CORONA GAMBIT QUILL

DEPARTMENT OF THE AIR FORCE
WASHINGTON

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OFFICE OF THE UNDER SECRETARY

X Ref 5.1.3

January 11, 1965 5.2.1.1

MEMORANDUM FOR THE SECRETARY OF DEFENSE

SUBJECT: Quick Reaction Surveillance Systems

Reference is made to the following task you recently gave me:

"Propose a plan to develop the capability for instantaneous satellite reconnaissance with at least G resolution for various uses (particularly in relation to TITAN-III) such as monitoring the arms control agreements, tactical uses, etc."

The stated requirement could be met by day and night photography from a synchronous satellite, reported back in real time electronically. As will be commented on later, this combination of technical capabilities is not likely to be attainable in the foreseeable future.

As a means to approach the desired capabilities, I propose - and indeed have underway - a fairly specific three-phase program: (i) improve existing systems, (ii) incorporate the desired characteristics to the maximum practicable degree in the next generation of satellite systems, (iii) continue studies and hardware investigations looking toward a further generation. Some specifics on each of these phases follow after a brief general discussion. An attached chart summarizes the situation now and at a specific point in the first phase, and sets out for comparison the goals of the first and second phases.

The requirement implied by your task to me is closely related to one enunciated by the Chairman, JCS, in a memorandum to you of March 31, 1964. The attached chart shows that, on missions for which orbits and target programs are prepared in advance, our planned improvements in reaction time will, during the first phase, meet the desired performance in this regard as described by the Chairman's memorandum.

BYE 36008-65

General Discussion

To approach the kind of resolution stated, we must look to photographic systems operating at medium to low altitudes and limited to daylight photography. For such systems, the daily cycle of the sun limits the times at which desired targets can be covered. The laws of orbital motion and the distribution of desired targets fix the orbit and the rate at which targets can be photographed on a given mission, and thus constrain the times and places at which film or information can be recovered. In addition, bad weather over the target area may preclude photography at the time desired.

In addition to these constraints, which are intrinsic in nature and introduce delays varying with the mission to be flown and with the weather, there are other sources of delay introduced by hardware and by procedures, some of which can never entirely be eliminated. Assuming that a mission is defined by a statement that a particular set of targets must be photographed, a complex sequence of preparatory actions must take place converting this <u>mission</u> into plans for a <u>flight</u>, and then accomplishing the flight. In general terms the actions are of the following kinds, although not necessarily conducted exactly sequentially:

A. Determination of the orbit to be used and preparation of necessary instructions and documentation that are specific to a mission and orbit. These plans define a <u>flight</u> except that they may contain the date of launch as an open parameter.

B. Establishing hardware in a condition for use that is not specific to a particular flight.

C. Preparation of hardware that is chosen specifically for a flight, into a condition specific to that flight but not necessarily specific to a date of launch.

D. Determination of a date of launch.

E. Issuance to the range (WTR) and to the Satellite Control Facility (SCF) of instructions specific to the flight and to the date of launch, and preparation of the WTR and the SCF accordingly.

F. Final countdown and launch, representing the completion of actions initiated in B, C, and E.

An ideal mode of operation is one in which the planning operation, A, is accomplished in a few hours by computer, and steps B through F are then accomplished in a rapid countdown. In practice, I am sure we will always have to undertake B in advance, and depend upon a checked out system standing by in a reasonably ready condition.

Step A, preparation of flight plans, will always have to be accomplished largely in advance of those other than B and D. It can be expedited by computer. Because of the many constraints imposed upon a flight plan by the mission itself, by the requirements of range safety, by the limitations of the booster, and by the characteristics of guidance systems, a great deal of computation and checking by people must be done in this step. I cannot visualize cutting it much below 24 hours even with the most sophisticated of systems. Fortunately, as with ballistic missiles, the likely missions can be anticipated and a library of flight plans prepared in advance. On a mission covered by the library, the time consumed by step A does not contribute to delay.

Step C, commitment of the hardware to a specific flight, and step F, final countdown, depend upon the hardware involved. In principle, at least, they can be cut to a few hours by proper design. In fact, on GAMBIT today they are not controlling; step C will be controlling on CORONA as long as the THOR is used as its booster.

Step E, preparing the range and the Satellite Control Facilities for a specific flight on a specific date, is largely procedural. Many support activities are involved, people must be informed and perhaps even rehearsed, and potentially conflicting requirements must be identified and resolved. Range safety is of major concern. In principle, procedures can be tightened sharply, but in practice it is probably this step and the requirement for daylight over target that will ultimately control the minimum delay between completion of A, the determination of a flight plan, and launch.

Another factor in connection with quick-reaction missions that is of interest, although not directly connected with delay, is efficiency. Short missions necessarily cover fewer targets than long ones, and one would like to get as much intelligence return per launch as possible. In the case of interest here, he would like to do so without compromising quick return of the primary data. Obviously a multiple recovery system helps greatly in this connection. Also, anything that allows a broader or more flexible selection of orbits leads to the possibility of more efficient and more expeditious coverage of desired targets.

There are many detailed changes over present systems and practices that can serve to improve or shorten the preparatory actions A through E discussed above, and can improve efficiency or flexibility of target coverage. Important improvements of degree or kind possible within the framework of CORONA and GAMBIT, and of our present launch and recovery facilities, are:

1. Improve the ability of the hardware to stand in a ready condition for long periods, facilitating or economizing step B.

2. Reduce the time required to prepare new orbits and camera programs, facilitating step A.

3. Reduce the delay in configuring the hardware to match a desired orbit, facilitating step C.

4. Recover in the present recovery area at night and on South-to-North passes, providing for earlier or more flexibly chosen recoveries.

5. Process recovered film while in flight from the recovery area. This attacks a significant source of delay in present operations.

6. Add alternate launch facilities or, alternatively, increased boost capabilities, to permit orbits more efficiently covering areas such as Cuba, the Soviet missile belt, etc.

Further improvements can be considered which require significant to major new developments. These are listed below roughly in an order of increasing difficulty and decreasing incremental effectiveness:

7. Develop a multiple recovery system to maintain efficiency in total coverage even if early recoveries are made, say after one day or after one pass.

8. Develop a land recovery system. The reduction in time-in-transit of recovered film may not be particularly useful in the presence of (5), but in general, land recovery will increase the number of recovery opportunities per day. As a simpler step, one could consider deploying our present recovery forces to new bases for special missions. The time required to do this, perhaps a few days, would have to be counted as a preparatory delay. The alternative of setting up permanent recovery forces in many areas would be expensive and inefficient. In fact, the present Hawaiian recovery base is very conveniently located relative to most of the orbits that can be launched from the U. S., and it provides uniformly good weather. Its principal drawback is its distance from Washington, and (5) attacks this problem.

9. Develop a maneuverable land recovery system, further extending the flexibility of selecting recovery times.

10. Add extensive fuel for orbit adjustments to allow somewhat freer selection of targets and of recovery times and places.

11. Develop the capability [redacted] This contributes to efficiency but, in the presence of (1), perhaps not much to elapsed time.

Consideration has several times been given to developing an air-launched satellite system, one of its attractions being flexibility in selection of launch sites, and hence of orbits. Such systems have always been discarded, however, because the payload available has been inadequate to support adequate photographic resolution.

One of the most troublesome problems, practically, in achieving any kind of quick-reaction capability is the reliability of the equipment. Our latest CORONA launch, for example, went through four countdowns before it was finally - and successfully - launched, five days late. I am afraid that a long and difficult period of evolution will be experienced before the theoretical possibilities of any particular quick-reaction system will be regularly realizable in practice. There are no dramatic actions or inventions that can be expected to substitute for the meticulous continuing attention to detail that is required to design and maintain a complex system capable of a high state of readiness.

Improvements to Present Systems

Phase (i) applies to CORONA and GAMBIT, and concentrates on items (1) through (6) outlined in the preceding section. Specific information is given in the paragraphs below, correspondingly numbered.

1. During February, we plan to launch a CORONA that has stood in the R-1 condition for at least 15 days. The criteria defining the limits of this hold condition are not sharp, and we expect to be able to improve beyond this point. I wish to defer experiments with GAMBIT in this direction until actions now under way to improve its recently unreliable performance show results.

2. Preparing flight plans for CORONA is, for accidental but unavoidable reasons, a very clumsy process. Fortunately, the variety of significantly different possible missions is low, so that a useful library of flight plans is practicable. Flight planning for GAMBIT is well automated, and can be done rapidly ab initio, provided one does not ask for optimized coverage of too large a list of targets. On the other hand, a comprehensive library of GAMBIT flight plans could be very extensive.

We have a small library of CORONA flight plans now, and are working with the intelligence community to identify, in an order of priority, useful additions to it. In the case of GAMBIT, we plan to establish a library of critical missions, and then simply accept the fact that if a new mission must be planned quickly, we cannot expect it to be optimized for ancillary coverage. We are working with the intelligence community to identify the missions most important for this library. By summer I think we can have a useful library for both CORONA and GAMBIT, and will have in operation a regular procedure for keeping it up to date.

3. To configure a THOR for a particular launch trajectory requires physical disassembly of part of the booster and physical changes to its autopilot. During this month, improvements to this process will be effective so that it can be done at day R-8; this is about the limit of improvement short of a major change in the launch vehicle. The ATLAS booster is not handicapped in this way, and is ready to fly on any launch trajectory within its capabilities down to the point that final countdown begins.

4. Recovery forces are training on night recoveries and on recoveries on South-to-North passes at the present time, using air-dropped training equipment. I may later recommend flying an extra CORONA J mission for an operational test of these and other capabilities. Alternatively, we may find it acceptable to test them on a scheduled mission without great risk to the intelligence take.

5. Contractors are preparing bids now to develop a film processor that can fly in a C-135 and process satellite film with satisfactory quality. Use of such equipment would remove about 14 hours of delay that now occurs in transporting film from the recovery area to the processing plant. It will probably be about a year in development, hence not available much before the end of FY 66.

6. Planning for an alternate launch site at ETR is in process and will be reported to you soon. It appears that we may be able to achieve the same results more quickly and at less expense by certain payload and booster changes which will allow a much wider selection of orbits from the present launch sites at WTR. I want to report on this alternative at the same time.

In connection with this last point, there is no question that it is relatively easy to substitute an ATLAS for a THOR booster on CORONA. This would eliminate any real need for launching CORONA from ETR. Equally important for this discussion is the fact that it would permit other changes so that CORONA could have the same pre-launch and on-orbit flexibility as GAMBIT. If this is done, then, CORONA could be expected finally to show the same flexibility as that shown for GAMBIT in the column on the attached chart labelled "GAMBIT Goals." I expect to report to you soon on this possible change of booster for CORONA.

Turning specifically to the chart: the first column shows CORONA as present procedures operate. The improvements in going to the second column are largely procedural, but include an actual change to the THOR to facilitate step C. This column also shows, as a goal, the effects of introducing an airborne film processing plant.

The differences between the two GAMBIT columns are entirely procedural and somewhat conjectural, except for those due to the proposed airborne processing. The most difficult problem is to tighten up the preparatory procedures on the range without sacrifice of range safety (Step E). The 12-hour goal shown is simply a goal and should not be regarded as certain of accomplishment on a regular basis. It is more likely of achievement on a few highly prepared and stereotyped missions than on an arbitrary new and complex mission.

The G3 goals differ from those of GAMBIT only in the hope that the TITAN IIIX booster may permit simpler countdown procedures and longer holding times.

Examination of the chart shows that, even exploiting all of the improvements (1) through (5), and using a pre-determined orbit, at best about 36 hours will elapse between the R-1 condition and the initial reading of a day's photography. For surveillance of some areas, one could recover after one pass, in the best case then cutting the elapsed time to 22 hours at the expense of a drastic reduction in coverage. In the worst case, that in which a decision to launch comes too late to meet the first launch window (set by the requirement of daylight over the target), one must add about 22 hours to the figures quoted.

New Satellite Systems

The next generation of photographic satellite systems consists of GAMBIT-3, a high resolution pointing system, and a new search/surveillance system now going through its early definition phase. Both of these systems will incorporate to the best reasonable extent the operating conveniences represented by (1), (2), and (3) above, and can of course take advantage of improvements such as (4) and (5). Flexibility in choice of orbit can be expected because of the capabilities of the TITAN III-X or TITAN III class boosters to be used. Here again, however, a delay of 22 to 60 hours can be expected between the R-1 condition and reading of the first recovered film.

Consideration is being given to incorporating in each of these new systems the option to use multiple recovery vehicles. This does not influence reaction time, but greatly improves the efficiency of operation, measured in coverage per launch, when an early recovery is required.

Among the possibilities for new search/surveillance systems is one that could search the whole Soviet Union, at say 4 feet resolution, in four days. Such a system trades resolution for a very impressive "quick reaction" search capability.

Longer Term Prospects

Ideally, the "instantaneous" requirement calls for a satellite stationed at synchronous altitude, capable of taking pictures day or night, and reporting these pictures back electronically. To achieve the stated resolution of about three feet from synchronous altitude would require a lens or mirror more than 80 feet in diameter - some 20 times larger than we are willing to attempt with the required precision today. Consequently, even for the distant future, one must think of systems which fly at much lower altitudes, covering target areas and encountering recovery or read-out stations only periodically. Granting this, some very rough estimates are given below of what may be possible, perhaps after major new developments.

Daylight photography: Using TITAN III-C, and not extending the optical art much beyond that envisioned for GAMBIT-3, one might look forward to a system which flew at about 400 n.m. altitude and provided a resolution of 3 feet on the ground. On each pass over the United States such a system could report back electronically, at the indicated resolution, pictures of a few targets each 10 miles by 10 miles square. Perhaps an ultimate practical read-out speed might permit ten targets per pass per read-out station.

Night and foul weather: Using laser illumination, a capability for night photography at perhaps 10 foot resolution might be achieved on a TITAN III-C. Read-out of several targets per pass over the United States would be possible. Alternatively, a radar system might achieve resolutions almost this good, and would work in foul weather as well as at night. Either of these possibilities would require a nuclear power source for reasonable lifetime on orbit. Both require, and are getting, further study.

Exploratory Program

There are some specific efforts in the NRO program to explore or to develop the capabilities that are critical to the several kinds of capability discussed earlier. The more important activities are listed below.

The NRO budget for FY 66 contains funds earmarked for initiating development of a new recovery system. It is expected that this development will provide for multiple recoveries, returning four to six separate packages of film from a single mission. Requirements will be defined in detail as the characteristics of the new general search/surveillance system are clarified. The objective is to have a multiple recovery system available during FY 1967 as an option on GAMBIT-3 and on the new search/surveillance system.

The START program, funded in the Air Force budget, is presently studying the long-term prospects for development of a highly maneuverable recovery system. Two kinds are under examination, one to return a large payload, and the other, to return a small payload, as might be appropriate for a multiple recovery system. Emphasis is currently on the latter system. Any development that results will be several years in coming, and will require a further definition of requirements appropriate to the sensor systems expected then to be available.

Under the classified code name QUILL, an experimental high resolution radar satellite has just successfully undergone a test in orbit. This is one of the more dramatic milestones in a continuing program of study and development exploring the technology of satellite borne radar systems. Although it seems unlikely that such systems will ever achieve the three-foot resolution suggested in your statement of requirements, I plan, during the next several months, and using the results of the QUILL tests, to try to develop a definitive report on what one might expect to accomplish with a radar satellite, and to relate this to various potential requirements.

Electronic read-out has always been an attractive objective. The SAMOS project included two read-out systems, E-1 and E-2. E-1 flew and successfully returned results in January 1961, with pictures showing about 100 foot resolution. E-2 successfully transmitted pictures from the payload during countdown, but efforts toward flight were stopped after launch failures. The USSR is known to have a read-out system operating at an estimated resolution of about 75 feet.

The NRO continues to support study and development efforts in the technology of read-out systems. The critical limiting factor has always been the actual reading out and transmitting of pictures at a speed high enough to permit a useful return during the time that the satellite is visible from a read-out station. Current technology permits transmitting only about one target per pass per read-out station, and limits the area covered by, or the resolution of, that particular return. Fairly definitive results bearing on future possibilities are now coming out of our NRO studies. An attempt will be made to summarize these and evaluate their implications for several potentially interesting applications, including the application to quick-reaction surveillance systems.

You have recently directed me to undertake studies and hardware efforts related to surveillance systems to be flown at synchronous altitudes. Although such systems, as I noted earlier, cannot be expected to support image forming sensors with three-foot resolution, they may be expected to collect important collateral information for surveillance purposes.

Brockway McMillan
Director
National Reconnaissance Office

Attachment

cc - DepSecDef

BYE 36008-65