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DEPARTMENT OF THE AIR FORCE
WASHINGTON

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OFFICE OF THE SECRETARY

FEB 9 1967

MEMORANDUM FOR DR. FLAX

SUBJECT: Application of MOL to Astronomical Observations

Attached is a letter I have just received from Homer Newell regarding the use of the DORIAN sensor for astronomical observations. Dr. Newell essentially confirms that the sensor is useful for planetary observations. On this basis we shall fit planetary observations into our flight program on a non-interference basis with the basic reconnaissance mission.

Dr. Flax,
Suggest you read attachment to Dr. Newell's letter.
HLE

I note that Dr. Newell considers that we should first collect planetary photography, and then work out any security procedures which may arise once the data can be examined and their relevance to NASA missions understood. I consider this reasonable.

Dr. Newell also points out that significant benefits could be realized in NASA programs by adaptation of MOL telescope technology. I agree with this, and will refer the subject to the NRO for further action.

I am not prepared at present to accept Dr. Newell's other comments relative to the use of the DORIAN sensor as an astronomical telescope. From our previous brief analysis, it does not appear to be unduly difficult and expensive to improve attitude reference, and broaden the spectral response capability of the instrument. However, I will pursue these points in more detail and advise you of results at a later time.

Harry L. Evans

HARRY L. EVANS
Major General, USAF
Vice Director, MOL Program

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a/s

DORIAN

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Dr Haf

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

OFFICE OF THE ADMINISTRATOR

FEB 7 1967

Major General Harry L. Evans, USAF
Vice Director
MOL Program Office
Department of the Air Force
Washington, D. C. 20330

Dear General Evans:

In response to your letter of August 4, 1966, a working group was established to examine the suitability of MOL telescopes and flight missions for astronomical research. This working group has met with personnel of your office on several occasions, and has reviewed with me and my staff their findings and recommendations relevant to your suggestion.

The application of MOL technology to astronomical research can be examined in four categories, as follows:

(1) Use of existing design and equipment configuration, requiring no significant modification or addition to the basic instrumentation or operation plan.

(2) Provision of an alternate image station in the current design of instrument, to accommodate specialized analytical detectors such as spectrometers, interferometers, photometers, and polarimeters.

(3) Designing the following generation of instrumentation to provide capabilities for specialized astronomical observations.

(4) Application of MOL technology (components, subsystems, procedures, etc.) to the development of NASA's cognate instrumentation.

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The high degree of specialization of the present MOL configuration severely restricts its potential for astronomical use. The limitation is most critical in the area of attitude control in the inertial reference system, and attitude stabilization commensurate with the optical resolution of the telescope, over a time scale as long as the orbital period. Precise attitude control is essential to direct the light of a selected star into the slit of a spectrometer, while wide field photography of faint objects requires steady guiding over lengthy integration times.

In the framework of category (1) use, only bright objects, such as the moon and nearer planets, appear to be suitable targets. Useful observations of these objects can be made in the short exposure times available, and they are easily acquired by visual sighting or coarse attitude control. However, NASA's Lunar Orbiter and Apollo Mapping and Survey System Program are expected to provide superior observations of the moon sooner than MOL could. With respect to the planets, there is some rationale for securing random observations as the opportunity arises. The scientific interest in such observations is indicated in the attachment, "Use of a High Resolution Orbiting Telescope for Astronomical Observations by Direct Photography in Visible Light".

Accordingly, I commend to you the acquisition of such observations of the planets as your missions can support on a non-interference basis. Since there exist no specific requirements for such observations, NASA can provide at this time no guidelines for selecting targets, modes of observations, or optimum times of observation. The principal uses of such data would be to support NASA planetary missions such as Mariner and Voyager flights. I suggest that security procedures relating to any eventual data should be worked out after the data can be examined, when their relevance to NASA missions can be better understood.

The use of auxiliary equipment in conjunction with MOL telescopes, in the sense of Category (2) above, does not appear meritorious. High resolution analyzers of star light require lengthy integration

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exposures and precise guidance, and this would demand extensive modifications to the MOL attitude control and stabilization systems. However, the potential gain, compared to existing ground-based telescopes, does not make this an attractive opportunity.

The same reasoning applies even more forcibly to Category (3), the provision of astronomical observing functions in the basic design of follow-on systems. The cost of developing adequate guidance and control systems would be very high. We do not believe it would be a good investment unless accompanied by redesign of the optical system to permit observations below 2900A°. In these respects, astronomical requirements appear to be in conflict with some of the requirements on MOL hardware. Accordingly, I do not recommend pursuit of Category (3) developments.

In considering the last category, adaptation of MOL technology to NASA programs, it is clear that significant benefits can be realized. Much of the telescope technology could be directly beneficial to work planned in the NASA program. I therefore recommend that we continue to explore this category of cooperative effort, in order to identify particular items of technology that would be of benefit, and to create procedures which would allow their use by unclassified programs.

Sincerely,

/s/ [signature]
Homer E. Newell
Associate Administrator for
Space Science and Applications

Enclosure
as stated

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DRAFT
HJS:bf
9 Dec. 1966

Use of a High Resolution Orbiting Telescope for Astronomical Observations by Direct Photography in Visible Light.

This report considers the usefulness of observations of astronomical objects by photographs in visible light with cameras capable of providing angular resolution between 0.2 and 0.3 arc seconds. Experience has shown that astronomical observations by direct photography can exceed nominal theoretical resolving powers (for certain classes of objects) for a given telescope when enough essentially redundant observations are available to permit image averaging. Another assumed advantage is that the observational program will allow extended observations, approaching continuity, with picture rates ranging from a record every few minutes to several records per day, over a time scale of a month or more.

Mars is an obvious first choice for attention by the instrument under consideration. An obvious requirement is for cartographic survey maps of the entire planet. Only a few exceptional ground-based photographs have attained comparable resolution, but major areas of the planet's surface have not been so well studied. For example the Mariner '64 pictures are not matched by highest resolution observations of the zone photographed during the fly-by. Time sequence photographs of the surface of Mars in visible light are highly desirable, especially at intervals of about 30 minutes. An important use of these observations is to determine whether the cloud surface velocity is what is claimed from quite rudimentary and scarcely adequate ground-based observations. Theory predicts that

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surface winds on Mars must be of the order of hundreds of kilometers per hour. In point of fact, clouds appeared to move across the surface of the planet at lower velocities of the range 20 to 50 kilometers per hour. However, the observations are fragmentary and incomplete, so that the conclusion is equivacable. Moreover, the limited resolution hitherto available has made the identification of a single cloud feature from one night to the next, conjectural, and in many cases dubious.

Venus has been observed to show vague dark markings in the cloud structure, especially in the near ultraviolet (between 3,000 and 4,000 angstroms). Observations by French astronomers indicate that the dark markings rotate retrograde with a period of about four years. This remarkable phenomenon must be checked by observations which provide reliable high resolution and continuity over several four-day periods. The investigation is quite difficult, however, since the visibility of these dark markings is maximum when they are near the terminator of the gibbons phase of the planet. Another program of Venus observations would be the search for airglow on the darkened hemisphere of the planet. Conflicting observations of this alleged phenomena on have been reported. The technical parameters of such an investigation are not clearly defined, but it is possible that a conventional telescope could contribute useful information. However, it is likely that a more refined, specialized instrument (such as a coronagraph) would be necessary to control the light of the much brighter sunlit portion of the disk, and to prevent it scattering into the optics of the telescope.

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Jupiter is a very well marked planetary body, with numerous vividly-colored and photometrically well differentiated markings on its globe. Some of these markings appear to have very rapid proper motions relative to the average motions of the surface associated with diurnal rotation. A fraction of the observed structures is seen to appear or disappear in association with the famous large red spot. It is not known what observations achieving 0.2 arc seconds will reveal to us of the physical processes involved in the structural dynamics of Jupiter. The morphology of familiar markings suggests, however, that higher resolution would reveal another order of magnitude of physically interpretable phenomena. Such observations must be made consecutively, to permit observing periods up to a full rotation of a planet. Satellites of Jupiter in some cases show traces of an atmosphere. Uncertain observations in the past also suggest that there are traces of surface markings that would permit the establishment of rotation periods. One of the Galilean satellites appeared to have a higher albedo after an eclipse of the sun by Jupiter. High resolution observations should permit testing the hypothesis that this change in albedo was the result of a snowfall after apparent sunset on the satellite.

Mercury has revealed to the most skillful observers some very faint, low contrast markings. However, these features have never been photographed. The observation of markings on Mercury is especially important as a way to test the recent radar observations of the planet's rotation period. The classical surface observations indicated that the planet rotates in 88 days; however, radar data have recently indicated with some certainty that the rotational period is only 59 days.

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Comets do not present any specially challenging investigation topics for high resolution direct photography. Shape variations of comet tails near perihelion passage, under the influence of varying solar activity conditions, are a well known phenomenon. However, the hydromagnetic processes prevalent in defining the shape and extent of the comet's tail are not known to produce structures of the size significantly smaller than can be resolved by ground-based telescopes. A large, well-developed comet certainly ought to be observed by the proposed instrument to validate the assumptions made about scale length of interplanetary disturbances.

Saturn still presents a fascinating object for astronomical research by direct photography. When Saturn's ring system tilts to include the earth in its plane, the ring, as seen from the earth, appears progressively thinner until its cross section almost vanishes. This extreme aspect of the ring occurred in 1966. Measurements of the actual thickness of these rings will provide important clues to the dynamics and stability of the whole ring system. In addition, straightforward studies of the zonal divisions in the rings will also contribute to our understanding of the nature of the rings and the mass distribution in the Saturnian system.

The outer planets (Uranus, Neptune and Pluto) are less well known, but very deserving of high resolution observations. The diameter of Pluto lies below the limit of measurements by ground-based telescopes, and should be examined visually if possible. Surface features of Uranus and Neptune are inconspicuous and little known. The low surface brightness of these remote bodies would, however, require longer exposures than would be needed for Mars or Venus.