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WASHINGTON, D.C.

AFF

January 21, 1971

MEMORANDUM FOR DR. McLUCAS

SUBJECT: HEXAGON Near-Real-Time Readout

During our recent visit to Perkin-Elmer you asked me to return at a later date to learn more about the possibility of adding a Near-Real-Time capability to HEXAGON. As you know, I have been unable to obtain authorization for such a visit. However, OSP has made available to me a P-E proposal for a study of the subject. Because it is a proposal, not the study itself, one should not expect study results. Therefore, critical comments should be viewed with this in mind.

Enclosed is my critique of the P-E proposal to the extent that information could be gleaned from their document. There is no system description as such; some possible techniques and components are suggested but the full range is not treated. I have asked OSP for their comments on my remarks and, for your information, have included their response as an attachment to the enclosure. Of significance is the remark that "The vagueness of system characteristics is partially attributable to lack of guidance from the government on what the system should do and to the fact that there are many possible configurations."

Further investigation requires that I be authorized to visit P-E, or at least have an opportunity to talk with the proper P-E personnel. In any case, I strongly recommend that further exploratory work be done to develop a system concept.

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D R A F T

1. In a study proposal made available by OSP (Sensor Subsystem P-13 Definition Study) the Perkin-Elmer Corporation proposes to investigate the possibility of extending the HEXAGON mission by adding a near real time (NRT) capability to the present vehicle. The proposed configuration would provide a total orbit lifetime of 135 days, 45 days of the primary HEXAGON mission at an altitude of 80 miles, followed by a boost to an altitude of 124 miles allowing 90 more days of NRT operation. The increased orbital lifetime is obtained by the decrease in drag at 124 miles and the addition of drag makeup fuel. This added weight, and the weight and space needed for the NRT module would be obtained by eliminating some of the secondary payloads and subsatellites.

2. Thus, after an initial transient period of 45 days, four launches per year, properly phased, would provide a continuous NRT capability in orbit in addition to the normal HEXAGON mission. In effect there would be four 45 day periods with two HEXAGON systems in orbit, one performing the primary stereo HEXAGON mission while the other is performing the monoscopic NRT operation. The latter mission would also fill in the remaining four 45 day periods.

3. The NRT module consists of a separate supply and take-up, an NRT looper, an on-board film developer and scanner, and an associated data transmission system. It is proposed that the module utilize either Horizon's free radical film or 3M dry silver film. It is calculated that 13,100 feet of film may be carried in the module. Liquid developer is not required, the developing and fixing process requiring only radiation and heat. In operation, the NRT film is spliced on to the end of the primary film at the end of the 45 day primary mission. Either of the two cameras may be used.

4. The processed film is scanned with either a laser scanner or a solid state array with electronic scanning. The scanning signal is transmitted to a relay satellite (a COMSAT vehicle is proposed), thence to a [redacted]
The proposal contains a statement to the effect that using a single communication satellite, "all of the 13,100 feet of NRT film can be transmitted using a video bandwidth of 11.5 MHz." Exactly what this means in terms of practical mission operational capability is not clear. Although the unqualified statement quoted above may literally be true, there is no way of determining how much of the 13,000 feet will frame areas of interest.

There is no mention in the proposal of what would be necessary in a ground station.

5. The following two tables are extracted from the P-E proposal. Whether they represent realistic operational capabilities or are simply calculations without regard for meaning is not clear. They should be viewed with care and some skepticism.

TABLE 1

PHOTOGRAPHIC GROUND COVERAGE

Frame Length (Degrees)	Total Frames	Avge Frames/Day for 90 Days	Total Nadir Coverage
3	37,666	418	3.03×10^6 (NM)
15	9,336	103	3.78×10^6
30	4,812	53.5	4.00×10^6

TABLE 2

NRT FILM TRANSMISSION

Resolution of Reconstituted Image	Frame Length (Degrees)	Frames Per Day	Satellite Access Time	Time Per Frame
140 L/MM	30	54	10 hr	11.1 min
140 L/MM	15	104	9 hr,30 min	5.6 min
140 L/MM	3	421	8 hr	1.14 min

NOTE: 140 L/MM yields resolution of 3.5 feet at 124 NM.

6. The notion of adding an NRT capability to HEXAGON is a very appealing concept. The fact that eliminating the secondary payloads allows an additional 90 days in orbit (albeit at an altitude of 124 NM) is sufficiently attractive to justify vigorous pursuit of the means to achieve reliable and operationally useful film read-out capability. Unfortunately, the P-E proposal falls considerably short of providing the information necessary to judge whether the particular scheme advanced by them has sufficient merit to justify full scale development along the lines proposed by P-E.

7. The areas in which information appears to be lacking include the film characteristics, the film handling and developing procedures and processing time, and to some extent the scanning and read-out operations and times. Perhaps most disappointing of all is the vagueness of the description of the practical operational capability of the proposed system. At one point in the study it is estimated that a limiting factor is the maximum transmission capability per orbit. According to P-E the 38 minutes available per orbit will allow the scanning and transmission of approximately 12 feet of film. One supposes that the time required for developing

and fixing the film is included in this time estimate. At another point one might infer that the capacity of the NRT looper, in which the exposed film is stored for subsequent processing and scanning, is 17 feet of film. So if one optimistically assumes six useful daylight orbits per day, then in the one case there will be a yield of 72 feet per day (6480 feet for 90 days) or in the second instance a yield of 102 feet per day (9180 feet for 90 days). One wonders, then, how the numbers in table one were calculated. In fact, both of the above tables may be quite misleading. For example, in Table 2 one sees an entry of 10 hours Satellite Access Time. In reality, for the scheme proposed by P-E, there will be only about 4 hours of useful Satellite Access Time.

8. In addition, one should know, of course, the present state-of-the-art with regard to the Horizon film, the adaptability of the developing and fixing processes to the environment, and the rate at which the technology is evolving. It will also be necessary to learn more about the read-out technology. These two factors, of course, are common to any film read-out system.

9. To conclude, one may say that the utilization of HEXAGON in a read-out mode is an appealing concept which appears to

hold much promise. The manner in which P-E proposes to realize such capability appears to have some unexplained deficiencies. Clearly, the subject should be pursued and an attempt be made to find a more satisfactory mechanization. No cost figures were given in the document.

The following comments apply to the various paragraphs of the critique. Paragraph numbers below correspond to the paragraph numbers of the critique.

1. The extension of operating lifetime, while still retaining the planned overall system reliability, is more a problem of the vehicle than of the camera. The weight and performance estimates are gross estimates developed by the payload contractor and need to be more completely determined by the vehicle contractor. There are many options on how a mission might be flown. There has been no attempt to determine what the optimum mission would be principally because there has been no requirement established for a NRT capability for HEXAGON. Most of the increase in weight could be accommodated by elimination of the terrain mapping camera. The requirement for this camera in the time period of concern is not known to the SSPO.

2. On the operating basis proposed, it is not possible to provide continuous NRT coverage since the system will have some finite value of reliability--probably 75-80%. This would mean, on the basis proposed by PE, five launches per year to maintain a system continuously in orbit. In the event of early failure there could be a period of at least 10 days without coverage and 40 days without NRT readout. Other analyses have shown, however, that if the life is extended somewhat longer, the film capacity of the system is adequate to supply projected 1975 and beyond requirements with three missions per year, which, assuming the same reliability would require four vehicle launches per year.

4. Solid state array scanning is by far the most promising offering better overall resolution, design simplicity, and operational reliability and flexibility. The data rate using a laser scanner is limited by a scanning rate of about 50,000 lines/minutes. Data rate with solid state arrays is essentially unlimited in this application. Since the information is stored

on film the readout rate can be set to stay within the bandwidth requirements of available downlinks. For an early operational capability the Contractor has proposed a COMSAT type link since it was assumed that such a link could be available within the time frame under consideration and that it would be highly dependable. Since the system is a storage system, it is possible to trade time for bandwidth. The total amount of information is, of course, the time-bandwidth product so it is desirable to have as wide a bandwidth as practical. The 13,100 feet of film is based upon estimates of the number of surveillance targets which would be expected to be photographed during the 90 days of NRT operation. The video bandwidth of 11.5 MHz is adequate to transmit the information from the film within the 90-day operating time assuming a single satellite relay.

5. The values given in Tables 1 and 2 are calculated values using the information which now exists on the camera and readout devices. For the most part they represent capabilities which have been demonstrated but not in the configuration in which they will be used.

6. There are certain discrete steps which should be undertaken if HEXAGON is to be considered for a NRT readout system. These are:

a. Establish with the Intelligence Community the General Operational Requirement (GOR) for readout as applicable to HEXAGON.

b. Develop preliminary design and mission profiles for meeting the GOR.

c. Perform cost/effectiveness studies of the various designs and select a design/mission concept.

d. Prepare Design and Performance specifications.

e. Develop and qualify the system.

7. Considerable improvement in the free radical film must be achieved before this film could be successfully used. A contract for the development of aerial film for HEXAGON application is in being with Horizons, Inc., and good progress has been made over the past year. At the present time it appears encouraging that a satisfactory film will be developed; however, the free-radical film characteristics are not fully understood and there is some risk that a satisfactory film may never be achieved. PE is working closely with Horizons to assist in directing the development to be directly applicable to the HEXAGON camera. They have done some work in processing and evaluating the photographic and physical characteristics of this film. The vagueness of system characteristics is partially attributable to lack of guidance from the government on what the system should do and to the fact that there are many possible configurations. This has caused the proposal to be general in overall tone yet specific in some areas without showing the basis on which specific values were

established. This proposal is not so much the results of a study as it is a proposal to conduct a study. Some of the confusion is caused by more than one design concept being considered without tying it to a full system. For example, both laser and solid state array readout systems are considered, also both direct transmission to ground and satellite relay were examined. The variations which were examined tend to confuse the reader as to what is proposed. If readout in HEXAGON is desired a complete review of the backup data from which the proposal was prepared should be made.

8. The film status was mentioned earlier. The major development problem is to increase the film speed. During the last year this has been increased from less than ASA speed of .01 seconds to over 1.0. A value of 3.5 is desired. It appears that the speed will be achieved within the next six months. The second major problem is life which at present is a matter of a few minutes. This is sure to improve, but how much is not known. Other options are

possible, such as activation on-orbit. The general requirements for image intensification, developing and fixing are well established, but may be subject to some change as the film characteristics are changed.

9. If a readout requirement is established for HEXAGON and done in the immediate future, the capability would be introduced in a Block II design which would incorporate several design improvements such as the large looper, simplified electronics, etc. It would be desirable, if practical, to hold design competition on the Block II system. This would require an early establishment of the operational requirement.