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TAB D

CAPABILITIES OF THE MOL SYSTEM

I. INTRODUCTION

The value of a long duration manned orbiting system, regardless of its mission, must be measured in terms of all of its capabilities, because inherent in man's presence is the fact that any system will be capable of great flexibility unless severe artificial constraints are placed on man and system. Thus, if the manned system is designed as a high resolution optical intelligence gathering system, its value must be measured not only in terms of ground resolution, but also in terms of ability to return photographs of special intelligence value, rapidity with which intelligence can be returned to the user, flexibility to meet crisis situations, flexibility to gather different kinds of intelligence such as economic, arms control, tactical, strategic, and capability to perform other missions or accommodate other payloads. This value judgment must be exercised against development risks, times and costs, operational costa and growth potential.

Based upon any criterion but initial development costs, the MOL system is superior to an unmanned system to even meet the DORIAN requirement. Furthermore, no single unmanned system could approach the total capabilities and growth potential of the MOL system. Thus, the development costs to realize all the capabilities of the MOL system with unmanned systems would be very much greater than for the MOL system alone. Most likely such an unmanned capability would never be developed because of the prohibitive costs and hence, we would deprive ourselves of the wealth of mission possibilities and flexibility we otherwise could have achieved with the manned MOL.

The MOL system capabilities can be treated in four different stages:

A. Basic MOL/DORIAN system capabilities for additional missions without any additional equipment.

B. Basic MOL/DORIAN system capabilities for mission enhancement with minor equipment additions or changes.

C. Basic MOL vehicle capabilities for other than high resolution optical reconnaissance missions.

D. Growth potential capabilities towards higher resolution and better cost effectiveness.

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The first case of using the MOL photographic system against an expanded target model which contains mobile targets, [redacted] planets has been treated in TAB C. This tab summarizes MOL capabilities which can be achieved with varying degrees of modification of the present MOL baseline system.

II. BASELINE SYSTEM WITH DORIAN PAYLOAD

A. System Enhancement

Several improvements to the existing system could occur during the next phase of the MOL Program. Effort is now being expended in studies toward this end. One such effort is research by Owens-Illinois Glass Company involving manufacture of Cer-Vit material for the primary and tracking mirrors to replace fused silica. Cer-Vit has a very low coefficient of expansion ($0.05X10^{-6}$ in/in ^{o}F) which will eliminate many of the present thermal problems and permit substantial weight savings in thermal protective devices. Cer-Vit has equivalent polishability characteristics and rigidity per unit weight as compared to fused silica. This development will become particularly useful for very large optical systems leading towards [redacted] on resolution.

Study effort is underway to investigate techniques for reducing the MOL vehicle's vulnerability to hostile attack. The study will determine the signature and vulnerability of the MOL configuration compared to the expected threat. The spectrum of defense aids and operational strategies will be investigated as to their feasibility, constraints, effectiveness and costs. Various mixes of existing defense elements will be considered with particular emphasis on man's presence in the system.

B. Electromagnetic Pointing System

Studies are presently underway to develop a small, lightweight auxiliary electronic sensor system to enhance the system effectiveness of the primary optical sensor. The Electromagnetic Pointing System will be capable of identifying and locating emitters with sufficient accuracy to assure they fall within the field-of-view of the High Resolution Optics. Additionally, the system will provide [redacted] and an ability to analyze specific signals to obtain their detailed technical characteristics. Overall system weight including antennas will be less than 300 pounds, peak power less than 250 watts, and total volume less than 5 cubic feet.

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The primary employment of the Electromagnetic Pointing System (EPS) will be to furnish information to the operator which will increase mission effectiveness by giving him options of:

1. Observing that pre-programmed photography is possible and appropriate in terms of the electromagnetic environment;

2. Determining that a pre-programmed alternate target is more appropriate; or

3. Determining that a non-preprogrammed "possible" target is more appropriate.

In the latter two cases this action will be "appropriate" either because of the transitory nature of the target or the necessity for real-time photo and electromagnetic intercept of a target emitter. [redacted] The technical analysis capability will permit the operator to obtain detailed wide-band photographic recordings of complex signals on a pre-programmed basis.

The design of the EPS will be such that its inclusion with the primary photo sensor will neither degrade its operation nor result in a lower reliability for the system. There will be no direct automatically controlled connections between the photo sensor and the EPS. Coordination of the pointing functions of the two sensors, through the computer, will only be initiated upon manual command of the operator.

C. Ship Detection

In-house studies have defined a radar system with modest capabilities, power and orbit sustenance requirements which could be used for detection of ships on the high seas from MOL. The system can cover a swath 100 miles wide and can detect ships of the size of trawlers. Its weight is estimated at 400 pounds. It can enhance the intelligence value of the MOL mission by detecting moving targets, such as ships, which cannot be accurately programmed into the MOL target deck. It would be used in specified limited areas to alert the MOL crew to obtain high resolution photographs of ships.

D. Astronomy

The DORIAN optical sensor is capable of being used as a rather precise astronomical instrument. It can be employed for planetary photography without change, as was discussed in Part II. In its baseline configuration, however, it has limitations for stellar astronomy because of stabilization problems. With improvements in the precision in pointing which are within the state-of-the-art, however, the DORIAN sensor could provide 0.1 seconds of arc resolution for distant stars. One second of arc is the limit from the earth's surface due to atmospheric limitations.

The refractive optical elements in the Ross corrector prevent spectral analysis and observations outside the visible range of the spectrum. A search for sources of ultraviolet radiation could be made, however, by replacing the present Ross corrector elements with Quarts. There exists no data on this part of the spectrum because of the filtering effect of the earth's atmosphere. In a search for unknown phenomena like this ultraviolet sensing mission the presence of man is indispensable. Spectroscopy could be accomplished by providing special adapters which could circumvent the Ross corrector elements.

III. BASELINE MOL WITH OTHER PAYLOADS

The MOL Program was approved on the basis that in addition to performing optical reconnaissance, other mission capabilities would be examined on a secondary basis. Specifically, the Ocean Surveillance and SIGINT missions were considered of great importance. The use of MOL as a scientific laboratory was also to be considered. A discussion of these additional uses of MOL Orbiting Vehicle follows below.

A. Ocean Surveillance

The objective of the MOL Ocean Surveillance mission under study is to conduct operational tests of satellite sensors and sensor usage concepts, in order to obtain information needed to design a follow-on ocean surveillance satellite system.

The following types of sensors are being considered:

1. High-Resolution Synthetic Aperture Side Looking Radar.
2. Conventional Search and Detection Radar.
3. Photo-Optical Equipment.
4. Passive Electronic Signal Intercept Equipment.

It is not yet known to what depth of detail ocean surveillance satellites must collect information about detected targets. It is possible that with improved and properly integrated ground systems, the satellites need only supply accurate location information for detected targets. At the other extreme, it may be necessary for the satellite to classify every target as to type and identify some percentage of targets in the open ocean, and in addition frequently send information about conditions in selected ports and harbors throughout the world.

The Ocean Surveillance system will be designed to operate in at least four modes according to the amount of information to be obtained on various test runs. The role of man in the various modes will range from no participation to complete integration in a man-machine combination. The four modes in order of increasing transmission requirements are:

1. Target detection and location only. Fully automatic operation, with all data transmitted to ground.

2. Fully integrated man-machine operation, with the astronauts performing image interpretation and data analysis aboard the satellite.

3. Semi-automatic operation of full array of sensors, with man intervening for functions such as selection of targets for high resolution sensors, and selection and cropping of imagery for transmission to the ground. Image interpretation to be performed on the ground.

4. Target detection and location, plus heading and speed determination (if feasible) and collection of high resolution imagery. Fully automatic operation, with all data to be transmitted to ground.

B. SIGINT

SIGINT Studies are currently underway aimed at determining [redacted] Other types of sophisticated electronic systems are also in the development phase as indicated by intercepts of emitters identified as missile and satellite tracking radars.

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The improbability that automatic collection systems can be developed to completely cope with the complex electronic environment of the 1970's makes it very desirable to investigate the improvement in system effectiveness which can be achieved through the use of man's ability to make complex decisions and adjustments rapidly.

In addition to our presently approved studies in the area of intelligibility we propose to investigate other areas in which it appears most difficult for automatic systems to operate effectively. This will include the possibility of checking out and adjusting a system on orbit to permit it to subsequently operate automatically.

At the conclusion of these studies it is proposed to devise a SIGINT system which would incorporate a number of SIGINT missions most effectively done by a system including man. [redacted]

C. Multi-Purpose Laboratory

In addition to its other capabilities, MOL has the potential for providing a unique laboratory environment for the execution of specific experiments. These experiments can support the objectives of both NASA and the DOD. The MOL has 1,000 feet of pressurized volume, and can provide up to 3,000 feet of unpressurized experiment volume in the Mission Module. It can carry up to 8,000 pounds of experimental equipment into polar orbit on 30-day missions with a crew of two.

The experiments considered of interest to the Department of Defense can be grouped into the following three categories:

1. Those having potential for improving the ground resolution capability of the primary mission sensor;

2. Those which demonstrate and test concepts and components necessary for advancement and growth of the primary mission capability;

3. Those which explore future potentials leading to the designation of new military space objectives.

Examples of these various categories of experiments which might be conducted with the MOL for the Department of Defense are listed below:

Knowledge is needed on the performance of large mirrors on orbit. The alignment, erection, pointing and tracking, focusing, figure control and the behavior of materials such as beryllium, Cer-Vit, fused silica, pyroceram are all essential to improving ground resolution capability of the primary sensor.

To establish our potential for new manned military missions, experiments must be conducted in the area of communications [redacted] Experiments to establish countermeasures against hostile attack of the MOL are needed. Experiments to improve techniques for nuclear detection and arms control are also essential.

IV. MOL GROWTH POTENTIAL

The MOL system is well suited to grow beyond its present development program status towards greater operational utility. It can grow in two ways which are mutually supporting. The optical sensor can be increased in size [redacted] Because of the necessary weight growth of such a large optical system and the natural conclusion that orbital life longer than 30 days is more cost effective, the system will grow in size. The consequence of this size, weight and life growth is that a bigger booster is required or the rendezvous approach be employed. The large optical sensor and rendezvous are discussed in greater detail below:

A. Large Optical Sensors

Studies indicate that primary and tracking mirrors up to about [redacted] in diameter are feasible under existing technology. Larger size optics will probably require new construction methods primarily due to structural rigidity, test and handling problems in the earth's gravitation environment. Ground resolution improves with increasing mirror diameters of up to about [redacted] where vehicle vibration, atmospheric turbulence, reduced field of view, weight and other such system factors assume much greater significance. The present state of technology should permit the acquisition of optical systems capable of [redacted] photographic ground resolution.

The capability to achieve [redacted] ground resolution can develop readily from the MOL baseline program. The development risk will be inherently high but minimized by the presence of man. The need for the man in system operation will be definitely higher than for the present DORIAN system. The fabrication difficulties, complexity and costs may well dictate a rendezvous approach to minimize the number of sensors required. It is estimated conservatively that a sensor with [redacted] ground resolution will weight a minimum of 20,000 pounds.

B. Long Duration and Rendezvous

For satellite missions involving complex, heavy, or costly payloads, cost effectiveness is generally improved by increasing the orbital lifetime. The lifetime of an integrally launched satellite is limited primarily by the size of expendable supplies such as fuel for power and propulsion, film, gas, etc., that can be injected into orbit with the selected booster. For a manned satellite, expendables such as food, water, and atmosphere and adverse physiological effects such as yet unknown effects of zero gravity and accumulated radiation dosage further limit the lifetime. In either the manned or unmanned case, equipment reliability is also a limiting factor, although in the manned case the test, maintenance and repair capability decreases this probability of complete mission failure. Essentially then, longer life missions are obtained by larger boosters, increased equipment mean-time-to-failure, and rendezvous.

At present rendezvous is conceived of as applicable only in the manned case. The operations of docking, transferring expendables, etc., are too complex to be accomplished completely automatically. Orbital rendezvous is advantageous for long life missions requiring resupply of expendables, crew replacement or rescue, and assembly of large space objects too heavy to be injected integrally into orbit. The cost effectiveness trade-off of increasing booster size versus resupply for satellite missions varies with the value of the payload remaining in orbit and the mission lifetime.

It has been determined that the expendables section of the automatic mode configuration of the baseline MOL can be sized so as to evolve into a follow-on configuration with minimum modifications. The automatic mode vehicle would be launched as the first vehicle in a rendezvous program. The resupply vehicle would consist of the same expendables section mounted as a trailer to the Gemini B. Early in the program, a vehicle could be maintained on orbit continuously with 3 and 5 launches of the mission and resupply vehicles, respectively.

Shown below is a comparison of the yearly "take" for 6 launches per year of the MOL baseline; 12 launches per year of an unmanned DORIAN system; and the rendezvous approach for which the recurring cost per year would be lower than the other two approaches.

Comparison of Different Approaches To Meeting DORIAN Mission Requirements

	12 Unmanned Flights	6 MOL Baseline Flights	Follow-On Program (Cont. on-orbit) (3 AMV + 5 RRV)
Total Number of Clear Photographs/ Year	17,500	9,700 *	20,500 *
Total Number of Clear, Special Photographs/Year	636	1,056	2,070

* 10% for weather improvement, assuming that the crew concentrates on active target indicators.

It can be seen that, in addition to being lower in operational costs, the rendezvous system returns considerably more technical intelligence.

The payload capability of the rendezvous and resupply vehicle on the T-III 7-segment booster would permit launch of the [redacted] ground resolution sensor. In addition to providing improved performance and economics, the rendezvous system has the following attributes:

1. Simple evolution from baseline program;
2. Minimum development risk for [redacted] resolution sensor;
3. Continuous, on-call, operational capability.
4. Maximum acquisition rate and readout of special intelligence photographs;
5. Minimum recycle time (as low as one day) to photograph specific targets;
6. Continuous, on-call, multi-mission sensor capabilities;
7. Maximum returns of technical intelligence at moderate operational costs.