(S) NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

OFFICE OF THE DIRECTOR

March 15, 1969

MEMORANDUM FOR THE DIRECTOR, CIA RECONNAISSANCE PROGRAMS

SUBJECT: FY 1969 Funding for Readout Technology

This is in reply to your memorandum of January 7, 1969 and your message (PILOT 2763) of January 31, 1969, recommending increased levels of funding for readout technology programs.

In response to the PSAC and the discussions at the EXCOM meeting of November 13, 1968 an increase in the level of FY 1969 funding for readout technology is being authorized. However, as I indicated at the EXCOM meeting, this increased funding is to be at a level not to exceed $2 million and is being divided between the readout technology programs of CIA/OSP and SAFSP. Accordingly, it has not been possible to fully fund all of the program expansions and additions which you have recommended.

The December 19, 1968 memorandum report of the Land Panel to Dr. Hornig is being given heavy weight in the allocation of funds since half of the increased funding is being assigned to solid-state array efforts in spite of the fact that these are not currently the most promising concepts in terms of near-term overall system effectiveness and costs. It is recognized that major technical advances in the solid-state array technology may radically alter this situation. However, it is not possible to meet the Land Panel recommendations as to level of funding within FY 1969 budget constraints and the need to meet other NRO funding requirements.

I am authorizing the release to CIA/OSP of $1 million for the purpose of accelerating and adding efforts in readout technology. It is intended that these funds be used entirely to augment efforts in solid state transducers and directly associated efforts in optical systems and image processing studies. However, if you desire to apply these funds to other areas of readout technology, please advise us prior to obligation of funds in order that we may assure complementarity with planned SAFSP programs. In this connection, I would like to make it clear at this time that, while CIA/OSP programs in this augmented FY 1969 program are being recommended for concentration on solid-state arrays and SAFSP programs in FY 1969 are concentrated on electron optical devices, there is no intention to make this a hard and fast division. In view of the uncertain status and potential rates of progress in new readout devices, it is desired to provide maximum latitude to CIA/OSP and SAFSP to explore a range of novel and promising approaches to readout technology.

It is considered premature to proceed to system design or subsystem development based on undemonstrated electro-optical components. System studies should be limited to effort necessary to define the ranges of parameters for electro-optical components. As indicated at the November 13, 1968 EXCOM meeting (Budget Issue No. 9), funds are being programmed in FY 1970 to permit work to begin toward engineering models of components and brassboards and to initiate system conceptual design efforts starting about mid-FY 1970 if component development warrants.

Although the only operational requirements objectives currently identified are those described in the COMIREX report of January 5, 1969 "Requirements for Image Forming Satellite Reconnaissance Responsive to Warning/Indication Needs (USIB D-46.4/3 (COMIREX D-13.7/4) BYE 0002-68)," at the present stage of advanced technology exploration it is not desired to limit pursuit of applied research in readout technology to only those concepts which would satisfy these particular requirements objectives. However, progress in the applied research and advanced technology programs will be monitored with a view toward identified specific components and concepts which have direct application to the COMIREX requirements objectives. A summary of other potential capabilities and applications of satellite reconnaissance readout systems will be found in the NRO staff study "Satellite Image-Forming Reconnaissance Systems with Near Real-Time Return of Imagery", dated March 12, 1969.

Alexander H. Flax

Alexander H. Flax

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THE WHITE HOUSE

WASHINGTON

BYE 11,899/68

October 21, 1968

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Dear Al:

Here is the report from the Land Panel on its October 2 meeting. I believe you and your staff have been aware of the substance of the Panel opinion and that they plan to look further into the transducer technology at another meeting.

There seems to be some exciting opportunities in the offing and, as you see from my letter to Paul Nitze, I am asking that at our November 13 meeting we discuss how FY 1969 monies could be made available for additional sensor development and design studies if additional investigations by you and the Panel show that to be desirable. I also suggest that our FY 1970 decisions allow the flexibility to put additional effort if necessary.

Sincerely,

Don

Donald F. Hornig
Special Assistant to the President
for Science and Technology

Enclosures - BYE 11,896/68, Cy #4
BYE 11,898/68, Cy #2

Dr. Alexander H. Flax
Assistant Secretary of the Air Force
Washington, D. C. 20330

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MEMORANDUM FOR: DR. DONALD F. HORNIG

Since the beginning of the concept of satellite reconnaissance, the ultimate goal has been to give decision-makers an "on-call" capability to view any interesting area of the world in real time. Our dream has been, in effect, to "see it now." So far, however, technical limitations have forced us to compromise this goal. To get high resolution and reasonable area coverage we have had to use photographic film, physically recovered from orbit. In addition, short equipment operating lifetimes have been an economic barrier to keeping satellites in orbit continuously over the U.S.S.R. and China.

We have just reviewed the technology programs being sponsored under the National Reconnaissance Program by the Air Force and the CIA and we would like to let you know that the necessary technology for a "see it now" system has become available. From a technical standpoint, it will be possible within the next year or so to begin development of a system of satellites which could view any location in the U.S.S.R. and China every few hours and send a high quality (KH-7 like) image immediately to Washington. Here are the capabilities that have been developed over the past few years which now make this a realistic expection: ?

1. We have learned how to build satellite systems which can operate reliably for a year and more in space. Thus, we can confidently build an economical system which will have satellites over the Soviet Union and China every day, year after year.

2. We have learned how to send great quantities of information very rapidly from satellites to the ground. This technology is immediately applicable to the relay of information from satellite to satellite. Thus, we can build a communication link which can immediately transmit a picture from a satellite over Russia or China directly to Washington.

3. The technology of satellite electro-optical imaging systems has advanced to the point where we can foresee in the very near future the capability to view the ground with high resolution and in a manner which makes this image available for rapid and, with some systems, immediate transmission to the U. S.

However, in order to be prepared for a system development decision within the next few years, it will be necessary to give priority attention and funding to the development of each of the several feasible imaging system alternatives and to studies of the optical and communication system characteristics that may be peculiar to each of these approaches. The

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imaging techniques that have potential for supporting a near term system decision are the following:

a. A reusable electrostatic tape storage/electron beam scanner, funded by the Air Force at CBS Laboratories.

b. A return beam vidicon system, proposed by the CIA but not now being funded.

c. A line array of solid state detectors arranged in the image plane of the optical system, funded by the CIA at Fairchild and at TRW.

All of these systems have advantages and disadvantages, but all have promise and -- in view of the tremendous potential of a real time surveillance system -- all should be funded at a level which will establish a basis for decision by, say late 1969.

We are especially attracted to the solid state array which offers the possibility of building a simple solid system having no moving parts and no electron optics, with further possible advantages in redundancy and adaptability to optical designs exploiting curved fields. We intend to investigate the solid state array and the return beam vidicon further, but our tentative opinion is that both these alternatives should be carried as rapidly as possible through advanced development of a transducer system, as we understand is planned and as we also recommend for the CBS electrostatic image camera. We estimate that all three of the approaches could be carried through to at least a critical technology feasibility demonstration within the next year. We also plan to investigate the possibility of a transducer which would use standard return-beam vidicons whose target would be a continuously-rotating drum of photoconductive material -- drum being "exposed" by the optical system on one side and "read out" by the vidicons on the other.

With the potential gain so large, the panel is concerned that the present funding squeeze is diverting resources from these relatively inexpensive programs. As a result, two of the image system possibilities -- the solid state array and the vidicon -- are not being pushed along as rapidly as the technology would allow and the key demonstrations of feasibility have not been defined and scheduled to assure that within a year or so the data on which to make a system decision will be available.

Furthermore, the panel is unanimous in feeling that the system studies in this area to date have lost sight of the ultimate goal, <u>essentially instantaneous information from an always available sensor</u>. The communication links suggested were, for example, of limited capacity even though current technology will support a system of sufficient bandwidth to handle all the information as it is produced. The computers on the other hand, were unnecessarily ambitious, emphasizing light weight at the expense of reliability and long lifetime. As the Air Force and the CIA proceed with component engineering development and the necessary design analyses to define the parameters of other components of the system, it is important that the following system characteristics remain uncompromised until such time as a full-scale system development program is begun:

1. Long life in orbit; therefore, long-lifetime components and highly redundant design.

2. High-resolution imagery.

3. Immediate transmission to the U.S. of all the information at the sensor at the rate at which it is produced.

In addition, attention must be given to techniques for processing the data on the ground and displaying and recording it in a manner which will capitalize on the real time nature of the information. We saw no indication of any current activity to investigate technology relevant to this need.

To meet our requirements of the future we will have to continue to use film-based systems to photograph large areas for search and get very high resolution for technical intelligence. The Hexagon and Gambit Cubed will provide this capability. Now the technology is nearly available to build a system which will provide the real time, always available surveillance which we have found to be so important and which Hexagon and Gambit cannot provide. The potential value of such a system is so great that all applicable technologies, component development and system studies should be funded concurrently and at a level adequate to allow system definition about a year from now -- if necessary, at the expense of some current operating capability. The system that is finally selected will benefit by a wide participation by, and competition among governmental and industrial organizations and we suggest that both the CIA and the Air Force be given wide latitude to investigate system designs and trade-offs applicable to the sensor systems each has proposed and to recommend component development programs for them.

Edwin H. Land

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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
WASHINGTON

October 25, 1968

MEMORANDUM FOR

Colonel Lew Allen, Jr., SAFSS

Dr. Garwin has provided the following discussion of potential uses of linear arrays for TV scanning:

"Although most TV pictures are produced these days by imaging a scene onto the photocathode of an image orthicon or a vidicon, a promising alternative would be to use an array of photodiodes, each connected to an integrated-circuit capacitor, an integrated-circuit switch and thence to an output line. In this way, if the scene is scanned over the linear array by a single rotating mirror or by other means, then the entire set of integrated circuits should be read out in the time that it takes one resolution element in the scanning direction to cross the linear array. Thus, if one wants 1,000-line TV, with a frame rate on the order of one per second (suitable for many applications not involving entertainment) then each of the 1,000 elements can be allowed to store charge for on the order of one millisecond, and a single serial output amplifier is switched at megacycle rates from one element to the next. For this same frame rate, 100-line TV could accept one hundred microsecond switching times and 10 millisecond integrating times, while 10,000 line TV would require 10 nanosecond switching time and about 100 microsecond integrating times.

"Bell Labs Videophone has an array of about 500,000 photodiodes rather than the usual electron-beam-scanned photocathode. With the linear array, as one improves the resolution, the required object brightness increases, if only because the allowable time for integrating the current varies in proportion to the number of resolution elements across the frame.

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"Thus, for high-resolution pictures it would be valuable to amplify the current in order that it can compete better with noise in the individual transistor circuits and in the switching arrangement. This can be done without introducing significant noise by using avalanche photodiodes rather than ordinary photodiodes. Individual avalanche photodiodes are sold, for instance, by Texas Instruments, which have a quantum efficiency of 20 per cent and a normal gain of 200. The technology of making avalanche photodiodes seems entirely compatible with the standard integrated-circuit technology, and thus one should be able to work with scene brightness a factor 100 below those usable with ordinary photodiodes.

"The one problem which seems to exist with avalanche photodiodes is the necessity to use some kind of adaptive, gated, or adjusted biasing scheme for each photodiode, since the photocurrent gain is such a steep function of an applied voltage. Two possibilities are to trim tantalum film resistors or other types of resistors to an accuracy of the order of 0.1 per cent to 1 per cent as Bell Labs does in their thick-film integrated circuits, or alternatively, in the interval between frames, to expose the linear array to a uniform calibrating light pulse of substantial amplitude and to use individual holding circuits for each of the avalanche photodiodes in order to set the applied voltage so that a standard current results from the calibrating pulse.

"Some people at IBM Endicott (for example) have been producing arrays of 72 ordinary photodiodes. In measuring these photodiodes, the avalanche voltage has been found to vary from 8 to 15 volts, although of course these diodes were not produced for use as avalanche diodes and so this voltage was not purposely controlled."

We would like to ask the qualified industrial contractors, with the above background discussion in mind, to prepare detailed technical papers which would treat three separate subjects:

1. The performance of avalanche photodiode-integrated circuit arrays if avalanche photodiodes are feasible.

2. An estimate of the feasibility of producing avalanche photodiodes and integrated circuits on the same chip.

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3. A survey of possible schemes for trimming or adaptive biasing of the avalanche photodiodes, together with a tentative choice of a method.

In addition, we would plan to ask the contractors to discuss these papers with the Panel in a November meeting.

Donald H. Steininger

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