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May 19, 1967

MEMORANDUM FOR RECORD

SUBJECT: Manned Versus Unmanned MOL Cost Comparisons

REFERENCE: Paper on "An Unmanned DORIAN System", dated May 16, 1967

As part of the preparation of a new estimate of costs and schedules on a wholly unmanned DORIAN system, the following estimates on costs have been made.

In the referenced paper, it is stated that total cost of the presently constituted bi-modal MOL Program is expected to be $2.2 billion which is consistent with a recent congressional statement by Mr. McNamara. The corresponding cost of a wholly unmanned system, based on a 10-flight program, is stated at $1.7 - $1.8 billion. These figures are quoted for Phase II beginning with September 1, 1966. To arrive at a figure of approximately $1.8 billion for the unmanned system, the basic MOL estimate of 14 April 1967 was used. It quoted a total of $2.4 billion for a program with a 15-month extension from the baseline. Since this figure is a rough order of magnitude estimate and since the program is presently being redefined to a 12-month schedule slip, a $2.2 billion figure would seem appropriate and the costs of its individual segments approximated by a 10% reduction from those which make up the $2.4 billion. The specific cost figures used for the basic MOL and the unmanned programs are listed in Attachment #1. The estimates for the FY 68 requirements for the wholly unmanned system are listed in Attachment #2. They are based on a 1 July 1967 termination of the Douglas and McDonnell contracts and a new competition for an orbiting control vehicle.

MICHAEL I. YARYMOVYCH
Technical Director
MOL Program

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a/s

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Dr. Yarymovych/SAF-SL/50961/cmr

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Attachment 1

MANNED VS. UNMANNED MOL

COST COMPARISONS

From September 1966
(Million Dollars)

	MOL (7 flights)	Unmanned DORIAN Program (10 flights)	Remarks
Experiments	338	378	Includes 10 payloads at $8M
Mission Module	306	275	
Laboratory Vehicle	836	150	Costs to 1 July plus Termination @$43M
New OCV	---	450	$250M plus 10 Vehicles @ $20M
Gemini B	235	50	Costs to 1 July plus Termination @ 15
Titan III-M	332	390	Includes 10 Launch Vehicles at $20M
Crew	12	---	
Test Operations	30	25	
Pre-MOL	3	---	
Aerospace	70	60	
Other	42	40	
TOTAL	2204	1818	

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Attachment 2

FY 68 REQUIREMENTS FOR

UNMANNED DORIAN PROGRAM

Experiments	125	
Mission Module	50	
Laboratory Vehicle	45	Termination
New OCV	70	Completion & Start
Gemini B	15	Termination
Titan III-M	55	
Other	25	
TOTAL	385	

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May 16, 1967

AN UNMANNED DORIAN SYSTEM

The question of the cost of an unmanned DORIAN Reconnaissance Satellite System R&D Program vs the cost of the manned/unmanned MOL/DORIAN R&D Program has been raised. The answer (including FY 67 funds) is approximately \$1.7 - 1.8 billion for a purely unmanned program vs approximately \$2.2 billion for the present combined manned/unmanned program. However, these two programs are not directly cost-comparable in terms of timing, risk, quality and quantity of product, and future potential; thus, a further understanding is required in order to evaluate the estimates in their proper context.

The President approved the MOL program on August 25, 1965. While the general public announcement referred to MOL only as a program to determine the utility of military man in space, the President actually had approved four very specific program objectives contained in Secretary McNamara's recommendation to him:

1. Semi-operational use at the onset to secure photography of significant targets at a ground resolution of [redacted] (about [redacted] better than the GAMBIT-3 unmanned satellite reconnaissance system which is now in its R&D flight test phase).
2. To develop high-resolution optical technology and camera systems for either manned or unmanned use. This technology

would both permit the [redacted] resolution objective and also be aimed at ultimately achieving systems with even better ground resolution [redacted].

3. To provide an orbital facility for the development, test and use of other potential military space applications (such as: SIGINT; radar observation; ocean surveillance; etc.).

4. To provide an experimental program for the determination of man's utility in assembling large structures, and in adjusting, maintaining and processing the output from complex military equipment in space.

The MOL Program today is oriented toward the early achievement of [redacted] resolution operational photography in a manned vehicle; the subsequent demonstration (when feasible) of a similar capability in an unmanned vehicle; the optical technology and orbital hardware necessary for the future achievement of photography [redacted] and the development of an orbital facility for the test and use of other potential military space applications. Subsequent to the President's program approval, detailed contract definition activities and numerous technical analyses have consistently reaffirmed the feasibility of these fundamental goals and the order in which they are being pursued.

In the early conceptual phase of the MOL/DORIAN Reconnaissance Satellite System, successful operation of the very high resolution camera, with its attendant narrow field of view (approximately 1.4 miles diameter on the ground from orbital altitudes), in an unmanned satellite was not considered feasible. Continued investigation of the precision devices necessary for such an unmanned system (highly accurate -- on the order of 1/20 of one percent -- image motion sensing; image motion compensation across the entire format; remote on-orbit optical alignment and focus adjustment; and more precise automatic navigation) led to the conclusion that they were feasible, albeit technically quite difficult to achieve.

The desire to also develop an unmanned system stemmed from several reasons. First, it could provide a continued national capability for very high resolution reconnaissance photography of otherwise denied territory should international objections or foreign threats prevent manned operations, or if man should prove physically unable to perform as expected in MOL for extended periods in orbit. Further, Dr. Hornig, the President's Scientific Advisor, believed it possible, from an operational standpoint, that an unmanned system would eventually be desired to complement the manned system by performing the more routine reconnaissance missions or missions undertaken during times of particular political stress. Thus, in view of these considerations, plus the apparent feasibility of developing the necessary automatic devices, an unmanned DORIAN system of maximum interchangeability with the manned system was added as the final phase of the MOL Research and Development Program.

It was also immediately apparent that the incorporation in the MOL/DORIAN system of many of the precise automatic devices necessary for the unmanned system would enhance man's contributions to the reconnaissance mission by freeing him from routine equipment operations. For example:

1. By viewing through both the twin tracking/acquisition scopes and the main optics, the astronauts would be able to apply the final "vernier" adjustments in pointing, image motion compensation, etc., to insure consistent maximum performance by the camera system.

2. By observing alternate targets through the tracking/acquisition scopes, the astronauts would be able to select and photograph the maximum number of cloud-free targets. (This is a significant factor since the Sino-Soviet Bloc averages some 60 percent cloud-cover at all times. Analyses indicate that the manned system, with the astronauts performing a cloud avoidance function, would return approximately 15-25 percent more cloud-free photographs than would an unmanned system on identical missions).

3. By observing alternate targets through the tracking/acquisition scopes even when weather avoidance was not a concern, the astronauts would be able to selectively choose targets of highest intelligence value (for example,

an erected missile on a launch pad, in lieu of a nearby "empty" pad. Analyses indicate that these transitory intelligence gathering opportunities occur rather infrequently -- only about 6 percent of the time -- and that the manned system would photograph 2-3 times as many such targets in a 30 day mission as would the unmanned version).

4. By viewing selected targets through the tracking/acquisition scopes, the astronaut could determine the best viewing angle from which a target should be photographed (for example, if approaching a parked aircraft from the rear and needed intelligence could only come from examining the fore end, the astronaut could wait until he passed over and take a backward-look picture).

5. By viewing photographed targets both through the tracking/acquisition scopes and the main optics, the astronauts could immediately report successful target photography to the ground and thus assist the establishment of retargeting priorities for photographic operations on subsequent days (analyses indicate that this orbit-by-orbit verification of coverage can increase the number of unique targets photographed in a 30 day mission by approximately 10 percent over that possible in an unmanned system which would then return a film capsule each 7 or 8 days).

Some additional reconnaissance functions are possible and planned for the manned version which are not now incorporated in the unmanned system design. These include: the rapid verification and optimization on-orbit of optical system performance (possible by direct viewing through the main optics of the target being photographed); reporting and readout to the ground of intelligence information of a perishable nature (this involves on-board processing of film from the secondary camera and either on-board interpretation and verbal reporting or electronic transmission of the pictures to the ground); [redacted] selection and use of alternate film (color, infra-red, etc.) in the secondary camera used in conjunction with the primary optical system. It is of course conceivable that these and other functions might be performed in the future by some automatic system or combination of systems; however, the possibility in the manned system to experiment with a wide variety of alternatives and techniques is attractive and valuable in both time and money, whether or not the function is ultimately performed by man or by automatic device.

Further contributions to the early achievement of the reconnaissance objectives will be realized through man's ability to analyze on-orbit failures and malfunctions and either select alternative equipments and operating modes or replace directly with his own capability the function of failed equipment (for example, manually control the pointing of the main optics, or manually compensate for apparent image motion). The net result is an early and continued reliability advantage of the manned system over that of an automated and complex unmanned system.

There are other facets of the present MOL/DORIAN Program unique to manned space flight. For example, for the foreseeable future, we see no reasonable approach to achieving photography [redacted] except via a man-controlled system on-orbit; the MOL GEMINI/Laboratory/ Booster combination can be used essentially without change in meeting this goal. The possible future resupply and reuse of equipment on-orbit, using manned rendezvous and docking techniques (as demonstrated in the GEMINI Program, and which are an integral part of the APOLLO Program), indicate potential for highly cost-effective long-duration missions in any follow-on MOL Program.

As indicated by Secretary McNamara in his recent testimony before the House Appropriations Committee, the MOL Program is estimated to cost $2.2 billion (from the beginning of engineering development on 1 September 1966 through the final R&D flight in 1972). Seven test flights are included: two unmanned launches in 1970 to qualify the Gemini B, Laboratory and Mission Module structures, certain subsystems, and the Titan IIIM booster (which has seven-segment, solid rocket motors in contrast to the five-segment motors used by the T-IIIC); three manned missions, beginning in December 1970; and two unmanned missions. Of the total cost, it is estimated that approximately $200 million is attributable to R&D associated with the unmanned version.

If the manned portion of the MOL/DORIAN Program were cancelled on July 1, 1967, two alternative approaches to the continued development of an unmanned system are possible. The first would be to simply eliminate from the present program all sub-systems and hardware pertaining solely to the manned system (i.e.: terminate the GEMINI portion of the program; delete all life-support systems and man-operated equipment from the Douglas and General Electric Laboratory and Mission Module efforts). The second possibility would be to continue the camera system and booster developments (eliminating all man-safety considerations from the latter), cut back the GE Mission Module effort to only that necessary for an unmanned system, and design a completely new spacecraft and data recovery system which have been optimized as an unmanned spacecraft. In both cases, the cost from September 1, 1966 (including necessary termination costs for efforts now underway pertaining to a manned system) through a ten-flight R&D program, culminating in late 1973, is estimated to be approximately \$1.7-\$1.8 billion. In both cases, the first unmanned flight probably could occur at about end CY 70.

It is our estimate, based upon experience in the GAMBIT-3 Program (five flights have been completed in the 8-launch R&D Program), that the absence of man increases the development risk and that at least ten unmanned DORIAN system R&D launches would be required to have a reasonable possibility of achieving the same program maturity expected at the completion of the current MOL/DORIAN manned system R&D Program. Although many of the same automatic devices necessary for the unmanned version have been included in the manned system, it should be noted that many of the devices have either never before been used in orbital reconnaissance systems or else represent large extrapolations in precision, accuracy, or other characteristics from the present technology base. While these devices can ultimately be made to perform reliably within desired tolerances, it is by no means certain as to how long it might take to achieve those results. Nor is it certain that an unmanned system will ever be as reliable as a manned system. For this reason, the risk of early achievement of [redacted] resolution is assessed as considerably greater in the unmanned system than in the manned system. However, by initially including manned flights in the development program, the [redacted] resolution unmanned capability should be achieved earlier than through an independent unmanned development program.

As indicated previously, the differential development cost for including a manned operating mode and a manned vehicle development as well as an unmanned operating mode in the MOL/DORIAN Program is estimated at approximately $400 million more than that required for an independent unmanned system. From a cost-effectiveness standpoint, if the weather avoidance compensation potential of the manned system is realized to the extent of a plus 20 percent, this difference would be almost entirely offset by the increased photography collected by the manned system. The additional benefits derived from astronaut selection of those targets of highest intelligence potential is not calcuable in terms of dollars.

From another standpoint, the cost differential should be viewed as greatly increased confidence in achieving the desired operational capability at the earliest possible date. To be more specific, if some of the automatic devices failed to function in the manned system, the net result would only be a certain reduction in the quantity and/or quality of photographic product; however, failure of the same devices in an unmanned system would mean total failure as a photographic reconnaissance system. Since these devices do represent very advanced technology, it is believed their operation and test initially in a manned space system will reduce considerably the time required for them to meet design specifications with acceptable reliability.

Last, the MOL laboratory module has sufficient flexibility to develop the equipment necessary for extremely high resolution photography [redacted] as well as other military missions. New military missions, when validated, 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 (control and operating equipment) to the laboratory module; other elements of the system can be used without change. All of our studies of such applications validate that longer lifetimes on orbit and the use of the equipment will be greatly augmented by inclusion of manned missions in at least the development phase.

Thus, in light of all of the preceding, it appears conclusive that the additional incremental development cost of developing a manned/unmanned MOL/DORIAN system over that of an independent unmanned program is more than offset by both the near term advantages and the long range potential.

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COST/SCHEDULE COMPARISON

Case A: Current MOL/DORIAN Mixed Manned/Unmanned Program

Case B: Wholly Unmanned DORIAN Program

CY 70 (FY 71 begins July 1970)

	J	F	M	A	M	J	J	A	S	O	N	D
Case A: Launch Schedule (DORIAN system)				X 1		X 2						X 3
Est. Cost - $2.2 billion												
Case B: Launch Schedule												X 1
Est. Cost - $1.7-$1.8 billion												

CY 71 (FY 72 begins July 1971)

	J	F	M	A	M	J	J	A	S	O	N	D
Case A: Launch Schedule (DORIAN system)				X 4				X 5			X 6	
Est. Cost - $2.2 billion												
Case B: Launch Schedule				X 2				X 3				X 4
Est. Cost - $1.7-$1.8 billion												

CY 72 (FY 73 begins July 1972)

	J	F	M	A	M	J	J	A	S	O	N	D
Case A: Launch Schedule (DORIAN system)		X 7										
Est. Cost - $2.2 billion												
Case B: Launch Schedule				X 5				X 6				X 7
Est. Cost - $1.7-$1.8 billion												

CY 73

	J	F	M	A	M	J	J	A	S	O	N
Case A: Launch Schedule (DORIAN system)											
Est. Cost - $2.2 billion											
Case B: Launch Schedule				X 8				X 9			
Est. Cost - $1.7-$1.8 billion											

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