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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 ████

    ████████████████ 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

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Page 1 of 12 pages
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would both permit the ███████ resolution objective

and also be aimed at ultimately achieving systems with

even better ground resolution ██████████.

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

█████████ 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 ████████████████████

██████ 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

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dev A, Cy 1
Page 2 of 12 pages
Copy 1 of 1 copies
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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.

3

TOP SECRET

Page 3 of 12 pages
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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,

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TOP SECRET

Page 4 of 12 pages
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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).

Page 5 of 12 pages
Copy 1 of 1 copies
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BYE-2/153-67

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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); ▮▮▮▮▮▮▮ ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ 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

TOP SECRET

Page 6 of 12 pages
Copy 1 of 1 copies
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~~TOP SECRET~~

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 ███████████████ of resolution

████████ 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

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Dev A, Cy 1
Page 7 of 12 pages
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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

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TOP SECRET

Page 8 of 12 pages
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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 ███████ 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 ████ ████ 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.

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Rev A, Cy 1
Page 9 of 12 pages
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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 ▮▮▮▮ 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.

10

Page 10 of 12 pages
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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.

~~TOP SECRET~~

Page 11 of 12 pages
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COST/SCHEDULE COMPARISON

PROGRAM SCHEDULE

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

Launch Schedule (DORIAN system)

Est. Cost - $2.2 billion

Case B: Wholly Unmanned DORIAN Program

Launch Schedule

Est. Cost - $1.7-$1.8 billion

	CY 70	FY 71	CY 71	FY 72	CY 72	FY 73	CY 73
Case A launches	X1 X2	X3	X4 X5	X6 X7			
Case B launches		X1	X2 X3	X4 X5	X6 X7	X8	X9 X10

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Page 12 of 12 pages
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