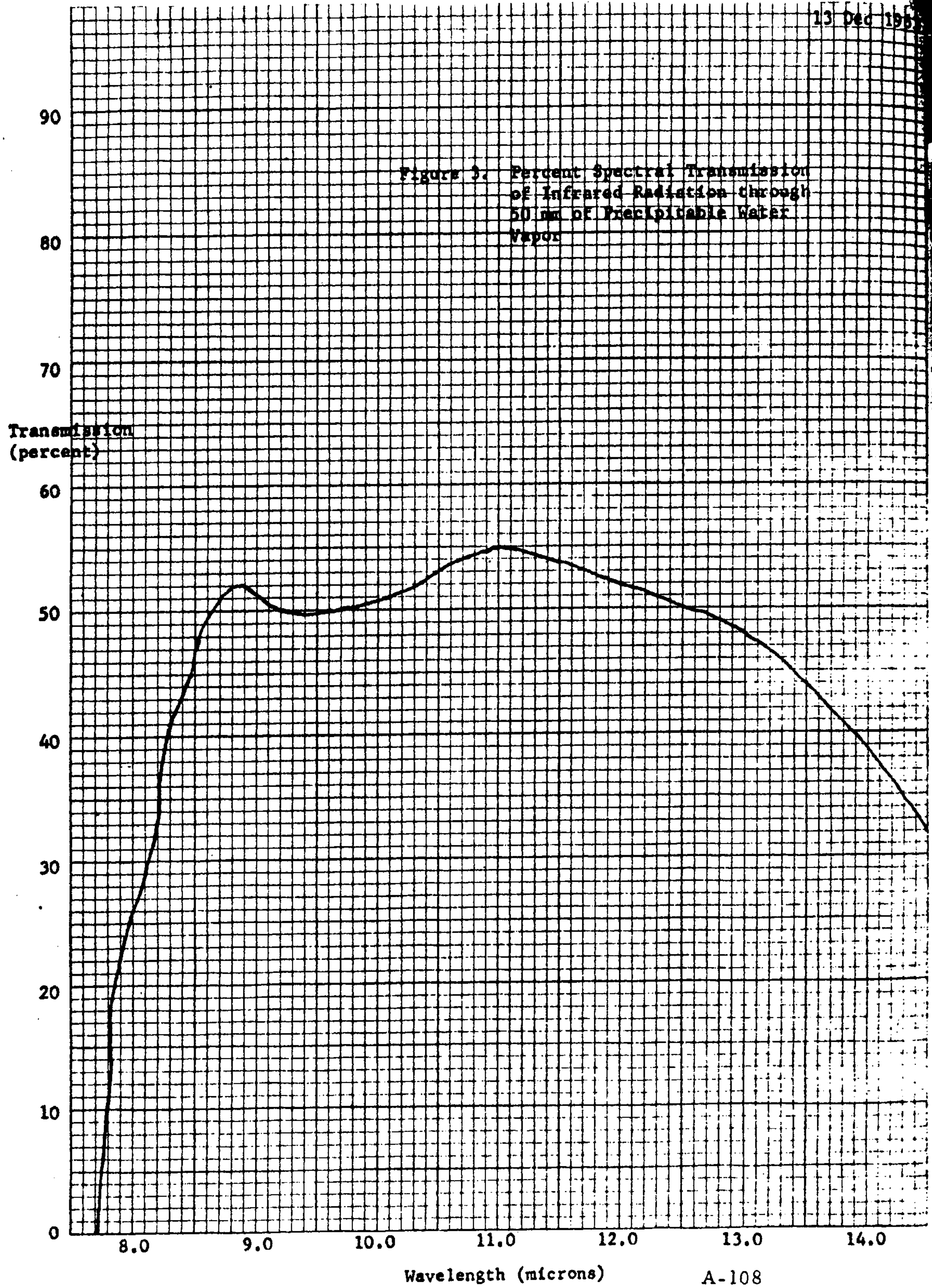
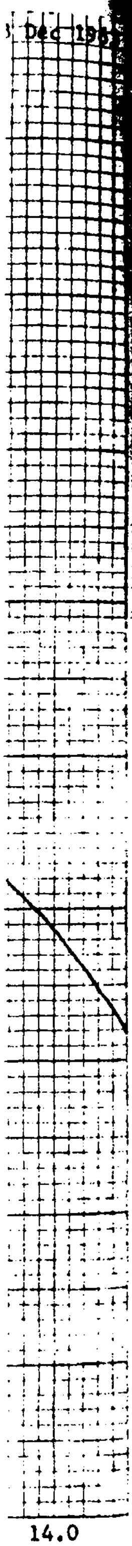


Figure 3. Percent Spectral Transmission of Infrared Radiation through 50 mm of Precipitable Water Vapor



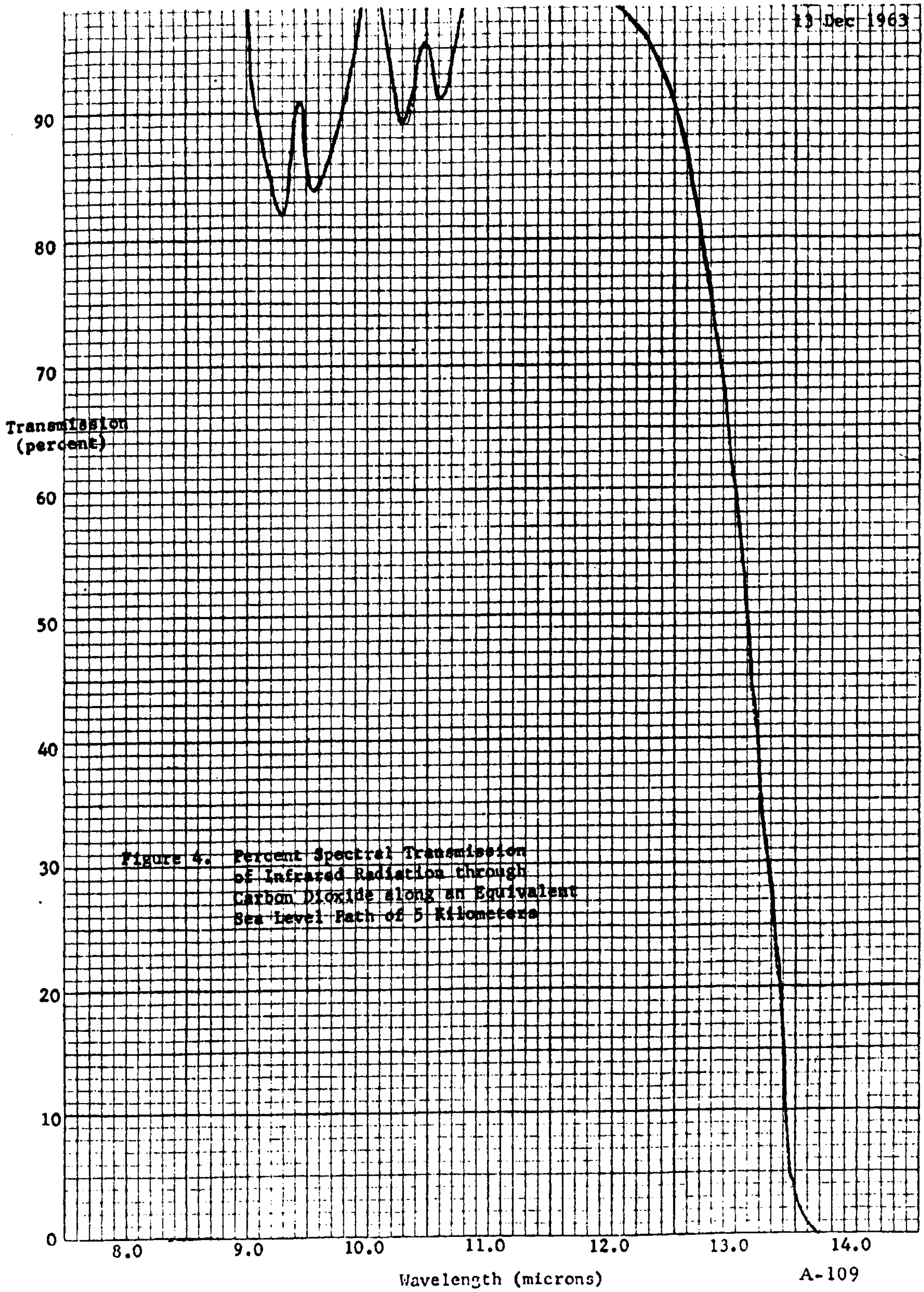


Figure 4. Percent Spectral Transmission of Infrared Radiation through Carbon Dioxide along an Equivalent Sea Level Path of 5 Kilometers

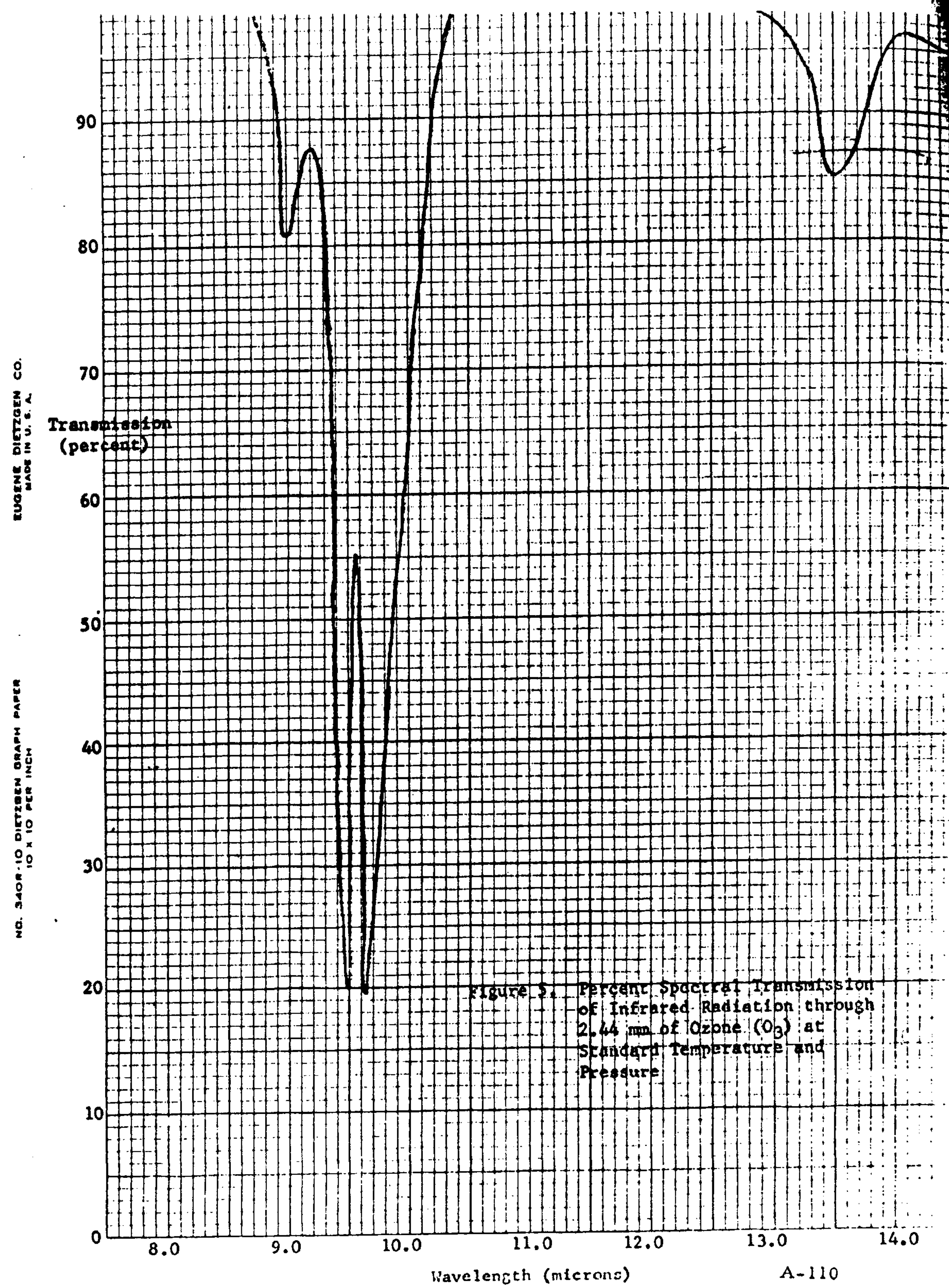


Figure 5. Percent Spectral Transmission of Infrared Radiation through 2.44 mm of Ozone (O_3) at Standard Temperature and Pressure

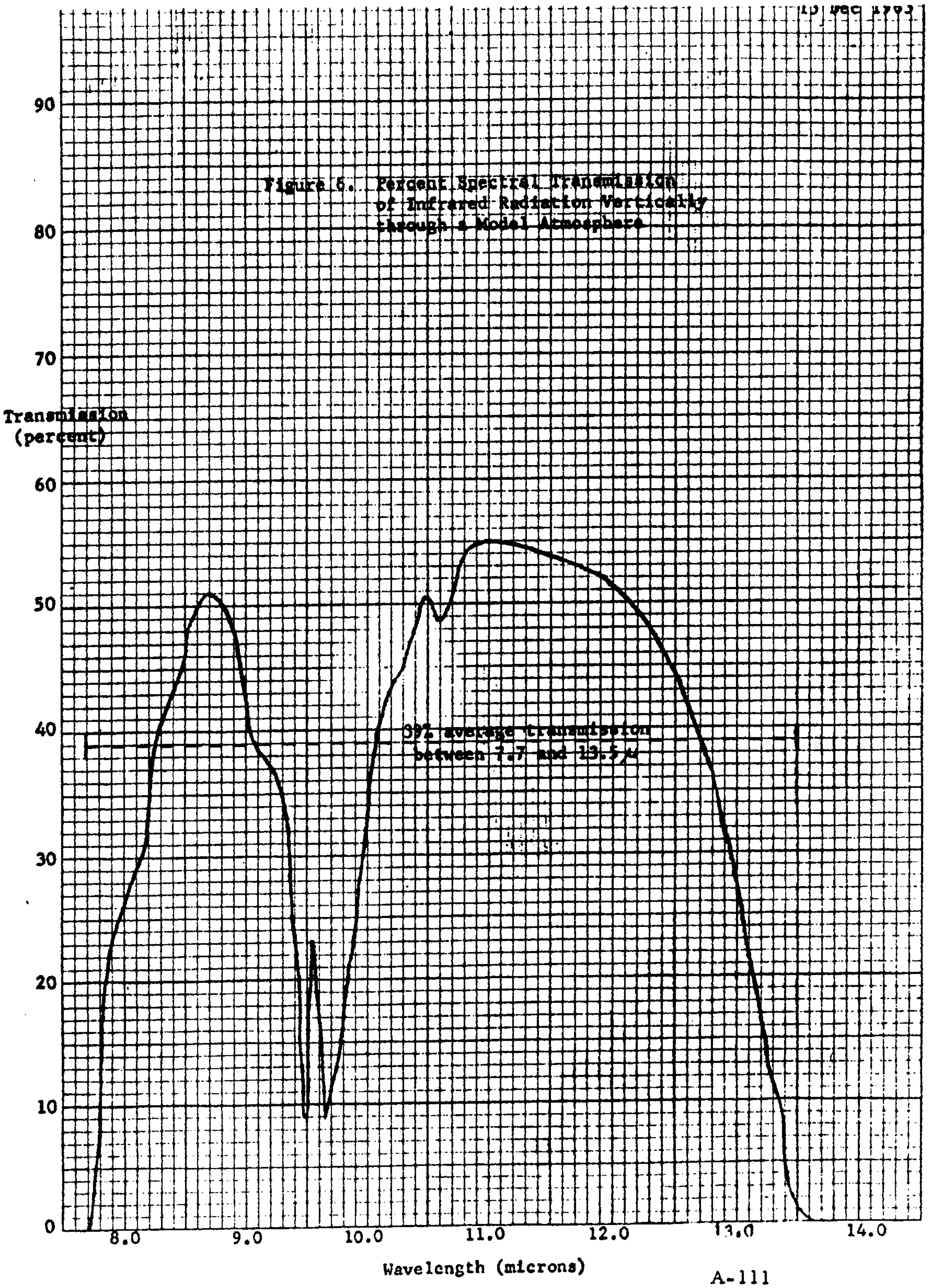


Figure 6. Percent Spectral Transmission of Infrared Radiation Vertically through a Model Atmosphere
Transmission (percent)
90
80
70
60
50
40
30
20
10
0
39% average transmission between 7.7 and 13.5 μ
8.0
9.0
10.0
11.0
12.0
13.0
14.0
Wavelength (microns)

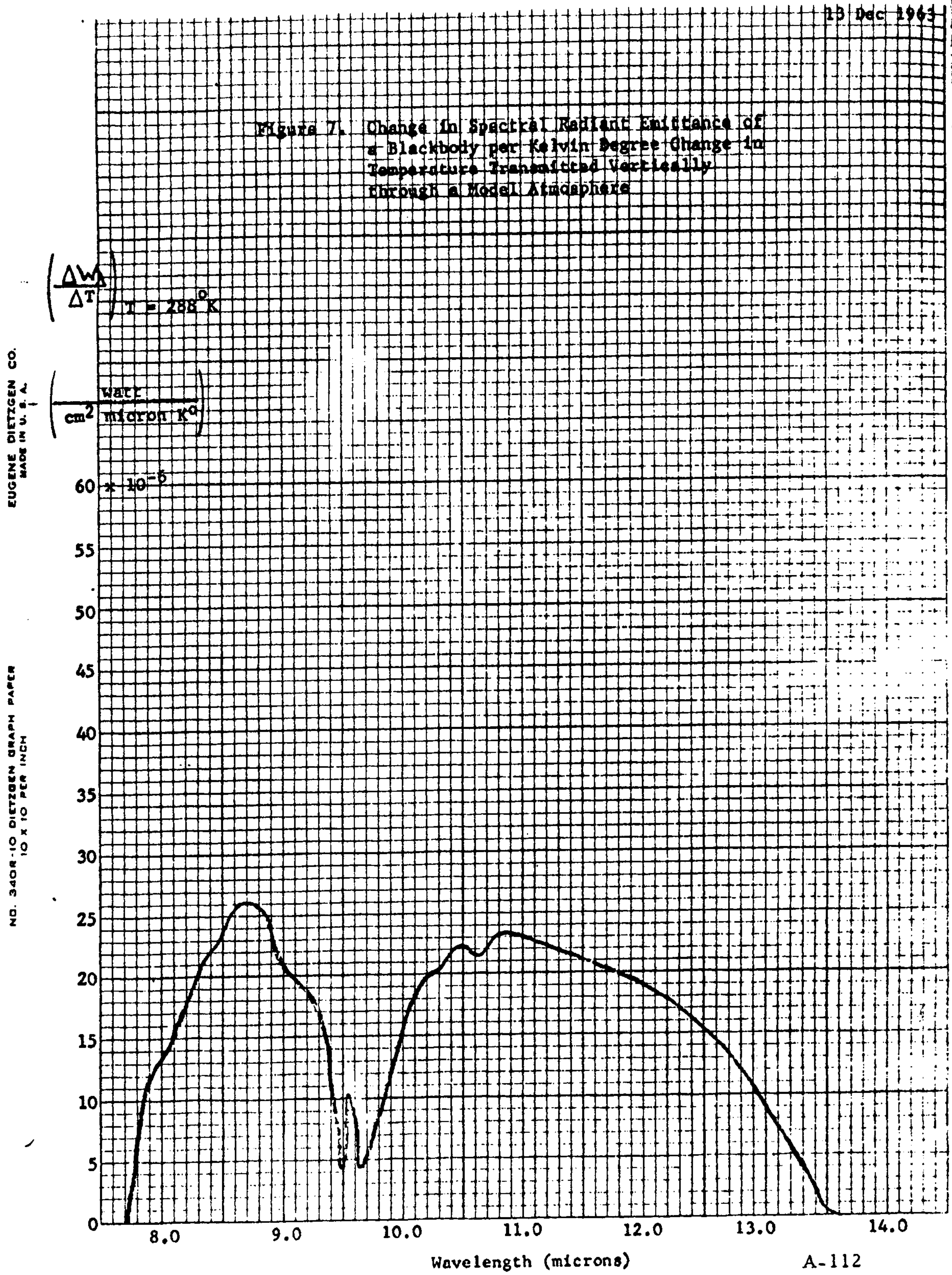


Figure 7. Change in Spectral Radiant Emittance of a Blackbody per Kelvin Degree Change in Temperature Transmitted Vertically Through a Model Atmosphere
$\left(\frac{\Delta W_\lambda}{\Delta T}\right)_{T = 288^\circ K}$
$\left(\frac{\text{watt}}{\text{cm}^2\ \text{micron K}^\circ}\right)$
60 x 10^{-6}
55
50
45
40
35
30
25
20
15
10
5
0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
Wavelength (microns)
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340R-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

Dec 1963

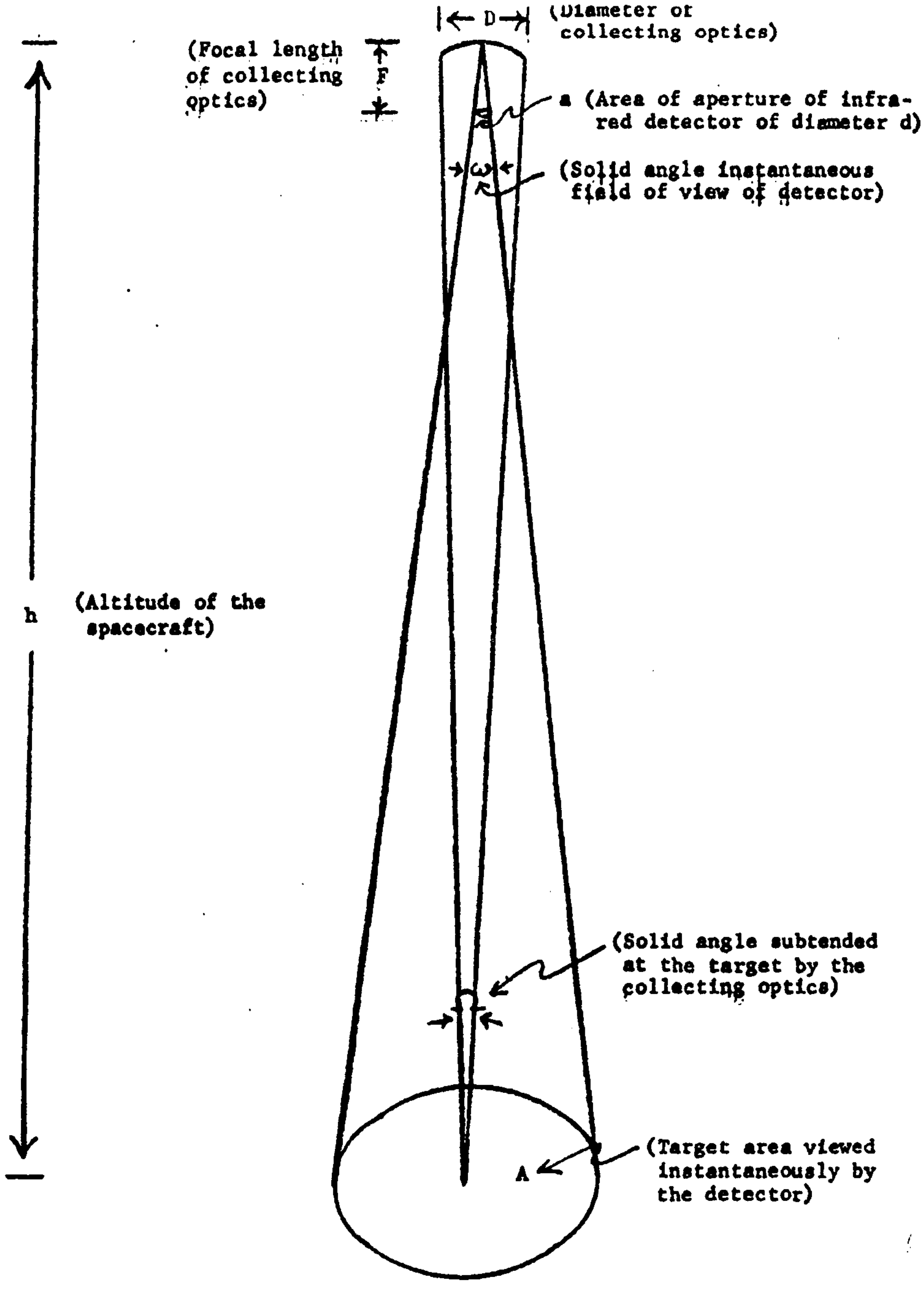


Figure 8. Definitions of Terms Used in Optical System Calculations

14.0

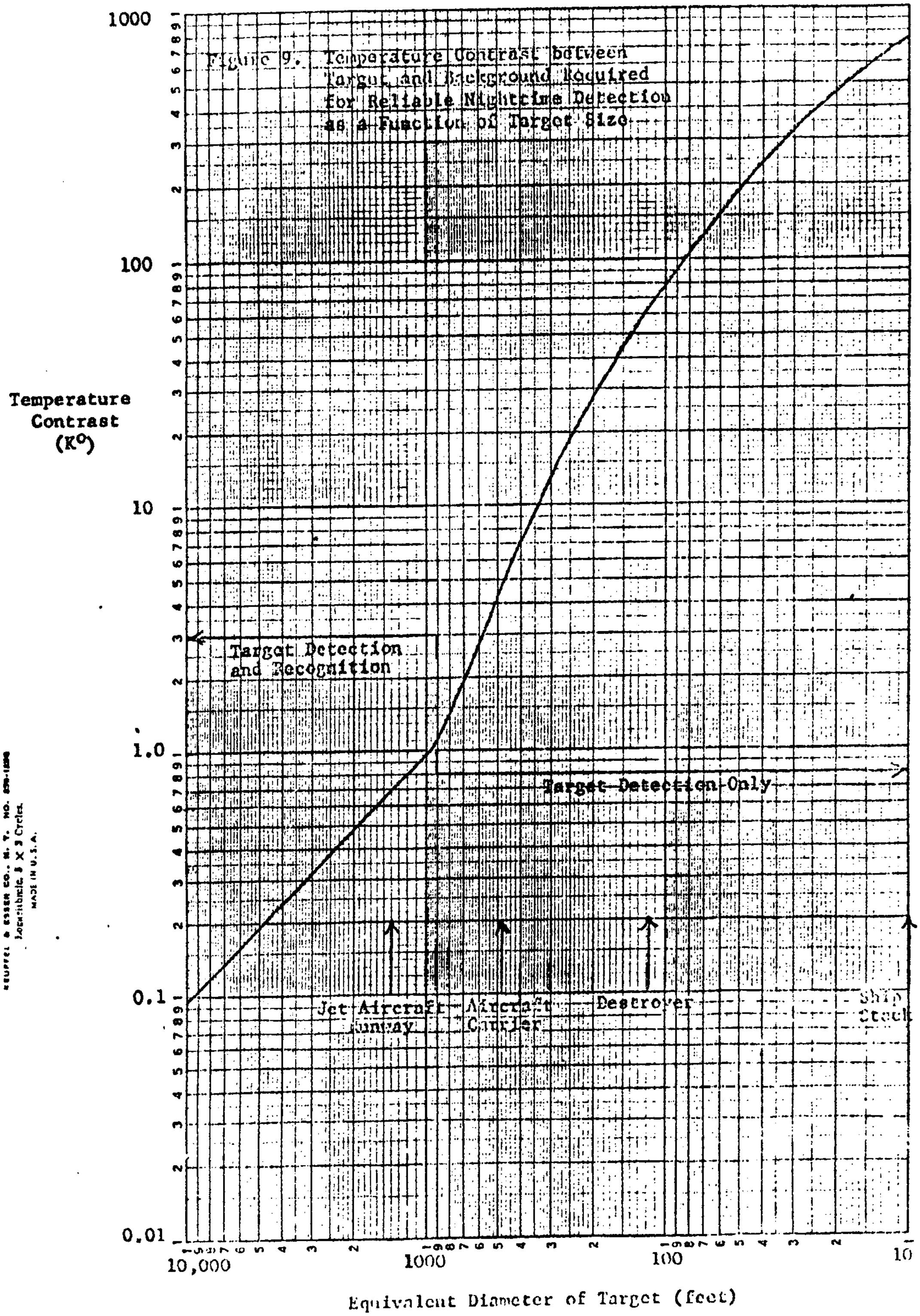
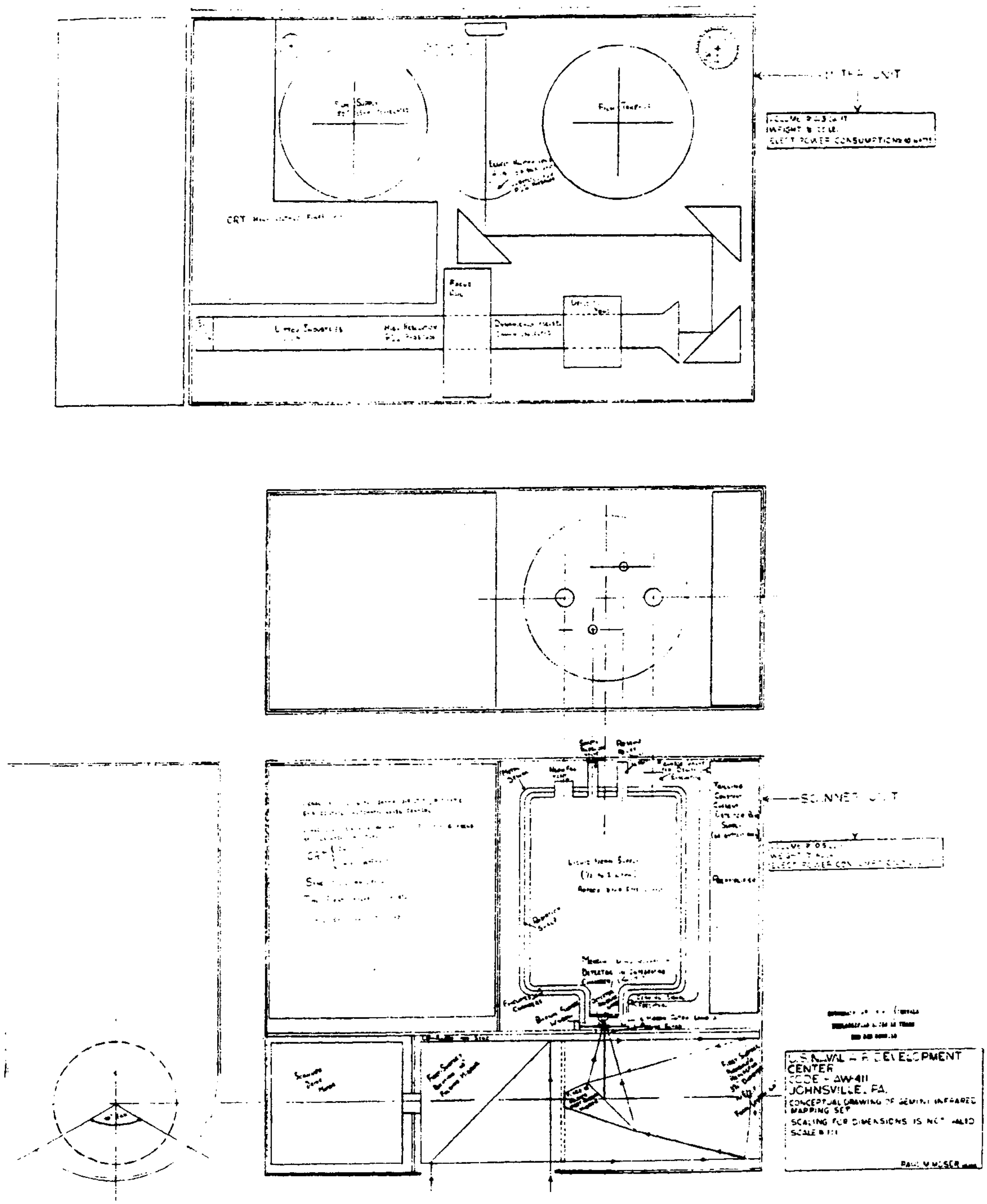


Figure 9. Temperature Contrast between Target and Background Required for Reliable Nighttime Detection as a Function of Target Size
Temperature Contrast (K°)
1000
100
10
1.0
0.1
0.01
Target Detection and Recognition
Target Detection Only
Jet Aircraft Runway
Aircraft Carrier
Destroyer
Ship Stack
10,000
1000
100
10
Equivalent Diameter of Target (feet)

NRO APP
RELEASE

~~CONFIDENTIAL~~



~~CONFIDENTIAL~~

Title of Experiment <u>Electronic Surveillance of Ocean Targets for Ocean Surveillance</u>

I. Test Objective

This experiment is expected to establish the feasibility of performing a portion of the ocean surveillance mission by performing identification and position determination by intercept of electronic emissions from ocean shipping.

II. Importance of the Test

This test is required to provide complete coverage of the useable frequency spectrum of ocean vehicle emissions for the purpose of ocean surveillance. Only from an orbiting platform can adequate coverage of the oceans be obtained. In-as-much as elint alone is a necessary but not sufficient ocean surveillance medium, it requires integration and assimulation of data with all other sources (optics, radar, infra-red scaners) Scanners to provide a positive degree of intelligence. The output of the multi-sensor array necessary for effective ocean surveillance can be best obtained and managed by a human performing a selection, sequencing, rejecting, and analysis function. Provision of this additional source of real-time data to the astronaut attempting to manage the variety of tasks required for ocean surveillance will, without doubt, contribute to the assessment of man's ability and utility in space.

III. Description of the Experiment

This test involves the intercept of radio frequency emissions from ocean vehicles for the purpose of identification and location of shipping as a part of the ocean surveillance mission. It is anticipated that provision of such data, properly identified and displayed, to the astronaut, will greatly enhance the demonstration of his capability to perform an effective ocean surveillance experiment from space. Problem areas are expected to be encountered in rapid positive identification of intercept, suitable display devices and adequacy of intercept range.

a. Configuration of test Items

This test will can be implemented by provision of a suitable ~~omni-~~ direction~~al~~, broad-band antenna array with L, S, and X band capability feeding computation and display equipments. Antenna systems to be located on the MOL exterior with computation equipment located as convenient within the MOL in pressurized or non-pressurized spaces and display equipment located in the ocean surveillance "information center". Further detail provided in attachment A.

b. Test-Support Equipment Required

(1) Routine test and maintenance equipment, spare parts, signal generators, auxiliary power supplies and related equipment to support this test will be required in the spacecraft.

(2) Necessary ground test equipment exclusive of that above will include test radar, elint simulation equipment, antenna calibration and alignment devices and associated equipments. Additional detail will be provided in Attachment B.

c. Test Procedure

This test will be accomplished as part of the general ocean surveillance test and, as such, will utilize pre-arranged target-ship formations stationed within known range of the MOL orbital path. Ships within the test patterns will be configured with suitable radiators to serve as characteristic elint targets and the ability of the astronaut to identify the emitter and effect correlation with other data will be directly assessable. The astronaut will utilize this experiment as another data source and his ability to identify the signal, confirm location and effect correlation with other data sources will provide measurement of the man's contribution. A precise definition of testing sequence is unknown at this time. However, it is anticipated that the elint experiment would operate automatically and would remain active continuously during each test period.

d. Category of Experiment

Category B. This experiment will contribute directly to the MOL objectives, however, it is not expected to have appreciable effect on the laboratory design.

e. Cost

	Prior	FY65	FY66	FY67	FY68	FY69	TOTAL
(1) Engineering & Development		100	500	1,750	1,500	800	4,650
(2) Installation				350	1,450	1,750	3,550
(3) Ground Support				300	350	400	1,050
TOTAL							9,250

f. Schedule

(1) Hardware and software available for test beginning in FY 67.

(2) Hardware and Software flight readiness date FY 68.

IV. Participating Government Agencies

Sponsor: Department of the Navy, Bureau of Naval Weapons

Test Equipment Acquisition: Naval Research Laboratory

V. Additional Requirements

a. Special Security

Normal security procedures associated with intercept and analysis of uncooperative RF data.

b. Manning Description Summary

See Attachment E.

c. Logistics

This experiment ~~can~~ will be supported from logistics point of view within available Department of the Navy supply system. No special logistics problems are anticipated.

d. Facilities

This experiment will require special simulation facilities as part of the integrated ocean surveillance mission experiment. Specific facilities for experiment definition and astronaut training will be required and provided by the experiment development program.

e. Simulation and Training

(1) Astronaut: To perform this portion of the ocean surveillance experiment the Astronaut must be a trained Elint/observer and must have technician capability for equipment maintenance. Simulation testing will be included as a portion of the integrated ocean surveillance experiment simulation and training program. Navy laboratories and training facilities include necessary capabilities.

(2) Ground Personnel: Ground personnel involved in simulation and training will be needed to provide necessary support in areas of physiological monitoring and planning, Elint instructors, training aids specialists, radar and electronic technicians, and project engineering and management. Many of these personnel will fulfill similar roles in the other experiments making up the integrated ocean surveillance experiment.

(3) Equipment: Equipment required for simulation and training will include RF generation equipment, radar simulators, signal displays, communication link, environmental control, physiological testing and measuring equipments, etc. With few exceptions, all necessary equipment in this category will be available in Navy laboratories.

VI. General

a. Communications and Data Handling Equipment: Attachment F.

b. Development Characteristics: See attachment G.

ATTACHMENT A

DESIGN CHARACTERISTICS TEST EQUIPMENT

1. EQUIPMENT TO BE TESTED
2. WEIGHT: 150
3. VOLUME: Stored 2 Cu ft In use 4 Cu ft.

   CRITICAL DIMENSIONS - SHAPES None
4. POWER
   a. Continuous
   b. Stand-by 30 watts
   c. Average operating 60 watts
   d. Peak 125 watts
   e. Duty cycle
5. SPARES
   a. Volume 1.0 Cu ft.
   b. Quantity
   c. Weight 40 lbs
6. TOOLS
   a. Volume .5 Cu ft
   b. Quantity —
   c. Weight 25 lbs
   d. Power
7. HEAT OUTPUT To be determined
8. STABILITY
   a. Moving parts
9. VIBRATION LIMITS As required by MOL Environment

10. SHOCK LIMITS See #9

11. HAZARDS (fire, explosion, electrical, toxics, other) Routine Electronic equipment hazard

12. TEMPERATURE LIMITATIONS: Normal Electronic Equipment Tolerances

13. TYPE AND RANGE OF MEASUREMENT (definition of parameters to be measured while test is under way). [redacted]

14. SPECIAL ENVIRONMENTAL REQUIRE[redacted]

15. ORIENTATION AND POSITION ACCURACY REQUIREMENTS:

Station: ± 1.0 Degree each axis

Equipment: To MOL Tolerance

16. EQUIPMENT OPERATING CYCLE

Frequency: Maximum Once per Orbit

Time Duration: Approximately 25 Minutes per Test.

17. EQUIPMENT LOCATION REQUIREMENTS Not critical internally except Display console required in Ocean Surveillance Experiment Center.

18. SPECIAL MOUNTINGS REQUIREMENTS Antennae require ± 75 degree lateral field of view.

Apertures HF-VHF (4'-6')

Booms

Windows: None

Antennae Telescoping stubs for HF-VHF, flush mounted spirals for L, S and X Band intercept and DF.

Bracketry As required

19. PRESSURE VESSELS - fluids, gasses, etc. None

20. ELECTRO MAGNETIC INTERFERENCE (spurious generation, special shielding req, etc.) Standard Mil spec Tolerance

21. MAINTENANCE REQUIREMENTS

Ground None

Space Modular replacement of experiment variables and spares

ATTACHMENT B

TEST SUPPORT EQUIPMENT

1. RECORDING MEDIA

   a. Tape - As Required

   b. Film - As Required

   c. Other - Unknown

2. HANDLING

Component equipment comprising this experiment will be compatible with manhandling and will require no special equipment.

3. PACKAGING - To be determined

4. CALIBRATION

Pre-launch calibration of antenna alignment and equipment capability will be required. Possible post-launch calibration may be required to be determined.

5. JIGS AND FIXTURES - As Required

6. NUMBER OF LEADS FROM OUTSIDE TO INSIDE STATION

Not known at this time. However, some quantity of antennae on the spacecraft exterior will require electrical connection with equipment within the spacecraft.

7. SENSORS - None

8. TRAINERS/SIMULATORS - As required

9. INSTRUMENTATION - As required

10. RELATED SUPPORT EQUIPMENT

   a. Targets - To be arranged within operating constraints of the development test activities of the fleet units.

   b. Ground Stations - Indeterminate at this time. To be accomodated within existing DOD ground station networks where practical.

   c. Handling Equipment - None

11. AGE -

Routine electronics ground support and evaluation equipment will be required and available within the Navy system.

12. ENVIRONMENTAL TEST EQUIPMENT - None

13. FACILITIES

Available within the Navy laboratory system.

ATTACHMENT C

TEST OPERATING CHARACTERISTICS

1. ORBITAL PARAMETERS (desired)

a. Altitude: 100-200 nautical miles

b. Inclination: For purposes necessary to MOL requirements, inclination of orbit is not critical. However, an operational ocean surveillance capability derived from MOL type experiments will require near polar inclination.

c. Epoch: Coincident with MOL launch.

d. Ellipicity: Near Circular

2. PLANE CHANGE: Not required

3. ALTITUDE CHANGE: Not required

4. TIME ON ORBIT: Thirty days

5. TEST DURATION: Tests will be a function of time spent over ocean areas and in particular over pre-arranged test target complexes.

6. TOTAL NUMBER OF TESTS: Unknown at this time. Part of training and simulation program may be performed in an airborne laboratory which will permit better definition of this item.

7. TEST FREQUENCY: To be determined as above.

8. INTERVAL BETWEEN TESTS: As required by Astronaut duty cycle and experiment requirements. To be determined.

9. CREW TASK LOADS: To be determined

10. CREW TASK FREQUENCY: To be determined

11. FIELD OF VIEW REQUIREMENTS: $\pm$ 75 degrees across orbit track-narrow beam 45 degrees ahead of spacecraft.

12. GROUND CONTROL LIAISON DURATION: To be determined by overall Ocean Surveillance experiment.

13. GROUND CONTROL LIAISON FREQUENCY; As 12 above

14. EXTERNAL TEST ITEMS: None

a. Launched from station - none

b. Launched from resupply - none

c. Launched from ground - none

15. QUALIFICATION TESTS:

a. Ground - Astronaut training, equipment calibration, astronaut calibration

b. Atmosphere - None

16. SEQUENCE OF EVENTS AS THEY OCCUR DURING FLIGHT: Intercept system operating passively will receive a series of test signals which will be processed and presented via a suitable grid display to Astronaut for (a) Identification and (b) for location notation of emitter followed by action taken with other related sensors.

17. HANDLING PROCEDURES: Not Applicable

ATTACHMENT D

F U N D I N G   S U M M A R Y

BUDGET REQUIREMENTS BY FISCAL YEAR

	PRIOR	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
Engineering, Developmental Environmental Testing		100	440	1,350	1,200	400	3,490
Integration & Installation			50	350	1,050	1,525	2,975
AGE				300	350	400	1,050
Simulators/Trainers			10	400	450	400	1,260
Data Reduction					50	75	125
Equipment Rework					200	150	350
Other							
TOTAL		100	500	2,400	3,300	2,950	9,250

Thousands of Dollars

ATTACHMENT E

MANNING DESCRIPTION

1. ASTRONAUTS

a. Number required - one

(1) Man's function

(a) As part of test - monitoring elint intercept display - tentative identification of ship class - decision making utilizing elint display output.

(b) As technician conducting test - equipment adjustment for fine grain tuning - varying display parameters - adjustment and repair of equipment.

b. Crew skill requirements - Electronics specialist with specialized training in elint signal analysis and recognition; capable of equipment troubleshooting and minor repair.

c. Manpower Profile - one or two per test mission

d. Critical Functions - None anticipated

e. Work Positions - In ocean surveillance experiment data center for conduct of experiments and as required for maintenance and adjustment of equipment

f. Time Controlled Tasks -

g. Human Performance Measures - To be determined.

h. Physiological and Psychological Measures - As required. To be determined as means of analyzing and measuring the effect of the Astronauts ability to perform the work tasks on the ocean surveillance experiment.

i. Selection Factors - Qualified Astronaut plus requirements of 1b. above

j. Training Requirements - See 1b and 1i above.

2. GROUND PERSONNEL

Ground personnel requirements for this experiment have not been defined, however it is anticipated that existing Navy organizations and personnel capabilities will be directly applicable.

ATTACHMENT B

TEST SUPPORT EQUIPMENT

1. RECORDING MEDIA

   a. Tape - As Required

   b. Film - As Required

   c. Other - Unknown

2. HANDLING

Component equipment comprising this experiment will be compatible with manhandling and will require no special equipment.

3. PACKAGING - To be determined

4. CALIBRATION

Pre-launch calibration of antenna alignment and equipment capability will be required. Possible post-launch calibration may be required to be determined.

5. JIGS AND FIXTURES - As Required

6. NUMBER OF LEADS FROM OUTSIDE TO INSIDE STATION

Not known at this time. However, some quantity of antennae on the spacecraft exterior will require electrical connection with equipment within the spacecraft.

7. SENSORS - None

8. TRAINERS/SIMULATORS - As required

9. INSTRUMENTATION - As required

10. RELATED SUPPORT EQUIPMENT

   a. Targets - To be arranged within operating constraints of the development test activities of the fleet units.

   b. Ground Stations - Indeterminate at this time. To be accomodated within existing DOD ground station networks where practical.

   c. Handling Equipment - None

11. AGE -

Routine electronics ground support and evaluation equipment will be required and available within the Navy system.

12. ENVIRONMENTAL TEST EQUIPMENT - None

13. FACILITIES

Available within the Navy laboratory system.

~~CONFIDENTIAL~~

5260-21:CVP:mp

TO : Code 7000

DATE: 9 March 1964

FROM : Code 5260

SUBJECT: Identification of Ships

1. It appears very likely that the identification of ships may be carried out without increase in equipment carried by the ships by making use of Mark X (SIF) IFF equipment already installed aboard our ships and those of Great Britain, Canada, and possibly other NATO countries. By pre-arrangement with these ships, it would be possible to determine their individual identity by making use of the three modes of interrogation and over 4096 reply codes provided by the IFF system.

2. Major technical obstacle to this project appears to be the design and engineering of a directional antenna to be installed aboard the satellite. Most promising approach would be utilization of a second feed to the radar antenna and similar techniques to those proposed for the radar operation. The maximum slant range required of 350 miles will require somewhat higher effective peak power than normally provided by the nominally 200-mile range IFF system. However, the 32 db antenna gain anticipated for the radar antenna, if duplicated for IFF, would more than make up the deficiency in effective radiated power, and insure operation on both interrogation and reply paths.

3. Push-button identification could be provided with the four octal-digit reply codes displayed on a separate small indicator by active readout equipment already available or, if desired, displayed on a PPI near the radar echo.

4. Replies from U. S. and allied aircraft will be elicited by the same interrogations which produce replies from ships. Distinction between the two types of vehicles may be necessary by code assignment in lieu of recognition of their widely different velocities which may not be possible from a rapidly-moving satellite.

5. Assuming that the antenna problem can be solved as part of the radar antenna program, the remaining equipment would be very similar to existing airborne IFF equipment. Present equipment weighs 50 to 100 pounds and costs 10 to 20 thousand dollars. Microelectronic versions would weigh much less, cost slightly more at the present time, but less later on as production develops.

F465 Total
$10. [illegible]

C. V. Parker

C. V. PARKER
Head, Security Systems & Avigation Branch
Electronics Division

Excluded from automatic
downgrading and declassification.

~~CONFIDENTIAL~~

Beacon System

I TEST OBJECTIVE

To locate a ground station equipped with a simple, low powered UHF beacon.

II IMPORTANCE OF TEST

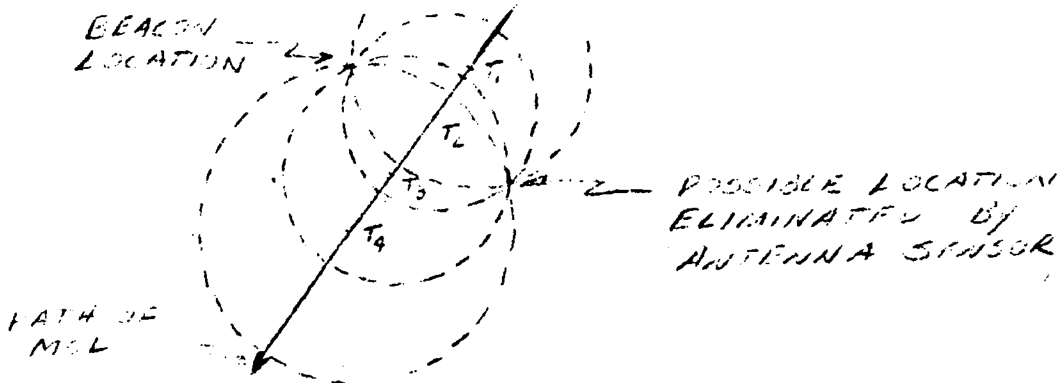
A test is needed to determine the accuracy of location. Since the MOL can cover an enormous area of land and sea within a few hours, it is a logical vehicle to be used in search operations for air crash or ditching locations. If successful, this test could lead to the adoption of an automatically ejected crash beacon that would be precisely located within several hours. Prompt location would increase the probability of rescue of survivors, and at the same time obviate the need for large numbers of search aircraft.

III EQUIPMENT IN MOL

1. UHF crystal controlled multi-channel receiver.
2. Pulsed UHF transmitter.
3. Digital range indicator
4. Digital clock indicator
5. Data recorder
6. Dual antenna

IV DESCRIPTION OF TEST

Beacon equipment would be installed in several aircraft, ships, and ground stations. Each beacon would operate on a separate crystal controlled channel. Upon interrogation from the MOL, a coded reply on a present frequency would be transmitted. As the MOL comes within range of the beacon, the coded replies are received and range and time are printed on a tape. Since the path of the MOL over the surface of the earth will be known from data supplied by ground tracking stations, range and time information will produce two possible beacon locations. A sensor on the dual antenna will determine which is the true location. A ground station for computing true latitude and longitude from telemeterred data may be desirable.



If the location of the beacon is known, range and time information can be used to compute the path of the MOL.

V Estimated Total Cost

$250,000

~~CONFIDENTIAL~~

13 March 1964

Title of Experiment: Electromagnetic Communications

I. Test Objective: The objectives of this experiment are threefold, namely:

(1) To determine to what degree communication coverage from surface radio stations in the ELF to HF frequency range, particularly those located in the continental USA, is available to MOL.

(2) To measure the impedance of radio antennas over the ELF to HF range in the plasma surrounding the spacecraft.

(3) To obtain as much information as possible on the propagation characteristics of radio signals from ELF through HF in and through the ionosphere.

II. Importance of Test: Electromagnetic signals below the HF range are generally presumed to be limited in usefulness to the space between the Earth's surface and the ionosphere. However, low frequency propagation in and through the ionosphere has come to be recognized (e.g., whistler mode) and has been demonstrated at VLF by the LOFTI program. This circumstance points to the possibility that low frequency transmissions may provide the answer to a vexing problem, namely communication to or control of spacecraft over any part of the Earth by demonstrating that communication over the bulge of the Earth can be provided by such transmissions. The tests described herein are also designed to investigate other frequency ranges up through the HF band, to enable prediction of the performance of transionospheric communications in these ranges and to provide design criteria for antenna systems for proper coupling to the magneto-ionic medium surrounding the spacecraft.

III. Description of the Experiment: A major objective of this program is to determine the effectiveness of ELF through HF transmissions for Naval communication to spacecraft. It is expected that a series of simple tests by the astronaut will provide the necessary information. Basically the objectives and procedures are simple and can be carried out easily, although the attention of an astronaut for considerable periods may be required.

a. Configuration of Test Items

Items required for this program are ELF through HF receiving equipment capable of being tuned to the several U.S. and other transmitters, the necessary cables, headphones, loop antenna and dipole antenna (both of which are external to the craft), appropriate telemetry and recording equipment and antenna impedance measuring means used in connection with or integral to the receiver.

b. Test Support Equipment Required

(1) The total weight of the spacecraft equipment is estimated to be about 60 pounds, with the volume about two cubic feet (antennas not erected). A dipole and a loop antenna attached to the MOL are needed, arranged so that they may be extended after orbit is achieved.

(2) Ground support will require suitable signal generators (2 to 4), oscilloscopes (2), auxiliary receivers and other miscellaneous radio equipment.

c. Test Procedure

In the first portion of the experiment, the astronaut simply observes and records the signal strength of the ELF through VLF stations that he hears in various parts of the orbit. He tunes across these bands and records in broad detail what he receives. Next, he makes similar observations in the LF through HF range.

He then makes observations designed to determine the impedance and related characteristics of the dipole and loop antennas extended external to the spacecraft. Such information is essential for proper design of antennas for coupling of a receiver or transmitter to the magneto-ionic medium. These observations should be programmed so that antenna impedance in different parts of the orbit may be determined. These measurements will later be related to the Langmuir probe observations of electron density to be made in other experiments and to orientation of the antennas relative to the Earth's magnetic field.

Lastly, data for determination of the propagation characteristics of ELF through HF signals is collected. Observations for determination of the apparent direction of arrival of signals, time of arrival of signals at the spacecraft, etc., are made.

(1) The experiments are so designed that man is an essential part of the program. Inclusion of man in the experiments will allow determinations to be made from observations carried out during one or two orbits which would require much more elaborate instrumentation and much more time if an unmanned vehicle were used.

(2) The astronaut will serve primarily as a technician in conduct of the prescribed experiments.

(3) In brief, the testing sequence will first require that the man simply observe and record signals over all parts of the globe. This will require fairly continuous monitoring of a receiver by an astronaut. The other experiments can be performed perhaps five to ten times during an occasional orbit and will require approximately a total of about 10 minutes for each observation.

d. Category of Experiment

(1) Category (b).

e. Cost (thousands of dollars)

FY 65	FY 66	FY 67	FY 68	FY 69
600	300	300	300	500

f. Schedule

Not now available.

IV. Participating Government Agencies: Sponsor - BUWEPS (NRL).

V. Additional Requirements:

a. Security: No special security.

b. Manning Summary: See attached sheet.

c. Logistics: Unknown

d. Facilities:

Existing facilities can be used; equipment required in spacecraft can be brought from Laboratory to launch site for integration.

e. Simulation and Training

(1) Astronaut: The astronaut is not required to perform difficult scientific tasks and can easily be trained as a technician to carry out the program. A briefing of two days plus four hours of simulated training should be ample. Detailed experimental procedures for the astronaut to follow will be provided by NRL.

(2) Ground Personnel: Ground personnel must be NRL-trained engineers and technicians, intimately familiar with the details of the equipment.

VI. General:

a. Some simple telemetry and recording facilities will be required in the spacecraft. Existing telemetry equipment aboard MOL can be time shared.

MANNING DESCRIPTION

1. ASTRONAUTS

a. Number required: (1)

(1) Man's function: Astronaut will function as a technician conducting test.

b. Crew skill requirements

A briefing of two days and training period of four hours should be sufficient.

c. Manpower profile

Essentially continuous attention of one astronaut will be needed during at least two orbits to determine the ELF through VLF coverage, with similar attention for LF through HF. About 75% of an astronaut's time for two or more orbits will be required to record the essential data in the antenna impedance observations.

d. Critical functions

Observation of signal characteristics (including apparent direction of arrival) and recording of antenna impedance data.

2. GROUND PERSONNEL

a. Number required: 2 engineers and 2 technicians

(1) Function: Mainly technical, conducting tests, observing anomalous data, etc.

b. Crew skill requirements

Ground personnel must be highly trained relative to all aspects of installation, test, and operation of equipment. Laboratory people who have participated in the design and development of the equipment will be assigned.

c. Manpower profile

All ground crew members will be required to be on hand where needed 6 weeks prior to flight, to complete installation and test. The pre-flight number of personnel should drop to one as soon as all installation and check out is completed, but will increase to two before launch.

d. Critical functions

Check out.

No special requirements for other items.

DESIGN CHARACTERISTICS OF EQUIPMENT
(FOR SPACECRAFT)

1. Equipment (to be provided by NRL): Receivers, antennas, impedance determination means.
2. Weight: 60 pounds
3. Volume: One cu. ft. (receiver and impedance determination means) plus one cu. ft. for antennas (unextended). The antenna packages will be attached to MOL and will be extensible by the astronaut.
4. Power required:
   a. 250 milliwatts continuous
   b. 2 watts peak for 60 minutes
5. Spares:
   a. Volume - One cu. ft.
   b. Quantity - 1
   c. Weight - 20 lbs.
6. Tools: No special tools required.
7. Heat Output: Maximum, 2 watts for 60 minutes; 1/4 watt at other times.
8. Stability: No special requirements.
9. Vibration Limits: Vibration tested prior to installation.
10. Shock Limits: Shock tested prior to installation.
11. Hazards: None
12. Temperature Limitations: 10-40°C desired range.
13. Type and Range of Measurement: Radio signals received, apparent direction of arrival, Doppler shift, time delay, antenna impedance from ELF through HF.
14. No special environmental requirements.
15. Orientation and Position Accuracy Requirements: Information on antenna attitude and spacecraft location sufficient to relate measurements in spacecraft to observations on the ground.
16. Equipment Operating Cycle: Receiving equipment will be operated continuously through several orbits to initially define limits of reception. Other measurements can be made at intervals throughout orbit (10 per orbit).

No special requirements for other items.

Title of Experiment: [redacted] BW ltr 00432 of 2/20/64

[redacted]

SUMMARY

Title of Experiment: SPACE STUDIES USING FAR ULTRAVIOLET IMAGE ORTHICON ABOARD A MANNED SATELLITE

I. Test Objective*

Preparation of star maps and tables giving the brightness of stars in the far ultraviolet (1230-1700 Å).

Determination of utility of far ultraviolet orthicon in providing dawn warning.

Determination of utility of far ultraviolet orthicon in making visible subvisual auroras, day auroras and particle dumping zones in the earth's atmosphere.

Determination as to whether air molecular impacts on solid objects moving at orbital velocity produce recordable intensities of far ultraviolet radiation.

Determination as to whether gas leaks and exhausts trails are rendered visible by 1230-1700 Å orthicon device.

II. Importance of the Test

The star mapping program is of astronomical interest in that it provides a measure of the main emissions from early type stars. As such it provides the critical test of radiation transfer theory as applied to hot stars. It is

---

*Objectives are detailed in accompanying documents: "Military Aspect of Far Ultraviolet Orthicon Program and Application to MOL," by T. A. Chubb and "Proposal for Mapping of Night Sky by Means of a Far Ultraviolet Image Orthicon Aboard a Manned Satellite," by G. T. Hicks, T. A. Chubb and H. Friedman.

important in estimating the total energy output of the galaxy. The mapping also is crucial in providing additional knowledge concerning mechanisms of interstellar absorption. Militarily, accurate knowledge of the vastly simpler sky observable in the far ultraviolet combined with the far weaker sun may make possible simpler celestial missile guidance schemes than those currently available.

Tests of the 1230-1700 Å far ultraviolet orthicon as regard its utility in providing dawn warning, particle dumping warning, detection of solid objects moving at satellite speeds, and detection of gas leaks and rocket wakes; these tests all relate to orbital technology and defense of orbiting vehicles.

Studies of subvisual and daytime auroras relate to the mechanisms producing the Van Allen Belt.

The celestial mapping must be done in space because the atmosphere absorbs the radiation of interest. The technological tests must be made in space because the collection of atomic and metastable molecules making up the upper air cannot be duplicated on earth and because of wall deactivation.

The above studies can in principle be done in unmanned satellites. In practice, however, hand tuning and adjustment of the closed circuit orthicon camera chain has been found essential for ground based low light level television. In addition, photographic recording of data is required, hence recovery is required.

The usefulness of far ultraviolet imaging devices in space work cannot properly be assessed without the above types of test. The view of a far ultraviolet orthicon is completely different from the view of the human eye. Distant vision with far ultraviolet imaging devices has never before really been practical.

III. Description of the Experiment

The proposed experiment consists of mounting in a manned spacecraft a television camera chain consisting of the following components:

A far ultraviolet sensitive orthicon and camera electronics mounted at the focus of a reflection - optics wide-angle Schwartzchild Camera.

Camera control and monitor package modeled after the Navy BX-7 closed circuit television system.

A synchronized movie or multiple exposure camera unit operating at low frame speed to photograph the television monitor screen, as used in the NRL meteor astronomy program.

The tests consist of the procurement of a set of photographs of the television raster screen made at a set of prechosen view direction orientations and under varying day-night conditions. Provision should also be made to permit placing of surfaces in the free air stream so that they may be viewed by the orthicon detector.

a. Configuration of Test Items

The far ultraviolet orthicon and optical system consist of a single unit and must be mounted so that it can look outside the MOL. Communication to the inside of the spaceraft can be by a hermetic sealed wiring header. The viewing port should be six inches in diameter or greater. The camera control and monitor package consists of a separate electronic chassis containing a small cathode ray viewing screen. This unit must be mounted inside the MOL. The synchronized movie or multiple frame camera unit is used for photographing the television raster for recording of data. The camera can be a conventional electrically operated movie camera if desired, or single frames of the television raster may be individually photographed on a simple multiple exposure camera.

Estimated weight, power and volume for the electronics of the orthicon system are:

30 pounds; 70 watts at 24 volt d.c. during operation; and 1 cubic foot.

The total system is packageable in a voume of three cubic feet, with a total weight of about 40 pounds and power as indicated above.

c. Test Procedure

(1) What is man's role with relation to the experiment?

The astronaut adjusts the orientation of the spacecraft in accordance with a pre-chosen orientation schedule and he who also serves as a television operator. He adjusts the camera controls for best television image and the monitor for proper framing, brightness and focus. It is recommended that the astronaut be given four to six weeks experience in operating a ground-based closed-circuit television system of the same type as the flight unit (except for spectral range of the orthicon tube).

e. Cost

	FY 65	FY 66	FY 67	FY 68
(1) Engineering & Development	430 K	355 K	100 K	100 K
(2) Installation (Spacecraft Costs)	....	300 K	300 K	300 K
(3) Ground Support	90 K	160 K	75 K	75 K
TOTAL	520 K	815 K	475 K	475 K

The above costs were conceived as applying toward two flights, one in Fiscal Year 1967 and one in Fiscal Year 1968.

IV. Participating Government Agencies

Sponsor: The U. S. Navy under technical direction of Herbert Friedman, Talbot A. Chubb, Grady T. Hicks, and Edward T. Byram, of the U. S. Naval Research Laboratory.

PROPOSAL

for

Mapping of Night Sky By Means of a
Far Ultraviolet Image Orthicon Aboard a Manned Satellite

Prepared by

G. T. Hicks
Project Scientist
Meteor Astronomy Section

T. A. Chubb
Head, Upper Air Physics Branch

H. Friedman
E. O. Hulburt Center for Space Research

U. S. Naval Research Laboratory
Washington, D. C. 20390

10 October 1963

Proposal for

Mapping of Night Sky By Means of a

Far Ultraviolet Image Orthicon Aboard a Manned Satellite

by the

E. O. Hulburt Center for Space Research

U. S. Naval Research Laboratory

Washington, D. C. 20390

I. INTRODUCTION

The development of rockets and of orbiting vehicles has permitted a major extension of astronomical research into spectral regions inaccessible from the surface of the earth. The space astronomy studies thus far accomplished have been concerned mainly with the ultraviolet emission of early type stars and the present proposal continues this line of study.

Past experiments in far ultraviolet astronomy have been made from Aerobee rockets equipped either with simple reflecting telescopes and narrow band photometers or objective grating spectrographs. Although considerable information has been obtained from the rocket flights, it has been limited to only the brighter ultraviolet stars. Moreover, the information has been sketchy; major portions of the sky have not been surveyed and major gaps in knowledge exist in those portions of the sky that have been explored. The rocket techniques encounter severe problems in identifying individual stellar sources in the Vela, Puppis, Carina region of the Southern Milky Way, because of the high density of relatively bright (less than 6th magnitude) early type stars. Finally, the exploratory character of the early rocket work makes it most desirable that conclusions reached in these early studies be checked by other experimental techniques.

II. SCIENTIFIC OBJECTIVE

The scientific objective of the proposed experiment is to map the celestial sphere in the far ultraviolet region of the spectrum from about 1230-1700 Å, so as to provide relative photometric intensities for the early type stars. The achievement of system sensitivities several orders of magnitude greater than those used in the present rocket photometer scan studies will be sought.

It is not possible to predict all the scientific results which might develop out of a far ultraviolet orthicon mapping program, but some possibilities are listed below:

1. Improved spectral classification of early type stars: It is presently known that visible photometry

and MK spectral classification can be used empirically to predict stellar brightness in the far ultraviolet. The observed far ultraviolet brightnesses, however, scatter about the empirically predicted values by about one stellar magnitude, suggesting that present methods of stellar classification may be inadequate.

2. Tests of stellar model calculations for early type stars: The orthicon mapping program may not provide an immediate direct test of model theory, since only relative far ultraviolet stellar brightness measurements are likely to result from early orthicon requirements. If, however, the orthicon photometric scale is calibrated by rocket flights, giving data on a few stars, the results can then be converted to absolute flux readings. Even without rocket calibration, the mapping program should provide some check on stellar model theory, since it will provide photometric comparison between early A stars and the B and O stars.

3. Measurement of interstellar absorption: If the expected increase in sensitivity over rocket photometer mapping techniques is achieved with the orthicon unit, stars sufficiently distant should be seen so that the flux arriving at the earth will have been affected by interstellar absorption. Brightness comparisons between

near and far stars will then measure interstellar absorption and a comparison between light absorption in the far ultraviolet and in the visible should then be possible. Such absorption data should lead to a better understanding of the size distribution and character of matter in space and of the resulting absorption process.

4. Far ultraviolet emission from extragalactic nebulae: If the expected orthicon sensitivity can be obtained, it appears that far ultraviolet emission from the Andromeda nebula may be detectable. Such a measurement, combined with presently available visible and near ultraviolet data should give a realistic measure of the relative importance of far ultraviolet radiation in galactic energy release.

5. Emission nebulosities in the far ultraviolet: At present there is no good measure of the far ultraviolet brightness of emission nebulosities. If the far ultraviolet emission from such nebulosities is at all comparable with energy release in the visible, it should be measurable with the orthicon system.

6. Far ultraviolet images of moon and planets: The far ultraviolet image orthicon system sensitivity should be adequate to detect the full moon as a source, and thereby to measure the albedo of the moon. Such a measurement may

be interpretable in terms of Lunar surface characteristics. The optics planned for initial studies would most likely be designed for too wide an image angle to provide for study of detailed features on the Lunar surface, although future studies could be directed toward this goal. Detection of Jupiter may also be possible, most likely because of the high albedo expected in the far ultraviolet caused by Rahleigh scattering in its extensive H_2 atmosphere.

III. ORTHICON IMAGING VS. DIRECT PHOTOGRAPHY FOR FAR ULTRAVIOLET MAPPING FROM MANNED SATELLITES

This choice of orthicon televsion techniques as the means of carrying out the far ultraviolet mapping program, as opposed to direct photographic mapping, is based on two factors. First, we do not know how to do the work by direct photography. Secondly, the use of image orthicons permits the work to be done faster and requires less perfect vehicle stabilization than direct photography. This second factor is a result of the greater optical speed (higher sensitivity) of the orthicon detector as compared with film.

The use of direct photography for mapping the night sky below 1700 Å is difficult because there exists no satisfactory optical filter material which will block the visible and near ultraviolet and at the same time transmit any radiation in the far ultraviolet. No photographic film is available which is sensitive to radiation below 1700 Å and not sensitime to radiation in the near ultraviolet and visible regions of the spectrum. Because of these two factors, film and filter cannot provide imaging sensitivity confined to the 1230-1700 Å or similar spectral band. In contrast image orthicon units can be built with CsI photosurfaces which are quite sensitive below 1700 Å while being dead to near ultraviolet and visible radiation.

The great sensitivity achievable with image orthicon detectors has been demonstrated many times. For example, image orthicon systems are capable of recording meteor trails too weak to record on visible film. With very modest optics, image orthicon systems have been very effective in picking up the ANNA satellite even when its light flashes were operating at very reduced intensity. At Organ Pass, New Mexico, orthicons have provided good images of extragalactic nebulae with about 16 seconds integration time.

IV. PROPOSED EXPERIMENT

The proposed experiment consists of mounting in a manned spacecraft a television camera chain consisting of the following components:

1. A far ultraviolet sensitive orthicon and camera electronics mounted at the foxus of a reflection - optics wide-angle Schwartzchild Camera.

2. Camera control and monitor package modeled after the Navy BX-7 closed circuit television system.

3. A synchronized movie camera unit operating at low frame speed to photograph the television monitor screen, as used in the NRL meteor astronomy program.

4. An astronaut who adjusts the orientation of the spacecraft in accordance with a pre-chosen orientation schedule and who also serves as a television operator; who adjusts the camera controls for best television image and the monitor for proper framing, brightness and focus. It is recommended that the astronaut be given four to six weeks experience in operating a ground-based closed-circuit television system of the same type as the flight unit (except for spectral range of the orthicon tube).

V. ESTIMATED WEIGHT AND POWER

Estimated weight, power and volume for the electronics of the orthicon system are:

30 lbs; 70 watts at 24 volt d.c. during operation; and, 1 cubic foot.

The total system is packageable in a volume of three cubic feet, with a total weight of about 40 lbs and power as indicated above.

MILITARY ASPECT
OF FAR ULTRAVIOLET ORTHICON PROGRAM
AND APPLICATION TO MOL

By

Talbot A. Chubb

12 February 1964

U. S. Naval Research Laboratory
Washington, D. C. 20390

MILITARY ASPECT OF FAR ULTRAVIOLET ORTHICON PROGRAM AND APPLICATION TO MOL

CONTENTS

OR
015

MILITARY ASPECTS OF FAR ULTRAVIOLET ORTHICON PROGRAM AND APPLICATION TO MOL

I INTRODUCTION

The Far Ultraviolet Orthicon Program was originally conseived mainly as a program for mapping the heavens in a radiation band 1230-1700 Å. As a stellar mapping device the system was proposed for inclusion in the Gemini program. Use of such a system promises to extend enormously our knowledge of the emission character of early type stars and also of the laws governing interstellar absorption. It also provides a unique means of detecting unusual and unexpected astronomical objects and of mapping emission nebulosities in the far ultraviolet. It is not beyond possibility that Doppler shifted Lyman α radiation might be detectable from distant receding galaxies.

Although the initial applications envisaged for the far ultraviolet orthicon program were more or less classical astronomical applications, it is also apparent that there may also exist important military and space technological applications. Probably the most important of such applications cannot truly be recognized prior to preliminary orbital explorations. Nevertheless, it seems worthwhile to document some of the possibilities, so that they may be properly explored should this program be adapted as part of the MOL effort.

II PROPERTIES OF FAR ULTRAVIOLET RADIATION

An examination of the military potentials of far ultraviolet orthicon technology must start off with an understanding of the properties of far ultraviolet radiation. In the body of this report we will confine our considerations to the spectral band 1050-1700 Å, namely that region where optically transparent materials are available and in which sensitivity is provided by Cs I photosurfaces. The important region 1700-3000 Å (Cs_2 Te photosurface region) is not considered, although it may have important application to early detection of high altitude missiles after their partial penetration of the ozone barrier below 150,000 feet.

Far ultraviolet radiation (1050-1700 Å) has several important characteristics. First, it is strongly absorbed by molecular oxygen. This means visibility toward the earth does not extend below 80 km. This means that it cannot be used for earth reconnaissance. It also means that when applied to space surveillance, it is never interfered with by lights or happenings on earth. Space at orbital altitude is quite transparent. Secondly, it is basically a high energy radiation, requiring energies of more than seven electron volts for its production. As a result, it is apparently not produced by the normal chemical reactions occurring in the upper air which produce the night air-glow. It is produced by the sun, early type stars, electrical discharges, particle impacts such as occur in the aurora. It is produced in shock waves (particle-object impacts at these pressures) strong enough to cause ionization, and undoubtedly, therefore, is produced by meteors. A very few specific wavelengths of far ultraviolet radiation are resonantly scattered by atoms in the high atmosphere. The third important character of the near earth space environment relating to far ultraviolet is the character of the naturally occurring emitting sources. The set of stars emitting far ultraviolet radiation are far fewer and differently clustered than in the visible. They are much more strongly concentrated near the Milky Way. The sun is far weaker in the far ultraviolet, and its strongest emission, the Lyman α line at 1216 Å, is strongly scattered to the dark side of the earth. The result is that the difference between day-night illumination level in the far ultraviolet (if one does not filter out 1216 Å radiation and if one excludes wavelengths longer than 1400 Å) is only 600:1, in contrast to differences of the order of 10^8:1 in the visible.

The applications of far ultraviolet orthicon technology will depend significantly on whether the systems are designed to accept or reject Lyman α radiation. This difference is the result of the "night Lyman α glow." The entire earth is bathed in a diffuse monochromatic light at 1216 Å, at an illumination level of 0.01 erg/cm^2/sec. This single wavelength intensity is so strong that it equals about five times the total intensity of all visible starlight, and is 1/600th as intense as the illumination of sunlight in a 200 Å band centered at Lyman α. The diffuse glow is present day and night. At orbital altitude at night glow is seen below the satellite as well as above; the intensity looking down being 40% that looking up. The change in brightness occurs in a narrow band at the horizon. The same situation probably applies during the day.

The far ultraviolet orthicon system proposed for Gemini excludes the Lyman α glow. At midnight such a system would see no airglow except that excited by auroral or other high energy particles or by electrical discharge or shock wave. As one leaves sunset or approaches dawn, however, such a system sees sunlit illuminated air. At altitudes as low as 200 km, the sunlit horizon is visible with the sun depressed 22 degrees below the horizontal. Thus, far ultraviolet radiation provides the earliest warning of the approaching blinding onset of sunlight.

III POSSIBLE APPLICATIONS OF FAR ULTRAVIOLET ORTHICON TECHNOLOGY TO FURTHERING THE MOL MISSION

Let us now consider how far ultraviolet orthicon technology may be applied to furthering the MOL Mission. In discussing these points we will indicate any differences between the system proposed for Gemini and that needed to accomplish a given objective. Where not obvious we will indicate why use of far ultraviolet techniques may have advantages over visible light techniques. Where the application is speculative we will so indicate.

1) Horizon Location: A LiF window orthicon must be used. The advantage of a far ultraviolet system over a visible or infrared system is that in far ultraviolet the same order of magnitude of light level is encountered day and night, provided the sun is not directly viewed. The far ultraviolet horizon may not be as sharp as in IR, but the transition altitude is higher and not influenced by clouds. The system could provide an astronaut with clear up-down reference.

2) Dawn Warning: Horizon view in the far ultraviolet provides an early dawn warning permitting shutting down of damageable sensitive visible systems prior to encountering dangerous light levels.

3) Detection of Dangerous Particle Zones Prior to Entry: This useage is based on the emission of far ultraviolet radiation by air during particle bombardment. It may not be important during a peacetime low latitude mission. Auroral activity over Canada has been clearly seen in far ultraviolet radiation from a rocket flown at Wallops Island, Virginia, at night. It seems probable that selective optical filtration could make such events visible during the day, thereby providing warning prior to entering the danger zone.

It also seems possible that the lower portion of the STARFISH radiation zone would be visible from a distance in the far ultraviolet. Airglow background of visible light would make the visible portion of the spectrum a poor bet for detection of danger zones.

4) Angle of Attack Determination: There seems to be a possibility that far ultraviolet orthicon viewing could be used to measure angle of attack. The method would be based on airglow or surface glow induced by atom impact at orbital velocity. One possible method would involve viewing a disk partially shadowed by a second smaller disk placed in front.

The front disk would then intercept a portion of the atomic beam produced by the satellite motion through the air and the location of the resultant shadow in the atomic beam would show the angle of attack.

This method of angle of attack determination is speculative since it is not clear as to whether the impact zone would be bright enough for viewing. It is also not entirely clear that the optical method is competitive with ion collection schemes, which have been shown to work quite well, although the optical scheme probably has higher potential accuracy.

5) Detection of High Velocity Man-Made Objects by Self-Emission: The possibility of detecting man-made passive objects by self-emission in the far ultraviolet is speculative. Such detection depends on the brightness of far ultraviolet emission produced by particle impacts at satellite velocity, and needs orbital study, since the atomic oxygen upper air is not duplicatable on earth. It is possible that orbital wakes and trails might be visible.

6) [redacted]

[redacted]

7) Application of Far Ultraviolet Orthicon Technology to the Rendez-vous Problem: It is not clear to the author what is presently planned as regards solving the rendez-vous problem. In considering applications of the far ultraviolet orthicon, we will envisage that rendez-vous is effected in the following manner. Consider Craft A actively "rendez-vousing" with Craft B. First, the orbital period of Craft A is matched to Craft B using ground based orbital period data and the judicious application of thrust parallel to zero angle of attack. Second, perigee and apogee altitudes and phases are adjusted by judicious application of thrust parallel to zero angle of attack. Third, the orbital location of Craft A is matched to that of Craft B by judicious application of thrust along local vertical, thereby temporarily changing the orbital period of Craft A.

Craft B should now be visible from Craft A. Fourth, orbital plane is adjusted by judicious application of thrust in a horizontal direction perpendicular to orbital plane. Repetitive adjustments are required. Fifth, physical contact is made by final phase adjustment through reapplication of thrust along a vertical line, contacts being made from above or below.

It seems clear that all the terminal adjustments in rendez-vous should be made on the basis of information available in the spacecraft from optical and radio means. Optical contact would appear particularly valuable. Assuming rendez-vous with a friendly craft, Craft B could easily be equipped with flash lamps that would make it visible at great distances. Since we are considering almost coplanar orbital planes, two such lamps mounted at the ends of rods extended perpendicular to the orbit would permit easy accurate position and direction determination from Craft B, at close distances. At large distances, use of radar techniques or of command triggering of flash lamps could also permit accurate position and direction determination. Radial velocities could be determined by optical or radio Doppler methods, transverse velocities by measuring angular motion rates relative to a coordinate system anchored to the earth's horizon.

We now consider where far ultraviolet optical techniques may have advantages over visible optical techniques. The first advantage lies in the very much lower light levels that are encountered in the far ultraviolet during the day. These low levels should permit daytime viewing of suitable flash lamps by the orthicon system. They should also give an advantage to far ultraviolet Doppler systems over visible Doppler systems for radial velocity measurement. The second advantage is related, namely the greatly reduced optical shock problem in day-night traverses. During final contact phases the relatively uniform illumination by Lyman α glow may permit steady viewing of spacecraft B at quite adequate illumination level. The possibilities of horizon and angle of attack measurement have been mentioned.

8) Detection and Location of Gas Leaks and of Rocket Exhausts: It has been mentioned previously that far ultraviolet orthicon techniques are capable of detecting the sunlit upper portions of the atmosphere prior to detection of visible manifestations of sunlight. This detection is based on the resonance scattering of 1300Å sunlight by atomic oxygen. Similar resonance scattering occurs when other species of molecules or atoms are illuminated by proper radiations of light. In particular molecular oxygen

shows resonance scattering at wavelengths near (just beyond, I believe) the long wavelength edge of the spectral band under consideration. Therefore, if the outside of a leaky spacecraft were viewed in sunlight through suitable optical filters, the leaking gas stream should be luminous. At other wavelengths in the far ultraviolet, leaking gas (air or fuel) streams should appear black by absorption. The contrast should be very much greater than that observed when NO_2 leaks into air at ground level.

Rocket exhausts and outgassing wakes should be similarly visible.

9) Military Application of Far Ultraviolet Stellar Mapping Program: The scientific program of mapping the stars in the far ultraviolet may have significant eventual military application per se. The reason is as follows: The sky in the far ultraviolet is a much simpler sky than in the visible. The sun itself is by far the dominant source, but is relatively vastly less dominant than in the visible. In selected far ultraviolet wavelength bands the sun is of the order of 10^4 times as bright as the brightest star, as compared to 10^{10} in the visible. The far ultraviolet moon is an insignificant object. The two brightest stars are believed to be Zeta Puppis and γ Velorem,

that lie close together in the sky and thereby define a line in space. Most of the other bright ultraviolet stars map out a circle in space, defining the galactic plane. The star Beta Cepheus dominates the northern polar region of the sky. Thus the far ultraviolet sky, even as presently known provides a far different and simpler sky map that may have applicability to simpler automatic stellar navigation systems than those based on visible starlight.

ELECTRONIC SURVEILLANCE EXPERIMENT

A. The problem of Ocean Surveillance requires utilization of all sources of information that will serve to locate and identify ocean traffic. Electromagnetic radiation from a vessel may be used to announce the existence of a vessel, determine its location, and perhaps establish its idenity. This information or any part of it provided to an Astronaut attempting to perform an Ocean Surveillance experiment from the MOL will be of benefit in the assessment of the man's ability and utility in space.

B. Development of The Navy Plan for the Electronic Surveillance Experiment.

1. The Navy technical panel considered three electronic surveillance experiments that were proposed by Navy Laboratories for inclusion in the MOL. A general comment applicable to the experiments as proposed is that they were directed more toward improving capabilities in electronic surveillance than they were toward assessing man's capability of performing a militarily useful function in space. In addition, the proposals did not provide a clean explanation of why the man was required or why the experiment must be performed from space. The functions that a human operator can perform to improve performance of electronic surveillance systems are well known and there is little to be gained by placing a man in space to perform these functions except to measure his ability to perform them in space. This analysis concluded that the experiments as proposed would be of relatively low importance for meeting MOL requirements.

2. However, each of the experiments included techniques and equipment proposals that were determined to be an essential part of the ocean surveillance experiment. The utilization of Elint and Comint practices and equipments will provide the Astronaut with another tool to better determine

his ability to be useful in space. As result, a single experiment proposal was prepared to support and become a part of the integrated ocean surveillan experiment. The experiment objective is as follows:

"This experiment is to establish the feasibility of performing a portio of the ocean surveillance task by effecting identification and location by intercept of electronic emissions from ocean shipping."

3. This test is required to provide complete coverage of the useab frequency spectrum of ocean vehicle emissions for the purpose of ocean surveillance. Only from an orbiting platform can adequate coverage of the oce be obtained. In-as-much as elint alone is a necessary but not sufficient ocea surveillance medium, it requires integration and assimulation of data ~~with~~ all other sources (optics, radar, infra-red scanors) to provide a positive degree of intelligence. The output of the multi-sensor array necessary for effective ocean surveillance can be best obtained and managed by a human performing a selection, sequencing, rejecting, and analysis function. Provision of this additional source of real-time data to the astronaut attempting to manage the v of tasks required for ocean surveillance will, without doubt, contribute to the assessment of man's ability and utility in space. While a great deal of the entire ocean surveillance experiment can and will be simulated it is believed by the panel that only in an actual situation - over the ocean, in orbit - can a true measure be made of man's ability to contribute to solution of this militar requirement. Data rates, sequencing of data types, precise knowledge of signal strengths and density and many other necessary parameters are unknown and, most probably, vary randomly. A research program to establish the above quantities for purposes of simulation of a MOL type experiment would prohibitive in cost and time.

C. Development Schedule:

A detailed development schedule for this experiment is not available and will be generated by planned study efforts. However, the equipments involved, development of which would normally be the pacing item, are largely available and will require only re-packaging, integration into the overall experiment, and re-work necessitated by the resulting interface.

D. Cost Schedule

FUNDING SUMMARY
BUDGET REQUIREMENTS BY FISCAL YEAR

	PRIOR	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
Engineering, Developmental Environmental Testing		70	2460	2060	870		5460
Integration & Installation			280	535	680		1495
Age				455	230		685
Simulators/Trainers			60	610	280		960
Data Reduction					30	340	370
Equipment Rework					130	150	280
Other							
TOTAL		70	2800	3660	2230	490	9250

Thousands of Dollars

E. Recommendations for Further Study

1. A study program to initiate and later support the experiment development is recommended. Immediately, a study is required to: (a) outli the anticipated interface; (b) identify the types of equipment required; (c) prepare a detailed experiment development and cost schedule; (d) provide estimates of weight, volume, power required, heat balance, spare parts and in-flight maintenance and test equipment. Concurrently, it will be necessary to analyze experimental situations to determine in-flight experiment procedure This type study will probably be continued at some level throughout the MOL program. Just prior to initiating equipment development, a simulation program based on a study will be initiated. A part of the simulation study will cover training requirements.

Enclosure 1. Description of Proposed Studies

TITLE: Project ARGUS Contributions to MOL

Description of Experiments:

1. Validation test of group composition findings from Project ARGUS, to determine the reliability of laboratory findings in predicting and controlling social-emotional compatibility among team members through matching personality, temperamental, and other charecteristics of individuals. Although team members will presumably have interacted for some time on the ground and established a satisfactory relationship, the stress of isolation and confinement, separation from other sources of social satisfactions, reduced gravitational fields and other environmental effects may place greater strains on interpersonal relationships, resulting in greater likelihood of communication breakdowns, loss of morale, and loss of interpersonal coordination. It therefore seems important that, within the limitations of available astronauts and MOL vehicles, crew composition be varied or controlled and the resulting social-emotional adjustment monitored and measured. Performance effectiveness of differently-composed teams would then be compared to assess the value of the alternative crew composition procedures.

2. An examination of alternative crew sizes for manned spacecraft. Several laboratory studies have indicated the importance of crew size in the determination of performance. Because of the high cost of each increment of crew size, it is important to determine the gains in effectiveness associated with increased numbers of crew members. Only with this information can rational decisions be made regarding the appropriate design of spacecraft or other small vehicles intended for long durations of manned operations under conditions of reduced contact with society. The range of crew sizes in the MOL program permits comparative studies of crews operating under considerable stress with similar missions. Laboratory findings should be validated in MOL, and perhaps reduced to quantitative terms to permit cost-effectiveness trade-off analyses with regard to other vehicle design considerations.

3. A study of the effects of duration of isolation under conditions of reduced gravity. Further information is needed regarding the build-up of frustrations, the accumulation of strain over time. There is laboratory and anecdotal data indicating that, though men can perform well under stress for short periods of time (3-4 days), prolonged stress has an accumulative effect which can only be compensated up to a point beyond which performance decrement occurs. This question is relevant to the frequency of rotation of MOL crews, and again involves cost-effectiveness trade-offs since each launching for crew rotation will be an expensive event. Laboratory data can provide help in this determination, but only MOL itself can provide conclusive answers. The study would involve alternative lengths of time in orbit, and intensive monitoring of physiological and behavioral data.

4. A study of territoriality and mobility requirements for men in isolation and confinement. The importance of this study lies in its relationship to living space and the design thereof. Current research in Project ARGUS and elsewhere suggests the crucial role of man's need for "personal space" and activity. Intensive study of these problems is desirable prior to the design of MOL, and should be continued in MOL to determine whether conditions of reduced gravity affect spatial or mobility needs. The study envisioned would vary the size and arrangement of crew living space to include provisions for individual privacy, and permit variations in mobility (perhaps including the possibility of excursions outside the capsule). Although much of the basic work could and probably should be done in terrestrial laboratories, verification of laboratory results in MOL would be necessary for optimal design of future manned space vehicles.

5. An evaluative study of psychiatric assessment and screening of personnel for assignment to space vehicles. Utilization of such psychiatric assessment techniques as have been developed in Operation Deepfreeze should be checked for adequacy in MOL. This requires gathering extensive data on personnel prior to their entry into the program, and a very intensive monitoring of psychiatric adjustment in space. Although obviously poor psychiatric risks would be eliminated from the program, there will still undoubtedly be a range of personality and character structures with which to work. Laboratory research prior to MOL is needed to determine the validity of current assessment procedures.

6. A study of the importance of external visual stimulation. The MOL could be designed with or without transparent windows through which crew members could view earth and the stars. It could also include or not include television receivers for visual contact with earth. Since both of these may be important design considerations in future systems, their importance to the emotional adjustment of men should be assessed. The question here is not whether man as a visual observer can make effective use of such contact, but rather, what value has it in providing him with a greater sense of contact with reality, a lesser sense of emotional disturbance, and a lesser disruption of diurnal cycles.

7. A study of the significance of verbal communication to and from earth (or other orbital vehicles). Some potential military applications of manned spacecraft might require crew members to maintain radio silence to prevent detection. However, it is very probable that lack of communication with earth would be very threatening to crew members. The ability to talk and receive feedback might be very important in maintaining emotional stability. The study, then, would compare the performance effectiveness and emotional adjustment of crews under conditions of complete communications black-out, transmitting but not receiving, receiving but not transmitting, and unrestricted communication.

8. A comparative study of the reliability of manned vs. unmanned systems. Man's ability to diagnose and repair malfunctioning equipment offers a trade-off with regard to equipment redundancy or increased reliability engineering which should be critically examined. The all-too-frequent failure of space probes because of equipment failures suggests that a maintenance capability in space might be desirable. This study, then, would assess the increased reliability of mission accomplishments when human maintenance trouble-shooting and repair are utilized. Recording of every instance of equipment failure repaired by men would provide useful information. The study would also compare the reliability of manned vs. unmanned missions, either in different or the same vehicles.

9. A study of space-flight stress. Several unique stresses are involved in space flight which cannot be effectively counteracted without additional information. The gravity reduction is an obvious example, but measures to provide artificial gravity by rotation conflicts with vestibular adjustment mechanisms. Only in MOL does it appear feasible to collect the necessary data to determine the optimal trade-off between performance decrement through gravity loss and performance decrement through vestibular activity. The launch and re-entry stresses also appear to be significant, and data should be gathered to shed light on the emotional as well as physiological problems associated therewith.

10. A study on the management of crises over sustained periods of time would shed light on the extent to which personnel can maintain adequate levels of performance over time. Since it is likely that crises may occur unpredictably and over sustained periods of time, it is critical that some understanding of the ability of astronauts and scientists in MOL to handle such issues be explored. Initial work would have to be of a laboratory nature and probably of non-experimental analyses of reactions to crises in the actual MOL.

11. A study of the process of adapting to space flight conditions. In spite of a high degree of training prior to MOL entry for the first time, it is likely that personnel will go through an adaptation period of a physical, psychological and interpersonal nature. They will have to adjust to the new environment. As they become more experienced in the situation--over repeated missions--it is likely that the adaptation period will speed up. To facilitate this adaptation process, it is important in the early stages of experience that information about the nature of the process and its rate of stabilization be understood. Little by way of actual experimentation in orbit would be conducted in the early stages of such research, but continuous data samples, retrospective reports, and some laboratory experimentation would be conducted. Subsequently, attempts to facilitate adaptation to space flight would be evaluated in the MOL.

12. A study of the emotional impact of isolation. Research findings suggest that consistently effective and appropriately oriented human

performance over time is dependent upon maintaining an immediate environm that (1) is stimulating to an intermediate degree, and (2) provides contin ous psychological linkage of the individual to others. Behavioral research on the effects of isolation in monotonous settings has shown disturbances in activation level, sleeping and dreaming patterns, and attentional and information-processing capabilities, as well as bizarre emotional reactions distortions of reality, and disturbing alterations in self image. A genera concept of psychological isolation further suggests that some of these effects may occur even when an individual has duties to perform while functioning as a member of a group. Since the MOL setting appears to posse uniquely certain features conducive to stress, psychological separation of individuals, and their remoteness from their normal world of reference, the collection of behavioral data on activation level, intellective processes and subjective emotional experiences would be of great scientific benefit. The MOL research would greatly extend and validate the ongoing research prog on isolation.

The research would involve obtaining measures at various times during the mission from each MOL member. Insofar as feasible, physiological measures indicative of arousal level, sleeping and dreaming would be sampled from continuous medical monitoring. Periodically, MOL members would also take brief performance tests designed to detect changes in ability to receiv and process information. By answering questions and making ratings on specially developed tests confidentially and privately, members would provid indication of their emotional and subjective states. Monitoring of physiolo gical measures would require standard and developing techniques of transduce placement whose signals would presumably be telemetered to earth. The intellectual performance and subjective reaction research would require private two-way communication with each member; quite possibly the tests could be pre-recorded and automatically administered from a miniature tape recorder on site, which might also serve to record the man's verbal and/or coded responses. If possible, some means of visual presentation of test stimuli, perhaps on a TV tube, would greatly increase the flexibility and adequacy of the tests. As a baseline against which to compare psychophysiolo gical, performance and subjective data, it would be highly desirable to arrange a ground-based group of control subjects.

13. A study of the effects of monitoring and feedback on performance. Although crews will no doubt be trained to a peak level of individual and team performance efficiency, the variety of novel features in the environment of MOL crews may produce actual or perceived performance decrements. The extent of and the reasons for such decrements may be a cause of concern to crew members. Since all crew members will be subject to the same stresses, the value of others as comparison objects will be reduced. Thus, external evaluations, both objective and subjective in nature, may be important in maintaining individual morale and harmonious crew relations. On the other hand, too frequent external monitoring and evaluation over extended periods may have adverse "big brother" type effects. Thus, laboratory and in-orbit studies of the effects of monitoring and feedback on performance over

extended periods are necessary to determine the optimal rate, schedule, quality, and other characteristics of such monitoring and feedback.

14. Psychopharmacology input into man's cognitive and psychomotor performance under MOL stress conditions. It is certain that operation within the closed MOL ecology for extended periods of time will impose bizarre stresses on the human component of the system. The results of these stresses, in terms of subtle or pronounced alterations in performance of man during the course of the mission, may well constitute the critical element in execution of the overall MOL program. Accordingly, it is proposed that psychopharmacological techniques be assessed for their value in assuring that man's performance is completely under cognitive control during the mission, both with respect to mental acuity in his tasks and his muscular performance of physical work. To achieve this goal, the use of new drugs and organic chemicals on man, in controlled concentrations, is envisaged. These agents group into two types insofar as their sites of action in the body are concerned: (1) the first type is able to penetrate the blood-brain barrier and reach the central nervous system, at which point processes of central excitation or depression can be drug-mediated; (2) the second type is restricted by structure to operate only in the peripheral, effector areas of the body, and can trigger neuromuscular effector systems to deliver any possible desired degree of amplification of muscular contractility in the performance of a physical task.

Now, we specifically propose to enter into a double-barreled pharmacological study of structure-dose-response relationships found in both classes of chemical agents, with attention focused on the ultimate criteria of human performance under the influence of these agents. This work begins on the laboratory scale, to evolve quantitative dose-response relationships, and then must proceed to the MOL testing arena to observe the modifications produced in dose-effect parameters by the peculiar MOL stresses. In the area of drugs which alter behavior by action at the central level, we propose to study: (1) drugs which act as psychic energizers and increase the flow rate for stimuli which emerge to the peripheral neuromuscular systems; (2) drugs such as 4-hydroxybutyric acid which act specifically at the chemoreceptor loci controlling sleep, without otherwise altering metabolism; and (3) drugs which are specifically tailored to negate the impairment of abstract thinking, which might otherwise develop in a confined ecology subject to small-group occupancy. In the area of drugs and chemical agents which act peripherally to alter performance, we propose to study those which can mechanically amplify the degree of muscular contractility, as a close function of dosage ingested via the aerosol route.

This work, on the ground laboratory level, will proceed through performance studies with small animals, thence into larger animals and primates, and finally into man in artificial confinement situations. Then, the extension to man and his performance in the MOL situation will be logical, and imperative.

Test support equipment required

The studies herein described have a common core of equipment requirements. Physiological monitoring and telemetering equipment for detecting EEG, EKG, skin resistance, body temperature, blood pressure, blood chemistry, urine content, weight, activity level and sensory ability changes would be required. It would also be necessary to have behavioral monitoring equipment such as intercom recording or transmitting, intra-capsule television cameras and transmitters, and location-sensing devices and recorders (or transmitters). For subjective emotional reactions and cognitive functioning measurements, perhaps a private charactron console for presenting questions and eliciting answers could be included. Facilities for presenting standard tasks and tests for measurement of abilities and learning curves would also be desirable. AGE for receiving, recording, and reducing all of this data would be essential, including analog-to-digital conversion capability. A considerable amount of digital computer time for analysis would also be required to provide results of tests in a timely manner.

Test procedure:

The exact procedure for each of the studies would vary, but as many tests as possible would be packaged in each mission. Assuming six MOLs and an average rotation cycle of 60 days, 36 crews would be orbitted per year. This large an N would permit variation of several dimensions simultaneously for inter-crew comparisons, while the length of each mission should permit variation of several variables for within-mission, intra-crew comparisons. The test procedure would consist of determining and controlling the composition, size, and duration of each mission by pre-experimental planning. This obviously requires working within the framework of the requirements of other scientific disciplines, but nonetheless should permit a powerful experimental design. Within a mission, tests of visual stimulation, verbal communication conditions, maintenance capabilities, and territoriality restrictions would be programmed. Monitoring of physiological and social-emotional reactions to these experimental manipulations and to space-mission stresses would be required for all flights.

Since these are exclusively life sciences studies, man's role as the object of study is clear. In addition, it may be necessary to include on each crew a man who has been trained at least to take blood samples, urine samples, run analyses of these, operate EEG and EKG equipment, take blood pressures, etc. In small (2-man) vehicles, these would necessarily be supplemental duties for one or both of the astronauts, and should probably be supplemental in all cases, since the amount of time required for these activities should be minimal.

The testing sequence cannot be determined without regard to other MOL activities. However, to the extent possible an experimental design would be utilized to produce the maximum information yield per observation. The interrelated nature of these studies suggests a series of programmed designs that permit each observation to provide information on several experimental variables (as, for example, in a nested or unfolding hypercube).

Some terrestrial laboratory work prior to the orbital laboratory research is needed for methodological development, particularly in the areas of measurement techniques and shake-down of experimental procedures. An engineering systems analysis would be required to determine the design implications for MOL of some of the studies.

Category of experiment:

Most of the studies proposed above fall into Category 'b', contributing to the MOL objectives but without significant implications for the design characteristics of MOL. Studies concerned with size, duration, and territoriality may have significant design implications.

Cost (Budget Requirements by Fiscal Year)

The following budget estimates are offered as very tentative figures, expressed in thousands of dollars.

	Prior	FY65	FY66	FY67	FY68	FY69	Total
1. Engineering and Development	-	75	175	200	75	75	600
2. Installation	-	-	-	100	275	275	650
3. Ground Support	-	125	200	200	200	250	975
TOTAL		200	375	500	550	600	2,225

Participating Government Agency: Naval Medical Research Institute

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco, California 94135

PROJECT PROPOSAL

for the

AIR FORCE SPACE SYSTEMS DIVISION

For Implementation Aboard the Manned Orbital Laboratory (MOL)

Title of Experiment - Heavy Particle Dosimeter

I. Test Objective

To measure the radiation exposure during space flight from the primary cosmic radiation, distinguishing between the proton component and the heavy charged particles. Radiation exposure from the proton component will be measured directly. The flux and charge distribution of the heavy particles will be recorded over select intervals. From this information the total dose contribution from charged particles will be determined.

II. Importance of the Test

It is important to measure the total radiation exposure received in manned space flights. These measurements should be complete enough so that the biological significance of the radiation exposure can be properly evaluated. Because the biological effectiveness of the heavy particles in the cosmic ray environment is different from that of the proton component some means of differentiating between the different particles is necessary. It is generally not appreciated that most integrating dosimeters suitable for dose measurements during space flights (glass, photographic emulsions, thermoluminescent phosphors) measure the heavy charged particles with considerably reduced efficiency over that for high-energy protons and gamma rays. Additional detectors are therefore required to provide a complete description of the cosmic ray background.

The system to be described is intended for use in all manned space missions as well as in those containing biological payloads. This is a passive system that requires recovery. Data interpretation will be made at the Laboratory.

III. Description of the Experiment

The detection system will contain several types of dosimeters together with a series of charged particle detectors. These will include photographic emulsions (dosimeter film), silver phosphate glass and LiF dosimeters. Evaluation of the heavy component will be made with nuclear emulsions and with heavy particle detectors (mica and several plastics) of different sensitivity that will register tracks only if their rate of energy loss is greater than the threshold energy for recognizable damage in the material.

a. Configuration of Test Items

See attachment A.

b. Test Support Equipment Required

No test support equipment will be required. (No attachment B.)

c. Test Procedure

This will be a passive integrating dosimeter system that will require no attention once it has been positioned in the space vehicle or placed on the astronaut (no attachment C). Although the proposed system does not require the utilization of the astronaut's time it does serve the very important function of determining his radiation exposure in a complete and detailed manner. This information could be of great value in determining the adequacy of conventional dosimetric systems for future missions.

d. Category of Experiment

(3) Category c.

e. Cost

See attachment D.

f. Schedule

(1) Hardware and software available for test: Dec 1964.

(2) Hardware and software flight readiness date: Dec 1964.

IV. Participating Government Agencies

Sponsor: Bureau of Ships (Code 364).

Test Equipment Acquisition: U.S. Naval Radiological Defense Lab.

V. Additional Requirements

a. Special Security: None.

b. Manning Description Summary: Not applicable. (No attachment E.)

c. Logistics: It is not understood what information is required over and beyond the funding summary of attachment 4.

d. Facilities: Existing facilities can be utilized.

e. Simulation and Training:

(1) Astronaut: This will be a passive dosimetry requiring no attention during the flight.

(2) Ground Personnel: The only requirement on ground personnel is that they install the dosimeters prior to flight and recover them for delivery to the Laboratory.

(3) Equipment: No additional equipment is required.

VI. General:

a. Communications and Data Handling Requirement. (No attachment F.)

b. Development Characteristics. (See attachment G.)

ATTACHMENT A

DESIGN CHARACTERISTICS TEST EQUIPMENT

1. EQUIPMENT TO BE TESTED: Charged particle dosimetry packet.

2. WEIGHT: 3 lbs or less.

3. VOLUME: Stored $\underline{20\ \text{in.}^3 \text{ or less}}$. In use $\underline{20\ \text{in.}^3 \text{ or less}}$.

4. POWER: None.

5. SPARES: None.

6. TOOLS: None.

7. HEAT OUTPUT: None.

8. - 11.: None.

12. TEMPERATURE LIMITATIONS: min: None.
max: 80°F.

13. - 16.: None.

17. EQUIPMENT LOCATION REQUIREMENTS: Inside vehicle attached to Gemini capsule. Considerations are also given to miniature packets placed in the astronaut's clothing.

18. - 20.: None.

21. MAINTENANCE REQUIREMENTS:

Ground: None.

Space: See 12.

ATTACHMENT D

F U N D I N G   S U M M A R Y

BUDGET REQUIREMENTS BY FISCAL YEAR

	PRIOR	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
Engineering, Developmental Environmental Testing	-	20 K*	20 K*	20 K	20 K	20 K	100 K (40K to be funded by BuShips)
Integration & Installation	-	5 K	5 K	5 K	5 K	5 K	25 K
AGE	-	-	-	-	-	-	
Simulators/Trainers	-	10 K	10 K	-	-	-	20 K
Data Reduction	-	-	10 K*	10 K	10 K	10 K	40 K (10K to be funded by BuShips)
Equipment Rework	-	-	-	-	-	-	
Other	-	-	-	-	-	-	
TOTAL	-	35 K	45 K	35 K	35 K	35 K	225 K

* Source of Funds: BuShips Subproject SR 007 11 01, Task 0549, at USNRDL.

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco, California 94135

PROJECT PROPOSAL

for the

AIR FORCE SPACE SYSTEMS DIVISION

For Implementation Aboard the Manned Orbital Laboratory (MOL)

Title of Experiment - Nuclear Radiation Personnel Monitor for Space Flight

I. Test Objective

To establish requirements and criteria needed in the development of a high performance nuclear radiation personnel monitor for space flight.

II. Importance of Test

High performance radiological hazard monitors will be important to military missions involving manned space flight. During these missions, personnel may be exposed to radiations having a wide range of intensity (mr/hr-kr/hr), and the radiological hazard state within the vehicle must be known continuously. Monitors to perform this function accurately and reliably over a wide intensity range are now being developed.

This development will require in-flight evaluations. Experience in the development of military radiacs has demonstrated the need for tests and evaluations conducted under actual field conditions in order to achieve necessary performance and reliability levels. Although these levels may be reached in large measure through design judgment and laboratory tests (based on operational experience in the field), it is the field evaluation that ultimately relates instrument, operator, and actual use conditions, thus providing a realistic assessment of performance leading to the establishment of instrument requirements and criteria for successive application.

The MOL will provide a means for flight evaluation of a combination dose and dose rate monitor designed for manned space flight. Results of this evaluation will yield data on calibration and man-instrument performance and reliability needed in the design and human engineering of high performance monitors.

III. Description of Experiment

A radiation monitor which continuously indicates dose rate and displays accumulated dose will be installed in the MOL for in-flight evaluation of calibration, performance, and reliability.

a. Configuration of Test Items

The monitor occupies a parallelopiped volume less than 150 cu in. and weighs less than 32 oz. Location in the MOL is not critical but installation near the center of the MOL volume will be desirable. Operation will be continuous. Power required will be less than 250 mw peak and may be from self-contained batteries. Bracket mounting will be used with no special mounting or shielding requirements. (See Atch A.)

b. Test Support Equipment Required

No support equipment will be required in the spacecraft or on the ground. (See Atch B.)

c. Test Procedure.

The evaluation to be performed will be functional. Dose and dose rate displays will be observed and recorded manually on a predetermined schedule. Scheduled calibration and instrument performance checks (through self-contained means) will be performed and results noted. These data will be used in conjunction with other radiation or environmental data recorded and estimated during the flight to assess performance and reliability. This assessment, together with operator experience and reaction in the use of the monitor, will be employed in establishing data requirements and design criteria for monitors in this application and may lead to redesign and subsequent flight evaluations. (See Atch C.)

d. Category of Experiment

Category b. Although the experimental results will not have a significant influence on the design characteristics of the MOL, they will influence design of hazard monitors important to the capabilities of manned military space missions.

e. Cost (Budget Requirements by Fiscal Year)

Engineering and development of the first monitor, pre-flight calibration and testing, and post-flight data analysis will be conducted using funds already available to NRDL under BuShips Subproject SR 007 11 01, Task 0549. Installation of the monitor and integration with the MOL program will require $25,000 of additional funding during FY 1965 and $15,000 during FY 1966. Budget requirements beyond the first flight evaluation are anticipated but not yet defined. (See Atch D.)

f. Schedule

(1) Hardware and software available for test and calibration in 1965.

(2) Flight readiness date: late 1965 or early 1966.

IV. Participating Government Agencies

Sponsor: Bureau of Ships (364)

Test Equipment Acquisition: Current plans under Subproject SR 007 11 01, Task 0549 will satisfy all test equipment requirements with exceptions noted in Sec V.c.(2).

V. Additional Requirements

a. Special Security: None

b. Manning Description Summary:

(1) Astronauts: Astronaut will be part of operator-instrument evaluation (his impressions and reactions important to experiment objectives). He will observe and record monitor displays (meter and register) at regular intervals (not more frequently than once every 6 hours) and will make brief performance checks periodically (approximately 24 hour intervals). These observations and checks can be performed by a single crew member; however, more useful data will be obtained by involving both crew members in the evaluation. It is estimated that less than one minute will be required for each observation and each performance check. Adherence to precise time schedules is not required, and it is planned that this item be included as part of the astronaut's regular operating schedule. (See Atch E.)

c. Logistics:

	CY 64	CY 65	CY 66	TOTAL
(1) Manpower (MY)				
*(a) Hardware	.2	1.3		1.5
(b) Installation		.1	.1	.2
*(c) Operation (calibration, pre-flight tests, data analyses)		.5	.5	1.0

*Provided by BuShips Subproject SR 007 011 01, Task 0549 at USNRDL

(2) Facilities

Existing facilities will be used for calibration and most pre-flight tests. However, portions of the pre-flight tests (environmental) will be conducted in a flight simulator which must be made available.

d. Simulation and Training

(1) Astronaut: Astronaut will not require special skills. Training will be in monitor operation only. Necessary training will be short (several hours) and will not necessitate simulation testing.

(2) Ground Personnel: None.

(3) Equipment: Radiation monitor only.

VI. General

a. Communications and Data Handling Requirement: Data will be recorded manually from a single meter display (analog) and a single register (digital). No on-board data processing will be required. These records (together with operational notes) will be flown down with recovery capsule. There will be no requirement for data or voice communication to ground stations. (See Atch F.)

b. Develcpment Characteristics: At least one flight test is planned. Subsequent test will depend upon results obtained. The monitor design will be based on the current design of the NRDL Dose/Dose-rate Meter (AN/PDR-65) and data on radiation instrument performance in space being developed by the NRDL/BUSHIPS subproject. (See Atch G.)

ATTACHMENT A

DESIGN CHARACTERISTICS TEST EQUIPMENT

1. EQUIPMENT TO BE TESTED: Combination dose and dose rate meter
2. WEIGHT: 2 lb
3. VOLUME: Stored 150 cu in. In use 150 cu in.

   CRITICAL DIMENSIONS - SHAPES: (See Sec. III.a.)
4. POWER: (See Sec. III.a.)
   a. Continuous: 0.15 w
   b. Stand-by: 0.1 w
   c. Average operating: 0.15 w
   d. Peak: 0.25 w
   e. Duty cycle: Continuous
5. SPARES: None
   a. Volume: None
   b. Quantity: None
   c. Weight: None
6. TOOLS: None
   a. Volume None
   b. Quantity: None
   c. Weight: None
   d. Power: None
7. HEAT OUTPUT: 0.15 w

8. STABILITY

a. Moving parts: Meter and electromechanical register

9. VIBRATION LIMITS: MIL-STD-167 (Type I)

10. SHOCK LIMITS: MIL-S-901

11. HAZARDS (fire, explosion, electrical, toxics, other): None

12. TEMPERATURE LIMITATIONS: -40° - $+50^{\circ}C$ operational
-62° - $-75^{\circ}C$ storage

13. TYPE AND RANGE OF MEASUREMENT (definition of parameters to be measured while test is underway): Dose to 200 r and dose rate to 10,000 r/hr (gamma-proton).

14. SPECIAL ENVIRONMENTAL REQUIREMENTS: None

15. ORIENTATION AND POSITION ACCURACY REQUIREMENTS: None (See Sec. III.a.)

Station: None

Equipment: None

16. EQUIPMENT OPERATING CYCLE

Frequency: Continuous

Time Duration: Continuous

17. EQUIPMENT LOCATION REQUIREMENTS: Location inside laboratory not critical (See sec. III.a.)

18. SPECIAL MOUNTING REQUIREMENTS:

Apertures: None

Booms: None

Windows: None

Antennae: None

Bracketry: Simple mounting bracket (See Sec. III.a.)

19. PRESSURE VESSELS: None

20. ELECTRO MAGNETIC INTERFERENCE (spurious generation, special shielding req, etc): None

21. MAINTENANCE REQUIREMENTS:

Ground: None

Space: Calibration and operation checks (See Secs. III.c. and V.b.(1).)

ATTACHMENT B

TEST SUPPORT EQUIPMENT

1. RECORDING MEDIA

   a. Tape: None

   b. Film: None

   c. Other: Manual recording of monitor readings (See Secs. III.c and V.b.(1).)

2. HANDLING (special equipment required to handle items being tested): Non

3. PACKAGING: None

4. CALIBRATION - alignment, deployment: Yes (See Secs. III.c. and V.b.(1))

5. JIGS AND FIXTURES: None

6. NUMBER OF LEADS FROM OUTSIDE TO INSIDE STATION: None

7. SENSORS (TRANSDUCER - OUTPUT SIGNALS): None

8. TRAINERS/SIMULATORS: None

9. INSTRUMENTATION - cockpit and/or laboratory (note effect of time sharing instruments with other experiments); None

10. RELATED SUPPORT EQUIPMENT: None

    a. Targets: None

    b. Ground Stations: None

    c. Tracking: None

    d. Handling Equipment: None

11. AGE: None

12. ENVIRONMENTAL TEST EQUIPMENT: Yes (See Sec. V.c.(2).)

13. FACILITIES: USNRDL with exception noted in Sec V.c.(2).

ATTACHMENT C

TEST OPERATING CHARACTERISTICS

1. ORBITAL PARAMETERS (desired)

    a. Altitude: No requirements

    b. Inclination: No requirements

    c. Epoch: No requirements

    d. Ellipticity: No requirements

2. PLANE CHANGE: None

3. ALTITUDE CHANGE: None

4. TIME ON ORBIT: Days

5. TEST DURATION: Days

6. TOTAL NUMBER OF TESTS: Depends on test duration

7. TEST FREQUENCY: Approximately 4/day

8. INTERVAL BETWEEN TESTS: Approximately 6 hours

9. CREW TASK LOADS - man hours: Approximately 5 minutes/day

10. CREW TASK FREQUENCY: Approximately 4/day

11. FIELD OF VIEW REQUIREMENTS: No requirements

12. GROUND CONTROL LIAISON DURATION: None

13. GROUND CONTROL LIAISON FREQUENCY: None

14. EXTERNAL TEST ITEMS:

    a. Launched from Station: None

    b. Launched from resupply: None

    c. Launched from ground: On MOL

15. QUALIFICATION TESTS (other than space): None

a. Ground: None

b. Atmosphere: None

16. SEQUENCE OF EVENTS AS THEY OCCUR DURING FLIGHT: Read dose and dose rate displayed on monitor and record with time

17. HANDLING PROCEDURES: Select calibration and operation check mode of monitor (switch operation) and correct changes by front panel controls (See Sec. V.b.(1).)

ATTACHMENT G

DEVELOPMENT CHARACTERISTICS

	Standard Dosimeters	Emulsion	Heavy Particle Dosimeter
1. DEVELOPMENT TIME	None	None	9 months
2. FINAL DEFINITIVE TEST DESIGN TIME	6 months	6 months	1 year
3. NUMBER OF TESTS REQUIRED	2	2	2
4. TYPE OF DEVELOPMENT TEST ITEMS	None	None	None
5. SUPPORT EQUIPMENT DEVELOPMENT TIME	None	None	None
6. NUMBER OF TEST ARTICLES REQUIRED FOR:			
a. Ground Test			
b. Balloon Flights			
c. Space Test			
7. DATA AVAILABLE FOR TESTS	1965	1965	1965
8. CURRENT DEVELOPMENT STATUS			
a. Proposed only	no	no	yes
b. Test item under study	yes	yes	no
c. Funds expended to date	none	5 K	none

ATTACHMENT D

F U N D I N G   S U M M A R Y

BUDGET REQUIREMENTS BY FISCAL YEAR

	PRIOR	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
*Engineering, Developmental Environmental Testing	---	$45K	---	---	---	---	$45K
Integration & Installation	---	20K	$10K	---	---	---	30K
AGE	---	---	---	---	---	---	---
Simulators/Trainers	---	5K	5K	---	---	---	10K
*Data Reduction	---	---	10K	---	---	---	10K
*Equipment Rework	---	10K	---	---	---	---	10K
Other	---	---	---	---	---	---	---
TOTAL		$80K	$25K				$105K

*Source of Funds: BuShips Subproject SR 007 11 01, Task 0549, at USNRDL

233

ATTACHMENT E

MANNING DESCRIPTION

1. ASTRONAUTS

   a. Number required: 1

      (1) Man's function

         (a) As part of test: Yes (See Sec. V.b.(1).)

         (b) As technician conducting test: Yes (See Sec. V.b.(1).)

   b. Crew Skill Requirements: See Secs. V.b.(1) and V.d.(1).

   c. Manpower Profile: See Secs. V.b.(1) and V.d.(1).

   d. Critical Functions: See Secs. V.b.(1) and V.d.(1).

   e. Work Positions: In MOL

   f. Time Controlled Tasks: Yes (See Sec. V.b.(1).)

   g. Human Performance Measurements: Yes (See Sec. V.b.(1).)

   h. Physiological and Psychological Measures: None

   i. Selection Factors: See Sec. V.d.(1).

   j. Training Requirements: See Sec. V.d.(1).

2. GROUND PERSONNEL: None

   a. Number Required

      (1) Man's function

         (a) As part of test

         (b) As technician conducting test

   b. Crew Skill Requirements

   c. Manpower Profile

2. GROUND PERSONNEL (Contd)

d. Critical Functions

e. Work Positions

f. Time Controlled Tasks

g. Human Performance Measures

h. Physiological and Psychological Measures

i. Selection Factors

j. Training Requirements

ATTACHMENT F

COMMUNICATIONS AND DATA HANDLING

1. DATA HANDLING: ON-BOARD

   a. Functions to be measured (Categories of data, i.e., sensor data)

      (1) Data rate/frequency response: Approximately 4 readings/day
      Volume of Data: 2 data points/reading
      Accuracy required: See Sec. V.b.(1).

      (2) Form of data - analog/digital - output of transducer: Meter and register reading

      (3) On-board processing - human judgment - computer - data reduction: record data only

      (4) Communication requirements (to ground) - analog/digital - raw/processed - permissible delays: None

   b. Requirements for Processing and Analysis

      (1) Data reduction - data editing - data compression: No

      (2) Computation: No

      (3) Evaluation: No

      (4) Pictorial analysis: No

      (5) Real-time monitoring: Yes

      (6) Displays: Yes

   c. Permanent Data Records (for fly-down with recovery capsule)

      (1) Photographic (or other pictorial records): Yes, data log

      (2) Magnetic tape recording - analog/digital: No

2. COMMUNICATION REQUIREMENTS

   a. Data Transmission to ground: No

   b. Two-way communication data feedback from ground: No

(1) Data processing on ground

(2) Allowable delays

(3) Ground transmission (one center to another)

(4) Accuracies

(5) Data Recording

(6) Security - Crypto

ATTACHMENT G

DEVELOPMENT CHARACTERISTICS

1. DEVELOPMENT TIME: Approximately 4 months

2. FINAL DEFINITIVE TEST DESIGN TIME: Approximately 4 months

3. NUMBER OF GROUND OR FLIGHT TESTS REQUIRED: One (See Sec. VI.b.)

4. TYPE OF DEVELOPMENT TEST ITEMS

   a. Vacuum Chamber: Yes

   b. Shaker: Yes

   c. Thermal: Yes

   d. Acoustic: No

   e. Simulators: Yes

   f. Aircraft: No

5. SUPPORT EQUIPMENT DEVELOPMENT TIME: None

6. NUMBER OF TEST ARTICLES REQUIRED FOR:

   a. Ground Test: One

   b. Atmospheric Test: None

   c. Space Test: One

7. DATE AVAILABLE FOR TESTS: Approximately June 1965

8. CURRENT DEVELOPMENT STATUS

   a. Proposed only: Yes

   b. Project or program is approved and test item is under study, breadboard stage, etc.: No

   c. Funds expended to date: None

Title of Experiment: Orbital Plasmas Characteristics

I. Test Objective: The experiment would determine the size and characteristics of plasmas which attend orbital vehicles. The results will aid in development of improved radio detection devices for orbiting, suborbiting and space probe vehicles.

II. Importance of Test: The experiment is required to develop methods of detecting orbiting, suborbiting and space probe vehicles. The experiment must be conducted in space since such plasmas exist only in space. They must be studied in MOL since no other method of obtaining the required detailed knowledge is known to exist. Knowledge is required to assess man's ability and utility in space, as well as to obtain information essential to the understanding and design of electromagnetic transmitters and receivers.

III. Description of the Experiment:

(1) The first part of the experiment consists of irradiating the plasma with beamed rf energy from a steerable antenna on MOL and observing the scattered radiation at ground stations. The direction and frequency of the beams are to be controlled from MOL, successive measurements to be based on results of previous measurements.

a. Configuration of Test Items

Key characteristics on MOL are steerable external antennas and tuneable rf energy sources, 200 lbs., 5 cu. ft.

b. Test Support Equipment Required

(1) Spacecraft - Scatter receiver, 50 lbs., 2 cu. ft.

(2) AGE - Existing receiver sites

c. Test Procedure

(1) Necessary to select antenna directions and frequencies, to be selected by astronaut as experiment proceeds.

(2) The astronaut will steer antennas and change frequencies to optimize scattering, thus determining spatial and electrical characteristics of the plasma.

(3) Try various antenna directions and frequencies to obtain scatter magnitude as function of variables.

(2) The second part of the experiment consists of exciting the plasma to resonance, the exciting frequency, the coupler loading and the radiation pattern providing the required plasma characteristics.

a. Configuration of Test Items

Characteristics on MOL are extendable antennas for coupling to plasma and tuneable rf energy sources, 400 lbs., 5 cu. ft. Antennas of considerable length are expected to be required for the desired excitation. Lengths of the order of miles to tens of miles are envisioned for the early experiments. Later experiments may use much longer antennas.

b. Test Support Equipment Required

(1) Spacecraft - Antenna impedance measurement equipment.

(2) AGE - Existing receiver sites

c. Test Procedure

Adjust antenna length and direction. For each case tune couplers for maximum loading.

(1) Man's role - Select antenna adjustment, exciting frequency and adjust loading to optimize plasma excitation.

(2) Success of experiment depends on his ability to observe results, then make successive studies to optimize excitation for various altitudes and directions.

(3) Continuing adjustment of parameters to determine plasma characteristics.

d. Category of Experiment - b

e. Cost

	FY65	FY66	FY67	FY68	FY69	TOTAL
(1) Engr. & Devel.	50K	100K	25K	25K	25K	225K
(2) Installation		50K	50K	50K	50K	200K
(3) Ground Support			75K	75K	75K	225K
Total	50K	150K	150K	150K	150K	650K

f. Schedule

(1) Available for test - FY67
(2) Flight readiness date - FY68

IV. Participating Government Agencies: Sponsor - NAVY

Test Equipment Acquisition: Navy and contractor

V. Additional Requirements

a. Special Security - Routine

b. Manning Description Summary - One scientist, 2 hrs/day in MOL; one scientist at each ground station position manned during MOL passage.

c. Logistics:

	CY64	CY65	CY66	TOTAL
(1) Manpower				
(2) Hardware Development				
(3) Installation				
(4) Operation				
(5) Additional Support				
TOTAL				

d. Facilities

Ground Facilities - Existing - need additional receivers and recorders at some bases. No special facilities before flight.

e. Simulation and Training

(1) Technician or scientist with training in use of scatter experiments. Six months to one year training required if not experienced in scatter experiments and equipment.

(2) Ground personnel - similar to above.

(3) Tunable energy generators, steerable antennas, receivers and recorders.

VI. General

a. Communications and Data Handling Requirement

Communication link to ground stations required to coordinate frequency tuning and antenna steering. MOL data relayed to ground for analysis.

b. Development Characteristics

Proposed only. Uses commercial equipment mainly.

DESIGN CHARACTERISTICS TEST EQUIPMENT

1. EQUIPMENT REQUIRED FOR TEST

   RF energy source, steerable antennas, receiver and recorder

2. WEIGHT: 200 lbs. total

3. VOLUME: Stored 5 cu.ft. In use 5 cu.ft.

4. POWER:

   a. Continuous - None
   b. Stand-by - None
   c. Average operating - 500 w
   d. Peak - 500 w
   e. Duty cycle - 2 hrs/day

5. SPARES:

   a. Volume - 0.5 cu.ft.
   b. Quantity - 1 box
   c. Weight - 20 lbs.

6. TOOLS:

   a. Volume - 0.1 cu.ft.
   b. Quantity - 1 set
   c. Weight - 5 lbs.
   d. Power - None

7. HEAT OUTPUT - 450 w

8. STABILITY - Excellent

9. VIBRATION LIMITS - Normal for electronic equipment

10. SHOCK LIMITS - Normal for electronic equipment

11. HAZARDS - Electrical - negligible

12. TEMPERATURE LIMITATIONS - Normal

13. TYPE AND RANGE OF MEASUREMENT - RF frequency, received energy level, antenna direction

14. SPECIAL ENVIRONMENTAL REQUIREMENTS - None

15. ORIENTATION AND POSITION ACCURACY REQUIREMENTS: 5 degrees, 10%

16. EQUIPMENT OPERATING CYCLE - Ten minutes when over ground stations

17. EQUIPMENT LOCATION REQUIREMENTS - External steerable antennas

18. SPECIAL MOUNTINGS REQUIREMENTS - Antennas, steerable

19. PRESSURE VESSELS - None

20. ELECTROMAGNETIC INTERFERENCE - Needs investigation for possible interference with or from other electronic equipment

21. MAINTENANCE REQUIREMENTS - Negligible.

FUNDING SUMMARY

BUDGET REQUIREMENTS BY FISCAL YEAR

	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
Engineering, Developmental Environmental Testing	50K	100K	25K	0	0	175K
Integration & Installation	0	0	50K	50K	50K	150K
AGE	0	50K	50K	50K	50K	200K
Simulators/Trainers	0	0	0	0	0	0
Data Reduction	0	0	25K	25K	25K	75K
Equipment Rework	0	0	0	25K	25K	50K
Other	0	0	0	0	0	0
TOTAL	50K	150K	150K	150K	150K	650K

I. Test Objective: The purpose of this experiment is to study the plasma environment in the vicinity of MOL. Information obtained here has a direct bearing on the operation of all electromagnetic equipment on MOL having to do with transmission and reception of signals as well as the detectability of MOL by radar.

II. Importance of Test: These experiments are required so that a knowledge of the environment of MOL can be obtained which will provide information to be used in the design of electromagnetic equipment aboard the vessel. Specifically how the plasma sheath around the craft affects the design and operation of antennae (especially V.L.F.), as well as the radar cross-section.

Such experiments can only be carried out in space where the proper plasma conditions exist on a sufficiently large scale. A study of the plasma state near MOL is essential to provide a working knowledge of the conditions of the environment in which man must live and work.

The observations to be determined and recorded in these experiments are related in a great degree to phenomena of extraterrestrial origin. Because of this there is uncertainty in the nature of physical conditions attending planned observations. It is considered that the timeliness of personal observation, initiative and interpretation on the part of the astronaut will contribute significantly to the value and success of the experiments. Since the astronaut in general will be moving at a rate of approximately 300 miles a minute and traversing a changing magneto-ionic medium, it is apparent that the judgment and skill of the astronaut would make a contribution to the experiment that could not be achieved without his help.

The course of future similar and related experiments might be best determined and accomplished by other means only as a result of the flexibility provided by the astronaut in these initial MOL experiments.

III. Description of the Experiment: The detailed experimental program is:

(1) To study the electron energy distribution in the plasma surrounding the MOL.

(2) To determine the electron and ion densities in the plasma.

(3) To relate the above factors to the propagation and reception of electromagnetic waves.

(4) To study the formation and size of the plasma sheath around MOL and determine how this affects (if any) the currents flowing in the MOL as well as in the medium and the ability of the astronauts to leave the MOL.

(5) Correlate the data with radar ground stations and NAVSPASUR to determine the effective radar cross-section of MOL.

a. Configuration of Test Items

Retractable probes will be placed at (5) different equispaced positions from nose to tail of the craft. Each probe will be generally of the Langmuir type and designed so that its direction relative to MOL can be varied (20-160°) and extended to 100 meters from the craft. A multichannel recording electrometer will be required on board the MOL so that simultaneous recordings of the probe currents may be obtained.

b. Test Support Equipment Required

None

c. Test Procedure

When the MOL is in position to allow experiments to be performed, the probes will be extended a given distance and sit at a prescribed angle. Recordings then will be made of probe currents as a function of probe voltage. Such observations will be repeated for different probe lengths at the same angle. After a complete set of observations are made for one probe angle another may be chosen and the experiments repeated. All observations should be done as near to one point in space as possible as the plasma conditions may change as a function of position and time.

(1) Man is essential to a proper functioning of the experiments as a judgment must be made as to when or (or determined by sampling) how much data should be taken.

(2) Experiments will be essentially manual and require the complete attention of one astronaut at a time.

d. Category of Experiment

(1) Category (b).

e. Cost

FY 65	FY 66	FY 67	FY 68	FY 69
100K	200K	300K	150K	50K
200K				1.600M

f. Schedule

Not available as yet.

IV. Participating Government Agencies: Sponsor - NRL

V. Additional Requirements:

a. Security: No special security.

b. Manning Summary: See attached sheet.

MANNING DESCRIPTION

1. ASTRONAUTS

a. Number required: one

(1) Man's function: As technician conducting test.

b. Crew skill requirements

Some briefing will be required to acquaint the astronaut with the objectives of the experiment. A brief training period of an hour should be all that is required to provide sufficient information to the astronaut to operate the equipment.

c. Manpower profile

It is expected that approximately the full time of an astronaut for two complete orbits should be sufficient time to complete the experiments.

d. Training requirements

See (b) above.

2. GROUND PERSONNEL

a. Number required: 2 - 3

(1) Man's function: To set up and test equipment.

b. Crew skill requirements

Crew must have intimate knowledge of equipment.

c. Manpower profile

It is expected that the crew will be required 6 weeks before shot time to finish installation, and do checkout experiments.

d. Training Requirements

Technicians from Laboratory will be sent to install and test apparatus.

ATTACHMENT A

DESIGN CHARACTERISTICS TEST EQUIPMENT

1. Langmuir probe equipment

2. 10 lbs.

3. Vol. 1 cu. ft.

4. Power: 25 watts continuous

5. Spares: None

6. Tools: Usual

7. Heat Output: 25 watts

8. Stability: Normal

9. Vibration Limits: Normal

10. Shock Limits: Normal

11. Hazards: Usual for electronic equipment.

PROPOSAL FOR AIRGLOW HORIZON PHOTOGRAPHY FROM THE MANNED ORBITING LABORATORY

by the

E. O. Hulburt Center for Space Research
U. S. Naval Research Laboratory
Washington, D. C., 20390

1. Test Objective

It is necessary to have a knowledge of the altitudes at which the various night airglow emissions occur in order to interpret the photochemical processes that take place in the upper atmosphere. These emissions have such very low energy that measurements of their altitude distribution made with adequate spectral resolution have hitherto been impossible. The color photographs of the nightglow horizon obtained by Astronaut Cooper aboard the MA-9 Mercury capsule, however, established the feasibility of making spectral nightglow measurements from man-pointed space vehicles.

Nightglow distributions of intensity with altitude will contribute greatly to the aeronomical investigation of the upper atmosphere and a comprehensive group of global measurements will reveal any variations that may be associated with latitude, longitude, or season.

2. Importance of the Test

The proposed measurements of nightglow altitudes are needed to provide for the benefit of prospective space travelers information about the character and variability of the nightglow background over the earth and in as large a wavelength range as practicable, especially in the spectral regions inaccessible from the ground because of atmospheric absorptions. Further, such data are needed to evaluate the feasibility of the scheme to use the nightglow horizons as spatial references for nighttime navigation for man and missiles.

It is only from a man-directed space vehicle such as the Manned Orbiting Laboratory that the high resolution spectrographs required for the task can be pointed at the nightglow horizons for time intervals long enough to give adequate observations. Attempts to do this job from rockets have failed for lack of adequate means for pointing the instruments in the proper direction for long enough periods of time. This experiment is one of those that appears possible only when performed in a manned space vehicle.

3. Description of the Experiment

The airglow horizon as seen from an orbiting spacecraft appears as a thin line some 6 degrees skyward from the earth horizon. It is proposed to use a high speed camera fitted with a grating in front of the lens to form an objective spectrograph. The thin line of the nightglow horizon would serve as the spectrograph slit and as such will be imaged as a spectrum according to the emission lines or bands present. If all the emissions originated at the same altitude this "spectrum" would fall accurately on the dispersion curve of the instrument. Departures of the images from this normal dispersion curve would then be a measure of the relative altitudes of the emission.

The overall dimensions of the spectrograph camera would be approximately 9" × 3" × 4" and the total weight could be kept under 15 pounds. Only an accurate description of space available could permit more accurate specifi-cations. Exposure times of 2 minutes or so would be controlled by a photoelectric exposure meter if space permits. It is contemplated that the astronaut would point the camera out his viewing window while the pilot kept the spacecraft pointed accurately and steadily at the visible nightglow horizon. A quick exchange film cassette would be used for 20 to 30 exposures, or more if schedules and weight permit. About 300 mw of power would be needed only during actual pointing of the camera and operation of the shutter.

Proposal for Cosmic Ray Observations Aboard the

Manned Orbital Laboratory (MOL)

Cosmic Ray Branch, Nucleonics Division
U. S. Naval Research Laboratory

I. Scientific Objectives:

(1) To investigate the composition, flux, and energy spectra of the nucleonic component of the primary cosmic radiation outside of the earth's absorbing atmosphere.

(2) To study the primary γ-ray and electron components of the primary radiation about which little is now known. Directional investigations of γ-rays (i.e., "gamma-ray astronomy") will be pursued, exploiting the assistance of astronauts (cf. below).

(3) It is planned to make the foregoing observations as a function of time, and in particular of the phase in the solar cycle.

(4) While pursuing the main programs above, the physicists will, of course, be searching for rare particles and other novel phenomena that might conceivably appear in the detectors owing to the absence of an air blanket or other overlying absorber.

(5) Some of the contemplated experimental set-ups will permit the study of high-energy particles of solar origin, expecially during solar flares.

II. Importance of the Program:

The cosmic-ray composition well outside the earth's atmosphere is deduced, at present, mainly by extrapolation. Yet it is that composition which is most relevant to problems in space science and astrophysics.

This program of observations on the primary cosmic radiation is desig (a) to advance significantly our knowledge of this important phenomenon in spac and (b) to take advantage of the presence of astronauts in MOL for manual assi ance in experiments that would be extremely difficult without the presence of men. The term program is used advisedly, for the plan contemplates the perform of several closely related experiments which will complement each other and gre enhance the reliability of the measurements made in each.

XII. Description of the Experiment

It is intended to employ several methods of detection: nuclear researc emulsions, several types of counters, and spark chambers.

A schematic tabulation of the experimental program is shown below:

Subject of Experiment	Detection by Counters	Detection by Nuclear Research Emulsions
Primary Cosmic Ray Nuclei (Especially Z ≥ 2) (Solar Particles as well)	Cerenkov Solid State Scintillation	Application of latest techniques and development of new techniques including chemical processing in space
γ-Rays and Electrons γ-ray astronomy	Spark Chambers	

(a) Configuration of apparatus

See Atch A. The requirements for each of the three parts in this program are listed in separate columns on each attachment sheet, where necessary.

(b) Support Equipment Required

See Atch B.

(c) Experimental Procedure

Since our intention is to treat least two different systems for detection, the operation of each will be described separately.

1. Detection with nuclearresearch emulsions would require the astronaut to place a package containing the emulsions outside the MOL on a boom which he would erect. The package would weigh 10-20 lbs.and would remain outside for times ranging up to several days, depending on the experiment. It could be brought up to the MOL by "ferry" and returned the same way, after exposure. Its recovery is essential since nuclear research emulsions must be processed and then examined under a microscope to find the tracks produced by charged particles. Another extremely helpful intervention by astronauts would be the chemical processing of nuclear emulsion aboard the MOL, which would restrict the prohibitive background of tracks that now makes it almost impossible to detect primary electrons or gamma rays with this useful detector.

2. Detection with counters and spark chambers would most likely require these apparatuses to be in place on the MOL when launched and to be placed into operation by the astronaut when a successful orbit has been achieved. Data could be telemetered from counters, but cameras will probably be required to photograph the spark chambers. Various

servicing operations would be required of the astronaut such as changing film in the cameras. Emergency in-flight repairs could also be accomplished by him. See Atch C.

d. Category of Experiment

Category (1). These experiments would contribute directly to MOL program objectives through their need for and critical utilization of the astronaut's services. Among the requirements thereby imposed on the design characteristics of the MOL are the following:

(1) An air lock to permit extension of apparatus on a boom outside of the vehicle.

(2) Provision of a "dark-room" or dark-chamber space of about 1 cubic foot for chemical processing of nuclear research emulsions. This requirement - while highly desirable - may be considered marginal.

e. Cost

See Atch D.

f. Schedule

(1) Facilities now in existence at NRL or under development could provide hardware and software for this program.

(2) Same as (1).

IV. Participating Government Agencies

Sponsor: Office of Naval Research.

Scientific Equipment Acquisition: U.S. Naval Research Laboratory.

V. Additional Requirements

a. Special Security

Strict environmental control on ground before launching apparatus either on MOL or on "ferry",

b. Manning Description Summary

See Atch E.

c. It is not clear to us what information is sought here. We shall try to find out, and then supply the required data.

d. Facilities

Existing facilities will be used for construction and pre-flight testing of equipment.

e. Simulation and Training

(1) Astronaut:

(a) Emulsion experiments: Astronaut would, on occasion, follow prescribed mechanical and chemical procedures at the level of a technician. Approximately 40 hours of training would be required.

(b) Electronic experiments: Astronaut would, on occasion, follow prescribed mechanical and electronic check-out procedures. Some detailed knowledge of the apparatus and its workings would be required at the level of an electronic engineer. Approximately 100 hours of training would be required.

e. continued ...

(2) Ground Personnel

(a) Emulsion experiments: No training requirements.

(b) Electronic experiments: Personnel trained to handle communication-receiving equipment. Approximately 40 hours of technician-level training would be required.

(3) Equipment

No additional equipment requirements.

VI. General

a. Communication and Data Handling Requirement: See Atch F.

b. Development Characteristics: See Atch G.

Additional background information on this proposal and on the Cosmic Ray Branch can be found in the attached preliminary version of this proposal.

M. M. Shapiro

Maurice M. Shapiro
Principal Investigator

ATTACHMENT A

DESIGN CHARACTERISTICS TEST EQUIPMENT

		EMULSION	CHEMICAL PROCESSING	ELECTRONIC Cerenkov Scint.	ELECTRONIC Spark Chambe
1.	EQUIPMENT TO BE TESTED				
2.	WEIGHT	20 lb	30 lb	N.A.*	N.A.
3.	VOLUME:				
	Stored:	1 ft^3	1 ft^3	1 ft^3	1 ft^3
	In Use:	1 ft^3	1 ft^3	2 ft^3	10 ft^3
	CRITICAL DIMENSIONS - SHAPES	N.A.	N.A.	N.A.	
4.	POWER				
	a. Continuous	≈ 0.1 w	N.A.	N.A.	
	b. Stand-by	"	"	"	
	c. Average operating	"	"	"	
	d. Peak	"	"	"	
	e. Duty cycle	continuous	"	"	
5.	SPARES				
	a. Volume	NONE	NONE	N.A.	
	b. Quantity	"	"	"	
	c. Weight	"	"	"	
5.	TOOLS				
	a. Volume	NONE	NONE	N.A.	
	b. Quantity	"	"	"	
	c. Weight	"	"	"	
	d. Power	"	"	"	
.	HEAT OUTPUT	0.1 w	N.A.	N.A.	
.	STABILITY	N.A.	N.A.	"	
	a. Moving parts	"	"	"	
.	VIBRATION LIMITS	"	"	"	

*N.A. = Not Available

		EMULSION	CHEMICAL PROCESSING	ELECTRONIC
10.	SHOCK LOADS	N.A.	N.A.	N.A.
11.	HAZARDS (fire, explosion, electrical, toxics, other)	NONE	NONE	"
12.	TEMPERATURE LIMITATIONS	Min. None Max. 75°F	68°F	"
13.	TYPE AND RANGE OF MEASUREMENT (definition of parameters to be measured while test is underway).	NONE	Temp.	"
14.	SPECIAL ENVIRONMENTAL REQUIREMENTS	Avoid Radioactiv.	Avoid Radioactiv.	Avoid Radioactiv
15.	ORIENTATION AND POSITION ACCURACY REQUIREMENTS:			
	Station	Various	NONE	N.A.
	Equipment	± 30' to ± 5° Depending on exp.	"	"
16.	EQUIPMENT OPERATING CYCLE			
	Frequency	continuous	1-2	continuous
	Time Duration	"	1-2 hrs	"
17.	EQUIPMENT LOCATION REQUIREMENTS	Outside Vehicle	Inside Vehicle	Outside Vehicle
18.	SPECIAL MOUNTING REQUIREMENTS			
	Apertures	1 ft^2	NONE	N.A.
	Booms	10 ft	"	"
	Windows	NONE	"	"
	Antennae	"	"	"
	Bracketry	YES	"	"
19.	PRESSURE VESSELS - fluids, gasses, etc.	NONE	Fluids	"
20.	ELECTRO MAGNETIC INTERFERENCE (spurious generation, special shielding requirements, etc.)	"	NONE	"
21.	MAINTENANCE REQUIREMENTS			
	Ground	See 12	NONE	N.A.
	Space	See 12	See 12	"

ATTACHMENT B

TEST SUPPORT EQUIPMENT

	EMULSION	CHEMICAL PROCESSING	ELECTRONIC
1. RECORDING MEDIA			
a. Tape	NONE	NONE	YES
b. Film	Nuclear Emulsion	"	"
c. Other	NONE	NONE	Telemeter
2. HANDLING (special equipment required to handle items being tested).	"	"	NONE
3. PACKAGING	"	"	"
4. CALIBRATION - alignment, deployment	YES	"	YES
5. JIGS AND FIXTURES	NONE	"	N.A.
6. NUMBER OF LEADS FROM OUTSIDE TO INSIDE STATION	"	"	"
7. SENSORS (TRANSDUCER - OUTPUT SIGNALS)	"	"	"
8. TRAINERS/SIMULATORS	"	"	"
9. INSTRUMENTATION - cockpit and/or laboratory (note effect of time sharing instruments with other experiments).	"	YES	YES
10. RELATED SUPPORT EQUIPMENT			
a. Targets	NONE	NONE	NONE
b. Ground Stations	"	YES	YES
c. Tracking	YES	NONE	"
d. Handling Equipment	"FERRY"	"FERRY"	"FERRY"
11. AGE			
12. ENVIRONMENTAL TEST EQUIPMENT	YES	NONE	YES
13. FACILITIES			

TEST OPERATING CHARACTERISTICS

	EMULSION	CHEMICAL PROCESSING	ELECTRONIC
1. ORBITAL PARAMETERS (desired)			
a. Altitude	100-200 miles	No Requirements	100-200 miles
b. Inclination	Close to Equatorial and Polar	"	Close to Equatorial and Polar
c. Epoch	Over Solar Cycle	"	Over Solar Cycle
d. Ellipticity	Circular	"	Circular
2. PLANE CHANGE	NONE	"	NONE
3. ALTITUDE CHANGE	"	"	"
4. TIME ON ORBIT	DAYS	"	DAYS
5. TEST DURATION	12 hr-48 hr	~ 1-2 hrs	> 12 hrs
6. TOTAL NUMBER OF TESTS	Several	Several	Several
7. TEST FREQUENCY	Continuous	Once/Flight	Continuous
8. INTERVAL BETWEEN TESTS	One/Month	"	One/Flight
9. CREW TASK LOADS - man hours	~ 1 man hr	~ 1 man hr	1 man hr/day
10. CREW TASK FREQUENCY	~ 2 operating intervals/exp.	~ 3-4 operating intervals	~ 2-4 operating intervals/day
11. FIELD OF VIEW REQUIREMENTS	~ 2 π Solid Angle	NONE	~ 2 π Solid Angle
12. GROUND CONTROL LIAISON DURATION	NONE	NONE	Intermittent
13. GROUND CONTROL LIAISON FREQUENCY	"	"	"
14. EXTERNAL TEST ITEMS:			
a. Launched from Station	NO	NO	NO
b. Launched from resupply	"	"	"
c. Launched from ground	Yes, on MOL or "Ferry"	Yes, on MOL	Yes, on MOL
15. QUALIFICATION TESTS (other than space)			
a. Ground			
b. Atmosphere			

	Emulsion	Chemical Processing	Electronics
16. Sequence of events as they occur during flight	(a) Initiating operation (b) Attach to boom (c) Extend boom (d) Exposure internal (e) Retract boom (f) Shut down operation	(a) Install emulsions (b) Developer operation (c) Shut down operation	N.A.
17. Handling Procedures	Included under 16(a) and 16(f) Details N.A.	Included under 16(a) and 16(c) Details N.A.	N.A.

ATTACHMENT D

FUNDING SUMMARY

BUDGET REQUIREMENTS BY FISCAL YEAR*

	PRIOR	FY 65	FY 66	FY 67	FY 68	FY 69	TOTAL
Engineering, Developmental Environmental Testing	—	20K	50K	120K	120K	120K	430K
Integration and Installation	—	5K	10K	20K	20K	20K	75K
AGE	—	—	—	—	—	—	—
Simulation in balloon flights	—	22K	30K	30K	20K	—	102K
Data Reduction	—	—	10K	20K	20K	20K	70K
Equipment Rework	—	—	—	15K	15K	15K	45K
Other; Travel	—	2K	2.5K	2.5K	3.5K	3.5K	14K
TOTAL	—	49K	102.5K	207.5K	198.5K	178.5K	736K
		50K					750

Source of Funds - Hitch Line Number

* These figures must be considered crude (preliminary) estimates.

ATTACHMENT E

MANNING DESCRIPTION

1. ASTRONAUTS

   a. Number required 1

      (1) Man's function

         (a) As part of test .... —

         (b) As technician conducting test...... Yes

   b. Crew skill requirements .... See V(e)

   c. Manpower Profile .... "

   d. Critical Functions .... "

   e. Work Positions .... In/or out of MOL

   f. Time Controlled Tasks .... Yes

   g. Human Performance Measures .... None

   h. Physiological and Psychological Measures .... "

   i. Selection Factors .... See V(e)

   j. Training Requirements .... "

2. GROUND PERSONNEL

   a. Number required::Emulsion Exp. - 1; Chem. Process. - 0; Electronic - 2

      (1) Man's function

         (a) As part of test .... Yes

         (b) As technician conducting test ..... "

   b. Crew Skill Requirements .... See V(e)

   c. Manpower Profile .... "

   d. Critical Functions .... "

   e. Work Positions .... At Voice Comm. Center to advise Astronaut

   f. Time Controlled Tasks .... Yes

   g. Human Performance Measures .... None

   h. Physiological and Psychological Measures .... "

   i. Selection Factors .... See V(e)

ATTACHMENT F

COMMUNICATIONS AND DATA HANDLING

		Electronic Exp. only
1.	DATA RATE	~ 1000/min.
2.	FUNCTIONS TO BE MEASURED	Voltage pulse
3.	TYPE OF ANALYSIS REQUIRED	N. A.
4.	PICTORIAL DATA REQUIRED	Oscilloscope-type photography
5.	REAL TIME MONITORING REQUIREMENTS	Yes
6.	DATA EDITING OR COMPRESSION	Probably compression
7.	READ-OUT TIME	N. A.
8.	REQUIREMENTS FOR PERMANENT DATA RECORDS	Yes
9.	MANUAL AND/OR AUTOMATIC CONTROL	Manual/or Automatic
10.	SIMULTANEITY	———
11.	GROUND COMMANDS REQUIRED	Yes, for in-flight repairs

ATTACHMENT G

DEVELOPMENT CHARACTERISTICS

		Emulsion	Chem. Processing	Electronic
1.	DEVELOPMENT TIME	None	~ 6 mo.	~ 1 yr.
2.	FINAL DEFINITIVE TEST DESIGN TIME	~ 6 mo.	~ 6 mo.	~ 1 yr.
3.	NUMBER OF GROUND OR FLIGHT TESTS REQUIRED	~ 2	~ 2	~ 4
4.	TYPE OF DEVELOPMENT TEST ITEMS			
	a. Vacuum Chamber	Yes	No	Yes
	b. Shaker	"	Yes	"
	c. Thermal	"	No	"
	d. Acoustic	No	"	"
	e. Simulators	"	"	"
	f. Aircraft	"	"	"
5.	SUPPORT EQUIPMENT DEVELOPMENT TIME	None	None	~ 1 yr.
6.	NUMBER OF TEST ARTICLES REQUIRED FOR:			
	a. Ground Test	~ 2	~ 1	~ 4
	b. Atmospheric Test - balloon flights	~ 2	—	~ 4
	c. Space Test	~ 2	~ 1	~ 4
7.	DATE AVAILABLE FOR TESTS	1965	1965	1966
8.	CURRENT DEVELOPMENT STATUS			
	a. Proposed only	No	Yes	Yes
	b. Project or program is approved and test item is under study - breadboard stage, etc.	Yes	No	No
	c. Funds expended to date.	5K	None	None

Preliminary Draft of

Proposal for Cosmic Ray Observations Aboard the
Manned Orbiting Laboratory (MOL)

Cosmic Ray Branch, Nucleonics Division
U. S. Naval Research Laboratory

This is a preliminary proposal for a program of observations on the primary cosmic radiation designed (a) to advance significantly our knowledge of this important phenomenon in space, and (b) to take advantage of the presence of astronauts in MOL for manual assistance in experiments that would be extremely difficult without the presence of men. The time required for assistance by the astronaut will be minimal, but the nature of the help will in some instances be crucial. The term program is used advisedly, for the plan contemplates the performance of several closely related experiments which will complement each other and greatly enhance the reliability of the measurements made in each. It is intended to employ several methods of detection: nuclear research emulsions, several types of counters, and spark chambers.

For 15 years, the Cosmic Ray Branch of the U. S. Naval Research Laboratory has been investigating various phenomena in the cosmic radiation. During the past decade, the emphasis has been on the composition of the primary radiation, together with related questions such as its energy spectra. Particular attention has been devoted to the heavy primary nuclei of the cosmic radiation (whose biological effects on man in space are as yet incompletely evaluated), and vital contributions have been made to our knowledge of this component and of primary helium. During this decade the principal aim has been to elucidate the nature of the primary radiation itself, and its implications for space science and astrophysics. The main tool in these investigations has been the photographic emulsion technique, in which nuclear research emulsions are used as the detectors. In the application of this powerful method to cosmic-ray research, the staff of the Cosmic Ray Branch in the Nucleonics Division of the U. S. Naval Research Laboratory is without question the most experienced group of physicists in the United States. The names of the investigators, together with quantitative data on their experience in this and closely related specialties, are supplied below. A later version of this proposal, which will be submitted several weeks hence, will list the relevant publications of this group and supply vitae on the individual scientists.

Our present knowledge of the heavy nuclear component of the galactic cosmic radiation as well as the fast heavy nuclei from the sun has come mainly from the exposure of emulsion stacks on high-altitude balloon flights and rockets. By using emulsions of various sensitivities and grain sizes, much has been learned about the charge spectrum of particles with $Z \geq 2$, near the top of the earth's atmosphere and above it. Information has also been obtained about their fluxes and energy spectra. These particles have short interaction mean free paths and, therefore, observations at balloon altitudes are made on an admixture of primary particles, plus secondary ones coming from interactions in the residual atmosphere above the balloon. The cosmic-ray composition well outside the earth's atmosphere is deduced, at present, mainly by extrapolation. Yet it is <u>that</u> composition which is most relevant to problems in space science and astrophysics.

clearly the great value of visual methods (photographic emulsion stacks, cloud chambers, bubble chambers, spark chambers) in the exploratory phases of research. The weight required to operate a cloud chamber or bubble chamber is very great compared to that for emulsions, and is also greater than that for spark chambers. One of the distinctive advantages of the emulsion technique in space research is that it permits the collection of a great deal of information per unit weight. Its principal limitation is the requirement of recovery. Accordingly, it is particularly desirable to exploit this method of detection in missions where recovery is essential anyway.

Hitherto, opportunities for exposing nuclear emulsions in outer space have been limited because most vehicles are not recoverable. Also, with the exception of the Goddard Center's experiment, "NERV", these exposures have been "parasitic", and therefore, very little control was available over conditions during exposure. For example, on the Discoverer satellites, exposure of one pound of emulsion is possible only under 2 gm/cm^2 of material, which is no better than a very high balloon flight.

With the advent of large recoverable payloads, such as those in the Gemini program, more suitable exposure conditions for emulsions could be obtained, e.g., it became feasible to expose a reasonably large stack of emulsions (one liter weighing approximately 10 lbs.) with no absorbing material between one surface of the stack and the zenith direction during exposure.

The National Aeronautics and Space Administration has accepted our proposal (and a parallel one by C. Fichtel of the Goddard Space Flight Center), for the exposure of emulsion stacks on Gemini vehicles. We are now actively engaged in the design of the Gemini experiments, scheduled for launch in 1965. The valuable experience gained in these space exposures will, of course, be brought to bear on the experiments now proposed for the MOL.

Scientific Objectives

(1) To investigate the composition, flux, and energy spectra of the nucleonic component of the primary cosmic radiation outside of the earth's absorbing atmosphere. This would be done with stacks of nuclear research emulsion and, in parallel experiments, with arrays of Cerenkov, solid-state, and scintillation counters.

(2) To study the primary γ-ray and electron components of the primary radiation about which little is now known. Directional investigations of γ-rays (i.e., "gamma-ray astronomy") will be pursued, exploiting the assistance of astronauts (cf. below). The main detectors would be spark-chambers; however, the development of new emulsion techniques is being explored with a view to getting gamma ray and electron data by at least two different methods.

(3) It is planned to make the foregoing observations as a function of time, and in particular of the phase in the solar cycle, assuming that participation will be authorized in several flights.

(4) While pursuing the main programs above, the physicists will, of course, be searching for rare particles and other novel phenomena that might conceivably appear in the detectors owing to the absence of an air blanket or other overlying absorber.

(5) Some of the contemplated experimental set-ups will permit the study of high-energy particles of solar origin, especially during solar flares.

A schematic tabulation of the experimental program is shown below:

Subject of Experiment	Detection by Counters	Detection by Nuclear Research Emulsions
Primary Cosmic Ray Nuclei (Especially $Z \geq 2$) (Solar Particles as well)	Cerenkov Solid State Scintillation	Application of latest techniques and development of new techniques including chemical processing in space
γ-Rays and Electrons γ-ray astronomy	Spark Chambers	

In some of the γ-ray and electron experiments it will be particularly valuable to have elongated telescopic arrays of counters. These need not be heavy, but should be extensible in at least one direction. The apparatus can be compact during ascent and descent. Then, thanks to weightlessness and the help of astronauts, it can be appropriately extended during experimental runs (some of them extra-vehicular) without cumbersome automatic equipment.

Another extremely helpful intervention by astronauts would be the chemical processing of nuclear emulsion aboard the MOL, which would restrict the prohibitive background of tracks that now makes it almost impossible to detect primary electrons or gamma rays with this useful detector.

It is also hoped to take advantage of the possibility of returning stacks of emulsion to earth after an exposure of suitable duration (i.e., a sufficiently short exposure to minimize interfering background).

Preliminary estimates of the weight, volume and power requirements for these experiments will be furnished shortly in a supplement to this preliminary draft proposal, together with information as to the type of orbit desired.

The following physicists work in the Cosmic Ray Branch in the Nucleonics Division of the U. S. Naval Research Laboratory:

M. M. Shapiro
(Principal Investigator)
R. G. Glasser
A. J. Herz
B. Hildebrand
F. W. O'Dell
N. Seeman
R. Silberberg
B. Stiller

It is of interest to note that these eight scientists possess an <u>average</u> of 12 years of research experience in cosmic radiation and high-energy physics. Six of them have each had between ten and twenty years of such experience.

M. Shapiro

Maurice M. Shapiro, Principal Investigator

7140-RT:mgw
February 1964

PROPOSAL FOR DIRECT OBSERVATION AND PHOTOGRAPHY OF THE WHITE LIGHT CORONA OF THE SUN AND SURVEILLANCE OF THE SKY CLOSE TO THE SUN

by the

E. O. Hulburt Center for Space Research
U. S. Naval Research Laboratory
Washington, D. C., 20390

1. Test Objective

It is proposed to equip the Manned Orbiting Laboratory (MOL) with a device which would make it possible for an astronaut visually to observe the sun's white light corona and also to record the corona by means of a camera. Briefly, the idea is to erect an occulting disk outside the MOL capsule at as great a distance as practical, and in front of the viewing window through which the astronaut looks at the outside world. To view the corona the astronaut would steer the capsule into a position such that the occulting disk precisely covers the sun and casts a complete shadow on the window. Under these conditions and in the absence of sky light the astronaut should be able to see with his naked eye the corona extending from the sun in much the same fashion that it can be seen during the total phase of a solar eclipse. With a simple camera placed within the shadow of the occulting disk, it should be possible to record the white light corona on photographic film. It would also be possible to detect

23 extremely small objects, or larger but distant objects, lying close to the sun in angle, which would otherwise be completely invisible.

The white light corona consists of two parts. (1) The K-corona, produced by free electrons in the sun's outer atmosphere, showing almost no trace of Fraunhofer lines, and strongly polarized, is the more intense component within one solar radius of the limb. This is the portion associated with the sun's atmosphere and varying with conditions in the sun. (2) The F-corona, due to scattering by dust, containing the Fraunhofer lines, and nearly unpolarized, is more intense than the K-corona far from the limb of the sun. This is the component which merges into the true zodiacal light, which is sometimes seen from the ground shortly after sunset or before sunrise along the ecliptic and produced by material in the plane of the earth's orbit.

From eclipse photographs the K-corona is known to be of the greatest interest. The patterns and shapes presented by it are weird indeed, and are never the same from eclipse to eclipse. Streamers, some extending far from the sun, seem to outline the sun's magnetic field. Tremendous changes take place in the corona from year to year, and from sunspot maximum to minimum. There must also be short-period changes, with solar rotation and with solar activity.

2. Importance of the Test

An important possible application of the direct observation of the corona over a relatively long period of time is the possibility that the expulsion through the solar corona of the clouds of plasma that are known to reach the earth following solar flares can be observed directly. One might expect an astronaut to see a bright localized region develop in the solar corona and travel out through the corona, perhaps following a coronal streamer. The rate of travel away from the sun of such a mass of plasma has been estimated from radial velocities measured above flare surges by the Doppler effect, and from the rate of growth of surge prominences that occur on the limb. The velocities often exceed 500 km/sec. To travel one solar radius from the limb would require 23 minutes at 500 km/sec. It is within the realm of possibility that an astronaut, observing the solar corona continuously over a period of one-half hour, might see such an event taking place in the corona. This could very possibly serve as a means of forecasting the onset of a magnetic storm on the earth, or even serve to forecast the occurrence of a severe proton event such as would be a great hazard to life for an astronaut in space, if sufficient shielding were not provided. An early warning would give the astronaut time to turn his vehicle so that the shielded side would afford him maximum protection.

It is expected, of course, that the corona will be studied automatically by means of orbiting coronagraphs in unmanned satellites. The advantage to equipping a manned spacecraft such as MOL with the means of observing the corona visually is that it should be possible under such conditions for the entire corona to be studied continuously, rather than at intervals of some 15 minutes, and with far greater sensitivity and resolving power than can be done with automatic equipment from a small satellite such as the orbiting solar observatory. Under these conditions, the chance of observing a small mass of plasma travelling out through the corona is much greater than with a small instrument of low resolving power producing intermittent records. The human eye is probably able to detect changes of this sort, with more sensitivity than can be done through inspection of telemetered data.

Another possible application of such observations is the search for comets close to the sun, or possible objects near the sun. These objects cannot be looked for from the ground at night, of course, nor can they be seen from the ground if they lie very close to the sun. Dossin has reported the first detection of such a comet during the total phase of the solar eclipse of July 20, 1963. With the coronagraph arrangement, provided that the occulting disk could be made sufficiently effective, there would be a strong possibility that any such objects could be detected in the field of view.

Another application of the coronagraph might be as a defensive weapon for an astronaut against an enemy astronaut who decided to approach under cover of the bright sun. Without a coronagraph it would be completely impossible for an astronaut to see another object approaching him if the sun were within his field of view.

The coronagraph would make it possible to observe debris coming out of the vehicle with the greatest possible sensitivity. Looking close to the sun, the background would be black, except for the corona. But small objects, illuminated by sunlight, would shine with great brilliance, since scattering at small angles is intense.

3. Description of the Experiment

The coronagraph for MOL would consist simply of an occulter placed as far from the capsule as possible and arranged to eclipse the sun by producing a perfect shadow at the viewing window through which the astronaut observes. Coronagraphs of this sort have not been used on the ground because of their unwieldy nature, since it is necessary to employ a large occulter situated at a very considerable distance from the observer. The effectiveness of a circular occulter with a smooth edge increases in proportion to the distance between the occulter and the observer. The moon lying at a distance of 240,000 miles is the perfect occulting disk, whereas a small occulter situated within a few feet of the observer would be of little use unless it were designed in a very special fashion, such as has been done for the coronagraph for the Orbiting Solar Observatory. The difficulty is in reducing the light diffracted from the edge of the occulter until it is negligible.

The intensity of the light diffracted by the occulter can be calculated qualitatively as follows: The total flux, F, diffracted from the occulter edge is proportional to the circumference of the disk of radius R. The flux per unit area received by the observer is inversely proportional to the square of the distance, D, between the observer and the disk, and directly proportional to the circumference of the disk. Thus the flux per unit area is proportional to R/D^2. Since R/D must remain approximately constant, in order for the occulter to obscure precisely the sun, the flux per unit area is proportional to $1/D$.

The first proposal is to employ an occulter at a great distance from the capsule; the minimum useful distance is believed to be of the order of 100 ft and for this distance, the occulter should be approximately 1 ft in diameter. Greater distances would be far better. A simple occulter might be constructed from an opaque balloon, arranged to be propelled away from the capsule until held by some sort of non-flexible line. The propulsion might be effected by means of a small gas jet and the balloon itself might be held to the capsule by means of a tripod consisting of three small rods tied to the capsule in the neighborhood of the window at a separation of some 6 or more inches. Under these conditions all three rods would lie in the shadow of the balloon when it was pointed at the sun. If the rods were made in the form of small tubes, it might be possible to maintain the gas pressure in the balloon by flowing gas through the tubes, otherwise some vaporizable material could probably be used to maintain a sufficient gas pressure in the balloon to keep it forces out against the three legs forming the tripod. The astronaut, when using the balloon to obscure the sun, would be required to orient the capsule until the balloon cast a perfect shadow on the viewing window. He would then see the corona extending beyond the edge of the balloon against the black sky.

It is entirely possible that a single occulter would not reduce the light diffracted from the edge of the occulter sufficiently to show the corona unless it were situated at a distance much greater than 100 ft. To use a 10-ft diameter balloon at 1000 ft is not an impossibility. A simpler solution, however, might be the use of a double or multiple occulter. A double occulter would consist of a pair of flat disks, the one slightly larger than the other, aligned perfectly with the axis of the tripod. They could be propelled into position by a jet from a gas bottle, and the bottle itself could be used as the mounting structure for the disks.

It is difficult to estimate the weight and volume of such a system. It would appear possible to provide a simple occulter for use at 100 ft for less than 10 pounds weight and a space of well under 1 cu ft. The more complicated type would probably weigh 20 pounds.

A second type occulter could be made in the form of a rigid spar supporting at its end, a metal occulting disk of a complicated nature such as is being flown in the Orbiting Solar Observatory. A reasonable length of spar might be 15 ft with an occulter supported on a short arm from the end of the spar. Gas pressure could be used to erect the spar and some kind of wire could be used to pull it back into the capsule.

With a 15-ft length spar, the occulter diameter would be of the order of 2 inches. It would be necessary to use an occulter, either of the toothed type employed in the Naval Research Laboratory satellite coronagraph, or a multiple disk occulter such as is being used by Newkirk in the coronagraph he is constructing for a stratosphere balloon. The weight of such an occulter would probably be of the order of 20 pounds and the volume when stowed is estimated to be a cylinder 2 ft long and 3 inches in diameter.

The window through which the astronaut would view the corona would of necessity have to be quite clean. This, however, is desirable from many other points of view. The camera for photographing the corona could be hand-held by the astronaut inside the window.

No electrical power would be required for the operation of the coronagraph.

7140-RT:mgw
February 1964

PROPOSAL FOR AIRGLOW SPECTROSCOPY FROM THE MANNED ORBITING LABORATORY SPACECRAFT

by the

E. O. Hulburt Center for Space Research
U. S. Naval Research Laboratory
Washington, D. C., 20390

1. Test Objective

An astronaut in Manned Orbiting Laboratory (MOL) has the unique opportunity of flying a high resolution airglow spectrograph, and recording the ultraviolet spectrum of the night and day airglows on photographic film. Only on such a mission is there available a sufficiently long time to record these faint emissions at high resolution; the ability of the astronaut to point the instrument at the brightest part of the airglow, and then to bring back with him the exposed film is essential for an experiment of this type.

The night airglow in the visible and ultraviolet has been investigated by the Naval Research Laboratory since 1956, using rockets and narrow-band filter photometry. Recently, the Johns Hopkins University and the Kitt Peak National Observatory have studied the day airglow with rocket-borne, scanning spectrometer techniques. Both methods have produced results of great aeronomical value in connection with the photochemical processes occurring in the upper atmosphere when solar radiation is absorbed, and afterward at night, when the excited atoms and molecules tend to return to their ground states. To identify fully the various atomic and molecular species present and the reactions involved, it is necessary however to obtain spectra of far higher resolution than presently available. This is where it is necessary to resort to a manned vehicle such as the MOL with recovery of the photographic film.

2. Importance of the Test

There is a need for the Defense Department to know the complete spectral character of the night and day airglow background over the spectral region 2000 - 3000 Å in addition to the longer wavelength regions accessible from the ground. In this particular region, 2000 - 3000 Å the earth looks black from above because of absorption by the ozone layer. For this reason, there is much interest in airborne devices using this spectral range. The question "what is the ultraviolet background" is frequently asked; only partial answers can be given until the complete spectrum is known.

3. Description of the Experiment

It is proposed to furnish a high-resolving, high light-gathering power grating spectrograph for the MOL. The preliminary design is already available. The dispersion, 20 - 25 Å/mm should be adequate to resolve the molecular band structures anticipated and the 6-inch focal length f/2 camera lens would provide a good exposure for the night sky to be made in two or at most four orbits. Day airglow spectra could be recorded in a few seconds on the other

ED FOR
LY 2015

hand. In order that appropriate exposure times are chosen, a photoelectric integrating system would be incorporated in the spectrograph to signal the astronaut when the proper exposure time had elapsed. In lieu of integration, a precalculated table of exposure times could be used. It is anticipated that the astronaut would need only to point the spectrograph at the airglow horizon by turning the capsule, then push buttons to start exposures and actuate the film transport. Pointing would be done with the aid of some sort of visual sighting device such as a small telescope boresighted with respect to the spectrograph. An accuracy of pointing within $1/4^{\circ}$ would be adequate but if this could not readily be achieved, increased exposure could be traded for less accuracy in pointing.

The spectrograph would be approximately trapezoidal in shape, measuring about 15 inches in altitude, 11 inches at the base, 6 inches across the top with a depth of 4 1/4 inches. The weight will depend largely on vibration specifications needs and can probably be kept to within 25 pounds. It is proposed to mount the spectrograph inside the capsule, looking either forward or aft. The light path through the capsule wall would be a cone of no more than 5° total angle with a quartz or sapphire lens of 1 1/2-inch diameter, both imaging the airglow horizon on the slit and serving also as the window to maintain pressurization. A cap or valve of some sort would probably be required to protect the window from debris during the launch phase and from the heat of re-entry. Electrical power consumption would be about 500 milliwatts only during times of exposure, with pulses used to operate the exposure mechanism and to transport the film.

It is emphasized that, although the equipment described could be reduced in size, weight, and cost at the expense of spectral resolution, only an experiment that yields data of this very high resolution is worthy of consideration for a MOL; less powerful spectrographs can be flown in unmanned, less expensive spacecraft.

GENERAL SCIENCE

A. Statement of Problem

A great number of purely scientific experiments have been proposed for MOL that would contribute both to basic scientific knowledge as well as to a better understanding of conditions in space. These experiments are intended to take advantage of the opening of a new frontier -- namely manned space flight. Their importance lies in their relationship to technical developments and requirements for space flight. In order to understand the problems facing astronauts and what can be accomplished it is necessary to provide a sound basis for scientific hypothesis and factual scientific development.

In response to a request, a large group of Naval organizations contributed a total of forty-five proposals for pure scientific experiments (including geodesy) which are recorded in Appendix II. The problem confronting the MOL technical panel was to categorize these experiments and choose those that may contribute to a program which could yield scientific knowledge of value.

B. Development of Plan for Naval Experiments

In order to develop a plan, the proposed experiments were first divided into three categories. Experiments of category I consists of those which are vehicle or mission oriented. As such they do not play a major role in the design of the vessel but they meet the objectives of the program by demonstrating man's utility in space as well as providing urgent scientific knowledge. A knowledge of the environment surrounding MOL is essential to a correct design and utilization of electromagnetic devices, e.g., the plasma surrounding MOL may affect directly the operation of V.L.F. and H.F. equipment.

The second group of experiments are not as directly related to MOL as those of the first category, however they are deemed to supply scientific information that may have a bearing on the operations of military spacecraft. For example, the astronaut's ability to see near the sun as determined by the solar corona may have a direct bearing on his survival.

Experiments of the last category are those of general scientific interest which may yield useful information at little additional cost. There were in this category many interesting experiments that have physical implications and will contribute to a knowledge of the environmental conditions of space, but most were able to be carried out in an unmanned vehicle or simulated in some way.

Experiments in each category were further divided into scientific fields: e.g., Plasma and Space Physics, Physics of Detonation, Weather and Related Fields, Planetology, Geodesy, and a miscellaneous group which did not obviously fit anywhere else. Every suggestion and proposal was carefully considered but the great majority of the proposals were rejected. The major reasons for rejection of proposals were primarily that such experiments could more easily be done in an unmanned vehicle or did not satisfy the objectives of MOL. Experiments proposed for MOL by the technical panel are given in Table I, while Appendix I describes each experiment in detail.

The experiments of category I are largely concerned with the environment of MOL. The Orbital Plasmas (Scatter) experiments will study the large plasma cloud accompanying MOL. Such plasmas have been detected previously and may lead to a large radar cross-section for MOL or to enhanced detectability in general. In a military operation it would be desirable to determine the extent of such plasma clouds and the mechanism of their production so the chance of detection can be reduced. The orbital plasma scatter experiments are designed to study the extent of the plasma trail and determine their cause.

The Electron Density and Temperature Experiments are designed to study the character of the plasma in the vicinity of MOL. Because of the size of the space ship there may be a dense plasma (relatively) sheath developed near the MOL. A knowledge of the environment of MOL is essential to a correct understanding of the electromagnetic transmitting and receiving equipment aboard the MOL. Furthermore, the nature of the environment surrounding MOL may lead to deleterious effects. In particular, effects produced by the simultaneous application of ultra violet and a fairly warm plasma are extremely difficult to study in the laboratory, and the surface behavior of metals may be affected by the environment such that welding and/or metal working may be difficult.

The far U.V. Image Orthicon experiments (while included under another section) are also discussed here for completeness. The applications of the U.V. device will be to determine if the trails of spacecraft formed by leaking gas containing water vapor will be visible against the universal glow of the sky in the U.V. Early dawn warning may also be provided. In addition it is estimated that heavy air molecules striking the MOL surface at orbital velocities may produce recordable intensities in the far U.V. so that an estimate of the relative numbers of such molecules can be made. In addition to the purely mission oriented aspects of the U.V. system, a complete mapping of the sky in the 1200-1700A° region can be obtained. As such it provides a measure of the main emissions from early type stars and may provide a critical test of radiative transfer theory as applied to early hot stars. Such information is essential to providing a more accurate record of the energy output of the galaxy and may provide information concerning interstellar absorption.

The Airglow Horizon photography experiment is designed to provide information about the character and variability of the nightglow background over the earth in a large spectral range. The usefulness of such observations arise in the possibility of using the nightglow to determine a spatial reference for navigational purposes. It is only from a man-directed vehicle such as MOL that sufficient light can be obtained from the nightglow to provide adequate recording. Attempts to carry out this experiment from rockets have failed for lack of exposure time.

In category II, the experiments of long range military interest are again primarily concerned with space physics, emphasizing a study of radiation unique to space. The cosmic radiation experiments will provide measurements of the radiation received by astronauts during long voyages as well as the particle radiation from solar flares.

The aims of the Airglow Spectroscopy experiment is similar to the Airglow Photography experiment described in the discussion of category I, however, the military applications are somewhat more long range. However, it should be no that there may be very bright emission lines which may define the horizon. Another completely different application of the results may arise in Vela Hote where an understanding of the high altitude emissions may be essential to a detection of a clandestine nuclear explosion in space.

Observations of the White Light Corona of the sun may provide information pertinent to visibility of objects near the sun. In addition it is possible that explusion of large amounts of plasma from the sun may be visible which may allow prediction of solar effects on the earth.

In group III, those two experiments of general scientific interest that survived the considerations of the panel are primarily astronomical in design and may contribute with little additional cost. Both experiments are primarily photographical in nature and use the photographic equipment on MOL. Both planet and earthly photographs will be made. The absence of the atmosphere will contribute to obtaining good views of the planets. Photographs of the earth will perm a more precise study of the geology of the continental structure to be made.

C. Development Schedule

All the general scientific experiments can be made to fit any reasonable schedule. However it is proposed that the following development be followed:

C.Y. 64	C.Y. 65	C.Y. 66	C.Y. 67	C.Y. 68
Start planning	Complete planning and initiate Lab. models	Lab. Models Completed and Tested	Fabrication of final models and start installation in vehicles	Final installation and Test

D. The cost schedule for the experiments are estimated as follows:

	FY 65	FY 66	FY 67	FY 68	FY 69	FY 70
Category I						
Orbital plasmas (scatter)	.05	.2	.6	.4	.1	--
Electron Density & Temp.	.2	.2	.6	.4	.1	.1
Far U.V. Orthicon	included elsewhere					
Airglow Horiz. Photo.	.2	.2	.6	.4	.1	--
Category II						
Cosmic Radiation	.05	.10	.25	.3	.05	--
White Light Corona	.20	.2	.6	.4	.1	--
Airglow Spectroscopy	included					
Category III						
Photo. of planets	.03	.03	.03	.03	.03	.03
Geology of Earth	.03	.03	.03	.03	.03	.03

F. Recommendations for future study

There remain several problem areas relative to the proposed experiments that should be mentioned and will require consideration during the design and development stage of the experiments. Several of these questions have to do with integration of the experiments while some have to do with direct questions as to experimental detail. In order to delineate the problems the questions will be proposed experiment by experiment.

1. Orbital Plasmas (Scatter): Problems remain here to determine if the radar transmitter and antenna would serve as the radiator. Further questions of ground support and correlation of data also remain to be resolved.

2. Electron density and temperature: The general techniques of this experiment are well understood, however some development will have to be carried out with deHaviland to provide an extendable insulated probe (uninsulated devices are in general use). Miniaturization of the five channel recording electrometer should prove to be only a routine laboratory job.

3. Far U.V. Orthicon: Mounting of the T.V. camera in the MOL in the proper aspect will require some study. Consideration of the problem of automatic training of the equipment must also be considered. In general, the development of the T.V. system seems fairly well defined.

4. Airglow Horizon Photography: One of the major problems associated with this experiment appears to be the maintenance of a stable platform during the exposure time of about two minutes. It is possible that the astronaut may be able to maintain the spacecraft heading with sufficient accuracy to achieve correct exposures. However some consideration will be given to automatic training of the equipment.

5. Cosmic Radiation: Further work will be required to clarify the experimental measurements with spark chambers. Film processing aboard the MOL is desirable but may be too difficult to achieve. This is desirable in order to prevent the nuclear emulsions from responding to extraneous particles.

6. White Light Corona: Occulting disks and booms necessary for this experiment remain to be designed in detail as well as mechanisms to erect the occulting structure outside of MOL. Success of the experiment depends largely upon the ability of the astronaut to position the vehicle in the precise manner desired; studies of the positioning accuracy must therefore be carried out and compared with the requirements.

7. Airglow Spectroscopy: Recommendations fur further study here are much the same as for the airglow photography.

8. Photography of Planets and Geology of Earth: Here the exact experimental procedure must still be defined as experimental details were not written. It is suggested that the cognizant agency investigate the procedures to be used. As an aid they should consult with the U. S. Naval Observatory and Scripts Institute.

Title: Orbital Plasmas; Scatter Experiments

Description of Experiment:

The experiment consists in irradiating the plasma accompanying MOL with beamed r.f. from a steerable antenna mounted on MOL. Radiation scattered fr the plasma will be observed at ground stations. Direction and frequency of beams are to be controlled from MOL.

Test Hardware:

The experimental equipment will consist of a steerable antenna mounted on MOL with tuneable r.f. sources also aboard the vessel. It is possible that t existing radar antenna on MOL may be used for this purpose. The weight of th equipment is about 50 pounds and will occupy a volume of 1.5 cu. ft.

Test Procedure:

The experimental procedure is as follows:

1. The astronaut will select antenna directions and transmit for selected times.
2. Astronaut will steer antennas and change frequencies to optimize scattering.
3. Several antenna directions will be tried to obtain magnitude of scattered signal as function of variables.

Test Objectives:

The detailed experimental program is:

1. To determine the size and structure of the large plasma clouds (or discontinuities) observed to accompany satellite, by scattering electromagnetic radiation.
2. To determine the electron density and characteristics of the plasmas.
3. To devise a theoretical explanation for the existence of the phenomena.

Title: Electron Density and Effective Temperature

Description of Experiment:

These experiments are designed to study the plasma environment near MOL. In order to carry out this program several retractable insulated probes will be arranged around the vehicle and the probe currents observed as a function of applied voltage. Tests will be carried out in different parts of the orbit to observe diurnal effects.

Test Hardware:

The experimental equipment will consist of retractable Langmuir probes arranged at five different positions along MOL such that sampling of the plasma can be made at different directions relative to the orbital velocity. Probes will consist of modified deHaviland extensible devices made so there is a thin layer of plastic insulation over the stainless steel. Probes will be designed to be extended to about 300 feet. A five-channel recording variable range electrometer will be required so that currents from all probes may be recorded simultaneously. The dynamic range of the electrometer should be designed to record currents from 10^{-10} to 10^{-4} amperes.

It is estimated that recording equipment will occupy approximately 1/2 cu. ft. and will weigh 10 pounds. The five probes will be mounted on MOL and will occupy no more than 1/2 cu. ft. on the interior.

Test Procedures:

To carry out the desired test the astronaut will extend the five Langmuir probes and record the current as a function of probe voltage for different lengths of probes. The probe voltage must be varied from negative to positive values such that the electron and ion currents both reach saturation.

Test Objectives: The detailed experimental program is:

1. To study the electron energy distribution in the plasma surrounding MOL.
2. To determine the electron and ion densities in the plasma.
3. To relate the above factors to the propagation and reception of electromagnetic waves.
4. To study the formation, size and diurnal variation of the plasma about MOL.
5. To relate the size and density of the plasma to radar cross section.

Such experiments can only be carried out in space where the proper conditions exist. MOL is sufficiently larger than most satellites so that there should be appreciable differences from other devices. There is a great deal of uncertainty in the physical observations so that it is considered that personal observation, initiative and interpretation on the part of the astronaut will contribute to the success of the experiment.

VED FOR
ULY 2015

Title: Space Studies using Far U.V. Image Orthicon

Description of Experiment:

The proposed experiment is designed to study the night sky in the far U.V. region between about 1200A° and 1700A°. To carry out this experiment it is necessary that a U.V. sensitive orthicon and camera electronics be mounted at the focus of a wide angle camera and appropriate display units be in the MOL. The astronaut will observe and take pictures of the night sky on the T.V. disp[lay] under varying conditions of day and night.

Test Hardware:

The basic part of the experimental equipment consists of a T.V. camera chain made up of the following:

1. Far U.V. sensitive image orthicon with camera electronics.
2. Wide angle Schwartzchild Optics (camera mounted at focus).
3. Camera control and monitor package similar to Navy BX-7 closed circuit T.V. system.
4. A synchronized movie or multiple exposure camera to photograph the T.V. screen.

It is estimated that the electronics for the orthicon system weighs 30 pounds, occupies 1 cu. ft. and requires 70 watts during operation. The total system is packageable in a volume of three cubic feet with a total weight of 40 pounds and power as indicated above. It is possible that the closed circuit T.V. may be that used in the surveillance system.

Test Procedures:

The astronaut adjusts the orientation of the spacecraft (and/or T.V. camera system) in accordance with a pre-chosen schedule. He also adjusts the camera controls for best T.V. image and monitor for proper framing.

Test Objective:

The scientific objectives of this experimental program are:

1. To determine the utility of the far U.V. orthicon system in providing dawn warning.
2. To study the trail of space vehicles (especially MOL) and missiles (if possible) to determine if there is sufficient absorption by leaking water vapor to leave a dark streak against the bright night sky (in U.V.).
3. To determine intensity of radiation produced by air molecular impacts on MOL.
4. To study subvisual aurora, day aurora and particle dumping zones in the earth's atmosphere.
5. To map the night sky in the U.V. and in particular study the emission of early type stars. It is desired to correlate the latter with radiative transport studies as results may provide a crucial test of current stellar models.

Title: Airglow Horizon Photography

Description of Experiment:

The purpose of this experiment is to study the night airglow emissions from the upper regions of the atmosphere. As the airglow horizon as seen from an orbiting spacecraft appears as a line some 6° skyward from the earth's horizon and is very faint, long exposures must be made from a stable platform.

Test Hardware:

Equipment used in the experiment will be a high speed camera fitted with a grating in front of the lens to form an objective spectrograph. The thin line of the airglow will serve as the slit and be imaged as a spectrum according to the emission bands or lines present. The overall dimensions of the spectrograph camera would be approximately 9"x 3"x 4" and the total weight less than 15 pounds. Only 300 milliwatts of power are required during actual pointing and operating of the camera.

Test Procedure:

The astronaut will point the camera out of the viewing window while the pilot keeps the spacecraft heading steady. Exposures will be of the order of two minutes. A quick change cassette would be used to obtain 20 to 30 exposures for a total time requirement of about an hour.

Test Objectives:

The objectives of this program are:

1. To study the structure and variability of the airglow in order to determine its usefulness as a spatial reference for navigation of spacecraft.

2. To study the distribution of nightglow with altitude to provide information for a comprehensive theory of the chemical processes taking place in the upper atmosphere.

3. To determine if there is any variation of the nightglow with season latitude or longitude.

Title: Cosmic Ray Observations aboard MOL

Description of Experiment:

It is planned to investigate the composition, flux and energy spectra of the nucleonic component of the primary radiation as well as to study the primary γ-ray and electron components. In order to carry out this program nuclear emulsions will be placed outside MOL; observations will also be made by means of Cerenkov counter or spark chambers.

Test Hardware:

The experimental equipment consists of the following:

1. Package of nuclear emulsion; 10-20 pounds.
2. Erectable boom to be constructed outside MOL after orbit is achieved.
3. Cerenkov counter with small package of electronics having a combined weight of 5 pounds and a volume of 1/3 cu. ft.
4. Spark chamber with small package of electronics having a combined weight of 5 pounds and a volume of 1/3 cu. ft.

Test Procedure:

After an orbit is achieved the astronaut will erect the boom outside MOL with the emulsion package in place on its end. The package will remain in place several days. After exposure it is highly desirable that chemical processing of the package be carried out in MOL so that further exposure of the package will not take place.

Data will also be recorded by Cerenkov counters and spark chambers. The Cerenkov data will be telemetered to earth via the telemetry system on board. Spark chamber data will be taken by photographing the chambers during flight: This simply requires that the shutter of a camera integral to the spark chamber be activated. The astronaut will change the film in the camera after several hours exposure.

Test Objectives:

The detailed experimental program is:

1. To investigate the composition, flux and energy spectra of the nucleonic component of the primary cosmic radiation outside earth's absorbing atmosphere.
2. To study the primary γ-ray and electron components of primary radiation.
3. To correlate experimental data with solar phenomena.
4. To search for rare particles and other novel phenomena that might appear in the detectors.

Title: Direct Observation and Photography of the White Light Corona of the Sun and Surveillance of the Sky close to the Sun

Description of Experiment:

This experiment is designed to observe and photograph the solar corona from MOL. Occulting disks will be erected outside MOL so that the sun's disk is precisely covered. It will be possible to photograph the corona with a simple camera under these conditions and it may be possible to detect small objects lying close to the sun which would otherwise be obscured.

Test Hardware:

The basic coronagraph for MOL consists of a 1 ft. diameter occulter placed on a boom 100 ft. from MOL. For such a device it appears that the weight may be less than 10 pounds and the stored volume of about 1 cu. ft. No power requirements exist for the operation of the equipment.

Test Procedure:

The astronaut first erects the occulting disk at 100 ft. outside MOL. He then aligns the spacecraft precisely so that the occulter covers the disk of the sun. Observations and photographs of the white light solar corona are then made.

Test Objectives:

Objectives of this experiment are:

1. To observe the white light of the solar corona around the edges of the occulting disk.

2. To photograph the solar corona.

3. To search for objects lying near the sun's limbs.

4. To determine if it is possible to observe the erruption of plasma from the sun's surface.

5. To study the long streamers extending from the sun and estimate their extent.

Title: Airglow Spectroscopy

Description of Experiment:

This experiment is designed to study the spectral distribution of the night and day airglow. It can only be carried out in a manned vehicle as demonstrated by previous attempts from rockets and satellites, as only on a manned mission is there sufficient time to record and bring back a record of the faint emissions at high resolution. A spectrograph will be on MOL and will be pointed at the airglow. Observations will be made either according to a table or timed by an integrating photometer.

Test Hardware:

The f-2 spectrograph to be used in these experiments is trapezoidal in shape measuring 15 inches in altitude, 11 inches at the base, 6 inches across the top with a depth of 4-1/4 inches. The weight depends largely on vibration specification needs and can be kept to within 25 pounds. Mounting of the spectrograph will be inside the spacecraft such that the equipment looks either forward or aft. The light path through the capsule wall will be a cone of no more than 5° total angle with a quartz or sapphire lens of 1.5 inch diameter, both imaging the airglow horizon on the slot and serving as a window to maintain cabin pressure. Electrical power consumption would be 0.5 watt during times of exposure with pulses used to activate the shutter and transport the film. The dispersion of the spectrograph is 25A°/mm.

Test Procedure:

The astronaut will point the spectrograph at the airglow horizon by turning the spacecraft and aligning it with an accuracy of 1/4°. (If this cannot be achieved increased exposure could be traded for less pointing accuracy). Exposure and film transport mechanism will be actuated electrically after correct heading of the spacecraft has been achieved. Correct timing of the exposure can be carried out by means of a photoelectric integrating system.

Test Objectives:

Objectives of this experiment are:

1. To record the ultraviolet spectrum of the day and nightglow.

2. To determine the photochemical processes taking place in the upper atmosphere.

3. Study the application of the results of this work to navigation problems.

Title: Photography of Planets and Photographical Study of the Geology of the Earth

Description of Experiments:

The optical surveillance and photographic equipment aboard MOL will be utilized in these experiments. Photographs of the planets will be made at the high resolution at different periods covering a period of about 30 days. Photographs of the earth will also be made to study the continential structure.

Test Hardware:

All the basic equipment required for these experiments will be aboard the spacecraft for the surveillance experiments. Additional film may have to be carried to record the additional observations required.

Test Procedure:

The astronaut will align the space vehicle and optical system such that selected planets may be photographed. Exposures will be carried out according to a table. Photographs of the earth under fairly low wide-angle resolution will be made. Certain portions of the earth may also be studies under high resolution.

Test Objective:

The scientific objectives of these experiments are:

1. To study the geology of the earth's continents.
2. To study the shore line of continents and determine the width of continential shelves.
3. To study the geology of certain islands and their structure.
4. To determine the possibility of observing ocean currents from MOL by studying changes in hues.
5. To study photographs of planets during different parts of their seasons (if possible).
6. To compare results of MOL planetary photography with that from observatories.

APPENDIX B

Complete Listing of All Proposals for Experiments Received by the MOL Technical Panel

No.	Originator	Title/Description
1	BUWEPS	"Electronic Surveillance of Ocean Targets for Ocean Surveillance." Intercepted electronic emission from ocean shipping is utilized for classification.
2	NPIC	"Proposal for a Photo Interpretation Experiment to be Conducted in a One-Man Gemini Satellite." In-orbit development of MOL exposed high-resolution film to permit photo-interpreter classification of "targets of opportunity."
3	BUWEPS	"Optical Surveillance Sensor Equipment." Determines feasibility of combining man and a semi-automatic recording optical surveillance sensor.
4	NADC	"Global Television Surveillance." Utilizes closed TV system for classification and identification of targets at night.
5	NADC	"Infrared Mapping." Surveys oceans and terrestrial features including weather and icebergs using infrared techniques.
6	NRL	"MOL Forward-Looking Radar." Proposes one of three radar possibilities for MOL ocean surveillance.
7	NRL	"Identification of Ships." Proposes use of Mark X (SIF) IFF equipment to assist astronaut in identification of friendly targets.
8	INS	"Multi-Sensor Observation of Ocean-Based Target Complexes." Assesses the ability of satellite-based astronaut to interpret data from a variety of scanning and viewing sensors.
9	APL	"Ocean Surveillance." Similar to 8.
10	NPIC	"MOL Earth Reconnaissance and Surveillance." Utilizes photo interpretation and multi-sensor techniques to assist astronaut in determining which targets are of military interest.

11	NADC	"Photographic Ocean Surveillance Test Program." Assesses the capability of a high-resolution photographic reconnaissance system to perform surveillance over ocean and coastal areas.
12	NRL	"A Photographical Study of the Earth From Space." Similar to 2.
13	BUWEPS	"Visibility of Ocean Targets." Determines the capability of an astronaut to observe and report naval forces with the aid of optical devices.
14	BUWEPS	"Cooperative Shipping Surveillance Experiment." Effectively reduce ship densities through use of a cooperative system that will permit selected ships to identify themselves.
15	INS	"Visual Observations of Ocean-Based Target Complexes." Assesses man's visual capability for acquiring and identifying selected ocean targets and target motion from an orbital platform.
16	NOTS	"Visual Acuity Experiment." Assesses the astronaut's ability as a surveillance instrument to observe, describe, record, and interpret detail of objects and areas from an orbital platform.
17	NRL	"Infrared Scanning of Sea Surface." Analyzes infrared signals generated by small ocean areas and determines opaqueness of cloud cover.
18	NADC	"Night Surveillance." Utilizes an image intensifier direct-viewing device for observing the dark side of the earth from the satellite.
19	NADC	"Infrared Detection of Ballistic Missile Launchings." Determines critical parameters for infrared detection of ballistic missile launchings.
20	NOTS	"Infrared Sea Scanner." Similar to enclosure 7.
21	NADC	"Ocean Surveillance (Sonic-ASW)." Sonobuoy signals received in the MOL are used to classify ocean targets.
22	NMC	"Ocean Surveillance Radar Parametric Tests." Utilizes variable radar parameters in MOL to determine optimum configuration for radar in future manned satellites.

23	NADC	"Radar for Ocean Surveillance." Determines practicality of radar for ocean surveillance and optimizes system parameters for this and related applications.
24	NOL (WO)	"Buoy and Mine Field Interrogation." Determines the feasibility of establishing a sonobuoy or mine field surveillance system in MOL.
25	NADC	"Beacon System." Tests feasibility of using MOL in search operations for air crash or ditch victims.
26	NRL	"Manned Orbiting Laboratory Combat Information Center." Determines feasibility and establishes the technological basis for the development of combat information centers aboard manned orbiting satellites.
27	BUWEPS	"VLF Communications Experiment." Determines feasibility of continuous VLF communications between astronaut and U. S. ground stations.
28	NADC	"A VLF/HF Radio Propagation Experiment Involving the MOL." Investigates HF and VLF radio-wave propagation through different portions of the ionosphere.
29	NRL	"VLF-HF Electromagnetic Communications." Determines VLF communication effectiveness, measures VLF-HF dipole antenna impedance and measures propagation characteristics of VLF-HF radio signals through the ionosphere.
30	BUWEPS	[redacted]
31	NRL	"Space Studies Using Far-Ultraviolet Image Orthicon Aboard a Manned Satellite." Measures the effectiveness of an ultraviolet image orthicon for UV star mapping, dawn warning, viewing subvisible auroras, satellite gas leaks, and exhaust trails.
32	NADC	[redacted]

33	NRL	"Neutron Flux and Spectrum Measurements in Space." Utilizes neutron flux measurement for interception and identification of unfriendly or aggressive satellites.
34	NOL (WO)	"Missile and Aircraft Signature." Proposes IR and visual survey including spectral distribution of rockets against earth background.
35	NADC	"Laser Surveillance System." Utilizes laser to determine cloud cover and sea state with secondary objective of satellite surveillance and laser-illuminated photography.
36	NADC	"Basic Emitter Density and Location Experiments." Determines ELINT gathering capabilities of MOL.
37	NMC	"Space-borne Manned Electronics Surveillance. Determines ELINT gathering capabilities of MOL and tests vulnerability of U. S. Fleet to electronic surveillance from space.
38	NRL	"Selective Radio Spectrum Interception." Similar to Nos. 17 and 18.
39	NOL (Corona)	"ELINT Analysis." Analyzes ELINT data in MOL to determine features such as frequency diversity, pulse compression, and other techniques not easily determinable in unmanned satellites.
40	NMRI	"Project ARGUS Contributions to MOL." Utilizes Project ARGUS determinations to attempt resolution of MOL psychological problems.
41	NADC	"Comparative Evaluation of Terrestrial and Orbital Ratios of Potentially Useful Working Time to Sleeping Time." Records and measures the terrestrial time course and the orbital time course of sleep, drowsiness, and alert wakefulness of a MOL crew member.
42	NRDL	"Nuclear Radiation Personnel Monitor for Space Flight." Determines criteria for development of personnel radiation monitor for space flight.
43	NRDL	"Heavy Particle Dosimeter." Distinguishes between the protons and the heavy charged particles from primary cosmic radiation.

44	ONR	"Personnel Compatibility Predictors." Use Operation DEEPFREEZE personality prediction techniques for selection of MOL occupants.
45	ONR	"Vigilance and Diurnal Cycles." Explores work-rest and diurnal cycle correlations.
46	NOTS	"The Behavior of Simple Spores in a Space Environment." Observes and studies the behavior of spores under conditions of high vacuum and radiation.
47	ONR	"Aids to Vision and Protection." Determines the effectiveness of filters under conditions of white out haze, etc., and the use of a photographic lens system for protection against "flash-blind."
48	ONR	"Electromagnetic Auditory Masking." Determines the effects of the space environment on man's acoustic sensations.
49	ONR	"Human Troubleshooting." Explores man's efficiency in MOL as a troubleshooter.
50	ONR	"Human Visual Efficiency." Measures man's ability as an observer from the MOL.
51	ONR	"Environmental Odors." Investigates the effects of human odors and anti-perspirants upon team effectiveness.
52	ONR	"Gravity Retraining." Measures the efficiency of space-borne training simulators to recondition the astronaut to gravity-state prior to re-entry.
53	ONR	"Physiological Accompaniment of Gravity-Free State." Explores the gravity-free state in relation to man.
54	NRL	"Orbital Plasmas Characteristics." Determines size and characteristics of plasmas which will attend MOL.
55	NRL	"Electron Density and Effective Temperature." Studies plasma environment in the vicinity of MOL.

56	NRL	"Cosmic-Ray Observations Aboard the Manned Orbital Laboratory." Utilizes emulsions, counters, and spark chambers to measure cosmic activity as a function of time and solar cycle.
57	NRL	"Proposal for Airglow Horizon Photography From the Manned Orbiting Laboratory." Measures airglow composition as a function of latitude, longitude, or season.
58	NRL	"Proposal for Direct Observation and Photography of the White Light Corona of the Sun and Surveillance of the Sky Close to the Sun." Measurement of the corona and sun surveillance are accomplished during a simulated eclipse utilizing an occulting disc between the sun and the MOL.
59	NRL	"Proposal for Airglow Spectroscopy From the Manned Orbiting Laboratory Spacecraft." A spectrograph and film are utilized to obtain the high-resolution ultraviolet spectrum of airglow.
60	NRL	"Flare Dynamics and Prediction." Studies solar flares by determining the hydrodynamic motion of various ionic species and the state of the plasma.
61	NRL	"Doppler Frequency Shift and Celestial Navigation." Utilizes doppler shift from three fixed earth radio stations to obtain the space vehicle velocity vector.
62	ONR	"General Test Experiments." Determines mode, velocity of propagation, and generating mechanism of the geomagnetic field through analysis of time variation measured in space.
63	Scripps	"Sea-State Determinations From Manned Orbital Laboratory." Tests the ability of an astronaut to measure and report sea state at a designated observable spot on the ocean surface.
64	NOTS	"Measurement of Near-Space Dust Particles." Utilizes back scatter from a gas laser beam to determine particle description and population in the vicinity of MOL
65	NOTS	"Weather Observation and Prediction." Visual/optical terrestrial atmospheric conditions are reported via two-way radio to assist in forecasting weather trends on a continental basis.

66	NOTS	"Investigation of the Earth's Horizon in the Infrared." Utilizes measurements of the earth's IR horizon as a function wavelength, spatial distribution and solar illumination angle to determine the apparent nature of the earth-atmosphere-space boundary region.
67	NOTS	"Effect of Zero Gravity on Liquid Helium." Uses photographic and pressure measurement techniques, together with direct visual observations to determine the behavior of liquid helium under zero-gravity conditions.
68	NOTS	"Astronaut Monologue Broadcasts." Broadcasts are made by the astronaut to nations in their own language while the MOL is visible to them.
69	NOTS	"Pyrotechnic Communication Experiment." Tests the feasibility of a possible emergency communication system utilizing pyrotechnic charges triggered by an orbiting astronaut.
70	NOTS	"Photogrammetry of the Solar Planets." Recognizes the advantage of high-quality planet photography taken above the earth's optically disturbing atmosphere.
71	NOTS	"Photogrammetry of the Geology of the Earth Continents." Provides photographs of earth continents for analysis by competent earthbound geophysicists.
72	NOTS	"Mass Spectrometer Experiment." Categorizes and identifies ionized particles in the region of the spacecraft.
73	NOTS	"Gas Chromatograph Experiment." Utilizes a simple and miniature gas chromatograph to determine the gaseous constituents of the atmosphere surrounding the MOL spacecraft.
74	NOTS	"Precise Measurement of the Solar Constant." Utilizes astronaut operated radiometer-type instrument to obtain a more precise measure of the Solar Constant.
75	NOTS	"Airglow Experiment." Proposes measurements outside the atmosphere of illumination energy originating within the atmosphere.
76	NOTS	"Photogrammetry of Sferics." Photogrammetry of lightning occurences from above the atmosphere would assist the prediction and interpretation of weather.

77	NOTS	"Spectral Radiance Measurements of Earth-Cloud Cover." A radiometer manipulated by the astronaut will yield spectral radiance measurements of the earth and its cloud cover.
78	NOTS	"Optical Surface Experiment." Studies the degradation of an optical reflecting surface after prolonged exposure to a hostile space environment.
79	NOTS	"Ozone Concentration Experiment." Utilizes an astronaut for ozone measurement.
80	NOTS	"Extra-sensory Perception Experiment." Attempts telepathic communication between the astronaut and ground observers.
81	NOTS	"The Behavior of Relay and Switch Contacts After Prolonged Exposure to a Space Environment."
82	NOTS	"The Effects of High Vacuum and Intense Radiation Exposure of Explosives and Explosive Devices."
83	NOTS	"The Process of Detonation Physics for Conventional Explosives in a Space Environment."
84	NOTS	"IR and UV Spectroscopic Measurements of Stars and Planets From a Manned Space Laboratory."
85	INS	"Oceanographic Observations and Interpretation From Satellite Platforms." MOL multi-sensor data is integrated and interpreted by an astronaut to provide oceanographic information for operational use by sea-based forces.
86	NOL (WO)	"Tracking Device." Determines feasibility of a laser pointing and tracking device for a MOL communication, navigation, or weapon function.
87	NOL (WO)	"Anti-Surface Laser Weapon." Determines feasibility of utilizing a high-energy laser to damage sea-launched missiles or aircraft targets.
88	NOL (WO)	"Earth Magnetic Field." Maps earth's magnetic field and time variation and determines the feasibility of using this information for guidance purposes.
89	NOL (WO)	"Geodesy." Determines feasibility of using MOL for mapping military targets in inaccessible areas of the world.