DEPARTMENT OF THE AIR FORCE
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Policy: MOL

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MEMORANDUM FOR THE DIRECTOR DEFENSE RESEARCH AND ENGINEERING

SUBJECT: MOL Versus an Equivalent Wholly Unmanned System

Reference is made to your letter of April 6 requesting a comparison of performing the MOL reconnaissance/intelligence mission unmanned versus manned. The results are summarized herein and the attachments have supporting data. We are, of course, prepared to provide such briefings as you may require.

In order to respond to your requests, it was necessary to perform a definition of the wholly unmanned system. The description, performance, and costs of the unmanned system are contained in TAB A, as derived from two contractor studies and a separate in-house study, employing an optics module essentially identical to that of the MOL. The booster was a five-segment solid rocket motor version of the Titan III, without transtage, modified to provide radio guidance. Within the performance of that booster, a wholly unmanned spacecraft was configured for a nominal thirty-day orbital lifetime to provide approximately [redacted] ground resolution with data return weekly by recoverable capsules.

A comparison of the probability of success of the unmanned system with that of the manned system shows that ten development test flights will be needed for the unmanned system to achieve an acceptable system maturity.

I estimate the development cost of the unmanned system, including the ten development flights, to be approximately $1.12 billion. This estimate is a value judgment based on a range of submitted estimates between 95 percent and 110 percent of this figure. The basic reason for the variance related to differing appraisals of the development difficulty involved. TAB A provides an explanation of the above costs and presents recurring costs in the amount of approximately $45 million per launch.

DORIAN/GAMBIT

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The MOL orbital development testing can be completed one year sooner than the ten-shot unmanned series. Besides shortening the time, the participation of the MOL crew gives an added confidence that major obstacles can be overcome. The MOL system can be operationally ready one year in advance of the unmanned system.

As you have been apprised, the development cost for the seven-shot MOL Program amounts to $1.822 billion (see TAB B). This program provides both a manned and an unmanned capability. The cost difference over the wholly unmanned program is approximately $700 million. This differential, however, is more than offset by outstanding advantages in the MOL. These advantages appear directly in terms of cost effectiveness on a recurring flight-by-flight basis because of MOL's superior success probability and ability to produce intelligence information in higher quality and quantity and indirectly in terms of the much greater flexibility of the MOL system to cope with new reconnaissance missions, additional mission capabilities and natural growth, in comparison with an unmanned system having minimal flexibility and growth. TAB C compares the two systems in terms of capability to perform the basic reconnaissance mission and cost effectiveness. This tab also treats briefly several additional missions the baseline MOL system can perform. Other MOL capabilities are discussed in TAB D.

Before summarizing the comparisons, however, it is pertinent to discuss briefly the effect of the field of view of the DORIAN optical system. Optical systems have a field of view that diminishes with resolution, a very significant factor in mission planning against various target models. The following table presents a comparison:

System	Width, N.M., of Field of View	Area Covered per Photo, Sq. Mi.
GAMBIT	9	180
GAMBIT 3	4.5	90
DORIAN	1.5	2.0

The small field of view significantly affects pointing accuracy, requiring accurate target locational information and very precise navigation and attitude control. On actual target models now in existence, it is evident that some means of target selection is mandatory in order to insure maximum intelligence collection.

On pure theory and assuming that pointing accuracies, equipment alignment and adjustment, image motion compensation and tracking can be done unmanned as well as manned, the resolution results of all targets covered during a thirty-day mission will average approximately $\frac{1}{2}$ inch better manned than unmanned because of man's ability to center images of obliquely located targets. Inherent is the assumption that all equipment is maintained at peak performance for both systems. We expect on a thirty-day mission that the manned system will be able to maintain peak resolution performance without degradation, such as might occur in the unmanned system, since the man can make the necessary adjustments. The manned system will use electronic readout and will return daily practically all of the information collected which has been judged to have high intelligence value. (The primary photographs will of course be recovered later.) In transmission the resolution will probably be degraded by about 15 percent. The response time of the manned system by this method is very much less than that of the unmanned system. Since the improvements in resolution by the man are offset by his use of readout, the difference between the two systems in terms of resolution only is so small that a comparison is not worth further consideration.

Of the many factors on which the two systems can be compared, three are of a nature to permit numerical evaluation:

a. Relative probability of success;

b. Improvement from operator avoidance of weather obscuration;

c. Improvement from operator verification of target photography.

Success Probability Comparison

To evaluate relative success probability, the criterion which has been selected is the ratio of the number of launches of the unmanned system to the manned system which are needed for the same number of operating days on orbit. Our studies have clearly shown, as we indicated almost a year ago, that the initial probability of success of a manned system is much higher than that of an unmanned system. The MOL development program is scheduled to be completed after five manned launches. We believe that, operationally, the average mission days per launch will be about 28. The unmanned system, on the other hand, will have ten development launches and will average operationally about 24 mission days per launch.

These values assume that man does nothing other than to align equipment, analyze failures, maintain equipment, and act as a backup system. The ratio of the mission-day factors cited above make one

MOL launch equivalent to about 1.2 unmanned launches. Operationally, the MOL will cost $85 million per launch. The corresponding unmanned cost at $45 million per launch, adjusted for probability of success alone, is $54 million.

Selection of Clear Weather

The second step in the effectiveness comparison assesses the increase in number of photographs returned by having the operator observe the weather ahead and switch to a pre-programmed alternate target if the primary is obscured.

An extensive study of this mode of operation was conducted by members of the NRO staff. A summary appears in TAB C. Target decks derived from representative intelligence requirements and weather models based upon actual observed conditions from satellite photography of the Sino-Soviet Bloc were employed. Human reaction time, orbital photo system dynamics, primary and alternate target distribution, individual weather characteristics, orbital parameters and many other influences were factored in. Employing the GENIE computer program, results were obtained which showed a 35 percent advantage in number of clear photographs obtained in a thirty-day period for the manned system over the unmanned system. A total of 1880 photographs were produced by the manned system, as compared to 1385 from the unmanned system. In running the mission, the function of the operator was confined to viewing the weather and switching to automatic acquisition of an alternate target if the primary was found to be obscured.

Applying this 35 percent improvement factor to the previously determined unit cost increases the equivalent cost of the unmanned system to $73 million per MOL launch at $85 million.

Verification of Photography Accomplished

A loss factor in an automatic system occurs because there is no way of verifying that a programmed target has been photographed clearly. An important target may be photographed several times to assure its acquisition, reducing the available time for other targets, while targets programmed only once or a few times may be missed. An operator can make the desired positive verifications. Once a clear photograph has been obtained, that target can be eliminated from the succeeding program. The demands upon the operator are small. He has merely to observe and record the result. An assessment of the improvement possible by this means, considering the number of such opportunities in a representative mission, results in an estimated 10 percent advantage for the manned system over the unmanned system.

Applying this factor to the costs quoted above raises the cost of an equivalent quantity of unmanned target coverage to $80 million compared to $85 million for MOL.

The following summarizes the cost effects of the three factors discussed above:

Factor	Percent Improvement in Manned System	Cumulative Equivalent Unmanned Cost per Manned Launch
Success Probability	20	$54 million
Weather	35	73 million
Verification	10	80 million

Target Selection

A factor quite as important as those discussed above is the ability of an operator to select, by real-time inspection, targets of high value. The DORIAN optics field of view will cover approximately one-half of a 12,000-foot runway system. In order to insure that photographs are obtained of military aircraft parked on the perimeters of such a runway, one must have either a prior knowledge of their location at the start of a mission or must in some manner select in real time the portion of the airfield to be photographed. This is a simple case in which a single GAMBIT or GAMBIT CUBED target separates into two or more targets for DORIAN because of its smaller field of view. Not only does the number of targets proliferate, but to insure maximum intelligence content, target selection becomes mandatory. A complex such as Tyuratam, with overall dimensions of 50x100 miles and containing twelve launch complexes, could break into more than sixty individual targets. These targets are sufficiently close that photographs of all cannot be taken on a single pass; hence the need for some means of selection of those which contain items of high intelligence interest. Our studies show that man can make a major contribution in this role of target selection to increase intelligence content.

To estimate the usefulness of this function, analytical runs were made of the DORIAN system against a realistic target deck. Results showed that crew participation in target selection yielded three times as many photographs of targets with active indicators as could be taken by an unmanned system on the same mission. Details are in TAB C. Representative of the operations performed are:

a. Location of a break in the clouds containing ground force vehicles.

b. Selection of a portion of a launch complex containing special radar equipment.

c. Detection of a silo with an open door.

d. Detection of a missile being transported.

e. Choice of a technically valuable angle of view of a new radar.

Because of the particular value of such photographs, it is not reasonable to compare them with the usual target coverage. Even in the current GAMBIT program some of the most important intelligence returned has not been pre-programmed. The DORIAN system will permit the exploitation of this source through planned missions rather than by chance acquisition.

The foregoing analyses provided specific data when comparing manned and unmanned high resolution reconnaissance systems. There are many added capabilities in the MOL Program which are beyond the planned performance of the unmanned system. These additional capabilities fall in three general areas and are discussed in turn below.

Additional Manned Actions Which Can Improve Intelligence Information

In addition to maintaining the system, assessing weather, validating cloud-free targets photographed, and selecting targets of high intelligence interest, man can, without interrupting the photography sequence, perform visual reconnaissance such as simple counting, color discrimination, classification of activity, and detection of movement. He can, on call, place aerial color film, infra-red film or other special films in the secondary camera so that their special discrimination characteristics can be realized. Man can process photographs in orbit, edit them and transmit the images to the ground. In conjunction with this capability, he can make judgments and render specific decisions as to the relative importance of information to be processed on orbit and transmitted to the ground. He can also, over limited areas, search for mobile targets whose exact locations are not known or whose presence is only suspected.

Additional Reconnaissance Capabilities

The MOL system can, during times of crisis, be transferred from its nominal 80-mile orbit to an orbit of approximately 200 to 250 miles. In this higher orbit the system will have access to all targets in the Soviet Bloc approximately once every three days, taking photographs at resolutions of about [redacted] The crew can also employ the acquisition and tracking scopes, with a resolution of about nine feet, for intelligence by direct viewing. The absence or presence of aircraft, ships in port, cargo accumulations, parked vehicle build-up and railroad activity are examples of such intelligence. The vehicle can remain in this higher orbit for a week or so, providing daily reports on activity indicators which are of significant value in determining the posture and state of readiness of the Soviet forces.

[redacted]

The foregoing additional reconnaissance capabilities can be accomplished with essentially no change to the baseline MOL system.

Additional Military Missions and Growth

The MOL laboratory module has been designed with sufficient flexibility to support missions other than high resolution reconnaissance. Although not of military significance, the MOL, without change, can produce a photographic map of Mars at approximately fifty miles resolution, essentially a six-fold improvement over ground-based systems. New military missions, such as communications intelligence or ocean surveillance, can be added to the MOL Program by the fabrication of new mission modules and some minor modifications to the laboratory module. Other elements of the system can be used without change.

In addition to these military uses, the MOL has the potential of providing a unique laboratory environment for the execution of scientific experiments. The MOL has 1,000 cubic feet of pressurized volume and can provide up to 3,000 cubic feet (8,000 pounds) of unpressurized experiment space. It is currently under consideration by NASA for use in their earth-orbital experiment program.

Finally, the MOL Program, as currently configured, is well suited to grow beyond the applications outlined in the foregoing paragraphs. Our studies have indicated that growth to sixty days on orbit is feasible, as is rendezvous and resupply. Exploiting either of these two growth areas provides increased cost effectiveness and would permit, by incorporating larger sensors, the provision of ground resolutions on the order of approximately [redacted] All of our studies involving applications validate the necessity for man and verify that longer lifetimes on orbit and the use of larger higher resolution optical devices require the kind of manned space flight experience that will accrue from the present MOL Program.

In conclusion, I wish to single out a point which impresses me greatly: although a direct comparison of two systems has been attempted, such an appraisal is almost invalidated by the fundamental divergences in system characteristics. A few significant inequalities are:

a. Some quantitative correspondence between the two can be identified, but there exists a positive superiority under all conditions in the intelligence content of the product of the manned system.

b. As a reconnaissance system, the unmanned development leads to a specific end imposed by a rather well-defined limit in system resolution and utility. The MOL, on the other hand, has a substantial growth potential.

c. The development schedule for the unmanned program lacks the confidence contributed by the attendance of an operator. There are individual inventions and extensions in technologies which threaten to become the cause of impasses during the orbital test phase.

d. The MOL program encompasses the growth of a system having the prospect of great versatility for missions of a wide range. The unmanned system will be narrowly limited in comparison.

In any plan actually to impose a program reorientation, serious attention must be given the fact that we are now proceeding in a direction which will produce both a manned and an unmanned high-resolution reconnaissance system. Even disregarding the certainty of program disruption and termination expense that would be caused by such redirection, a crucial question must be faced: can we afford to apply less than our best efforts to achieving the benefits of a high resolution satellite photographic system at the earliest practical time?