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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

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OFFICE OF THE ADMINISTRATOR

Honorable Robert C. Seamans, Jr.
Secretary of the Air Force
Washington, D. C. 20330

Dear Dr. Seamans:

As you requested, NASA has participated in the DOD analysis of the MOL inventory of equipment, capabilities, and facilities that might play a role in NASA's space flight activities. NASA has received considerable assistance in the general areas of spacecraft and ground equipment. Of the DORIAN elements, the most significant items of interest at this time appear to be:

a. The acquisition and tracking telescope system (ATS), together with the General Electric simulator.

b. The Eastman Kodak facility and capability for building large optics near the diffraction limit.

We can foresee the use of the ATS or a derivative for earth observation from orbital workshops and space stations in connection with earth resources survey activities — if simulation and test programs point in that direction. We further see an early development of large orbital astronomical facilities which would be built around large reflectors of DORIAN quality.

The principal problem we would face in pursuing these ends is the one of preserving the security of the DORIAN program and the related intelligence activities while at the same time maintaining the open, unclassified character of the NASA program. If it were possible to make equipment and facilities available to NASA without any chance

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that their DORIAN origin would become evident, we would feel it to be in the best interests of all to proceed in the normal unclassified mode. On the other hand, the Eastman Kodak facility has an apparent continuing value and utility to the NRP and should therefore not be compromised.

What we feel might work is as follows:

a. Evaluate, through the GE simulator, the utility of man in earth resources survey. We would have to request clearances for a very few key people for this job.

b. If the results are positive, NASA could contract as appropriate with ITEK and GE for development and procurement of the ATS. The equipment history could perhaps be revealed as coming from USAF supporting development without being linked to the MOL.

c. In the near term, NASA is most interested in finding out what can be done with DORIAN-type hardware along the lines of a follow-on to our ATM. We would like to have Eastman Kodak, with your approval and guidance, undertake a small engineering and feasibility study of this matter. On a longer term basis, we are interested in the overall capability of Eastman Kodak in building very large optics for future astronomical systems; we plan to discuss the technical possibilities with already cleared astronomers.

d. If these actions are approved and lead to subsequent decisions to proceed with system developments, it might be feasible to sole-source such activities to Eastman Kodak on the grounds that they have unique propietary processes for grinding and polishing large optics. This would preserve Eastman Kodak's role in DOD programs without compromise.

The above is admittedly an outline only of the problems and of possible solutions; if they appear feasible, we would like to work out the details together as soon as possible.

Sincerely,

Homer E. Newell
Associate Administrator

DEPARTMENT OF THE AIR FORCE
OFFICE OF THE SECRETARY

MEMORANDUM

September 5, 1969

Col Allen

Attached is a copy of

1. the proposed memorandum for General Hedrick's signature to Mr. Hansen

2. the draft paper on the proposed ATS experiment for the AAP.

I am told that the paper is under rewrite by Sam Hubbard per General Hedrick's request. I understand that the changes are essentially editorial -- with the exception of a statement to the effect that Air Force has no FY 70 dollars for this purpose, but that NASA should credit Air Force for dollars previously spent as the Air Force contribution for FY 70.

WILLIAM R. YOST
Lt Colonel, USAF

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AFRDS

ATS - An Experiment for AAP

SAFRD (Mr. Hansen)

1. As you requested, a review of the applicability of the MOL Acquisition and Tracking System (ATS) as an Apollo Application Program experiment has been conducted. An account of this review is attached.

2. Following your request, I discussed the matter briefly with Mr. Dan Fink of General Electric, the contractor involved, and made arrangements for an appropriate presentation. Subsequently, I asked Colonel Stanley C. White, formerly Bio-Astronautics Assistant for MOL and Mr. Samuel H. Hubbard, Chief of the MOL Engineering Division and Technical Advisor to General Stewart, to conduct a more detailed analysis. The attachment is the product of their efforts.

3. I have reviewed the experiment proposal and feel it is a fair statement of what might be accomplished. There are numerous problems associated with implementing such as experiment and some of these are mentioned in the attachment.

4. In addition, there is the major matter of National Reconnaissance Policy which should be resolved by the Excom as a first order of business. I understand that Dr. McLucas has initiated some action to this end. As you may be aware, this evolves from the "so called" McMillan rule as adopted by the NSAM 156 Ad Hoc Committee some years ago. Specifically, this limited NASA to employment of down looking image forming sensors in earth orbit to resolutions poorer than approximately 20 meters. As you will note in the report, the ATS is capable of resolution that betters this figure by a factor of 10 or more.

5. An important but less pressing item which I feel is soft is the estimate of costs involved. We are attempting to improve our understanding of these but a precise estimate

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will come with the definition study addressed in the attachment. Whatever the costs turn out to be, I think full recognition should be given to the past Air Force investment which is not only substantial but is also directly applicable. In any event, it is also necessary that NASA be queried at once as to their interest in proceeding with this experiment and willingness to absorb the initial funding requirement. This of course will include the cost of storing and maintaining the equipment prior to go ahead.

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a/s

ATS - AN EXPERIMENT FOR AAP

Definition of the Problem

The report from the Ad Hoc Committee on the disposition of the residuals of the MOL identified the following points:

1. A key feature of the MOL Program would have been its potential for quantitatively assessing the contribution of the astronaut in enhancing the performance of equipment in space. This has been and remains a goal of NASA's Manned Space Flight Program which has never been attained in a measurable way. Consequently, there remains an urgent need for the DOD and NASA to undertake a formal program to establish what man's roles should be during future space-flight missions. Data collected in this program should identify man's capabilities and limitations in operating in the space environment. It also should provide quantitative data on the relative value or contribution of man's input in the performance of a task as compared to that of having the same task done automatically. Through proper study planning the data on man's performance should be established through the use of data gained in the real environment while

he is operating equipments that have direct mission applications to DOD and NASA. By selecting a realistic mission task, motivation of the crewman can be assured throughout longer mission periods and thereby man's worth during extended missions can also be addressed.

2. The Acquisition and Tracking System (ATS) in the MOL space vehicle provided the mechanism by which man's contribution to the mission could have been measured. Engineering models of the ATS components were well along in fabrication and could be continued as an experiment to be flown in the AAP. Through the operation of the ATS system man would have exercised a full range of his abilities to perform a broad spectrum of demanding manual and mental tasks. Specifically the tasks ranged from those of pure manipulatory nature, such as rate killing, pointing and tracking, through more complex tasks requiring both manipulatory and mental decision making inputs, such as weather avoidance, activity identification and analysis of a scene for information content. If the degree of complexity built into the ATS experimental hardware approached that in MOL, a direct comparison of man's contributions could be compared to that of a sophisticated automatic system performing the same task.

3. As a natural adjunct to the experiment flight phase, a portion of the MOL mission development simulator, as completed at the time of MOL termination, would provide an excellent tool for collecting the necessary ground based data for comparison with flight results. The simulator would also provide the equipment for testing and refining the flight experiment program.

4. Preliminary estimates for completion of the development, integration of hardware into the workshop and flight of the ATS subsystem on the AAP indicated approximately $25.0 million additional funds would be required. The preliminary estimates also showed that approximately $15.0 million of funds spent before MOL termination would be directly applicable to the proposed experiment program.

5. The Ad Hoc Committee recommended that a study should be undertaken in order that many of the continuing questions related to man's future role in spaceflight may be answered.

Subsequent study of the recommendation by the Ad Hoc Committee has confirmed the importance to both DOD and NASA of obtaining data which will permit definitive mission and operations planning for future space missions.

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Analysis of the results of man's specific contributions to the flights to date are impressive insofar as there are many incidents where he has been able to take over when there has been inadequacy of instrumentation or failure of equipments. However, these events have been unplanned in the main and man's entry into the situation has been only due to his presence and the provision of an alternate manual mode for entry into the failed systems.

On the other hand the design of vehicle systems and the selection of man's roles in operating the systems have not addressed the problem of insuring that the ideal or best use of man has been used. This can be explained in part by the initial reservations concerning man's ability to live and operate during spaceflight. Man by his outstanding performance has allayed these initial reservations up through 14 days of flight. Further, data collected from flight indicate that this same optimistic result can be expected for longer missions if detailed data on defining man's adaptation to the space flight are obtained and proper crew support is provided.

A major part of the explanation for not doing a better job of design for ideal manned operations other than the

routine vehicle housekeeping tasks can be attributed to the lack of the available data on how to assess military missions and scientific tasks in space operation from a manned point of view. This deficiency became quite evident during the maturation of the role of man in the MOL Program. As the MOL Program progressed, major changes in the crew station design and the time-line activities planned for the men resulted from the lack of definitive planning data at the beginning of the Program. It was on this basis that the MOL Program gained insight into the need for a scientifically designed study of performance and crew roles while operating the specialized MOL mission equipments. At the same time, the MOL Program recognized that the mission equipments and its operations offered a near ideal and unique flight opportunity for obtaining much of the deficient data. The MOL ATS system and man's operation of it were the essential ingredients for this proposed effort. Therefore, the Ad Hoc Committee recommendation to continue this part of the program is confirmed.

Experiment Plan

Description of Experiment

This discussion will be limited to an outline of the initial thoughts on the experiment content. Further detailing of this experimental protocol is a first order of business, however, it must be done with recognition of taking the current residual MOL hardware and packaging it for incorporation into the AAP vehicles.

Generally the format of the experiment proposes to divide the assessment of man into four areas:

1. Assessment of man's inputs while using his sensory and manipulatory functions to gain the maximum efficiency in pointing, tracking, centering of points of interest in the optics and the selective control of mangification.

2. Assessment of man's ability to analyze and report scene content gained visually through the optics which are pointing and tracking automatically. Categories of activity, in this area will include weather avoidance, detection of activity in the scene, and detection, description of details of objects studied that will be selected to vary in size from

the gross scene to those approaching the physical limits of the ATS optics. Test objects proposed would include the currently used standard TRIBAR displays and also real world scenes where characteristics such as shape, relationships of objects to its surroundings, color, etc would be studied.

3. Assessments where combinations of 1 and 2 above are undertaken. These tasks will test both man's ability to simultaneously manipulate and to analyze scene content and will provide a sufficient spectrum of complex work to approach the limits of the capacity of the crewman to perform. The combined tasks will provide the means to assess man's daily capacity and performance, and his ability to maintain or continue this level of performance efficiency over prolonged periods.

4. Compare the product of man's performance of the ATS operations either totally manually or in combination with partial automatic sequences, to that obtained through automatic programming of the ATS, and camera system.

It is envisioned that the capabilities of man, noted above will be studied while using three general types of space mission objectives. These include:

1. Spacecraft to ground observation - In this case two categories of activities are proposed. First there are those studying large scene features which will address the questions being addressed by the NASA Earth Resources Survey Program. Secondly, there are those scenes which will attempt to exploit the maximum return from the optical system and will address the military interest in gaining maximum detailed information.

2. [redacted]

3. Spacecraft to celestial body observation - This mission objective will address the questions that have been raised concerning the value of having the observation on the station during celestial observations done outside of the atmosphere and on a stable platform.

Experiment Equipment Description

The ATS as configured for MOL consisted of the following elements:

1. Acquisition optics
2. Acquisition optics drive
3. Manual control stick assembly
4. Magnification control stick assembly
5. Cue display equipment
6. Computer and computer interface

This equipment was to be used in duplicate in MOL but as an AAP experiment would be comprised of a single unit. In addition to the equipment listed above, a camera with suitable fidelity and capacity for preserving a precise record of the equipment operation through the telescope will be required.

A typical diagramatic arrangement of the components is presented in Figure 1. This figure illustrates the arrangement for MOL which may vary somewhat as influenced by the experiment application.

Performance

The ATS system characteristics are as follows:

1.	Scan field	+70° -- -40° Pitch ±45° Roll
2.	Maximum Gimbal Rate	50°/Sec
3.	Magnification	16X -- 32X continuous zoom 64X -- 127X continuous zoom
4.	Field of View	4.4° -- 2.2° 1.0° -- 0.5°
5.	Aperture	10 inches
6.	Exit Pupil	2 - 4 mm
7.	Derotation	Pechan Prism
8.	Focal Length	[redacted]
9.	Filters	Up to 3 plus clear
10.	Other	Protective cover Manual override Sun Viewing Protection

Magnification	Field of View	Resolution
16X	5.6 n. mi.	15.3 ft.
32X	2.8 n. mi.	11.5 ft.
64X	1.4 n. mi.	5.7 ft.
127X	.7 n. mi.	3.6 ft.

The above performance figures assume a nadir view from 80 n. mi. of a 2:1 contrast scene with luminance of 530 ft - lamberts.

Figure 2 and 3 summarize adjustments of the MOL ATS characteristics to the AAP altitudes (200-300 n.mi.) and mission.

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Status

The engineering design of this equipment is better than 95 percent complete in the MOL configuration, component testing is complete and most of the prototype fabrication is 90 percent complete. Performance of the Telescope/Scanner has been verified by testing as has the performance of the visual display projector.

Weight

The various components of experiment hardware, qualified and ready for installation are expected to weigh between 500 and 600 pounds. This allows 100 pounds for an airborne digital computer of the IBM 4 pi type.

Power

Estimates of electrical power for operation of this experiment are as follows:

Peak Power	$\sim$ 600 Watts
Average Power	$\sim$ 300 Watts

Schedule Related Activity

Schedule

The schedule shown in Figure 4 considers only that period associated with development and qualification of one set of flight hardware. Prior to initiation of that effort, a definition study of perhaps four months duration is required. The purpose of this study is to identify all experiment parameters, complete preliminary experiment design and planning, refine cost and schedule information, provide preliminary integration estimates, and identify and isolate applicable MOL residual equipment.

This hardware schedule also omits reference to the period that must be devoted to flight hardware installation and integration, flight plan development and crew training. Much of this latter activity lends itself to parallel implementation.

The Apollo Applications Workshop first flight is currently anticipated in the second quarter of calendar year 1972. If the ATS experiment is to be proposed for that flight, then the definition study discussed above must be initiated immediately. Such a schedule would also require satisfaction of integration fit and form checks through use of prototype or mocked up

hardware. Delivery of flight hardware would then be in late third quarter 1971 which calls for development contract go ahead in 1st quarter calendar year 1970.

Funding Estimates

Funding availability to support this activity is estimated as follows in thousands:

FY 70	FY 71	FY 72
$3,400*	$12,500	$9,000

The second AAP Workshop flight is tentatively scheduled for mid calendar year 1974 and would provide a second opportunity to fly such an experiment with ample time to consider results from the first flight. If the decision should be made to by pass the first workshop flight in favor of a single experiment on the second, a more leisurely but possibly more costly funding schedule could be accommodated. The combined funding for both the early and late AAP flights might appear as follows:

	FY 70	FY 71	FY 72	FY 73	FY 74
1st Workshop	$3,400*	$12,500	$9,000		
2nd Workshop			$2,500	$10,500	$5,500
2nd Workshop Only	$ 400*	$ 1,000**	$4,500	$15,500	$5,500

* 400K required for immediate commitment.
** 1000K required to preserve and maintain equipment pending development go ahead.

Management Approach

Because of the resolving power of the optical chain in the ATS and the necessity for collecting a photographic record of performance, a question of military sensitivity arises. The apparent NASA policy of complete freedom of disclosure could require further examination to alleviate this problem. It is potentially feasible and would produce useful though not optimum results to constrain such an experiment to operation only over the continental U.S. and remote states, possessions and foreign based U.S. military facilities. A lesser but still useful result could be obtained by targeting geologic landmarks, and other features of interest to the NASA Earth Resources Survey Program. A final but less exacting experiment protocol could devolve from targeting astronomical bodies.

A combination of the experiment disciplines suggested above would appear to provide the most optimum spectrum of data for providing material for public disclosure without limiting or jeopardizing military goals or security.

In view of the above technical content of the experiment, three options for managing the experiment offer themselves for consideration:

1. The DOD Sponsor the ATS Experiment. The DOD would undertake the total program as a military manned spaceflight experiment in AAP.

This approach has the advantage of minimizing the management of the experiment development, operation and exploitation. Also, the design and development of the ATS was dictated by the severe technical requirement needed by the military for gaining the maximum data on military targets of interest. The numbers of targets to be observed, the details of data needed from each target and the diversity of types of targets indicate that the military requirements are far more stringent than could be expected from NASA missions related to earth resource and celestial observation. Fulfilling the military requirements will also fulfill the NASA data requirements. This approach assures maximum return on the military questions.

Complications arising from this approach include the security questions raised earlier plus the rather sizeable costs involved. The basic question to be answered by the experiment while being of intense interest to the DOD is required of NASA by that agency's charter. This would tend to call for a deeper involvement by NASA than might prove practical in a DOD experiment.

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2. The NASA Sponsor the ATS Experiment. This would envision that NASA would fund and manage the experiment in its entirety accepting DOD mission data requirements that will satisfy the military needs for data regarding man in space. NASA personnel operating the experiment would have to become familiar with the DOD goals and work closely with DOD missions and operations people to insure that the data collected is pertinent.

Such an arrangement also has a fairly streamlined management potential which would be advantageous. This arrangement would pose disadvantages similar to those envisioned for a DOD only experiment. The security questions remain; the cost is the same; and the question of DOD interest being adquately served in a NASA only managed experiment.

3. Joint NASA/DOD Sponsorship of the ATS Experiment. Both NASA and the DOD have proposed requirements for viewing the earth [redacted] NASA also has the requirement for celestial observations. The combined program with joint DOD/NASA management could insure that both areas of interest are addressed on an equal basis and that results are most meaningfully developed for the national need. This arrangement while not removing the problem of security would

make it more manageable. As discussed earlier, the multitude of experiment goals available in a joint program should provide ample cover for the sensitive portion of the experiment.

In addition, joint funding responsibility shared between DOD and NASA will soften the impact of the large cost of the experiment.

Preliminary evaluation of what the funding arrangements might be for such a joint program indicates that it would be reasonable to plan for equal sharing of costs. In this case, DOD might be expected to provide the funds for construction of the hardware, while NASA would provide funds for integration, crew training and flight operations. During the immediate initial definition phase both should jointly share costs since both are interested in the final engineering design of the ATS experiment package, the integration definition and the final drafting of the flight experiment protocol. A similar joint arrangement for any follow on hardware appears appropriate.

In summary, the analysis indicates that the joint NASA/DOD sponsorship of the ATS experiment would appear to be the one of choice since it will tend to alleviate the security problem, minimize funding impact upon each agency and will better serve the individual requirements of each sponsor.

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Security

The proposal to fly the ATS system aboard the NASA AAP does have inherent within it a problem of special security which must be addressed. The presence of the ATS on the MOL, its application, and the techniques for crew operations are all carried under the special security constraints of MOL. However, the ATS system equipments and their operations lend themselves mechanically to separation from the MOL mission and environment.

If it is considered important enough to undertake bringing this equipment out of the special security provisions, a special plan for handling the security aspects will have to be drawn up. There are no obvious reasons that this could not be accommodated.

Previous precedence has been set through the successful arrangement for the transfer of similar types of equipments to NASA programs. Guidelines used for these may be appropriate for the problem of transfer of the ATS.

Conclusions

1. The DOD and NASA should formally undertake an experimental program to develop data which will define what missions and tasks should include man in future space-flight, will define his role(s) in the performance of these missions, and provide a basis for quantitatively establishing his contribution in the performance of his duties.

2. The objectives of the program noted above can be best accomplished by reactivating the efforts related to the MOL acquisition and tracking system and applying this equipment and portions of the MOL mission development simulator into design and development of an experiment for flight on the NASA AAP. These equipments uniquely meet the experiment objectives because they produce a product which addresses both scientific and real military mission objectives of significance.

3. The analysis of the management approach to be used for the experiment recommends that a joint NASA/DOD experimental program be developed in order that the multitude of DOD and NASA experiment goals may be met. A joint program will also soften the cost impact to both agencies.

4. The use of the equipments aboard AAP offers a problem in security management. However, previous experience on other programs and the self contained aspects of the ATS and mission development simulator engineering design indicate that this can be accommodated.

5. The production, qualification, integration and flight of a single ATS experiment is estimated to be $25.0 million new funds. Immediate funds needed during FY 70 to insure the experiment is able to meet the AAP flight schedules is $400,000. These funds will fully define engineering integration and experiment definition.

As pointed our earlier to meet the first workshop flight date, additional funds of about $3,000,000 will be required in first quarter calendar 1970.