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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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from earlier drafts
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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Illustrations have been separately bound in an Appendix volume.

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 1, 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 Corona 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

[redacted]

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) [redacted] received tentative approval for development. [redacted] on contract by January 1961.*

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

* 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 [redacted] raised the issue of whether all three major recovery systems should be carried to completion. They had several overlapping qualities. Lockheed had total responsibility

[redacted]

for E-5 and for the rapidly withering E-1 and E-2 satellite programs, and had prime responsibility for <u>Corona</u>, 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 <u>Corona</u>--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 1015 [redacted] 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 abou[redacted]Greer and King felt that something between [redacted] 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 [redacted] 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 1015 [redacted] 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 abou[redacted]ss than an E-2 payload.* The real issue was not whether [redacted] 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 [redacted] for the Atlas, [redacted] for the Agena, [redacted] for an E-2 payload and [redacted] for the E-5 payload, plus about [redacted] for laun[redacted]nd [redacted] for management se[redacted]

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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, [redacted]

E-5-[redacted]

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

[redacted]

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

[redacted]

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

[redacted]

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 [redacted] Accumulated program costs would therefore peak at [redacted] Approximately [redacted]f 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 L. C. Meyer, de facto treasurer for the satellite reconnaissance program. Rather than the [redacted] that some officials seemed to believe would be shifted from E-5 to other programs, about [redacted] 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 [redacted][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 [redacted] delayed availability, and probability of detracting from general system reliability made it seem unattractive to the program office. But Undersecretary Charyk was extremely [redacted] 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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* [redacted]

[redacted]

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

[redacted]

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 [redacted] 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 [redacted] 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 [redacted] explained that the USAF hoped to find part of a satellite. After several hours of delay, a direct phone call from Washington ordered [redacted] 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.

[redacted]

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 [redacted] 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,

[redacted]

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 [redacted] (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 [redacted] Costs would be somewhat higher, however, if Thorad were used--an expedient that would give the system a six-day life.[37]

[redacted]

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 [redacted] 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.

* 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, competi- [redacted]

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 [redacted] and Thorad development another [redacted] Thors and Agenas for the five proposed launches would cost another [redacted]

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."

[redacted]

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 [redacted] 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.*

* 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 Genera[redacted]eading 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 [redacted][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 [redacted]

[redacted]

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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 [redacted] each, while General Electric had received advance authorizations totaling [redacted] Program costs for the three were then estimated at [redacted] of which Itek would receive [redacted] and Lockheed [redacted] The total still was less than General Greer's estimate that the payloads would cost all of the [redacted] 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 abou[redacted][47]

Not until October 1962 was that basic schedule modified, and then by the purchase of three additional Lanyard payloads which would [redacted] 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[redacted]and[redacted] respectively, up a total of[redacted]over the original program estimate.[49] The cost of the entire Lanyard effort, it developed, would increase about[redacted]to a total of[redacted] 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 [redacted] 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 [redacted] as the officer responsible for the camera system.

Redelegation of contracting officer authority from CIA headquarters to [redacted] (a CIA officer assigned within the SAFSP establishment) served to pin down responsibility for the contractual elements of the program. [redacted] 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 [redacted] 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.

[redacted]

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]

[redacted]

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 Lanyard 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

[redacted]

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

[redacted]

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

[redacted]

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 [redacted]

General Greer emphasized, however, that the primary purpose of the study should be to uncover any payload technical problems that might [redacted]

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 [redacted] 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. [redacted] 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 [redacted]

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

[redacted]

developed, flight schedules would be jeopardized. Schedules were then so tight that the last sequence of camera tests had been re-scheduled 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

[redacted]

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

[redacted]

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

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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 [redacted]

But at the time there was considerably less assurance of [redacted] 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 Lanyard program as a consequence of the two successive disappointments.

[redacted] 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 <u>Corona</u>. If [redacted] Program. (It should be recalled that of the several reconnaissance systems carried to the point of orbital operation, only <u>Corona</u> 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 <u>Lanyard</u> 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 [redacted] If Lanyard use had to be accelerated following an onset of [redacted] 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 [redacted] on that score alone, discounting booster, Agena, and launch costs.[79]

[redacted]

[redacted]

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]

[redacted]

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 [redacted] 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]

[redacted]

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 [redacted] 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 [redacted] 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. [redacted] 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 [redacted] 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 [redacted] 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. [redacted] 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 [redacted] (including all contractor expenditures through September 1963).[89] Excluding vehicle, launch, and control station costs, the effort was scheduled to absorb roughly [redacted] 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 [redacted]

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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9. Ibid; ltr, Col [redacted] V/Dir/SP, to LMSD, 16 Jan 61, subj: E-5 and E-6 Priority, in E-6 [redacted] files.

10. Memo for Record, BrigGen R.E. Greer, Dir/SP, 16 Feb 61, subj: Trip Report, in Greer files, Samos policy.

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18. Samos Prog Rpt, 30 Sep 61, in SP Samos files.

19. TWX LMS[redacted]001/47-67-40, LMSC to SAFSP, 31 Oct 61, in SP Samos files, R&D 38-51/61; SAFSP Hist Chron, Jul-Dec 61.

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27. TWX conference between J. Schaub, LMSC, and Col W.G. King, D/Dir/101B, 20 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 [redacted] SAFSP, by [redacted] 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. [redacted] 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 [redacted] 15 Dec 51, subj: Comparative Evaluation of ITEK 0[redacted] Lens and The Perkin Elmer Lens; TWX [redacted]-18-12-125, SAFSP to LMSC, 18 Dec 61; TWX [redacted]18-12-124, SAFSP to ASD, 19 Dec 61; ltr, King to LAC, 15 Jan 62, subj: Comparative Lens Evaluation Test Conduct; TWX [redacted] 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.

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

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44. Msg [redacted] CIA to SAFSP, 4 Apr 62, in Lanyard files.

45. Interview, LtCol [redacted] and LtCol R.J. Ford, Corona ofc, 11 Oct 62, by R.L. Perry, Hist Div; memo, prep by Maj [redacted] 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 [redacted] 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] SAFSP to CIA, 18 Jun 62, in Lanyard files.

46. Msg [redacted] CIA to SAFSP, 7 May 62, in Lanyard files.

47. Msg, [redacted] SAFSP to CIA, 11 May 62; msg [redacted] LMSD to Itek, 11 May 62; msg, [redacted] 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 [redacted] files, Funding.

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

50. Progm Rpt, Nov 62, in [redacted]iles; ms[redacted] CIA to Itek, 25 Oct 62, in [redacted]les; msg [redacted] 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 [redacted] in Corona files, MFR's; msg [redacted] CIA to SAFSP, 6 Sep 62, in [redacted] files.

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

53. Msgs: [redacted] LMSD to Itek, 16 Oct 62; [redacted] Itek to LMSD, 19 Oct 62; [redacted] LMSD to Itek, 23 Oct 62; [redacted] CIA to Itek, 19 Nov 62; [redacted] CIA to D/NRO, [redacted] Nov 62; [redacted]o EK, 19 Dec 62, all in [redacted]les.

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

55. Msgs: [redacted] Itek to CIA, 13 Sep 62; [redacted] LMSD to Itek, 24 Oct 62; [redacted] Itek to CIA, 26 Oct 62; [redacted] LMSD to CIA, 3 Nov 62; [redacted] Itek to LMSD, 19 and 26 Nov 62, all i[redacted] files.

56. Msgs: [redacted] Itek to CIA, 26 Nov 62 [redacted] LMSD to CIA, 27 Nov 62 [redacted] Itek to CIA 4 and 18 Dec 62: [redacted] LMSD to CIA, 19 Dec 62, and [redacted] Itek to CIA, 29 Dec 62, all in [redacted] files.

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

58. Msg [redacted] Itek to CIA, 18 Jun 62; msg, [redacted] 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] 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/[redacted] 29 Jul 64.

64. Msgs [redacted] 3 Jan 63, [redacted] 9 Jan 63; [redacted] 15 Jan 63, and [redacted] 26 Jan 63, all Lockheed to CIA, all in [redacted] files.

65. Msg, [redacted] Itek to Lockheed, 31 Jan 63; msg, [redacted] Lockheed to CIA, 31 Jan 63; msg, [redacted] Lockheed to SAFSP, 5 Feb 63; msg, [redacted] Itek to Lockheed, 8 Feb 63, all in [redacted] files.

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

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

68. Msgs, [redacted] VAFB to CIA, 18 Mar 63; msg, [redacted] VAFB to CIA, 19 Mar 63; msg, [redacted] LMSC to CIA, 19 Mar 63, all in [redacted] files.

69. Msg, [redacted] CIA to D/NRO, 2 Mar 63; msg, [redacted] D/NRO to SAFSP, 5 Mar 63, both in [redacted] 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, [redacted] CIA to D/NRO, 20 Feb 63; [redacted] NRO to CIA, 20 Feb 63; [redacted] SAFSP (MajGen R.E. Greer) to CIA, 26 Feb 63; [redacted] CIA to SAFSP, 28 Feb 63; and [redacted] SAFSP (Greer) to CIA, 5 Mar 63, all in [redacted] files.

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

73. Msg, [redacted] CIA (Col J.C. Ledford) to Dir/NRO Staff (Col John Martin), 3 Apr 63, in [redacted] 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] Lockheed to CIA, 15 Apr 63; [redacted] Lockheed to CIA, 23 Apr 63; [redacted] VAFB to NRO Staff, 18 May 63; [redacted] VAFB to NRO Staff, 20 May 63; [redacted] VAFB to NRO Staff, 21 May 63, all in [redacted] files.

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

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

78. Msg, [redacted] NRO to SAFSP, 24 May 63, in [redacted] files; memo, LtCol [redacted] 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] SAFSP to Itek, 31 May 63, in [redacted] files, passed the order to Itek.

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

80. Msg, [redacted] NPIC to D/NRO, 17 Apr 63; msg, [redacted] LMSC to CIA, 18 Apr 63; msg, [redacted] NRO to SAFSP, 19 Apr 63; msg, LMSC to SAFSP, 24 Apr 63; msg, [redacted] NPIC to LMSC, 24 Apr 63, all in SP-12 [redacted] 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 msg [redacted] LMSD to CIA, 24 Jan 63, and [redacted] NRO to SAFSP, 4 Jun 63, both in [redacted] files.

81. Msgs, [redacted] VAFB to SAFSS, 31 Jul 63 and [redacted] VAFB to SAFSS, 2 Aug 63; msg, Eastman Kodak to NRO, 5 Aug 63, all in [redacted] 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] LMSC to CIA, 3 Sep 63; msg, [redacted] D/NRO to SAFSP (MajGen R.E. Greer), 23 Oct 62 (the termination directive); msg, [redacted] CIA to LMSC, 23 Oct 63; msg, [redacted] SAFSP (Greer) to D/NRO (B. McMillan), 2 Nov 63, all in NRO files, Lanyard.

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

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

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

86. Msg, [redacted] 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 [redacted] NRO Staff, 24 Apr 64, 1 Jul 64.

88. Martin interview, 18 Sep 64.

89. Msg, [redacted] tek to CIA, 2 Oct 63, in [redacted] 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

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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

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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

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