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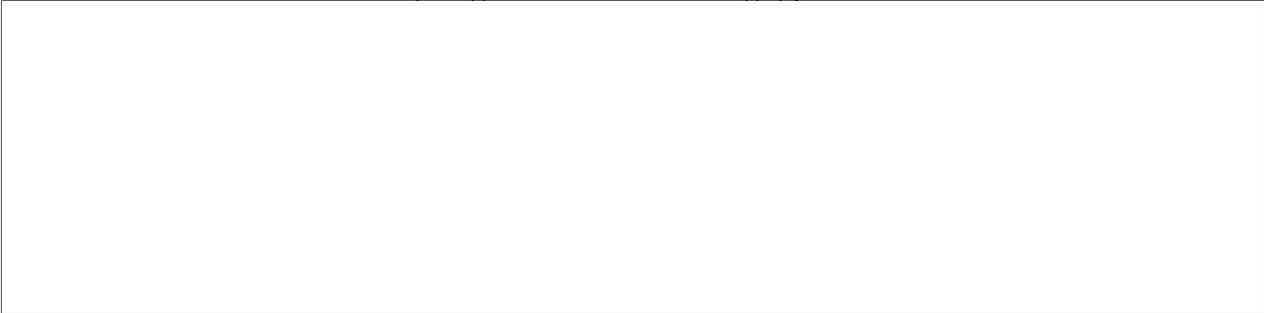
June 23, 1969

MEMORANDUM FOR

Dr. Edwin Land

SUBJECT: My Review of Solid-State Sensor Technology for the
Electro-Optical Intelligence Satellite ("EOI")

As you requested, I have undertaken to review the status of the photo
transducers for the EOI program. Accordingly, I have undertaken with



In making these visits, we are considering not only the present status
but also the potential of the various approaches and the magnitude of the
development and demonstration program which will be required to give
confidence in performance and life on orbit.

What I have seen thus far confirms the view of the Panel that the
solid-state technology is a viable approach and that there is a high
probability that a system commitment and choice of detailed approach
could be made by December 1969 or by March 1970 at the latest. This
is, of course, a provisional judgment. 



 Although their original approach was to have a chip with
diodes, and a separate chip with switches and shift registers, I believe
that what was initially their backup approach, to integrate the output of
each diode on to a separate amplifier and to switch the amplifier outputs,
will probably win out as it is getting more attention. Their photo lithography
work is good, and their turn-around time for producing new devices has
been as low as a week, which makes for a responsive program less likely
to be mired in conservatism and initial errors.

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WORKING PAPER

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With a [] field of view, and with a scan which reduces the image motion by a factor 10 in order to increase the integrating time and thus the charge on a photo sensor by that same factor, the time required to photograph an area is on the order of [] I, myself, believe that the eventual system in order to maintain simplicity and high optical quality will slew the whole vehicle to point from target to target, thus eliminating the need for a large flat and allowing a very great flexibility of targeting, even in the case of clustered targets. Such a system, of course, at an altitude of 150-300 miles corresponds to an extremely small field of view and to a larger F number, making the optical system very easy to realize and eliminating all kinds of corrections which are ordinarily ticklish.

As you may remember, I have always been interested in the use of a photo cathode and accelerating potential in front of the solid-state array to serve as an image intensifier and thus to reduce the developmental problems associated with switching noise, to reduce the lower light level capability of the system and to eliminate the need for back scan which is now used to increase the integrating time on a given photo sensor. [] has demonstrated the production of linear image intensifier photo cathodes and has an apparatus in which such cathodes can be formed and transferred under vacuum to mate in a vacuum enclosure with the photo diode array. I believe that the resolution which [] will obtain on their image intensifiers is inadequate, in my opinion, as a result of their having used only electrostatic acceleration.

I am very pleased to report that I have seen at [] a demonstrated

[] This input stage is thus ideal, without changes, as an image intensifier for the solid-state array, and I shall recommend to the sponsors of the solid-state array work that they buy such image intensifiers from [] and transfer them to the solid-state contractors early in the exploratory development process.

To summarize my present knowledge of the solid-state array work, [] has demonstrated the capability to produce arrays of diodes, [] to the chip, arrays of switches, and shift registers. They have operated these together and the remainder of their program

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is to refine the design choices and to increase the yield of their approach. [] has been working on a photo transistor system, and my one hour with them last month was inadequate to give a definite statement as to their status. In my opinion, these two contractors each have the capability to move ahead rapidly and to demonstrate not only individual segments of the photo sensor and readout system but to integrate these

[]
I expect at that time we will have a firm yield and cost data, but any projection of the cost of a completed [] array shows that it is negligible in the overall system budget. The availability of the image intensifier of demonstrated performance removes all my doubts as to the achievability of the all-passive solid-state approach.

There has also been progress on the [] electronic camera. You will remember when we were briefed last fall, [] promised to assemble and demonstrate their electronic camera within a week or two. Attempts to do this failed, and it is only in the last few weeks that the individual portions of the system have been brought up to some kind of operating capability and have been made to work together. The cumbersome focusing of the input stage by the use of large coils has been replaced now by the permanent magnet focusing, which works extremely well. Images have been written by simulated techniques onto silicone dioxide films coated on to metal substrates and have been read out by developmental type electron guns. There might be some chance of realizing [] through this system, but in my opinion it would not be worth the candle, and I agree with some comments by Air Force personnel that [] might be a better choice in this case.

As you will remember, the guns are extremely cumbersome, using a velocity modulated readout at an angle to the incident electron beam. A narrow angle gun has been devised and shows promise, as has also a system in which the return beam is not separated in angle from the incident beam but is rather collected on a multiplier surrounding one of the apertures in the incident electron beam. These various approaches all have individual problems, but there is substantial progress demonstrated, and as the [] people say, "In the last few weeks we have gone from millimeters per line to lines per millimeter, and we have shown that there are no physical barriers to the actual operation of the system."

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The system is, however, complicated. There are problems of producing the storage material and of obtaining uniformity and cosmetic quality. The system does, of course, have some storage, but the storage plans (100 feet) is adequate only for some 200 pictures which might be only a single orbit's worth. Of course, if use is made of the storage capability, then one does not have the [] viewing and adjustment capability which might be desired in order to optimize the quality of each picture. My judgment is that with adequate time and effort, the [] electronic camera might be developed into a capable EOI system, but that there are so many technologies involved and the system is so complicated that the required development and demonstration program will be much longer than for the solid-state array.

In general, I find that the Panel concept of a simple satellite oriented by [] with a simple optical system imaging the ground on to a solid-state array (probably with a permanent magnet focused image intensifier stage preceding the array) continues to hold promise as the most straightforward program for realizing this capability at an early date. There appears to be no problem in obtaining a relay satellite and an adequate transmission bandwidth to handle the [] (slowed down) video data, and the existence of [] viewing can be used to increase very substantially the quality of the pictures.

Shortly after July 1, [] and I will present to you a joint report on our findings in this program. That will have more technical content than is required for the present purpose, and I hope together with the review by [] will lay a firm foundation as to the possible date of a system go-ahead.

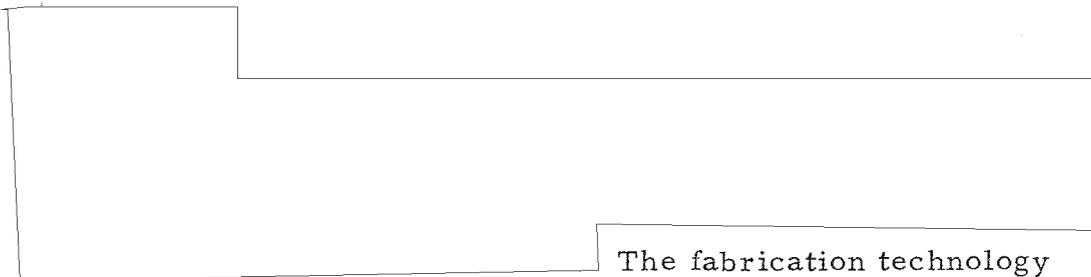
Incidentally, I gather that the [] expected for 1969 support of the solid-state arrays has not yet materialized, and that only some [] has been suggested by the NRO for technology for Fiscal Year 1970 instead of the \$0M which the Panel estimated might be well spent in order to advance the operational date of a soundly conceived EOI system. Probably Don Steininger can give you more information on this matter. Sorry I can't make this report to you in person, and I apologize for not being able to revise a written draft. I hope that this may be of some help.

Richard L. Garwin

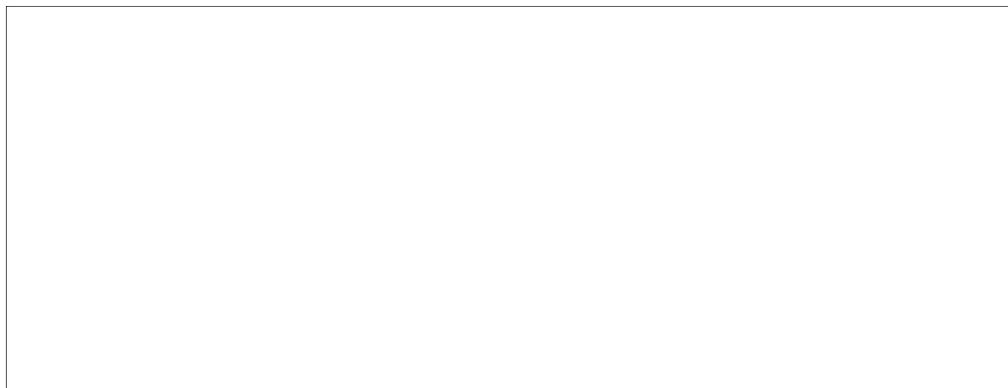
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20 June 1969

EOI SOLID STATE ARRAY PROGRAM SUMMARY



The fabrication technology appears to be in hand. The geometric layout of the detectors places severe requirements on the vehicle attitude control system. The next phase of the program will be a chip geometry redesign and assembly into a multi-chip test array.



20 June 1969

EOI SOLID STATE ARRAY PROGRAM SUMMARY

[REDACTED]

By March, [REDACTED] had produced test results that were quite promising. These tests were performed on units where the photodetector and switching functions were located on separate chips. After further testing on these units and breadboarding in discrete form of an advanced circuit, a new chip design has been built with sensors and switches on single chips. The first fabrication runs were completed on 12 June. Calibrated optical tests have not been completed, but preliminary testing indicates that the devices work and have a performance comparable to the previous design. The program plan calls for a [REDACTED]

[REDACTED]

20 June 1969

EOI SOLID STATE ARRAY PROGRAM SUMMARY



has built both photodiode and switching chips. They appear, in the early stages of testing, to equal predicted performance. Current effort centers on completing measurements, perfecting manufacturing techniques and designing a new switching circuit. The final array design will utilize air isolation and beam-lead interconnection. The program plan calls for a

