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A History of Satellite Reconnaissance
Volume IIB

PREPARED FOR

THE NATIONAL RECONNAISSANCE OFFICE

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A HISTORY OF SATELLITE RECONNAISSANCE

VOLUME IIB - SAMOS E-5 AND E-6

by

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of 1964 and 1965

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PREFACE TO VOLUME IIB

This volume is a continuation of Volume IIA of A History of Satellite Reconnaissance, separated chiefly because the bulk of pages makes it impractical to put the whole of the lengthy and complex history of the Samos program between one set of covers. Volume IIA includes those chapters concerned with the two major program segments that began in 1960 and 1961 and continued through October 1963: Samos E-5 (plus Lanyard, which was half of an E-5 camera system in a different vehicle housing) and Samos E-6 (plus Spartan and SP-AS-63, the proposed re-engineered successors to E-6).

Early drafts of these chapters were prepared in 1964 and 1965, while the author was an employee of The Rand Corporation. Correction, editing, expansion, and elaboration of those early drafts began in 1972 and was completed in 1973 while he was a member of the staff of Technology Service Corporation. Because documentary sources have mostly been dispersed or destroyed in the intervening years, and because most major program participants have long since left government service, it seems unlikely that further research will prove fruitful or that these volumes will again be expanded.

The Samos program participants and National Reconnaissance Office people who provided information for or reviewed these pages are too numerous to acknowledge singly here. Most are noted, by name, in source citations or prefatory sections in other volumes. For such errors of fact or interpretation as may have survived review, the author is wholly responsible.

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X THE E-5 AND LANYARD PROGRAMS

The technique of using a reentry capsule to return exposed film from orbit was seriously proposed as early as June 1956. The Rand Corporation, which first urged the concept, felt that reliable methods of recovering film could be developed much earlier than comparably effective readout techniques. But in 1956 there was no way to demonstrate that recovery was feasible, no way to finance a test of the concept, and so little interest in satellite reconnaissance in general that even the preferred readout concept was indifferently funded.

Coincident with Sputnik I, Rand in November 1957 suggested development of a family of recoverable satellites. Although the idea had been conceived and most of the supporting research performed much earlier, Sputnik got it a hearing. The perceived need for a reconnaissance system to be available in the near term caused attention to be concentrated on Thor-boosted satellites, and Corona was the only immediate product. But in March 1958 the concept of a recoverable photographic payload hoisted by an Atlas-Hustler (Atlas-Agena) vehicle was revived. It remained a minor option through July of that year, receiving no more than passing mention in the development plans of the period.

A marked change in the Air Force attitude toward recovery of photographic intelligence was signalled by the 26 September 1958 publication of a new General Operational Requirement covering satellite reconnaissance. It embodied a "big" camera and film recovery. By December, the Advanced Research Projects Agency, then custodian of space program responsibility, had endorsed the approach. But it appeared that ARPA enthusiasm was not entirely altruistic. ARPA scientists were less interested in pursuing the original approach as in adapting the long focal length camera proposed for the recoverable satellite to use in an electrostatic tape readout system. And ARPA's interest in recovery was probably as much motivated by the desire to conduct a military man-in-space program as by any concern for recovering photographs. Thus the film-recovery concept embodied in <u>Corona</u> became a film-plus-cameras-recovery mode in ARPA's plan. And perhaps coincidentally, so large a capsule could also return a man from orbit. So expanded, the recoverable capsule proposal had been transformed into a development plan by January 1959 and by April had received "general approval." One Discoverer capsule had by that time successfully reentered, but none had been recovered. Enthusiasm for recovery was momentarily high.

Funding difficulties, the introduction of new and complicating proposals (the E-4 mapping satellite and the E-3 electrostatic tape reconnaissance system), plus a general decline in ARPA fortunes as NASA gained more influence, led to virtual cancellation of the embryonic recoverable camera program in June 1959. Strong protests from the Air Staff and several air commands followed. It seemed impossible to satisfy the September 1958 requirement for photographs having a ground definition of five feet without a big-camera recoverable system. Largely in response to pressure from the newly established Directorate of Defense Research and Engineering, ARPA in early September reinstated what was now designated the Samos E-5 program--though initially limiting approval to camera development alone, authorizing recovery subsystem development only when further pressure was brought to bear. By 9 September 1959, one year after publication of the formal requirement, the E-5 system had formal approval for development. On 17 November, with the return of satellite reconnaissance program responsibility to the Air Force, ARPA obstructionism became moot.

The next difficulty was predictable. The Air Force Ballistic Missile Division (BMD) wanted to fund an accelerated E-5 program without reducing the total of funds allocated to the E-1 and E-2 readout systems. That notion generated little sympathy in the Pentagon. Both DDR&E and the Air Force Ballistic Missiles Committee (AFBMC) strongly favored recovery emphasis and were gradually hardening their objections to continuing expensive readout systems. Cancellation of the E-3 and an elaborate ferret proposal (the F-4) had not provided sufficient funds to support E-5 work; DDR&E and AFBMC were cool to suggestions that an accelerated E-5 program be financed by adding new funds to the basic satellite reconnaissance program and that E-1 and E-2 be continued at their existing levels. Dr. H. F. York, DDR&E chief, was particularly outspoken in his disparagement of the E-1 and E-2. He was equally forceful in his endorsement of the E-5 approach. Through the first four months of 1960 there was no reconciliation of these disparate viewpoints.

When the U-2 incident occurred in May 1960, BMD (with the firm support of most of the Air Staff) still was holding out for an undiminished readout program plus a co-equal and separately funded E-5 recovery program. Air Force Undersecretary J. V. Charyk, who had been in that post since the previous August (he had earlier been Chief Scientist of the Air Force), took the Gordian option of directing a complete shift of emphasis from readout to recovery.

E-5, he ordered, was to receive first attention. Two months later, in July, the United States Intelligence Board realigned the requirements for satellite reconnaissance in a fashion that made readout an almost totally unacceptable solution. For the moment, E-5 was the only in-progress system that might satisfy needs, and even there it was coming to be appreciated that E-5 was conceptually deficient in ways that might make it no more than marginally useful.

In August 1960, the recovery of the first Corona products overcame lingering doubts about the feasibility of film retrieval. Concurrently, complete reorganization of the reconnaissance satellite program and a National Security Council decision to sponsor at least one alternative to E-5 again changed the technical complexion of the Samos program. Still later, in October, both the E-6 panoramic camera system (with lower resolution but appreciably greater area coverage potential than the E-5) and the highly promising Gambit (with resolution and coverage potential far better than the E-5) received tentative approval for development. Both were on contract by January 1961.*

From a scheduling standpoint, the intricate maneuvering between September 1959 and August 1960 had meant relatively little

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* This resume is essentially a restatement of a longer narrative which appeared in earlier chapters. Supporting detail and specific citation of sources are included in the earlier text.

to E-5. A total of seven vehicle flights was programmed throughout the period, two "diagnostic" vehicles being added in August 1960.[1] The E-5 had also remained relatively stable in terms of design details. As compared to the E-2 of the same era, it had the following design characteristics:

System:	E-2	E-5
Focal length:	36 inches	66 inches
Altitude:	260 nautical miles	180 nautical miles
Ground resolution:	20 feet	5 feet
System resolution:	100 lines/millimeter	100 lines/millimeter
Strip width:	17 miles	60 miles
Aperture:	f/4.0	f/5.0
Film size:	70 mm by 4520 feet	5 inches by 250-500 feet

Additionally, the E-5 was a stereo system, the E-2 a single frame system.[2] The camera had been developed by Itek under subcontract to Lockheed, the system contractor. Each camera consisted of a sunshade and mirror, a window, an eight-element lens (with a temperature tolerance of but one degree), a camera body terminating in a five-inch curved film plane with a three-second pan cycle, and a complex film take-up subsystem. The 20-degree panoramic arrangement provided coverage of a ground swath 12 by 65 miles on each side from 180-mile orbits, with the resulting strip of exposed film measuring 4.5 by 23 inches. (Estimates of image quality varied but generally ranged from 100 to 115 lines per millimeter at a 2:1 contrast ratio--on SO-213 film.)[3]

Although the E-5 had been anything but a hastily conceived undertaking, details of the design had been criticized by one source or another virtually from the moment it was proposed. In August 1960, when the Samos program reorientation was in full swing, program office reservations about Lockheed's conduct of the development began to assume major proportions. Colonel W. G. King, Jr., the Samos program office chief, expressed particular concern at the lack of test data on the system's thermal environment. King believed that uncompensated temperature effects on mirror, lens, platen and supporting structures might well limit system utility. The camera as then designed was some 150 pounds overweight, and the inclusion of thermal protection devices could only make it heavier.

Lockheed did not agree. The contractor seemed convinced that the strategy of developing various subsystems in parallel--an approach that had been successful in the ballistic missile program--would provide adequate safeguards against the failure of any single technical feature. Though Lockheed's reaction was partly Pavlovian (R&D mores did not admit of the possibility that a contractor had not foreseen all possible contingencies), the emergence of E-6 and Gambit raised the issue of whether all three major recovery systems should be carried to completion. They had several overlapping qualities. Lockheed had total responsibility for E-5 and for the rapidly withering E-1 and E-2 satellite programs, and had prime responsibility for Corona, but was no more than a vehicle supplier in the E-6 program. Lockheed, therefore, was vitally interested in having the E-5 remain attractive. E-5 was then considered to be a logical successor to Corona--still generally treated as an interim system with slight growth potential--although in fact E-6 was a more promising candidate. King, who had custody of the E-5 and all its predecessors but who had no important role in E-6 or Gambit development, was less parochial. As early as 27 September he suggested that the overlap of E-5 performance with that anticipated from E-6 could well bring on cancellation of one or the other. Because E-6 had greater technical promise than E-5, the leading candidate was obvious.[4]

As with the E-1 and E-2, part of the discontent with E-5 arose from the fact that it did not represent the latest in satellite reconnaissance concepts and techniques. Even though development had not gotten well under way until September 1959, the basic proposals embodied in E-5 dated from 1958, and considerable advances in optics, vehicle stabilization, and camera mode technologies had marked the ensuing two years. General Greer and Undersecretary Charyk were agreed that the E-5 system was unduly complex and that its Itek camera was far too cumbersome and complicated to represent a sound solution to satellite reconnaissance requirements.[5]

Lockheed, aware of waning confidence in the prospects of E-5, proposed accelerating the program toward an April 1961 diagnostic flight and a subsequent launch rate of one satellite each month. An early demonstration could dispel doubts of the system's usefulness. The contractor estimated in October 1960 that such an acceleration would cost about $11 million; Greer and King felt that something between $15 and $20 million was more nearly the correct figure. Notwithstanding their uneasiness about E-5 progress, they felt that program acceleration might be in order. It would, if successful, provide a high-resolution recoverable system at least a year in advance of the first E-6 and some two years sooner than the first Gambit satellite, a consideration that could not well be ignored in an atmosphere of program urgency. Further, both King and Greer were realistically aware that E-6 and Gambit might encounter development problems. In that case, E-5 might represent the only insurance against program disaster.

Both E-1 and E-2 were phasing down toward cancellation by late 1960. Some money to support acceleration of E-5 might be found in those programs. Launch costs were essentially the same for all three, but an E-5 payload cost about $550,000 less than an E-2 payload.* The real issue was not whether a half million dollars might be diverted for each cancelled readout launch, but whether E-5 acceleration would serve any useful purpose.

Lockheed had received authorization for a modest acceleration on 2 September. After three weeks of discussion, the company on 7 October made a formal presentation to Greer and Charyk suggesting greater effort--at higher costs. Three days later General Greer created a special task force to analyze the proposal. On 17 October Lockheed received a non-specific authorization to redirect the E-5 program toward the "most accelerated" effort, called "Tornado", but no full and explicit approval of that effort followed. On 1 November, General Greer telephoned H. L. Brown, of Lockheed's top management group, to ask for more details on "Tornado." Another two weeks were consumed in obtaining and refining the needed data. General Greer's doubts about the reliability of Lockheed's cost estimates were not dissipated by the supplemental information and he expressed little confidence in Itek's ability to satisfy schedules. There was also some feeling among Charyk's staff, in Washington, that diagnostic

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* In October 1960, basic costs included $1.83 million for the Atlas, $1.81 for the Agena, $1.44 for an E-2 payload and $0.9 million for the E-5 payload, plus about $1.4 million for launch services and $184,000 for management services.

flights could not profitably be slipped into the schedule without adversely affecting the viability of the first programmed operational launch.

On 22 November 1960, Greer's office notified Lockheed that there would be no "crash program" for E-5.[6] But that did not entirely dispose of notions that something might yet be done to get the system into operation earlier than programmed, or that it might be economically adapted to perform the E-6 mission, thus eliminating need for the latter system and freeing considerable sums. One member of Charyk's staff co-sponsored, with Amron Katz (of Rand), the idea that flying the E-5 at a higher altitude would provide 10-foot definition and coverage comparable to that expected of the E-6. Nothing came of the discussion, but in December Charyk authorized early diagnostic flights of degraded E-5 cameras to get telemetry data, prove out payload operation, and demonstrate the feasibility of capsule recovery in the E-5 configuration. (It was apparent that Itek could not accelerate delivery of fully qualified cameras.) So acceleration of a sort was approved for the E-5 effort before the close of 1960.[7]

Any impression that the E-5 had thus become more highly regarded than the still embryonic E-6 was dispelled early in February with Charyk's ruling that the E-6 had priority over any other E-series development. (In point of fact, Charyk had also accorded the E-4 mapping satellite payload a higher priority than the basic E-5 payload, but that development was little known.)[8] The February ruling represented a re-interpretation of the National Security Council's 25 August decision on system priorities; it was a severe blow to the prospects of the E-5.[9]

The crux of the priority issue was not so much the development status of E-5 as that E-6 represented a solution to requirements for gross coverage, which carried higher priority than the specific target coverage mission for which E-5 had been designed.[10] Further, confidence in E-5 success had never been high since SAFSP acquired the program, and Gambit --which promised far better coverage and resolution than E-5--had begun development by February 1961.

The character of the E-5 test program had gradually been changed by the various program decisions of late 1960 and early 1961. In February 1961, that evolution received formal recognition in the statement of a test philosophy, essentially a determination that the early flights would contain very large quantities of instrumentation and would have limited functional objectives. Particular attention was to be devoted to reentry phase instrumentation since the sea-recovery-oriented E-5 capsule represented a considerable departure from the pattern set by Discoverer capsules--relatively light and designed for air catch. Operations during flight test would gradually progress from the simple to the complex as success permitted. (For example, no steering maneuvers were to be attempted during the initial E-5 flight because a failure in that mode probably would prevent test of the reentry system.) In essence, the E-5 tests were to be cautious research and development investigations rather than attempts to operate fully functional prototypes. That approach was in part a reflection of a general philosophy Charyk and Greer favored and in part was a consequence of experience with the E-1 and Discoverer programs. It also reflected Colonel King's conviction that reconnaissance satellites would remain one-of-a-kind creations of some years to come, that the notion of standardizing early on an "operational" vehicle was completely fallacious.[11] Charyk and Greer agreed early in March 1961 that the best approach to E-5 would be to start "R&D launches" in September 1961 and continue through a series of eight, the last coming in May 1963. The extent of success with that aspect of the program would determine later plans.[12]

Another important modification of earlier practice lay in General Greer's determination to reduce the role of the missile assembly phase (at Vandenberg). He wanted flight-ready vehicles delivered to the launch base. He was particularly insistent that modifications, subsystem tests, and instrumentation should be complete before the Agena, the Atlas, and the payload were mated and checked through the missile assembly building. That departure from earlier habits would, hopefully, reduce delays, complexities, and potential errors arising from extensive tinkering with the vehicles between their delivery and their erection on the launch pad. To this end, Greer insisted on comprehensive pre-delivery checks of critical subsystems, including "hot firings" of the Agena engines. That practice had for some months been the subject of a "running debate" between a group which held that repeated pre-flight operations of the rocket engine increased the chance of flight failure and a group which held that only through extensive engine tests could prospective faults be surely identified and corrected. It was not that SAFSP intended to run every Agena through such a test series, but as Greer emphasized, the first of each kind of system would be most extensively tested and about every fourth vehicle thereafter would go through the same checkout process.[13]

Inevitably, as first flight date approached, technical difficulties began to crowd together. Early plans to convert vehicle 2201 to a diagnostic system (the term was no longer used but the connotation remained) proved impractical as early as March 1961. The vehicle was so far toward completion that modification would be unduly costly and time consuming. Lockheed proposed instead to upgrade the second in the series, 2202, and by concentrating attention on that vehicle to push it to launch readiness by 15 September. By early June 1961, emphasis had shifted entirely to 2202, and 2201 had effectively been phased out of the E-5 program. Unhappily, Lockheed's optimistic appraisal of 2202's readiness came unhinged when Itek fell behind schedule in camera subsystem tests, forcing use of the third Agena (2203) in some of the work at Lockheed's Sunnyvale plant. In July, the capsule had to undergo structural modifications because of a failure in qualification testing, and early in August Itek was in such deep trouble that a special management team from Lockheed took up residence on the east coast to help push the camera through its test phase. By that time there was no possibility of meeting original flight schedules, the delivery of the payload having slipped by several weeks.[14]

Similar difficulties were common to most high-priority programs even though contractors customarily seemed unable to anticipate them. But some problems were peculiar to the E-5. By July there were three areas of major concern: a demonstrated weakness in Itek's management and in the effectiveness of Itek's engineering approach to the E-5 camera; shortcomings in the lens itself, principally evidenced by the inability of the delivered optics to pass specification checks; and Lockheed's failure to obtain essential computer inputs for the flight programs. (Colonel King felt that it might be necessary to subcontract the computer task and to subcontract optical work to some firm that could meet the specifications.) Recognizing that schedule pressures might well induce further technical troubles, particularly if too-rapid testing led to oversights and thence to defects that either had to be corrected after delivery or which, escaping detection, would endanger mission chances, General Greer secured Undersecretary Charyk's acceptance of a "relaxed schedule," although the fact of that relaxtion was not immediately communicated to Lockheed.[15]

Difficulties with the Itek-manufactured payload persisted even after its eventual delivery to Lockheed. Rework and the installation of replacement parts continued through September. The slippages had by that time become so substantial that certain of the earlier system tests had been invalidated (those which had to be conducted within a specific period during the weeks immediately before the launch) and had to be performed a second time.[16]

As it happened, other factors had intervened to insure a relaxation of E-5 launch schedules. On 9 September an Atlas-Agena carrying an E-2 payload exploded 1.5 seconds after ignition, severely damaging Pad 1 at Point Arguello. Initially there were estimates that the pad could be readied for an E-5 launching by 1 November, but later evaluation of both the damage and the status of the E-5 payload caused the program office to slip the initial launch date to 12 December. (Vehicle 2203 slipped from 7 December to 18 January 1962 and 2204 to 22 February 1962.)[17] Vibration tests of the 2202 payload a few days later disclosed faults in the film carriage portion of the camera subsystem, making the postponement seem particularly well advised.[18]

Pressure for an improvement of the revised launch schedule increased during early October and, as it became clear that the pad damage would not be the limiting factor in schedules, the pace of activity stepped up. On 17 October, General Greer directed Lockheed to make every effort to launch 2202 by 2 December rather than 12 December. The contractor reacted by shaping a "hard core group of key personnel" into a task force with a 24-hour, seven-day-per-week assignment: meet program objectives. Engineers and launch crews were shifted from the Midas program to provide the necessary work force.[19]

The effort was extraordinarily successful. At 1245 hours on 22 November, 12 days in advance of the most optimistic schedule proposed in October, 2202 was launched from Pad 1. Every effort had been made to insure a successful launch, including special provisions of "super clean" propellant tanks and X-ray checks of questionable transistors. But 247 seconds after lift-off, the Atlas lost pitch attitude control and shortly thereafter another programming error caused premature engine shutdown. That combination of errors caused the Agena to stabilize in a tail-first attitude after separation. When the Agena engines were ignited the vehicle promptly decelerated into the Pacific.[20]

Taken together with the record of Itek failings and Lockheed problems, the launch failure had immediate repercussions. After hearing presentations on the status of the program and discussing its prospects with General Greer, Charyk on 4 December directed that all work on the E-5 program be halted except that in support of 2203 and 2204 launches. Lockheed was instructed to treat the action as a "partial termination" for the convenience of the government, a euphemism designed chiefly to prevent speculation by the press and within the aerospace industry. If questioned, SAFSP was to explain that the decision represented ". . . part of a continuing process of review and refinement of the USAF space program."[21]

Vehicles 2203 and 2204 differed from their predecessor in having a more comprehensive (ultra-high frequency) command and control system and more intricate telemetry. The camera was somewhat more refined, as well.

Those vehicles effectively cancelled by Charyk's order were either like 2203 in most respects or, in the case of 2207, 2208, and

2209, were slated to be "refined" along lines determined by early test results.[22] With the cancellation of the final five vehicles in the original schedule, E-5 funds requirements for fiscal 1962 dropped to $55.6 million. Accumulated program costs would therefore peak at $258 million. Approximately $23 million of the total would be needed to complete and launch 2203 and 2204.[23]

As had been true of earlier terminations, and as was to be true later, financial considerations apparently played a considerable role in the decision to halt work on E-5. During meetings with Lockheed early in December and with Charyk's staff later that month, Greer's people were particularly concerned by an apparent belief that the E-5 "partial termination" would bring about a considerable improvement in the financial status of remaining elements of the satellite reconnaissance program. The net effect would be substantially less than seemed to be anticipated. For instance, if the Atlas boosters scheduled for E-5 use were not so expended and their "bookkeeping" costs transferred to the E-6 program, no net reduction in costs would occur, merely a reallocation. Transferring Agenas from E-5 to E-6 had the same effect. E-5 cameras, capsules, and accessories were well along toward completion by December 1961. Most costs and liabilities had been incurred and could not be recovered.

Certain of the "peculiar items" being bought for the E-5 effort alone could be cancelled, but in Greer's eyes this amounted to "small potatoes in the big picture. . ." He also emphasized that two launches still were on schedules. "This means that everything didn't grind to a crashing halt on 5 December," he told [redacted] de facto treasurer for the satellite reconnaissance program. Rather than the $50 million that some officials seemed to believe would be shifted from E-5 to other programs, about $14 million was actually recoverable. In part, that somewhat discouraging appraisal reflected facts of life which had not become apparent until December: slippages and cost increases incurred while 2202 was nearing launch readiness had increased total program costs by an unprogrammed $11.9 million![24]

Even in financial matters E-5 sometimes seemed a child of misfortune. A case in point was the decision of April 1961 to cancel the requirement for a secondary propulsion system in all but the first E-5 vehicle, which was then so far toward completion that the deletion would have cost more than it saved. Bell Aircraft Corporation, which manufactured the secondary propulsion system, halted work on the hardware but continued research and development. The equipment still was scheduled for use on E-6 and Midas vehicles, but in large part its cost was being charged to E-5. Colonel King was not pleased, a sentiment he communicated to the purchasing officer of E-5. Ultimately there was an agreement that no post-September charges would be levied on E-5, that E-6 and Midas would actually provide the funds, but the payments continued to be made through the E-5 contract. In King's judgment, the episode confirmed the lack of financial and management responsibility displayed by Lockheed through the course of the E-5 effort.[25]

Termination of the extended E-5 program also relieved pressure in other areas. The contentious requirement for a secure command system in E-5 had been troublesome since early 1961, mostly because its cost (in excess of $2.5 million), delayed availability, and probability of detracting from general system reliability made it seem unattractive to the program office. But Undersecretary Charyk was extremely interested in reducing the risk that uncoded commands might be intercepted by the Soviets, or that the Soviets might insert their own commands into the E-5 control system. Both military and political consequences could be serious in either event, a possibility that alarmed senior officials of both the State and Defense Departments.* Not until October 1961

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* Should an E-5 recovery capsule be successfully commanded to reenter in Soviet territory, not merely film, but the entire camera system would be available for examination. Of the several recovery-mode systems in development or operation (Corona, Gambit, Argon, E-5 and E-6), only E-5 included camera recovery provisions.

was the requirement for an encrypted command link deleted, and then reluctantly.[26] With cancellation of plans for extended E-5 launches, concern diminished.

In the midst of the termination proceedings, and while the program office was trying to sort out the residue of a complex program, 2203 reached launch readiness. It climbed free of Pad 2 at Point Arguello at 1145 hours on 22 December, after two days of delay for the correction of minor defects. Countdown went well, and though there was a fault in the Atlas propulsion cutoff system the net effect was to put the Agena in an orbit with a period 4.5 minutes longer than planned.

Once on orbit the payload began its scheduled operation. At first all seemed well, and there were clear telemetry indications that the camera had functioned, but either the frame counter failed or the camera shut itself down earlier than scheduled. That was not too serious, even if undesirable. But a faulty command actuated the reentry sequence on the sixth pass and through a combination of errors the payload, after separating, went into a new and higher orbit. (That was not an unmitigated misfortune; the payload had "tried to reenter" over New Boston.) The dead Agena, relieved of its cargo, continued to circle the earth somewhat below the capsule. Because the reentry command had activated all systems in the capsule portion, the battery was dead by the time it was needed to ignite squibs and actuate the drag parachute. Further, the retro-rockets had been ignited during the unplanned maneuver sending the capsule into its high orbit, so any reentry would be entirely ballistic.

The Agena fell back and burned up somewhere south of Borneo on 31 December. Tracking stations calculated that the capsule would encounter enough atmospheric resistance to bring it down about 9 January. Air recovery would be impossible because of the complete absence of the retro-rocket and parachute phases, but it was conceivable that the vehicle might survive reentry forces and impact where the payload could be recovered.[27] In the course of Pegasus reentry experiments during September and October 1961, one reentry test vehicle had survived a ballistic return from an altitude of nearly 200,000 feet after its parachute failed to deploy.[28]

E-5 program people bled the Spacetrack centers for whatever information they could obtain on the course and probable decay of the satellite. During the second week of January 1962 the tracking stations reported that the capsule had passed over the northernmost tracking screen but had not been picked up by the radars of the next belt southward.

Lieutenant Colonel V. M. Genez immediately contacted the 6594th Aerospace Test Wing, activating an earlier plan for the contingent recovery of decaying capsules that might enter intact. There was every indication that the payload had come down in northwestern Canada, so a C-119 carrying Lieutenant Colonel Lon Berry and a recovery crew flew into Great Falls, Montana, stopping there to get Canadian permission for a search along a specific path. The Royal Canadian Air Force wanted to know why. Colonel Berry explained that the USAF hoped to find part of a satellite. After several hours of delay, a direct phone call from Washington ordered Berry and the C-119 back to California. No reason was given.

It later developed that the area of the proposed search was along one of the Strategic Air Command's most heavily used polar patrol routes. Canadian authorities suspected that a B-52 had accidentally released a nuclear weapon and that the Air Force wanted to recover it surreptitiously. The issue was not of the sort that promised quick resolution, so the search party was ordered home.

Later a pair of U-2 aircraft flew along the suspected reentry path, photographing the terrain in hopes there might be some sign of the capsule. Nothing turned up, and the affair ended on an inconclusive note.[29]

The third and final E-5 vehicle was launched on 7 March 1962 at 1410 hours, after an extended series of aborted countdowns. The Agena auxiliary power system and the command and control subsystem of 2204 had been substantially modified to reflect experience with the first two E-5's. Nevertheless, problems with the Agena, the Atlas, the guidance programmer, and various switches had delayed the launch since 22 February. Despite that omen, the launch and orbit injection were "near nominal." For the first 13 passes, all went reasonably well. Then the New Hampshire tracking station improperly transmitted reentry sequence commands. The vehicle assumed and maintained reentry attitude, however, and over a period of several passes expended most of its attitude control gas. In part, the sequence of misadventure resulted from failure of the Fairchild timer. A recovery attempt on pass 17 failed because of another tracking station error, and by pass 21 all control gas had been exhausted. The only remaining recourse was to trigger the reentry system while the vehicle was in an appropriate reentry attitude. But instead of reentering, the capsule went into a higher orbit, much like its immediate predecessor.[30]

More than a year later, in July 1963, the satellite had decayed to the point of imminent reentry. As the heavy heat shield still was attached, there seemed a chance that it would survive. Greer's staff, aided by computers and operators of the Aerospace Corporation, calculated the probable reentry path and impact point. They concluded that the satellite would impact toward the center of the Arabian Sea. Since any possibility of parachute deployment had passed months before, and since the shock of striking cold sea water after an uninhibited ballistic reentry almost certainly would breach the satellite casing, there seemed no possibility of retrieval. No recovery was attempted. All the available data suggested that the capsule had actually come down in the predicted impact area. Like both its predecessors, nothing more was heard of it.[31]

Much the same fate had befallen the E-5 program. After the failure of 2203, the program disappeared from organizational charts. No final report was written. On 1 March 1962, even before the last E-5 launching, Colonel King had been transferred to a new assignment and the residue of the program office had been dispersed.[32] As E-5, the program was thereafter of interest mostly to antiquarians.

But the camera, and the E-5 requirement, tenuously held to life notwithstanding the lack of program success. Charyk's decision to cancel the E-5 program had been taken on Monday, 4 December. Two days later, Jack Carter of Itek proposed to Charyk that tests be run on Itek and Perkin-Elmer lenses to determine whether an improved lens might be substituted for the original in the still-pending 2204 flight. A comparison began early in January.[33]

While arrangements for that work were in train, Carter suggested to General Greer that advances in the camera and satellite arts since the start of E-5 should be adapted to a new reconnaissance system based on the Itek E-5 camera. After refining the original idea, he formally submitted it on 19 December 1961.

What Carter proposed was combining a single re-engineered E-5 camera with the Discoverer-Corona capsule, a Thor booster, and a modified Agena.* He estimated that the resulting orbital system would have a two- to four-day mission life. Exploiting the lower altitude of the Discoverer satellite, the modified E-5 promised object definition on the order of four feet and, in combination with Kodak's new SO-131 film, a resolution of about 100 lines per millimeter.[34]

The idea was not unattractive. On 28 December 1961 General Greer, Colonel H. L. Evans (his deputy), and Colonel King met with Carter to discuss in greater detail both the concept and its application. Greer recommended that Charyk give the proposal a careful hearing. The general suggested, however, a complete departure from the contract and management structure that had characterized the original E-5 development. He favored a covert program and an associate contract arrangement that would put Itek (camera), General Electric

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* Although Itek's record in E-5 development was scarcely faultless, the failures of the system had all originated in Atlas and Agena subsystems, mostly peculiar to the original E-5 design. Corona had a much better record by late 1961, and Itek's reputation for camera development was quite respectable.

(capsule), Lockheed (Agena), and Douglas (Thor) at roughly the same level, with Lockheed providing whatever systems engineering and integration work might be needed. He felt that the Corona office should have overall program management responsibility. (Corona operated partly inside, partly outside the established structure of Greer's organization, Greer having "focal point" authority but the CIA still largely directing program affairs.)

The arguments favoring Carter's proposal were few but weighty. There had been no real relaxation of the original E-5 requirement, even though enthusiasm for the E-5 as a system had mostly evaporated. The Carter approach offered a relatively inexpensive way of performing the basic E-5 assignment, given the proposition that leftover E-5 cameras would serve as the basis of all payloads. The greatest technical problem was that E-5 camera systems, even if modified as Itek proposed, would weigh substantially more than Corona cameras. But offsetting this was the potential of an improved Thor, then called Thorad, which by utilizing the additional thrust of strap-on solid-fuel Sergeant rockets could orbit such a payload. The near-term availability of a Thor-boosted E-5 camera promised high detail photographs of Soviet installations sooner than any other reconnaissance satellite in development, and at a much lower cost.

Undersecretary Charyk was disposed to favor the idea. On 29 December he told Greer that he wanted some assurance of general feasibility before committing himself and that he would make a decision once he had been fully briefed on the status of Thorad, the capsule problem, and the details of proposed operations.[35]

Colonel H. L. Battle, principal Air Force manager in the Corona program, expressed initial reservations about the soundness of the approach. He was quite reluctant to assign systems integration responsibilities to Itek, an aspect of the original Carter proposal which General Greer had dismissed in making his first recommendations to Charyk. Battle was also apprehensive that the modified E-5 might become a substitute for Corona rather than an addition to the existing program, a notion that did not stir up much enthusiasm in the Corona office.[36]

After giving the proposal further study, the Corona people suggested that the Central Intelligence Agency contract for the payload (from Itek) and the recovery vehicle (from General Electric). Such an arrangement would make the new program in many respects a contractual counterpart of Corona itself. The Air Force Space Systems Division would, in that context, procure Thors and Agenas and Greer's organization would manage a covert systems engineering contract with Lockheed.

Corona experience and refined estimates indicated that the basic Thor-Agena combination could put the 775-pound payload, including

40 pounds of film into a two-day polar orbit. Average photographic altitude would be 140 nautical miles, although perigee would be about 100. Use of Thorad would substantially improve orbital life span.

One premise of development was a joint Itek-Lockheed payload structure design, Lockheed fabricating the framework and shipping it to Boston, where Itek would install the camera system. After inspection and acceptance at Itek's plant, the composite structure would be shipped back to California where Lockheed would mate it with the recovery capsule before sending it off to Vandenberg.

With immediate program approval, it seemed possible to get the first payload delivered by 22 August 1962 and later payloads at one-month intervals thereafter. The first launch could be scheduled for December 1962. It was generally assumed that problems with the booster, or for that matter with the Agena, would be slight because the payload would be essentially interchangeable with those being built for Corona operations, which then were going rather well. Thor engines would be the pacing items unless there was a slippage in payload fabrication.

Initially it appeared that the cost of development and initial payload procurement would total $7.8 million. Costs would be somewhat higher, however, if Thorad were used--an expedient that would give the system a six-day life.[37]

Within Greer's organization, the Carter proposal was called Lanyard, a word known only to about a dozen people during the first weeks of program consideration.*

Not much could be done until Charyk obtained an essential endorsement of Lanyard from the Secretary of Defense, the general concurrence of CIA, and final approval from the National Security Council. By early January 1962, much of the general uncertainty had dissipated. In response to a request from Defense Secretary R. S. McNamara, Dr. Charyk prepared a general resume of the status of Gambit and the options open to satellite reconnaissance for the next year or so. The information was needed for the President's "special group," which conducted periodic reviews of general reconnaissance program status. In his resume, Charyk included a paragraph declaring the feasibility of the Lanyard approach and a statement that the reconnaissance office was giving serious consideration to funding the program. Colonel J. R. Martin, head of Charyk's special staff, carried the proposal directly to McNamara for final review. McNamara went over the draft in detail, making only one significant suggestion for change.

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* The word first appears in an 11 January 1962 memorandum written in the Pentagon but it was earlier used as the code identifier for "the simplified E-5" in discussions on the West Coast. A special Lanyard clearance procedure was in effect by late February.

Instead of proposing the possibility of Lanyard development, he told Martin, the resume should state that development was in progress.

So modified, the memorandum went forward for Secretary McNamara's signature. For practical purposes, it represented approval of Lanyard development. Nevertheless, it seemed unwise to do much toward formally starting work until final endorsements had been received from the presidential review level.[38]

The McNamara memorandum did not go forward for National Security Council review until March 1962. More than a month earlier, on 22 January, Undersecretary Charyk discussed Lanyard's situation and prospects with General Greer and the West Coast project group. He emphasized that Lanyard would be, in at least one sense, competitive with the current notion of accelerating Gambit development. Should Gambit become available at about the same time as Lanyard, there would be no real need for the latter. Conversely, if Gambit should be delayed, or if the Gambit effort should encounter major technical difficulties, Lanyard would serve as a substitute. The two programs were complementary, being aimed at obtaining high-resolution pictures during the early months of 1963. Charyk wanted it to be understood that Gambit was the main effort; Lanyard he characterized as a probable transitory development to insure against the consequences of Gambit delay or failure.[39]

By early February, Battle had refined the financial estimates and had committed Lanyard to the Thorad approach. It was now plain that payloads would cost at least $8.5 million and Thorad development another $3.4 million. Thors and Agenas for the five proposed launches would cost another $20.9 million.

Although the cost figures were no longer quite as attractive as they had seemed a month earlier, compensating technical advantages had appeared. Close study of Lanyard mission potential indicated that because of the improved thrust of the Thorad the guidance systems in both the Thor and the Agena could be operated over longer periods than had been anticipated. A considerably enhanced precision in orbital injection would result. Additionally, it now appeared that a 15-day life for the Lanyard system might be achievable.

Convinced of Lanyard's appeal and reassured by McNamara's previous endorsement of the program, Charyk decided to request Lanyard approval in a pending presentation to the "special group." He saw Lanyard principally as insurance against a major setback in Gambit and planned to present the program in that light.

The still embryonic Lanyard project team was developing a different outlook. Characteristically, those who became intimately associated with Lanyard tended, in time, to forget or ignore the original concept of Lanyard as a transitory, interim program. In the eyes of its managers--and its contractors--it acquired an aura of permanence that Charyk had not intended. More than a year later, when Lanyard and Gambit payloads were essentially standing side by side for launch countdown, there was relatively little program office acknowledgement of Lanyard's transient status.[40]

Still undecided in March 1962 was the question of who should administer the covert contracts with Itek, General Electric, and Lockheed. The matter was complicated by the nature of the still embryonic National Reconnaissance Organization (NRO), headed by Charyk, which included both CIA and USAF participants in satellite reconnaissance. Although it seemed inevitable that the NRO would be the actual Lanyard program custodian, effective control tended to remain with the organization that directly administered the contracts. The CIA had been fully cognizant of the Lanyard affair virtually since its inception and CIA management of covert contracts had been one of Colonel Battle's first suggestions. Yet Carter's proposal had first been made to Greer, E-5 had been a Samos program, and there seemed no compelling reason for allowing it to drift into another organization's control.*

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* The evolution of the NRO and its influence on the progress of the several satellite reconnaissance programs is the subject of a separate chapter. For the purposes of this portion of the narrative it seems sufficient to note that the organization existed and that its functions and authorities had not been entirely clarified.

On that ambiguous note, General Greer--anxious to get Lanyard underway before its value was substantially lessened by the passage of time--suggested to Brigadier General R. D. Curtin, heading Charyk's NRO staff, that he be authorized to let a "level of effort" contract with Itek to cover an initial 30 days of work. He also urged the need to start work on a covert cover plan, since a first launch was planned for December 1962, only 10 months distant. Acknowledging that he was uncertain what decision might be made on the matter of contract authority, Greer suggested that it would be better to have the CIA take such first steps if it seemed probable that the agency would ultimately get program management authority.[41]

That the program would be totally covert and not, as proposed at one point, a highly secure "white" effort, became certain during the third week of February 1962. Stimulated by CIA concern about the rather large numbers of people who were becoming aware of such "ultra sensitive" covert programs as Corona and Argon, President J. F. Kennedy directed that only individuals specifically approved by the CIA could become involved in the Lanyard effort. By implication, in so ruling, the President also approved the Lanyard program and made the CIA its custodian. Charyk planned to recommend to the President's Special Committee on Reconnaissance that Lanyard be handled as Corona had been.

Early in April the undersecretary found a way to split the hair, letting CIA have contract responsibility but keeping the critical technical elements of program management in Greer's hands. He proposed to Herbert Scoville, CIA's Deputy Director for Research and Richard Bissell's successor as de facto manager of the CIA's role in satellite reconnaissance, that Greer be made immediately responsible for all Lanyard contracts except the covert agreements, that CIA administer all covert contracts, and that Greer be "completely responsible for technical management of Lanyard," including the payload and recovery elements. That line of command would be reinforced by making the configuration control board responsive only to Greer.

Operations would be patterned after Corona. In effect, CIA would exercise responsibility for pre-mission planning and on-orbit operational decisions involving target selection. The CIA would also manage security aspects of the program. Communication would employ Corona message circuits.

The solution Charyk proposed was a compromise between the original concept of management by the Corona office under Greer's direction, and management along the lines of Corona -- which meant by the CIA. Charyk reminded Scoville on 2 April that it was urgently necessary to agree on a division of responsibilities if the NRO was to meet the schedules promised to the President. And he noted that some project activity had begun even without an agreement on responsibilites.[42]

The need for such a communication, in effect a negotiated agreement between the director of the NRO and his nominal deputy, could be appreciated only in the context of personal and organization animosity that had developed since the departure of Bissell, Scoville's predecessor. The evidence would indicate that President Kennedy approved the Lanyard approach early in March but that differences between NRO and CIA, or between Charyk and Scoville, delayed further action for at least three weeks.

Scoville eventually accepted the Charyk proposal of 2 April, though remarking that giving General Greer the total responsibility for technical management of all aspects of Lanyard was a departure from Corona precedents.

Details of the arrangement were somewhat more complex than could be summarized in the phrase "complete technical management responsibility," but that was the essence of the arrangement. The immediate program director would be Colonel Battle, though he would be entirely responsible to General Greer rather than, as with Corona, to CIA for some matters. And although CIA had the authority to make "on-orbit operations" decisions, Greer would exercise a technical decision function during the conduct of Lanyard missions. In case of conflicts, Charyk would decide--if time permitted; otherwise Greer prevailed. Absolute CIA control of Lanyard security was tempered by the ruling that General Greer would determine program need-to-know, only questions involving people not engaged in program management being subject to a joint agreement between Charyk and the CIA. Finally, the Corona secure teletype network was to be extended to include Greer's group, Charyk's office, and the NRO staff. (Until that time the Corona managers had passed along to General Greer those messages they thought would be of interest; there was no arrangement for transmittal of complete information.)[43]

Even before Charyk and Scoville reached their understandings on program responsibilities, Lanyard had begun the transition from proposal to development. By 28 March 1962, Lockheed had been authorized to construct five orbital systems in accordance with technical instructions originated by Greer's staff. Pending negotiation of a formal contract, Lockheed was permitted to spend $1.0 million.[44]

As in the past, one of the first problems that had to be faced was getting Lanyard under cover. The program was largely based on the use of existing E-5 cameras which had been openly developed and procured for the Air Force inventory. Arranging to have them disappear from accountability without actually leaving Itek's possession promised to be tricky.

The affair was arranged by an ingenuous feint. Using ordinary communication channels, Itek offered to buy from Lockheed the residual inventory of E-5 equipment. The sale price came to $1, 008, 000, roughly 55 percent of what the government had paid upon original delivery. The money actually was provided by the CIA and, as paid, represented the first $1 million of program funding. For the record, General Greer formally asked Air Force Systems Command headquarters to authorize transfer of the residual E-5 inventory to Itek. After an appropriate interchange of coordination correspondence which alerted all those earlier concerned in E-5 affairs, permission was granted. As far as the "white" satellite organization knew, E-5 was dead and buried. Itek had legal and physical possession of the cameras and could proceed to modify them to Lanyard specifications without alerting anyone.

Other elements of the defunct E-5, including a test chamber and a collection of relatively expensive specialized tooling, had remained at the Itek plant near Boston. Itek asked that all such property be transferred from the E-5 contract to an existing industrial facilities contract between Itek and Wright-Patterson Air Force Base. At the same time, the camera contractor submitted a list of non-usable items, such as the E-5 fairing, lens barrels, and the like, to be processed as scrap under the authority of the local Air Force plant representative. The remaining

E-5 residue was the subject of another Itek offer to buy, which received routine approval. Because some conscientious procurement monitor might protest Air Force readiness to sell scarce high quality lenses at 50 or 60 cents on the dollar, the lenses were exempted from the arrangement and nominally assigned to the Aeronautical Research Laboratory at Wright-Patterson. Actually, they were transferred to Itek on a hand receipt. This seemingly intricate sequence of actions was, in practice, less complicated than many routine matters of covert contract administration. It succeeded in getting the necessary equipment transferred to Itek so circumspectly that no suspicion was aroused. And since Itek facilities included a "black" area where Corona cameras had been developed and built, no difficulty was encountered thereafter in concealing the actual modification work.[45]

By early May 1962, Lanyard technical proposals from Itek, Lockheed, and General Electric had been received and were being processed. Lockheed and Itek were working under interim authorizations totaling $1 million each, while General Electric had received advance authorizations totaling $.78 million. Program costs for the three were then estimated at $11.7 million, of which Itek would receive $7.2 million and Lockheed $3.5 million. The total still was less than General Greer's estimate that the payloads would cost all of the $14 million recovered from the E-5 termination.[46]

The Lanyard panoramic camera system was then expected to weigh 635 pounds, the cassette 20 pounds, and the stellar-index camera system another 20 pounds. About 78 pounds of film would be carried for the main camera plus two pounds for the stellar-index system. Greer had suggested that six additional cameras be added to the original Lanyard order for use during calendar 1964, but Undersecretary Charyk had balked, limiting the total procurement, for the moment, to five cameras. Charyk agreed to consider buying two additional cameras for 1963, however. The approved five-vehicle program, including boosters and launch costs, would run about $34 million.[47]

Not until October 1962 was that basic schedule modified, and then by the purchase of three additional Lanyard payloads which would provide for interim high acuity reconnaissance in the event that Gambit operations were not wholly successful during 1963. The new payloads were tentatively slated for launch during January, February, and March 1964.[48] Total costs for the Lockheed and Itek portions of the program thus rose, for the eight programmed flights, to $5.96 and $10.8 million, respectively, up a total of $5.62 over the original program estimate.[49] The cost of the entire Lanyard effort, it developed, would increase about $10.5 million to a total of $44.85 million. The prospect that early success in Lanyard flights would cause a further extension of the program appeared later in October, when Itek was authorized to buy optical glass needed for nine additional systems. Since the cost was less than $300,000, however, nothing in the way of a significant commitment to a continuing Lanyard effort could be deduced from the decision. Lead time for optical glass was the most critical element in long-term planning, so such a purchase implied no more than elementary precautions against unanticipated problems.[50]

The immediate responsibility for technical aspects of Lanyard development was firmly fixed by early July, with the assignment of Major B. W. Quinn as the officer responsible for the camera system.

Redelegation of contracting officer authority from CIA headquarters to Arthur Leach (a CIA officer assigned within the SAFSP establishment) served to pin down responsibility for the contractual elements of the program. Leach was formally empowered to sign all covert contracting documents "regardless of amount" provided only that the proper funding allocations had previously been approved.[51] Such a measure promised additional safeguards for the security of the basic Corona activity, a matter about which CIA headquarters was expressing increased concern as the unfolding of Lanyard exposed more and more people to the facts concerning the origin of the Lanyard film recovery technique.

In the midst of Lanyard acceleration there developed a new squabble over the scope of National Reconnaissance Organization responsibilities, and in consequence the funding authorizations for Lanyard became embedded in an organizational dispute between Charyk and Scoville. In September and October 1962, the question of whether CIA would assume total responsibility for all covert contracting in satellite reconnaissance became a warm issue.* While it went unresolved, funds for Lanyard and other covert programs were withheld. By October, the reserve of NRO funds had vanished and, in General Greer's words, the contractors were working on trust.[52] The problem was ultimately resolved by compromise, but not before alarming both General Greer's establishment and the Lanyard contractors.

Late in 1962 there was some difficulty with schedules for the stellar-indexing cameras which, in the case of Lanyard, were vital to the functioning of the total system. Stellar-index records were the only sources of attitude reference provided in the Lanyard system,

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* The rather complicated question of authority and responsibility is discussed in greater detail in a following chapter on the NRO. In essence, the CIA did not want to assume covert contracting responsibilities for all programs, arguing that exposure was certain if its relatively small activities in that area were increased by such programs as Gambit. Charyk, as director of the NRO, wanted a rigid definition of functional responsibilities which would effectively confine CIA to security and covert contracting (plus certain operational functions), but which would give NRO directors complete technical authority. Corona, still largely controlled in technical and financial areas by the CIA, was the real question at stake.

no horizon camera being incorporated. (Corona systems included a horizon camera, permitting independent determination of vehicle attitude and making stellar-index information a highly useful but not vital accessory.) In October, the configuration control board decided that the stellar-index cameras in Lanyard should incorporate a capacity for 500 feet of index film and 250 feet of stellar film--a substantial increase over the amount originally contemplated. After some minor quibbling over costs and fees, Itek began working on the change. Difficulties came in December, when Itek disclosed that the required supply spools and take-up cassettes could not be made available before mid-March 1963--some two weeks after the currently scheduled first flight date. The possibility that one or two Lanyards might have to conform to the older pattern of stellar-index operation did not vanish until early 1963, when it became apparent that the first system could not be launched before April.[53]

Another problem that subsequently solved itself involved [redacted]. Apogee limits for Lanyard (200 nautical miles), [redacted] late in October 1962--with the qualification that they would be reactivated in the [redacted][54]

The chief difficulty encountered in payload development arose from deficiencies in and shortages of test equipment and related facilities. By November 1962, a general slippage in several subsystems had cast doubt on the validity of the very tight delivery schedule. In September, platten fabrication problems delayed progress. By late October, difficulties in installing the thermal blanket for the camera subsystem were becoming critical. Agena completion had slipped a week by early November, and construction of the joint between the Agena and the payload section was then two weeks behind. By the time Itek was ready to ship the first camera subsystem it had become essential to waive requirements for full qualification of the beryllium mirror and to provide for a later retrofit of the data block recording subsystem, which had operated poorly in preliminary tests. The stellar-index unit was not yet available and could not be tested in conjunction with the main camera. More significant, though not immediately recognized as such, was a notation that a light corona effect had caused film fogging in some of the early camera system checks.[55]

Notwithstanding such difficulties, each of which briefly seemed to presage a major crisis, Itek managed to push the first <u>Lanyard</u>

camera system through preliminary acceptance tests by 19 December 1962. Changes to the beryllium mirror still were necessary, however, and final optical tests could not be run until a critical test facility had been completed and checked out. Lockheed was still reporting trouble with thermal shielding and the roll joint structure, with modifications of the command decoder unit, and with facility qualification.[56]

One of the problems of the Lanyard schedule was inherent: the first launch vehicle would be as unique as its payload. The initial Lanyard was scheduled to be lofted by the first thrust-augmented Thor, now generally called TAT rather than Thorad. Additionally, the Bell Telephone Laboratories' guidance system which later was to be made integral with the Agena stage would, for the first launch, be located in the Thor. Thus a special set of ascent equations was required. Additionally, the program office hoped to use Lanyard mission data in planning for later low-altitude Corona flights and in obtaining precise information on the prospective life expectancy of the dual-capsule Corona-J systems scheduled for first use during the spring of 1963. The abundance of such factors thoroughly compounded the normally hectic environment of any first flight.[57]

Remarkably enough, Lanyard experienced relatively few significant changes during its early development. The substitution of a beryllium mirror structure for the aluminum structure originally planned was one which would have long-term influence, and complexities of the stellar-index camera installation promised to be important, but on the whole the program had been rather stable. (The beryllium structure provided better rigidity than aluminum at a 40-pound saving in weight, but the additional film capacity of the stellar-index camera unit absorbed much of the difference.)[58] In that Lanyard was significantly different from its E-5 predecessor, however, it represented a continuing development problem, one not completely obvious if the abbreviated system development schedule was used as an indicator of design novelty.

Apart from being considerably lighter than the E-5, largely a factor of employing one rather than two cameras, Lanyard principally differed from the original system in that only the film was recovered from Lanyard flights. E-5 recovery had included both cameras and virtually the entire forward structure of the total system. Additionally, Lanyard employed a unique roll-joint technique, which permitted the camera to point toward selected ground targets without requiring a roll maneuver by the Agena. Finally, the new system was based on single-camera stereo techniques. Its pictures would cover a 50-nautical-mile swath eight miles deep along the flight path, with a 10 percent overlap. Ten of the major E-5 subsystems were incorporated in Lanyard. Seven others had been completely eliminated (including a weighty and complex computer), and the remaining five had been substantially simplified.

E-5 had been a pressurized system; Lanyard resembled Corona in operating at ambient pressures. Simplification had its most marked effect in the film transport and shutter mechanisms, which leaned heavily on Corona experience.[59] The dynamic operating modes of Corona and Lanyard cameras were quite similar, which was not surprising since both were Itek developments stemming from 1959 concepts. Nonetheless, in bulk and in many of their physical details the two systems were more dissimilar than might have been anticipated, given the fact that the Lanyard approach involved substituting Corona techniques for those of the original E-5.

The recovery sequence was a real point of difference between Lanyard and E-5. The original E-5 capsule design had been markedly influenced by the notion of modifying the payload section to a manned-space-flight configuration. Although recovery and re-use of an expensive camera was the customary justification for provisions that would require reentry of the entire E-5 front end, the remarkable likeness between the E-5 capsule and that proposed by Lockheed for the abortive Man-In-Space-Soonest system (1958) could not be ignored.

In E-5, once the photo mission was complete, the first of 13 separate recovery events was to increase pressurization of the capsule by seven to ten pounds, to stiffen it for reentry. The Agena was then reoriented so that engine ignition would effect capsule ejection, the mirror was jettisoned and the lens retracted. The covers on the various apertures for mirrors and lenses were closed to shield interior components against reentry heating effects. Thereafter the entire camera compartment separated from the Agena. After capsule passage through the upper atmosphere, the fairing doors were opened, the drogue gun fired, and the drogue chute released. Drogue and mid-body fairings were next jettisoned, followed by deployment of the main parachute, discard of the ablative shield, and inflation of the water impact bags.

Lanyard's recovery sequence was, by comparison, quite simple. After Agena reorientation and severance of the film, the film gate was sealed, the recovery capsule system separated from the camera, the retro-rockets fired, and reentry commenced. Deployment first of the drogue chute and subsequently of the main chute completed the seven major events of reentry.

Adoption of Corona-proven techniques implied several significant advances toward a simpler system. Elimination of pressurization promised to reduce a potential for image degradation arising from internal air turbulence and to eliminate any need for internal error control stemming from pressurization factors. Lanyard needed no counterbalance for the linear motion effects of the image motion control mechanism, eliminating requirements for the servo-drive counterweights needed on the E-5 image motion compensator. (In Lanyard, the Agena could be programmed to ignore rate inputs that fell below two milliradians per second.) Similarly, Lanyard required no counterweights for spool actions, as in the E-5, since in Lanyard film take-up forces were compensated for by counter-rotation on the pitch axis of the orbiting vehicle.[60]

The proof of the pudding remained for the future, of course. Most satellite reconnaissance programs of the past had been notably high on promise and substantially limited in performance--leading to a notoriously high mortality rate. In December 1962, when the first Lanyard system was being assembled for transport to Vandenberg, the last of the original Samos systems, the E-6, was in the process of cancellation. To that time, only Corona and its siblings had returned reconnaissance pictures. (Products of the single successful E-1 flight were treated as interesting photographs taken from orbit--curios with no real potential for utility.) And in the case of Lanyard, a question of requirements had begun to cloud prospects. As early as August 1962, the National Photographic Interpretation Center (NPIC) had registered with NRO Director Charyk a mild disclaimer of belief in any real need for Lanyard. NPIC expressed doubts, based chiefly on Corona experience, that the Lanyard vehicle could be programmed with sufficient precision to provide stereo coverage of vital targets. NPIC suggested that Lanyard's limited transverse, which would permit photographs of a 50-mile strip from a 125-mile orbit, was too slight for surveillance assignments although the probable photographic quality of the system indicated that surveillance should be its chief role. As it happened, NPIC's real interest of the moment was inducing the NRO to improve the stellar-camera features of Lanyard, a move to enhance the value of the recovered product by increasing confidence that the precise location of the photographed area could be determined. But the inquiry had an ominous ring, nonetheless.[61]

Perhaps anticipating that the tempo of quibbling would increase with time, General Greer late in September 1962 approached Undersecretary Charyk with the suggestion that it might be useful to conduct a comparative technical evaluation of the Gambit and Lanyard systems. A similar evaluation had recently been completed for the E-6 and Mural. General Greer emphasized, however, that the primary purpose of the study should be to uncover any payload technical problems that might have been overlooked in either development program rather than to put the two systems in any sort of competition. But useful comparative data would emerge in any case. Then, should a situation develop ". . . in which a choice between the two systems is forced by budgetary or other considerations," the information on which to base a decision could quickly be brought to hand.[62]

There were other advantages to the study--and some possible disadvantages. On the negative side, it was conceivable that a weighted evaluation would lead to a finding that Lanyard promised considerably more in the way of reconnaissance value than Gambit. Unlikely though such an outcome seemed, Lanyard's capacity for wide-sweep photography at roughly the same resolution as Gambit might be attractive in some quarters, particularly if coupled to financial estimates which showed Gambit costing substantially more. It would be advantageous to the reconnaissance programs, in the long term, if the study showed early that no real need for Lanyard existed; considerable money would be saved by cancelling the program at an early stage rather than, as with E-5 and E-6, after development was essentially complete and flight test well along. The same case might be made for cancelling Gambit early in its life. Greer was particularly concerned lest it should later seem that his group was specializing in the development of redundant, expensive, and duplicative systems.

No formal answer to General Greer's suggestion came back. Instead, Charyk told the general early in October 1962 that there was a firm Gambit requirement, that the Lanyard program was a useful back-up, and that in such terms there was no current need for a detailed comparative evaluation. "We are going to develop Gambit," he said emphatically.[63]

It was during the late months of 1962 that the Lanyard development process began to encounter a succession of seemingly minor difficulties which, standing alone, meant little, but when taken together tended to delay the availability of critical articles. The camera portion had been mated to the frame of the orbital vehicle by early January 1963 and about a third of the total flight preparation routine had been completed. But delays in availability of the Agena set back the start of compatibility testing by a week at that point, causing a general slip in schedules. The program office, fully aware that some such problems were inevitable, had inserted a small pad of slack time early in the development. Unhappily, Itek and Lockheed had eroded away most of that cushion somewhat earlier. By mid-January, Lockheed was conceding to "an extremely tight situation." If any major problems developed, flight schedules would be jeopardized. Schedules were then so tight that the last sequence of camera tests had been rescheduled to follow rather than precede system environment checks, a change required by the delayed availability of a completely suitable calibration facility.[64]

On 31 January, Itek advised Lockheed that the beryllium mirror originally slated for use with the first Lanyard flight payload was "not acceptable." The camera firm recommended using one of the aluminum mirrors already available, since a beryllium replacement could not be provided before 11 February and the deadline for shipment of the qualified payload to Vandenberg was 15 February. (An aluminum mirror had been installed in the first flight system for use through ground tests, being scheduled for replacement shortly before final subsystem checks. What Itek was actually proposing, therefore, was retention of the aluminum mirror for the first flight.) Lockheed, after giving the matter considerable attention, concluded that a beryllium mirror was "essential to program objectives" and held out for the original plan. Itek finally agreed, drawing the needed mirror from another Lanyard system in final assembly.[65]

In the meantime, a succession of failures in both the payload section and in the thermal altitude simulator chamber had effectively ended hope that original flight schedules might be maintained. The first unit entered the thermal-altitude chamber on 5 February, roughly a week late. Two days later it had to be removed for failure analysis and necessary modification. An incorrect command from the test console had induced roll-joint failure. (The unit overran its rotation limit of 30 degrees, severing the connecting cable.) Additionally, electromagnetic interference had shorted out the programmer clock, and it developed that telemetry needs of the stellar-index camera had not been satisfied before the tests started.

After three shifts worked at rewiring the unit, it started through the test chamber again on 8 February. The tests were halted the following day when the roll-joint refused to respond to commands and the cameras ignored automatic shut-down signals. This time the roll-joint had failed because of a short circuit in the camera wiring harness. Quick repair permitted a test resumption by 11 February, but later that day there was a repetition of the camera mode failure. Wearily, test personnel pulled the payload section out of the test chamber and sent it back to assembly.[66]

The fourth attempt at a thermal-altitude chamber test began on 13 February. The stellar-index camera failed the next day, during a cold chamber exposure. Concurrently, roll-joint difficulties reappeared.

In this instance, however, the roll-joint problem was traced to a fault in the Lanyard's command decoder unit. The stellar-index camera failure was mechanical in origin, while refusal of the main camera to shut down on command (another problem which had reappeared) was attributed to a faulty transformer. After each of these defects had been corrected, the system finally completed its thermal-altitude checks on 18 February. The missing mirror made its appearance four days later. After a succession of minor difficulties which further slowed progress, the subsystem tests were completed on 4 March. The shipment left Sunnyvale the next day.[67]

In one respect, the frustrating delays in completing Lanyard ground qualification seemed to have been fortunate. While Lanyard had been stalled in chamber tests, a standard Corona payload had been substituted in the launch schedule--the first TAT booster launch, on 28 February. Because of a technician's failure to press hard enough when inserting an umbilical connector, one of the TAT's solid rocket units did not ignite and the satellite was lost. But the skein of misfortune which had accumulated about the first Lanyard was not yet complete. When the launch finally came, on 18 March, it was unsuccessful. Because of an electrical system failure, the gas valves which governed Agena stabilization during injection operated only for the first second of Agena burn. Lacking attitude control, the Agena stage began to roll at a rate which built up to 24 degrees per second at burnout. Burnout came 13 seconds early, probably because centrifugal force generated by the rapid roll rate prevented fuel from reaching the ignition chamber. The last hope for a miracle vanished when the Kodiak station failed to report any contact with the satellite at the time of its first scheduled appearance.[68]

Lack of success in the first Lanyard launch was a most untimely misfortune. Starting with a Corona launch on 7 January and including the initial TAT failure on 28 February, three successive attempts to obtain coverage of key Soviet areas had been barren. No photographs had been returned since 18 December 1962, a situation which brought expressions of particular concern both from the new director of the NRO, Brockway McMillan, and from CIA's Herbert Scoville. (Even before the abortive Lanyard trial, McMillan had directed a "maximum effort" to get early returns from a Corona-Mural, a course urged by CIA. Indeed, Scoville had suggested substituting a "normal" Corona-Mural payload for the first Lanyard, a measure that was impractical in the time remaining before the Lanyard launch.)[69]

In the wake of the Lanyard failure, separate and detailed reports covering flight difficulties went to Secretary McNamara and

CIA Director John McCone. Scoville, though unhappy with the continued absence of photographs, seemed to be favorably impressed by the forceful approach General Greer's organization was taking toward Lanyard difficulties. McMillan agreed with Greer's observation that there was no useful or consistent pattern to the recent failures and that the best course for the moment was to continue scheduled launches. (Two Corona flights were set for April and one for what remained of March.) In the case of Lanyard, the matter of greatest urgency was to discover precisely what had caused the electrical failure in the Agena and to prevent its recurrence. The best explanation seemed to be that the act of blowing off the camera doors immediately after booster separation had somehow brought on a short circuit in a junction box, but determined efforts to reproduce the effect in ground tests were fruitless.[70]

In the meantime, while the first Lanyard had been moving toward a most premature reentry, the project had become the center of a determined CIA effort to reassert greater control over major elements of the satellite reconnaissance effort. Late in February 1963, the agency urged that Lanyard security procedures be merged with the extant Corona-Mural system, the name itself to survive only as a camera identifier. By implication, since Lanyard was approaching the status of an operational system (from the agency viewpoint, at least), the entire program would thereafter conform to the pattern established for Corona-Mural. General Greer, speaking as Lanyard program director, voiced firm opposition to the notion. In this stand he was supported by the NRO staff. But the agency arguments seemed to stand a considerable chance at the moment, since Undersecretary Charyk was leaving government service at the end of February and no successor for the post of NRO director had been named. Indeed, it seemed possible to some reconnaissance program participants that the departure of Dr. Charyk might signal the end of the NRO itself.

The appointment of Dr. Brockway McMillan to succeed Charyk early in March scuttled rumors that the NRO would be discontinued and for practical purposes channelled the current Lanyard format controversy into a somewhat unrealistic discussion of security procedures. In that area too, it developed, General Greer had a highly defensible position. He pointed out, with quiet logic, that the agency was actually advocating establishment of dual security systems, one of a general nature for members of the Washington establishment, and another rigidly compartmented for personnel in the various field stations. That arrangement, Greer suggested, would be an invitation to security compromise since it would inevitably cause the proliferation of artifical security compartments. He expressed particular concern at the increasing abundance of code words and the fertility of the creation process suggesting that what was needed was not so much the elimination of one security category (Lanyard) as a careful plan for a totally new approach, one adaptable to the real situation.[71]

For the moment, at least, the security clearance situation did not change. But immediately before the first Lanyard launch General Greer proposed that his establishment be made the action addressee on launch and orbit operation messages. He observed that such a change was entirely logical in the light of Lanyard's technical adolescence. (The system is "clearly in the early R&D stage," Greer pointed out.) CIA's Lanyard agent, Colonel J. C. Ledford, instantly responded that until relieved of responsibility for "satellite missions under my control" he proposed to follow "established procedures." In this instance, he meant to assert the authority to decide when an early recovery was necessary, a matter that Greer (as director of the technical program) felt better qualified to judge and which, by the terms of the original Lanyard agreements of April 1962, was his responsibility in any case.

The issue was resolved by NRO Director McMillan's ruling that Greer would exercise responsibility for all actions on which successful recovery hinged except that he would not extend a mission once the operational control center in Washington had decided on an early recovery. Such an early recovery decision was, however, to be based only on considerations of reconnaissance urgency, the probability that mission success might be endangered by some special hazard, or political expediency.[72] Since that ruling confirmed General Greer in the responsibility for deciding all other issues, including that of how satellite functioning on orbit should figure in the timing of recovery operations, it had the effect of strengthening the authority of the program office and the program director. It did not entirely resolve the basic issue, however; Colonel Ledford continued to insist that his organization had the basic responsibility for "the development of payloads and methods of operation" as well as overall security.[73]

The vitality of the Lanyard requirement was not seriously questioned during the authority and responsibility discussions of the spring of 1963. Indeed, John A. McCone, in his role as chairman of the United States Intelligence Board, told McMillan early in April 1963 that "since the success of the GAMBIT system is quite uncertain" it would be advisable to purchase additional Lanyards, thus insuring the receipt of high resolution coverage during the period August 1963 to August 1964.[74]

But at the time there was considerably less assurance of Lanyard success than Gambit success. Not until mid-April did the second Lanyard get through its preflight checks and go to Vandenberg. It did not leave the pad until 18 May.* Then, for a time, all seemed to go well. The boosters and the Agena operated properly, injection into orbit was accurate, and everything needed for a first trial of the camera system appeared to be available. But the payload refused to respond to ground commands--a reluctance finally ascribed to the fact that no electrical power was getting to the decoder, which therefore could not hear the commands. There was no way to route orders around the decoder circuit and the possibility that the ailment might heal itself was unrealistically remote. All that could be done was to attempt recovery, using the "lifeboat" system (which was independent of the main command circuitry and had its own magnetrometer and gas supply). On 21 May the capsule was recovered from the water near Hawaii. Lanyard II proved no more useful to the reconnaissance program than Lanyard I.[75]

Reminiscent in some degree of the problems which had plagued the early E-5 flights, the difficulty of second Lanyard (vehicle 1165)

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* Lanyard II did not have as much difficulty as Lanyard I in qualifying for launch, but it did encounter problems similar to those noted above in the case of the first Lanyard. There is no point to detailing them, however; nothing of major significance to the total program emerged.

was eventually traced to a short circuit of uncertain origin on the payload side of the interface with the Agena. In all probability, a faulty cannon plug connector was the cause, since that was one of the few suspect items which could go undetected during the prelaunch checkout process. The obvious remedy, which was immediately adopted, was to revise checkout procedures. Additionally, a stepped-up routine of shock and vibration testing was grafted to the existent program and greater emphasis was accorded payload integration testing.[76]

One of the problems peculiar to early 1963 flights arose from the introduction of the Agena D--the "standardized" upper stage. Over the previous five years the Agena B had become a thoroughly familiar and generally reliable instrument for space reconnaissance. Familiarity inevitably bred laxness and the cursory performance of some checks. When this situation became quite clear, in April and May 1963, reforms were prompt and effective. Specifically, General Greer's people saw to it that Lockheed re-established "a strong systems engineering and systems integration control," a course which had highly beneficial long-term consequences.[77]

There was no serious thought of reducing effort on the <u>Lanyard</u> program as a consequence of the two successive disappointments.

Gambit still had not flown, and though Greer's people had unlimited confidence in Gambit's ability to perform as required they were admittedly putting their faith in an entirely untried system. Lanyard, even though it had returned nothing from orbit, still had the character of a more conservative system, one with fewer technical uncertainties and one more nearly resembling the highly successful Corona. If Gambit were to meet with problems similar to those which had affected all other reconnaissance satellites during their initiation period, Lanyard remained the single option open to the National Reconnaissance Program. (It should be recalled that of the several reconnaissance systems carried to the point of orbital operation, only Corona had as yet proved useful. E-1 was of no practical value, E-2 had been cancelled after one unsuccessful launch, while both E-5 and E-6 had proven operationally futile and had been cancelled in consequence. Substantial profits to research and development arising from experience with the E-series satellites did not count for much with intelligence specialists who rated programs on a scale that began with useful photographs returned from orbit.)

In such an environment, the Lanyard program was on 24 May 1963 expanded to include five additional payloads. At that time, three remained of the original five ordered from Itek, with the three "spares" earlier authorized constituting the entire reserve. Although Itek had accumulated seven sets of optical glass for Lanyard use, until the 24 May order no provision had been made for obtaining complete camera systems. The Special Projects Office in Los Angeles, appreciative of these circumstances and understanding their implication, had in April recommended an early start on a "follow-on" Lanyard program. The launch and upper stage vehicles might have to be diverted from either the dual-capsule Corona program (Corona-J) or one of the electronic reconnaissance programs. If Lanyard use had to be accelerated following an onset of Gambit difficulties there would be too little time to fabricate additional Thors and Agenas.[78]

By mid-July, Itek and Lockheed had received financial authorization to proceed with fabrication of the additional payloads and associated structures. Program cost would go up by $9 million on that score alone, discounting booster, Agena, and launch costs.[79]

On 12 July 1963, the first Gambit was launched from Point Arguello. Its objective, defined many months before, was to return one good high resolution picture. The first Gambit mission did considerably more; it demonstrated that the optical and mechanical elements of the system were capable of exceeding the original (1960) requirements, and it proved that the rather complex orbital vehicle could perform its basic assignment. No effort was made to "exercise all capabilities" during the first Gambit mission, though a considerable assurance of total system reliability was obtained in its course.

By 15 July, when those facts were generally known to most of the "cognizant" intelligence community (which did not include everybody involved in Lanyard, by any means), much of the rationale underlying Lanyard development had begun to evaporate. Still, there was no immediate suggestion that the next scheduled Lanyard launch, only about two weeks away, should be scrubbed. One success did not a program make. But a continuation of Gambit success coupled with Lanyard difficulties would certainly weaken the case for continuing Lanyard.

On 30 July 1963, the third Lanyard launch attempt was a success. The TAT and Agena functioned normally, guidance into orbit was highly accurate, and orbital parameters almost precisely matched those programmed. Most encouraging, the camera system seemed to be operating as planned. (The flight scheme called for keeping the roll-joint locked for the first 16 orbits, so that a failure in that mode would not prevent a working test of the camera elements, and for securing vertical pictures of the greatest possible number of first priority targets.)

Still, there were problems. The stellar-index camera malfunctioned almost immediately, the index camera portion failing after only three frames and the stellar camera element operating quite erratically thereafter.* Then on pass number 23 neither the main camera nor the stellar-index camera system would start. (The roll system had gone dead during pass 18, after only two orbits of use, but camera operation was not immediately affected.) A quick check of telemetry indicated that intervalometer failure during an engineering test on the previous pass was the probable difficulty. All modes of command were tried, without success, after which the recovery operation was scheduled for the next appropriate orbit.

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* Stellar-index camera operation was particularly important to Lanyard, and in conformance to Murphy's Law, particularly troublesome. Results of early flights in Corona-Mural configurations had demonstrated by April 1963 that stellar imagery returned to that time was quite useless for attitude determination--and in Lanyard the critical information on camera platform attitude during operation of the main camera was almost entirely dependent on successful functioning of the stellar-index camera subsystem. Largely on the basis of the discouraging advice (from National Photographic Interpretation Center--NPIC) that previous stellar images could not be used to determine vehicle attitude, Itek late in April 1963 made special efforts to improve the quality of stellar-image returns from Lanyard. Modifications included alteration of the pop-out door, the addition of light baffles along the path to the stellar-camera lens, and changes in exposure settings. More sensitive film (SO-130) was also substituted for that originally used (SO-206).[80]

There was no recovery difficulty; an air catch attempt proved entirely successful. Examination of the capsule confirmed that it included exposed film--which was rushed to development and evaluation.

The best resolution contained on the recovered film permitted general examination of ground objects measuring four to five feet across their greatest dimension. Vehicles, small aircraft, and runway markings could be consistently identified. However, the greatest portion of the film gave a definite impression of softness--an out-of-focus effect. Imperfect image motion compensation was not entirely at fault; it had remained within one percent of specification through the first nine passes and had never fallen below a three-percent level. The most probable explanation for out-of-focus photography seemed to be a combination of the image motion compensation error,[*] an internal temperature 15 to 20 degrees higher than would normally be expected, and instrument dynamics.[81]

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[*] The attempt to correct the rate of image motion compensation on pass 22, while the satellite was over Vandenberg, was the prime suspect in the search for an explanation of camera failure on the next pass. The camera system had been operating during the attempt to make an image motion compensation ramp change, and it seemed likely that either the intervalometer or the intervalometer motor had failed as a direct consequence. Telemetry had indicated a gradual degradation of image motion compensation after pass number 10. The roll-joint had remained locked through the first 16 passes, and

In September the lens assembly next scheduled to fly a Lanyard mission was returned to Itek for rework, chiefly to correct for soft imagery. (The camera specialists in General Greer's organization were confident that a combination of lens-element shims and lens-barrel venting, to eliminate temperature variations which might have caused element spacing to exceed predicted tolerances, would correct the main difficulty.) By that time, however, there were some indications that continuation of Lanyard at its previous rate was no longer carrying a high priority. Funds to provide for the five-vehicle program extension were slow to arrive, and in Washington there was acknowledgement of the reduced need for Lanyard now that Gambit was proving itself capable. (By 10 September the second set of Gambit returns had been processed--with most pleasing results.) On 23 October, while the fourth and fifth of the original Lanyard systems were being prepared for launches scheduled to take place during the remainder of 1963, NRO Director McMillan ordered an immediate and complete termination of the Lanyard program. At that point in time the five "follow-on" payloads were between 80 and 100 percent complete (two had gone through

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was thus removed from the list of degrading elements. Its operation during passes 17 and 18 appeared to be normal, although failure of the stellar-index camera to operate properly made it difficult to determine with precision how accurately the roll-joint had functioned during its brief period of activation.

fabrication and were ready for check-out), and the remaining five were somewhere further down the line. Itek wanted to complete all of the first five "follow-on" payloads but General Greer opposed the proposal on the irrefutable grounds that there no longer was any requirement for Lanyard cameras. While the matter of residual inventory was pending, Lanyard joined its ancestors, the last of the reconnaissance systems descended from the original line of E-series programs to come to an end.[82]

Because of the peculiar relationship between Gambit and Lanyard (the Lanyard-originated roll-joint was being used in the first Gambits without the knowledge of all Lanyard-associated contractor personnel), instructions to Lockheed concerning termination had to be phrased so as to exclude Gambit-required components. McMillan's instructions to Greer, on 23 October, had also authorized the general to determine how much more work was in the government interest--that is, how many payloads were so near completion that it would be worthwhile to carry them through the acceptance process before sending them to storage. As with other cancelled satellite reconnaissance programs, "payload peculiar" equipment was to be securely stored against some unpredictable future need.[83]

Subsequent to his original instruction, Undersecretary McMillan authorized completion, through acceptance testing, of the three payloads nearest to delivery readiness. The work would cost about $245,000. On all other aspects of Lanyard, Itek halted work by 25 October; Lockheed had stopped by 23 October.[84]

Still later, on 15 November, McMillan approved a proposal from General Greer that Itek be issued a level-of-effort contract, at a rate of about $70,000 per month, the money to be drawn from the residual of Lanyard funds. The agreement, which eventually took the form of a long-term study contract, also permitted Itek to keep two cameras (cameras 02 and 06) for use in the level-of-effort work. Except for these and one other set of items, all remaining Lanyard-peculiar hardware had been put in bonded storage by the end of March 1964.[85] The "other set" was made of two complete lenses (not camera systems) and five sets of Lanyard optical glass, transferred to the photo reconnaissance laboratory at Wright-Patterson for "high altitude research programs."[86]

The conversations that preceded the final decision to cancel Lanyard involved both the chief of the CIA and the Secretary of Defense. It was generally agreed, after the fact, that the cancellation had been brought about by a combination of factors. Gambit's undoubted success was the chief of these. But the chronic shortage of NRO funds, the existence of several programs and advanced developments which could profit from a higher level of financing, and the lack of a specific requirement for a system with Lanyard's performance characteristics certainly weighed in the decision. Then there was the matter of technology itself. Although every promise of better results seemed to be valid, Lanyard had returned pictures clearly inferior to those produced by Gambit. System dynamics, one of the principal villains cited in the original analysis of the "soft" pictures obtained in July, prejudiced the Lanyard case. Whatever its theoretical merits--and there were several--Lanyard remained the product of 1958 technology that had been outdated by later progress. Its incorporation of some elements of Corona technology was not a sufficient corrective; 1962-vintage Coronas generally returned a high percentage of good photographs, but the system invariably produced a larger number of substantially poorer negatives. Those faults were to require special attention in 1963 and after. Finally, as one specialist described it, the Lanyard camera included a lot of things that clanked back and forth, sometimes rather violently. Compared to Gambit and to new systems being proposed on the basis of six years of increasingly valuable experience in the development of cameras for orbital operation, Lanyard seemed too complex, too "uncoordinated" and too susceptible to failure.[87]

One of the key factors in Lanyard cancellation was at once obvious and obscure. It was obvious that Gambit was providing the service Lanyard had been designed to insure. Obscuration derived from the fact that almost no one closely associated with the Lanyard program in 1963 paid much heed to the fact that Lanyard had been approved as insurance against Gambit failure or delay, that early presentations had emphasized such a program justification, and that senior defense and CIA officials had never looked on Lanyard in any other light. Predictably, typically, and commendably, Lanyard people had become so committed to their project that they ignored its intended impermanence. Some, indeed, were not fully aware of the Charyk-McNamara interchange of late 1961 which had been chiefly responsible for securing initial program approval. The lack of such information was at the root of much of the apparent bewilderment that characterized program office reaction to Lanyard cancellation.[88]

By the time of its cancellation, the Lanyard payload development program had cost $11.789 million (including all contractor expenditures through September 1963).[89] Excluding vehicle, launch, and control station costs, the effort was scheduled to absorb roughly $7 million more.

Not everybody was content with the cancellation decision, of course. Some of the camera specialists in the Special Projects Office on the West Coast continued to maintain that the relatively minor optical problems could have easily been fixed and that the panoramic features of the Lanyard camera in combination with its high resolution made it a valuable instrument for satellite reconnaissance. But, in fact, by 1963 far more promising search and surveillance systems were entering design and development phases, Corona was on the verge of a substantial quality improvement that in less than two years would make it nearly as capable as Lanyard might have been, and Gambit was entering a product improvement stage that led to a far better photographic product than Lanyard could ever have produced.

Lanyard had one attribute that set it off from the six other photographic satellite subprograms approved and undertaken as part of the original Samos effort that dated from 1954. Lanyard had returned photography, and the photography had intelligence utility. Only one other mission of the many attempted in the intricate program that ran from E-1 through E-6 and Lanyard had recorded any photographic success, the E-1 flight of January 1961. And E-1 photography had little more than engineering interest by the time it became available; Corona had made it entirely obsolete. Of course Lanyard was not a typical E-series Samos program, having been conducted in a setting that resembled Corona rather than any "normal" program organization. But that too had more than passing significance.

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23. TWX SAFSP-X-6-12-77, SAFSP to AF Plant Rep, LMSC, 6 Dec 61, in SP Samos files, R&D-10, Termination, 1961.

24. Ltr, MajGen R.E. Greer, Dir/SP, to Hq USAF [redacted] Ofc Asst SAF for Fin Affairs), 3 Jan 62, subj: Partial Termination of Contract, in SAFMS files, Gen; TWX SAFSP-X-6-12-7, 6 Dec 61.

25. Memo for Record, prep by [redacted] BMC, 25 Sep 61, subj: Delection of SPS - Program I; TWX LMSD 388757, LMSD to SAFSP, 12 Apr 61; memo, Col W.G. King to LtCol J. T. Seay, D/Dir Proc and Prog Mgt, SAFSP, 3 Oct 61, subj: Secondary Propulsion System, all in SP Samos files 101A/101B 60-61.

26. TWX SAFSP-L-3-10-19, SAFSP to OSAF for SAFUS, 3 Oct 61; ltr, Col W.G. King, D/Dir Prog I, Samos Proj Ofc, to SSD, 5 Oct 61, subj: Deletion of Requirement for Secure (Encrypted) Command Link for SAMOS Vehicle, in SP Samos files, C&C.

27. TWX conference between J. Schaub, LMSC, and Col W.G. King, D/Dir/101B, 26 Dec 61, cy in SP Samos file, R&D 2-5, 2203, 1961; SAFSP Hist Chron, Jul-Dec 61.

28. SAFSP Hist Chron, Jul-Dec 61.

29. Interview, Col V.M. Genez, SAFSP, by R.L. Perry, Hist Div, 31 Mar and 16 Apr 64. Probably because the E-5 program was all but defunct after mid-December 1961, relatively few records of such activities were made, and fewer survived.

30. TWX VWZS-7-3-23, 6595th ATW to SAFSP, 8 Mar 62; TWX TWRC-13-3-4-E, 6595th ATW to SAFSP, 13 Mar 62; Critique Charts, 2204 Review, Mar 62, all in SP Samos files R&D 2-6, 2204, 1961-62; SAFSP Review, Mar 62, all in SP Samos files R&D 2-6, 2204, 1961-62; SAFSP Hist Chron, Jan-Jun 62.

31. Genez interview, 16 Apr 64.

32. SAFSP Hist Chron, Jan-Jun 62, entry for 1 Mar 62.

33. TWX SAFMS-SEN-61-162, SAFMS to SAFSP, 11 Dec 61; memo for record, Col W.G. King, D/Dir SP-L, 15 Dec 51, subj: Comparative Evaluation of ITEK 05 Hopkins Lens and The Perkin Elmer Lens; TWX SAFSP-L-18-12-125, SAFSP to LMSC, 18 Dec 61; TWX SAFSP-L-18-12-124, SAFSP to ASD, 19 Dec 61; ltr, King to LAC, 15 Jan 62, subj: Comparative Lens Evaluation Test Conduct; TWX SAFSP-L-13-12-151, SAFSP to SAFMS, 14 Dec 61, all in SP Samos files, 101A/B, 60-61. The tests were conducted at ASD although Lockheed had originally been slated to do the work.

34. Interview, MajGen R.E. Greer, Dir/SP, by R.L. Perry, Hist Div, 4 Mar 63; ltr, J. Carter, V/Pres Itek, to Hq SSD (SAFSP), 19 Dec 61, subj: Technical and Cost Proposal for a Simplified High-Acuity Panoramic Camera, in SAFSS files, Lanyard.

35. TWX SAFSP-F-28-12-171, MajGen R.E. Greer, Dir/SP, to BrigGen R.D. Curtin, SAFMS, 28 Dec 61; TWX SAFMS-M-1-209, Curtin to Greer, 29 Dec 61, both in SP-3 files, Funding.

36. Memo, Maj Mark Farnum, Corona, to LtCol R.J. Ford, Corona, 29 Dec 61, no subj, in Corona files.

37. Memo for Record, Maj H.C. Howard, SAFMS, 11 Jan 62, subj: Simplified 66" System (SSD black code word: LANYARD), in SAFSS files, Lanyard.

38. Interview, BrigGen J.R. Martin, D/Dir/SP, by R.L. Perry, 18 Sep 64.

39. TWX SAFMS DIR 62-25, BrigGen R.D. Curtin, SAFMS, to MajGen R.E. Greer, Dir/SP, 1 Feb 62, in SP-3 files, Genl.

40. Memo for Record, Col J.R. Martin, D/Ch SAFMS, 13 Feb 62, subj: SAFUS-SAFSP West Coast Conference 9 Feb 62, in Gen Martin's files; Martin interview, 18 Sep 64.

41. TWX SAFSP-F-13-2-195, MajGen R.E. Greer, Dir/SP, to BrigGen R.D. Curtin, SAFMS, 13 Feb 62, in SP-3 files, Funding.

42. Msg ADIC 7878, CIA to Corona OFC, 21 Feb 62, in Corona files; memo, Maj H.C. Howard, SAFMS, to [redacted], NRO Compt, 6 Mar 62, no subj, in SAFSS files, Lanyard; memo, J.V. Charyk, SAFUS, to D/Dir/CIA, 2 Apr 62, subj: Management of Lanyard, in SAFSS files, Lanyard.

43. Memo, Charyk to D/Dir/CIA 2 Apr 62; memo, H. Scoville, Jr., D/Dir/Res, CIA, to SAFUS, 5 Apr 62, subj: Management of Lanyard, in SP-3 files, Progs.

44. Msg ADIC 9518, CIA to SAFSP, 4 Apr 62, in Lanyard files.

45. Interview, LtCol Mark Farnum and LtCol R.J. Ford, Corona ofc, 11 Oct 62, by R.L. Perry, Hist Div; memo, prep by Maj Mark Farnum, 30 Mar 62, subj: Trip Report, in Lanyard files; ltr, Itek to LMSC, 16 Apr 62, subj: Offer to Purchase Residual Inventory, cited in msg ADIC 1347, CIA to LMSD, 18 Apr 62; ltr, MajGen R.E. Greer, D/Sat Progms, SSD, to Hq AFSC, attn MajGen O.J. Ritland, D/Cmdr Manned Space Flt, 4 Jun 62, subj: Request for Disposition of Terminal Inventory; ltr, Ritland to Hq USAF (attn LtGen Mark Bradley, DCS/S&L, 6 Jun 62, same subj: ltr, Bradley to Greer, 6 Jun 62, same subj, all in SAFSS files: Lanyard; msg, [redacted]2189, SAFSP to CIA, 18 Jun 62, in Lanyard files.

46. Msg ADIC 0769, CIA to SAFSP, 7 May 62, in Lanyard files.

47. Msg, [redacted] 2134, SAFSP to CIA, 11 May 62; msg [redacted] 3915, LMSD to Itek, 11 May 62; msg, [redacted] 00004, D/NRO to CIA, SSD (for MajGen R.E. Greer), 22 May 62, all in Lanyard files.

48. TWX SAFSS-DIR-M-2098, SAFSS to SAFSP, 8 Oct 62, in SP-3 files, Funding.

49. Msg, [redacted] 2595, SAFSP to CIA, 10 Oct 62, in Lanyard files; msg ADIC 8085, CIA to Itek, 19 Oct 62.

50. Progm Rpt, Nov 62, in SP-3 files; msg ADIC 8299, CIA to Itek, 25 Oct 62, in [redacted] files; msg ADIC 9233, CIA to Itek, 19 Nov 62, same file.

51. Memo for record, MajGen R.E. Greer, Dir/SP, 5 Jul 62, subj: Special Assignment: Major Bernard W. Quinn, in Corona files, MFR's; msg ADIC 6065, CIA to SAFSP, 6 Sep 62, in [redacted] files.

52. Msg ADIC 7121, CIA to SAFSP, 27 Sep 62, in [redacted] files; msg [redacted] 2428, SAFSP (MajGen R.E. Greer) to SAFSS (Col J.R. Martin), 26 Sep 62, and [redacted] 2488, SAFSP to SAFSS, 9 Oct 62, in Corona files.

53. Msgs: [redacted] 5495, LMSD to Itek, 16 Oct 62; ACORN 162, Itek to LMSD, 19 Oct 62; [redacted] 5539, LMSD to Itek, 23 Oct 62; ADIC 9233, CIA to Itek, 19 Nov 62; ADIC 9543, CIA to D/NRO, 26 Nov 62; ADIC 0619 to EK, 19 Dec 62, all in [redacted] files.

54. Msg, [redacted] 5170, LMSD to CIA, 18 Sep 62; msg, [redacted] 5514, LMSD to Itek, 22 Oct 62, both in [redacted] files.

55. Msgs: ACORN 061, Itek to CIA, 13 Sep 62; [redacted] 5548, LMSD to Itek, 24 Oct 62; ACORN 172, Itek to CIA, 26 Oct 62; [redacted] 5641, LMSD to CIA, 3 Nov 62; ACORN 234 and 242, Itek to LMSD, 19 and 26 Nov 62, all in [redacted] files.

56. Msgs: ACORN 241, Itek to CIA, 26 Nov 62; [redacted] 5831, LMSD to CIA, 27 Nov 62; ACORN 284 and 291, Itek to CIA 4 and 18 Dec 62; [redacted] 6093, LMSD to CIA, 19 Dec 62, and ACORN 312, Itek to CIA, 29 Dec 62, all in [redacted] files.

57. Msg, [redacted] 5820, LMSD to CIA, 27 Nov 62, in [redacted] files.

58. Msg, ACORN 0855, Itek to CIA, 18 Jun 62; msg, ACORN 0312, Itek to CIA and SAFSP, 29 Dec 62, both in Lanyard files.

59. Summary Rpt, PROJECT LANYARD, undated, aprox Jul 62, in SAFSS files: Lanyard.

60. Rpt, "PROJECT LANYARD," undated, aprox Feb 62, apparently prepared for SAFUS by SAFMS, in SAFSS files, Lanyard.

61. Memo, [redacted] for A.C. Lundahl, Dir/NPIC, to D/NRO, 17 Aug 62, subj: Comments on Certain Collection Systems, in SAFSS files, Corona, Gen.

62. Msg, [redacted] 2436, MajGen R.E. Greer to SAFUS, 28 Sep 62, in SAFSS files: Lanyard.

63. Interview, MajGen R.E. Greer, Dir/Spec Projs, OSAF, by R.L. Perry, 27 Jul 64; interview, Col W.G. King, Dir/Gambit, 29 Jul 64.

64. Msgs, [redacted] 6166, 3 Jan 63, [redacted] 6219, 9 Jan 63; [redacted] 6276, 15 Jan 63, and [redacted] 6369, 26 Jan 63, all Lockheed to CIA, all in [redacted] (Leach) files.

65. Msg, ACORN 378, Itek to Lockheed, 31 Jan 63; msg, [redacted] 6393, Lockheed to CIA, 31 Jan 63; msg, [redacted] 6412, Lockheed to SAFSP, 5 Feb 63; msg, ACORN 404, Itek to Lockheed, 8 Feb 63, all in Leach files.

66. Msg, [redacted] 6468, Lockheed to CIA, 14 Feb 63, in Leach files.

67. Msgs, [redacted] 6530 and 6570, Lockheed to CIA, 28 Feb and 8 Mar 63, msg, [redacted] 6504, Lockheed to SAFSP, 25 Feb 63, all in Leach files.

68. Msgs, BISON 0021 and 0022, VAFB to CIA, 18 Mar 63; msg, IBSON 0024, VAFB to CIA, 19 Mar 63; msg, [redacted] 2825, LMSC to CIA, 19 Mar 63, all in Leach files.

69. Msg, ADIC 3835, CIA to D/NRO, 2 Mar 63; msg, [redacted] 0308, D/NRO to SAFSP, 5 Mar 63, both in [redacted] (Leach) files.

70. Memo, B. McMillan, D/NRO, to SOD and Dir/Central Intel, 20 Mar 63, subj: Status Report of LANYARD; memo for record, H. Scoville, Jr., Dep Dir/Res/CIA, 25 Mar 63, subj: Meeting held on Friday, 22 March, on Reconnaissance Satellite Reliability, both in SAFSS files, Lanyard.

71. Msgs, ADIC 3303, CIA to D/NRO, 20 Feb 63; [redacted] 0301, NRO to CIA, 20 Feb 63; [redacted] 2774, SAFSP (MajGen R.E. Greer) to CIA, 26 Feb 63; ADIC 3719, CIA to SAFSP, 28 Feb 63; and [redacted] 2792, SAFSP (Greer) to CIA, 5 Mar 63, all in [redacted] (Leach) files.

72. Msg, [redacted] 2805, SAFSP (MajGen R.E. Greer) to CIA, 13 Mar 63, in SAFSS files, Lanyard; msgs, ADIC 4273, CIA to SAFSP, 13 Mar 63 and [redacted] 0332, NRO to CIA, 15 Mar 63, in [redacted] (Leach) files.

73. Msg, ADIC 5272, CIA (Col J.C. Ledford) to Dir/NRO Staff (Col John Martin), 3 Apr 63, in [redacted] (Leach) files.

74. Memo, J.A. McCone, Chm USIB, to D/NRO, 9 Apr 63, subj: Photographic Satellite Reconnaissance Program, in NRO files, Lanyard.

75. Msgs: [redacted] 6868, Lockheed to CIA, 15 Apr 63; [redacted] 6972, Lockheed to CIA, 23 Apr 63; BISON 0078, VAFB to NRO Staff, 18 May 63; BISON 0087, BISON 7177, VAFB to NRO Staff, 20 May 63; BISON 0104, VAFB to NRO Staff, 21 May 63, all in [redacted] (Leach) files.

76. Msg, [redacted] 3158, SAFSP to D/NRO, 12 Jul 63; msg, [redacted] 3013, SAFSP to D/NRO, 28 May 63, both in [redacted] (Leach) files.

77. Msgs, [redacted] 2952, SAFSP to D/NRO, (MajGen R.E. Greer) to D/NRO B. McMillan), 1 May 63 and [redacted] 2970, same origin and address, 3 May 63, both in [redacted] (Leach) files.

78. Msg, [redacted] 0437, NRO to SAFSP, 24 May 63, in [redacted] (Leach) files; memo, LtCol H.C. Howard, Asst for Sys Engr, NRO Staff, to Col J. Martin, Dir/NRO Staff, 1 May 63, subj:

Brief LANYARD History, in SAFSS files, Lanyard; msg, [redacted] 3024, SAFSP to Itek, 31 May 63, in Leach files, passed the order to Itek.

79. Msgs, all from SAFSP: [redacted] 3037 to D/NRO, 6 Jun 63; [redacted] 3047 to Lockheed, 10 Jun 63; [redacted] 3183 to Lockheed, 18 Jul 63, all in [redacted] (Leach) files.

80. Msg, SPECTRE 0672, NPIC to D/NRO, 17 Apr 63; msg, [redacted] 6914, LMSC to CIA, 18 Apr 63; msg, [redacted] 0379, NRO to SAFSP, 19 Apr 63; msg, LMSC to SAFSP, 24 Apr 63; msg, SPECTRE 0687, NPIC to LMSC, 24 Apr 63, all in [redacted] (Leach) files; plans for use of roll joint and COMOR (Committee on Overhead Reconnaissance) requirements were contained in memo, J.Q. Reber, Chm, COMOR, to D/NRO, 5 Feb 63, subj: Requirements for the First LANYARD Mission, in NRO files, Lanyard, and in msgs [redacted] 6359, LMSD to CIA, 24 Jan 63, and [redacted] 0214, NRO to SAFSP, 4 Jun 63, both in [redacted] files.

81. Msgs, BISON 0231, VAFB to SAFSS, 31 Jul 63 and BISON 0263, VAFB to SAFSS, 2 Aug 63; msg, Eastman Kodak to NRO, 5 Aug 63, all in [redacted] (Leach) files; memo, BGen J. L. Martin, Dir/NRO Staff, to D/NRO, 9 Aug 63, subj: Mission 8003 Preliminary Analysis, in NRO files, Lanyard.

82. Msg, [redacted] 3389, LMSC to CIA, 3 Sep 63; msg, [redacted] 0695, D/NRO to SAFSP (MajGen R.E. Greer), 23 Oct 62 (the termination directive); msg, ADIC 5352, CIA to LMSC, 23 Oct 63; msg, [redacted] 3678, SAFSP (Greer) to D/NRO (B. McMillan), 2 Nov 63, all in NRO files, Lanyard.

83. Msg, [redacted] 0695, D/NRO to SAFSP, 23 Oct 63; memo, A.R. Leach, Contr Ofcr (SAFSP) to Hq CIA, 27 Nov 63, subj: Termination of Lanyard Program, in Leach files; msg, [redacted] 3668, SAFSP to LMSD, 1 Nov 63, in Leach files.

84. Memo, Leach to Hq CIA, 27 Nov 63; msg, [redacted] 0731, D/NRO to SAFSP, 7 Nov 63, in [redacted] (Leach) files.

85. Msg, [redacted] 4565, SAFSP to D/NRO, 1 Apr 64, in NRO files, Lanyard; msg, [redacted] 0782, D/NRO (B. McMillan) to SAFSP MajGen R.E. Greer), 6 Dec 63 (confirming verbal orders of 15 November), in NRO files.

86. Msg, WHIG 0950, Dir/NRO Staff to SAFSP, 24 Feb 64, in NRO files, Lanyard.

87. Interview, MajGen R.E. Greer, Dir/Spec Projs, OSAF, 6 May 64; interview, LtCol H.H. Howard, NRO Staff, 24 Apr 64, 1 Jul 64.

88. Martin interview, 18 Sep 64.

89. Msg, ACORN 971, Itek to CIA, 2 Oct 63, in [redacted] (Leach) files.

XI THE E-6 PROGRAM

Note:

At various times of no particular consequence the E-6 program was officially known by other titles: Program II, Program 201, Program 698BJ, Program 722. The term most commonly in use in 1963 was "BJ." For the purpose of this account, and in the interests of narrative continuity, the identifier "E-6" is used throughout.

Through the long spring and summer of 1960, while matters of project structure and program objective were being debated at various levels between the project office and the White House, the sixth and last of the Samos camera systems to receive formal designation was also taking shape. The suggestion of developing a recoverable-capsule photo-payload very different from the E-5 was first voiced in May. Its antecedents stretched into the much more distant past.

In a very real sense, the E-5 program had been created and carried on to insure against complete reliance on the original readout systems and to provide for the collection of higher resolution than could be obtained by any readout system based on 1956-1958 technology. In 1958 there was not much serious consideration of abandoning readout in favor of recovery. But by the early months of 1960 it had become apparent to many that the fundamental conception of surveillance by means of readout satellites might well be unsound. Limitations in scale and resolution, insufficient bandwidth flexibility, and technical difficulties encountered in the course of subsystem development were partly responsible. But the increasing probability that an operational readout system could be extremely costly also influenced opinion. Not merely the vehicles but the facilities to support readout promised to be more complex and costly than the missiles and missile sites then straining the national budget. Estimates of potential investment in collecting, processing, interpreting, and disseminating readout photography became more alarming as a final development phase approached.[1]

A second factor influential in the readout-recovery debate of 1960 was disagreement about the proper role of concurrency in the Samos program. Concurrency, a costly strategy that nonetheless was highly regarded in some quarters, assumed the existence of a pressing need for operational systems and the availability of mature technology that could be exploited by simultaneous development and deployment. Concurrency lost its attractiveness if the deployed weapons were likely to become operationally ineffective soon after being handed over to operational forces, or if they could not be delivered on schedule. The expense of concurrency had to be justified by the presence of a grave threat to national security that could best be countered by a cost-be-damned weapons acquisition policy.

Most Samos program managers were by 1960 pretty certain that cameras in orbit would remain "few-of-a-kind" devices for at least another decade; "mass production" was almost inconceivable, and unique space vehicles mostly unlike one another neither required nor could be accommodated within a complex of expensive, standardized ground facilities with inflexible operational attributes.

Finally, the application of concurrency concepts to the acquisition of reconnaissance satellites assumed that operational responsibility for the satellites would be assigned to an operating command--the Strategic Air Command. Concurrency was not warranted if there was no certain need to assign the developed articles to an operating command. Where satellite reconnaissance was concerned, not only was need uncertain, but United States national space policy of the 1950s began with the assumption that overt overflight by U.S. reconnaissance satellites could provoke violent objections from such diverse states as France, the Soviet Union, China, India, and the Arab nations. Add the reasonable prospect that an expensive complex of readout vehicles and stations could become obsolete overnight with the emergence of new technology, and concurrency became increasingly unattractive. But concurrency, the plans for an extensive ground-station readout complex, and the near-term assignment of reconnaissance satellite operating responsibility to the Strategic Air Command were the three most prominent attributes of the pre-1960 Samos program.[2]

By April 1960, Corona had experienced its eighth successive failure (Discoverer IX) and was entering a limbo of engineering overhaul that would postpone further trials for two months. Early in May the U-2 incident abruptly halted use of the only other reconnaissance system available to take photographs over the Soviet heartland. The E-5 satellite system then in development was so designed that it would return relatively narrow film strips, each covering only about 15 by 53 miles along the ground. Moreover, it was still many months from its scheduled first trial.

The Air Staff reaction to that situation was to require the early exploitation of the "pre-operational photographic potential" of the Samos program. That action, taken on 9 May, was followed 10 days later by instructions from Air Force Undersecretary J. V. Charyk that the Air Research and Development Command was to prepare a new Samos development plan embodying the Air Staff concept. On 27 May, Charyk expanded his instructions and ordered the Air Force to explore the possibility of using "off the shelf" camera components to accelerate the pace of the photo-recovery program.[3]

Late in May and early in June were heard suggestions that a completely new photo-recovery system should be developed. One thread of origin started with Colonel W. G. King, in the project office; others began in the office of the Director of Defense Research and Engineering (DDR&E) and with Charyk himself. Then on 5 July the United States Intelligence Board issued a revision of satellite reconnaissance requirements, emphasizing the need for locating Soviet ballistic missile sites and calling for a search camera system capable of resolving objects 20 feet on a side before the end of 1962.[4]

That a new system would be required was all but incontestable, even without the catalyst of U-2 failure. The transitory value of U-2 operations had been conceded since overflights began,* the Corona system had thus far been totally ineffective, that neither E-1 nor E-2

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* A Central Intelligence Agency spokesman who briefed the Royal Air Force in 1957 described the U-2 as a "diminishing asset" with increasing vulnerability. That it operated effectively for another 30 months over hostile territory was a compliment to the skill with which it was employed and a provocative commentary on the Soviet air defense establishment. From the evidence, it is clear that the CIA had long anticipated the inevitable; cover stories were in being to satisfy almost all potential wants. The explosive international consequences of the U-2 affair were, therefore, less the product of faulty planning for the inevitable than of imperfect execution.[5]

could perform search missions was nowhere denied, and the E-5 had not been designed to provide wide-area coverage which, by early 1960, had been recognized as essential. (The suggestion that the E-5 be flown in a higher orbit to provide broader ground coverage was sometimes heard in the summer of 1960. It got a generally unfavorable reception from system-conscious engineers who were sensitive to the tender interrelationships among payload weights, orbit altitudes, booster performance, and on-orbit stabilization.)

A new system could conceivably have used readout technology, but in May 1960 that was unlikely. The often acrimonious debate over the respective merits of readout and recovery during late 1959 and early 1960 had been brought on by many factors involved. Fundamentally, the Strategic Air Command and its partisans on the Air Staff (including the Air Force Assistant Chief of Staff, Intelligence) were insistent on the urgency of readout. Mostly they wanted Samos E-2, a readout system with a nominal potential for obtaining pictures with about 20-foot resolution--but not many pictures, or frequently. SAC depreciated the hard fact that E-2 technology was incapable of satisfying basic needs for strategic warning and would be almost wholly unsuited to the task of locating Soviet missile sites.

The Advanced Research Projects Agency (ARPA), which had official responsibility for military space programs between early 1958 and May 1960, took as its principal policy the contention of one group of scientists that readout was desirable but readout using the bimat technology featured in the E-1 and E-2 Samos systems was not feasible. Rather than recovery, however, influential ARPA spokesmen endorsed a technique using electrostatic tape and high-magnification optics in place of the halide film and on-board processing of the E-1 and E-2. Another ARPA group wanted to expand E-5 activity because E-5 had a little-mentioned capability for carrying a man into orbit rather than a camera--which went far to explain why E-5 was the only recovery system ever to provide for recovery of camera as well as film.

Senior Samos project officers (notably Colonel W. G. King) were convinced that the bimat process readout system would never satisfy national needs--but rather than urging some more exotic and risky readout substitute, had come to favor film recovery. Some of the leaders of the Air Force Research and Development Command who had been contributors to the early development of Corona had concluded that only a heavily funded, heavy staff development program would produce an operationally effective reconnaissance satellite--and they mostly favored the parallel development of E-2 and E-5 using a concurrency approach.

Until early July, the Air Force Ballistic Missiles Division (BMD) expressed a preference for some relatively minor modification of the E-5 system rather than a new development. A 12 July BMD development plan revision, however, featured a proposal for a new camera payload--designated E-6--to be combined with a new recoverable and maneuverable reentry body. Simultaneously, the Directorate of Defense Research and Engineering (DDR&E) expressed strong distaste for earlier Samos program goals. Almost immediately thereafter the question of what new system was submerged in proposals for a total Samos program reorganization. On 11 August, in the midst of maneuvering for program control, BMD issued still another development plan which proposed an E-6 system generally conforming to the USIB statement of requirements. Featuring a panoramic camera with 20-foot or better resolution, eight days on orbit, and a highly precise recovery system, it was intended to provide broad coverage of those areas serviced by the Soviet railway network.

Even earlier, on 27 July, Colonel Paul J. Heran, then of the 6594th Test Wing, had been named to head a source selection board which was to evaluate contractor proposals for an E-6 system.*

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* Other members of the board included Colonel J. L. Martin (Directorate of Advanced Technology, Air Force headquarters),

Requests for proposals were dispatched to a selected list of contractors--from which Lockheed had been excluded--on the day the development plan was issued, 11 August. During the period of pre-proposal briefings the Samos project was formally assigned to the Office of the Secretary of the Air Force, acquired a new military chief (Brigadier General R. E. Greer) and a secretariat-level overseer (Air Force Undersecretary Charyk), and in its revamped form received Presidential endorsement. The basic performance requirement was also modified to include 10-foot resolution ("or better") and five days on orbit.[6]

Dr. Charyk had notified BMD of the modified performance requirements on 23 August and with a minor alteration had confirmed them on the 26th, the day following the National Security Council meeting at which President Eisenhower personally approved the revised Samos program. The program that Charyk defined in his presentation to the President and a somewhat earlier statement of E-6 "fundamentals by which selection board actions would be conditioned" established the parameters of the E-6 program as it existed at the time the Secretary of the Air Force Samos Project Office was activated. The source selection board considered the E-6 to be a back-up to the E-5 system,

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Colonel A. L. Wallace (Director of Technology at Wright Air Development Division and former chief of the Reconnaissance Laboratory there), and Major H. C. Howard (also Directorate of Advanced Technology).

with assured recovery over land being more important than rigid adherence to the photography specifications. The board operated on the premise that it would be more desirable to develop "crude", "insensitive" subsystems which were simple and reliable than to concentrate on "elegant, sophisticated, fancy, cute, tricky, fussy subsystems." E-6, of itself, had to be "useful and usable even if the primary thing it's backing up also works." By implication, E-6 had to differ from existing or programmed solutions to the reconnaissance problem. Otherwise it would be duplicative--and undesirable.

The system Charyk described to Eisenhower was composed of a precise land recovery subsystem--with air pick up a possible alternative--integral with a photographic subsystem that included a 24- to 36-inch panoramic camera.* First flight, assuming progress consistent with that outlined in the development plan, was planned for January 1962. Seven flights, possibly augmented by two diagnostic tests, were on the proposed schedule.[7]

The source evaluation was conducted in an atmosphere of mild uncertainty. Neither the reporting channel nor the precise functions of the new project office had yet been officially defined.

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* As originally conceived, E-6 might have been described as a high-reliability Corona.

In many respects the E-6 requirement seemed to negate all earlier project objectives and to reject the concepts applied by the existing program office. None of the earlier payload programs had been undertaken except through the contracting route provided by Lockheed, but the E-6 was specifically arranged to exclude that contractor. Owing mostly to the poor performance of Corona, Lockheed was in general disfavor during those weeks when E-6 took form. The relationship between the existing program office and the existing BMD organization was not apparent, and indeed there seemed a possibility that Samos might be recombined with Midas and Discoverer under the over-all management of General Greer, with the individual satellite offices remaining intact. Perhaps fortunately, the month during which such matters were resolved was also the month during which the principal duty of the source selection board was to wait for proposals from contractors.

The choice of subsystem contractors had, for practical purposes, been completed before the end of October--by which time the new Samos office structure had also been clarified. The source selection board, with the foreknowledge of both Charyk and Greer, recommended awarding the camera payload contract to Eastman Kodak and the recovery subsystem contract to General Electric. Accessory considerations prevented immediate action on those recommendations, however. The board generally favored making Aerospace Corporation responsible for all systems integration work not included in the basic assignments to Eastman and General Electric, while Dr. Charyk had expressed reservations about giving Aerospace any great degree of systems integration authority. Moreover, certain members of the E-6 board also constituted a sub-rosa source selection group concerned with Eastman's proposal to develop a 77-inch panoramic camera subsystem. (Known as "Sunset Strip," the 77-inch camera had been treated as a follow-on or parallel development during the August presentation to the National Security Council. Late in September, Charyk and Greer had agreed that "Sunset Strip" was too promising to pass up and had decided that it should be covertly developed to provide a reserve reconnaissance capability in the event that political factors should force cessation of acknowledged reconnaissance satellite programs. ("Sunset Strip" eventually became Gambit.) Finally, there still was uncertainty on the course and emphasis of land recovery developments and on the technical feasibility of proposals for such systems.

Charyk's decision to limit the systems engineering-technical direction role of Aerospace Corporation decided one issue; formal action to "cancel" "Sunset Strip" resolved another. (The "cancellation" was part of the cover plan which led to the separate establishment of Gambit, a program aimed at the clandestine development of the 77-inch camera and an appropriate recovery subsystem to be flown in E-6 vehicles.) Attempts to make the Reconnaissance Laboratory at Wright Field responsible for camera payload developments in the E-6 program had been halted somewhat earlier, in September, at Charyk's insistence and to the considerable dismay of ARDC headquarters. The relatively rapid establishment of a functioning SAFSP organization cleared the air of other organizational inconsistencies.[8]

Notwithstanding such progress, the matter of defining Aerospace Corporation responsibilities became critical again in November and remained something of an issue until late in December; the question of whether land recovery should be a primary, parallel, or subordinate objective had not been finally resolved; and late in November there was another skirmish over the relationship of Samos to ARDC programs. Finally, the source selection board had found no alternative to using Lockheed's Agena as the upper stage to inject the E-6 payload vehicle into orbit, and Lockheed thus became part of the contractor complex. (Technical integration of the payload, upper stage, and recovery subsystems, however, was reserved for General Electric rather than Lockheed, which had that responsibility for all other Samos payload systems and for Corona.)

Such factors kept the source selection board in session until early December. Not until the 14th of that month did the chairman, Colonel Heran, formally advise the BMD commander, Major General O. J. Ritland, that General Electric and Eastman had been chosen to develop recovery and camera subsystems, respectively. The maneuverable reentry aspect of the original requirement had been reduced to an applied research program aimed at the eventual design of a "terminally guided lifting type vehicle." (Construction and flight test of such a vehicle had been recommended for inclusion in the E-6 program as late as November.)

On 21 December, General Ritland approved the board's recommendations. By that time the troublesome issue of systems integration responsibility had been finally settled. Aerospace was to do "general systems engineering and technical direction," working as part of a team that included the members of the SAFSP office and clearing all technical decisions with the military program managers. A definition of "general systems engineering," which General Greer had wryly described as "locally controversial" was worked out in the course of a 20 December luncheon meeting between Charyk and Brigadier General R. D. Curtin, Chief of the Samos Pentagon office. It was Charyk's "intent. . . that Aerospace would not function as STL functions in detailed systems engineering in the missile programs" but would act more in the role of an associate contractor reporting to the program office.

A final attempt on the part of ARDC headquarters to cement a management relationship between Samos and the basic ARDC organization had ended in failure even before the selection board completed its work. Late in November, Dr. Charyk and General Greer decided that Samos funds would not under any circumstances be used to support development of the Avco Drag Brake as a backup to the Martin recoverable reentry vehicle. Thus concluded the last of several energetic efforts to secure for Wright Field a share in management of the reconnaissance satellite program--or to tap its funding reservoir.[9]

Even though the land recovery objective of the program defined in August had been substantially reduced in importance by December, the expectation that Martin's glide-control reentry technique would eventually be combined with the E-6 camera system remained a basic program concept through the early months of 1961. Fears for the possible loss of a Samos satellite over unfriendly territory, with repercussions perhaps more extreme than those of the U-2 incident, prompted continued concern for positive control of recovery modes and for the improvement of reentry accuracy. Nevertheless, throughout the period of source selection, and through the many perambulations that attended establishment of SAFSP, program managers retained a realistic grasp of the basic program objective: to acquire an orbital reconnaissance system which overcame objections both to the electronic readout systems so favored in the late 1950s and having better resolution than Corona. The final definition of program objectives, as expressed in work statements issued to the principal contractors, was remarkable in dispensing with the less attainable--though desirable--elements of the largely theoretical system described to the President in August. From an engineering viewpoint, there was every indication that the E-6 program would indeed result in the creation of a reliable, high acuity, photographic satellite system.[10]

Delays in completion of the source selection process had forced a slippage in the original program deadlines. During the last days of 1960, a technical direction meeting conducted by Aerospace produced revised milestone goals: delivery of the payload vehicle to Vandenberg Air Force Base and the first flight-ready Agena B to the missile assembly building by 20 November, availability of the assembled vehicle on the pad by 18 December 1961, and first flight by 1 February 1962.[11] It was a schedule that seemed wildly optimistic in the light of earlier space program achievements--13 months from program approval (source selection) to first flight. Nevertheless, the E-6 project group expressed no serious reservations about the feasibility of satisfying such exacting requirements, and confidently set about the task.

For almost precisely one year thereafter, the SAFSP group, Aerospace, General Electric, and Eastman Kodak worked industriously to meet deadlines and to provide technical items that satisfied specifications. Even though the original concept of the E-6 had emphasized "off-the-shelf" technology and "available" hardware, the translation of requirements into functional space systems, together with vital ground control and tracking stations, recovery teams, and launch capacities, was an enormous task. The emphasis on early availability of militarily useful systems was apparent in the original shift from a land recovery technique to water recovery and on reliability rather than sophistication. Still, some pessimism seemed warranted. Only four capsules and three film packets had actually been recovered from orbit at the time the source selection action was completed, and this in 18 trials. Perhaps more to the point, the Atlas-Agena combination destined for E-6 program had, to that time, only one attempted Samos application--and that a spectacular failure.

Preparation of work statements began in January, proceeded routinely in the case of Lockheed and Convair, went well for Eastman

Kodak, and encountered serious snags for General Electric. A draft version prepared by General Electric proved unacceptable to the project office, and an SAFSP version failed to satisfy Aerospace Corporation objectives. Not until late February did Lockheed and General Electric reach agreement on the interface between the payload vehicle and the Agena-B stage. By March, Lockheed was behind schedule on Agena-B work, the original decision to use Johnson Island as the recovery site had been imperiled by plans for possible resumption of atomic tests in the Pacific, the camera lenses and mirrors were on the critical lip of a delivery schedule slippage, and delays in securing funds for the missile assembly building at Vandenberg had brought the timely availability of that facility into serious question.[12]

Some of the configuration details of the E-6 were decided less by engineering logic than by the need to camouflage Gambit. During the early months of the E-6 program it seemed essential not only to hide the Gambit technical effort under a screen of E-6 activity, but also to make the orbital vehicle portions of the two systems resemble one another in outward appearance. Thus, in theory a Gambit could be launched without alerting many people to its real nature. Unhappily, the secondary objective of developing a system which could be covertly employed in the event of E-6 cancellation was incompatible with the thesis of "look-alike" orbital stages. If political considerations forced cancellation of the acknowledged reconnaissance satellite program, certainly no vehicle which almost precisely resembled the cancelled item could be approved for launch.

The real advantages of the E-6 relationship with Gambit were in providing cover for contractual actions and for contractor activity. There was a possible profit in the element of technological surprise, as well. The specifications for the E-6 had reached the general public through a trade magazine, and even though Soviet intelligence might reasonably suspect the validity of any performance specifications so casually revealed, lapses in the United States security system were not uncommon and the premature disclosure of system details not unprecedented. The Gambit system, developed largely within the E-6 effort, would through its vastly better resolution provide means for much more detailed intelligence than could be expected from E-6. But by the same token, Gambit payloads disguised as E-6 payloads became politically vulnerable, the price for such technological surprise.

Although the concept of concealing one reconnaissance payload by means of another had inbuilt frustrations, the notion of "look-alikes" survived long enough to have a substantial impact on the configuration of the E-6. The native characteristics of the E-6 camera subsystem were less influential in deciding the nose cone structure and mid-body shape of the E-6 vehicle than the fact that those sections also had to house the still greater bulk of the Gambit optics and film transport complex. The fact that a portion of the forward body of the Agena vehicle had to be cleared of equipment so that it would not interfere with the functioning of the Gambit payload could not logically be explained in terms of E-6 needs, nor could a modification of the Agena or mid-body to conform to peculiar Gambit requirements.

In similar fashion, operating details of the E-6 tracking and control network had to be compatible with Gambit even though E-6 might not require such refinement. The establishment and activation of a north-latitude tracking and control station that could give final instructions to a Gambit satellite immediately before it began a spot-reconnaissance pass fell into that category. The E-6, taking a wide-swath picture, actually needed nothing so sophisticated, but the narrower-swath Gambit camera was thought incapable of sufficient targeting precision without such final guidance.

Even though the futility of attempting to make Gambit vehicles look like E-6 "birds" was conceded before the end of 1961, it endured long enough to have a lasting effect on the final configuration of the E-6. Because of the tight development-test schedule, details of the E-6 had to be fixed quite early in the program, and very often they showed the effects of the attempt to make one element of the total vehicle compatible with payload components of both. The final evidence of futility came after E-6 details had been decided and vehicle fabrication undertaken; the technical evolution of Gambit continued with the result that Gambit rapidly assumed an appearance and character completely distinct from that of the final E-6 configuration.[13]

Thus, a succession of major technical decisions interlocked with programming actions to complicate the first months of the E-6 development. Even before formal completion of selection board actions, Lockheed was advised of substantial changes needed to adapt the basic Agena-B vehicle to E-6--and Gambit--uses. (The interface definition remained for a later decision.) Principally, Lockheed had to remove a number of components not needed for the E-6 application: solar cells, portions of communications and programmer subsystems not needed for ascent and de-boost, all auxiliary power not required for a normal mission (the final reduction from eight-day to five-day mission requirements was not approved until the technical meetings of 29 December), and the sun position indicator. The Agena airframe had to be modified to accept the E-6 midsection and the reentry vehicle--and to provide for the much greater bulk of the 77-inch Gambit camera. The secondary propulsion system required modification to provide two-way thrust needed for orbit adjust maneuvers. Provisions had to be made for special telemetry required by General Electric. Somewhat later, in mid-December, it became necessary to relocate the S-band beacon in the reentry vehicle from its original station in the Agena and to relocate other programmers. Not until the key technical meetings of 28 and 29 December were firm decisions made on the weight limitations of the Agena-B (2080 pounds plus gas and gas bottles), the payload vehicle (1650 pounds), and the photographic subsystem (1250 pounds). Each such weight specification, of course, had to accommodate Gambit as well as the basic E-6.

After considering a number of alternatives, several of which were impractical because of the lead time requirement, the program office late in January 1961 decided to rely on the existent Verlort tracking net for communication and control functions, re-opening the Annette Island, Alaska, site for the addition of one new Verlort station. (Annette was needed for Gambit rather than E-6.) The communication problem was further complicated in February with the emergence of a requirement for an additional vehicle-contained S-band for the Verlort radars, for an S-band command decoder compatible with those radars and with security encoder requirements; and for a transponder that would satisfy requirements for range rate measurements. Reliance on the Verlort network obliged program managers to provide for modification of existing stations to include a digital command capacity, a requirement peculiar, at that time, to the E-6. The decoder requirement which caused a change in vehicle configuration also affected the Verlort stations, leading to installation of a command decoder in each.

Some questions of basic facilities were troublesome through the entire winter of 1960-1961. Thus the formal decision to use Johnson Island as the descent and recovery zone was not made until late February and it was another month before a program office survey group could actually visit the site and estimate needs. In much the same fashion, a decision to convert part of the E-2 area in the missile assembly building at Vandenberg to E-6 purposes was made in January, but it was not until 24 March that an agreement on a beneficial occupancy date emerged.

One of the last of the major technical redirections that could be incorporated before the program got so far along that each change meant a significant delay was the 16 February 1961 deletion of air-catch considerations from the recovery subsystem. As with the E-5, the E-6 would depend on de-boost, aerodynamic deceleration, and water impact (and flotation) for its recovery mode. Sheer bulk was a principal deterrent to aerial recovery; the reentry body was 12 feet and three inches in length with a maximum diameter of eight feet and four inches![14]

Although alternate modes of reentry and recovery operation were considered later, by March 1961 the basic techniques of E-6 launch, orbit, and recovery had been decided. The operation would begin with launch of the Atlas-Agena combination from Point Arguello and its control (in Atlas sustainer and vernier phases) by Atlas radar guidance. At Atlas burnout, the satellite vehicle (Agena-B, camera section, and recovery vehicle) would coast to apogee, at which point the Agena-B would deliver the impulse required to place the satellite combination in a preselected orbit within the Agena's guidance and control tolerances. Orbit insertion would take place at approximately 125 nautical miles altitude.

After insertion, the orbit would be defined from telemetry returns, angle track data, and Verlort radar track information. The required orbit correction would be computed from track and rate radar derivations, and introduced as velocity changes provided by Agena re-burn. The final orbit correction system relied on a hydrogen peroxide propulsion unit contained in the camera section.

Photographic coverage normally would begin on the eighth orbit. The photographic subsystem was built around a pair of 36-inch (focal length) cameras (for stereo coverage) with horizon recording for attitude control.

Upon completion of the photographic portion of the mission, de-orbit requirements would be calculated from ephemeris data and sent to the orbiting vehicle. The Agena-B would thereupon be oriented to the proper attitude by its gas jets and de-orbit thrust impulse applied to acquire the desired de-orbit trajectory.

The recovery vehicle would separate from the Agena B by retro-thrust derived from the orbit correction nozzles and would then be re-oriented to the desired reentry attitude by the nitrogen jets provided for reaction control. Pre-orientation of the Agena was intended to make the de-orbit technology relatively uncomplicated. Reliance on gas jets for spin-up was intended to eliminate the possibility of an unstable spin arising from unbalanced solid rockets.

Use of a parachute recovery system in combination with the recovery vehicle (based on General Electric's RVX-2) presumably provided a safe rate of descent plus adequate ablative protection for the recovery payload through the aerodynamic heating zone to the point of recovery. (Maximum reentry forces exceeded 15 g during deceleration, and heating intensities were comparably extreme.)*

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* Much later, with vision sharpened by hindsight, Aerospace Corporation project engineers carped that the General Electric ballistic recovery

Recovery aids in the General Electric vehicle were intended, ultimately, to insure prompt retrieval within the bounds of the Las Vegas Bombing and Gunnery Range. Initially, however, water recovery was to be employed, the vehicle floating until secured by frogmen and recovered by a ship.

Tracking, telemetry, and command equipments were contained in the recovery vehicle. Such devices had to be compatible with the Mod III track and command systems at the Atlantic and Pacific Missile Ranges; the Verlort S-band tracking radars at Hawaii, Kodiak, and Vandenberg; and the VHF and UHF telemetry receivers and command transmitters at various sites in the western hemisphere. During on-orbit operation, the satellite vehicle was controlled through time-coded binary signals transmitted by the Verlort tracking link. The satellite itself had a memory circuit adequate for the storage of commands

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system had been selected "despite the rather casual treatment given this system in the proposal document. . ." There is no indication in contemporary sources, however, that the adequacy of the General Electric reentry vehicle proposal was seriously questioned. The RVX-2 design was apparently well proven, was available, and was applicable to the program as then conceived. The General Electric approach required the least research and development of any that had been proposed and offered the greatest assurance of satisfying flight schedules--and of a reliable system. Although General Electric was the target of considerable later criticism, it was not until the final two months of E-6 flight testing that questions about the adequacy of the basic design of the reentry system were raised.

necessary for both vehicle and payload operations during orbit. In actuality, some of the more precise circuitry required for command of the payload portion was essential to the Gambit system rather than the broad-swath E-6 camera, but for obvious reasons that fact was not widely known.

The original plan of an initial launch by December 1961, followed by six additional launches at 40-day intervals (and including two diagnostic launches from the Atlantic Missile Range, if necessary), had by early 1961 been changed to reflect a 9 March 1962 first-launch target date. The entire slippage, at that point, had resulted from an August 1960 decision to permit prospective bidders more time than originally contemplated to develop their proposals.[15]

The early objective of controlled land recovery became less than an integral of the total program after 9 March 1961, when Under-secretary Charyk reduced the Martin effort to a study-through-mock-up activity more slowly paced and less fully funded than initially proposed. The Martin Company's work statement was rewritten in April to reflect the changed emphasis and thereafter had no significant influence on the basic program.[16]

In some part, the cutback in Martin's activity was indicative of financial difficulties that began to trouble the E-6 program as early as March 1961. The chief offender, from the standpoint of unplanned expenditures, was General Electric, which late in March reported fiscal 1961 costs of $18 million against an approval program of $11 million, and estimated cumulative costs of $42 million through fiscal 1962, against an approved figure of $28.8 million. To SAFSP managers there seemed no hope of accommodating the General Electric development program within the total of currently approved funds; the only escapes appeared to be rescheduling or increasing funds. (The basic E-6 program, exclusive of the Martin reentry vehicle effort, had in November 1960 been costed at a fiscal 1961 total of $36.3 million and a fiscal 1962 total of $42.1 million.) There being no alternative, and the urgency of the E-6 not having diminished, the contract with General Electric became an agreement to complete the first seven vehicles for $42 million. Contract negotiations were completed in August 1961; in March 1962 General Electric advised the program office of an additional $4.7 million fiscal 1962 overrun which promised to grow larger by the end of that year. At that point, General Electric was estimating that its part of the program would ultimately cost $53.2 million rather than $18 million, $28.8 or $42 million, the earlier figures.[17]

A detailed survey of the E-6 procurement situation in July 1961 turned up other disturbing factors. The original cost estimates by the three principal contractors had totalled $53.2 million ($16.8 million from Eastman Kodak, $18 million from General Electric, and $18.4 million from Lockheed). The letter contracts had been issued on the basis of costs derived from the original work statements. By April 1961, when definitive work statements and refined cost estimates became available, the program total had risen to $112.0 ($26.6 million from Eastman, $46 million from General Electric, and $40.4 from Lockheed). In the view of the Air Force inspector general, "It was apparent that the contractors had originally priced over-simplified programs against requirements not specifically resolved" and in detailing costs had gone through clarification and redirection phases which completely changed original conceptions. Thus between November 1960 and April 1961, General Electric had added slightly to its hardware cost estimate but had expanded the sum of engineering and test activity to account for half of the $46 million revised estimate. The bulk of Kodak's increase was for additional engineering ($6.7 million), although an accelerated development schedule and more rigid specifications accounted for a considerable sum. Lockheed's estimates went up as a direct result of design changes in the Agena vehicle.[18]

Although arithmetically correct, the inspector general's survey essentially overlooked the fact that the E-6 had originally been presented as an "off-the-shelf" solution to a difficult technical problem. The differences between November 1960 and April 1961 figures reflected not so much bad estimating as the effects of redefining E-6 technical objectives. Given a choice, the Samos office elected to expend money rather than time and to pay for equipment that promised to satisfy the basic requirement in full rather than settle for what was available and compromise performance. It was unlikely, in any event, that the contractors' initial cost estimates would have long retained any inherent validity. Experience had demonstrated that in radically advanced developments the "normal" pattern included a rash of technical difficulties and a considerable number of significant design or detail changes. The financial integrity of project managers was of little consequence in such circumstances; costs went up as engineering expenses increased and as test programs expanded.

Nevertheless, the E-6 office learned a lot from its early experience with cost estimating. About a year later, when a follow-on program was being weighed, the office proposed a cost-plus-incentive-fee contracting technique (for General Electric) that made contract performance a pivot on which bonuses and penalties hinged. Review at the level of the air secretariat prompted compliments, and even though later developments invalidated the need for follow-on procurements, the lessons of early E-6 contracting experience were not lost.[19]

Requirements for support facilities for the E-6 program were defined later than had been anticipated and included items not foreseen when the program had been approved for development late in 1960. In addition to a growth in the projected cost of the Annette Island station, a tracking station at Thule, Greenland (approved 30 June 1961), and the erection of a vehicle support building at Point Arguello (defined in April 1961) became essentials. Consequently, the support funds for the E-6 program had become quite substantial by the end of fiscal 1962. Annette Island reactivation cost $8.14 million, the Thule tracking station $5.98 million, and the E-6 equipment for stations used in common by several space programs another $1.33 million. The provision of multiple-satellite handling features added $4.5 million to a support funds total that reached $25.2 million in May 1962--by which time all essential facilities presumably had been provided for, since the flight program was then in progress. The only significant exception was the land-recovery aspect of the total program, which did not become a major cost item until fiscal 1963.

In July 1961, Colonel Heran estimated a total requirement for $7.7 million in fiscal 1963 military construction funding to cover a de-orbit control station, a land recovery support facility, and additional installations at the Atlantic Missile Range. All were required for the

Martin reentry vehicle development. By November, however, deletion of all but the Canaveral construction had eliminated $5.1 of that total.[20]

While such matters continued to trouble the program, the principal effort was inevitably applied to remaining on schedule in the development, fabrication, and test aspects. The first key date was Kodak's delivery of a payload mock-up to General Electric--completed on schedule: 21 April. The first three flyable recovery vehicle cassettes reached General Electric before the end of June; in August, thermal environment tests of prototype lenses began; and on 18 September the first drop test of a recovery vehicle (from a B-52 at Kirtland Air Force Base) ended in success. By the first week of October, the initial flight vehicle (Number 2401) was going through the telemetry checkout station. Payload weight was 30 pounds greater than the 2159 pounds predicted in June, but a reduction in control gas requirements had compensated for more than half of the increase. On 10 October 1961, therefore, Colonel Heran assured Undersecretary Charyk that by all available indications the first launch would take place when scheduled: 9 March 1962. On the day of his report to the undersecretary, Heran learned that the initial water-drop test of the reentry vehicle had also been successful, both in parachute deployment and in flotation characteristics. At the end of the month, recovery site facilities were complete.[21]

At that point, some of the bright expectations began to dull. An early indication of pending difficulty was a complaint from General Electric that Aerospace Corporation had been responsible for delays in the issuance of requirements statements and detailed specifications on which the vehicle contractor's schedules were dependent. Aerospace, of course, had another interpretation. Concurrently, Aerospace was assuming responsibility for a command programming assignment originally slated for General Electric. The Philadelphia-based contractor, it developed, lacked the manpower for the task. Lockheed, the first alternate, was overloaded because of other programs. Consequently Aerospace Corporation (as an organization--distinct from the program office element) exercised its systems engineering-techical direction authority and purchased computer time from an outside contractor (Systems Development Corporation). The effect of the late-term reassignments was not immediately felt, but within 90 days began to appear as delayed and incomplete computer programs. Without the appropriate computer data, the satellite control establishment at Sunnyvale could not support the launch--and a launch date slippage would inevitably result.[22]

As it happened, the computer program slippage did not become the critical factor in the schedule. General Electric was to deliver the first flight vehicle on 1 December. That day came and passed without event, as did the remainder of December. On 2 January 1962, the contracting officer of the Philadelphia Air Procurement District formally notified General Electric that the government was considering termination of the contract by default. In actuality, the notification was a "show cause and cure" instruction intended to prompt General Electric to more energetic efforts to satisfy contractual requirements, but the possibility that the contractor's failure to perform might influence the award of follow-on contracts could not be overlooked. The chance that the government might terminate the contract before the original seven vehicles were delivered was slight indeed.[23]

The notice had two effects, nonetheless. Most important, it stimulated General Electric to push completion of the first flight article somewhat more earnestly than had earlier been the case. A Space Systems Division acceptance team ended its inspection and signed for the vehicle on 19 January, but not without criticism. The haste of the completion and inspection process disturbed the acceptance team. The team chairman reported that his fellow members had developed "a general lack of enthusiasm" during the certification process because of the "hurried and hectic" conduct of the required tests. He remarked that some "informal" procedures on the part of the General Electric people had not actually been witnessed by the team, and he noted that all of the pre-acceptance tests had not been completed because of the lack of time. They were slated for completion during field tests of the vehicle.[24]

The secondary consequence of the "cause and cure" notice was to prompt General Electric to an impassioned (and thoroughly subjective) defense of its conduct of the program. The contractor cited the complexity of the system and the requirement for design, development, and test completion in only 13 months; the "continual" program and technical redirection by Air Force and Aerospace Corporation managers (in the opinion of Colonel H. L. Evans, SAFSP's vice director, the program had been subjected to fewer changes than comparable programs); technical problems with the General Electric reentry subsystem (which had been selected originally because the contractor represented it to be a proven system requiring little refinement); and compatibility problems with Eastman Kodak which "substantially exceeded expectations."[25]

To the uninitiated, at least, it appeared that General Electric had a weak case. Some weeks later, when it became apparent that the delivery slippage had been attended by a substantial underestimate of costs, General Electric's Missile and Space Vehicle Division manager, H. W. Paige, cited "changes in system requirements and in details of implementation" as the chief causes of schedule and cost inaccuracies. Paige also complained that some design changes judged to be within the scope of the contract should have been handled through contract change notice procedures and predicted that "further technical difficulties" would arise from the flight program.[26]

That much, at least, was a valid analysis.

Although General Electric's vehicle acceptance schedule had slipped by some seven weeks, the flight schedule showed only a two-week slippage and as late as mid-January the reentry vehicle contractor was confident of meeting a 23 March launch date.[27] Progress during February appeared to justify such optimism. Early that month, the program office concluded agreements with the 6595th Aerospace Test Wing which formalized the assignment of responsibilities for various portions of the launch and test operation to follow. (The basic philosophy was that Aerospace Corporation would continue to provide systems engineering-technical direction for the program, acting through Colonel Heran's SAFSP office, and that SAFSP would retain final responsibility for approving all significant changes to cost, scheduling, and contractual arrangements.) The relatively recent complication of scheduling flight operations so as neither to interfere with nor be adversely affected by the nuclear test series being conducted in mid-Pacific was disposed of by agreement with Joint Task Force 8. Caution was advisable, [redacted] Final arrangements for return of recovered film cassettes from Hawaii to the processing laboratory at Westover, Massachusetts, were completed several days in advance of the actual launch--which had slipped, by that time, to late April. Because of the urgency of the mission, a C-135 jet transport was assigned from Military Air Transport Service resources to service the E-6 program requirements. The cargo was identified merely as two boxes weighing 270 pounds each plus a possible courier passenger. MATS was also advised, however, of a requirement to transport unidentified cargo to Washington, Wright Field, St. Louis, and Offutt Air Force Base from Westover during the several days following the initial delivery to that base.[29]

Such administrative matters were arranged with relative dispatch. The same circumstances did not characterize pre-launch efforts involving the first E-6 vehicle. Apart from the late delivery of the payload vehicle and its incomplete state of preparation upon acceptance, program difficulties at this stage extended into pad and vehicle readiness. In General Greer's understatement, "The 201 program [E-6] had a lot of problems in getting the first flight item in a condition for launch." Electromagnetic interference was one of the most notable, but it did not stand alone. A succession of equipment problems combined to delay flight readiness from the "revised" goal of 23 March to an actual launch date of 26 April.[30] In retrospect it was apparent that the slippage represented a day-for-day equivalent of the delay in acceptance of the General Electric vehicle. Even without allowances for the fact that the vehicle, when delivered, did not satisfy original readiness requirements, the time between delivery and launch was less than had originally been allowed. The launch came almost precisely 16 months after selection of the contractors. It represented a very considerable achievement.

At 1056 hours (local time) on 26 April 1962, the Atlas-Agena carrying E-6 number one climbed away from its launch pad, leaned toward the south, and vanished from the sight of observers at Vandenberg. At the proper time the Agena separated, the booster fell away, and the programmed injection into orbit began. Propulsion and guidance proved excellent. The orbit was near perfect; no adjustment was necessary. Telemetry signaled a possible failure of the camera window shields to open, and there was a clear indication of excessive use of control gas to maintain proper vehicle attitude, but it appeared that at least one of the cameras had operated as planned throughout the mission. The other of the camera pair showed no sign of functioning after orbit number seven. During the attitude adjust maneuver immediately before de-boost, however, the plume of the ullage rocket impinged on the Agena's rocket exhaust nozzle and caused an unprogrammed pitch up, and the vehicle failed to enter through the proper "window." It could not be recovered.[31]

Immediate technical changes resulting from first flight experience were limited. Lockheed relocated the solid ullage rockets to minimize the possibility of a repetition of the "impingement" incident, and Kodak strengthened the film transport assembly to prevent recurrence of the camera system failure--traced to that item.[32]

Although the changes to vehicle number two were not major, they combined with other circumstances, including crowded launch stand schedules, to delay the second flight. It finally occurred on 17 June, two days later than the revised forecast. Again the launch and orbit placement phases were "near nominal" and the photographic subsystem functioned adequately, but premature exhaustion of attitude control gas forced a call-down attempt during orbit 10 rather than during orbit 18, as originally planned. Again the de-boost phase was ineffective. The attitude control system of the Agena malfunctioned, a power failure prevented separation of the reentry vehicle from the Agena, and they re-entered as a unit. Because of that circumstance the deceleration parachute did not deploy and the satellite completed a free-fall trajectory, impacting about 750 nautical miles further down range (north) than planned. The hard impact ruptured the recovery capsule, which sank before ships or planes could locate it. Agena telemetry had not been programmed to operate during de-boost, so the precise sequence of key events could not be established and there was some uncertainty about the exact cause of the failures.

Corrective measures included the incorporation of redundant circuitry in the de-boost phase, rewiring and physical shielding of critical elements (it appeared possible that shrapnel-like fragments from one of the explosive squibs might have disabled the separation programmer), and reprogramming to insure telemetry reception during de-boost.[33]

The third trial, on 18 July 1962, produced another excellent orbit. A succession of difficulties of varying magnitude plagued the vehicle thereafter. The S-band beacon operated with marginal effectiveness throughout most of the mission and failed completely during orbit 18. The forward (main) camera failed to advance after the 10th orbit, the film cutter refused to function, and on revolution 18, during de-boost, the Agena secondary propulsion system again refused to ignite. Without ullage, the main engine would not fire, so no de-boost increment was available for the reentry operation. Again there was no recovery.

Changes introduced as a result of the third failure of the recovery system included redesigning circuits to isolate the secondary propulsion system from the solid ullage rockets and improving the pre-flight inspection of the circuitry.[34] With these changes, trial number four began on 5 August 1962.

In what had by that time become an established pattern, the launch and injection operations resulted in an orbit within two percent of "perfect." No orbit adjust was needed. On-orbit telemetry was quite satisfactory, although some S-band peculiarities were noted in retrospect. (They caused a minor error in prediction of the impact point.) Steering gas consumption was normal and the command system performed with desirable efficiency. The camera payload, unhappily, developed some defects. Telemetry returns showed the main camera to be "operating" through pass number seven, but the film transport remained non-functional throughout the entire mission. The rear camera operated through revolution number six, after which both the transport and the read-in elements failed. However, there was a clear indication that at least 1500 feet of film had been properly exposed.

During the reentry and recovery phase, disabling defects again appeared. Individual incidents of the de-boost sequence came in proper order, but the Agena imparted only 1450 feet-per-second deboost velocity instead of the programmed 1600 feet-per-second. Nevertheless, the reentry sequence continued as scheduled until the vehicle emerged from the ion-sheath blackout. One second later, primary telemetry failed. Although telemetry signals briefly resumed after a lapse of 16 seconds, there was no indication of parachute operation and recovery aircraft in the impact zone were unable to secure a clear bearing on intermittent beacon signals which persisted over the next 40 minutes. Both electronic and visual search continued for four hours after presumed impact, but there was no sighting. A helicopter search over the next 24 hours produced nothing more tangible.

Analysis of the fragmentary telemetry indicated that excessive heating, principally in the aerodynamic wake of the reentry vehicle, had caused a failure in the parachute deployment circuitry. Confident that the flaw was not in the vehicle design and that it could be remedied, General Electric thickened the thermal coating around the ballast tanks of number five vehicle, changed the composition of the primary thermal coating at the aft bulkhead, and increased the amount of insulation in other suspect locations. Although the telemetry failure had prevented the acquisition of detailed heat data for the blackout period, there was general agreement between SAFSP program office members, Aerospace Corporation engineers, and General Electric's specialists that the additional insulation would prove adequate.[35]

The relatively rapid succession of flight tests--and mission failures--had not proceeded in a management vacuum, nor had work on improvement of the central E-6 configuration ceased. In the area of a system improvement, two items were of particular interest during the months between April and October 1962. One was improved retrieval, either water-to-air or air catches. The second was the addition of an indexing camera which would more adequately pinpoint the location of sites photographed by the stereo cameras.

The index camera consideration began with a directive from Undersecretary Charyk to provide a combination terrain framing and stellar-indexing camera "as soon as possible." (Corona experience was the real justification.) Charyk reconfirmed the requirement early in May 1962. After carefully examining production and procurement time factors, Colonel Heran on 18 September advised the undersecretary that the indexing system could be incorporated in the tenth and subsequent E-6 vehicles. Two days later, General Greer validated the schedule and directed that the effort continue even though other improvement proposals of the time were being deleted as unnecessary.[36]

The proposal for either air catch of the descending reentry vehicle or sea-to-air retrieval of the floating payload was, in one sense, a revival of the original option of August 1960, deleted from the program in February 1961. A means of water-to-air recovery offered some prospect of overcoming the several objections to air catch; it need not be so prompt, it need not be limited to one or two passes at a descending object but could if necessary be continued over a period of hours, it was presumably a somewhat less delicate maneuver, and it could take advantage of frogman teams dropped into the ocean to rig the recovery vehicle for pick up.

The first tests of the rigging-for-retrieval process, conducted on 27 March 1962, were thoroughly unsuccessful. Forty minutes of effort to slip a harness around a floating dummy recovery vehicle ended in complete frustration. Nobody had allowed for shrinkage of the cotton sleeves around the nylon netting. A second trial, using a modified harness, saw frogmen encase the vehicle in about eight and one-half minutes--but 10 people spent the next 45 minutes attempting to inflate the balloon which was supposed to carry the extended tow line across an expanse of water so that a hook trailed from a retrieving aircraft could engage it. Once the balloon was inflated, and before it had lost all its helium, the pick-up aircraft made a pass at the assembly--and punctured the balloon. A second pass by the JC-130 at a new balloon and line was successful, the recovery vehicle started to lift from the water, and the tow line loop broke!

Although the succession of difficulties involving the harness, the tow line, the balloons, and the winch in the JC-130 frustrated hopes for immediate success, the experimenters were not discouraged. Earlier trials had shown that floating objects comparable in size to the E-6 recovery vehicle could be retrieved from the ocean by JC-130s. The question of the moment was whether two scuba divers could attach the harness in a high sea, inflate a balloon, and keep the tow line from coming into contact with the water.[37]

In June, the E-6 program office proposed a slightly different water-to-air technique involving the use of a buoy attached by a line to the rear of the recovery vehicle. Another variant with potential was use of the descent parachute as a "buoy" with the retrieval aircraft hooking the line between the parachute and the recovery vehicle. Because a relatively lengthy test and development program was involved, and because the technique had more promise in theory than in practice, General Greer recommended deletion of the water-to-air recovery program from the E-6 effort late in September 1962. For the moment, however, General Electric was directed to continue feasibility tests.* Lack of significant progress caused final cancellation of the water-to-air recovery efforts on 25 October 1962.[38]

While the flight tests continued, several changes to the program were approved which gave it the character of a long-term effort. The basic flight program had been built about the seven originally scheduled tests plus the two "optional" trials (earlier treated as diagnostic flights). In January 1962, funds were allocated to a follow-on program and on 27 March 1962 contractors were advised that the nine-vehicle program had been expanded to 26 vehicles. Letter contracts with General Electric and Eastman Kodak had been signed and distributed

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* As defined in July 1962, the objective of the water-to-air recovery program was to establish the feasibility of bringing a towed recovery vehicle into a JC-130, and to incorporate the technique in the tenth and subsequent E-6's. Simplicity, ease of operational employment, a minimum of vehicle and aircraft modifications, and few requirements for additional or special equipment were prime considerations. General Electric, acting under an addition to the follow-on vehicle contract, was to collect and analyze aircraft flight data and wind tunnel information on recovery vehicle performance (when towed) by early August and was to have a full-scale test program underway by 15 October.

by the end of that month. Because of the fact that the original nine vehicles were well along in fabrication by that time, changes and improvements in the configuration of the E-6 satellite were generally scheduled for the tenth and subsequent vehicles--unless, of course, they involved modifications necessary to the success of the early flight program. The index camera, air and water recovery, a back-up stabilization system, and the expansion of telemetry in the Agena vehicle (as opposed to the reentry vehicle) fell into the "long term" category. In the course of a major program review in September 1962, Charyk and Greer approved the addition of a secondary command system to the sixth and later vehicles plus deletion of the secondary propulsion system in the tenth and later vehicles (the precision of orbit injection during the first four flights had made orbit adjust requirements redundant). The inclusion of "back-up" attitude control and engine sequencing provisions in number 12 and subsequent vehicles remained under consideration.[39]

The first objective of the E-6 program, to demonstrate that the system could operate efficiently, still was unsatisfied. A successful mission was essential. In the longer view, the remaining vehicles in the original batch of nine were intended to demonstrate system performance, provide data that would permit refinement of the basic equipment, and define the operational limitations of the vehicle-camera combination. Only with the tenth vehicle would intelligence collection become the principal mission objective. As had generally been true since inception of the E-6 effort during the summer of 1960, the policy of the program office was to make configuration changes only when they promised to improve the vehicle or its product--or, of course, to correct defects discovered during the test program. "No frills" was a hard and fast rule.[40]

Thus far there had been only four significant deviations from the payload design conceptions approved at the time of source selection, in November-December 1960. The lens design had been changed from one involving folded optics and a near vertical orientation to one based on a horizontal orientation and unfolded optics when it was demonstrated that the dual use of the mirror in a folded-optics system was risky. Window shades had been added to reduce power requirements by providing a higher degree of thermal control, the film cutter and seal had been made a single rather than a double unit (severing and shielding both film strips with a greater assurance of reliability in operation), and the total of available image motion compensation speeds had been increased from 10 to 15 in order to reduce the potential for motion blur on the processed film.

The reentry vehicle had been altered somewhat in the course of development, but again not radically. The original scheme of building in three structure sections had given way to a four-section design, spin springs and a shaped charge had been added to improve separation characteristics, a multi-element thermal shield had been substituted for the original single-material type, the structure had been lightened, land recovery provisions had been deleted, and the destruct system had been removed. Some relatively minor additions had been made to the tracking, command, and telemetry installations--but as much because of Gambit requirements as because of E-6 needs. As compared to other systems, in terms of design and configuration changes the E-6 had been remarkably stable.[41]

The secure future of the program became somewhat less certain following the failure of the fourth test vehicle (5 August). On 21 August, Undersecretary Charyk told General Greer that "high government officials" were "concerned about the four consecutive failures" and asked for an explanation and a summary of proposed corrective actions. Charyk also asked Greer to examine the possibility of adapting the E-6 payloads to a thrust-augmented-Thor (TAT) launch vehicle and a Discoverer (Corona) recovery capsule. The undersecretary indicated that he intended to make several major program decisions within a week.

The response from the Los Angeles complex was not such as to encourage hope for an easy or inexpensive adaptation of the E-6 payload to what would essentially be a Corona configuration. Colonel Heran emphasized that the launch and orbital performance of the E-6 system were "quite impressive in several respects." The command subsystem and the payload stabilization provisions had also operated with a high degree of efficiency. On that basis, the suggestion of shifting to a TAT launch vehicle seemed unjustified.

Heran also pointed out that use of TAT would force "almost complete redesign and packaging" of the E-6 system, would reduce the quantity of film by at least one-half, and would essentially constitute a new program with all the complications inherent in such a procedure. Its effect would be to substitute a new launch system for one which had worked quite well.

Colonel Heran was convinced that de-boost problems which had marked the first three flights had been eliminated. The recovery system, he noted, had been given only one chance to operate. He felt that the E-6 was much closer to fruition than any alternate that could be readily provided.[42]

In Charyk's view, the real objective of the test program was to create confidence in system reliability and adequacy. The established schedule was not sacred, he told General Greer, and "in no case will any launch be conducted unless the results of previous missions have been thoroughly studied and the necessary measures. . . taken to prevent a recurrence of any non-nominal performance."[43]

On 18 September 1962, General Greer's group conducted a complete program review for the undersecretary. Cancellation of the follow-on program was by then being actively considered, so the summary included a resume of work status, prospective contract costs, and the comparative costs of a 9-vehicle as against a 17-vehicle follow-on program. The 9-vehicle effort would cost $144.4 million to complete, the 17-vehicle program $237.3 million. Although not at all enthusiastic about the options, Greer's people agreed that alternate systems to contain the E-6 payload were feasible in the event of E-6 program cancellation. Among the potential options was use of an enlarged Discoverer capsule ("Big D") with an Atlas-Agena launch combination; the use of a Thor with solid-rocket boosters (TAT) to orbit the current payload and recovery vehicles; and the use of TAT with the "Big D" recovery vehicle and the existent E-6 payload section. The alternative of using a modified E-5 reentry vehicle and a ribbon parachute (to permit supersonic deployment) also seemed feasible, if not particularly attractive. In the eyes of the E-6 program office, none of the alternatives was preferable to continuing the current effort.[44]

The future of the follow-on program still remained uncertain for another two weeks although stop-work orders had earlier been issued to the principal contractors. The final decision came on 3 October 1962, with Charyk's order that work on all vehicles additional to the nine originally programmed be halted. The undersecretary had decided to withhold action on further vehicles pending "complete resolution of project difficulties and demonstration of actual performance of sufficient quality to justify further procurement. . . ." He felt that the remaining flight tests might lead to significant redesign and modification.

Charyk further directed that three of the remaining five payloads be scheduled for flight in accordance with a philosophy of taking all the time necessary to insure a "maximum probability of success" and with intervals between the flights sufficient to permit complete analysis of all data from the previous flights and the incorporation of necessary changes. The final two payloads (the "diagnostic" items, as originally scheduled) and payload vehicles were to be stored for possible future use, and the Atlas-Agena combinations were to be made available to other programs.

In effect, Undersecretary Charyk thus limited the scope of the E-6 program to the three remaining flights on the original schedule.

From a program office viewpoint, the qualification that a successful flight might change such arrangements was the only entirely hopeful note contained in his instructions.[45]

On 4 October, General Greer notified General Electric, Eastman Kodak, Lockheed, and the Space Systems Division of Charyk's decision. He cautioned each to say no more to the press than that the cutback represented a work phase termination and a contractual adjustment in accordance with the "continuing process of review" of all Air Force space programs.[46] But even though three more E-6 flights were still scheduled, cancellation of the follow-on procurement had implications for the total reconnaissance effort considerably more serious than was at first apparent.

Because of the highly effective security screen erected around the Samos program in December 1960, virtually no information on the success or failure of individual flights or total programs had been available even to the "cleared" members of the Air Force for nearly two years. During that period, considerable quantitites of reconnaissance film obtained from Corona overflights of Soviet territory had been processed and forwarded to operating commands. A major overhaul of United States strategic warfare policy had in part been based on information drawn from such sources. Able to number and locate

Soviet missile bases, the nation was no longer dependent on a massive retaliation policy openly directed at eradication of Russian cities and "known" military stations. Relatively few people were aware of the Corona program and its success. The implication that some unspecified quantity of the "take" had been obtained from "Samos" flights was present in virtually any "unwitting" estimate of the known situation.

The E-5 effort had ended in termination by January 1962. With the last E-6 flight, the known "cover" for both Corona and the still untested Gambit would vanish. Another casualty of E-6 program termination would be the known justification for the existence of General Greer's organization--SAFSP; only those with access to the cover programs appreciated that the E-6 effort was but a minor part of a major activity being managed from the fourth floor suite of offices in the "SSD complex" along El Segundo Boulevard in Los Angeles.

Corona program managers were particularly concerned that announced cancellation of E-6 might expose the Corona effort. Other SAFSP staff officers could realistically harbor fears that some details of other covert programs might float to the surface once E-6 no longer could be used to explain SAFSP's existence. If the original objectives of SAFSP establishment were to remain valid, E-6 cancellation (should it finally occur) had to be accompanied by new camouflage for the covert programs, a logical explanation for continuation of SAFSP as an organization, and--ideally--a new overt program to cancel in case of a political decision to halt "open" support of satellite reconnaissance. One of the chief reasons for continuing the E-6 in its original form had been to permit its public cancellation, and the clandestine continuation of other satellite reconnaissance activity, should international events so dictate.[47]

Thus quite apart from considerations of technology, the launch of the fifth E-6 vehicle promised to be of considerable significance.

By late September, that vehicle had been prepared for its flight. Intensive Agena-reentry vehicle separation tests had been completed, heat-effect tests were continuing, the recovery subsystem test procedures had been exhaustively reviewed and changed, and the vehicle had been subjected to a substantial number of retrofit and modification actions. The additional insulation around aft bulkheads and near the ballast tanks was in place, a number of critical switches had been relocated, electrical cable had been rerouted around heat-sensitive zones, the cover for the parachute cavity had been recoated with an improved insulator, the beacon and flasher assemblies had been strengthened and reinsulated, a special baffle had been added forward of the main vent valve, and the entire reentry vehicle had been delicately weighted and ballasted to minimize any side effects of inertial imbalance. Representatives of General Electric, Lockheed, Aerospace Corporation, and the program office made a final appearance before General Greer to assure him again that they had a very high degree of confidence in the chances of mission success.[48] Launch occurred on 11 November 1962.

It was the wrong season for optimism. System operation to the point of reentry was in many respects even better than during any of the earlier missions. Lift-off and orbit injection again resulted in establishment of a near-perfect ephemeris (112-128 nautical miles, 88.72 minutes period). The only possible malfunction, suggested by telemetry but unconfirmable, was failure of hatch removal. The command system functioned without disorder and the photographic subsystem transported 3400 feet of exposed film. De-boost sequencing was near perfect, and the reentry vehicle appeared to be performing without any error until it entered the blackout zone. Thereafter, events roughly paralleled those of flight four. There was some indication of parachute deployment, derived principally from telemetry indications that descent had lasted longer than would have been the case with a free-falling reentry body, and again one aircraft reported 16 minutes of indistinct beacon signal reception following impact. But none of the search craft sighted the vehicle, no further signals were reported, and at dark on the evening of 12 November the search ended. (Some surface ships cruised the area the next day, but with little hope.) The fact that a recording station heard both SOFAR bombs detonate indicated to recovery team personnel that the vehicle had broken up on impact or sunk shortly thereafter.[49]

Evaluation of the reentry process indicated that erratic aerodynamic heating effects which had marked reentry of the fourth vehicle had been responsible for the fate of the fifth. Although telemetry reception was not greatly improved over the August test, some additional data emerged which indicated that the ablative sheathing had burned away well forward of the vehicle's after structure and that some of what had earlier been characterized as "wake effect" probably had actually been caused by aerodynamic gasses passing completely through the vehicle from an opening (or openings) burned through the conical forward structure. General Electric's specialists in reentry aerodynamics offered no assurance that they could correct the difficulty for the next flight, and the mood of the several contractor and E-6 program office representatives who reviewed the program's prospects for General Greer was not cheerful.[50]

Not until January 1963 did the Aerospace Corporation complete a resume of E-6 program difficulties and suggest measures to overcome faults discovered as a result of number five flight. Engineers concluded, on the basis of telemetry which had been obtained from the fifth flight but which because of programming imperfections had not been acquired for the fourth, that the addition of .05 inches of ablative material to the main heat shield, the elimination of most ablation inserts in the main shield, and the revision of attachment fittings for the main parachute hatch cover would correct the known defects of reentry. As additional measures, they recommended revising the vent channels in the vehicle to prevent flow-through of leaking gasses, thermal coating all components and cabling required for post-entry operation, and relocating some systems-monitoring instrumentation to provide positive verification of system operation after reentry. The Aerospace group suggested that it would be possible to demonstrate the soundness of the revised vehicle by firing it--without the camera payload--atop either an Atlas or a Thor-Agena booster. (General Electric estimated that it would cost $400, 000 to refurbish a reentry vehicle, to fabricate the necessary adapter, and to provide test support for the vehicle.[51]

For nearly a month the results of the fifth flight and the prospects of the remaining two were carefully weighed against cost considerations and the prospect that Corona-Mural cameras could return intelligence data equivalent in value to any the E-6 could provide. The political and economic consequences of complete E-6 cancellation were similarly evaluated. In the scale against the chances of the E-6, apart from competition provided by Corona, was the timing of the crisis. Coming as it did midway through the fiscal year, when rising costs and earlier underestimations in other programs were causing a search for additional funds, the E-6 represented an appealing target for fiscal economy. On the other hand, experience indicated that relatively little would actually be returned to the government if the program were cancelled at that point. The vehicles were available (and paid for), and launch and tracking costs would be but slightly affected by cancellation. (Since launch and tracking station expenses were continuing in nature they could be considered as running overhead costs.) Moreover, the payload had shown every indication of usefulness. Inasmuch as all earlier calculations of system resolution in the Corona program had proved to be conservative when measured against actual "take," there was a strong possibility that E-6 products might be substantially better than Corona products. If that proved true, E-6 would provide a desirable intermediate between the optimum 13-foot resolution of Corona-Mural (although perhaps half of the Corona-Mural results showed resolution on the order of 30 feet) and the predicted five-foot resolution of Gambit.[52] There was some feeling that E-6 either should have been cancelled much earlier, when the possible overlap with Corona-Mural first became apparent, or should not be cancelled before completion of the two remaining test flights and a comparison of anticipated with actual intelligence returns.

A factor in the considerations was the conviction of some Department of Defense and CIA officials that the E-6 was of dubious worth, that Corona-Mural would do as much without the additional cost of an E-6 program, and that the greater cost of Atlas-Agena launches over Thor- or TAT-Agena would validate a cancellation decision.[53]

In any event, on 11 December 1962, Air Force Undersecretary Charyk advised General Greer of his decision to terminate the E-6 program immediately. All remaining payloads and payload vehicles were ordered into storage. Greer was given discretion in permitting completion of items then well along in fabrication and the assembly of reports and test data analyses then in progress.[54]

Simultaneously, Charyk asked Greer to look again into the feasibility and desirability of orbiting an E-6 camera payload in a Thor-Agena vehicle (using the Corona recovery system) to obtain information on the value of the camera system alone. Precisely such a course had been followed upon cancellation of the E-5, resulting in the still unproven Lanyard system. The option of sending only one of the stereo cameras into orbit and of limiting the quantity of exposed film made the project seem somewhat less difficult than the earlier suggestion of boosting an entire E-6 payload into orbit with a Thor or TAT. Charyk's notion was that if the project seemed feasible, it should be presented as a new program, independent of the original E-6 except in employing available assets of the defunct program. On the basis of the possible adoption of such an approach, SAFSP received authorization to retain Eastman Kodak support and to continue payload work pending a final ruling on the prospects of an E-6-Thor-Agena combination. (An additional, but unmentionable, justification was the need to continue Eastman efforts in support of the Gambit-oriented work at Vandenberg.)[55]

After exhaustively evaluating all the possibilities, Colonel Heran's office endorsed three feasible approaches to a revised E-6 program. The first involved an Atlas-Agena boost combination, a midsection adapter to take the E-6 payload (minus one camera), and a reentry stage consisting essentially of a Corona nose capsule. Heran's office also suggested using a Strategic Air Command Atlas adapted to carry the E-6 reentry vehicle, thus permitting further tests of the vulnerability of that component to aerodynamic heating effects. The third option required use of a TAT-Agena, a new midsection, and a Discoverer reentry body. The Thor- or TAT-Agena combination afforded the prospect of covering most of the Soviet Union on its initial pass and of being subject to recovery on the second pass, assuming a nighttime recovery operation. In view of the first-pass reconnaissance, second-pass recovery feature, it could afford "invulnerable reconnaissance." Simplicity, reliability, and the use of proven components (except the TAT, which had not yet flown) were obvious advantages. Using existing hardware, one E-6 camera, and the Corona reentry vehicle, a first flight was conceivable by April 1963. With a redesigned midsection, one camera, and the Corona reentry body, November 1963 seemed a feasible first flight date. (Either the Thor-Agena or the TAT-Agena would theoretically be usable by that time.) Adaptation of the Corona reentry vehicle to a one-camera configuration and the Atlas-Agena booster would permit first flight by April 1963; introduction of a "dual-Discoverer" reentry vehicle configuration (like the later Corona-J) would require a delay until August 1963 but would permit use of both cameras. Conversion of the payload system to a narrower film with dual takeup in a Corona reentry body would delay the flight only to June 1963.

SAFSP recommended immediate preparation for a one-camera test using the Atlas-Agena and a Corona configuration reentry body, a test of the original reentry body on a Strategic Air Command Atlas, and the start of design work on a light-weight single-camera stage. SAFSP also observed that a combination recovery-readout capacity could be developed from available E-6 and E-1 or E-2 hardware, with a first flight conceivable by November 1963. (Five E-1 and three E-2 payloads were still in storage and the necessary ground equipment was available.)[56]

For 28 days there was no verdict. Then, on 31 January 1963, Charyk formally notified General Greer that all proposals for further orbit tests of the E-6 payload had been disapproved. The undersecretary desired "no further action in this regard."[57]

Because of the general character of SAFSP programs and their uniformly sensitive nature, the third and fourth floor offices which housed most of the Greer establishment were seldom treated to the general badinage characteristic of many program offices. Chatter concerning the reconnaissance program was infrequent, and was generally confined to a few individuals who knew precisely what all their listeners had been cleared for. And since the general security rule was to clear as few people as possible, and for as few items as possible, many of the E-6 program participants were aware of no other SAFSP programs--except those previously cancelled--or at most knew of Gambit because of its earlier alignment within the E-6 office structure. Few knew of Corona, and fewer still were aware that the cancelled E-5 had reappeared in a different form as Lanyard.

But some knew, and knowing were tempted to quip, quietly and privately, that it was a wise man who knew his own payload, that E-6 might have been cancelled, but it was equally possible that General Greer or Colonel Heran had found a way to stuff the E-6 cameras into something else and weren't telling.

At the close of the 9 January presentations during which the several possible modes of flying E-6 payloads in new configurations had been discussed, Dr. Charyk, General Greer, and General J. L. Martin retired to Greer's office to consider the options. They were convinced that it would be useless to schedule the two remaining payloads for routine launching in their original modes since there still seemed no way of getting reasonable assurance that the recovery system would work. But they were also convinced that the potential of the E-6 optics and film transport system should be demonstrated before any final decision to abandon the enterprise. Aware of the growing disbelief in E-6 adequacy at Department of Defense levels, they concluded that the proper course was to devise an alternate approach which would produce the results they wanted quickly and cheaply. There was little hope of securing approval for a large-scale program, in any event. The pendulum of opinion had recently swung toward relatively small research and development experiments as opposed to larger programs. The idea of proving a capability and then proceeding to a full-scale program was generally in favor. And the considerations which had caused effective cancellation of the full-scale E-6 effort still persisted: the E-6 recovery system seemed fatally uncertain; budget pressures required a major cutback in expensive programs; and there was an influential, vocal group (chiefly within the CIA element of the National Reconnaissance Organization) which was convinced that E-6 was redundant, that Corona-Mural or an improved Mural (M-2) would serve the nation better than E-6.[58]

Charyk, Martin, and Greer brought no one else into their deliberations until the last day but one in January. Then, by telephone, General Greer summoned Colonel Heran, E-6 director, and Lieutenant Colonels Mark Farnum, Ned Hand, and D. J. Yockey to his office. There he disclosed a plan to use E-6 payloads in an experiment to demonstrate 6-7-foot resolution from orbit. He told them Charyk had agreed to establish a new "black" program office with that mission, its first task being to prepare a work statement acceptable to Charyk. Heran was to prepare the statement, working with General Electric and Eastman Kodak in meetings that would begin the following morning (31 January). It was to be ready by 5 February.

The program, General Greer continued, would use a 315A number as a temporary identifier (315 was the "random number" designator for the Elint F-2 (698BK) system in its current incarnation). All work would be conducted away from the SAFSP office complex, in a suite leased by Eastman Kodak on Manchester Avenue, a long block north of the main SSD buildings. (Among the witting, the obscure offices were known as "Marty's Place," in honor of the resident Eastman employee, Martin Hauseman. Air Force visitors were forbidden to go there in uniform, were under orders to arrive and depart singly or in pairs, and were not permitted to park cars carrying Air Force identity stickers in the immediate neighborhood.)

The use of thrust-augmented Thor boosters was assumed, but remaining to be decided were issues of Agena B as against Agena D, what guidance system to use in the booster, the need for a new midsection, how to procure the reentry capsules ("buckets") from the <u>Corona</u> program without disclosing the scheme, a funding channel, and a cover plan. The possibility of pretending that the payloads were Program 698BK's F-2 ferret packages seemed feasible but required study.[59]

In advance of convening the meeting, Greer had composed a set of instructions for Charyk to send him. They paralleled the details he had given Heran, Hand, Yockey, and Farnum, emphasizing the need for quick, inexpensive, and sure results. Toward the end of the message as it came back to Greer's office was the injunction, "The approach should be Spartan in nature, as simple as possible, and should take no consideration of any future system applications." From that phrase came the name by which the program was thereafter generally known: Project Spartan.[60]

In discussions with Eastman Kodak and General Electric representatives the following day (31 January, the day of formal E-6 cancellation), Colonels Heran and Yockey outlined the general system parameters and defined the chief hardware problems, as then foreseen. Security, still a matter of confining program discussions to the original core of about 10 knowledgeable people, was made more certain by the appointment of Colonel Farnum as security control officer and by the decision to use a "limited handling" system even more secure than the "special handling" in effect for Gambit. Although the Spartan designator was generally used throughout the period of program consideration, more formal nomenclature was assigned on 2 February: SP-AS-63, for Special Project-Advanced Study 1963.[61]

By 2 February the outlines of the proposed "experiment" had taken shape, and by late afternoon of 4 February they had been transformed into a work statement. Generally, two design approaches were to be considered. In one, early launch was the objective, and the technique would be to couple a single E-6 camera and the original E-6 midsection to an A-45 (Corona-type) reentry vehicle and a Fairchild programmer-timer. For the other, a redesigned midsection integral with an enlarged reentry capsule capacity was to be considered. Either a scaled-up A-45 or A-45s in tandem were feasible options. The payload would be one camera with an adapter to provide stereo photography, very much like Lanyard in concept. The objective of the effort, under either option, was also to include hardware procurement and fabrication sufficient to protect a June 1963 initial launch date, with stereo capacity by November 1963.[62]

The first major obstacle appeared at about the same time. On 5 February, Dr. Charyk had Lieutenant Colonel Jack Sides brief CIA's Dr. Herbert Scoville, who was deputy director of the National Reconnaissance Office, on the background of the proposed experiment. Scoville was deeply suspicious of the whole proceeding. He refused to accept as valid the statement of primary purpose: to get search-type photographs at 6.5-foot resolution for evaluation. He insisted that the Lanyard system was quite good enough, even though only providing spot coverage, and in a rather lengthy discussion made it apparent that he thought the proposed experiment to be the prelude to a new system development. He denied that the E-6 camera could produce 6.5-foot resolution, even with stereo, and in Sides' opinion left the meeting with the confirmed impression that focal length was the only critical factor. Holding to the view "that somebody was playing fast and loose with the figures," Scoville would not concede that an improved lens-film definition (from 78 to 110 lines per millimeter) and a decrease in satellite altitude (from 125 to 100 nautical miles) could contribute to significantly improved resolution. It was the general opinion of those Charyk people present at the briefing that Scoville would firmly resist approval of the Spartan experiment "at the possible expense of the program he considered to be his"--the "improved Mural", M-2.[63]

Although the Scoville reaction could have been entirely spontaneous, there was a greater possibility that it represented yet another flare-up in the increasingly acrimonious relationship. Since the October 1962 Cuban crisis and Charyk's success in transferring a large share of U-2 operations from CIA to the Strategic Air Command, he and Scoville had often been at odds. Tension arising in disagreement about a proposed revision to the NRO charter added to the problem. During part of the October-December 1962 period, both their personal and their official relationships were severely strained. The late January announcement that Charyk proposed to retire from his Air Force post to head a commercial communication satellite development did little to ease the tension. It was clear that insofar as Scoville spoke for the CIA, Spartan would receive little support from that element of the NRO.[64]

Notwithstanding Scoville's negative reaction to the Spartan proposal, work at the Los Angeles office continued apace. The original cost estimate presupposed that $3.87 million would be required to fund Eastman and General Electric studies (and long lead-time procurement) with a total of $20.348 million being required in all of fiscal 1963. Project personnel estimated that four launches, starting in July 1963, could be conducted for a total program cost of $32.273 million.

Cover for the effort was to be supposed SAFSP participation in development of a reconnaissance system for the B-70 or the X-20. (That story was for most of the traditionally suspicious SAFSP assignees; non-SP people would be told only that the effort was one more in the directorate's general "no details" assignment.)

The process for keeping E-6 equipment in the hands of Spartan contractors without uncovering the entire effort required special attention. Essentially, the scheme was to have Charyk instruct Greer to make E-6 equipment available to the Aerial Reconnaissance Laboratory at Wright-Patterson, much as had been done in establishing Lanyard. Colonel Heran's people would then direct the transfer of the equipment from appropriate contractors to the laboratory and would get shipping instructions from a contact at Wright Field. After the exchange of many, many itemized lists and numberless detailed queries and replies, the equipment would have been moved to a secure area in the General Electric and Eastman Kodak "black" facilities, the Wright Field contact would have signed for the equipment and then been relieved of responsibility, and the actual equipment receipts would be so deeply buried in the paper morass of the Los Angeles Procurement District that nobody would be able to track down the equipment itself. (Accountability for "Program 206" equipment, actually Gambit hardware, was similarly maintained.) The charm of the scheme lay in the fact that nothing more bulky than several dozen misleading signatures was moved about, so only the individual culprits at Wright Field and in the Procurement District need be briefed.[65]

Then on 12 February Dr. Charyk disapproved the Spartan proposal as "not justifiable for the purpose of determining the increase in intelligence content obtainable from 6-7-foot ground resolution." The tenor of his statement and the suggestion that the objective could be met sooner, and at less cost, through other National Reconnaissance Program efforts, clearly indicated that the reason for the disapproval lay in Scoville's objections. Scoville, with the support of the CIA element of the National Reconnaissance Office, was thoroughly committed to the "M-2" approach--a Mural-type system embodying a new camera designed for 6-8-foot resolution (based on an improved 39.3-inch lens Itek had designed).

Although the original scheme apparently disappeared in the face of such new direction, the substance was misleading. Both Greer and Charyk were convinced that the Mural system had inherent mechanical inhibitions which would always prevent the acquisition of consistently high resolution photography. Some of the Mural pictures would be of high quality, but because of the character of the combined lens-film transport-panning mechanism, the quality of Mural photography would remain variable. The E-6 system, however, had an apparent potential for consistency in quality, and at a level that made it comparable to the best of Mural. In essence, Greer and Charyk believed that the Spartan experiment would show the E-6 camera system to be superior to the proposed "M-2."

Even though it had not yet proved possible to get Dr. Scoville's endorsement, Charyk did not give up on the Spartan approach. In formally disapproving the original scheme, he added the proviso that NRO interest in a general search system which might possibly use the eight surviving E-6 cameras justified an "appropriate minimum design study" that would take advantage of the experience acquired by the General Electric and Eastman Kodak personnel with E-6 backgrounds. To that end, Charyk authorized General Greer to conduct "black" studies to define the usefulness of the E-6 camera in a Thor-boosted general search system. Not surprisingly, the studies were to be oriented toward stated Spartan objectives: a single camera with an optional stereo mode if later desired. Charyk authorized the initial commitment of $500,000 to the effort.[66]

Such changes notwithstanding, on 15 February letter contracts with General Electric and Eastman Kodak went into effect.* Their

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* The timing of the contract was one of its several unique features. Initial discussions between the Heran group and the prospective contractors did not begin until 31 January, yet a work statement was in existence by the late afternoon of 4 February and a formal letter contract had been written, reviewed, revised, and approved by 15 February. (Eastman Kodak did not formally sign until 18 February, but that reflected a mailing delay.) Subsequent extensions and amendments were consistently written, coordinated, and issued in less than 48 hours from point of decision.

goals were those first defined in the work statements of 4-5 February, with the proviso that technical and cost proposals for the actual hardware effort were due by 15 March. Interestingly enough, the funds were to be spent for procurement and fabrication of long lead-time items needed to meet a 30 July launch date rather than to fund the studies themselves. The cost of preparing proposals was to be covered in overhead charges to other contracts.[67]

The situation was somewhat peculiar. Ostensibly, Spartan had been disapproved and cancelled, and correspondence reflected that status.[68] But the contracts continued in effect, and indeed in terms of the discussions then involving Heran's group, Eastman Kodak, and General Electric, the objectives of the effort had broadened somewhat. By 18 February, the day Eastman accepted the "2113 contract," the camera contractor had established both concepts and general configurations which promised remarkable things from the E-6 photographic systems. It seemed entirely possible to get six-foot resolution from stereo arrangements of a mirror on a single E-6 camera, and several possible recovery capsule options had been identified which promised to expand the limited film capacity of a Thor-boosted system. Eastman indicated that recent improvements in optical coating techniques would permit 48-percent effectiveness in light transmission with "improved" mirrors against a 38-percent figure for the original E-6. The 36-inch lens system coupled to such a mirror and using improved film emulsions would conceivably have six-foot resolution potential, in a swath coverage of 17 by 140 nautical miles. (With inclusion of a greater roll capability, the potential area of coverage could be increased to 200 miles, though only 140 miles of terrain could be photographed in a single sweep.) Eastman Kodak went to an extreme the firm had never before permitted itself, proposing the in-house construction of a complete photographic vehicle ("Ph/V" in the argot of the "black" conversations) which would substitute for the customary General Electric camera-containing structure. Eastman concluded that the proposed "PhV" would provide substantially better results than the original "BJ" configuration. Resolution and acuity improvements could well be exploited to provide an option for monochrome or color stereo, while addition of what the camera engineers called the "cosine platten drive" would virtually eliminate image smear along the line of vehicle motion.[69]

As a consequence of the concentrated effort between 30 January and 18 February, and in part because of conversations and presentations at the Washington level, the character of Spartan changed radically by late February. Scoville's opposition had prompted the "cancel Spartan" message of 12 February but had not prevented the issuance of the letter contracts. Instead, the work had ostensibly been changed from "experiment" to "study," though in point of fact the objective of a 30 July 1963 experimental flight remained in effect. (Indeed, the date was formally changed to 30 July from 15 September after the letter contracts had been signed.) The "transfer" of E-6 equipment to B-70 and X-20 contractors went through on schedule (with frequent references to an otherwise unidentified project called "Sky Gem," which was mysteriously cancelled a few months later). In reality, then, the effect of the "cancellation" had been to cause redesignation (Spartan formally was replaced by SP-AS-63) and to expand the scope of investigation so that stereo would clearly be included among the potentials.[70]

Eastman and General Electric submitted their "proposals" on 15 March, as scheduled. They were generally compatible with the concepts outlined early in February, elaborating on the original idea but adding little. Eastman's proposal for July launch (dubbed the Type A configuration) embodied a very simple monoscopic system which would provide for exposure of film in a slightly modified E-6 camera and recovery by means of a Corona capsule. The photo firm estimated that four payloads could be assembled and delivered between

between 21 July and 15 September 1963 for a total cost of $1, 039, 743 (including a $91, 377 fee). Both General Electric and Eastman Kodak also submitted proposals for "Type B" systems embodying provision for stereo photography, enlarged film capacity, and higher resolution system features. The major innovations were the "scaled up" reentry capsule proposed by General Electric (and multiple installations of both the original Corona capsule of 33-inch diameter and the enlarged 45-inch capsule) and three technical features of the Eastman proposal: optional film transport mechanics which could provide either improved reliability or expanded film utilization; a programmable slit which improved the potential for high-latitude photography; and an improved lens with a potential of 120 lines per millimeter and a promise of better than six-foot resolution. Eastman also emphasized the growth potential of the proposed lens system.[71]

While Heran's team analyzed the details of the Eastman-General Electric proposals, the contractors continued along the line of supporting a 30 July launch. But that prospect was gradually dimming. Outside the world of SP-AS-63 there began, on 20 March, a special study evaluation of an "improved search type satellite reconnaissance system," which, on instructions from the new NRO director, Brockway McMillan, was to include "applicable variations" of the E-6 system. In fact, the only candidates were the M-2 and the E-6.

One of the chief reasons for E-6 cancellation, as a specific program, had been the apparent overlap between E-6 and such developmental or proposed systems as Gambit, Lanyard, and M-2. Lack of program success, lack of confidence in the recovery vehicle configuration or General Electric's ability to "fix" it, and the budget pinch of late 1962 were the real determinants, but the apparent lack of a performance niche not at least partially occupied by another system was also important.

Early in 1963, after E-6 had been terminated but before Spartan had been translated from concept to specific proposal, the United States Intelligence Board had forwarded to the NRO a restatement of the requirement for five-foot resolution stereo search coverage. Mural could not satisfy the requirement, and neither Gambit nor Lanyard was fully qualified. For practical purposes, the ad hoc committee appointed in response to McMillan's instructions was charged with recommending a suitable system.

The committee, under the chairmanship of Colonel W. C. King, new Gambit program director, met through late March and early April. In that same period, SP-AS-63 was continuing toward a still retained 30 July launch goal. The apparent contradiction between an experiment involving the E-6 camera system and an evaluation of its abstract worth was no more than a reflection of the intense desire to be ready with something quickly responsive to the prospective committee recommendations. Early in the investigation, it became clear that the E-6 system had significant resolution advantages over the M-2. Through his own channels, General Greer saw to it that the products of SP-AS-63 were inconspicuously introduced into the King committee deliberations. It thus became clear that the most probable recommendation the King committee could reach would call for reactivating the E-6 program, and this in fact was the outcome.[72]

But there were political complications, or considerations, that in this instance counterweighted the technical evaluation. McMillan was relatively new as NRO director, and was at that moment involved in negotiating a new NRO charter, a modification of the version which had ill served the needs of the organization under Dr. Charyk. In part because of Charyk's departure and the interregnum, Dr. Eugene Fubini (of the Directorate of Defense Research and Engineering) had been taking a larger hand in the proceedings of the satellite reconnaissance program. Fubini had been instrumental in inducing cancellation of the E-6, at least in his own belief, although at the time it was cancelled Charyk and Greer had actually made the decision. (Secretary McNamara and CIA Chief McCone had been willing to continue the effort, on Charyk's recommendation, even though Fubini had independently recommended that it be halted.) Scoville was firmly opposed to E-6 continuance before its cancellation and to its reincarnation, in any form, thereafter. Fubini and Scoville were clearly committed to eradication of the E-6; it would be difficult to induce them to reverse their stands.[73]

The possibility that E-6 in some form might be approved, or that at least an attempt to prove out the camera system in actual orbital operation might be authorized, had prompted General Greer to keep the SP-AS-63 effort alive while the King committee deliberated. After 15 April, and the submission of King committee recommendations, the SP-AS-63 activity continued at a gradually decreasing pace, but still in the hope of a favorable finding. Additional funds were provided in April and May, and the definitization deadline was concurrently extended until it finally moved into July.[74] But it was also becoming clear that events were conspiring against E-6 reincarnation, in any form. The relatively slight ground coverage that would result from any of the feasible experimental configurations added to the fact that there would be either no stereo coverage or that stereo coverage would be limited because of the necessary arrangement of film and mirror, tended to reduce the value of the experiment in the eyes of those concerned with the utility of the returned film. (That the Spartan approach had been deliberately designed to test the resolution of E-6 cameras and associated subsystems apparently was little considered in the April-May deliberations.) In any event, the fact that the King report was not accepted, and that this chance of reviving the E-6 faded, virtually ended the prospect of SP-AS-63 continuance.[75]

Nonetheless, as late as May 1963 the objective of the study program still included specific launch deadline: 30 August 1963. Four payloads, each based on a single E-6 camera, were considered for relatively slight modification. Recovery was still to be by means of Corona reentry vehicles, adapted to the film system of the E-6.[76] But coming more to the front was the long-term goal of a substantially improved E-6 system adapted to somewhat modified requirements. In May, Eastman was predicting 5.5-foot ground resolution with improved image motion compensation and 6.7-foot resolution with less adequate image motion features. In this instance, the payloads would be based on E-6 designs but probably would incorporate such radically modified subsystems as to be for practical purposes new equipment. (Improvements were programmed in the optics, the camera dynamics, combined lens-film performance, mirror drive, optical mounts, film supply cannisters, the vehicle midsection, the aft payload structure, system flexibility, thermal control aspects, ambient pressure operation, and various specialized elements.) By late May, Greer's people had redirected the Eastman effort from further consideration of flying E-6 payloads to a preliminary study of the prospect of using E-6 technology to support development of a new gross-coverage system capable of satisfying recognized requirements. General Electric's effort had been turned toward development of a new scaled-up version of the A-45 capsule, a "Mk VIII" reentry vehicle. The character of SP-AS-63 was substantially changed by that evolution, less than 25 percent of E-6 components being applicable to such a new system. (One consequence was the abandonment of the elaborate cover scheme involving equipment originally funded by the E-6 program office.)[77]

Early in June, Eastman submitted a refined proposal for the development of a gross coverage, moderate resolution, convergent stereo system based on E-6 technology. The firm still offered to develop either a complete vehicle, including subsystems, or the payload portions only, and suggested that four flight-ready vehicles could be delivered for $19.7 million. Four payloads alone (camera, film handling system, and related components), said Eastman, would cost the government $11.3 million. Asked to rate the newly proposed system against the E-6, Eastman Kodak responded that the new system would be "definitely superior" to the original E-6 payload. The contractor considered that the chance to refine the E-6 design had permitted major improvements: greater film capacity to allow complete coverage at a lower altitude; a simplified (in-line) film transport system with a start-stop platten for greater reliability and versatility; a higher reflectance mirror coating with resultant T-stop improvement; a programmable slit to improve the quality of high latitude exposures; a greater number of image motion compensation speeds; improved temperature control; the incorporation of a roll-joint; a standard recovery system with multiple recovery vehicles, and general improvements in system reliability.

Impressed by the potential, and still hopeful that something might come of the King committee recommendations that would permit surfacing the SP-AS-63 work as a starting point, General Greer in early July obtained a final increment of funds to keep the work alive for a few more weeks. (The $150,000 approved on 2 July raised the total of funds authorized for SP-AS-63 to an even $1 million.) But seven days later, on 9 July, Colonel Heran passed the word to his procurement officer that the contracts with Eastman Kodak and General Electric were to be terminated. The "high level" decision so long awaited had been received; E-6 was again comatose. Colonel Yockey notified both major contractors by telephone and began making arrangements for formal termination proceedings. Official notices went to the contractors on 12 July, but work had ceased three days earlier.[78]

It was not at all impossible that E-6 might be again revived, though not in its earlier form, since the basic requirement for a stable-quality, moderate-resolution search system had not been fully satisfied at the close of 1963. With the cancellation of Lanyard, none of the original E-systems of 1960 survived in any form, yet the requirements that had caused their generation remained. But at the same time the basic objections to E-6, in any form, remained unsatisfied. Clearly the decision hinged on more than raw technology; the mash of engineering, economic, and political factors that had so consistently influenced the total satellite reconnaissance program had much to do with the eventual disapproval of plans to develop a new search system based on E-6 technology. The validity of that technology had never been tested, of course. E-6 had been cancelled, rightly, because it was dependent on a faulty recovery system. Although experience with Mercury (and later Gemini and Apollo) recovery bodies demonstrated that sea recovery was a feasible alternative to air catch, the E-6 recovery system had no real capability along those lines. At the end, the experience of E-6 payload development was to have a considerable influence on subsequent developments that led, by 1966, through the S-2 search system proposals to the eventual Hexagon program. But all that was in the future.

NOTES ON SOURCES

1. See Chapter IV.

2. Interview, F.C.E. Oder (Col, USAF, retired), 4 Mar 63; LtCol R. W. Yundt, 13 Mar 63; Col J.W. Ruebel, 15, 16 Apr 63; Col R.A. Berg, 16 Apr 63, all SAFSP, by R.L. Perry. Col W.G. King, Samos Proj Dir in 1960, and Oder, his predecessor, were particularly outspoken opponents of concurrency. (Interview, King by Perry, 19 Dec 63.)

3. Ltr, LtGen R.C. Wilson, DCS/D, USAF, to Dir/Adv Tech, 9 May 60, subj: SAMOS; ltr, MajGen V.R. Haugen, Asst DCS/D USAF to Cmdr ARDC, 16 May 60, subj: SAMOS Development Plan; ltr, Wilson to Cmdr ARDC, 1 Jun 60, subj: Exploitation of Initial SAMOS Data; TWX RDRB 19-5-36-E, ARDC to BMD, 19 May 60, in SAFSP Samos file R&D-1 and Air Staff files.

4. Memo, H. F. York, DDR&E, to SAFUS, 6 Jun 60, subj: Samos R&D Operational Plans, in SAFSP Samos file, R&D-1; ltr, Capt H. Mitchell, DCS/I, ARDC, to BMD, 13 Jun 60, subj: SAMOS R&D Operational Plans, with rpt, "SAMOS," 13 Jul 60 (a preliminary copy of the DDR &E "Billings Report"), in SAFSP Samos files; see also Chapter

5. Col J.W. Ruebel, SP-3, described the CIA briefing of 1957 to R.L. Perry in a 15 Apr 63 interview. The U-2 affair has been exhaustively examined in a variety of books and articles.

6. The details of these developments are provided in Chapter VI See also Technical Work Stmt, SAMOS, E-6 Photographic/ Recovery Subsystems, 26 Jul 60, in E-6 files, R&D-1, Jun-Dec 60; AFBMD SO 540, 27 Jul 60, in SSD Hist Div files; ltr, E.S. Silberman, Contg Ofcr AMC-BMC, to various firms, 11 Aug 60, subj: Request for Proposal; ltr, MajGen O. J. Ritland, Cmdr BMD, to H. J. Brown, V Pres and Gen Mgr, LMSD, 10 Aug 60, subj: Soliciting for SAMOS E-6 System; ltr, Brown to Ritland, 18 Aug 60, same subj, all in E-6 files, R&D-1, Jun-Dec 60.

7. Charyk originally directed a change in requirements to 8-10-foot resolution and 5 days in orbit, changing it to "10 feet or better" after the NSC meeting. Bidders were notified on 26 Aug, following two days of uncertainty at the project office. See TWX AFDSD-AT 80036, USAF to ARDC, 23 Aug 60, and AFDSD-AR 80857, 26 Aug 60; memo, LtCol R.G. Atwood for Col W.G. King, Dir/Samos, to E.S. Silberman, BMC, 24 Aug 60, subj: Technical Work Statement for E-6 Version of SAMOS, with notes by Atwood on 25 and 26 Aug conversations involving King and Col H.L. Evans; charts used in NSC briefing, 25 Aug 60, left with Charyk by a BSD courier on 22 Aug, are in Samos files (the charts specify an 8-foot requirement first stated on 23 Aug and modified three days later); ltr, LtCol W.B. Botzong, Chm (temp), Working Gp Source Selection Bd, 18 Aug 60, subj: Submittal of Factors, in E-6 files, R&D-2, E-6 Sep 1960.

8. Rpt, "Program Review," 698BJ briefing to J.V. Charyk, SAFUS, 18 Sep 62, in files of Col P.J. Heran, D/Dir/698BJ; TWX SAFMS-EXEC-60-19, BrigGen R.E. Greer (from Washington) to Col W.G. King, SAFSP, 27 Oct 60; TWX SAFMS 99533, OSAF to BMD, 7 Nov 60 (the authorization to "terminate") and request for cancellation of EK 77-inch development, 10 Nov 60; TWX SAFMS 87078, USAF to BMD, 21 Sep 60; TWX RDRS 239-58, ARDC to WADD, 23 Sep 60, all in SAFSP files.

9. Memo, BrigGen R.E. Greer to BrigGen R.D. Curtin, 9 Dec 60, no subj, in SAFMS files, Samos Gen '60; memo Col W.R. Hedrick, D/Dir Eng, SAFSP, to Greer, 22 Nov 60, subj: E-6 Version of SAMOS; ltr, Greer to LMSD, attn H.J. Brown, VPres and GenMgr, 23 Nov 60, same subj: memo, Greer to E.S. Silberman, BMC, 1 Dec 60, same subj, all in E-6 files; memo, Maj J.S. Smith, Ch, Space Probes Div, Dir/AF Space Boosters, to Dir/AF Space Boosters, BMD, 7 Jul 60, subj: Booster Support for the AVCO DRAG BRAKE Program; ltr, J.B. Trenholm, D/Ch, Dynasoar SPO, WADD, to BMD, 14 Nov 60, subj: AVCO Drag Brake Program; TWX SAFSP DE-28-11-33, SAFSP to WADD, 29 Nov 60, in E-6 files, R&D-2, Source Sel; ltr, Col P.E. Worthman, Dir/Space Sys, BMD, to SAFSP, 20 Dec 60, subj: "WDZYC E-6 Responsibilities; ltr, Greer to Worthman, 25 Jan 61, same subj, in E-6 files, Mgt-7, Policy; TWX SAFMS-DIR-60-66, USAF to SAFSP, 22 Dec 60, in E-6 files, R&D Gen, Jul-Dec 60.

10. Memo, Col P.J. Heran, D/Dir Prog II, SAFSP, to MajGen R.E. Greer, Dir/SAFSP, 21 Mar 61, subj: Questions and Answers for Members of Congress, in E-6 files, R&D-1; interview, Col P.J. Heran, D/Dir 698BJ, by R.L. Perry, 27 Feb 63; Reubel interviews, 15, 16 Apr 63.

11. Rpt, Summary of SAMOS E-6 Technical Directors Meetings, 28, 29 Dec 60, prep by B.P. Leonard, Aerospace, in E-6 files, R&D-1 Gen, Jul-Dec 60.

12. Chron, Samos Prog II, Jan 61 (SP-5, Hist-2 file); memo for record, Col P.J. Heran, Samos Prog II Dir, Feb 61, subj: Program II Technical Decisions, in E-6 files, R&D Gen 1961.

13. Interviews, Col J.W. Ruebel, LtCol John Pietz, by R.L. Perry, 6 Dec 62, and Pietz by Perry, 27 July 63.

14. Interofc corresp, E.T. Clark, Aerospace Corp, to Col P.J. Heran, Dir/Prog II, 10 Jan 63, subj: Brief Summary 698BJ Vehicle Development and Outstanding Problems, in E-6 files, Mgt-7 Policy; chron, Prog II, Jan 61; memo, Col P.J. Heran, Dir/Prog II, to SAFSP, subj: SAMOS Program II Historical Report for Feb 1961; memo, LtCol R.G. Atwood, Ch, Ops Plng Div, Prog II, to Dir/Prog II, 6 Mar 61, subj: Critical Program Areas, in E-6 files, R&D-1, Gen, 1961; ltr, Col P.J. Heran, Dir/Prog II to SAFSP-P (Admin), 11 Apr 61, subj: SAMOS Program II Historical Report for March 1961, in E-6 files, Hist.

15. Memo for record, A.L. Gitchen, Aerospace Corp, 12 Oct 62, subj: Early Program History, in E-6 files, Mgt-2, Hist Doc.

16. Ltr, Col P.J. Heran, Dir/Prog II, to SAFSP (Admin Ofc), 11 Apr 61, subj: SAMOS Program II Historical Report for March 1961, and 19 May 61, subj: SAMOS Program II Historical Report for April 1961, in E-6 files, Hist; TWX SAFSP-MS-SEN-61-29, SAFUS to SAFSP, 9 Mar 61.

17. Ltr, LtCol L.C. Jochim, Asst Dep Dir Plans and Progs, SAFSP, to Dir/Prog II, 3 Apr 61, subj: SAMOS Program II Financial and Cost Proposal, General Electric, 23 March 1961, in E-6 files, Fin-1; ltr, Col P.J. Heran, Dir/Prog II, to SAFSP (Admin Ofc), 14 Sep 61, subj: Program II Historical Report for July and August 1961, in E-6 files, Hist; ltr, H.W. Paige, GenMgr, GE MSVD, to MajGen R.E. Greer, Dir/SAFSP, 12 Mar 62, subj: Expected Overrun of Contract AF 04(695)-6, in E-6 files, Proc-5-1-1.

18. Memo, LtGen J.F. Carroll, IG USAF, to OSAF-Dir/Mis and Sat Sys, 26 Jul 61, subj: Survey of SAMOS. . . Program, in SAFMS files, Samos Gen 61.

19. TWX SAFSS-INS-62-142, OSAF to SAFSP (MajGen R.E. Greer et al), 12 Sep 62, in E-6 files, Mgt-7.

20. Ltr, MajGen R.E. Greer, Dir/Samos Prog, to BrigGen R.D. Curtin, O-SAFUS, 3 Jul 61, subj: FY-62 Construction Funds, in E-6 files, Fin-61; ltr, Col P.J. Heran, Dir/Prog II, to Plans & Prog Ofc, SAFSP, 10 Jul 61, subj: Program II Construction Requirements for FY-63, in E-6 files, Fin-60; ltr, Heran to Plans and Prog Ofc 30 Nov 61, subj: Military Construction Program, same file; ltr, Col W.R. Hedrick, Ch, Satellite Control Ofc, SSD, to LtCol N. Rehbein, Admin Ofc, SAFSP, 4 May 62, subj: Program 201 Costs, in E-6 files, R&D-28-8.

21. Ltr, Heran to SAFSP (Admin Ofc), 19 May 61; ltr, Hedrick to Admin Ofc, 14 Jun 61; ltr, Heran to Admin Ofc, 14 Sep 61; ltr, Col W.R. Hedrick, Asst Dep Dir/Prog II, to SAFSP (Admin Ofc), 6 Oct 61, subj: Program II Historical Report for September 1961, in E-6 files, Hist-2; rpt, "Program 201 Highlights, September 1961, prep by E-6 Ofc, 10 Oct 61, in E-6 files; ltr, Col P.J. Heran, Dir/Prog II, to SAFSP (Admin Ofc), 7 Nov 61, subj: Monthly Historical Report-Oct 1961, in E-6 files, Hist-2.

22. Memo, E.T. Clark, Aerospace Corp, to B.P. Leonard, Aerospace Corp, cy to Col P.J. Heran, Dir/Prog II, 30 Oct 61, subj: GE Letter 850-061 of 24 October; ltr,

E.A. Miller, GE MSVD, to Heran, 24 Oct 61, no subj, both in E-6 files, Mgt-4, Policy 1961; memo for record, Col H.L. Evans, Vice Dir/Spec Progms (SAFSP), 7 Mar 62, subj: Red Flag Message Regarding Slippage in Launch Date of Program 201 Vehicle, in E-6 files, R&D-7-1.

23. Ltr, [redacted] Admin Contracting Ofcr, Phila APD, to H.W. Paige, Gen Mgr, GE MSVD, 2 Jan 62, subj: Show Cause and Cure Notice, Contract AF 04 (695)-6, in E-6 files, Proc 5-1-1.

24. Ltr, E.A. Miller, Mgr, Recov Satellite Progs, GE, to LtCol J. McMahon, Chm Prog 201 Acceptance Team, SSD, 19 Jan 62, subj: Acceptance of PV 851 for Shipment to Field Site, in E-6 files, Proc 5-1-1; ltr, McMahon to Miller, 19 Jan 62, subj: Vehicle 851 Acceptance, same file.

25. Ltr, M. Morton, Mgr, Re-Entry Sys Div, GE, to [redacted]. [redacted] Phila APD, 12 Jan 62, subj: Show Cause and Cure Notice, in E-6 files, Proc 5-1-1.

26. Ltr, Paige to Greer, 12 Mar 62.

27. Ltr, Morton to [redacted] 12 Jan 62.

28. Ltr, Col P.J. Heran, D/Dir Prog II, to Dr. B.P. Leonard, Aerospace Corp, 12 Feb 62, subj: Memo of Understanding, in E-6 files, Mgt-7; TWX SAFSP-DIR-30-3-8, MajGen R.E. Greer, SAFSP, to BrigGen R.D. Curtin, O-SAFUS, 30 Mar 62, in E-6 files, R&D 1-3.

29. TWX AFSTP-RA 79817, USAF to MATS, 17 Apr 62, cy in E-6 files, R&D 7-1; TWX SAFSP-TEN-19-4-54, SAFSP to MATS, Scott AFB, 19 Apr 62, same files.

30. TWX, SAFSP-F-17-4-232, MajGen R.E. Greer, Dir/SAFSP, to BrigGen R.D. Curtin, O-SAFUS, 17 Apr 62, in SP-3 files, Gambit Progm.

31. Rpt, Program 698BJ Malfunction Summary Report, [9 May 62?] in E-6 files, R&D 1-2, Veh Flts.

32. Briefing Summary, "Program Review," prep by E-6 Ofc for Undersecy J.V. Charyk, 18 Sep 62, in E-6 (Col P.J. Heran's) files.

33. TWX SAFSP-SEVEN 27-6-57, SAFSP to Col J.L. Martin, O-SAFUS, 27 Jun 62; Interofc corresp, R. Wood, Aerospace Corp, to E. Clark, Aerospace Corp, 10 Oct 62, subj: Mission Recapitulation, both in E-6 files, R&D 1-2.

34. Briefing summary, 18 Sep 62; interofc corresp, R.A. Wood, Aerospace Corp, to E.T. Clark, Aerospace Corp, 10 Oct 62, subj: Mission Performance Recapitulation, in E-6 files, R&D 1-2.

35. Interview, MajGen R.E. Greer, Dir/SAFSP, by R.L. Perry, 12 Mar 63; interofc corresp, R.A. Wood, Aerospace Corp, to E.T. Clark, Aerospace Corp, 12 Oct 62, subj: Mission Performance Recapitulation; interofc corresp, J.T. Sorrells, Test Dir, 698BJ, Aerospace Corp, to Col P.J. Heran, Dir/SP-7, 7 Aug 62, subj: Two-Day Report for Program 698BJ Flight Test #4, all in E-6 files, R&D 1-2.

36. TWX, SAFSS-DIR-62-80, O-SAFUS to SAFSP, 14 May 62, in E-6 files, Mgt-7; Briefing Summary, 18 Sep 62; Briefing charts, "approved by Gen Greer 20 Sep 62," in E-6 files (Col P.J. Heran).

37. Interofc corresp, H.K. Epple, Aerospace Corp, to N.E. Palmquist, Aerospace Corp, 10 Apr 62, subj: Water-to-air Pick-up Test, Program 201, in E-6 files, Ops 20-1.

38. TWX, SAFSS-DIR-62-89, O-SAFUS to SAFSP, 1Jun 62, in E-6 files, Ops 20-1; ltr, E.T. Clark, Dir/Prog 698BJ, Aerospace Corp, to Col P.J. Heran, Dir/Prog II, 21 Jun 62, subj: Paravane and Water Line Retrieval Method, in E-6 files, R&D 20-12; Briefing Summary, 18 Sep 62; briefing charts, 20 Sep 62; memo, Col P.J. Heran, Dir/SP-7, to [redacted] (Contracts), 3 Oct 62, subj: General Electric Contract AF 04(699)-6-CCN#33, in E-6 files, Ops 20-1; ltr, Heran to [redacted] (Programming), 25 Oct 62, subj: General Electric Contract AF 04(695)-6-CCN#33 and handwritten notes by LtCol Campbell, E-6 ofc, in E-6 files, R&D 20-12.

The rapidity of the cancellation of water-to-air recovery trials was an excellent indicator of organizational efficiency. On 3 October, Col Heran authorized tests of the recovery vehicle in combination with a JC-130. After receiving a report which indicated that General Electric had made no progress, Heran at 1105 hours on 24 October directed one of his staff to have the entire effort cancelled. By 1135 hours that day, all concerned individuals had been notified; the formal cancellation notice was in the mail the following morning.

39. Hist chronology, SAFSP, Jan-Jun 62; Briefing Summary, 18 Sep 62.

40. Briefing charts, 20 Sep 62.

41. Rpt, "Program Review," 18 Sep 62.

42. TWX SAFSS-DIR-O-SAFUS to MajGen R.E. Greer, SAFSP, 21 Aug 62, in E-6 files, Mgt-7; memo for record, Col P.J. Heran, Dir/698BJ, 22 Aug 62, subj: Comments on SAFSS TWX #DIR-123, in E-6 files, R&D-1, Highlights.

43. TWX SAFSS-DIR-62-130, O-SAFUS to MajGen R.E. Greer, SAFUS, 24 Aug 62, in E-6 files, Mgt-7; TWX SAFSS-PRO-62-199, O-SAFUS to SAFSP, 24 Aug 62, same file.

44. Briefing Summary, 18 Sep 62.

45. Ltr, MajGen R.E. Greer, Dir/SAFSP, to SAFSS, Col J.R. Martin, 26 Sep 62, subj: Revised 698BJ Follow-on Program, in E-6 files, Mgt-7; TWX SAFSS-DIR-62-153, Martin to Greer, 3 Oct 62, same file.

46. TWX SAFSP-DIR-4-10-1, MajGen R.E. Greer, Dir/SAFSP, to GE, et al, 4 Oct 62, in E-6 file, Mgt-7.

47. Draft memo prep by LtCol R.J. Ford, SAFSP, Oct 62, in Corona files; interviews, various dates in Dec 62, Jan, Feb 63, involving Col J.W. Ruebel, LtCol John Pietz, LtCol Ford, by R.L. Perry.

48. Interview, Greer by Perry, 12 Mar 63; TWX, SAFSP-SEVEN-27-9-88, SAFSP to O-SAFUS, 27 Sep 62; in E-6 files, Mgt-7.

49. TWX AS-62-0000-00035, 698BJ Test Dir, Aerospace Corp, to SAFSP, 13 Nov 62, in E-6 files, R&D 1-2-1; ltr, Col P.E. Villars, D/Cmdr Space Sys Test, 6594th Test Wg (Satellite), to 698BJ Prog Ofc, 21 Nov 62, subj: 698BJ Recovery Evaluation Report, in E-6 files, Ops 20-1.

50. Interviews, MajGen R.E. Greer, 5, 12 Mar 63; Col P.J. Heran, 27 Feb 63; Col J.W. Ruebel, 5 Mar, 7 Mar 63; LtCol John Pietz, 5 Mar 63, all by R.L. Perry. Colonels Ruebel and Pietz particularly remarked on the gloomy attitudes of those program people who reported the test results to General Greer and their impression that the mood was "we don't know what comes next." General Greer commented on his conclusion that the group did not know what had actually happened to either the fourth or the fifth reentry bodies and could offer no real hope for the sixth, if it were launched. Because of the prompt cancellation of the E-6, relatively little definitive data was forwarded on the location or intensity of aerodynamic heating during the reentry of number five. (At least, little found its way into the files of the E-6 office.) General Greer and Colonel Ruebel independently drew representations of the burn-through effects on their office blackboards and the author later compared his copies of their sketches with the "official" sketches in the formal report on flight four. The same conclusion that flights four and five did indeed suffer the same fate, and from the same cause is inescapable.

51. Interofc Corresp, E.T. Clark, Aerospace Corp, to Col P.J. Heran, Dir/Prog 722, 10 Jan 63, subj: Brief Summary 698BJ Vehicle Development Outstanding Problems, in E-6 files, Mgt-7 Policy.

52. Greer, Ruebel, and Pietz interviews; see note above.

53. Greer and Heran interviews, see note 50.

54. TWX SAFSS-1-62-174, O-SAFUS to SAFSP, 11 Dec 62, in E-6 files, Mgt-7, Policy.

55. TWX SAFSS-1-62-175 and 1-62-176, O-SAFUS to SAFSP, 11 Dec 62, in E-6 files, Mgt-7 Policy; Ruebel interview, 15 Apr 63.

56. Briefing resume, "698BJ Briefing in response to SAFSS-1-62-175," 1 Jan 63, presented to MajGen R.E. Greer, 14 Jan 63, (after presn to SAFUS), in E-6 (Heran) files. The presentation to Undersecy J.V. Charyk took place on 9 Jan.)

57. TWX SAFSS-1-63-08, O-SAFUS to SAFSP, 31 Jan 63, in E-6 files, Mgt-7 Policy.

58. Interview, MajGen R.E. Greer, Dir/SP, by R.L. Perry, 30 Nov 63. There are no written records of these discussions; none of the participants committed anything to paper.

59. Mtg Notes prep by MajGen R.E. Greer following 30 Jan 63 mtg, in SPAS files, "Marty's Place."

60. TWX SAFSS-6-M-0020, SAFSS to MajGen R.E. Greer, SAFSP, 30 Jan 63, in SPAS files.

61. Memo, MajGen R.E. Greer, Dir/SP, to LtCol Mark Farnum, 2 Feb 63, subj: Spartan Security; memo, Greer to Col J.L. Martin, Dir/NRO Staff, 1 Feb 63, subj: Project Spartan Organization; notes, "Presentation," 31 Jan 63, all in SPAS files.

62. "SPAS-63 Briefing," [2 Feb 63]; Work Stmt to Ltr Contr AF 18(600)-2113, 15 Feb 63; notes by LtCol F. Ned Hand, 5 Feb 63, all in SPAS files.

63. TWX SAFSS-6-M-0281, LtCol J. Sides, SAFSS, to MajGen R.E. Greer, Dir/SP, 6 Feb 63, SPAS files.

64. <u>Ibid.</u>; interview, BrigGen J.L. Martin, Dir/NRO Staff, by R.L. Perry, 8 Nov 63; interview, MajGen R.E. Greer, Dir/SP, by Perry, 15 Nov 63.

65. Management Plan, SP-AS-63, 12 Feb 63; draft, Proposed Procedure for Transfer of E-6 Residual Inventory to SP-AS-63 Project, 12 Feb 63, in SPAS files.

66. TWX SAFSS-1-M-0037, SAFSS to MajGen R.E. Greer, Dir/SP, 12 Feb 63, in SPAS files; interview, Greer by Perry, 30 Nov 63.

67. PR #63-SAFSP-XP2, 15 Feb 63 and ltr contr AF 18(600)-2113 and -2114, 15 Feb 63, to EK and GE, respectively.

68. TWX SAFSS-1-M-0037, 12 Feb 63; TWX SAFSP [no cite number], SAFSP to Col J.L. Martin, SAFSS, 18 Feb 63, in SPAS file.

69. Mgt Briefing, "Ph/V," 18 Feb 63, in SPAS files.

70. Memo for record, LtCol Mark Farnum, SAFSP, 26 Feb 63, no subj: ltr, A.E. Watson, GE Re-Entry Sys Dept, to LtCol D.E. Yockey, SAFSP, 19 Feb 63, subj: Letter Contract . . . -2114; various TWX items concerning the "cover" transfer of accountability for E-6 items were written in "Marty's Place" and mailed to the Wright Field contact for insertion into the "open" circuit. Included were ASRNRD-1-15-3-11 to GE 11 Mar 63 and ASNRD-1-15-3-13 to EK. "Sky Gem" was "cancelled" by ASRNRD-1-23-7-43 to GE, 23 Jul 63; all are in SPAS files.

71. EK Proposal for Design and Production of Type B Camera Payload, 15 Mar 63; EK Program Plan, Schedule, and Estimates Costs for Type A Configuration, 15 Mar 63; GE "Study Phase B," 15 Mar 63; ltr, K.C. Garman, EK, to (Col) P.J. Heran, SAFSP, 22 Mar 63, subj: Additional Type B Proposal Data, all in SPAS files.

72. Memo, MajGen R.E. Greer, Dir/SAFSP, to Col R.A. Berg, D/Dir, 21 Mar 63, subj: Comparison Study, names Col W.G. King (chm), Berg, Col P.J. Heran, two Aerospace Corporation scientists, a Rand representative, LtCol Mark Farnum, four SAFSP and SAFMS technical specialists, and two CIA representatives to the ad hoc group; the basic study requirement was specified in msg, OSAFUS to CIA and SAFSP,

20 Mar 63, subj: Improved Search Type Satellite Reconnaissance System; memo, Greer to D/NRO, 15 Apr 63, subj: Comparative Evaluation, contains Greer's endorsement of committee findings contained in rpt, "Report of the Findings of the Ad Hoc Group appointed to Evaluate Potential Systems for an Improved Search Type Satellite Reconnaissance System," to Dir/Spec Projs, Apr 63. The report is valuable not merely because of its comparison of E-6 ("BJ") with Mural ("M-2"), but because it contains a critical appraisal of the potential of several techniques and subsystems, analyzes resolution in terms of useful intelligence rather than abstract standards, and carefully examines real system costs.

73. Interviews, Greer by Perry, 30 Nov, 19 Dec 63.

74. Greer interview, 30 Nov; amends 1, 2, 3 to ltr contr AF 18(600)-2114, 11 Apr, 8 May, 1 Jul 63; amends 1 and 2 to AF -2113, 7 May and 1 Jul 63, SPAS files.

75. Greer interviews, 30 Nov, 19 Dec 63.

76. Work Stmts, SPAS-63, 6 May 63, in SPAS file.

77. Ibid.; TWX SP-AS-63-29-5-4, MajGen R.E. Greer, Dir/SP, to Col J.L. Martin, Dir/NRO Staff, 29 May 63; ltr, LtCol D.J. Yockey, SPAS Prog Ofc, to [redacted] 6 Jun 63, subj: Transfer of Accountability. . ., all in SPAS files.

78. Ltr, R.D. Lorbach, Mgr, Contr Admin, EK, to Col P.J. Heran, SP, 10 Jun 63, no subj: TWX SAFSP-F-27-5-720 to EK, 27 May 63; TWX SAFSS-1-M-0152, to SP, 2 Jul 63 (also SAFSS-1-M-0037, -0093, and -0152, to SP, which were earlier funds authorizations); memo for record, LtCol D.J. Yockey, 9 Jul 63; subj: Termination of -2113 Effort; ltr, MajGen R.E. Greer, Dir/SP, to EK, 12 Jul 63, subj: Letter Notice of Termination to Prime Contractor. . . Contract AF 18(600)-2113 and similar letter to GE re -2114, same date; ltr, A.E. Watson, GE, to Yockey, 22 Jul 63, subj: Letter Notice of Termination . . . -2114, all in SPAS file; interview, Yockey by Perry, 25 Nov 63.