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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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Revised October 1973
from earlier drafts
of 1964 and 1965

Volume 11B consists of 183 pages.

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

A marked change in the Air Force attitude toward recovery of photographic intelligence was signalled by the 26 September 1958 publication of a new General Operational Requirement covering satellite reconnaissance. It embodied a "big" camera and film recovery. By December, the Advanced Research Projects Agency, then custodian of space program responsibility, had endorsed the approach. But it appeared that ARPA enthusiasm was not entirely altruistic. ARPA scientists were less interested in pursuing the original approach as in adapting the long focal length camera proposed for the recoverable satellite to use in an electrostatic tape readout system. And ARPA's interest in recovery was probably as much motivated by the desire to conduct a military man-in-space program as by any concern for recovering photographs. Thus the film-recovery concept embodied in 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 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, [redacted] 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

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

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

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

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

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

Lockheed did not agree. The contractor seemed convinced that the strategy of developing various subsystems in parallel--an approach that had been successful in the ballistic missile program--would provide adequate safeguards against the failure of any single technical feature. Though Lockheed's reaction was partly Pavlovian (R&D mores did not admit of the possibility that a contractor had not foreseen all possible contingencies), the emergence of E-6 [redacted] raised the issue of whether [redacted] major recovery systems should be carried to completion. They had several overlapping qualities. Lockheed had total responsibility for E-5 and for the rapidly withering E-1 and E-2 satellite programs, and had prime responsibility for Corona, but was no more than a vehicle supplier in the E-6 program. Lockheed, therefore, was vitally interested in having the E-5 remain attractive. E-5 was then considered to be a logical successor to Corona--still generally treated as an interim system with slight growth potential--although in fact E-6 was a more promising candidate. King, who had custody of the E-5 and all its predecessors but who had no important role in E-6 [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 about [redacted]reer and King felt that something between [redacted]as 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 [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 [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 about [redacted] less than an E-2 payload.* The real issue was not whether a [redacted] dollars might be diverted for each cancelled readout launch, but whether E-5 acceleration would serve any useful purpose.

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

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* In October 1960, basic costs included [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 launch services and [redacted] for management services.

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

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

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

The crux of the priority issue was not so much the development status of E-5 as that E-6 represented a solution to requirements for gross coverage, which carried higher priority than the specific target coverage mission for which E-5 had been designed.[10] Further, confidence in E-5 success had never been high since SAFSP acquired the program, [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 tinkering with the vehicles between their delivery and their erection on the launch pad. To this end, Greer insisted on comprehensive pre-delivery checks of critical subsystems, including "hot firings" of the Agena engines. That practice had for some months been the subject of a "running debate" between a group which held that repeated pre-flight operations of the rocket engine increased the chance of flight failure and a group which held that only through extensive engine tests could prospective faults be surely identified and corrected. It was not that SAFSP intended to run every Agena through such a test series, but as Greer emphasized, the first of each kind of system would be most extensively tested and about every fourth vehicle thereafter would go through the same checkout process.[13]

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

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

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

As it happened, other factors had intervened to insure a relaxation of E-5 launch schedules. On 9 September an Atlas-Agena carrying an E-2 payload exploded 1.5 seconds after ignition, severely damaging Pad 1 at Point Arguello. Initially there were estimates that the pad could be readied for an E-5 launching by 1 November, but later evaluation of both the damage and the status of the E-5 payload caused the program office to slip the initial launch date to 12 December. (Vehicle 2203