[redacted]

Remove this Page

[redacted]

Delete This

[redacted]

TOP SECRET

HANDLE VIA BYEMAN / TALENT-KEYHOLE CONTROL SYSTEM

A History of Satellite Reconnaissance Volume IIA

PREPARED FOR
THE NATIONAL RECONNAISSANCE OFFICE

BYE 17017-74

TOP SECRET

Warning

Published By

HQ AIR FORCE SPECIAL PROJECTS PRODUCTION FACILITY

~~TOP SECRET~~

[redacted]

A HISTORY OF SATELLITE RECONNAISSANCE

VOLUME IIA - SAMOS

by

Robert Perry

BYE-17017/74 3VL2A2 S

Revised October 1973
from earlier drafts
of 1963-1965, 1972

Volume IIA consists of 322 pages.

Copy 3 of 5 copies

Classified by BYEMAN - 1
Exempt from general declassification
Schedule of Executive Order 11652
Exemption category [ss 5B(2)]
Automatically declassified on
IMPOSSIBLE TO DETERMINE

ADDSY PROCESSED
Date -------- Initials --------

BYE 17017-74
Handle via Byeman/Talent - Keyhole
Controls Only

~~TOP SECRET~~

PREFACE TO VOLUME IIA

This volume of A History of Satellite Reconnaissance includes two parts, separated mostly because of bulk. It covers the origins, progress, and eventual demise of the satellite reconnaissance system generally known as Samos over a period extending from initial program acceleration in 1957 (following nearly 10 years of studies and very modest technical development activity, the whole costing rather less than $10 million) to the cancellation of the last photographic system in the Samos series in October 1963. Actually, work on the last of the "real" Samos systems was terminated in July of that year, but a half-breed survivor, Lanyard, lingered on for another three months.

Samos and its close relatives were distinguished from other photographic reconnaissance satellites in several respects. Notably, the six numbered systems in the E-1 through E-6 series were under high but ordinary security controls. Lanyard was an exception, and Spartan might have become a second had it survived; but Lanyard represented an attempt to transfer the better parts of one Samos system, the E-5, to the technical and operational environment of the highly successful Corona. It was attractive mostly in the absence of any alternative system with resolution better than that of Corona -- about 17 feet at the time. Once a better system emerged (and even

Corona shortly managed to surpass Lanyard performance, [redacted] made it totally inconsequential), Lanyard was an anachronism. As for the others, that they were given no special security protection said something of their reconnaissance programs.

The Samos family of photo reconnaissance satellites included three with readout antecedents (E-1, E-2, and E-3), four with film recovery capability (E-4, E-5, E-6, and Lanyard, a stereo-configured E-5 camera redesigned to fit a Corona payload and recovery package), and the spin-stabilized P-35 weather reconnaissance system. P-35 probably should not be counted as a Samos program because it was strikingly different in both technology and management. And the P-35 program had another distinction: success. It is included here partly for convenience, but mostly because it did not fit elsewhere.

The Samos program cannot be addressed in perspective without including consideration of [redacted] but conducted in quite another environment--and with very different results. The background and antecedents of [redacted] therefore, discussed in terms of their relationship to the original Samos effort as that becomes appropriate. However, [redacted] the [redacted] major photo reconnaissance satellite programs to emerge successfully

BYE 17017-74

Handle via Byeman/Talent-Keyhole Controls Only from the 1960s, are separately the subjects of Volume III in this series.

Matters of variant nomenclature were of sufficient concern for Volume I to warrant a prefatory discussion in that volume. They do not represent comparably troublesome items here. Samos titles and designators changed from time to time, often enough to insure the confusion of later researchers, but such changes are treated as they occur. References to program segments have been made consistent by adhering to the original E-series designators throughout.

CONTENTS, VOLUME IIA

Illustrations have been separately bound in an Appendix volume.

[redacted]

IV SAMOS: FROM SPUTNIK TO POWERS (1957-1960)

Note: The pre-1958 background of the Samos program has been treated in considerable detail in Chapter I, Volume I, of this series. It is only casually relevant to later events in the basic Samos program, which was influenced more by Sputnik and by the rapid pace of photo-satellite technology than by plans laid in the 1954-1957 period. Directly causitive factors are noted in the first pages of this chapter; for additional detail the reader should refer to Volume I and to other and more extensive narratives there cited.

Characteristically, the United States reacted to Sputnik and the threat it appeared to represent by dumping money and manpower into a hodgepodge of space and satellite programs. For practical purposes, the initial reaction was channeled into three general areas. First and foremost, there began a frantic effort to "restore the national image" by some sort of flamboyant feat that would demonstrate the excellence of American technology and prove the essential soundness of pre-1958 space program management. Predictably, the effort was a flat failure. The early beneficiary was Vanguard, the American "scientific satellite." Vanguard launches, starting in December 1957, probably represented the most widely publicized set of failures in modern history. Although some Vanguards eventually went into orbit--and the program consumed vastly greater sums than ever contemplated--the effort chiefly served to prove that the "space program" of 1955-1958 had been distinguished by strikingly bad judgment at the secretarial level. The Army's Explorer satellite, rescued from ignominious storage in a warehouse where it had been hidden for months, finally junketed into orbit four months after Sputnik I. It was the petulant contention of Major General J. B. Medaris, chief of the Army's rocket research program, that the feat could have been performed many months earlier had it not been for the intransigent obstructionism of the Secretary of Defense. For the remainder of 1958, a succession of discounted failures and over-publicized successes in space probe and satellite projects chased across the front pages of the nation's newspapers.

A second response to the Sputnik scare was the creation of new agencies, czars, committees, and study groups--each supposed to perform some magic that would suddenly compensate for five years of misjudgment and maladministration. Most were of transitory importance. Only two endured: the Advanced Research Projects Agency, named custodian of all military-purpose space activities, and the National Aeronautics and Space Administration, charged with conducting a peaceful-purposes scientific space program.

The third pattern of response to Sputnik was the acceleration, expansion, and modification of established space developments. With minor exceptions, these were based on the WS 117L reconnaissance satellite program, a starveling which until late 1957 had been carefully hidden from public view because it could not be easily accommodated to the "peaceful uses of space" image prized by the Eisenhower administration.

Conducted by a scant handful of imaginative scientists and engineers, WS 117L had been allotted sparse resources since its 1954 inception. Stunted though it was, it nonetheless represented the only well-grounded United States space program when space suddenly became respectable, in October 1957. As might have been anticipated, pressure for acceleration and for the creation of interim satellites focused on the project office immediately thereafter. Roles and assignments for the booster and second stage proliferated. A serendipitous compatibility of the WS 117L upper stage with the Thor missile permitted creation of a deviant program, later named Discoverer, which had some prospect of early success. But Discoverer was actually a cover program cloaking the quiet development of the Corona reconnaissance payload. For practical purposes, Discoverer-Corona went its own way, independent of the main course of WS 117L development and ignored by most WS 117L participants. They concerned themselves with the continuing effort to provide photographic reconnaissance from a system embodying the Atlas booster and the Lockheed second stage that ultimately became Agena.

Thor and Atlas became first-stage boosters for a variety of probe and satellite payloads, and the upper stage of the original WS 117L (Agena) was called upon to support several newly conceived satellite programs, both military and scientific in objective.

What remained in the 117L effort after the propaganda projects had been peeled away, after scientific satellites and communication satellites and navigation satellites and weather satellites had been shaped and separated, was a military reconnaissance satellite program that had rather surprisingly survived the first year after Sputnik.

Through most of 1958 the concept of 117L satellite reconnaissance involved an Atlas that would boost into orbit a camera-carrying Agena. Rather than detaching a reentry capsule to return exposed film (as did Corona), the orbiting Agena would rely on a scanner-transmitter to transform photographs into electronic signals and relay them to ground stations for reconstruction. Two alternative techniques involving infrared-sensitive detectors (subsequently the Midas program) and electronic signal recorders (later the individual ferret subsystems) still were embryonic at that time.*

*Midas, which was completely separated from the balance of the WS 117L effort during 1959, is not considered part of that effort for the purpose of this account. Electronic sensor subsystems and their development are treated separately.

Originally, WS 117L had been conceived around a television transmission system and magnetic tape as the mode of returning reconnaissance information from orbit. By 1956, however, the television-magnetic tape technique had been relegated to secondary consideration and primary emphasis shifted to a conventional film-camera combination with on-board film processing and electronic transmission.[1] The future use of either magnetic or electrostatic tape was not excluded from consideration, but for the moment technological difficulties made them less than feasible.

As late as March 1958, WS 117L embodied concepts refined in 1956. A "pioneer" system built around a six-inch (focal length) lens, and an "advanced visual" system embodying a 36-inch lens were conceived as the basic data gathering devices. Both infrared and electronic collectors were being considered by that time, but the chief emphasis remained with visual modes.[2]

Although "readout" remained the accepted data retrieval method, suggestions that physical recovery of a film capsule would be a preferable alternative had been heard at intervals since mid-1956. In June of that year, Rand researchers published an unassuming classified paper which suggested the feasibility of recovering satellite payloads, briefly noted reasons for considering that option, and defined the technical requirements of a recovery system. Two of the "justifications" were basic to the Corona program, adopted early in 1958: photographic coverage of closed areas in advance of the availability of a readout system, and the accumulation of knowledge concerning recovery techniques. A third justification was implicit in the subsequent conflict between recovery and readout: the amount of information a satellite could gather and return in a given period was considerably larger by way of capsule recovery methods than by readout. The study affirmed the technical feasibility of recovery, categorized it as an "inherently simple method," and included calculations indicating that a 50-pound payload could be returned in a capsule weighing only 228 pounds.[3]

Slight consideration was given the suggestion over the following year, partly because of funding difficulties that hobbled the entire reconnaissance satellite effort during that time but more immediately because there still was no proof that an encapsulated payload could be retrieved from orbit. Not until 1957, when the first ballistic missile nose cones were recovered, did scientists have empirical proof that any object re-entering the atmosphere from orbital altitudes could survive. Under the circumstances, it seemed sounder to hinge a reconnaissance satellite program on known and demonstrated image transmission techniques than on the considerable uncertainties of atmospheric re-entry. Moreover, satellite reconnaissance requirements as then understood tended to emphasize the need for attack warning rather than for targeting, search, or surveillance. The objective of obtaining prompt intelligence on specific activities of a prospective enemy made readout, with a quickly available product, seem much more attractive than recovery, with its indeterminate delay for retrieval and processing of film that might have been exposed days earlier.[4]

Interest in recovery revived in October and November 1957, partly because of a new Rand study which urged the substitution of a deboost and water recovery mode for the readout technique embodied in the current 117L program. Although paying particular attention to the feasibility of early systems based on Thor boosters, Rand also suggested development of a family of satellites that included vehicles lofted by Atlas boosters.[5]

Such proposals were generally submerged in the enthusiasm for the Discoverer-Corona programs that evolved during the early months of 1958. Nevertheless, as early as March 1958 the prospect of employing recovery techniques in the Atlas-boosted WS 117L began to receive renewed consideration. Indeed, one of the secondary justifications openly volunteered for the Discoverer at the time of its inception was that it might prove the value of recovery "as a data acquisition method."[6] Brief suggestions that such an option deserved investigation appeared in development plans that the Ballistic Missiles Division submitted to Air Force headquarters on 15 March and on 1 July 1958.[7]

If it had not other importance, the mention of recovery as an alternative to the accepted readout mode hinted that some question of readout adequacy had been raised. On the surface, there was as yet no indication that the question might become a controversy.

The "pioneer" readout system, later the E-1,* was intended to provide in-camera definition approaching 100 lines per millimeter, based on an f/2.8 lens in combination with a very fine-grain film. Orbital operation was predicated on the assumption that the camera system would function for five minutes during each pass over the "area of interest" and that on subsequent orbits three receiving stations within the continental United States would "read out" the intelligence thus acquired. (The stations were to be located at Fort Stevens, Oregon,

---

* The letter designators assigned individual WS 117L subsystems had the following basis: Subsystem A - Airframe; B - Propulsion; C - Auxiliary Power; D - Guidance and Control; E - Visual Reconnaissance; F - Electro-magnetic Reconnaissance (Ferret); G - Infrared Reconnaissance (later Midas); H - Communications; I - Data Processing; J - Geophysical Environment; K - Personnel; L - Biomedical Recovery. The E-designators ultimately ran from E-1 through E-6, the F-designators through F-4.

Ottumwa, Iowa, and New Boston, New Hampshire; Offutt Air Force Base was to be the satellite operations control center.) It seemed probable that an efficient processing and dissemination complex would permit at least 10 percent of the derived intelligence to reach the central analysis station within one hour of its receipt and the remainder within eight hours. The Strategic Air Command wanted an eventual "near real time" system, of course, hoping to use it for attack warning as well as general intelligence. Each of several vehicles to be aloft simultaneously was to have a useful time on orbit of 10 to 30 days, limited principally by battery life. The initial system (E-1) was designed to permit identification of ground objects measuring 100 feet on a side. The "advanced" E-2 was to produce images that would permit "visual resolution" of objects 20 feet on a side and was to have a potentially long orbital operating life--assuming the availability of either solar or nuclear power sources.

One key to a useful readout system was a data processing subsystem which would include the equipment, techniques, and procedures to transform recorded raw data into intelligence--and to disseminate it to using agencies. Ground receiving stations, therefore, would identify, record and retransmit information to an "Advanced Reconnaissance System Intelligence Center" (predictably dubbed "ARSIC"). The

Intelligence Data Processing Subsystem ("IDPS"--later Subsystem I) was to be capable of performing all functions needed to transform the raw data into useful intelligence: processing, screening, interpretation, collation, evaluation, indexing, storage and retrieval, analysis, display, dissemination, and presentation.[8]

The orbital vehicle--the upper stage and payload sections--was to be 19 feet long and 5 feet in diameter, was to carry a 2680-pound payload, and including 5080 pounds of propellants would weigh 9300 pounds at launch. The somewhat loosely defined operational concept of March 1958 anticipated that ultimately each of several E-2 satellites simultaneously on orbit would have a useful life of one year and be capable of providing 17-foot ground resolution.[9]

Spot surveillance of selected targets rather than general reconnaissance was the objective of the development program. Surveillance of this nature was intended to provide advance warning of an imminent attack, a concept emphasized by application of the name Sentry to WS 117L in June 1958. Unhappily, concept had little relevance to reality. Although a camera and readout system that could actually resolve objects 17 feet on each side would be capable of locating and identifying intercontinental missile sites, the total system was incapable of such precision. Moreover, within the existing state of the art, the capacity of the system to scan and transmit images to ground stations was severely limited.

Even though electronic transmission of photographs to ground receivers degraded definition, the chief objection to readout was that relatively little area coverage could be provided each day. Exposing the film, transporting it, and processing it presented few difficulties compared to the enormously complex and time-consuming tasks of electronically scanning each negative frame, transforming its photographic content into analog signals, transmitting those signals to ground stations, and reforming the images in those stations.

The readout technique that had evolved by 1958, and which was refined but not radically changed during the next two years, embraced a strip camera subsystem loaded with 4500 feet of 70-millimeter film. (Corona would carry about 15000 feet of three-inch film in its payload.) The film moved past a slit aperture, which served as a shutter, at a rate determined by image motion compensation settings. (The "slit" was actually a line scribed through the aluminum coating on a glass plate.)

Once exposed, the film was pressed against a chemically impregnated web at intervals over a period of approximately 16 minutes. The pre-soaked web contained all the necessary developing and fixing ingredients. After completing the processing stage, the developed film went to a storage section--a series of loops which held it in readiness for later scanning and transmission.

The readout mechanism consisted of a revolving drum line scan tube, a scanner lens system, a light collecter lens system, a photo multiplier tube and a video amplifier. An electron beam which focused on the phosphor-coated inner surface of the revolving drum was emitted through an optically flat window, the light beam going through a scanning lens that was moved vertically by a motor-driven cam. The lens moved a spot of light across the width of the processed film as the film moved laterally through a readout gate. The beam motion had the shape of a square wave, permitting continuous top-to-bottom, bottom-to-top travel rather than returning to a zero point for each scan operation. That portion of the beam which passed through the film was collected by another lens system capable of relaying 75 percent of the transmitted light to a photomultiplier tube which transformed the light energy into electronic signals. After passage through a video amplifier, those signals were relayed to the satellite's communication equipment section for transmission to ground stations.

Image motion compensation, exposure control, and focus factors were set by command from a ground station. Attitude recording, a key factor for interpretation, was provided through inscription of a binary code on the edges of the film.

The process, though complicated, could be performed by existing or available techniques and equipments. Limiting technical