DEPARTMENT OF THE AIR FORCE
WASHINGTON

OFFICE OF THE SECRETARY

MEMORANDUM FOR THE VICE DIRECTOR, MOL PROGRAM

SUBJECT: The Role of Man in the MOL

During the period which has elapsed since the approval of the MOL Program, significant progress has been made in refining the conceptual design of the baseline MOL, and in MOL mission planning. In this same interval, the National Aeronautics and Space Administration has conducted several highly successful manned space flights of significant duration in orbit, during which important and sophisticated maneuvers were conducted involving extensive participation by man-in-orbit. It appears timely to take advantage of the present situation to bring into sharper focus man's role in MOL. A fresh look at this problem may, and I believe will, suggest some actions that we should take to exploit more completely man's contributions in the conduct of MOL missions, and in particular the high resolution optical reconnaissance mission.

Accordingly, I desire that you undertake a study encompassing those considerations. You should insure that all possible United States experience in manned space flight is brought to bear. Our extensive Air Force experience in the effective utilization of man in the performance of unique and highly complex functions under conditions of extreme stress, typified by our aircraft flight test programs, e.g., F-12, X-15, XB-70, should also be examined for relevance as a possible source of hard, practical data.

The study group should be chaired by the MOL Program Office, and consist of a limited number of highly competent people who can approach this task effectively and knowledgeably from the viewpoint of crew function and performance. The MOL Systems Office should participate, particularly with respect to providing MOL Aerospace Research Pilots to serve on the study group. I consider that Major Crews and Lieutenant Truly would most appropriately serve in this capacity. In addition, you should make such arrangements with NASA as may be necessary to obtain access to data which NASA may have relevant to this study. You should also take the necessary steps to obtain, if possible, the assistance, on a

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consultant basis, of one or two of the most experienced NASA astronauts. It would be particularly desirable to request the services of Colonel Frank Borman, or, if this is not possible, Lt Colonel Ed White or Captain Walter Shirra.

I consider the study to be of sufficient importance to warrant a full-time effort on the part of the major participants. The study should commence immediately, and be conducted expeditiously, with a target date of 28 February for a preliminary report. A final written report supported by a comprehensive briefing should be completed 30 days later. When practicable, please advise me of the names of the group members, and provide me with a copy of their study plan.

B. A. Schriever

B. A. SCHRIEVER
General, USAF
Director, MOL Program

Copy to:
Deputy Director, MOL Program

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25 MAY 1966

REPORT

ON

MAN IN THE MOL

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THE ROLE OF MAN IN THE MOL

FOREWARD

On 17 January 1966 the Director, MOL directed the Vice Director, MOL to undertake a study to bring into sharper focus man's role in MOL, particularly in light of experience gained in the national manned spaceflight program, and in consideration of MOL progress since program approval in August 1965 (TAB A). The expressed purpose was to formulate recommendations leading to actions that might be taken to exploit more completely man's contributions in the conduct of MOL missions, and in particular, the high resolution optical reconnaissance mission.

In response, the Vice Director, MOL convened a study group under the chairmanship of Colonel Lewis S. Norman, Jr., with Lt Colonels Stanley C. White, Benjamin J. Loret, and Arthur D. Haas of the MOL Program Office, and Major Kenneth W. Weir of the MOL Systems Office, sitting as members. The study group commenced its activities in February. This report is the culmination of that effort.

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THE ROLE OF MAN IN THE MOL

SECTION I - INTRODUCTION

The scope of this study - the Role of Man in the MOL - was broad, and the quantity of relevant data, large. Time was an important factor, as study results needed to be available to the Director prior to his review of the MOL Phase I submissions and Phase II proposals. These circumstances precluded the study group from conducting detailed analyses of specific problems, hence the group was constrained to concentrate on a general survey of man's role in the MOL. The principle objective of the group was to define in specific terms those areas, problems, or activities arising in the course of the study which appeared to require further detailed study, additional emphasis (or de-emphasis) or a change in perspective, with respect to their influence on man's genuine contributions to MOL mission success.

The group also selectively reviewed elements of the MOL program with a view toward identifying possible situations in the system design which might impede the realization of man's full capability and value in the conduct of the high resolution optical reconnaissance mission. In this respect, constraints imposed by the inclusion of provisions for the unmanned mode were given particular attention.

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At the outset it was clear that there has been, is, and will continue to be, a need for a continuously updated rationale supporting the essentiality of man to MOL mission success. This rationale should be well understood by all program participants, and should be formulated and maintained in readily accessible form, e.g., a basic written document supported by a comprehensive graphic presentation. Many of the findings of this report, it is hoped, will be of value in structuring and maintaining this rationale.

The group is convinced that it must be anticipated that considerations of economy and the shifting international political situation, when viewed at the highest policy levels of government, will generate pressures dictating a periodic requirement to reassess the approach to the MOL program, even though the program currently provides for both manned and unmanned capabilities. As a consequence, the group directed considerable attention to this more limited, but extremely important, sphere of activity. In the light of events which have transpired since the original program submission, it was considered both prudent and essential that positive efforts be expended to determine where we stand today in the evolution of a rationale for man, and then to define specific activities which should be taken to reinforce, and, to the extent possible, quantify the argument for man.

The group's efforts were directed toward accumulating information from many agencies, offices, and individuals who were considered to be key sources of pertinent information (TAB B). Conferences with these sources were patterned to develop free and candid discussion.

It is important to note that the bulk of data reviewed consisted predominantly of expert and experienced opinions, value judgements, and considerations, voiced from many points of view. These data were subjected to the collective evaluation and judgement of the study group, hence, the findings, conclusions, and recommendations presented in this report do not necessarily represent a consensus of the sources heard.

The group was gratified by the cooperative participation which prevailed throughout the course of the study. In every case, the group found that discussion was open and candid. As was anticipated, many differences in viewpoint were heard. But it was the clear judgement of the study group that these differences were based on honest, open-minded evaluation of the particular issue as each individual saw it, influenced by his own background in his specialized area of responsibility. In no case was there evidence of withholding of information or reversion to biased "positions". In formulating its own considerations, the group benefitted greatly from its exposure to the differing views. The vantage point afforded by exposure "across-the-board" from both inside and outside the program has been invaluable to the group in facilitating an overall assessment of man's role in MOL.

SECTION II - DISCUSSION

THE BASIS FOR MAN

Prior to initiation of this study, the consensus of the study group was that the rationale for including man in the MOL seemed to have deteriorated since program approval in August 1965. (b)(1) (b)(3) Promising developments in automatic equipment appeared to threaten the primary argument originally put forth to justify man, i.e., that a manned system appeared capable of achieving [redacted] ground resolution whereas an unmanned system probably could not, or at least not as soon. Contrary to original expectations, the group has become more convinced as a result of its study that the argument for man is as strong now or even stronger than it was when the program was first approved.

The current rationale for a manned/unmanned MOL has not changed in essence from that contained in the letter of 24 August 1965 from the Secretary of Defense to the President recommending program approval (TAB C). In a finer and subordinate sense, what has changed is the relative value of the various unique contributions it was postulated man would make in conduct of the MOL mission.

In his letter to the President, the Secretary stated the photographic reconnaissance objectives of the MOL program to be the early achievement of photographs of significant targets of [redacted] resolution, in the manned mode and eventually in the unmanned mode, and the establishment of technology aimed at ultimately even better resolution [redacted] He further stated with regard to the manned/unmanned capability,

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> "...man's ability to select targets, to override the automatic controls when they function less well than expected, to choose data for prompt transmission, will improve the overall utility of the data. Furthermore, the presence of man in the development phase can be expected to shorten the development and improve the unmanned version of the system.
>
> "Beyond the initial objective of producing [redacted] ground resolution photography, successful automation will be increasingly difficult. Conducting the development program with a manned spacecraft will improve the prospect of achieving resolutions in the [redacted]

The study group subscribes to this rationale as being as valid today, almost nine months later in the program, as when the program was approved. Notwithstanding the fact that technological progress in development of automatic devices now provides some greater assurance that the unmanned Dorian configuration will be capable, from a technological feasibility viewpoint, of performance in resolution equivalent to the manned Dorian configuration --- and perhaps under certain circumstances better resolution when flown at 70 miles (if this is indeed feasible), as opposed to 80 miles for the manned version --- it does not invalidate the basis for the rationale quoted above. Even if it is postulated that a completely unmanned system would be more cost-effective in the long run than the current MOL manned/unmanned configuration in achieving [redacted] resolution objectives, the need for early achievement of this capability and for ultimate growth to higher resolutions, established as MOL program objectives by the Secretary of Defense, make it mandatory that the program proceed in accordance with the current plan, i.e., to retain man in the system.

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We believe the essence of today's argument is that, from a current program viewpoint, inclusion of man will virtually guarantee an earlier [redacted] resolution capability --- and earlier useful "take" --- even for the unmanned MOL configuration than would be possible in a wholly unmanned system. Further, we believe that a system capable of [redacted] resolution will be more cost-effective in a manned configuration if, in fact, [redacted] resolution is possible at all with an unmanned system.

RELIABILITY AND MISSION SUCCESS

The underlying reasoning for this conviction is based on the inherent capability of man to more nearly guarantee a high probability of mission success --- man's inherent "reliability"--- as opposed to that provided by automatic equipment.

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We have not quantified this value. But we do believe that there is a large store of raw data available, which if collected, analyzed and evaluated, would permit better quantification than has been done to date. However, the point of issue can be displayed in qualitative terms, and is perhaps best illustrated in graphical form, plotting probability of mission success (PMS) versus number of launches, as shown in Figure 1.

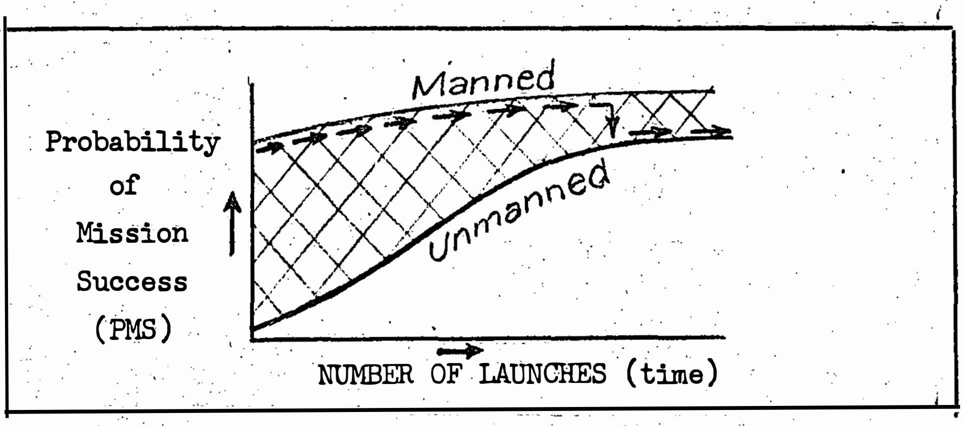

Figure 1

Two curves are shown, manned and unmanned. There is general consensus that, qualitatively, experience warrants drawing curves of the general shape shown for space vehicles with the sophisticated designs typical of today's practice. However, neither we nor apparently anyone else can presently put figures on either axis, nor specify relative values for the intervals separating the curves.

The manned curve is typical of Mercury and Gemini experience, or of any manned aerospace vehicle for that matter (X-15, B-70, etc).

It shows a very high initial probability of mission success, with a relatively small but gradual improvement toward an ultimate value. The unmanned curve is typical of unmanned systems, and probably for any complicated device. It shows a very low initial probability of mission success with a relatively slow initial improvement rate. This improvement increases somewhat with experience, but then levels off to a mature value with time.

We believe it significant to point out that in the case of the manned curve, the probability of mission success reflects man's performance in combination with machine. Despite the man-rating care which goes into design and manufacture of equipment used in manned systems, frequent failures of equipment have been and are being experienced, some of them in areas critical to mission accomplishment. Relative values of mission success on the manned curve are high, not for reasons of high reliability of man-rated equipment (although this does help), but rather because man has succeeded in mission accomplishment <u>despite</u> equipment failure. We believe a curve showing man's performance in itself, independent of the machine, would be significantly higher even than the one depicted for manned systems.

As pertains to the MOL mission, the shaded area between the curves would represent useful "take" achieved with the manned system in excess of that to be expected in a completely unmanned system.

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The plot also shows the advantage of achieving essentially full operational capability at a significantly earlier date.

From the point of view of total useful "take", we believe it indisputable that the completely manned program is superior. However, all factors considered (cost, international situation, etc), we anticipate that the program might well follow the course indicated by the arrows, i.e., use of man to provide early capability and to greatly facilitate early achievement of high reliability in an unmanned configuration. At some point during or after the development program, it would appear that the unmanned configuration could be used for performing routine reconnaissance. The option to proceed either manned or unmanned, or with a mix of the two would provide desired flexibility.

Although the contention that man provides high probability of mission success early and thereafter in the program appears to be accepted by all, there is considerable disagreement as to the degree of success to be anticipated in the earlier stages of a completely unmanned program.

Unmanned proponents argue that unmanned program experience and application of effort and quality control methods approaching those used in man-rating manned systems would insure early achievement of a reliable unmanned system, and that an unmanned program is more cost-effective over the life of an operational program.

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Manned proponents counter that early unmanned system reliability will be low, based on past experience involving systems of considerably less complexity, and that the automatic devices required as a consequence of the absence of man probably will not perform as well as anticipated and certainly with relatively low reliability, hence from a total "useful take" viewpoint, a manned system will be more cost-effective than an unmanned system, etc. The study group is not in a position to resolve these arguments. With regard to the differing views, the group noted with interest that designers or "inventors" were largely optimistic about both performance and reliability of machines, but that the engineers who must produce workable machines were considerably more conservative.

Also found was a consistent tendency to under-rate man's performance (as distinguished from his "reliability") and to overrate a machine's projected performance (again, distinguished from its reliability). In addition, probability of mission success was frequently found to be based on a machine's projected mature reliability, rather than on that which might be reasonably expected in early flights. These factors make the machine look better than it is. There is also a tendency to assess man's performance on a statistical probability basis, much like a machine. However, man is "self-healing", i.e., the probability is very high that he will not repeat a particular "mode of failure." He is also "adaptable", and can find ways to work around a problem for which no specific alternate mode has been devised. Machines can also be made "self-healing" and "adaptable", but only in the sense that they can "heal" and "adapt" to conditions and failure modes which are predicted in advance to be likely occurrences. Hence, there is much evidence that man's performance does not degrade in a simple statistical manner, but rather that his performance remains high under deteriorating conditions. It is very difficult to arrive at hard figures describing man's "performance" and reliability. But, as indicated earlier, we believe much can be done to improve our understanding of these factors.

More important, we believe that statistically calculated reliability is not the proper variable to use in cost-effectiveness comparisons in any case, but rather, probability of overall mission success, to which reliability is but one contributing factor. In our opinion the primary yardstick in calculating MOL cost-effectiveness is the quantity and quality of photo "take". Thus, we subscribe to probability of mission success as a mandatory ingredient in manned versus unmanned system comparisons.

We believe that more can be done to put to use available data which would permit more accurate assessment and projection of both manned and unmanned performance and reliability. Mercury and Gemini data should be exploited. The data being used by NASA and McDonnell to establish incentive fee performance would appear to be a promising starting point for such an analysis for the manned case. There is a mass of data on unmanned programs which could be examined to provide a reasonably realistic extrapolation of probability of mission success versus time (number of launches) for a completely unmanned system. Establishment of this projection must take into account the degree of complexity of an unmanned Dorian system above that of present unmanned systems, or of any other unmanned system that has been launched into space. We also believe an experience factor should be included, in which actual total mission performance of past unmanned systems should be compared with the system reliability which was originally predicted in design of those systems. The decrement (or increment) actually experienced should provide some sort of an experience correction coefficient which could be applied to any statistically derived estimate of reliability in computing predicted overall mission performance of an unmanned Dorian system. We believe such an approach would permit a more valid comparison of the manned versus completely unmanned modes. It would also certainly be of comparable value early in any space program as a means for estimating flight performance with more confidence than we have in the past.

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Summarizing the discussion thus far, we believe man's most important contribution to the current program is his ability to provide a Dorian capability at the earliest possible date and to expedite development of an unmanned system to perform in an overall lesser, but reasonably equivalent, manner. This approach we believe to be in complete consonance with MOL program objectives.

GROWTH IN PERFORMANCE AND CAPABILITY

We believe that any Dorian system growth to provide a capability for resolution approaching the atmospheric limit will require man's presence. This belief is based primarily on such factors as technological feasibility and operational program cost.

Although technology in automatic devices is improving at a rapid rate, we have heard no clear expressions of opinion that ground resolutions in the order of [redacted] are achievable with an unmanned system. Although progress may change this view, we are not convinced at the present time that development of an unmanned system capable of [redacted] resolution, or better, is feasible. On the other hand, development of such capability with a manned system appears no less feasible today than it did when it was projected last August. If this premise is accepted, the argument for man's presence in the current program is enhanced, in that development of the current system can lead directly to an advanced manned system. Incorporation of man today will provide invaluable

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experience and data applicable to optimizing design and operation of future very high resolution optical reconnaissance systems. Even if we postulate that the same capability can be achieved unmanned, we believe that a cost-effectiveness comparison of manned versus unmanned modes would still favor a manned system. The underlying rationale for this viewpoint involves consideration of system costs and, again, reliability.

The cost of providing for man in the current system is relatively large when compared to the mission sensor. This proportion will probably decrease significantly in comparison with the mission sensor in advanced optical systems. High sensor cost would make extended operation in orbit economically attractive. The manned version could provide for continued use of the large optics through rendezvous and resupply of crews, expendables, spare parts, and provision for some level of in-orbit repair and maintenance. Thus, cost of the mission module could be amortized over longer duration operations.

This advantage does not appear achievable in the unmanned mode, due primarily to reliability problems. These problems appear at present to be of sufficient magnitude as to preclude long life of any orbital system of the complexity we envision for an advanced Dorian system. We have heard general estimates that, beyond thirty to sixty days, such problems render complex unmanned systems economically unattractive.

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To the extent that the need for an eventual capability for [redacted] ground resolution photography is still valid --- and we have no evidence that it is not --- we believe that a study of feasibility and cost-effectiveness of an advanced system would be helpful in any re-evaluation of whether or not the current program should continue with man in the system. We believe that such a study would favor inclusion of man for reasons of feasibility and cost-effectiveness.

An additional aspect of growth which merits more attention is operational growth. Once the initial configuration of MOL has been developed, stabilized, and brought to peak performance with the help of man, its basic operational potential can be exploited by adding incremental operational capabilities. In this case, the basic Dorian optical system remains unchanged, and rendezvous and resupply is used to provide and support multiple payloads. For example, an optical search system could be added to the MOL, and perhaps as well, an ELINT system. Man's functions become supervising the operation and maintenance of the refined Dorian sensor, supporting the development of the newer sensors, and at the same time insuring that the entire family of sensors functions with peak operational effectiveness. Man's capability to conduct complex and sophisticated tasks would be extensively utilized under these circumstances. Certainly, the cost effectiveness of this approach would be most attractive, particularly if the multi-functional MOL could displace the need for flying some unmanned missions.

We believe, as in the case of technological growth to better resolution, that operational growth should be studied for feasibility and cost effectiveness. Again, we are persuaded that these factors will favor the inclusion of man, particularly with respect to providing a large increase in operational capability at modest cost by exploiting the initial investment in the current MOL configuration.

In terms of overall MOL program objectives we are convinced that today's rationale for the inclusion of man in the current MOL system must, in the national interest, include consideration of the benefits to be derived from follow-on, advanced MOL configurations, in both operational and technological areas of growth.

MAN'S SPECIFIC PERFORMANCE FACTORS

Eight specific functions and capabilities were originally considered to represent man's most important contributions in the conduct of the Dorian mission. We have found no new ones to add to the originals, i.e., target acquisition, visual reconnaissance, sensor pointing, target tracking, equipment adjustment, vehicle control, information management, and assembly and maintenance.

The nature of these contributions are summarized below in terms of relative emphasis, new factors which have come to light, and earlier points considered worthy of highlighting.

Target Acquisition. Man's real time capabilities to make judgements, and to render specific decisions continue to be powerful contributions. These capabilities are of particular value in assessing a target area and selecting the target of highest intelligence value in a cluster of accessible alternates, by searching and locating within the optical field of view targets whose exact locations are not known, and by evaluating cloud, haze, lighting and shadow conditions in the primary target area, and selecting suitable alternates when the primary is obscured. New and unexpected targets can be acquired in this manner, such as a new model aircraft which may be in the vicinity of a target airfield, and a missile or a booster being transported on an access road to a target launch complex. These functions contribute significantly to efficient utilization of time available during operational passes over target areas, resulting in a total "take" of greater image quality and quantity, and of considerably enhanced intelligence value.

The target acquisition task is a very effective use of man's capability to examine a complex scene, integrate in a fraction of a second the details of the scene with background information stored in his brain, and arrive at a conclusion --- something we cannot do so easily with a machine. Man's ability to distinguish color adds importantly to this process for it enables him to reach his conclusions more rapidly and more credibly. For example, smoke indicating the location of a target industrial complex may be obscure in the grey scale of a black and white scene, yet stand out clearly in a color scene.

We believe a quantitative measure of these values could and should be made through simulations of 30 day missions using a Dorian target list under conditions representative of those which would actually exist.

Visual Reconnaissance. The value of this function has been underestimated, in our opinion. Although we found that no additional study work has been done in this area, we believe that there is a very real value in acquiring intelligence information through man's ability to view the target at high resolution, in real time, and from changing aspect. It is highly likely, in our opinion, that by use of the magnification afforded through the primary optics, direct observation might allow recognition of high intelligence value objects not identifiable on the photographic image. Certainly man could satisfy some intelligence requirements, such as simple counting, discrimination of color, classification of activity, and detection of movement.

Some simulation work has been done, such as the recent investigations conducted by SAC using aircraft platforms and bombsights, in attempts to assess man's visual capabilities. But in general, much of this work consists of isolated, individual efforts which have not been oriented to covert reconnaissance. However, this work does indicate that trained personnel become highly proficient in recognizing objects which the ordinary individual cannot see. The group is strongly of the opinion that more simulation should be done in this field.

Pointing and Tracking. Both these functions were originally considered beyond the capability of automatic equipment to perform with the necessary degree of precision for the Dorian sensor. Development of an automatic cross-format IMC device now appears to promise that satisfactory resolution can be achieved, reducing the necessity of centering the desired target with precision, though there will still be some degradation of resolution on targets which fall at the periphery of the format even with the device. In addition, image tracking sensors have been demonstrated which promise .01% image motion compensation (IMC). If these devices successfully survive the transition from breadboard demonstration to actual engineering practice --- there is now considerably more confidence in some quarters that they will --- man's superiority in performing these functions will be lessened.

The quality of the pointing function in the automatic mode is dependent not only cross-format IMC but also on the degree of precision to which the location of the target and MOL vehicle are known. Although there is considerable confidence that the navigation problem will be solved, the unmanned configuration, particularly if flown at 70 NM altitude to obtain improved resolution, if flight at 70 NM is indeed practical, will probably require use of drag measuring devices on the laboratory vehicle to permit ephemeris determination of sufficient accuracy. There is considerable concern in the minds of some as to how well the drag measuring devices will operate.

The best manual tracking performance demonstrated in the LMSC and IBM simulations was .05% IMC as opposed to .01% in demonstrations of a breadboard model of an automatic tracking device. Although man's ultimate capability to track has not yet been established due to inherent limitations of the simulation equipment, it may be presumed that he probably will not surpass the .01% IMC figure. Hence, we can conclude that the argument previously made that man is superior to machine in the routine conduct of the two essentially mechanical tasks, pointing and tracking, will diminish, if not disappear, if and when these devices become perfected, and apart from consideration of reliability.

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However, even if man need not routinely point and track each target, his value in establishing initial conditions --- that is, calibrating --- routine sensor functions as the vehicle begins its flight over the area of interest must not be overlooked. Typically, targets occur in clusters, and their location, one with respect to others is more accurately known than are their actual locations on the earth with respect to the vehicle's orbit. Thus the presumed location of targets may be offset from their actual locations, and as a result, offset in the field of view of the optical sensor. Man can observe this offset, or bias, as the target area is entered, and correct it to center the desired target. At the same time, he may manually null any residual image motion. These correction factors will typically remain nearly the same throughout a target pass. The on-board computer can store the initial corrections and apply them to each target in the pass, as it proceeds in its pre-programmed automatic target photography sequence. These corrections will still hold if the man interrupts the automatic sequence and selects an alternate target.

In retrospect, it appears that perhaps too strong a stand was originally taken on routine pointing and tracking as being man's exclusive province. The fact that perhaps excessive emphasis was placed on man's contributions in these areas can best be explained in terms of the struggle the Air Force has had over the years in justifying military man in space. The tracking and pointing simulations for the first time provided quantitative data to support conduct of a manned program. It was natural to seize the data and to use hard numbers to prove man's capability to perform a manned military mission. In turn, this also perhaps explains the pessimistic view taken by many involved in the program as the accelerated unmanned device development effort over the past year has appeared to threaten to overturn these critical elements in the argument for man in the MOL.

As the study group sees it today, the unmanned developments --- the classic threat of automation replacing man --- are not to be dreaded but rather welcomed. They will largely free man from what are essentially routine and tedious mechanical jobs and permit him to make his contributions in areas which do not lie in the province of machines. When they do not work, he can take over their function. At the same time, he can contribute to their early perfection. More importantly, in our view, is that as long as man is aboard, and until perfection of the automatic devices is achieved, we can be assured that the pointing and tracking tasks essential to mission success will be performed.

Equipment Adjustment. In addition to important contributions man can make to the alignment and focusing of the optical system, he will be able to compensate manually for any residual bias remaining in the system which may not be otherwise completely corrected, such as optical system misalignment caused by vehicle distortion, and pointing errors uncorrectible in the automatic mode caused by out-of-tolerance performance of tracking drive components. He will be able to make a unique contribution in the quality of the photographic product through his ability, on call, to place aerial color film, infrared aerographic film, or other special emulsions in the secondary camera, depending upon the kind of target information desired. It appears that if one of a stereo photo pair is high resolution black and white primary record film, and the other is of lesser resolution but in color (or other emulsion) the advantages of both high resolution and improved or special discrimination characteristics of the color (or other emulsion) will be obtained. This will increase the photo-interpreter's ability to extract intelligence information not apparent in a black and white stereo pair. Man may also be able to contribute to the quality of photographs by selecting the proper film exposure settings based on his evaluation of instantaneous cloud, haze, lighting and shadow conditions in the vicinity of the target, both for the primary record black and white camera, and for the various types of film selected for use in the secondary.

Vehicle Control. In case of a loss of vehicle stabilization control, and depending on the degree of severity, we believe man in certain cases will be able to continue to obtain useful take with little if any degradation of resolution. This capability, essentially independent of much of the equipment associated with normal mode attitude control, is being provided. Manual attitude control using either attitude reference instruments or visual reference to the horizon can then be maintained. The ability of NASA astronauts to manually control both spacecraft attitude and direction, and to control both attitude and translational rates with a high degree of precision in the rendezvous and station keeping phase of the Gemini 7 and 6 flights, attests to achievability of this capability. In contrast, any degradation of vehicle attitude control under unmanned operation will probably result in mission failure.

Information Management. Man's unique capability in this area is one of utmost importance from the point of view of increasing the total effectiveness of MOL. In addition to the functions previously discussed (such as target selection and film exposure time determination), which are in a sense information management, the presence of man in the MOL results in a nearly real time capability to process selected frames of critically important intelligence data, edit them, and then transmit them by telemetry to the ground where they can be reconstructed with a resolution loss of less than 20 percent. As the man can view the target images during target passes, he can assess the overall situation and the instantaneous conditions as they unfold and transmit his evaluation to the ground both by voice, and by telemetry in computer language, and thus considerably enhance the intelligence value of the images he transmits. More important, his ability to provide nearly real time feedback concerning mission progress and success will permit extremely flexible real time mission reprogramming, superior to any that could be provided in an unmanned mode. Man's considerable contribution here toward a very high probability of mission success, based on the ultimate criteria of quality and quantity of "take", is inescapable. An automatic capability to conduct information management to the degree, and with the scope, to which the manned configuration is capable, appears to be too complex to be seriously considered.

Assembly and Maintenance. Man's ability to supervise or to assist in assembly, erection, and alignment of large structures in orbit is presently not applicable to the current program, although this ability may be necessary insofar as future applications of MOL may be concerned. However, it does appear that despite weight and space limitations, man's capability to perform some degree of in-orbit repair and replacement will be exploited in the current program, as it has both in Gemini and Apollo. At present, maintenance will probably be limited to trouble shooting and diagnosis, minor equipment repair and replacement to equipment to which he has access, and vital switching functions in case of failure of systems for which redundancy is provided. Very important will be man's capability to inhibit automatic equipment which malfunctions, resorting to manual operation. The inherent flexibility of man to work his way around unpredicted failures of "highly reliable" equipment will enhance probability of mission accomplishment. As an example, we envision his ability to go EVA and manually force open a stuck door covering the primary optics, which might possibly make the difference between complete, or at least partial, mission success, and complete mission failure. This is perhaps an extreme case. The door mechanism will undoubtedly be highly reliable. But so was the OAMS thruster sub-system on GT-8. To summarize in terms of the current program, we anticipate that man's contribution in the area of maintenance may be relatively minor. It will be a major contribution --- in fact essential --- in any advanced system capable of higher orders of resolution.

OTHER MILITARY MISSION POTENTIALS (b)(1)
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In addition to the factors just discussed, there are others which may be of lesser importance from the standpoint of the primary objective to provide [redacted] ground resolution, but which are nevertheless of importance from the point of view of overall military manned space program objectives. As such, any investigation

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of the value of military man in space would be incomplete without taking them into consideration, if only briefly.

As a general view, history has shown that past applications of technological development to military missions have taken place in an evolutionary manner. Application of the airplane to warfare is perhaps the most obvious example. There is little reason to believe that developments in space will stray from this path. Hence, extensive application of man in space to military requirements probably will not begin to evolve until the first step is taken, i.e., simply putting military man in space in a military space vehicle. Certainly a value cannot be attached to this argument nor can quantitative data be gathered to substantiate it. Nevertheless, it is a situation similar to ancient man standing on the ocean's edge, reasoning that he needs a boat to find out what is on the other side. The MOL, in a sense, represents that boat.

Turning to specific application of MOL to an evolving manned military capability in space, we note that Eastman Kodak has performed a preliminary in-house study of the feasibility of using the current Dorian configuration [redacted] Taking into account the constraints of the current MOL baseline system, achievement of some early, although limited, capability to perform this operational

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mission appears promising. That this is so has been borne out still further in studies now in progress in the MOL Systems Office (and Aerospace Corporation).

Of other missions postulated for MOL, the SIGINT mission appears most promising so far as man's utility is concerned in insuring mission accomplishment. In fact, many believe that man's contribution in conduct of the SIGINT mission will be even greater than it is in the HRO reconnaissance mission.

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In the 24 August 1965 submission of the proposed MOL program by the Secretary of Defense to the President, four important national requirements were established for which [redacted] resolution photography is considered extremely valuable or mandatory. They are technical intelligence, tactical photography during crises, policing arms control agreements, and credible and detailed photography of suspect activity without provocation of overflight. Although technical intelligence is the primary beneficiary of the current program, we believe that insufficient emphasis has been placed on the capability which the current system will provide in crisis situations. The inherently superior real time adaptable reprogramming capability of the MOL with man included appears to us to be of inestimable value. In our opinion this capability may well become of vital, but of presently unforeseen, importance to the nation during the years of the currently scheduled flight program.

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We are intuitively certain that man's ability to acquire targets, using low magnification with a wide field of view followed by successive increases in magnification as the target is selected, and followed by pointing of the main optics, can provide a source of intelligence information vital and unique in times of international crisis. Some have expressed the opinion that the Dorian sensor could be used very beneficially in tactical and strategic assessment in the current Southeast Asia situation. Certainly such possible application should not be overlooked in assessing the value of man in the current program.

We cannot quantify this value nor do we know whether it can be quantified. A study of how the MOL might have been used in the Cuban crisis or in Southeast Asia today might shed some light on the subject. Nevertheless, we are convinced that once a manned Dorian capability is achieved, it will be used for these vital missions.

THE QUESTION OF COST-EFFECTIVENESS

One final qualitative argument may be made in justifying man in the MOL. It hinges on cost-effectiveness considerations when the cost to place military man in orbit is amortized over several programs. It assumes that several other missions will eventually be conducted in space, from among such possibilities as Advanced MOL Dorian, SIGINT, Ocean Surveillance, [redacted] and Command and Control. A

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further assumption --- we believe it to be a heroic assumption --- is that automatic equipment could be developed to permit unmanned conduct of any missions so selected.

When one takes this larger view, and though for any one mission (including the current MOL mission) it might successfully be argued quantitatively that an unmanned mode is more cost-effective than the manned, it does not necessarily follow that total military manned space program costs over the long run would result in a cost-effectiveness balance unfavorable to man. We are convinced that the opposite situation will prevail. Once the price for man is paid, his flexibility, his adaptibility, and his immediate and highly responsive "reprogramability", comprise unique contributions which can be exploited for some or all of other missions, with cost outlays being principally confined to an increment associated with the particular mission. This situation, of course, also holds true for the operational growth versions of the MOL vehicle, as discussed earlier, where several missions would be conducted concurrently with the same vehicle, further reducing costs. In contrast, unmanned approaches to performance of new missions are usually approached on a one mission type per vehicle configuration. New missions, unmanned, usually involve new development, major new costs, and usually are faced with a low initial reliability.

An analogy can be drawn here to the situation confronting the businessman who has the option of buying a lower cost single purpose computer to meet today's requirement, or buying a more expensive general purpose computer which not only performs today's job as well or better, but also will reduce the cost of doing future business in new areas of enterprise. The decision must be based on the degree of confidence he has that opportunities for new enterprise will materialize,and if there is any reasonable expectancy that they will, the latter course of action is clearly better. In any event, the former precludes the possibility of growth except at excessive cost. It also involves the perhaps unacceptable risk that he may one day be run out of business by his competitor.

From the long range view of an evolving manned military space program, it becomes clear that the high initial cost to place military man in space is being charged entirely to the MOL program. A realistic manned/unmanned cost-effectiveness comparison in the current MOL program, from a total military manned space program viewpoint, would either have to include acknowledgement that the incremental cost for man in subsequent programs would make those programs considerably more cost-effective manned, or alternately, that the true cost for man in the current program should be only a fraction of apparent cost, the remainder to be amortized over future programs.

We fully recognize that the argument above probably would have relatively little weight in high-level considerations of whether or not man should be a part of MOL. The future is as yet nebulous, whereas imminent decisions may have to be based on current and near term military requirements and all-important economic considerations. Nevertheless, if the short-term view is to be taken, it should be fully acknowledged that the decision is based on a narrow view, and with full acknowledgement that long range considerations and implications are being ignored.

MAN'S PERFORMANCE IN THE SPACE ENVIRONMENT

In light of concern which has been expressed by the President's Science Advisory Committee and other authorities involved in reviews of the program, we believe the current rationale for man in the MOL would be incomplete without treating the subject of man's ability to withstand the environment of space and perform the MOL mission effectively during the 30 days in orbit. Just as in the case of unmanned program technological developments, considerable progress has been made in this area since last August, as a result of both Gemini experience and the continuing MOL program bioastronautic effort. Our confidence in man's ability to withstand the rigors of space, to perform effectively, and to withstand the stresses or re-entry and recovery is very high. We are virtually certain that there are no bioastronautic barriers to successful conduct of the MOL mission. Information elicited in discussions with experienced NASA astronauts supports the belief that anything man has been able to do in aircraft from a military mission standpoint he can do in orbit. Although the astronauts have been overworked from the point of view of the quantity of tasks (many of them routine) with which they have been burdened in space, they do not feel that their ability to perform sophisticated, unique, complex tasks has yet been taxed. On the strength of Gemini experience, i.e., successful demonstration of long duration flights, performance of complex tasks in orbit, and reaction to adverse situations, we believe that concern over man's ability to perform the MOL mission is not justified. In particular, astronaut ability to react quickly and effectively in an emergency was clearly demonstrated in the Gemini 8 flight, which experienced an unanticipated malfunction of a thruster subsystem, which was designed for high reliability and to fail safe. Again, the outstanding performance of Astronaut Stafford in simultaneously performing complicated and exacting calculations which would have permitted successful rendezvous of Gemini 6 and 7 in any of several alternate modes even if critical systems had failed (radar, computer, inertial platform) represent, in our opinion, incontrovertible evidence that man can and will perform the MOL mission successfully.

A review of developments and the current status on man's performance in the space environment is treated in detail in TAB D.

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THE PENALTIES IN A DUAL APPROACH

We believe there are several areas of program activity which require very close surveillance to insure that man is provided the maximum possible opportunity to apply his unique talents in accomplishing the MOL mission. These, in turn, point to the general need for a better manned orientation in all program activity, and on the part of all participants. We believe such renewed emphasis on man would result in a high payoff in the achievement of overall program objectives.

Of primary concern from a manned viewpoint is the fact that the program must provide for an automatic capability completely independent of man. We do not quarrel with this requirement. But we also believe full recognition must be taken of the fact that the bimodal manned/unmanned configuration of MOL is not an optimized manned configuration. Other than the fact that the optical configuration is, for all practical purposes, nearly optimum for application to either manned or unmanned configurations, there are definite penalties involved from the viewpoint of optimizing for man.

Aside from a clear compromise in system design which precludes the realization of an optimized manned configuration, the redundancy and added complexity associated with providing automatic operation does have an impact on the reliability of the overall system and does entail additional weight. Although the weight penalty may be relatively small, perhaps in the order of a few hundred pounds, it is significant in the light of the already-threatening MOL weight problem. We believe it important to point out that this additional weight could be used for expendables, which could lengthen the mission duration of an optimized manned system. This is the other side of the coin, which tends to be overlooked when the argument is made for the significantly greater weight savings that could be achieved by eliminating man. Even though small, the weight saving in an optimized manned design would affect any cost-effectiveness analysis between optimized manned versus optimized unmanned systems.

(This point may be briefly related to current activity relative to a "wholly unmanned system" in response to Bureau of the Budget queries. It is important to note that any comparison of such a system with the manned version of the MOL as it is presently configured will not represent a comparison of an optimized manned with an optimized unmanned system.)

The significant danger with the current MOL design is the possibility that if one of the critical automatic devices in series in the optical train fails, e.g., the automatic tracker, the entire system could be incapacitated. It is obvious that such automatic devices must be designed to permit man to bypass them completely and perform their function without residual interference in accomplishing the mission. We have been assured that the automatic devices will be so designed. But at present, there is no means to guarantee that they will. The important point to be made here is that there is a need for continuous surveillance in this and other critical design areas to insure that man's values are exploited rather than handicapped in accomplishment of the mission.

There appears to us to be some schedule incompatibility detrimental to manned system design. In the ideal case, the final design freeze and the firm program schedule and cost proposal should precede initiation of Phase II effort. It appears, however, that considerable analysis and simulation remains to be performed before the MOL Systems Office can develop a final design which will permit an optimum interface of man at the operational consoles with the mission sensor. Studies and simulations presently underway, primarily at General Electric, are designed specifically to answer many questions as how best to use man in performance of the operational task, so as to permit better design definition of the equipment and displays to be used. We are concerned that Phase I schedule requirements may result in a less-than-optimum system design for lack of timely input of study and simulation results. We see a need to maintain flexibility in system design until this critically needed information becomes available. We do not have a feel for the magnitude of this problem, but we do feel it is an area which should be looked into, with the intent of possibly expediting current simulation studies, initiating new short term studies if indicated, and, in any event, of insuring provision for sufficient flexibility in the program to permit incorporation of the results, as they become available, into final design of the system. In the course of design of manned systems, NASA has in many cases performed simple, "short term" simulations with rudimentary devices and mockups to help narrow down design problems in critical areas. This kind of an approach may be worth exploring in expediting final design of man's operational equipment in MOL. As an example, an accelerated study of the value of color in aiding man to perform the acquisition task, using the LMSC or IBM simulation equipment, would perhaps prove valuable in evaluating the desirability of providing man with a color viewing capability.

THE MISUSE OF MAN

There is another aspect of man's role in the program which bears watching. We refer here to possible trivial tasks that may be given him merely because he is there, which in turn may result in lessening his capability for optimum performance of critically important mission tasks, simply because he is overburdened. We subscribe strongly to a philosophy wherein primary focus is placed on man performing essential and unique tasks, without sacrificing the quality of his performance by requiring him to perform tasks which are routine, repetitive and easily mechanized without compromise to mission success.

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A hierarchy of priorities must be used in establishing man's work schedule. From a time-line analysis viewpoint, this should generally involve the following steps: (1) establishing a list of key manned tasks which are essential to mission accomplishment, and allocating sufficient time for him to perform these at peak efficiency, (2) establishing the amount of time he requires to maintain himself in peak physiological and pyschological condition, i.e., sleep, eat, exercise, rest, etc., (3) utilizing any time remaining after these priority activities have been accommodated for tasks of lesser importance. Remaining tasks should be mechanized or eliminated. It was the impression of the group that tasks of this latter category would be generally, though not always, amenable to being automated.

If anything has been learned from NASA manned space flight experience, it is that man has been overburdened with non-essential tasks, simply because he is there. Because of man's versatility, the engineer tends to take the easy way out, calling on the man to perform some monitoring or routine mechanical function which, if ingenuity were applied, could be performed automatically or possibly designed out of the system.

However, it is very important to take advantage of man's presence to perform some functions, even if they appear trivial, if they will reduce system complexity, insure reliability, effect a significant weight saving or enhance mission success. This must be done under the proviso that in their totality they do not distract him from, or sacrifice his effectiveness in, performing the tasks essential to mission success he alone can do. We must resist the tendency to encroach on man, to use him in marginal fashion to compensate for design deficiency.

The problems and considerations discussed above are symptomatic of a general need in the MOL program effort for increased emphasis on man. Greater and broader man-oriented emphasis must be placed by all involved in the program on design of the system. Without sacrifice of provision for an unmanned capability, the manned viewpoint should, and must, permeate the program. We believe considerable improvement can be made in this area. It is the area of our greatest concern.

CONSTRAINTS ON MAN'S UTILIZATION

There are several major constraints which tend to restrict us from making the best use of man in conduct of the MOL mission. First, there is the requirement that the mission payload system be developed so that it is capable of fully automatic unmanned operation. Second, the Air Force is pursuing a virgin effort in its first manned military space program. Some groping is to be expected, particularly in view of the relative inexperience of the Air Force, Aerospace Corporation, and many contractor personnel at Douglas, General Electric, and Eastman Kodak in designing an operational manned military space system. Finally, the already threatening MOL weight problem contributes to the tendency to divert attention from making efficient utilization of man, particularly where a weight penalty would be involved in providing man a particular control or capability which would be desirable but not essential under normal operational circumstances.

The need for greater orientation toward exploiting man in the system appears less among the military people and other individuals who are in relatively senior management levels in the program structure. However, these individuals are, per force, preoccupied with activity at the higher levels, busy with major program problems which arise in the course of normal business. They are virtually precluded by the press of time and the urgency of business at their level from being able to continually appraise in detail lower level activity from the viewpoint of the most effective use of man. This circumstance is of major concern, for it is primarily at the detailed design level that, for want of an inquisitive "how can this subsystem best be optimized to capitalize on man" attitude, opportunities to do so may be overlooked.

Considerable discussion on the subject of optimizing the design for man was held with the MOL crewmember group, with NASA astronauts, with Air Force and Aerospace personnel, and with contractor personnel.

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It was the opinion of the study group, at the conclusion of these discussions, that the participation of MOL crewmen in the engineering design of MOL to date had been very beneficial. We do not refer here to crew viewpoints which stem from penchant, such as might be thought to be the case, but rather of honest expressions of genuine man-machine integration engineering, with mission success as the principal motivating factor.

The crewmembers' general comment is that engineers at lower levels in the design effort in contractor plants, due primarily to lack of any concept of a pilot's (or crewman's) viewpoint, tend to overlook integration of human factors. In some few cases they are even antagonistic toward insertion of man-in-the-loop. Some brief examples quoted by the crewmembers illustrate the nature of this problem.

Apparently the inertial platform in the Gemini requires 10 - 12 minutes to erect in an automatic mode. Crewmembers suggested that in Gemini B, three toggle switches be provided to permit fast-slaving of the three gyros manually, thus reducing erection time to 2 - 3 minutes. Considerable reluctance was exhibited by the McDonnell design engineer, as this capability had not been provided in Gemini A, hence there seemed to be no reason to provide it in Gemini B. Apparently the reluctance was overcome and it is our understanding that such a capability will be included, thus providing a valuable, and perhaps essential operational mode, e.g., during an emergency re-entry.

The MOL baseline did not originally include provision for a window in the laboratory, for reasons variously described as lack of a requirement and weight and engineering penalties involved. A somewhat similar situation arose in design of the original Mercury spacecraft. A window in the MOL Laboratory vehicle has now been provided, primarily through the efforts of the crew. Hence the capability will exist for the crewmen to "fly" the MOL by visual reference to the earth.

Some design engineers take the position that they do not want man-in-the-loop in particular equipment and components for fear either that man will damage their "highly reliable", high-precision device, or that he may inhibit its function at the wrong time.

Crewmen are concerned that weight constraints and overly optimistic estimates of reliability will result in decisions which may restrict their ability to work around completely unexpected failures and still get the mission accomplished. For example, they are not convinced that the present design of the EVA umbilical will permit external access to the entire orbital vehicle to provide for unforeseen contingencies where EVA may be essential to mission success. Regardless of measures taken to design and manufacture components and equipment with the ultimate possible in reliability, unexpected failures do occur, a good proportion of which are in modes not foreseen in original design.

It is in the area of overcoming or working around unforeseen failures that we believe man's capability may have been overlooked. It is conceivable that for want of a screwdriver, or an ax, or 5 additional feet of umbilical, an entire mission might have to be aborted. To minimize such possibilities, an imaginative approach must be taken in making full utilization of man's inate abilities. In short, we subscribe to the philosophy that, in the general sense, every pound provided to enhance man's general purpose capability to bypass unforeseen difficulties is worth a considerable number of pounds devoted to the usual approaches to reliability and redundancy of equipment in insuring mission success. We cannot quantify this value. We do not think it can be quantified. But it is an important value that man contributes and we should make the most of it through an imaginative approach to systems design.

The above represents an operational viewpoint in large measure. We cannot argue the merits of each case, because we recognize that engineering problems, weight and space constraints, and similar factors, must be included in complex tradeoff studies in arriving at system design solutions. Nonetheless these considerations are symptomatic of the overall problem of optimizing man in the system.

INTEGRATION OF MAN AND MOL

We are convinced that the MOL design effort must include the manned viewpoint from the drawing board up, that decisions must be made based on tradeoffs which fully consider this viewpoint.

We do not subscribe to giving the crewmembers carte blanche in influencing design, nor do we espouse that exploitation of man's capability is the single overriding consideration. What we do emphatically maintain is that there is a requirement for some internal program procedure, formal as well as informal, to insure that every system design decision is given close scrutiny from a manned-mission-oriented perspective.

To illustrate the point, we may refer once again to the example of the benefits to overall MOL system effectiveness that might be achieved by providing man with a direct optical acquisition scope display, so that he may take advantage of color in rapid and accurate target identification and acquisition. Engineering problems involved in relaying the optical image to the acquisition display location on the operator's console, however, tend to favor the use instead of a black and white television display. A tradeoff comparison is obviously required which includes proper consideration of the value to system effectiveness by providing man color viewing of the acquisition scene, as well as cost in complexity, weight, and reliability of providing a visual versus TV image for the acquisition display.

We are not in a position, as a group, to make this tradeoff. But we do believe that the program must provide a guarantee that the manned factor is surfaced in design decisions such as the one above. We can easily visualize that the design engineer would tend to take the easy way out from an engineering viewpoint since, to him, engineering constraints are real whereas the human factor element is nebulous. The greatest danger lies in his perhaps being totally ignorant of the fact that color content of the display may have value at all. Thus, in this case and probably in many other similar cases, the opportunity to exploit man's capabilities may be lost.

We do not believe that indoctrination to the manned viewpoint of the thousands of individuals who work on the program would be a practical means to a solution, although any effort exerted in this direction would certainly be beneficial. We do believe that a practical solution would involve considerably more participation on the part of MOL crewmember personnel in a real all-systems engineering sense, as would establishment of periodic design reviews, looking at detailed design and configuration decisions specifically from the point of view of capitalizing to the maximum the unique abilities of man to enhance system effectiveness.

What is needed is an active and competent system engineering and integration function with decision power to bring about the real engineering integration of man.

One possible approach to insuring better manned input would be to establish a requirement at MOL Systems Office level for the conduct of a periodic formal review of the program from a manned viewpoint. Under chairmanship of the Deputy Director or his assistant, membership would include the crewmembers and key personnel from the Systems Office, the Special Projects Dorian Sensor Office, and Aerospace. Such meetings would be devoted specifically and exclusively to review of critical design problems, with respect to fully surfacing and considering all manned aspects in arriving at decisions in key design and operational problem areas. Perhaps similar internal reviews could be provided for under management procedures of each of the MOL associate contractors.

A second, and possibly better approach, would be to place considerably increased emphasis on the overall system integration effort. This could be done by raising this function from its present organizational level to Directorate level and vesting in the new office greater authority and responsibility. We envision the new office as functioning in an across-the-program capacity, with a well developed orientation toward utilization of man, and not in a limited functional engineering capacity, as may presently be the case. To be effective the office should be charged with validating all operational and engineering decisions from a total system integration viewpoint, and should be empowered to render authoritative decisions, subject only to

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review by the Deputy Director, MOL. We anticipate that the MOL crewmembers could play key roles in making the efforts of this office effective.

The study group has not had time to explore the extent to which the current program management structure provides for specific review of program activities from a manned mission viewpoint. We are not aware of the existance of any formal arrangements to perform this very critical function. In any event, we believe it would be beneficial to evaluate present methods being used to review design decisions and overall program progress from the point of view of maximizing man's ability to contribute to mission success. The objective of such a study would be to prescribe specific improvements to any procedures currently in use, with consideration given to the possible adoption of the recommended improvements suggested above.

The problem is not a new one. NASA has had years of experience in designing manned space systems. We believe MOL could capitalize on this experience. More specifically, we should investigate procedures used by NASA to insure astronaut input into systems design. Procedures used by NASA should then be tailored to fit into any procedural or organizational arrangement which might be adopted for MOL.

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UTILIZATION OF AEROSPACE RESEARCH PILOTS

We believe that a primary source of input of manned considerations is the MOL crewmember group. Accordingly, their participation in systems design should be expanded insofar as is possible.

The eight crewmembers currently assigned are too few to cover in depth all areas in which they should be actively engaged. Further, their attendance at the Aerospace Research Pilot School three days out of the week limits the time they can actively participate in the current critical phase of preliminary engineering design. With all due respect to the requirement for advanced MOL training, we support the MOL Systems Office view that the schedule at the school must be sufficiently flexible to permit their participation in critical design activities, as may be determined by the MOL Systems Office.

This situation could be relieved somewhat by early assignment of the second increment of MOL Aerospace Research Pilots to the program. At present, the next increment of five Aerospace Research Pilots is scheduled to enter the program in November 1966. The program would benefit by accelerating the date of their assignment to the MOL Systems Office. Although their contributions in the first few months would be minimal, the earlier they begin, the earlier they can become proficient, hence the earlier they will be able to participate effectively in systems design.

We believe some participation by NASA astronauts in engineering design would also be beneficial, particularly if they were granted clearances, so they would be able to view the program from an overall standpoint. Participation of one or two cleared NASA astronauts, if this could be arranged, as advisors at the above-proposed manned MOL systems design review meetings would provide an excellent opportunity to capitalize on NASA experience. We believe reluctance to grant clearances to NASA astronauts might be overcome by proposing to select only those who are no longer considered by NASA to be active candidates for orbital flights, e.g., Astronauts Slayton and Sheppard. Although we might prefer the participation of others, the compromise would at least permit some valuable benefit to MOL from NASA astronaut experience. Even though perhaps difficult to arrange, we consider it essential that NASA astronauts have some degree of participation in MOL even if they cannot be cleared. It is inconceivable that we should overlook this unique source of experience.

There is a hazard involved should crewmembers be given too free a role in making decisions concerning system design and flight operations, as has been the case, to some extent, within the NASA programs. However, we do believe that under the MOL military environment the probability that this problem will arise is minimal.

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So far as the role of the crewmembers in the program is concerned, we subscribe to providing them with very wide latitude in making known their views and their concerns pertaining to design problems and operational utilization of man in the system. At the same time we consider it mandatory that their input be absorbed into the program decision-making machinery in an orderly, non-disruptive manner.

The present program arrangements for crewmember input do provide for orderly assimilation into the decision-making framework. We believe that the overall study of methods for enhancing a manned program orientation should seek means for expanding crewmember activity in the R&D area and for integrating current procedures into a newly defined formal structure to insure a high-emphasis, more positive approach to maximize man's contribution to the MOL mission.

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SECTION III

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

A. In the light of the objectives for the MOL program established by the Secretary of Defense in August 1965, and all related events since that time, the current MOL program, providing for both manned and unmanned capabilities, is a sound and well conceived program which should be continued in its present form.

B. In the light of these same considerations, the rationale for man in the MOL, today, is at least as strong and probably stronger than it was when the program was originally approved.

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C. From a technological feasibility viewpoint, there are no barriers to achievement of a [redacted] operational capability with a manned system. Despite technological progress in the last eight months, the question of technological feasibility in the unmanned system is still present. Thus, the confidence that the manned system will achieve the desired capability remains very high, whereas confidence in the unmanned system, although increased, is not sufficiently high to warrant any consideration of removing man from the system.

D. Manned systems inherently exhibit a high probability of mission success early in their flight program. Unmanned systems exhibit a much lower probability of mission success in early flights, primarily because of inherent reliability problems associated with complex automatic equipment. Thus, man will virtually guarantee early achievement of an operational capability. Further, he will contribute to early achievement of the unmanned capability, by his presence in the manned/unmanned MOL system.

E. Any cost-effectiveness comparison between manned and completely unmanned systems which includes consideration of the value of early capability, and quantity and quality of useful take, i.e., overall mission effectiveness, would favor the manned system. There is historical data available from manned and unmanned programs which would permit such a comparison to be drawn in more realistic and more quantitative terms than in the past.

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F. Achievement of advanced Dorian objectives, i.e., ultimate resolutions of [redacted] can probably only be achieved with a manned system. Even if this ultimate capability is postulated as being achievable with an advanced unmanned system, cost-effectiveness considerations would still favor development of an advanced system which includes man. With careful extrapolation and projection of past manned and unmanned programs and current program data, this comparison can also be quantified.

G. The specific functions and capabilities originally considered to represent man's most important contributions to Dorian system effectiveness remain unchanged, although there has been a shift of relative value among them. Man's real time capabilities to make judgements, and to render specific decisions continue to be powerful contributions. Man's "adaptability", and his "self-healing" nature permit him to work around problems for which no specific alternate mode has been devised. These factors underlie the high probability of mission success, and enhanced value of intelligence "take" expected of the manned system.

H. Technological progress in development of devices to solve the pointing and precision tracking tasks for the unmanned mode tend to reduce the emphasis previously placed on man's demonstrated superiority to machine in precision pointing and tracking. These developments lessen the need for man's abilities to perform these functions as a routine task, but they do not obviate them. Nor do unmanned developments to any significant degree threaten to reduce the total value of man's unique contributions in providing an overall Dorian manned mission capability considerably superior to that possible with a completely unmanned system.

I. A manned MOL program, as the first step in an evolving military space program, will provide flexibility and capability amenable to rapid exploitation in conduct of other military missions from space which may be required for national defense. Insufficient emphasis has been placed on this aspect of the Program particularly with respect to the general goals set forth for MOL by the Secretary of Defense on 24 August 1965. From a long range, total military space program viewpoint, a conduct of a Dorian program without man is dead-ended and not cost-effective.

J. It appears that the manned Dorian system may be capable of providing at an early date [redacted] with minimum modification of the baseline system.

K. Man's contributions in conduct of the SIGINT mission from orbit appear to be even more valuable than they are in conduct of the current Dorian mission. His presence for the SIGINT mission may prove mandatory. (b)(1) (b)(3)

L. From an overall cost viewpoint, considering a military space program which will grow to include conduct of other promising military missions in space, the apparent cost of providing for man in the current MOL program is misleadingly high. The cost of man can be amortized by utilizing him in the conduct of other missions, perhaps utilizing the same laboratory vehicle with different mission modules or possibly even by conducting several different missions at the same time with essentially the same basic laboratory module. Thus, his cost per mission program would be significantly lower. In contrast, separate unmanned programs typically involve unique developments to satisfy unique mission requirements, with low initial probability of mission success, and correspondingly high cost. Cost-effectiveness comparisons which consider multiple use of man for several missions versus discrete complex unmanned systems applied to the several missions on a one-for-one basis, would favor man. Hence, they favor a manned approach to conduct of the currently approved Dorian mission.

M. Increase in confidence in man's ability to perform the 30 day MOL mission resulting from Gemini program experience and MOL bioastronautic program progress warrants the conclusion, today, that man will be able to perform the MOL Dorian mission with the same high degree of efficiency he has demonstrated in conduct of military missions in the atmosphere.

N. Space flight experience to date has disclosed that astronauts have been overburdened from the standpoint of the quantity of tasks (many of them routine or trivial) they have been required to perform in space. But it is clear that their ability to perform qualitatively complex and sophisticated tasks has not been taxed.

O. Increased emphasis is required to insure that the manned viewpoint is fully surfaced and considered in arriving at program design and operational decisions. Such emphasis would have a high pay-off in terms of man's ultimate contribution to Dorian mission effectiveness. A detailed study of current program organizational responsibilities, inter-organizational relationships, and program procedures for insuring maximum input of manned considerations into MOL system engineering design and overall program planning would be helpful in determining precisely what changes should be implemented to enhance the manned effort.

P. A primary source of manned considerations in MOL engineering design is the MOL crewmember group. Their participation in this aspect of the program should be increased. Consideration should also be given to earlier assignment of the second increment MOL crewmembers to the program so their useful contribution can begin as soon as possible.

Q. Participation of some NASA astronauts in the program in an engineering assistance capacity would be beneficial, particularly if these astronauts were granted clearances. This unique source of experience should not be overlooked.

R. Insufficient emphasis has been placed in systems design on making optimum utilization of man. As a result there is the possibility that opportunities for getting the important and logical jobs in man's hands, with the proper tools, essential to overall Dorian system effectiveness, will be overlooked. There is an attendant danger that many trivial job assignments would fall to man by default. This deficiency is attributed primarily to the lack of a manned-mission orientation on the part of many individuals engaged in the program, and particularly among the lower level engineers engaged in systems design. Other possible contributory factors are: the nature of the program which involves both manned and unmanned configurations; shortage of personnel, precluding adequate attention to activities in optimizing man; the enforced preoccupation, particularly at senior levels, with other urgent program problems, activities and tasks; presence of other, more obvious system design constraints, e.g., the total weight budget; lack of an organizational entity at high enough level charged with specific responsibility for integrating the overall system with the man; lack of hard data upon which to base design of man-optics interface equipment; constraints limiting participation by crewmembers in system design; insufficient cross-fertilization and interplay of human factors in systems design ideas and information among the many organizational entities in the program, particularly among the associate contractors, due to geographical separation, and particularly as pertains to manned mission considerations.

S. Although it is not directly related to the study task, the conduct of the Man in the MOL Study, in itself, has helped to some extent to stimulate some renewed thinking concerning man's role in

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the program and in emphasizing program-wide the requirement for a better manned orientation. In particular, the cross-fertilization of ideas made possible by the study group's travels from place to place and discussions with personnel in all areas of the program has helped to develop a better appreciation for the part man plays in MOL.

RECOMMENDATIONS

A. A cost-effectiveness comparison should be made between an optimized manned Dorian program and an optimized unmanned Dorian program. In measuring effectiveness, the time spans required to develop a significant operational capability for each system should be determined, with each system measured against the same Dorian target list. Such a list should include targets, both of a fixed and a tactical nature, which are appropriate to the capabilities and precision performance of the Dorian sensor, and the "take" from either system should be equivalent in both quality and quantity. The comparison should include:

1. A projection of the probability of mission success for each system, in which all factors contributing to success or failure are considered in terms of the value of the "take" rather than in terms of simple reliability numbers alone. The projections should be developed as a function of time.

2. The probability of mission success for the manned system should be based on realistic extrapolation of Mercury and Gemini experience. Results expected from the original Mercury and Gemini baseline programs compared with actual achievements should be considered for use as a base upon which to project expected manned Dorian results.

3. The probability of mission success projected for the unmanned system should be based on our previous unmanned system experience. The expectations of the original program baselines should be compared with actual results achieved.

4. The appropriate number of launches needed by each system to reach a mature level of system effectiveness should be provided for, and the programs should be projected throughout a sufficient time period to determine if a cost effectiveness cross-over point, if any, exists. It is also quite important to insure that costs projected for each system are equivalent with respect to the confidence of their accuracy, and their maturity. Experience has been that costs invariably increase beyond those originally projected during a program's lifetime.

B. A study should be concluded on the cost-effectiveness of an advanced Dorian system capable of one and one-half to two inches ground resolution, comparing again optimum manned and optimum unmanned configurations. Techniques such as rendezvous and resupply should be introduced if appropriate. Factors similar to those set forth in Recommendation A should be introduced into this study.

C. A broadly based parametric study should be conducted which considers all relevant factors of experience in past space flight, manned and unmanned. This should be essentially a detailed study of the record of our past performance from as many viewpoints as can be meaningfully described. This study should be sufficiently comprehensive so that its results may have broad applicability. It should be continuously updated.

D. A general MOL target model should be developed for use in supporting studies of the nature of Recommendations A and B, and to provide a basis for investigating the most effective and flexible utilization of MOL. This target model should be sufficiently comprehensive to exploit all the man-machine capabilities of MOL. The model should consider strategic, tactical, and economic intelligence target complexes, and mission modes which include [redacted] planetary photography, crises surveillance, battlefield support, and arms control. Although photographic and visual reconnaissance should be considered first, the target model should be eventually augmented to support SIGINT, Ocean Surveillance, Radar Surveillance, and Command and Control mission modes.

(b)(1)
(b)(3)

E. A study should be undertaken to investigate the operational growth capabilities of MOL. The basic MOL Dorian configuration should be used as a baseline, and the vehicle augmented with additional or improved capabilities. Rendezvous and resupply should be considered if appropriate. Needed technology, and steps for providing for its support, should be identified.

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F. A vigorous study and active simulation program should be undertaken to examine all aspects and factors relevant to visual reconnaissance. The effects of color, of fields of view, of magnification and resolution, of training, and similar considerations should be included.

G. A review of present organizational arrangements, interface relationships, and procedures being used in the current program should be conducted to evaluate their effectiveness in insuring that the manned viewpoint is maintained as a major program objective. This should include an evaluation of NASA experience in this area. The objective of this review should be the definition of specific actions which should be taken to strengthen orientation toward man in the Program. The advisability of implementing certain specific improvements suggested in this report should be considered, i.e., organizational changes in the MOL Systems Office to provide for more effective overall systems integration with emphasis on man, and/or establishment of a formal procedural arrangement for periodic senior level reviews of the program, at which the principal focus is placed on full exposure of manned considerations in arriving at trade-off decisions in MOL system design and operational problem areas. Extension of any recommended improvements into associate contractor organizations and their own internal procedures should also be given full consideration.

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H. Continuous management emphasis should be placed on insuring that those specific equipments not essential in the manned mode but which are included in the system to provide for an independent unmanned capability are not designed into the system so as to preclude manual operation if necessary to successful accomplishment of the mission.

I. The program schedule should be carefully re-examined from the point of view of determining what actions might be taken to expedite design definition of optimized man-optics interface equipments and of insuring sufficient flexibility in the schedule to permit incorporation of an optimized man-subsystem prior to commitment to final design.

J. Assignment of the second increment of MOL Aerospace Research Pilots to the MOL Systems Office should be completed as soon as practicable.

K. Immediate action should be taken to obtain NASA astronaut participation in the program on a periodic consultant basis, by:

1. Initiating requests for Dorian clearances for one or two selected NASA astronauts.

2. Requesting approval of NASA for the selected NASA astronauts to participate as consultants to the MOL Program.

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L. The portion of this report devoted to the requirement for a better manned orientation on the part of program participants, or a revised version thereof, should be given widest possible dissemination to all participants in the program.

M. A follow-up Man in the MOL survey should be conducted toward the end of the current year, with specific focus on determining those further improvements that may be made to enhance the manned effort.

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