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11 SEP 1963

MEMORANDUM FOR THE DIRECTOR, CIA

SUBJECT: Implementation of the Purcell Panel Recommendations

The Panel for Future Satellite Reconnaissance Operations headed by Mr. Edward M. Purcell made a number of comments and recommendations regarding the National Reconnaissance Program. Along with members of my staff, I have reviewed these comments and recommendations very thoroughly.

In response to certain of these recommendations, specific actions have been implemented. In regard to others, I believe that efforts already under way are adequate and in line with the recommendations. Listed in the attachment under each of the Purcell Panel recommendations is a description of our actions in the area of effort concerned.

I am gratified that the comments and recommendations of the Purcell Panel appear generally to support the present activities of the NRO. New actions that we have taken in response to them have fit well into the program already under way. It is interesting I think that the results of the recent GAMBIT and LANYARD successes substantiate some of the Panel's views.

Brockway McMillan
Director
National Reconnaissance Office

Atch
Actions Under way
Responsive to Purcell
Panel Recommendations

GAMBIT
LANYARD
CORONA

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ACTIONS UNDER WAY RESPONSIVE TO THE PURCELL PANEL REPORT RECOMMENDATIONS

1. Development of a new wide coverage, 4-6 foot resolution system is NOT justified.

The E-6 (698BJ) wide coverage photo system was cancelled earlier this year and the four sets of two 36" cameras each were placed in storage. Funds to support the development of the EKC 375 system (improved E-6) and the M-2 system (Itek 40" focal length M camera) were deleted from the FY 1964 budget and no NRP resources are being expended toward a new wide coverage, 4-6 foot resolution system.

A limited wide coverage, high resolution capability can be realized from the eight additional LANYARD payloads that will be available for launch starting in December 1963. This system with its 4-5 foot resolution can photograph a swath width of 45 miles over the area within 90 miles on either side of its path.

2. The M system should be improved to deliver peak resolution most of the time.

A program has been initiated for the improvement of the M system so as to achieve the best possible resolution. This improvement program covers the following corrective measures:

a. Utilization of a superior optical glass for the lenses.

b. Adjustment of the camera to peak focus (after completing confidence check of thermal control measures newly incorporated in the camera).

c. Testing for IMC errors. A Mauer IMC sensor (developed for an aircraft program) will be installed on an early NRO AGENA vehicle to record, more accurately than we have been able to do before, the image motion parameters (roll, pitch, yaw) during a CORONA mission.

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d. Incorporation of a crab control (yaw steering).

e. Development of a vernier attitude control mode.

f. Conduct flight exposure experiments.

g. Design of an exposure control system.

h. Consideration of programmer improvements. By going to a more flexible programmer (Fairchild Type IX) with more options, including the capability to make changes in the program during orbit, a more effective use of the mission could be realized and less film could be expended over areas of poor visibility or marginal weather.

i. Evaluation of the feasibility of going to a lower, circular orbit. Present variations in altitude (100 to 140 nm) are one of the basic causes of the variations in resolution that have occurred from one pass or one part of a pass to another. By dropping the orbit down to about 100 miles and by making it essentially circular, we can optimize and make more constant the resolution performance of the system. This technique has recently been made possible by the increased accuracy of injection into orbit that has resulted from moving the BTL guidance system from the THOR to the AGENA.

3. <u>Develop a standardized objective test of resolution quality in the final M negative.</u>

A committee has been selected under the auspices of AFSPPL whose members represent the major corporations and scientific institutions participating in aerial reconnaissance programs. This committee has agreed on the Reciprocal Edge Spread (RES) measurement as being the most promising method at present of measuring systems performance when ground resolution targets are not present. On occasion as many as two thousand individual RES measurements are made on a single mission to determine total system quality. Further details of this measurement technique are described in the reports prepared by Performance Evaluation Teams (PET).

The NRO has a contract which is managed under AFSPPL (sensitive operations) and the Aerial Reconnaissance Laboratory (unclassified and secret) which places contractor teams at target sites

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to obtain ground measurements on selected ground resolution targets throughout the United States. They measure all variables (wind, dew-point, haze, etc.) required to judge flight system performance.

This network has several targets in operation in the area of Edwards AFB, California. They are also used for X-15 tests. Another target range is currently operational at Wright-Patterson AFB and additional targets will be placed in the net as follows:

Toronto, Canada	by 5 Sep 1963
Ft. Huachuca, Arizona	by 15 Sep 1963
Webster Field NAS, Maryland	by 30 Sep 1963
Mobile Target Arrays	
Dayton, Ohio	by 15 Oct 1963
South Western U. S.	by 30 Oct 1963

The ground targets are supplemented with B-57D aircraft with targets painted on wings and fuselage. These aircraft are flown so as to pass over(and take photos of) the same ground at the same time as the satellite on an engineering photo pass. The objective is to get a photo from the satellite of both the detail on the ground and the pattern on the wings of the aircraft which is flying above most of the atmosphere. The aircraft photos taken of the ground target will also permit a good comparison for evaluating the satellite photo of the same area. On the last L mission a photo was taken of the BLACKBIRD aircraft from the satellite. Thin clouds at flight altitude reduced the utility of this test, but its data is being evaluated now.

The Itek Corporation has a USAF Aerial Reconnaissance Laboratory (ARL) contract, that is being closely monitored and coordinated by the NRO, to devise Image Evaluation Techniques for evaluating reconnaissance sensor systems and components performance under static, dynamic and flight conditions. Consideration is being given to sine wave, square wave and three-bar response, including line spread and edge gradient.

The facilities and techniques now in use will be improved as we get more experience and new knowledge is developed. We are establishing this type of a testing procedure for all take--C, G and L.

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4. Development effort should be directed at a high resolution limited coverage system.

I agree essentially with this general recommendation. We are presently following the pattern of the Purcell Panel Report's general observations in both our current systems and in our advanced planning effort. Detailed descriptions of our actions in this regard are covered under the specific recommendations.

5. GAMBIT should be tested under ideal conditions.

Special engineering evaluation passes were made on the first GAMBIT mission to obtain photography over several known target areas in the U. S. under the best possible conditions. Because of the stability problem encountered during the latter part of the GAMBIT mission, these evaluation passes were not successful. Such tests will be conducted on future GAMBIT missions (as well as on LANYARD and M missions) to obtain photography of the special target areas described under recommendation number three where all pertinent conditions can be measured at time of the overflight.

6. Continue with the VALLEY Program and do not freeze the design until such a time as new data on key parameters is better known.

The VALLEY program is presently directed toward the development of advanced components rather than a system. It will not be frozen in design at least until full evaluation of the results of L and G missions have been incorporated into our advanced planning studies and until we have the results of some of the other study and test efforts that are under way at present. In view of what we know already we will probably reorient the effort in the direction of a very high resolution pointing system. This will be done after the VALLEY program review, presently under way, has been completed and its results are studied.

7. Pursue the possibility of obtaining faster films at the same resolution.

We are extremely alert to the importance and potential payoff of more progress in this area and are continuing to work toward this end. However, the manufacture of photographic emulsion is a company proprietary and security matter with the Eastman Kodak Company. Considering

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the essential EK monopoly or capability, alternate development is hampered and any real knowledge of EK development tends to be restricted. It is company policy not to accept government funds for this type of research. The company states that they are working hard on the subject but state that the problem is most difficult.

The NRO has an R&D contract with the A&O Division of Eastman Kodak Company, which contains a project calling for investigations in intensification and hypersensitization for photographic emulsions. This should sponsor some intra-corporation cooperation which hopefully will bring about some accelerated research on emulsion technology.

The Technical Operations Inc. has a contract with the USAF Aerial Reconnaissance Laboratory for research on film emulsion and photo processing improvements. This research has resulted in rather complex processing procedures which increased the speed of plus X Aerocon type film from 40-100% over a range of development times without loss of resolution or an increase in fog.

I will continue to press EK for maximum effort in emulsion improvement by both direct and indirect means (i.e., personal contacts with management and contract elsewhere) and will continue to support promising research along this line.

8. <u>Proceed immediately with an investigation of the application of image intensification to satellite reconnaissance.</u>

A task force headed by Mr. Harry Davis, Deputy for Research to the Assistant Secretary of the Air Force (Research and Development), has been set up to investigate the application of image intensification to satellite reconnaissance. This group is presently reviewing the state of the art and investigating research projects and tube developments presently under way.

It appears now that the present state of the art could support an image intensification project directed toward satellite reconnaissance application. After completing our survey of present image intensifier developments, we intend to conduct a system synthesis study to define the requirement and the best type of intensifier for both satellite and aircraft photography. We will then be in a position to put FY 1964 development funds on a development program to satisfy our needs.

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The following projects under management of the USAF Aerial Reconnaissance Laboratory are being closely monitored by NRO:

a. De Oude Delft single stage 18 mm diameter format on 35 mm film.

b. De Oude Delft two stage 18 mm diameter format on 35 mm film.

c. RCA two stage 63 mm diameter format on 70 mm film.

d. Westinghouse 10" diameter tube.

e. Two-stage Fiber Optic coupled Image Amplifier on 4.5 x 4.5 format.

The Army Engineer Research Development Laboratory, Fort Belvoir, is funding $10 million per year toward developing light intensifiers for military observation at night. This work may provide some of the basic data required to develop camera system.

9. <u>Support research and development on very large optics (60" diameter f/2 on 10" slit and 40" diameter f/1.5 on 6" slit)</u>

An analysis of the photographic systems of the type recommended by the Purcell Panel is nearing completion. The Panel recommended ~~the~~ use of 60" diameter f/2 lenses with a 10" slit or 40" diameter f/1.5 with a 6" slit to do this job on the basis that these larger systems should be considered for use with the larger vehicles that would be available at the time the payloads could be ready.

The advantages to be achieved using lenses of the speed mentioned above are readily recognizable. Initial evaluation of their potential, however, indicates that a broader spectrum of possibilities should be investigated. This is being done on the assumption that one foot ground resolution rather than lens diameter or f number appeared to be a better basis on which to determine system constraints and tradeoffs that would effect the eventual selection of a specific approach to meet the one foot objective.

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Preliminary indications from this analysis are that:

a. A one-foot system appears possible within the capabilities of the existing booster combinations with modest advances in the technology.

b. An apparent weight and aperture optimum is reached somewhere between f/3.0 and f/3.5. This area would have the added advantages of using film widths compatible with existing RV's and having a depth of focus more than twice that of an f/2.0 system.

c. Attitude control, tracking, environmental control and pointing capability represent items that with normal growth can support a one-foot resolution and will have little influence on size or weight of the systems.

d. Projecting the eventual speed of EKC 4404 film from 4.0 to 8.0 or even 6.0 is sufficient to size a one-foot payload for an ATLAS AGENA.

e. Technical advances in the art of light weight optical material is needed for a system using an existing booster combination.

The planning is already under way for the initiation of a competition for the development of a very high resolution satellite reconnaissance system.

Pending completion of the analysis just discussed, we are preparing RFP's for the two wide-aperture cameras proposed by the Panel. Upon completion of the analysis, we may wish to enlarge the scope of our requests to industry to cover a broader spectrum of optical configurations and include other elements necessary to the development of a very high resolution system. We will consult Drs. Purcell and James Baker further before actually approaching the industry.

It is interesting that Itek has a contract with ARL to study, design, and fabricate a large optical system--36" f/1, T 1.1. Specifications are f/0.95 on a 9 x 9 focal plane, using a 45" light weight beryllium mirror with a 42" clear aperture. Delivery is scheduled for December 1964. The cost is estimated at $750,000.

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10. **Investigate the feasibility of image stabilization as compared with vehicle stabilization.**

No specific effort is being made to isolate the camera from the space vehicle for the purpose of stabilization except for isolation of vibration.

Our experience to date indicates that improvement to vehicle stabilization will be the best method of meeting camera requirements. The sensors and controls presently being used in the AGENA have demonstrated their ability to adequately support at least 3-4 foot resolution photography. New sensors are available or well along in development that have demonstrated, in test, significant increases in performance over the present equipment.

The new GE scanner using the 13 to 20 micron region has been test flown in an AGENA and will be used to stabilize the OCV of the fourth GAMBIT. The EK 160 scanner using about the same region has been successfully test flown. The GE Orbital Control Vehicle (OCV) performed to the specification required for 2-3 foot resolution on the first GAMBIT mission in July and will be exercised again this week. This new generation of sensors and controls plus a modest film speed increase can support a one to one and one-half foot resolution system.

The pointing to target problem for a spot coverage system appears to be in hand. The accuracy of ephemeris prediction by the existing tracking system (operated by the Satellite Test Center at Vandenberg AFB) appears to be adequate (after several passes) to meet GAMBIT requirements. The normal, expected improvement of this tracking system should make it capable of meeting foreseeable pointing requirements as they arise. Development of the UAC or SSGS inertial guidance system can also satisfy this requirement.

The Aeroflex Corporation has proposed an optical system wherein the forward element(s) are moved to effect image stabilization. However, evaluation by the USAF Aerial Reconnaissance Laboratory indicates that such a system offers more difficulties than advantages. In particular it would not be adaptable to existing cameras but would require the design of an entire new optical system.

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11. <u>Consider the question of atmospheric limitations to satellite photography.</u>

The Aerial Reconnaissance Laboratory is conducting an investigation under contract with Minneapolis-Honeywell to determine, through experimentation, the effect of natural atmospheric turbulence on aerospace reconnaissance photography. This will be accomplished by extensive analysis of photographs taken through turbulent layers of the atmosphere.

A balloon will be used to loft a high-acuity camera to the required altitudes. Two RB-57 aircraft with resolution patterns applied to the upper using surfaces will serve as target vehicles. The aircraft will be flown below the balloon-gondola establishing optical paths of varying lengths between the balloon camera and the aircraft target. This project is funded at $2,400,000.

The Aerial Reconnaissance Laboratory recently conducted a similar program to determine, by experimental methods, the reduction of photographic contrast of aerial photography as a function of altitude, wavelength band and meteorological conditions. It proved the feasibility of predicting contrast attenuation by observing meteorological conditions. Cost $500,000.

The data obtained from the above projects and from the M, L and G engineering test photos taken over our new ground target network will determine the nature and extent of future work in this area.

12. <u>Accelerate the present effort for reduction of satellite vulnerability.</u>

Detailed contingency plans are being prepared for actions to be taken in the event of nuclear or pellet attack on an NRO satellite. These plans include:

a. Specific plans of action to counter the pellet and nuclear attack threats including hardware development and operational utilization.

b. Dry runs of operational plans including the effect upon primary missions of the countering actions.

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c. Plans for actual flight tests of hardware and operational techniques.

An updated analysis of the threat has been requested of the CIA.

As a result of the program being conducted at the 162 program office at SSD, a number of simple countermeasures against attack are now available or will be available by January 1964. More sophisticated measures are under study or development.

In the radar detection and decoy area, hardware will be available for flight in late September or early October. A GE designed dart decoy is available for ground systems tests. After vibrational analysis and test this item can be flown. A radar signature alteration kit to be used with it on the AGENA is available. Scale model tests on this kit are completed; full-scale tests will be conducted at G. D., Fort Worth prior to flight. In addition, four other configurations of this kit will be available by July 1964. An operations plan is being written for use of this decoy.

Some additional experiments to calibrate SPASUR detection capability were flown in August (1169). Additional experiments to determine drag effects on decoys will be ready in November-December.

A pellet attack alarm system will be ready for full flight test on vehicle 1172 (now scheduled for October launch). The pellet attack alarm sensor (accelerometer) flew successfully on 1167 in July. The 1172 test will include intentional excitation of the sensor and exercise of the SCF reporting and reaction procedures.

Pellet shield design is complete and hardware will be available in September. After ground testing it will be ready for flight when required.

A STOPPER attack alarm system, designed to intercept Russian attempts to interrogate or otherwise control the satellite's command channel or to track the satellite, has been successfully flight tested. Additional flight tests are planned for near future. Real time readout and reaction procedures are being developed. At the present time early call-down of the recovery capsule is the only counter available if STOPPER indicates possible attack. This can be accomplished on both South-to-North (night) or North-to-South (day) passes over Hawaii.

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A study is being made to determine optimum orbit to be flown for high priority target coverage on short-lived mission (less than one day). Used in conjunction with J configuration, on orbit variation and South-to-North (night) recovery of the first capsule, this could provide means of completing essential mission before attack is possible while retaining capability for additional coverage if attack does not materialize or is not successful.

Methods for providing orbit variation after launch are also under development. Addition of retro or ullage rockets to the AGENA can provide up to 72 nm in track variation per rocket per orbit. AGENA engine restart can ultimately provide 200-900 nm in track variation per start. Tests of on orbit maneuver using the AGENA after recovery of all film are being planned.

A 120-day study on use of radar absorbent materials to reduce AGENA cross section is on contract with Conductron Corporation. Further effort depends on the results of this study.

Longer range studies include:

a. Long-life active and passive decoys.

b. Nuclear environment studies and hardening criteria for follow-on satellites.

c. Silent Bird operation.

d. Optical cross section investigation.

e. Thermal radiation change of AGENA.

f. Active electronic countermeasures.

g. Decoy systems studies.

13. <u>Continue to attack the problem of quicker reaction by reduction of the lead time involved in the launching of a previously unscheduled flight.</u>

At the present time quick reaction capability in the 162 program is limited by the time required to compute ascent trajectories and

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install them in the THOR autopilot. Routinely, computation requires nine days; installation, 19 days. On a crash basis these times can be reduced to six and 15 days. If the desired trajectory has been previously completed, the computation delay is eliminated and lead time becomes 19 or 15 days.

The best opportunity for a significant reduction in this CORONA lead time would be to go to an improved THOR autopilot and AGENA programmer. Both of these developments are under study. The Douglas Aircraft Company proposal for development of a new solid state autopilot would reduce the THOR mission preparation time to between one and two days. This development would cost about $8 million and require about 15 months to complete.

As a parallel development the Fairchild Type IX programmer (mentioned under Recommendation No. 2) for the AGENA will permit changes to the camera program to be made three to four days prior to launch. Cost of this development is $600,000 and time required is nine months.

With these two developments the R-7 vehicles can be started toward launch while trajectory and camera programs are being changed.

The next step--reduction of the holding position from R-7 to R-2 or R-3 is the subject of detailed study by the SSD 162 Program Office. Preliminary results of this study, which should be completed by 1 October, indicate that holding at R-2 or R-3 days is feasible.

14. <u>Study the possibility of a specially planned quick-reaction vehicle.</u>

This possibility has been looked into several times and although such a vehicle is feasible, requirement uncertainties, costs, and other problems have not appeared to justify proceeding with an active development program at this time. Further study will await the findings of a study effort presently looking at the problem of post strike reconnaissance that is reviewing quick reaction extensively.

15. <u>Study a storage on-orbit system for obtaining quick reaction.</u>

As a preliminary step we are approaching this goal through the CORONA J system. Further study on this means of obtaining quick

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reaction will continue as soon as we have obtained some experience with these J tests. A great deal of valuable information on the feasibility of storage on orbit will result from the first few J missions.

16. <u>Investigate the use of air launch as a means of realizing a covert satellite launch capability.</u>

I agree generally with the comments and plan to continue to update our knowledge in this area. An extensive study on submarine covert launch was completed by the Navy for the NRO this spring. Two extensive studies on the feasibility of air launch covert operations were completed earlier--one by Convair a little over a year ago and the other by STL almost two years ago.

These studies indicate that both types of covert launch operation--air launch and submarine--may be technically possible but that such operations based on the adaptation of existing vehicles would result in very limited performance in terms of payload and number of orbits and that the cost would be high. In both cases the performance is based on new and improved light weight guidance systems that would push the state of the art and be very expensive (up to $200 million). The Polaris submarine system is limited to about 300 lbs. payload capability which permits one or at most only a few passes per launch. The B-58-Minuteman system would also be limited to about 300 lbs. payload and a very few passes.

In view of these limitations there are several areas that need to be clarified before we proceed further.

There are large uncertainties regarding the true requirement for covert operations. We need to be sure that the operation would be worth the effort. We need also to understand much more clearly the circumstances under which such a system would be required. For example, if covert launch is required because we are <u>forced</u> to stop present satellite reconnaissance, operations must indeed be <u>completely</u> covert and such as to replace all forms of our present operation. Under other circumstances such as post strike reconnaissance or extended wartime operations the degree of covertness and the extent of operations would be decidedly different.

It is not clear at this time whether it is even possible to have a completely covert satellite operation. There are other problems besides being able to hide the launch and recovery not the least of which is determining the Russian capability to detect and track such a satellite.

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Once it has been determined that covert operation is possible and is worth the effort, then we should put all of our effort into defining the difficult problems which make the difference between success and failure. Then we should concentrate on these difficult problems until sufficient success can be reasonably established to justify proceeding on the other less difficult aspects of the problem.

17. Conduct a study of the requirement and possibilities of night photography.

Fast lenses and light intensification optics are being developed as noted elsewhere in these papers.

Tests are being performed by the Itek Corporation under CIA sponsorship from an aircraft flying at about 20,000 feet to determine the detectable light levels and light patterns. PI studies are being conducted of these light patterns to determine the value of the data obtained by this reconnaissance technique.

In November or December, night photographic tests will be conducted on a LANYARD mission. Prior to the actual test in a satellite, however, flights will be made using a modified "M" camera in a U-2 aircraft. Other tests are being considered by the Aerial Reconnaissance Laboratory wherein lenses faster than the "M" f/3.5 and fast films will be test flown over test areas.

As the feasibility of night photography and especially "lights at night" is proven there will be other tests and experiments scheduled.

18. Some research in improved readout techniques might be desirable.

We agree with the conclusion presented in the report. We will continue a modest advanced planning effort to remain knowledgeable of the state of the art in this area so as to be able to recognize and take advantage of any promising advances or potential advances in the field.

19. Insure that the clearness of focus and purpose originally achieved in the satellite reconnaissance program has not been diffused.

I agree fully that we must maintain the clearness of focus and purpose contemplated in the original establishment of the NRO, and, within my authority, will continue to take all steps necessary to the achievement of this goal.

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