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MEMORANDUM FOR THE DIRECTOR DEFENSE RESEARCH AND ENGINEERING

SUBJECT: Comparison of MOL to an Unmanned System of [redacted] Resolution

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 define the design of a 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.

An appraisal of the complexity of making orbital development tests of the system without a man concludes that ten development test flights would be needed for the unmanned system to achieve an acceptable system maturity, although even at "maturity", the unmanned system would be ~~materially~~ inferior to MOL in probability of success. I estimate the

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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 relates 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.

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 new developments needed to automate the system present an added risk during the orbital testing phase. Some functions involving important new components are:

Image motion compensation across the format.

Image tracking

Focus sensing

Remote optical alignment

Precision automatic navigation

A discussion of the new features appears in TAB C. Out-of-specification performance in any of these functions can defeat the objective of providing [redacted] resolution. The presence of a man during the orbital development period is a significant insurance factor.

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 ability to produce intelligence information.

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 puts a premium on pointing accuracy, requiring accurate target location and very precise navigation and attitude control. On actual target models now in existence, it has been shown that some means of target selection is mandatory in order to insure maximum intelligence collection.

Assuming that pointing accuracies, equipment alignment and adjustment, image motion compensation and tracking can be done unmanned, the resolution results of all targets covered during a thirty-day mission are expected to average approximately ½ inch better manned than unmanned because of man's ability to center images of obliquely located targets and to correct for offset errors introduced by navigation uncertainties. Inherent is the assumption that all equipment is maintained at peak performance for both systems. The man in the system will be able to maintain peak resolution performance, while the unmanned system may very well degrade. The manned system will use electronic readout and will return daily practically all of the information collected having high intelligence value. (The primary photographs will of course be physically 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~~ shorter than that of the unmanned system. Since the improvements in resolution by the man are offset by his use of readout, the difference between a manned system using readout and an unmanned system not using readout is small.

Of the many factors which cause the manned system to have a superiority, the following have characteristics which permit numerical comparison:

a. An increase in photographs returned per launch because of a higher probability of success.

b. An increase in photographs per mission resulting from operator selection of cloud-free targets.

c. A greater number of individual target photographs using operator target verification to eliminate redundancy.

d. A higher intelligence content per photograph by employing the man in a search for active target indicators.

e. An increase in intelligence value by the short response time provided by the readout system.

The effect of the above factors was evaluated by applying them against a representative DORIAN 30-day mission. By employing a realistic target deck and simulating DORIAN system characteristics, it was found that a total of 3988 camera operations resulted, for either the manned or the unmanned system. The improvements of using a man in such a mission are discussed in the paragraphs below.

Selection of Cloud-Free Targets

In a typical unmanned mission, the photographic loss is 50% from cloud cover alone. An effectiveness comparison assessed the number of targets which would be photographed by a manned system and an unmanned system on identical simulated missions. The concept of operations envisaged both systems being targeted automatically against the same primary targets, with the MOL astronauts assigned the task of observing the weather ahead and switching to one of several pre-programmed alternate targets (where available) when the primary target was obscured by clouds.

An extensive study of unmanned and manned system potential target coverage was conducted by members of the NRO Staff and the MOL Project Office. An MOL target deck was derived from current and projected intelligence requirements. A range of weather models were derived from actual KH-7 mission results and KH-4 photography of the Sino-Soviet Bloc. KH-7 computer programs (modified, as necessary, to properly reflect MOL system characteristics) were used to select the optimum combination of primary targets for the two systems;then up to three alternate targets (where available) for each primary target were selected for the manned system so as not to interfere with any other designated primary target.

In the simulated 30-day missions analyzed against average climatology, the manned system photographed from 16-20 percent more targets than did the unmanned system. When the simulated missions were analyzed against worse-than-average weather, the manned system photographed as many as 30 percent more targets than the unmanned system. Against target complexes like the Moscow area, whose weather is considerably worse than the overall Sino-Soviet Bloc average, the manned system might return 40 percent more target photos than an unmanned system. Conversely, operating against an area like Lop Nor, whose weather is consistently good, the manned system probably would return only 5-10 percent more target photos than an unmanned system.

The average improvement factor is 18 percent. In the unmanned case, an estimated 1990 good target pictures would be returned, while the MOL would produce 2360.

Verification of Photography Accomplished

A loss factor, even in an automatic system with capsules, occurs because there is a delay in verifying that a programmed target has been photographed clearly. A target may be photographed several times before removal from the deck, reducing the operations on other targets. An operator can make the desired positive verifications. Once a clear photograph has been obtained, that target can be eliminated from the succeeding program.

A comparison was made using the mission described above and assuming that the unmanned system would return a capsule every 7 days, the results of which could be applied to target verification. In the MOL, verification would be made soon after the target is photographed. TAB C describes the method of calculation. The calculations show a 39% improvement for MOL. The value is quite sensitive to the number of available replacement targets assumed. In no case considered has the improvement fallen below 20%. The unmanned system would return 1190 individual target photographs, whereas MOL would produce 1700 photographs. The MOL improvement estimate used here has been based upon the low 20% figure.

Target Selection

A factor having the same order of importance as those discussed above is the ability of an operator to select, by real-time inspection, targets of high value. For instance, 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. To illustrate, 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 almost three times as many photographs of targets with active indicators as could be taken by an unmanned system on the same mission with such cases occurring about 6% of the time. Details are in TAB C. Representative of the operations performed are:

a. Location of significant military vehicles

b. Inspection of special radar equipment

c. Detection of a silo with an open door

d. Detection of a missile being transported

e. Technically valuable view angle of new radar

An advantage incident to the process of searching for active indicators is the fact that the operators can inspect more targets than can be photographed. In many cases, their determination that nothing new can be seen will be equivalent to an additional photograph returned.

TAB C calculates that the unmanned system would return 4% special intelligence photos, while MOL will return 12%. If these are rated as three times as valuable in intelligence content, the MOL improvement is 15% in what will be termed "equivalent intelligence - photos," the MOL will return 2100 equivalent intelligence-photos to 1290 for the unmanned system.

Quick Response Intelligence from Readout

The value of most intelligence photographs decreases with time. In some instances the quality can be termed perishable. In those cases where quick response to the intelligence is important, a satellite-borne readout system is most useful. The MOL readout system will be employed to provide the needed timely information by scheduling photography to be performed by the operators using a special camera on pre-designated targets. The film will be processed on board and the intelligence-bearing portion of it will be transmitted quickly over the data link. It would be possible to have an alternate unmanned configuration designed to perform readout, but an entire mission would be consumed each time the readout configuration was flown. The loss of a regular mission could be tolerated therefore only in very unusual cases. Based upon an estimate that timeliness of information will be important about 10% of the time, the cumulative number of "equivalent intelligence-photos" becomes 2310 for MOL compared to 1290 unmanned.

Relative Probability of Success

TAB C compares the individual reliability factors in the two systems, including the benefits of manned attendance of the equipment. As shown there, the "mature" unmanned system can be expected to complete an average of 24 mission-days for each one launched. The MOL, on the same basis, will complete 28 mission-days per launch. Applying these factors to the two systems, the final numerical comparison shows that the ratio of the quantitative intelligence product per mission of the MOL to that of the unmanned system is 2150 to 1030, or about 2 to 1.

The table below summarizes the results:

MANNED SYSTEM IMPROVEMENTS

Factor	Unit of Comparison	Unmanned	Manned Improvement Ratio	Cumulative Manned
Operational Constraints	Camera Operations	3988	1.0	3988
Weather Loss	Good Target Pictures	1990	1.18	2360
Target Verification	Individual Targets	1190	1.2	1700
Target Selection	Equivalent Intelligence-Photos	1290	1.15	2100
Response Time	Equivalent Intelligence-Photos	1290	1.10	2310
Mean Mission Life	Equivalent Intelligence-Photos	1030	--	2150

The foregoing is our current best appraisal of the usefulness of man in performing certain well-defined functions. There are many more, however, and it will be remembered that in the Memorandum of August 24, 1965, for the President, a stated important objective of MOL was "to give us --- knowledge of the nature and value of critical contributions of man to photographic reconnaissance and to other military-related space missions . . ." These added contributions are of three general kinds, which 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. One feature, referred to above, is his ability to determine the best viewing angle from which a target should be photographed. For instance, if he is approaching a parked aircraft from the rear and the needed intelligence will come from examining the fore end, he can wait until he has passed over and take a backward-looking picture. 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 judgements 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 enter orbits of about 200 miles after one to twenty-one days, and still remain in orbit thirty days, permitting daily reports of activity of significant value in determining the posture and state of readiness of Soviet forces.

[redacted]

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

<u>Additional Military Missions and Growth</u>

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?

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TAB B

MOL PROGRAM COST SUMMARY

The planned total RDT&E cost of MOL Phase II development is $1,821.5 million. This figure is based upon the program schedule shown in Figure B-1 and the annual distribution of funds shown, by system segment, in Figure B-2.

The cost figures shown were derived through a deliberate, methodical, and systematic procedure which was formally instituted in January 1966, and which will continue through negotiation of Phase II contracts with all major associates. The cost estimating methodology employed has involved the generation of independent estimates concurrently with preliminary contractor estimates; reiterations of these procedures; detailed evaluation of final contractor proposals where such proposals were available; and detailed reviews of cost estimates by independent groups of highly-qualified individuals. The result is an estimate of MOL system costs which is believed to be entirely realistic.

It should be noted that the cost estimates shown in Figure B-2 provide only for an austere program. There is no allowance for system improvements beyond the primary optical reconnaissance mission. While the desirability and potential of other possible military applications of MOL, such as SIGINT and Ocean Surveillance, have been recognized, the costs for such secondary objectives are not included in the estimates shown. Neither are costs included for general scientific and technological orbital experimentation effort for which MOL may be particularly well suited.

To provide a basis for cost comparisons, the following estimates of recurring costs are shown. These costs assume a 5-year operational program with current baseline configuration at six flights a year.

MOL Recurring Costs
($ Millions)

Lab Vehicle	$ 28.0
Mission Module	23.0
Gemini B	14.0
Titan IIIM	16.5
Crew & Equipment	.5
Test/Operations	1.0
GSE/TD	2.0
TOTAL	$ 85.0

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Page 1 of 3 pages
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MOL SUMMARY SCHEDULE

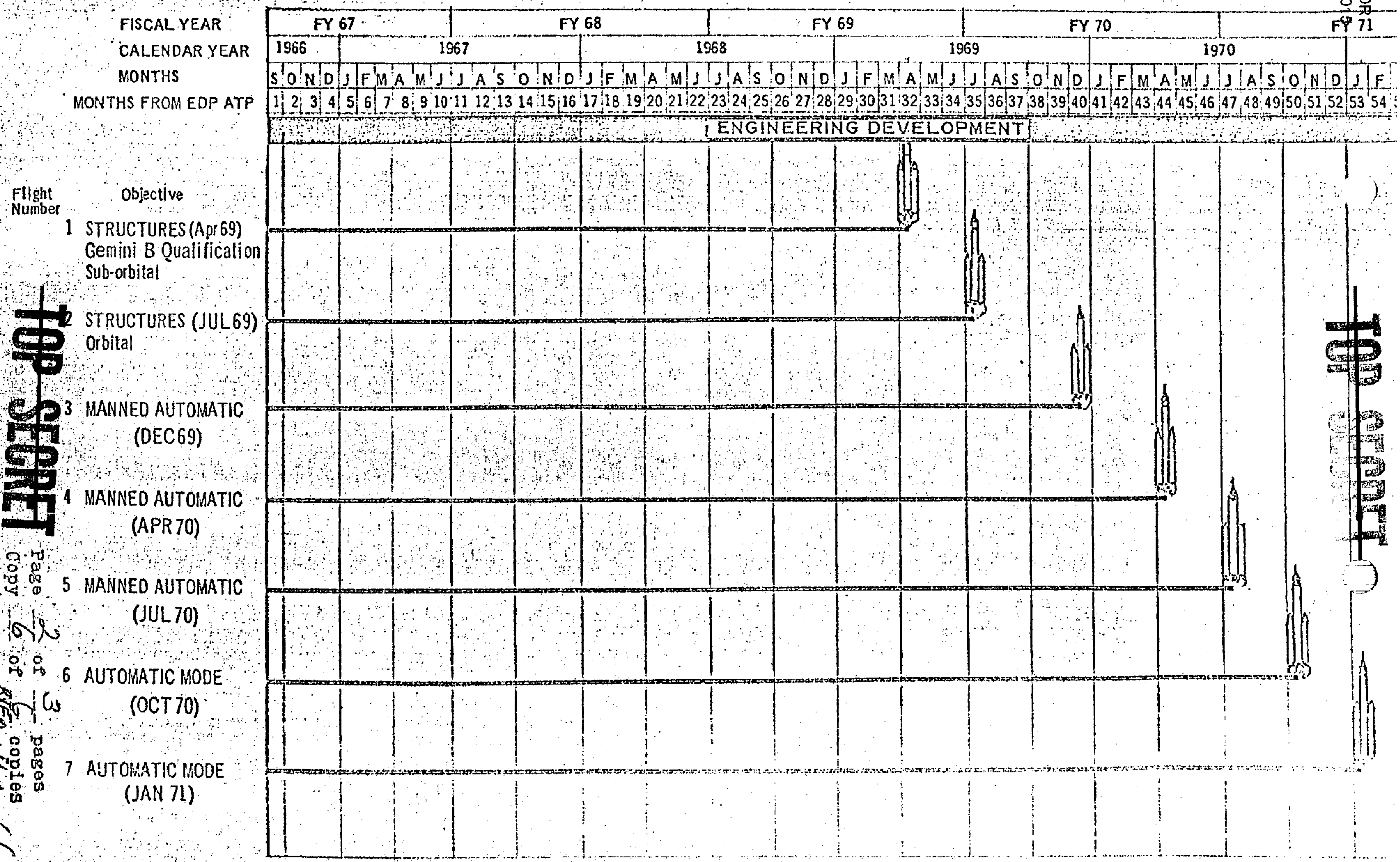

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Figure B-1

MOL PHASE II COST SUMMARY

SYSTEM	PRIOR	FY 67	FY 68	FY 69	FY 70	FY 71	TOTAL
Laboratory Vehicle	0	132.4	213.0	176.0	140.0	59.0	720.4
Mission Module	2.0	37.8	64.5	50.5	30.7	16.0	201.5
Payload	11.3	54.2	60.8	59.5	33.0	6.5	225.3
Gemini B	0	39.0	72.8	66.7	33.0	5.0	216.5
Titan IIIM	9.4	35.0	124.3	87.2	35.5	20.6	312.0
Other System Segments	0	2.6	11.0	7.5	7.0	2.9	31.0
GSE/TD	0	10.8	10.4	10.4	10.4	6.1	48.1
HSQ	17.5	5.0	0	0	0	0	22.5
Sub-Total (RDT&E)	40.2	316.8	556.8	457.8	289.6	116.1	1777.3
Facilities (Mil Con)	22.0	8.7	13.5	0	0	0	44.2
TOTAL	62.2	325.5	570.3	457.8	289.6	116.1	1821.5

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Page 3 of 3 pages
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Figure B-2

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Control System

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TAB C

BASELINE MOL EFFECTIVENESS FACTORS

Extensive analysis has been made of the functional and operational modes of the current baseline MOL, with particular attention directed to the contributions of man in the development of full mission potential. The findings of the analysis have shown that man's participation as an integral element of MOL results in

1. Reducing the initial development risk for both the manned and unmanned versions of MOL.

2. High probability of achieving mission success at program outset.

3. Attainment of mature systems reliability early in the flight program.

4. Significant increases in the quantity, and quality, timeliness, and uniqueness of the intelligence return over that expected of unmanned DORIAN configurations.

5. Alternate mission potentials of high intelligence value, such as [redacted] with no alteration in the vehicle configuration.

I. RELIABILITY, DEVELOPMENT RISK AND MISSION SUCCESS

The MOL Laboratory Module is based on current state-of-the-art subsystems, which in large measure have been adapted from the Gemini and Apollo programs. On the other hand, the Mission Module, which contains the DORIAN high resolution optical sensor, represents a major advance in the state-of-the-art, with an attendant high development risk. Additionally, MOL is designed to function both in manned and unmanned modes, hence its configuration is more complex than would be the case of a single mode. Many new components and subsystems must be developed, or adapted from existing designs to provide for this dual capability, such as

A. New Developments

1. Image Motion Compensation (IMC) across the Film Format

2. Image Tracking (V/h) Sensor

3. Wideband Photo Image Readout Subsystem

4. Tracking Mirror Drive Servo Subsystem

5. Acquisition and Tracking Scopes

6. Thermal Control Door and Louvre Assembly

7. Focus Sensor

8. Automatic Optical Alignment System

9. Low Drag Accelerometer

10. DORIAN Optical Assembly

11. Re-Entry Vehicle Launcher

B. Adaptation of Existing Designs

1. On-Board Computers

2. Star Trackers

3. Re-entry Vehicle

4. Consoles, Displays and Associated Instrumentation

5. Thermal Control System

Because of these new engineering requirements system reliability is a major factor in system design. In order to provide a basis for reasonable projection of reliability values, a failure analysis of the current GAMBIT program was conducted. The types of failures encountered fell into four general categories:

1. Design Deficiencies. Failures which can be corrected by change in basic design. An example is -- infrared horizon sensor locked on cloud rather than horizon.

2. Procedural Errors. Failures which can be corrected by procedural changes. An example is -- wrong command sent to satellite.

3. Quality Control. Failures can be corrected by better training, improved inspection, better acceptance testing. An example: stuck secondary propulsion system valve.

4. Random or Unknown. Failures which are not susceptible to specific corrective action, but result either in no change, or in added redundancy, more complete parts selection, or similar approaches. An example: malfunction of command decoder and programmer after period of successful operation.

Of GAMBIT failures, 21% were due to Design Deficiency, 5% to Procedural Error, 47% to Quality Control, and 26% were Random or Unknown. It is significant to note that while 74% of the failures were attributable to what might be considered "non-random" causes, only 26% were attributable to random or unknown processes, and thus of the type usually referred to as "reliability failures". The largest single category is that of Quality Control, i.e., failures where neither the design nor the procedure is deficient, but where fabrication and assembly techniques were faulty. It is also of interest to note that all non-random failures occurred in the first day on orbit, whereas the random or unknown failures were distributed throughout mission duration.

GAMBIT failure rates have been reduced in recent flight history through a sophisticated and thorough ground testing program in which incipient failures were detected and corrected before actual flight. This testing is analogous in approach, though neither as extensive nor similar in motivation, to the "man-rating" process which NASA has employed to a high degree of success, and to which MOL will be subjected.

With an intensive approach to ground testing, both random and non-random failures can be reduced, but it is clear that failures of either type cannot be completely eliminated. The Mission Module, representing advanced state-of-the-art, can be expected to experience malfunctions at a higher rate than the Laboratory Module, for which phenomenology and technology are well in hand.

However, the MOL is being designed to take the maximum advantage of the presence of man in the event of equipment failure. Equipment is being designed and installed wherever practicable to permit astronaut access for trouble shooting, adjustment, maintenance, repair, and replacement. The system is being designed to permit manual switching and override so that man can work around problems, choose alternate modes, or himself perform the function for which the faulty equipment was intended.

His capability for in-flight trouble shooting is expected to be one of the major contributions to the early success and maturity of MOL. He can detect malfunctions, both incipient and actual, diagnose, and institute corrective measures. He can also work in coordination with ground based technical support. This team approach, as shown by aircraft experience, is a powerful technique for overcoming in-flight problems. The recent XB-70 experience in which a nose gear failed to lower is an excellent case in point. Repeated consultations between flight crew and ground supported by trouble shooting in flight, permitted the diagnosis of the trouble, and a corrective action to be devised to lower the nose gear with the aid of a paper clip and save the aircraft. It is significant to note that no amount of pre-analysis would have predicted this particular failure nor its solution.

As a result of these design principles which have been factored into the MOL, it is possible to continue a manned mission despite cumulative equipment failures beyond man's capacity to repair. To examine this point in more detail, consider the two basic manned operational modes for MOL. The first, the usual mode, involves automatic programming both of the acquisition and tracking scopes, as well as the primary optics to pre-planned, and usually different targets, taking photographs automatically, and tasking the crewmen with altering this a automatic sequence to increase the quality and quantity of intelligence collected through weather avoidance, target selection,and target validation. In this way man exploits automaticity to produce data of considerably greater value than would result from automatic operation alone. The second mode is the manual mode in which the crew manually acquires the target, centers it in the field of view, nulls image motion, then activates the photography sequence through the main optics. Assuming MOL operating in the usual man-augmented automatic mode, the following equipment can fail cumulatively with little or no degradation in mission performance beyond the basic capability of the manual mode

1. Image Tracking (V/h) Sensor
2. Image Motion Compensation (IMC) Across the Film Format
3. Star Trackers
4. Data Recovery Vehicle Launcher
5. Wideband Photo Image Readout
6. One SGLS Command and Tracking Data Link
7. Two Fuel Cells

8. One Cryogenic Tank

9. Three Pairs of Attitude Control and Translation System Fuel Tanks

10. 25% of Attitude Stabilization System Thrusters

11. Automatic Mode for Orbit Adjust

12. One On-Board Computer

13. One Acquisition and Tracking Scope

14. Laboratory Attitude Reference System

15. Auxiliary Computer Memory Storage

The resulting performance in the manual mode after failure of the above equipment is approximately equivalent to an unmanned configuration with all of its automatic equipment functioning, except that overall mission photographic resolution still remains somewhat better in the manned mode due to man's target centering capability. In essence, the presence of man results in a MOL system less complex than a comparable unmanned system. A most important outcome of the flexibility of man is that trouble shooting, adjustment, maintenance, repair and replacement, or actual manual performance of machine automated functions will be done on much of the equipment in the high development risk category.

A numerical reliability analysis of the Mission Module alone in the unmanned mode results in a mature reliability figure for <u>random</u> failures of .892, although it is somewhat less (.8 to .85) early in the flight program. This analysis is based on a random failure rate of one failure per ten million hours per Active Element Group (AEG), and estimating that the Mission Module contains the equivalent of 10,000 AEG's in serial, and 19,000 in redundancy. For reference purposes, GAMBIT has an equivalent AEG count of 6500, and GABMIT CUBED is estimated at about 10,000. Clearly the Mission Module is a very complex system element.

Reliability estimates were then computed for the MOL as a system, as presently configured to function in both manned and unmanned modes, and for a comparable wholly unmanned system, both using the same Mission Module. A comparison of the two approaches was then undertaken to determine the number of unmanned launches which would be required for equivalence with the MOL flown in the manned mode. Then, with each of the systems operating in a similar orbit against the same target list, the following assumptions were established:

A. MOL in Manned Mode

1. Design Life = 30 Days

2. 5 Manned Launch Development Program

3. 6 Operational Launches per Year for 5 Years After Development Program

4. Man-Rated Booster Reliability (Random Failures) =.97

5. Manned Orbiting Vehicle Reliability, Including Mission Module (Random Failures)=.95

6. All Non-Random Failures Repaired or Alternate Modes Used by Crew

7. Combined Booster and Orbiting Vehicle Probability of Success for 35 Launches (Random Failures) =.92

8. Mean Mission Duration(Adjusted for Booster Reliability) = 28 Days

B. Equivalent Wholly Unmanned System

1. Design Life = 30 Days

2. 6 Launch Development Program

3. Operational Launches as Required over 5 Year Period After Development Program

4. Non-Man-Rated Booster Reliability (Random Failures) =.93

5. Orbiting Vehicle Non-Random Failure Assessment:

	First Ten (Incl. Dev. Launches)	Second Ten	Third Ten
Orbital Control Vehicle	1	0	0
Mission Module	3	1	0

6. Orbital Control Vehicle Reliability (Random Failures) =.91

7. Mission Module Reliability (Random Failures) =.81

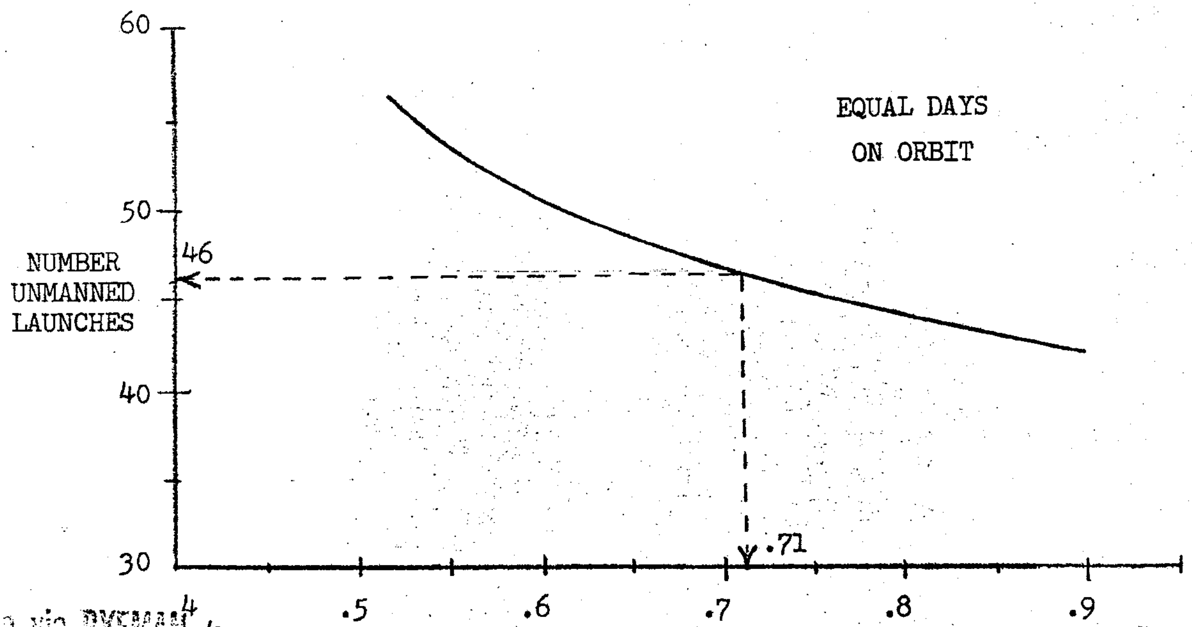
8. Combined Launch and Orbiting Vehicle Probability of Success (Random Failures) =.71

9. Mean Mission Duration (Adjusted for Booster Reliability) = 24 days

In the case of the Wholly Unmanned System, both random and non-random failures are taken into consideration. Four of the first ten vehicles are projected to fail in their first day or orbital life, on this basis. Of the second ten, only one failure of this nature is projected, and no others are assumed to occur after the twentieth launch, which reflects the improvement in the learning curve, assuming that experience in GAMBIT can in fact be applied to this system with success.

Due both to its "man-rating" and the presence of a crew, the MOL in the manned mode is not projected to experience any non-random failures and few random failures which cannot be repaired or otherwise overcome by crew selection of alternate modes.

The following curve shows the trend of the number of unmanned launches, including those which fail on the first day due to non-random failure processes, required to equal the number of days on orbit achieved by the 35 manned launches:



PROBABILITY OF SUCCESS (RANDOM FAILURES)

II. QUANTITY, QUALITY AND TIMELINESS OF INTELLIGENCE RETURN

The DORIAN high resolution optical system represents a major advance, not only in photographic art, but also in optical science. The size of this sensor, which requires a mission module 35 feet long and 10 feet in diameter to contain it, is difficult to visualize. The prime optical elements themselves stand taller than most men (they are six feet in diameter). Few astronomical telescopes approach this size, and even fewer, including the 200 inch Hale telescope on Mt. Palomar, can match DORIAN optical quality.

An optical system the size of the DORIAN sensor is essential to the achievement of [redacted] ground resolution from an orbit altitude of 80 nautical miles. But with this size, and with high resolution, the optical field of view, hence the area on the ground observed by the sensor, becomes very limited. This is apparent when the fields of view of current systems are compared with the DORIAN camera:

	Camera Field of View	Nadir Frame Width	Frame Width at Maximum Oblique
GAMBIT	6.4°	8.95 n.m.	17.94 n.m.
GAMBIT CUBED	3.2°	4.45 n.m.	8.95 n.m.
DORIAN	1.1°	1.54 n.m.	2.38 n.m.

GAMBIT and GAMBIT CUBED utilize strip cameras, in which film is pulled past a slit in the focal plane in synchronism with the satellite's apparent motion over the terrain. Strips of film are typically exposed for about 5 seconds, which represents about 21 miles along the satellite path over the earth. the DORIAN camera, on the other hand, is a frame camera, that is the film remains motionless while the scene is tracked and entire frame of film is exposed at the same time. At nadir, the camera frames have included areas of:

GAMBIT	188 sq miles (Rectangular format)
GAMBIT CUBED	93.5 sq miles (Rectangular format)
DORIAN	1.88 sq miles (Round format)

It is immediately obvious that a great premium is placed on the accuracy of target location, and the precision to which the DORIAN optics can be pointed so that the target will fall in the camera field of view. At nadir, a 12,000 foot airfield runway cannot be contained in the DORIAN field of view, hence we must now specify which end of the runway we wish to photograph. Two major effects arise from these circumstances; one, locations which represent one GAMBIT or GAMBIT CUBED target area (which in itself could contain several specific targets) will now represent several DORIAN sized targets; and two, careful target selection becomes of paramount importance because photographs of all targets which are closely clustered cannot be taken on a single active pass. Every effort must be made under these conditions to insure that each photograph is of the highest intelligence value.

It is here that man offers immediate capabilities to increase significantly the value of intelligence returned, principally due to

- Verification of Targets Photographed
- Avoidance of Weather
- Selection of Active Targets

1. Avoidance of Weather

By exploiting the automatic mode of the MOL baseline system, the crewmen need not routinely acquire and track targets for target centering and image motion compensation as long as all systems are functioning (of course, this remains a vital function when key subsystems have failed). Thus, they are free to perform other functions while over the target area. Operating in the automatic mode, they are freed to look ahead in the vehicle's path to perform a weather avoidance function.

A striking assessment of man's capability to perform a weather avoidance role has been developed in quantitative form in a study accomplished by the NRO Staff. This study evaluated the numerical improvement in the total amount of cloud-free photography obtained when man is used in the weather avoidance function.

A minimum of theory and a maximum amount of experience and realism was employed throughout the study. Every effort was made to use existing photographic reconnaissance requirements, actual target decks and existing weather. The MOL vehicle was programmed and operated in an almost identical manner to the present GAMBIT (KH-7) and contemplated for the GAMBIT-CUBED (KH-8).

The possible improvement due to man in the weather avoidance role was determined by measuring the relative amount of cloud-free photography of the MOL vehicle in the manned versus the unmanned mode of operation. Identical physical capabilities were used for each mode; the use of the man was the only variable. To assure that all identifiable effects of the voluminous number of variables were eliminated, identical operating environments were provided for each, i.e., the same targets, launch time, weather, target selection method, photographic requirements, etc. The selection of each of the above was carefully chosen so as not to provide an advantage for either mode.

The target deck consisted of 3428 targets containing 361 DIA selected targets and 205 targets external to the Sino-Soviet Bloc. The remainder of the targets were selected from the existing GAMBIT/GAMBIT-CUBED target deck provided by the USIB.

The orbit was selected by the best coverage of the highest priority targets within the actual MOL vehicle operational and functional constraints. The orbit selected provided 4 complete accesses to the Sino-Soviet Bloc in a 30-day period.

Individual targets to be photographed were selected by the GAMBIT/GAMBIT-CUBED computer software. This target selection provided an optimum sequential series of photographic operations based upon target availability, the orbit, target priorities, target photographic mode requirements and vehicle capabilities. This sequential list of target photographic operations represents the absolute maximum capability of the MOL vehicle and numbered 3988 operations for the 30-day mission evaluated.

Suitable alternate targets for the manned system were selected manually for each of the above designated primary targets. Alternate targets were limited to three for each primary target. Their average distance from the primary targets was approximately 30 miles. Approximately one-half of the 3988 targets photographed had at least one alternate, one-third had at least two alternates and one-fourth had three alternate targets assigned.

The unmanned MOL vehicle was required to photograph each of the 3988 primary targets regardless of weather. The manned MOL vehicle utilizing man in the weather avoidance function was permitted to select the best of the alternate targets where clouds covered the primary. Thus, both the manned and unmanned vehicle had to take a picture for each of the 3988 target operations. If man did not select an alternate the primary target was photographed. <u>If 100% clear skies had prevailed during the entire 30-day mission, both the manned and unmanned vehicle would have returned precisely the same photographic product</u>. Stated another way, the worst the manned vehicle should do, under these conditions, is the very best the unmanned vehicle could possibly do.

Recognizing the sensitivity of the comparison to the assumed weather (because the probability for each camera operation by the manned system is the mathematical sum of the primary plus alternate target probabilities), several different approaches were taken toward defining the "average" weather model:

a. A weather-distribution model was made based on the analysis of approximately 1200 individual frames of KH-7 photography (taken during three separate missions).

b. The results of more than 3,000 KH-7 camera operations (seven different missions) were analyzed and a second weather model was created based upon the actual results achieved vs the weather "observed" (weather observation broadcasts plus weather satellite inputs) at the time photography was attempted.

c. A third weather distribution model was created based upon the analysis of 152,000 frames of KH-4 photography. Additionally, a complementary weather distribution model was made for the alternate targets which averaged 30 miles distance from the primary targets.

d. The observed weather in the Sino-Soviet Bloc for each target area during the month of March 1960 was obtained and the probable results of 30-day missions by both manned and unmanned systems were computed. In this case, the number of targets photographed by the manned system were approximately 30 percent greater than the unmanned system; however, later analysis indicated that this particular 30 day period represented worse-than-average climatology and this condition favors the manned system optional use of alternate targets.

e. Additionally, several mission days (by both systems) were analyzed against observed weather in 1966.

The weather model based upon the analysis of 152,000 frames of KH-4 photography was judged to be the most generally representative of average Sino-Soviet Bloc weather (it correlated almost precisely with KH-7 results achieved over the life of that program). Using only the primary target operations for the unmanned system, the total number of targets photographed was determined. <u>This is the total unmanned product</u>. The total number of target photographs the manned MOL vehicle would acquire was determined by summing the probabilities for each primary target and its alternate targets (where available and appropriate).

Considering the conservative approach of this study, the results which were obtained are significant. Approximately an 18 percent improvement can be expected using man in the weather avoidance role. When the weather is worse than average climatology, the manned system demonstrates more than an 18 percent increase in the number of targets photographed. When the weather is considerably better than average, the manned improvement can be as low as 10 percent.

The weather studies indicated that approximately 25 percent of the time, the weather conditions encountered are 90-100% cloud cover; here, the manned system contributes little increase over the unmanned system in total targets covered in a weather avoidance role. In the remaining 40% of the time, the weather conditions encountered vary from 10-90 percent cloud-cover; here, the value of the weather avoidance function would vary in proportion to the amount of cloud-cover. Thus, it appears that the astronauts could be involved profitably in weather avoidance about 50 percent of the time during photographic operations.

The study resulted in 2191 clear plus partial targets for the unmanned system and 2594 clear plus partial targets for MOL. GAMBIT experiences 77% clear targets and 23% partials. Of the partials, 40% are evaluated as good photographs and 60% as poor to practically useless. For MOL, only good photographs can be considered, since high resolution is the objective. About 10% of all GAMBIT targets are larger than DORIAN targets. One would expect, therefore, that the percentage of partial DORIAN targets would be less. A reasonable estimate would be 15%. The weather-improvement factor is not sensitive to this estimate. Using the 15% figure and the 40% quality factor against the total clear photographs yields 1994 good target photographs for the unmanned system and 2361 for MOL.

2. Target Verification

This TAB discusses in a quantitative manner the improvement to be expected in the MOL mission by crew confirmation of successful photography. Applicable data for the analysis were obtained from the weather avoidance study conducted by the NRO staff. (See elsewhere in this TAB) The intent, however, was to divorce completely the target verification function from that of weather avoidance.

The measure of improvement most appropriate in comparing the manned and unmanned cases was considered to be the number of good photographs obtained of different or unique targets. Although multiple photographs of important intelligence objectives probably would be required in an actual 30-day mission, coverage of these objectives can be considered coverage of different targets. In this analysis the intelligence need was assumed satisfied if one photographic operation against a target was successful.

The NRO Study data applicable to this analysis are as follows:

a. The target deck consisted of 3428 targets -- 3223 within the Sino-Soviet Bloc and 205 external.

b. The total number of operations in the simulated 30-day mission was 3988. (An operation is equivalent to a primary target access).

c. 1990 good target photographs resulted from the unmanned simulation (including multiple photographs of a single target). This corresponds to an approximate 50% overall weather probability of obtaining good photography.

d. The number of different targets operated against was 1539 with the multiple-operation distribution as follows:

Number of Operations On Same Target	Number of Cases	*Cases With Alternate Targets Available
1	805	--
2	249	--
3	130	--
4	104	--
5	70	43
6	73	40
7	29	14
8	32	19
9	14	6
10 (or more)	33	14
Total Different Targets Operated Against	1539	

* Note: Cases of 1, 2, 3 and 4 operations were considered to have sufficient alternates. Cases of 5, 6, 7, 8, 9, 10 (or more) without alternates were classified as remote.

In the manned case it is assumed the crew member is completely accurate in his assessment of target cloud coverage. He will cause a target to be deleted from further mission consideration immediately after its photography has been determined successful. A replacement target will then be operated upon except in those remote areas where a replacement is unavailable. It is assumed that for those targets operated upon four times or less, during the NRO Study simulation, there is always a replacement target. The remote targets are those observed five or more times where no alternates were recorded in the NRO Study.

The following table tabulates the computation for the manned verification case. The good photographs of unique targets are derived by applying the 50% weather factor to the number of operations in each case of multiplicity. Although the remote targets are operated upon 926 times, only one good photograph of each can be included in the total. The resulting total good photographs of unique targets with manned verification is 1647.

Multiple Operations	Number of Unique Targets Operated On	Number of Operations	Good Photographs of Unique Targets
1	805	805	403
2	249	498	249
3	130	390	195
4	104	416	208
5	43	215	108
6	40	240	120
7	14	98	49
8	19	152	76
9	6	54	27
10 (or more)	14	194	97
Remote	115	926	115
Total	1539	3988	1647

In the unmanned case verification of target successful coverage is possible by examining the results of photography returned by capsule while the vehicle is still operational. For this computation, it is assumed that capsules, each containing one-fourth of the total mission photography will be recovered on the 7th, 15th, 22nd and 30th days of the mission. It is further assumed that four days will elapse from de-orbit until a feedback to the vehicle can be effected (this includes: capsule transport, film processing, film interpretation and reporting, command generation, and command loading). Therefore, 11 mission days will have passed before analysis of the first capsule take will change the target programming. Similarly, 19 days will be required for input from the second capsule, and 25 days for the third. The new replacement targets will be operated on for only two-thirds (approximately) of the mission in the case of the first capsule, one-third for the second capsule, and one-sixth for the third. In addition, successful coverage of the new targets resulting from each capsule return is subject to the same weather probability (or less) than that with no verification as determined by the multiplicity of observations. The remote targets were handled in the same manner as in the manned case.

The following table lists the computations. No verification whatever results in 1050 good photographs of different targets. The first capsule adds 77 to this number, the second 39, and the third 20, resulting in a total of 1186 good photographs of different targets unmanned with capsule verification.

(See Following Page for Table)

Based upon the NRO Staff simulation target deck and the assumptions contained herein, manned target verification results in obtaining good photography of 461 more unique targets than unmanned with capsule verification. This represents a manned improvement over the unmanned of 39 percent.

3. Selection of Active and Mobile Targets

Freeing MOL crewman from routine target acquisition and tracking tasks by operating the manned MOL vehicle in the automatic mode also permits employment of another operational technique, that of inspecting targets for indications or activities of a transient nature that would yield photography of especially high intelligence value.

5 (Cont'd)

Mult Ops	Unique targets operated on	Probability ~~Probability~~ of photographing individual target	Good Photos of Unique targets — no verification	Unmanned Case: Capsule # 1 $(\frac{1}{4})(\frac{2}{3})$	Capsule # 1 Good Photos	Capsule # 2 $(\frac{1}{4})(\frac{1}{3})$	Capsule # 2 Good Photos	Capsule # 3 $(\frac{1}{4})(\frac{1}{6})$	Capsule # 3 Good Photos	Total Good photos of Unique Targets
1	805	0.50	403	—	—	—	—	—	—	403
2	249	0.75	186	31	23	16	12	8	6	227
3	130	0.88	114	19	17	9	8	5	5	144
4	104	0.94	98	16	15	8	8	4	4	125
5	43	0.97	42	7	7	4	4	2	2	55
6	40	0.98	39	7	7	3	3	2	2	51
7	14	0.99	14	2	2	1	1	0	0	17
8	19	1.00	19	3	3	2	2	1	1	25
9	6	1.00	6	1	1	0	0	0	0	7
10 (or more)	14	1.00	14	2	2	1	1	0	0	17
Remote	115	1.00	115	—	—	—	—	—	—	115
Total	1539	—	1050	88	77	44	39	22	20	1166

To assess the value of this technique an analysis was conducted which

a. evaluated the effect of the limited DORIAN field of view when superimposed on actual GAMBIT photography on the size, number, and character of MOL targets;

b. determined whether certain activities or conditions might exist for periods of hours or a few days during which the value of technical intelligence would be particularly high, and

c. determined whether indicators would be present which the crewmen could detect by examination through the acquisition and tracking scope.

The extremely high resolution of the DORIAN sensor and its limited field of view are of overriding importance in the assessment of its coverage. This becomes evident from a sample of 140 frames of GAMBIT photography in which 700 DORIAN sized targets were found. Some of these were larger than the available field of view and hence would actually be considered two or more targets. This proliferation of targets renders target selection for DORIAN of particular importance. As a first step, indicators of transitory conditions of special intelligence value that crewmen might easily detect were defined. Utilizing the 140 frames of GAMBIT photography with its 700 DORIAN sized targets,

a. The fraction of the targets which had potential for active indicators of conditions of special intelligence value was estimated and

b. Of those, the fraction that would have active indicators present at any given time was determined.

Transient Activity Indicator Probabilities

Target Categories	Possibility of Occurrence	Likelihood of Occurrence
Missile Development & Test	99%	7%
Ground Forces	35	11
Airfields	75	18
Radar/Communications Deployment	35	4
Industry	5	2
Missile Production & Logistics	65	1
Nuclear Weapons	85	5
BW/CW	85	5
Nuclear Materials	5	3
Aircraft Production	75	24
Naval Activity	65	9
Radar/Communications Major & R&D	100	25
	70%	6%

The fraction of targets for which active indicators can be defined is relatively large while the incidence of indicators is low.

Because of its importance in yielding early technical intelligence data on the USSR missile and space programs, Tyuratam has been studied in some detail. In addition to its specific importance, Tyuratam is also a typical example of other high target density complexes such as Sary-Shagan and Kapustin Yar which contain large numbers of high priority, active targets. More than 60 targets can be identified currently at Tyuratam and the number is increasing steadily. Five GAMBIT frames laid down with care will cover the entire Tyuratam complex. Forty DORIAN fields of view have been defined, with specific locations, which would generally return the same "target take" as the five GAMBIT frames. With four over-flights per mission and two stereo pairs per over-flight, on the average, one unmanned DORIAN system flight will be about equivalent to one GAMBIT system flight in terms of the "target take" at Tyuratam. Therefore, with probable fewer flights of an unmanned DORIAN system, the "target take" at Tyuratam could be expected to be about half that which will currently be obtained with the GAMBIT system.

An analysis was made of Tyuratam photographs of pads and silos:

159 pad photographs yielded 9% with missiles on the pad.
77 silo photographs yielded 21% with doors open.

These are much higher incidences than would be expected from operational systems, which further emphasizes the importance of obtaining data in the early development phases.

The unmanned DORIAN system would require times from months to years to develop a high probability of catching a particular missile on a pad depending upon the priority structure given to the forty fields of view required to cover the complex.

However, MOL crewmen can examine targets for active indicators through their acquisition and tracking scopes, and can begin to yield a gain in the return of photographs of high intelligence value. An estimate of typical resolutions needed by the crewmen to detect active indicators was carried out with the following result:

Photo Target	Indicators	Decision Resolution
Missile Sites (Completed)	Missiles Exposed	10 Ft.
	Erection/Loading Equipment Exposed	10
	Vehicular Activity	10
	GSE Exposed	5
	Silo Door Open	5
	Special Vehicles	3
	Snow Removal	10
Airfields	New Aircraft	15
	Unusually Configured Aircraft	5
	Aircraft in Unusual Locations	15
	Disassembled Aircraft	5
	Aircraft/Ground Equipment in Weapons Loading Areas	
	Aircraft Subsystems Exposed	3
	Aircraft in Maintenance Docks	10
	Vehicle/Truck Activity Around Aircraft	5
Ground Forces, Major Installations	Vehicles Present	5
	Vehicle Types	3
Motor Pool	Maintenance Activity	5

The question of the practicality of this mode of operation hinges upon two points;

a. with what resolution can the crewman examine the target, and

b. how long can he examine the target before a decision is required.

It appears that a reasonable design for the tracking scope will permit the following range of operation:

Ground Resolution	Field of View
3 - 4 feet	1°
30 - 40 feet	10°

With the particular time constants of the MOL/DORIAN system, the crewman will have 10 seconds to examine and judge for the presence of indicators (starting the examination with the target at 36° ahead of the vehicle and ending at 11° ahead). If the judgement is affirmative, a 15° stereo pair can be obtained looking aft at -5° and -20°. If a larger aft angle is acceptable the examination time can be correspondingly longer.

The specific concept of the "examination for active indicators mode", is to program the primary optics as though the MOL vehicle were unmanned. In addition, the two acquisition and tracking scopes will be programmed automatically to acquire and track two targets in the immediate vicinity of the target programmed for the primary optics (specifically, the three targets will be chosen to establish to the most efficient roll angle between them, thus optimizing the time to slew the primary mirror from one to the other). At any instant that a crewman makes a judgement that active indicators are present (and the weather is good), he interdicts the automatic program, the primary mirror slews to the position of the acquisition scope mirror, and a stereo pair is obtained. At the end of the sequence, the primary optics returns to the next pre-programmed target.

The acquisition of a stereo pair requires 10 to 12 seconds. Depending upon when the automatic cycle is interdicted, 1 to 2 of the pre-programmed targets will be lost each time a crewman interdicts.

To determine the enhancement of the return of especially valuable intelligence photographs due to crew target examination, two days of runs against a typical target deck were made with and without crew participation. The results are shown below:

	Number of Attempts in The Automatic Mode	Number of Targets Examined by Crewmen
Day 1	93	111
Day 2	114	171

Averaging these two days, the resulting "take" with and without crew participation, is as follows:

Analysis of Collection of
Photographs of Special Intelligence Value

Assumptions

- 50% Cloud Cover
- Photographs are Stereo Pairs
- 70% of Programmed Photographs are Potentially Special
- 6% of Potentially Special Are in Fact Special
- 1.5 Programmed Photograph Reduction Factor for each Interdiction
- Crew Does Not Use Weather Avoidance Technique

DORIAN/GAMBIT

Automatic Mode Only

- 104 Programmed Photographs per Day
- 104 x 0.50 = 52 Cloud Free Programmed Photos per Day
- 52 x 0.70 = 36.4 Potentially Special Cloud Free Programmed Photographs per Day
- 36.4 x 0.06 = 2.2 Cloud Free Special Programmed Photographs per Day

Manned Target Selection Mode

- 141 Potentially Special Photographs per Day
- 141 x 0.50 = 70 Potentially Special Cloud Free Photographs per Day
- 70 x 0.06 = 4.2 Cloud Free Special Photographs per Day
- 4.2 x 1.5 = 6.3 Normally Programmed Photographs Lost Due to Interdiction
- 104 -6 = 98 Normally Programmed Photographs Retained per Day
- $\frac{98}{104}$ x 2.2 = 2.1 Clear, Special Photographs from Retained Programmed Photographs per Day

Manned Improvement Factor

- Cloud Free Photographs per Day with Crew Participation

$$\frac{104}{2} + 4.2 - \frac{6.3}{2} = 53$$

- Special Photograph Occurrences

  4.2 Handled By Crew
  2.1 Retained Program
  6.3 Total Manned

- Manned Improvement Factor for Cloud Free, Special Photographs

$$\frac{6.3}{2.2} = 2.9$$

Several key points emerge from the analysis:

1. Because of the low incidence of active indicators, the acquisition of pre-programmed targets is effected only slightly -- reduced from 104 to 98 per day.

2. The reduction in clear photographs returned in the automatic mode because of crew interdictions is offset by the added clear, special photographs, even if the enhance value of the special photographs is not taken into account.

DORIAN/GAMBIT

3. The ratio of clear, special photographs returned with and without crew participation is large -- 2.9. This number is believed to be conservative since it does not account for: (1) examining more than one target in the 10 second period in high target density areas and with possible slow panning by the crew to cover large targets like airfields and harbors, and (2) possible increases due to crewman examination and judgement of weather factors.

A digital data readout system in the MOL baseline system is capable of reading out 15 stereo pairs (1" x 1") to the ground per (9" x 9") and transmit to the ground all clear, special photographs (4 per day) which they have acquired. The remaining capability can be used to transmit photographs of high priority targets taken in the pre-programmed, automatic mode.

It is instructive to compare the "take" in a typical operational mission for the automatic mode (flown completely unmanned) and the manned mode:

Photograph Take Per Flight

	Automatic Mode (Mean Mission Duration = 24 days)	Manned/Automatic Mode (Mean Mission Duration = 28 days)
Clear Programmed Photographs Per Flight	1,248	1,484
Clear, Special Photographs Per Flight	53	176

Note: Photographs are Stereo Pairs

The return of clear photographs is moderately increased with the manned system due to greater reliability. But the dramatic gain is in the number of clear, special photographs returned with especially valuable intelligence.

Turning again to the previous example of Tyuratam, the number of special photographs collected based on the findings of the above analysis would be expected to be increased by a factor of 4 to 10 over an unmanned automatic mode. There are several reasons why the increase should be realized:

1. The targets tend to be clustered so that several may be examined in a single field of view or with a slight amount of panning.

2. Examining launch pads for the presence of missiles might well be done at 10 to 20 foot resolution, thus tripling or quadrupling the field of view examined by the crewmen as compared to the main optics.

3. The targets at Tyuratam have very little background clutter and the crewmen will become extremely familiar with them through repeated training and examination. Thus, it is expected that the time to examine a target will be much less than the allotted 10 seconds.

In general, the MOL system with crew participation can be expected to return 2 to 4 times more special photographs from Tyuratam than the current return with the GAMBIT system (with the MOL system flying half as many flights).

A special category of active targets deserves particular attention. These targets are not only transitory, but they are also mobile. Examples are (a) an experimental aircraft which may operate from a known airfield, but its location on the airfield is not known (b) a missile or space booster being transported on an access road in the vicinity of a target launch pad (c) tanks, mobile missile launches or similar materiel in a field or a general research and development area (d) trains on sidings. The specific location of these targets cannot be predicted with surety, but a search in the vicinity of the main optics field of view can surface these targets. The man can then make a vernier centering adjustment to bring the special target into the primary field of view. It is also quite possible for the crewmen to actively track moving targets to obtain high resolution photography. This function cannot successfully be done by the V/h or image tracking sensors. Man is indispensable in locating and tracking targets of this general category.

III. ALTERNATE MISSION POTENTIALS OF HIGH INTELLIGENCE VALUE

1. [redacted]

2. Crisis Surveillance and Tactical Targets

Man's particular capabilities both with respect to improving the basic performance of the DORIAN sensor, and in overcoming equipment shortcomings and failures, are largely a result of his capacity to reason, to make judgements, and to render specific decisions. These factors can be put to work under the circumstances of international crisis, particularly when a capability to observe and photograph critical events is better done without the provocation of visible overflight. Even should the presence of MOL in orbit be known, the fact that it is routinely so would obviate the element of provocation which might otherwise arise should other overt activities have to be mounted in response to the critical situation.

The MOL can, in times of crisis, be boosted from its 80-mile orbit to orbits of 200 to 250 miles. Although changes in orbit altitude and period can be readily detected by careful ground tracking, such changes might not be considered unusual, as MOL routinely (and detectably) adjusts its orbit to make up for losses due to drag.

The advantage of the higher orbits is that they permit access to all targets in the Sino-Soviet land mass once every two to three days or so depending upon the actual altitudes and orbital ellipticity selected. Altitude changes are accomplished by using fuel normally utilized to sustain the MOL in its usual orbit. When the orbit perigee is raised, fuel expenditure for orbit sustenance is sharply decreased, and duration on orbit can remain unchanged at the normal 30 days. The maximum circular orbit altitude which can be attained with available fuel is about 260 nautical miles, although the Gemini B sets a practical limit of about 240 miles. Above this altitude, insufficient thrust is available from the retro-rockets (on the presumption that only 5 of the 6 rockets provided function properly) to de-boost the Gemini for re-entry. Eliptical orbits can also be selected, rotating the line of apsides, for example, so that apogee occurs over the area of interest. Orbital limits in this case are set by permissible Gemini re-entry angles, and, at the higher average altitudes, the Gemini de-boost capability. The following shows the circular orbit altitudes to which MOL can be boosted according to when the change is initiated from a typical normal orbit (80 n.m. perigee, 180 n.m. apogee, inclination 80°). In all cases, re-entry is initiated after 30 days in the higher orbit.

*New Circular Orbit Altitude (n.m.)	Orbit Change Initiated On: 1st Day	7th Day	14th Day	21st Day
150	30	30	30	30
180	30	30	30	30
200	30	30	30	30 at 190 n.m.
250	30**	30 at 210 n.m.	30 at 200 n.m.	30 at 190 n.m.

*Note: 213.6 n.m. repeats every 2 days, 240.5 n.m. every 3 days.

**Marginal. Exceeds Gemini De-boost limit.

The field of view of the DORIAN sensor in terms of area of terrain observed is increased, and its resolution decreased at higher altitudes, although these factors should not affect crisis surveillance needs.

[redacted]

DORIAN/GAMBIT

Orbit Altitude Over Area of Interest	Nominal Resolution	Area Observed at Nadir
80	[redacted]	1.88 sq miles
150		6.56 sq miles
200		11.65 sq miles
250		18.25 sq miles
300		26.20 sq miles

In addition to the prime optical sensor, which can be utilized simultaneously in both photographic and visual modes, both of the acquisition and tracking scopes can be programmed to different suspect areas on the ground, multiplying the opportunity for the observation of activities of interest. Although acquisition and tracking scope resolution will fall off to about 9 feet at 250 n.m., the field of view is large compared with the DORIAN sensor, and some categories of activity can be readily distinguished visually, such as:

a. Gross count of large objects, such as aircraft, ships in port, tanks in park.

b. Verification of the absence or presence of aircraft on airfields, ships in port, cargo in port, army vehicles in camp.

c. Estimate of whether railroad yards are empty or full, and if full, general class of rolling stock present.

Hence, operated in this mode, advantage of man's flexibility and adaptability is turned to the return of urgently needed intelligence data on a daily basis.

Inherent in either normal or crisis surveillance modes, is the capability to program the MOL for the collection of both photographic and visual reconnaissance of tactical and battlefield areas. Although coverage would differ from that which aircraft reconnaissance provides, it may prove extremely valuable where certain sanctuaries exist (such as particular cities, buffer zones, and national boundaries) and aircraft overflight is denied.

3. Visual Reconnaissance

Apart from the support which visual observation affords the primary photographic mission in terms of target verification, weather avoidance and active and mobile target selection, and to the crisis surveillance mode in terms of verifying order of battle, and confirming presence or absence of major activity, visual reconnaissance remains a latent potential. It is highly likely that a critical examination of highly important targets, during the high resolution photography sequence, can provide supplementary information of major value. Events may be detected that may not be caught or identified on the photographic image. Targets can be inspected by the crewmen from a continuously changing aspect. They can do simple counting by class of object, discriminate detail by color, classify activity, and detect and classify movement. The value of visual reconnaissance from space is difficult to assess at this point in time, but the capability is present in the manned MOL system.

4. Observation and Mapping of Mars

It is expected that interest in the planet Mars will be heightened in the 1970 time period as the national space program looks beyond Apollo. In support of this interest, the DORIAN sensor, with no change in its configuration, offers a capability to examine and map the entire surface of Mars at about 50 n.m. resolution. This is considerably better then present ground based systems (300 n.m.) which are handicapped by the turbidity of the earth's atmosphere. At present, the DORIAN sensor appears to be the largest instrument capable of astronomical observation which will be in orbit during the time of interest.

Astronomical and planetary observations in addition to Mars can also be conducted. However, the current DORIAN pointing and tracking system is not configured to support the long exposure times needed for photography of distant objects. This aspect is treated in more detail in Tab D.

DORIAN/GAMBIT