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A History of Satellite Reconnaissance

Volume III B

PREPARED FOR

THE NATIONAL RECONNAISSANCE OFFICE

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A HISTORY OF SATELLITE RECONNAISSANCE

VOLUME IIIB - HEXAGON

by

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PREFACE TO VOLUME IIIB

This portion of A History of Satellite Reconnaissance covers the period of Hexagon gestation before April 1966 as well as the development and early operational missions of that system. At the time this preface was written, in November 1973, the agreed terminal point was July 1973. Therefore nothing that relates to Hexagon mission 1206 (the sixth flight) or subsequent operations is detailed here, and plans for improvements are discussed only as they existed in July 1973. It seems reasonable to assume that at some later time the subsequent flight and developmental history of the system will be completed, but that must for the moment be treated as conjecture rather than promise.

The author's research for this volume was supported by Robert A. Butler, at the time of writing a consultant with Technology Service Corporation, of Santa Monica, California. The history was prepared under terms of a contract between the Directorate of Special Projects (Program A) of the National Reconnaissance Office and Technology Service Corporation.

As detailed in the following pages, Hexagon was the outgrowth of effort undertaken in two earlier pseudo-program enterprises known as Fulcrum and S-2. Both have been treated here in somewhat greater detail than might ordinarily be warranted, given that Hexagon, as eventually operated, was strikingly different from its apparent predecessors. But the problems that beset Hexagon development from 1966 to 1971 were unmistakably derived, in considerable part, from the assumptions, premises, plans, schedules, and concepts that characterized those predecessor activities. As several principal officials of the sponsoring development agencies later conceded, Hexagon was prematurely advanced from engineering development to system development. Unwittingly, it became at once the most costly and the most lengthy of the several ambitious developments undertaken in the first 10 years of the National Reconnaissance Program. In the end it also became one of the most successful, and that happy outcome largely offset whatever criticisms might have been leveled at its pre-operational phases.

Because Fulcrum, as a program concept, and the Hexagon camera system as a whole were entirely CIA-managed efforts, a full history of the program should not be prepared without first reviewing CIA records. As written, this account is academically defective in that the author had no access to CIA sources. Nevertheless, the principal aspects of the total program appear to have been thoroughly documented in "Program A" records (kept in the El Segundo, California, offices of the NRO's Directorate of Special Projects) and in policy documents filed in the offices of the NRO staff (in suite 4C1000 of the Pentagon). To the author, therefore, it seems unlikely that any subsequent expansion or enlargement of the manuscript will cause significant alteration of either the recorded sequence of events or the interpretations attached to them.

As with earlier program history contained in this set of volumes, there is no reasonable prospect of understanding the course of events in one system program without taking account of developments elsewhere in the National Reconnaissance Program. Thus from time to time it is essential to discuss events in such programs as Corona, Gambit, Samos, and Kennan--and to consider in the broad the plans and policies adopted by the Director of the National Reconnaissance Program, the Director of the Central Intelligence Agency, the United States Intelligence Board, the Executive Committee for the National Reconnaissance Program, and the several other officials, boards, panels, and agencies which influenced the establishment, growth, and conduct of Hexagon. Many of the events so mentioned have been described in greater detail in other volumes of this history: Corona, Samos, and Gambit, for instance, are the subjects of Volumes I, IIA, IIB, and IIIA of this set of reconnaissance program histories. Readers concerned about background and detail that involved those programs with Hexagon should consult those other volumes.

In the interests of avoiding repetition, most interactions between Hexagon and other programs have only been summarized here. Such summaries have been included, even if occasionally repetitious of earlier volumes, in the expectation that some readers will want to have within one set of covers reasonably complete information on Hexagon alone. This volume has therefore been constructed so that it will stand alone, without recourse to other sources, although in some instances it will be necessary to consult those other sources in order to acquire a full understanding of incidents and events mentioned casually here.

The close interaction of Hexagon and Gambit is the principal justification for making histories of those programs Volume IIIA and IIIB of the complete set. Keeping them physically separate from one another has an additional advantage: should it later prove feasible and appropriate to do so, each volume can be extended to include the later histories of those programs without forcing revision of these chapters and pages.

Finally, it is essential to acknowledge the very considerable assistance of Colonel Frank S. Buzard in providing detail and background information and in clarifying both technical and management matters that for one reason or another were either casually explained or ignored in the voluminous documentation of the Hexagon program. The source notes that follow the text do not adequately credit the comments, additions of detail, and explanations of confusing events that he provided throughout the period of background research for this volume and--most particularly--upon reviewing the initial draft. This acknowledgement must serve as the author's apology for that shortcoming of the manuscript.

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Introduction and Background

Hexagon stemmed immediately from a program known as Fulcrum, which began as an Itek Corporation study initially funded by the Central Intelligence Agency in January 1964. But Fulcrum was preceded by an extended period of technological rummaging about in the requirements for a new search system--a replacement for Corona and for the failed Samos E-6. The conduct of Fulcrum and the subsequent emergence of a Hexagon program were marked by two years of variously intense controversies about requirements, schedules, technology, and organizational prerogatives.

Corona, it will be recalled, had never been intended to serve as more than an interim search system, a temporary and presumably inferior predecessor to other and more capable systems to be developed during the late 1950s and early 1960s. But by 1961 several of the planned successor reconnaissance satellite programs were in technical and financial difficulties while Corona was becoming an operationally effective and generally reliable search system with considerable potential for growth. How that potential should be exploited, and to what extent Corona might be utilized in the place of other and less attractive reconnaissance satellite systems, had become of considerable interest to the intelligence community by 1962; the composite issue of what system, if any, should eventually replace Corona, involved questions of institutional prerogatives, camera and space vehicle technology, and national requirements for overflight photography that were not acted upon until 1966 and were not fully resolved until 1970.

Once the dual-camera, stereo-capable Corona-Mural system had been proved technically feasible, it was inevitable that a still better system based on Corona concepts and hardware would be proposed. In March 1962, the CIA endorsed an Itek proposal to develop what came to be called the M-2 search system (for Corona-Mural-2). It involved the substitution of a single 40-inch f3.5 lens and a dual-platen film system for the dual-camera Corona-Mural then in use. The estimated cost of design and manufacture seemed acceptable in that the system promised to return broad-area photography with resolution of about four or five feet for considerably less than would be expended in obtaining such performance from alternative systems then proposed or in development.

The M-2 proposal was formally presented for NRO review on 24 July 1962. Six months earlier, in December 1961, the E-5 surveillance system being developed under the aegis of the original Samos program had been severely cut back, and in July 1962 a programming error had caused the last of the E-5 recovery capsules to stabilize in a high orbit where it would remain until decay and reentry "somewhere east of Africa" more than a year later. Lanyard, a relatively inexpensive composite of E-5 camera technology and Corona vehicles, was making reasonable progress toward a scheduled first launch in December 1962, but like E-5 and Gambit, Lanyard was predominantly a surveillance system.* If Gambit were successful, there would be no need for Lanyard.

Corona, E-5, and Lanyard were Itek camera developments. The need and real potential for Corona improvement was still uncertain. E-5 had been cancelled, and Lanyard was a dubious prospect. Corona, and to some extent Lanyard, represented the only satellite reconnaissance programs under CIA control. The various Samos efforts (by 1963 reduced solely to an E-6 effort with a record of five successive mission failures and a most unpromising future), Gambit, and the several radiation-sensing satellites, were under the cognizance of the NRO's Directorate of Special Projects, on the West Coast. If E-6 could be

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* E-5 and Lanyard were intended to be surveillance systems, and Gambit to be a technical intelligence system. But because only the latter became operationally available, it served as and often was characterized as a surveillance system, none other existing.

made to work, and Gambit performed as its developers anticipated, neither Itek nor the CIA could be sure of a continuing direct role in the development and operation of reconnaissance satellites.

That circumstance was well appreciated by the Department of Defense, the CIA, and all of the participating contractors. Although interagency working level relationships had been outstandingly effective during the earlier days of Corona operations, they were less so by 1963; the CIA and DOD participants in Corona were by then engaged in organizational skirmishing that was within two years to become a source of major concern to cabinet-level DOD and CIA officials.

Operating-level difficulties were paralleled by institutional conflicts at the NRO level, where they would contribute to the 1963 resignation of the CIA's designate as deputy director of the NRO (Herbert Scoville) and the later departures of an NRO director (Dr. Brockway McMillan), his CIA opposite (Dr. A. D. Wheelon), and several lesser officials. Although a variety of questions involving funding responsibilities, program management authority, and organizational prerogatives (as well as some personal differences) influenced events, a central theme in the whole period between 1962 and 1966 was the selection of a new search-mode reconnaissance satellite.

When the M-2 proposal first was formally presented to NRO program reviewers in 1962, the E-6 "successor system" originally intended to provide better search coverage capability than Corona was entering its yet-to-be-acknowledged final decline. E-6, carrying two 36-inch focal length cameras, could in several respects provide nominally better coverage than Corona, but by late 1962 a series of sequentially introduced Corona improvements had made the E-6 relatively less attractive. Then the first two attempts to operate E-6 on orbit ended in recovery failure; perhaps as important, they had been accompanied by serious camera system malfunctions. In July and August 1962, the third and fourth E-6 missions also ended in failure. In October, E-6 seemed so little promising that Major General R. E. Greer (NRO Director of Special Projects) and Dr. J. V. Charyk (then NRO director) decided to suspend plans for the purchase of operationally configured systems. The fifth E-6 sank in the Pacific in November 1962, damaged by reentry heating. Although there were indications of acceptable on-orbit camera operation before the reentry sequence began, by that time the potential advantages of E-6 over Corona-Mural had all but disappeared. The older system was returning film images with resolutions on the order of 13 feet. Even if E-6 could do better--still not at all certain--and could provide broader coverage because of greater film capacity, the Corona system had reliability attractions that E-6 seemed to lack. Notwithstanding determined efforts to diagnose and correct the defects E-6 had displayed in five successive mission failures, there was no real assurance that the system could be made to work. In January 1963, therefore, Charyk cancelled the E-6 program.[1]

The still undetermined future of Corona M-2 was clouded, during the late months of 1962, by the emergence of another Corona variant, the dual-capsule Corona-J system. Although not formally approved for development until October of that year, Corona-J had actually entered a phase of engineering design in July, with a first launch scheduled for May of 1963. (Because of problems mostly external to Corona-J, actual first launch did not occur until August 1963.) Another objection to proceeding with M-2 was the proposed development of an "improved" and re-engineered E-6 utilizing proven components in place of many troublesome elements of the original. Yet another was the lack of a stated requirement for a relatively high resolution search system, although the requirements that had warranted a 1961 start on E-6 development still remained to be satisfied.

Notwithstanding such uncertainties, the Directorate of Special Projects awarded a study contract to Eastman Kodak in January 1963 that called for examination of the high-resolution, broad-coverage mission and means of performing it. Called Valley, the project quickly focused on a large-optics system providing resolutions of 1.5 feet or better, to be placed in orbit by a Titan IIIC booster. The difficulties of providing wide area coverage at such resolutions finally caused termination of that part of the study effort. The promising consequences of flying very large optics led, however, to the development of Gambit-3. Moreover, research undertaken after cancellation of the original E-6 Samos program together with the search phase studies led toward Eastman's S-2 designs of 1964.

In the Spring and early Summer of 1963, CIA reconnaissance specialists had proposed two alternatives to M-2 as candidates for the "next generation" reconnaissance satellite. One was a vehicle that could be flown covertly, that could be represented to be something other than a reconnaissance vehicle. Disagreements about the validity of and need for such a concept had been involved in Scoville's resignation in June 1963.

The second concept was even more controversial: the agency suggested the need for a system that could perform wide-area coverage at very high resolutions, the proposed requirement emerging from a series of studies conducted by CIA system analysts in early 1963. Such requirements uncertainties were passed on to the Purcell Panel, a special reconnaissance study group established by John A. McCone, Director of Central Intelligence, in the Spring of 1963.*

Perhaps surprisingly, the Purcell Panel concluded that "the natural incompatibility of wide coverage and high resolution within a given payload, is becoming more acute. . . as the art advances." An effort to combine the two functions in a single system "with only a modest improvement in resolution. . . would not be a wise investment of resources," the committee decided. Rather than to focus immediately on development of a new system, the NRO was urged to concentrate on improving the average quality of returns from Corona. The Purcell Panel made a number of specific suggestions for lines of research that promised to lead in that direction. But the panel suggested that

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* The "Purcell Panel," headed by E. M. Purcell, included A. F. Donovan, E. G. Fubini, R. L. Garwin, E. H. Land, D. P. Ling, A. C. Lundahl, J. G. Baker, and H. C. Yutzy--perhaps the most distinguished group of authorities on reconnaissance, space, and photography ever to be collected in one study group. Many of the

a new system, though ultimately needed, was for the moment a lesser requirement.

The Purcell Panel report had several interesting repercussions, some of them delayed rather than immediate. One that was to become important somewhat later involved interpretation of the qualifications in the "not a wise investment" judgment. The CIA ultimately argued that the panel had endorsed development of a combined search-surveillance system with more than a modest improvement in resolution. The NRO's special projects directorate tended to emphasize the panel's view that combining high resolution with wide coverage was an exercise in natural incompatibility. But in any event, the panel plainly had refused to accept the findings of an earlier study group organized by Greer, at Charyk's direction, in April 1963. Concerned with the broad issue of what should be developed in the way of a new search system, the West Coast group (headed by Colonel Paul Heran) decided that an "improved" E-6 camera system coupled to an enlarged Corona-style recovery capsule should be developed in parallel with the proposed Itek M-2 system, the more promising of the two being produced once its superiority had been verified.

"Purcell Panel" members subsequently became members of the "Land Panel," which between 1965 and 1972 operated as the principal advisor for reconnaissance matters to the President's Scientific Advisory Group and the President's Science Advisor.

(It is worth recalling that by early 1963 the E-1, E-2, E-5 and E-6 had all been cancelled, Lanyard was in some early difficulty, while Gambit, still untested, was recovering from technical and financial troubles that in October 1962 had led to major program restructuring and the assignment of a new project head. The interest of the "Ad Hoc Group" in sponsoring parallel programs and in delaying a system choice until one or the other had demonstrated its capability for effective orbital operations becomes readily understandable in that light. So does the Purcell Panel conclusion: invest first in improved Corona quality; Corona works now. High-risk technology was in disfavor in the summer of 1963.)

The new NRO director, Dr. Brockway McMillan, ordered cancellation of M-2 work at Itek in July 1963.* Itek's efforts were to be principally focused on improving Corona product quality. To that end, General Greer's directorate made a number of specific suggestions for detail changes. CIA technical specialists in reconnaissance, now concentrated under Dr. Wheelon, concluded that the proposals

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* Nonetheless, the elements of M-2 reappeared, in proposal form, at frequent intervals in later years, not finally disappearing until the availability of an operational Hexagon became reasonably certain in 1971. In subsequent incarnations the basic M-2 was given several transitory names, Corona J-4 being the best known.

were inadequate, so in October 1963 Wheelon called into being a new special study group--the Drell-Chapman Committee--"to explore the whole range of engineering and physical limitations on satellite photography. . ." The group, acting under a loose charter proposed by John McCone in conversation with Roswell Gilpatric (Deputy Secretary of Defense), was to be concerned not merely with Corona improvements, but also with standards and needs for new systems.

Predictably, McMillan had pronounced objections to such proceedings. He did not learn of the committee until after it had been established, he felt that its "charter" was far too broad (USIB and the NRO were nominally responsible for generating and validating requirements), and he preferred to spend NRO study funds elsewhere. McMillan also protested that Wheelon had no official role in the satellite reconnaissance program.

McCone named Wheelon his "monitor for NRO matters" three days later, and Wheelon promptly declared his intention of ". . . get[ting] the CIA into the satellite business in a contributing, not just a bureaucratic way."

The most attractive prospect for new program creation still was in the search area. True, an ultra-high-resolution camera was also on the general requirements list, but it seemed several years in the future and, in any case, in 1963-1964 the surveillance concept that seemed most promising was embodied in the Manned Orbiting Laboratory-Dorian system, still embryonic but certain to be an Air Force undertaking. The Drell-Chapman Committee had been critical of progress in Corona improvement; in time, that criticism was to lead to the modifications incorporated in the Corona J-3 configuration, a remarkable improvement over the original Corona-Mural. But Corona J-3 still was only a proposal, and in any case there was agreement that no Corona redesign with less scope than the M-2 undertaking could substantially improve Corona's resolution capability. Camera specialists then believed that if resolution much better than 7 or 8 feet for about half of the returned film were wanted, refinement of the original Corona would not be sufficient.*

Two events followed in close order. On 18 November 1963, the NRO's West Coast directorate contracted with Itek for general

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* Consistent, rather than occasional, resolution of 7 to 10 feet was the Corona goal defined by the Purcell and Drell-Chapman recommendations and ultimately incorporated in the Corona J-3 program. The assumption that Corona could not generate photography with 4- to 5-foot resolutions, however much the system was modified, later proved to be incorrect. Corona J-3 ultimately provided "best resolution" of 4.5 feet.

feasibility studies of a new broad-area search system and for the preliminary parametric design of such a system. That action was the somewhat delayed response to the Purcell Panel findings of June 1963. It also represented, indirectly, a continuation of search system studies undertaken on the West Coast following the cancellation of Samos E-6, earlier that year. Not quite two months later the CIA separately authorized Itek to study a remarkably similar set of problems, but specified a somewhat more ambitious design goal based on the findings of in-house CIA analyses. The CIA action was a delayed response to the Drell-Chapman Committee findings of late 1963, but it indirectly represented a continuation of the search system research approach embodied in the M-2 studies undertaken by the CIA in an effort to find a feasible improvement mode for Corona-Mural. The "West Coast Itek Study" led to S-2; the CIA-funded Itek study was the genesis of Fulcrum.[2]

The CIA's intentions were generally known to the NRO staff in December 1963, somewhat before Itek formally began work. The probability that Greer's NRO group and Wheelon's CIA group would emerge from their respective study programs with competing proposals for a new search system caused some concern among program monitors high in Department of Defense ranks. (The NRO charter then in effect included no provision for anything resembling the NRP Executive Committee of later years; the Director of the NRO was responsible directly to the Secretary of Defense, CIA participation being assured by the assignment of individuals to various NRO posts--including that of deputy director.) Earlier in 1963, Dr. Eugene G. Fubini, then serving as a senior technical advisor to the Deputy Secretary of Defense, had begun acting as a defense department spokesman in NRO matters. (In the Charyk era no such intermediary function had existed, Charyk having such an effective relationship with Secretary Robert S. McNamara that it was not needed.) Fubini had by late 1963 assumed the role of a mediator in the increasingly acrimonious contacts between McMillan and Wheelon.* In December, speaking with the implied authority of Cyrus Vance, newly appointed Deputy Secretary of Defense, Fubini proposed to McCone that the CIA assign total Corona responsibility to the NRO in return for a free hand in the

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* The principal source of CIA-NRO contention in 1963 was Corona management responsibility and authority. McMillan wanted to concentrate all Corona authority under a jointly staffed West Coast project office reporting to the Director, Program A (then Greer, later Brigadier General John L. Martin, Jr.). Wheelon, firmly supported by CIA Director John A. McCone, argued that CIA control of Corona should be enlarged rather than curtailed. The issue is discussed in greater detail in the first volume of this history.

development of a new search system. McMillan apparently was unaware of the offer until McCone indirectly passed it along. He rejected the compromise out of hand, insisting that the NRO had to have full authority to control Corona and that a new search system could not be arbitrarily assigned to any organization. The disagreement thus expressed persisted into 1965. McMillan's efforts to resolve the issue by obtaining directive support either from McNamara or from the White House were unavailing. The President's Foreign Intelligence Advisory Board recommended strengthening McMillan's hand during a May 1964 meeting, but the draft Presidential directive sent forward in consequence of that meeting was never signed. (The 1964 election played some part in delaying a resolution of the several controversies that afflicted the NRO, the search system requirement, and the Corona program from May through November.)

The net effect was that by January 1964 the CIA had undertaken to sponsor studies with Itek, and subsequently with Philco Corporation and other subsystem specialists, leading toward a broad-area search system called Fulcrum, and the NRO's Special Projects Directorate (Program A) had begun to support a different set of studies oriented toward a different kind of search system, later called S-2. A secondary consequence was that the authority of the Director, NRO, either to control or to monitor the program of the CIA-sponsored effort had been successfully denied. McMillan certainly knew of the CIA's internal studies and of their general import. It does not appear that he learned of the existence of the funded studies by Itek and Philco until the spring of 1964, five months after their inception.[3]

Evolution of a System

As described by Itek in June 1964, Fulcrum was to be a Titan II-boosted system built around a pair of rotating 60-inch focal length cameras and a transport system for seven-inch film, the general arrangement somewhat resembling what later became Corona J-3. The scale was very different, of course (Corona carried 36-inch focal length lenses and used 70-millimeter film), but resolution was intended to range from two feet to four feet across a ground swath 360 miles wide. Carrying about 65,000 linear feet of film, the system would nominally be able to photograph more than 10 million square miles of the Earth on each mission. Although optics, camera mechanism, film transport, boost, and recovery subsystems were all "new," the film transport and recovery systems (one extremely large capsule) appeared to be the high risk items.*

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* To that time the only film-carrying reentry bodies to be recovered by the United States were variants on the original Corona capsule of 1958 vintage. Both E-5 and E-6 had used "large" capsules intended for recovery from the sea rather than aircatch. E-5 had faults other than in its recovery system, but that too may have been faulty--no capsules were ever recovered for examination. E-6 had been cancelled solely on the evidence of five recovery failures, and two were clearly the consequence of poor capsule design. Mercury and Gemini, NASA's man-carrying orbital systems, provided evidence that bigness was not an impossible constraint; the Mercury capsule was not unlike that tested with the E-5, for instance. But all concerned acknowledged that single "big" recovery bodies were difficult to develop, and recovery was the crucial element in any reconnaissance system of the 1960s.

S-2, as first conceived, was in some respects a simpler system than Fulcrum. Intended to have both panoramic and pointing capability, it would have better resolution in a pointing mode (three feet to four feet) than in a search mode (five to eight feet), and would cover a swath about 150 miles wide during search operations. The "early S-2" embodied new optics and camera mechanism, but would rely on the Atlas-Agena booster combination and an enlarged Gambit-style recovery vehicle. Interestingly, the first "engineering models" undertaken in the two programs were the optics of the S-2 and the film transport of the Fulcrum. Itek remained the principal Fulcrum system contractor; Greer's organization brought Kodak and Fairchild into the camera study program in September 1964 and subsequently funded space vehicle studies by both Lockheed and General Electric. Perkin-Elmer declined an invitation to bid for participation in the embryonic S-2 camera studies, but undertook some work in support of Fulcrum.

While such arrangements were being made, other events occurred that were to have a considerable influence on later developments. For one, Wheelon and McCone separately proposed to McMillan and Vance respectively that CIA responsibility for both development and operation of the new search system--Fulcrum--be formally confirmed. In the meantime, the CIA provided scant data on the status of or plans for Fulcrum and forbade Fulcrum contractors to release information about their progress to any agency other than the CIA. CIA proposed to establish an internal project office initially composed of five people, with Space Technology Laboratories providing technical support and serving as system integrating contractor; the principal companies concerned with Fulcrum in July 1964 were Itek, General Electric and AVCO (reentry vehicle), Lockheed (space vehicle), and STL.

That procedure, and particularly the withholding of Fulcrum information from McMillan's staff, was a particular irritant to the NRO. It was not, however, unprecedented. In 1963, while questions about the desirability of starting Corona M-2 development were being considered, Greer and Charyk had attempted and very nearly carried off a similar coup. It, too, involved a search system intended to succeed or supplant Corona. When E-6 was cancelled on 31 January 1963, they very circumspectly let contracts covering the study and initial development phases of Spartan, a repackaged, largely re-engineered E-6 camera in combination with a Corona reentry capsule and Thor-Agena launch-orbit vehicles. Scoville, directing CIA reconnaissance activities at that time, had harshly questioned both the technical feasibility of a "re-engineered E-6" and the motives that underlay its proposal. Had Spartan proceeded to successful operation, it would have provided better capability than Corona. Eastman Kodak was convinced that Spartan had great growth potential--which, if true, would have negated any need for CIA development of a new search system. In the face of Scoville's opposition, Charyk in mid-February 1963 formally disapproved Spartan--but in fact both the study and the procurement of long-lead-time items needed for on-orbit tests of the proposed system continued under the cover of Program A study contracts with Eastman Kodak and General Electric. The name changed. It was listed as SP-AS-63 (Special Projects Advanced Study - 1963), but in all other important respects it was Spartan.

Whether Scoville and the CIA ever learned the details of the effort remains uncertain. Special precautions were taken to prevent the untimely disclosure of "SP-AS-63" activity. All project work on the West Coast was conducted in a suite of offices provided by Eastman Kodak, located about a mile from the Program A complex on El Segundo Boulevard. Probably no more than a dozen people of the 150 or so assigned to the West Coast establishment (which included many CIA people) were aware of the activity. Even fewer were briefed in the Pentagon. No CIA people visited Eastman Kodak or that part of General Electric concerned with the "study."

The work continued until July 1963. By that time the contractors had completed the preliminary design of a system that had many of the attributes of the later S-2: wide area coverage at about five-foot resolution, dual recovery capsules, relatively simple film transport mechanism, and a variety of innovations in optics that promised consistently good returns. The replacement of Charyk by McMillan in the Spring of 1963 and the difficulty of obtaining funds to proceed from advanced study to system fabrication were, in combination, sufficient to cause abandonment of the main program in July. Eastman's private studies of improved search systems continued and certainly influenced later Eastman proposals for S-2.[4] In the event, little of the "SP-AS-63" effort was communicated to the CIA. The Agency's subsequent denial of Fulcrum information to McMillan and the NRO staff may not have been entirely motivated by the Charyk-Greer ploy of 1963, but there was implied jusitification for Wheelon's actions in the earlier Charyk-Greer maneuver.

By the end of June 1964, when McMillan first was exposed to a full briefing on Fulcrum, the CIA concluded that preliminary studies had been sufficiently exhaustive to confirm the feasibility of the system. The request that Vance confirm the CIA's responsibility for full development of Fulcrum had been submitted. There were strong indications that the United States Intelligence Board (USIB) would shortly issue an updated search system requirement to replace those dating from 1960. On 9 July, therefore, Dr. Wheelon proposed that the NRO provide the bulk of the funds needed to support a $60 million Fulcrum development effort during fiscal year 1965. Of that total, only about $18 million was to be devoted to the camera system; the remainder was to go to spacecraft, booster, and system support work (including preliminary investments in the construction of a launch facility for Titan III-boosted satellites).

The timing was bad. Late in June, Dr. Fubini had been exposed to details of the Fulcrum proposal and had concluded that although it had promise it also had problems, particularly in the highly complex transport system required to deliver large quantities of film to the platens at exceedingly rapid rates. At Fubini's urging, Vance on 8 July had ruled that although the CIA could perform whatever tests were needed to determine Fulcrum feasibility, the NRO's Directorate of Special Projects should conduct comparative studies of alternative search systems. (In effect, Vance was directing continuance of both

Fulcrum and S-2 work at the study and feasibility determination level, but his letter did not reach the CIA until Wheelon's request for full system funding had gone to McMillan.) By January 1965, Vance suggested, enough should have been learned about the various systems to support a rational decision on the desirability of starting full system development and, if appropriate, on the choice of a system to be developed. Given that decision, Fulcrum funding was extended at a level of about $1 million a month, roughly 20 percent of the sum Wheelon had requested.[5]

The various studies of 1963-1964 and the generous investment in pre-design research to that time encouraged the July 1964 statement of a new and formal search system requirement. Issued under the imprimatur of the United States Intelligence Board on 29 July, it called for a single-capability search-surveillance system with the area coverage equivalence of Corona at resolutions equal to those provided by Gambit. Another system was wanted that would permit interpretation of details at the one-foot resolution level with Gambit-scope swath widths.[6] Gambit-3 would satisfy the second of those requirements; Fulcrum, as then proposed, came closer to the terms of the first requirement than did the S-2 concept of mid-1964. The requirement was not obviously the product of any single faction in the intelligence community, nor was the coincident statement of a Fulcrum-oriented requirement and a Gambit-3 requirement merely an expression of an effort to provide continuing work for both the CIA and the NRO's Special Projects directorate. The USIB had taken account of such as the Purcell, Drell-Chapman, and Land Panel studies, the comparison of M-2 and "improved E-6" potential, and several lesser analyses. And even though Fulcrum seemed nearer the new requirement than S-2, neither of the proposed systems represented a fully satisfactory solution.

While the CIA-managed effort continued, chiefly under contract to Itek but also with Philco and Perkin-Elmer, the West Coast group was devoting equivalent attention to camera system studies being prepared by Itek, Eastman Kodak, and Fairchild. General Electric and Lockheed were performing space vehicle and reentry system research for both CIA and NRO sponsors. It seemed inevitable that some version of the solid-rocket augmented Titan III would serve as the boost vehicle, whatever the final system configuration.

Of the several contractors involved in some aspect of camera system design, Eastman seemed to the S-2 program office to have the most promising concept. The CIA clearly favored Itek's approach (which incorporated an optical bar system sponsored by the CIA's in-house lens specialists).

The relatively even tenor of development in parallel was rudely disturbed in February 1965; Itek abruptly renounced any intention of continuing Fulcrum work, advising both the CIA and the NRO that the company would forego any further development work on observation satellites rather than pursue the Fulcrum task as then defined. The decision was motivated by Itek's continuing disagreements with the CIA's technical monitors and the Agency's insistence that Itek defer to Agency specialists in technical matters.

Wheelon concluded that Itek's action had been prompted, or at least supported, by the NRO staff and that Itek had in effect been promised the S-2 contract in return for withdrawing from CIA-supported Fulcrum development. In fact, the NRO staff and McMillan were quite as surprised by Itek's action as were CIA officials; McMillan conscientiously advised Itek that the NRO evaluations of S-2 progress to that time showed the Eastman design to be the most attractive. McMillan had scant knowledge of Fulcrum's status at the time Itek withdrew, having received no written reports on the program since August 1964 and only sketchy verbal summaries. Nevertheless, because S-2 seemed to be proceeding nicely and the withdrawal of the chief Fulcrum design contractor could not but confuse and delay Fulcrum progress, it seemed likely that in any near-term comparison of system proposals leading to a system selection, the Eastman S-2 design would win easily.[7]

The Itek affair had extensive and unexpected consequences. Perhaps most important, it exacerbated the already disharmonious relationships between the CIA and the NRO and sharpened the existing antagonism between McMillan and Wheelon. Perkin-Elmer, rather than Itek, became the principal Fulcrum camera system contractor. And, as McMillan had predicted, when the S-2 project office was obliged to designate a preferred agent for S-2 development, in May 1965, Eastman got the nod. But in the end expectations that the development of a new search system would proceed from exploratory development status to system development in 1965 proved optimistic. Although McMillan approved a plan to spend $107 million on S-2 development in fiscal year 1966, in the event expenditures were limited to a rate somewhat below $11 million a year pending a decision on the start of the system selection process. Fulcrum funding was concurrently reduced to about the same level.

For practical purposes, the effect of the Itek affair had been to delay any decision on starting development of a new search and surveillance system. Approval of that start required the concerted support of the Director of Central Intelligence and the Deputy Secretary of Defense. On 24 June 1965, McMillan advised Brigadier General

John L. Martin, Greer's successor as Director of Special Projects (Program A) for the NRO, that no agreement on a system approval process had emerged from DOD-CIA meetings and that none could be immediately expected.[8] Vice Admiral W. F. Raborn, who had succeeded McCone as CIA director in April, proposed to Vance in June that no action be taken on the selection of a new search system until the basic issue of NRO reorganization had been resolved. The NRO charter of 1963 was by mid-1965 being honored chiefly in the breach. Extensive readjustments of responsibility and authority in program management, funding control, operation of on-orbit satellites, and the program decision process had been proposed in the interim. But however sweeping the reorganization, it was unlikely to result in a working relationship that could accommodate both Wheelon and McMillan. As early as February 1965, a week before the Itek affair, the deputy NRO director had resigned in frustration; a senior CIA employee assigned to the NRO, he found himself so thoroughly distrusted by both staffs that he was almost totally ineffective. The S-2 and Fulcrum project groups had little direct interaction, but they were bitter competitors for funds and held divergent views on how the search system requirement should be satisfied.

Raborn's intransigence on the search system issue, the definition of a new NRO charter without inputs from the NRO, and the virtual collapse of communications between McMillan and Wheelon, the principal managers of the National Reconnaissance Program, had their inevitable effect early in July. McMillan privately advised the NRO staff that he planned to resign his post and return to private industry. His decision apparently was precipitated by the failure of a final effort to force a decision to develop the Eastman S-2 system, keeping either Itek or Perkin-Elmer as a supporting contractor. Raborn balked, and was backed by the Land Panel's judgment* that as yet insufficient data were available to support the selection of a single search system for intensive development.[9]

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* The Land Panel, headed by Dr. Edwin Land, was created at the direction of the Special Assistant to the President for Science and Technology, Dr. Donald F. Hornig, early in July 1965. Its charter extended to "an overview of the NRP," but initially it was concerned with the technology of, requirements for, and status of search and search-surveillance systems in development or proposed for development. The group first met on 21 July 1965 and continued to meet at irregular intervals until President Nixon abolished the office of science advisor in early 1973. The panel provided specialized technical support to Hornig and his successors, operating in some respects as a counterpart (or counterweight) to the NRO and CIA technical staffs that supported the DOD and CIA members of the NRP Executive Committee. Generally, however, the Land Panel evaluated proposals, studies, and programs rather than generating them, as was the case for the CIA and NRO special staff groups.

Although McMillan did not officially depart until 30 September, his chosen successor, Dr. Alexander H. Flax, Assistant Secretary of the Air Force (Research and Development), began to act as NRO director in July, formally exercising authority in McMillan's absence and informally monitoring NRO affairs throughout the transition period.* On 11 August 1965, the NRO charter of 1963 was supplanted by a new document that significantly altered earlier arrangements. The chief innovation was the creation of a three-member Executive Committee for the National Reconnaissance Program, composed of the Deputy Secretary of Defense, the Director of Central Intelligence, and the President's Science Advisor. The NRO director was to be a non-voting member. The committee acquired much of the executive authority previously assigned to (though not always exercised by) the Director, NRO, including program and budget approval. If the NRO Director had until then nominally possessed the authority to select and fund a new search and surveillance satellite system program, that was no longer the case. The NRP Executive Committee would thereafter make such decisions; the NRO director would oversee their execution.[10]

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* Among other personnel changes in the satellite reconnaissance program in the late months of 1965 were Major General Robert E. Greer's retirement, in July, and Dr. Albert D. Wheelon's resignation, informally announced in October.

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The program proposal that went to the Land Panel late in July from McMillan was paralleled by a program summary prepared by the Fulcrum project group. After having weighed the evidence, the Land Panel advised Dr. Hornig that "there is no technical basis for selecting for development at this time one system over the other, nor does the Panel see any urgency for making a selection now rather than, say, three months from now." Hornig advised Vance, therefore, that work on all three systems (Itek and Eastman on S-2, Perkin-Elmer on Fulcrum) should be continued at about the same rate for at least three additional months "in order to better define the advantages and disadvantages of each system." Thus, Hornig hoped, it might be possible to substantiate the performance claims for the various proposals.[11]

Vance subsequently ruled that in the interim all effort was to be concentrated on the camera systems, which meant cessation of work on satellite vehicles, boosters, reentry capsules, and associated subsystems. That was decidedly awkward for both Fulcrum and S-2 managers, because in the early months of 1965 quite extensive preparations for full-scale development had included letting contracts of one sort or another with Lockheed, General Electric, and Martin. For the S-2, a Lockheed-General Electric competition was pending, while for Fulcrum a GE orbital vehicle and an AVCO reentry vehicle had tentatively been selected.[12]

The NRO-preferred configuration of S-2 in early August provided for a four-bucket recovery system (with potential growth to a six-bucket design) associated with a camera capable of providing three-foot resolution (at nadir) from an altitude of 120 miles. The payload would satisfy both search and surveillance coverage requirements if launched at a rate of six to nine systems per year. Carrying 1000 pounds of primary film (and 63 pounds of film for a stellar-indexing camera), S-2 would have a length of 50 feet, a diameter of 7.5 feet, and an on-orbit weight of 12,000 pounds for a 25-day mission. The incorporation of a supplemental crisis reconnaissance capabiltiy, as suggested by the Land Panel and the United States Intelligence Board, permitted complete access to any area of the earth between 20° North and 20° South latitude every five days.[13]

Compliance with Vance's instructions meant stopping General Electric's work on satellite control and reentry vehicles and confining Eastman's level of effort to that scheduled for August, actions that were taken early in September. The difficulties thus created were compounded by a special problem involving Eastman Kodak. That concern was then producing Gambit-1 payloads, developing and building initial lots of Gambit-3 payloads, building a Lunar Survey payload for

NASA under NRO cognizance,* and developing the S-2 payload. Added to that formidable set of tasks was Dorian, the high-resolution camera payload scheduled to be secretly incorporated in the Manned Orbiting Laboratory vehicles being built for the Air Force. Eastman had won the Dorian competition although the decision had not yet been announced in mid-August; there was no practical way for Eastman to proceed with both Gambits, the Lunar Survey payload, S-2, and Dorian. Something had to give. McMillan's solution was to propose transfer of the Eastman S-2 design to Itek, with Itek also continuing development of the second-preference S-2 camera already in process. Although complex, the transfer was not unprecedented, Itek's original Fulcrum camera design having been shifted to Perkin-Elmer in the aftermath of the February 1965 dispute between Itek and the CIA.

McMillan's proposal went to Secretary of Defense Robert S. McNamara on 30 August; on 22 September McNamara authorized termination of the Eastman S-2 activity and its transfer to Itek for

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* The NRO was involved in the Lunar Survey program because the readout camera being carried was a modest improvement of the Samos E-1 camera of 1960. Use of the E-1 camera and readout system was an economical means of performing the survey mission, the alternative being to develop a comparable camera system using NASA funds. In order to keep the nature and capability of earlier reconnaissance camera development secret, however, it was necessary to provide the E-1 through clandestine channels--which meant NRO control of the production process.

design completion. Concurrently, Eastman's selection as Dorian developer received approval. Finally, there emerged a clear understanding that three camera designs were to be competitively evaluated for selection as the new search-surveillance system: the Perkin-Elmer (Fulcrum) proposal, the Eastman S-2 design (generally known thereafter as the Itek/EK proposal), and the backup Itek design (usually identified as the "pancake" proposal, a term generally descriptive of the optical mirror layout preferred by Itek).[14]

Between February 1965, when the Itek-CIA disagreement suddenly flared, and October of that year, when Flax officially succeeded McMillan as Director of the National Reconnaissance Office, virtually every aspect of the search-surveillance system program had radically changed. The Land Panel and the NRP Executive Committee had come into being; both were to be dominant influences in the eventual selection of a design and a system contractor. McCone, McMillan, Wheelon, Greer, and several lesser figures in the S-2 and Fulcrum programs had left government service or moved to assignments remote from satellite reconnaissance. Perkin-Elmer had become the principal Fulcrum system developer, replacing Itek (and working more intently on the inherited Itek-Fulcrum design than on the original Perkin-Elmer design for Fulcrum), while Itek had acquired custody of the NRO-preferred S-2 system originated by Eastman (and was proceeding also with the Itek-pancake design that represented a backup for the favored Eastman S-2 proposal). Work on satellite and recovery vehicles, boosters, and supporting subsystems had largely ceased in September after having earlier advanced to the preliminary selection of design and development contractors.

On 6 October 1965, the Executive Committee for the National Reconnaissance Program held its initial meeting. The first order of business was the search-surveillance system. Colonel David L. Carter, for the NRO, and L. C. Dirks, for the CIA, briefed the committee on the three design proposals then being funded. (Until September there had been four. Perkin-Elmer had been working both on the design transferred from Itek and an alternative Perkin-Elmer design dating from the time when that company was the CIA backup for the Itek-Fulcrum design.) Although both suggested that proposals would be ready for evaluation by December 1965, there were indications that no competition could begin until sometime early in the following year.

Dr. Flax, charged by McNamara and Vance with reconciling the differences among the principals in the search-surveillance system controversy, presented to the Committee a comprehensive plan for proceeding toward system selection in an orderly fashion, one that would overcome the earlier tendency to use Fulcrum and S-2 as devices in an institutional squabble. Flax had early concluded that the requirement approved by the USIB the preceding year was inappropriate in that it specified technical capability rather than an intelligence objective. He proposed, therefore, to create a technical task group composed of representatives from the CIA (Fulcrum) and Special Projects (S-2) elements of the NRO. The task group, he suggested, would "prepare a statement of system operational requirements, . . . recommend the selection of a system configuration, . . . formulate plans for contractor selection, and . . . recommend a program plan including a schedule." Flax also advised the Committee that he intended to establish a separate task group to "define the project management structure"--which meant, in practical terms, to decide what roles the CIA and Special Projects groups would play in the eventual development of the chosen system.

Flax had prepared his ground carefully. None of the Committee principals was surprised by the carefully constructed proposal for proceeding. All had seen the material beforehand. Without much discussion, the Executive Committee endorsed the Flax plan and for the first time in two years the search-surveillance program had reasonable coherence.[15]

During its second meeting, in mid-November, the Executive Committee turned its chief attention to the many other problems of national reconnaissance. The search system requirement received brief but pointed attention. [redacted] the NRO's Comptroller, reported somewhat ominously that the Bureau of the Budget might well take "an adverse view" of the development proposal on grounds of cost. Cyrus Vance, the chairman, asked for a formal statement of the Bureau's views--particularly relevant because, owing to the various delays in the search system program, it now appeared that Corona operations would have to be extended for at least a year past the point at which the new system had been earlier scheduled to enter service. One of the interactive complications was the necessity of diverting to the procurement of additional Corona systems some of the funds earlier planned for allocation to search system development.[16]

In the meantime, Flax had issued instructions for the deliberative evaluation of search-surveillance system proposals. He named the chief of the NRO staff, Brigadier General J. T. Stewart, to chair a management evaluations committee that included John McMahon of the CIA and Colonel Paul Heran of the NRO's Directorate of Special Projects. Carter, Dirks, and Colonel W. G. King (NRO Special Projects) were appointed to a technical task definition group. With interesting promptitude, Carter issued a preliminary paper describing the search requirement and the plan for system development. (Both had long been in preparation, of course.) The concept included use of a Titan IIID booster (including two- or three-segment strap-on solid rockets for augmentation) capable of placing 13,000 pounds of payload in orbit; a satellite vehicle consisting of an orbital control module, a sensor module, and recovery vehicles (two reentry vehicles were suggested); and first launch 28 months "after development go-ahead." A discussion of the rationale for a two-bucket system provided some insight into the problems the new system would confront on the way to design approval: in the judgment of Carter's group, a two-vehicle configuration represented the best compromise of reliability and cost, although four or more reentry vehicles would provide a crisis reconnaissance capability only marginally present in the two-vehicle configuration. In the group's opinion, development of a three- or four-vehicle configuration would prove troublesome; Corona had provided experience in dual-reentry-vehicle operations, but there was no background for the complex cut-and-splice operations that would be required if more than two buckets were used. Finally, Carter's group maintained, "the severe weight and cost penalties of three or more RVs argue against compromising the primary mission and configurations for the crisis role."[17]

There was no question in anybody's mind that the camera system would be the pacing item in the development. It was with some dismay, therefore, that Martin and Flax learned late in October that Itek did not propose to complete a variety of essential tests, calibration efforts, and technical analyses until late July 1966. Until that work was in hand, there would be no fair basis for comparing the Itek-EK and the Itek-pancake designs. The transfer to Itek of the Eastman drawings, tools, and test data appeared to be an easy task; Eastman assistance to Itek was scheduled to continue until at least February 1966, by which time (the principals fervently hoped) Itek would be capable of carrying on independently.

Flax responded, somewhat acidly, that "the Itek schedule for completion of those activities is not compatible with the anticipated decision milestone for the new search/surveillance system." Assuming that Itek would tend to favor its original design over the less familiar EK design, Flax instructed Martin that unless Itek agreed to push both designs to evaluation readiness quickly, "we must . . . consider another course of action in this regard."*

*The Itek and EK approaches differed in concept as well as detail. In the judgment of S-2 program managers, the EK design was simpler, less risky (in a technical sense), more certain to appear on time, and potentially cheaper.

General Martin assigned to Colonel Heran the delicate task of inducing Itek to agree to complete the work necessary to permit evaluation of the three principal systems by 3 January 1966. After extended discussion with Itek officials, Heran obtained the necessary commitment, but he cautioned that owing to the short period left for completion of the scheduled work it was likely that evaluators would have less confidence in an Itek-EK design proposal than in the Itek-pancake design proposal. In passing Heran's findings to Flax, Martin urged that an additional period be provided for equalizing the confidence in the two designs, so that both Itek bids would be honestly competitive with the Perkin-Elmer submission.

Flax accepted the altered schedule, and Itek's assurances of conscientious effort on both the Itek-EK and Itek-pancake designs, but he was in no position to extend the period of preliminary design past that earlier specified. He insisted that by January 1966 the three designs be available for competitive evaluation, promising that evaluators would make the necessary allowances for status differences.[18] Itek reluctantly acceded to the conditions, and on 22 November the formal transfer of the EK design to Itek custody received Martin's endorsement.[19]

In the event, it was April 1966 rather than January before the several search-surveillance system proposals were eligible for the transition to a formal competition stage. The EK design--paper and hardware--was not fully in Itek's custody until mid-January; several intervening reviews of camera system design status in December 1965 and January and March 1966 indicated that Itek's ability to cope with the EK design was developing slowly.

For practical purposes, Colonel Carter's task force spent most of its time working out the details of a Request for Proposal to be issued to Itek and Perkin-Elmer when all else was ready. The earlier rivalry between Fulcrum and S-2 approaches had not vanished, even though diminished by Flax's skillful assignment of responsibility to special interagency task forces. The CIA draft version of the Request for Proposal, for instance, called for inclusion of what was, in Carter's opinion, "the most optimistic [schedule] which could be envisioned" and provided for holding the formal pre-proposal briefing some two weeks before Itek would have completed its effort to become fully conversant with the transferred EK S-2 design. But by February Itek was capably briefing such groups as the Land Panel on the status and prospects of both designs, and by late March Flax had concluded that nothing was to be gained by further delaying the start of a formal competition.[20]

The main elements of Flax's proposal were a plan for source selection and a management plan. For the first of those, little that was controversial remained for decision, and in other than a casual way the NRP Executive Committee did not look into its details. The management plan, however, specified the organizational arrangement to be honored during the development of the system and thus encompassed all of the highly controversial aspects of CIA-NRO relationships that had troubled the National Reconnaissance Program for more than three years. Even in its draft form, as circulated for comment, it had evoked strong reactions from both CIA and NRO spokesmen. The original proposal, as worked out in advance of the 15 October 1965 establishment of the task group on management, had represented a skillful compromise of organizational prerogatives. There was no longer any doubt that the CIA would exercise responsibility for the development of whatever camera subsystem won the competition. That much had been implied in the compromise arrangements of August 1965. But whether the sensor project office would be located with the main program office on the West Coast, as Martin wanted, or would continue to operate from CIA headquarters in Langley, Virginia, was argued at length, and the scope of sensor project office responsibility continued to be debated for months. (Would it extend to the surrounding spacecraft structure, to the whole of the payload-vehicle structure, or be confined merely to optics-plus-film-transport and supporting components?)

General Martin, who had been NRO staff director during much of the period when divided responsibilities and ill-defined command lines had made chaos of Corona management, argued that a combined program office was essential, that co-project-leader arrangements could never be made to work. Supported by most of the NRO staff and his own West Coast group, he held out for assigning system integrating responsibility to the principal program office and limiting the sensor project office to custody over the camera subsystem alone.

Flax eventually concluded that integration of the camera with the payload must be a System Program Office responsibility, the CIA retaining sensor subsystem design responsibility and the Program A group on the West Coast being totally responsible for the main vehicle structures. That Solomonian edict was one of the few of the Flax proposals that occasioned arguments during the Executive Committee meeting of 26 April 1966, where final decisions were confirmed. John J. Crowley, the CIA's principal agent for sensor development, urged the Committee to assign to the CIA full responsibility for the structure enclosing the sensor system as well as responsibility for the development, production, and integration of the stellar index camera. Crowley contended, with Admiral Raborn's backing, that so extending the CIA's responsibilities would reduce the amount of interagency interface required for program management "and thereby markedly improve the possibilities of satisfactory performance within the time limits of the program."

Only one other difference of viewpoint surfaced during the Executive Committee meeting. Dr. Flax had provided that both the Special Projects Directorate and the CIA project office were to be authorized to issue program access clearances, and that each would honor without question the need-to-know determinations of the other. The CIA asked for a veto; Flax responded that his object was "to eliminate the use of security as a means of frustrating . . . legitimate access to information. . ."

The three principals of the Executive Committee met privately and alone after the briefings and discussions had ended. Vance, the chairman, advised Flax as soon as the three-man group had completed its deliberations that the program proposal had been approved precisely as submitted.[21]

What had been approved was a detailed plan for conducting competitions for sensor systems and other elements of the reconnaissance satellite and a specification of the relationships that were to characterize the subsequent period of development and system operation. What remained for near-term decision was the choice of a camera design and a contractor, after which questions of satellite vehicle design, subsystem design, contractor selection, and booster design and selection might be taken up in order. The plan of April 1966 envisaged completion of development and first launch by mid-1968--roughly two years from the date of program approval.

The effort to do away with the institutional rivalry that had marked the preceding three years of search-surveillance system development extended, finally, to nomenclature. In his 22 April memorandum proposing a structure and schedule for the program, Dr. Flax had noted that the system to be developed would carry the designator Helix. That name lasted less than a week; it had unwittingly been assigned earlier to another activity. On 30 April, the CIA assigned a substitute nickname: Hexagon. Retroactively, it was introduced into the minutes of the Executive Committee meeting that signaled program approval. The names Fulcrum and S-2 that had epitomized the earlier stages of the Hexagon program disappeared. None of the many principals ever expressed regret.[22]

Hexagon: Program Onset to First Flight

The situation of Hexagon and the pattern of program development as anticipated at the time of program go-ahead were fairly represented by the several papers Dr. Flax submitted on 22 April, and which the NRP Executive Committee approved for action during its 26 April meeting.

The camera system, universally acknowledged to be the pacing element in a highly interactive program, then consisted of three potential proposals from two contractors, Perkin-Elmer and Itek. The principal Perkin-Elmer design represented that firm's elaboration on and improvement of a Fulcrum -based conceptual approach and engineering construct originated by Itek between 1964 and early 1966. Perkin-Elmer's own favored design of the early Fulcrum era had always been considered less promising than the CIA-sponsored Itek-Fulcrum approach and was not really in competition. Itek had two designs in process, the earlier NRO-sponsored Eastman S-2 design, transferred to Itek when EK became the prime Dorian contractor, and the native Itek S-2 design (Itek-pancake), which the NRO had earlier considered to be a prime backup to what was by April called the Itek-EK design. Flax characterized the Perkin-Elmer design as "considerably changed and improved from a prior Itek effort." Although Brockway McMillan, Flax's predecessor as NRO director, had endorsed and attempted to secure development approval for the Itek-EK design while it still was an Eastman program, and the Itek-EK design approach was generally favored by NRO special projects people over the Perkin-Elmer Hexagon proposal, Flax wisely ignored all such considerations in his 22 April resume. The major problem of the moment, as Flax saw it, was how to conduct an equitable competition among three camera designs at different stages of refinement, composed to satisfy somewhat different technical and operational requirements, and representing an amalgam of studies and engineering effort by seven different groups (General Electric, Lockheed, Itek, Perkin-Elmer, the NRO's Directorate of Special Projects, the NRO's staff, and the CIA's Directorate of Science and Technology). All three surviving design approaches were nominally capable of satisfying the 1964 requirement for Corona-scope coverage at Gambit-level resolutions (given that the Corona and Gambit capabilities of 1964 were treated as baselines--there being no real possibility that any of the optical systems proposed for Hexagon could perform at Gambit-3 resolutions). There was general agreement among USIB, NRO, and CIA authorities that what was wanted was 25-30 day orbital life with single-mission capability for stereo coverage of 20 million square miles, a stellar-indexing camera, and either two or four recovery vehicles. The probable launch vehicle was a Titan IIID-class rocket with two 120-inch diameter strap-on three-segment solid rocket accessory boosters, although an alternative five-segment strap-on rocket had determined advocates. Orbit weight of about 12,000 pounds seemed reasonable, although a slightly greater weight was not unlikely, given the growth tendencies of all previous reconnaissance satellites.

Flax had designed the management mode for Hexagon to comply with the provisions of the 11 August 1965 NRO charter and related agreements between the CIA and the Department of Defense. That essentially meant that the CIA would retain responsibility for sensor development and sensor-related activities, and the NRO's Special Projects directorate (in Los Angeles) for all else in the total program. The two agencies would, for each segment of their assigned responsibilities, provide system engineering, system integration, and management.

Given those fundamentals, Flax proposed to distribute a system operational requirement, an RFP (request for proposal) covering the sensor system, a management plan, and a schedule of planned NRO actions. Attached to the submission that went to NRP Executive Committee members on 22 April was a set of five papers that carefully explained the rationale underlying the operational requirement, the RFP, and the management plan.

Although both the CIA and NRO participants in the S-2 and Fulcrum aspects of the pre-Hexagon program had conducted competitions for the spacecraft element of the total system, and both had settled on General Electric designs, Flax proposed holding a new competition, contending that not all eligible contractors had been offered an opportunity to bid to the same requirements, and noting also that the requirements reflected in his draft system operational requirement differed in some important respects from those earlier specified.* The NRO's director urged that the recovery vehicle contracts should be recompeted for the same reasons. To arguments that recompetition was wasteful of time, Flax responded that even if the most optimistic schedule then suggested proved valid, recompetition would not delay the first launch for more than a few weeks. (He also proposed a competition for the Titan IIID strap-on solid rockets.)[23]

Implementing papers went to the CIA and NRO participants in the program on 28 April, two days after Flax received formal notification that his proposal had been approved as submitted. (Some minor points of disagreement on security arrangements remained for clarification, but that did not constitute a significant problem.) Apart from

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* In the event, General Electric won neither the satellite vehicle nor the reentry body competition for Hexagon.

the set of papers submitted to the Executive Committee, the 28 April directives included directions for the assembly of a sensor source selection board, preliminary budget guidance, and a memorandum to the Air Force authorizing the start of a competition for the Titan IIID and the preparation of system package plans for both the Titan IIIC and IIID. (As with the spacecraft and recovery vehicles, a final decision on configuration and design of the launch vehicle still had not been made.)

Sensor source selection, the first order of business, was assigned to a board headed by L. C. Dirks of the CIA and composed of four additional members, two from the CIA and two from the Directorate of Special Projects. They were scheduled to receive formal inputs from Itek and Perkin-Elmer by 22 July.* Booster source selection was entrusted to a similarly constituted board chaired by Colonel W. R. Taliaferro of the Titan III System Program Office. Booster proposals were due by 1 September; Flax expected contract negotiations to be completed by early November 1966.[24]

On 30 April 1966, both the Special Projects Directorate and the CIA officially established Hexagon project offices in their respective organizations. Flax confirmed the nomination of Donald Patterson

* The proposals had been in preparation since February and the technical aspects of the three principal submissions were well known to the evaluators.

of the CIA to direct sensor development and named Colonel F.S. Buzard to head the Hexagon System Program Office on the West Coast. In what was assumed to be a temporary measure, Buzard arranged to have the Hexagon office physically collocated with the existing Corona program office, sharing command of the composite organization with the Corona chief. The purpose of the arrangement was to permit Buzard to draw on the experienced Corona people to supplement his own relatively small staff resources. With the start of Hexagon development, there seemed little doubt that Corona would cease operations in the reasonably close future. Obvious advantages resided in an orderly transfer of search-system responsibility from the existing system to its successor. In the event, Hexagon became operational five years after program start, rather than two, as had originally been proposed, and the transition was much more gradual than Buzard had anticipated. The consequence was that at the end of three years the core of the Hexagon office was composed of people who had varied earlier experience with Corona but who had also accumulated considerable Hexagon experience.

With the approval of a Hexagon program and assignment of sensor subsystem responsibility to the CIA, existing S-2 contracts with Itek had to be terminated. Colonel Buzard negotiated the essential contract agreements with Itek between 6 May and 23 May 1966, and on the latter date Itek formally began work preliminary to a proposal for Hexagon camera system development. With issuance of the request for proposals on 23 May, both Itek and Perkin-Elmer became contractors to the CIA's newly created Sensor Subsystem Project Office.[25]

The matter of how many film capsules Hexagon would carry became the concern of a special study group on 24 May. The CIA's earlier Fulcrum schematic had been organized around the premise of one very large recovery vehicle; the S-2 proposal had never envisaged use of fewer than two capsules--and as many as four had been urged by members of both Fulcrum and S-2 study groups at one time or another.

On 25 May, Flax authorized the creation of a source selection board for the Satellite Basic Assembly (SBA) under Buzard's direction. The board included four NRO and two CIA members. By 8 June the formal Request for Proposal had received Flax's endorsement and eight days later it went to Lockheed, General Electric, McDonnell-Douglas, North American, and Hughes. (Hughes decided against participating in the competition.) Proposals were due by 22 August, one month after the scheduled receipt of sensor system proposals.

As could have been predicted, a renewed space vehicle competition was not welcomed by General Electric, which had won both the Fulcrum and S-2 "competitions" of the previous year. H. W. Paige, general manager of GE's space program organization, protested to Flax that it was basically unfair to GE to be forced to compete a third time, given that GE had originated the concept then being competed, had twice won competitions, had a skilled but unemployed space vehicle team available (unemployed because with the transition from Gambit-1 to Gambit-3 the orbital control vehicle around which Gambit had first been designed was no longer being used), and represented the only experienced alternative to Lockheed. Flax, who was aware of the problems created by his decision to recompete the space vehicle part of Hexagon, could but point out that Hexagon was neither Fulcrum nor S-2, that conditions had changed, and that he would give consideration to GE's experience when selection board recommendations were submitted.[26]

Although the final report of the recovery vehicle study committee had not yet been prepared, Buzard's people began writing the proposal guidelines for the recovery vehicle in June 1966. Because the number of recovery vehicles had not yet been decided, three designs were specified, providing for loaded film weights of 250, 525, and 1050 pounds.

On 21 June Buzard urged Dr. Flax to approve a four-bucket configuration, but Flax decided to postpone a final decision until booster configuration and weight budget were better defined. Nonetheless, on 6 July, Flax agreed to the commencement of reviews of recovery vehicle proposals and agreed to issuance of requests for proposals by 19 July. The issuance of a Request for Proposal for the Stellar Terrain camera in late August completed the formal actions needed to get Hexagon development underway, but hopes that the development itself could proceed as expeditiously were to prove unduly optimistic. Almost two years were to pass before the recovery vehicles were at last put on contract although initial estimates of first launch date for the new system postulated availability of all subsystems within 18 months of program start.[27]

On 30 August--precisely as scheduled--the sensor source selection board reported its findings to Flax. The evaluators unanimously concluded that Perkin-Elmer had the better proposal and recommended that sensor development be assigned to that contractor. The preferred design was an outgrowth of the much earlier Itek-Fulcrum approach; the loser was the Itek-EK design of S-2 vintage.

Proposals had been evaluated in two categories: technical and operational qualities, and management, production, and logistics.

In a scoring system that permitted a maximum possible score of 100, Perkin-Elmer accumulated a total of 69.3 points and Itek 54.7. Although the differences could be accounted for by many details of quality and resources, the board was influenced by Itek's emphasis on design for maximum resolution on the film as against Perkin-Elmer's approach of minimizing optical errors. Itek had larger and more complex optics; Perkin-Elmer emphasized other than optical considerations. The Itek design was based on use of a 48-inch Schmidt lens system with a maximum aperture of f/2.0; the Perkin-Elmer system on a 60-inch focal length lens with an aperture of f/3.0. In order to provide the desired ground resolution capability of 2.7 feet, the Itek system would have to be flown at an altitude of 84 miles as against the 92.5 nautical mile altitude required of the Perkin-Elmer optics for the same resolution. Optical design was also a factor in the weight characteristics of the two designs. For a 30-day mission, the on-orbit spacecraft weight of a Hexagon carrying a Perkin-Elmer camera system promised to be about 1000 pounds less than the comparable weight of a spacecraft carrying the Itek camera. Although there was little doubt that a booster-spacecraft combination capable of putting the heavier system in orbit could be obtained, it was difficult to ignore the obvious advantages of a weight differential so greatly in favor of Perkin-Elmer. (Camera weight differences totaled about 700 pounds--which partly represented the effects of a difference in design approaches but was in some respects a reflection of earlier Itek difficulties in getting the weight of the Itek-EK design down to the level specified during the S-2 phase of pre-Hexagon work.)

Other considerations of sensor system evaluation had a lesser influence on the decision than such fundamentals, but were not ignored. In the opinion of the evaluation group, the Itek proposals had a "significantly larger" development risk and the production tolerances required to insure proper operation of the Itek system would be much more difficult to meet than those of the Perkin-Elmer system. Further, because of optical surface quality requirements, the larger optical surfaces of the Itek system would create greater schedule and production difficulties than would the Perkin-Elmer optics.

Neither design was fully satisfactory in a technical sense. "Numerous errors" in design and analysis were sufficiently serious to cause the source selection board to question the adequacy of the engineering teams that prepared the two proposals. Yet in the end there was no reason to believe that either contractor lacked adequate technical resources. Perkin-Elmer was given a better chance of meeting the development schedule than Itek, although both schedules were admittedly tight.

Itek had a very slight lead in the management, production, and logistic aspects of the two proposals, and had proposed a development costing some $7 million less than the $81.85 million that Perkin-Elmer bid, but Itek production costs promised to be about 10 percent greater, and that offset the attractions of lower development costs.

In the end, Perkin-Elmer's 10 percent edge in weight and resolution, the lesser complexity of the Perkin-Elmer proposal, and the apparently greater maturity of the Perkin-Elmer design accounted for the appreciable difference in the scores awarded the two competitors.

Flax approved the findings of the source selection board as submitted. On 10 October 1966, Perkin-Elmer signed a contract calling for development of the Hexagon camera subsystem.

Flax received notice of the findings of the source selection board for the satellite assembly on 26 September 1966 and during November reviewed the initial reports of the source selection boards for the recovery vehicles and the stellar-indexing camera. He accepted the recommendation that Lockheed develop the satellite but withheld approval of the start of satellite vehicle work until mid-July 1967. In retrospect, that appeared to be an error of judgement because sensor design proceeded throughout that period without needed inputs from satellite vehicle designers. Through much of the intervening time, Perkin-Elmer and the Sensor Subsystem Program Office apparently believed that General Electric had won the competition. CIA sensor program managers and their principal supporting contractor, Thompson-Ramo-Wooldridge, encouraged a variety of Perkin-Elmer design approaches inconsistent with the Lockheed vehicle concept, but generally compatible with the General Electric approach. When Flax formally authorized funded Lockheed work on the satellite vehicle in July 1967, virtually the first and most difficult order of business was to redesign several features of both the satellite vehicle and the camera subsystem which, by that time, had become incompatible. Much of the work Perkin-Elmer had completed between October 1966 and July 1967 had to be redone during the last six months of 1967 and the vehicle-cum-camera interface definition process eventually required ten months of effort instead of the three months the System Program Office had originally allocated to that task. Still, the NRO director's decision to postpone starting work on the satellite vehicle seemed sound at the time; in his role as Assistant Secretary of the Air Force for Research and Development, Flax had recently seen the MOL program suffer various misfortunes because major subsystems had prematurely begun final design stages. He wanted no comparable problems to afflict Hexagon.

Proposals for both recovery vehicles and stellar-indexing camera were returned for further work, being technically inadequate in several respects. McDonnell-Douglas eventually won the recovery vehicle competition because of a superior heat shield design (an ingenious honeycomb-base silicon coating), and Itek the stellar-index camera competition (Fairchild's competing proposal involved a relatively risky electronic imaging technique as opposed to Itek's clever but conventional film-plus-lens design), but almost another year passed before contracts covering those subsystems became effective.[28]

The possibility that Hexagon might be partly or wholly substituted for Gambit had been entertained at the time of Hexagon program approval in 1965 but the issue did not become pressing until late 1966, when the United States Intelligence Board decided to give the question formal consideration. The immediate problem was finances; if Gambit purchases could be reduced, more money would become available for Hexagon development. But the high assurance of Gambit-3 success and the considerable value of 12-inch resolution photography thus generated warranted continued procurement of Gambit-3, so the USIB endorsed that course in December 1966.[29]

On the assumption that satellite vehicle development would shortly be approved, and in light of delays in the start of work on other major subsystems, the System Program Office late in 1966 proposed and secured approval of a new target date for first launch of Hexagon: April 1969. Contract definition for the recovery vehicles, stellar-indexing camera, and five-segment (rather than the originally proposed three-segment) solid-fuel augmentation rockets for the Titan booster was not scheduled until May 1967, but none was a pacing item in the program. Only about $1 million of the $34.6 million spent on Hexagon by the end of 1966 was committed to subsystems other than the sensor, and most of the cost increments associated with major subsystems remained to be defined. Geodesy requirements had yet to be specified.[30] Preliminary mapping, charting, and geodesy system studies were not completed until March 1967 (and remained contentious for another year); the number of recovery vehicles to be carried by Hexagon was not decided until May 1967.

Nevertheless, the camera subsystem continued to pace program schedules. On 3 April 1967, Patterson advised Colonel Buzard that sensor development schedule slippages made October 1969 the probable initial launch date (rather than April) and that if the camera were installed in the satellite vehicle by Lockheed instead of Perkin-Elmer a further delay to December 1969 was likely. (The System Program Office concluded that system test requirements were such as to make camera-vehicle mating under Perkin-Elmer auspices inevitable even if not wholly desirable on other grounds.)

Colonel Buzard's organization formally recommended, on 5 May 1967, that Hexagon carry four prime-payload recovery vehicles. Whether a fifth should be provided to return stellar-index camera film remained uncertain for the moment, so contract award was again delayed.

The first full year of Hexagon development cost $34.635 million. The fiscal 1968 budget was initially set at $85.32 million, but that sum increased by $11.3 million early in the year to cover additional Titan IIID costs. The approved budget included provisions for a four-recovery-vehicle configuration, an improved engine for the Titan, and the initial procurement of 10 Titan IIID's. It did not provide for development and procurement of a stellar-indexing camera, deferred pending further study.[31]

Continuing problems with the stellar-indexing camera specification were linked to the camera's ability to provide useful mapping data, principally to the Army. During the Spring of 1967, Perkin-Elmer proposed a system (dubbed SIMEC) based on the concept of printing calibrated reseau lines on normal Hexagon panoramic photography for mapping reference. Doubts about the quality of SIMEC induced Dr. Flax to convene a joint technical evaluation committee to examine the Perkin-Elmer proposal. The committee members (from Program A, the CIA, and such other groups as the Army Mapping Service and the National Photographic Interpretation Center) were not impressed. They concluded that SIMEC could not meet the Army's requirement for 1:50,000 scale maps, that it promised to be excessively costly, and that the reseau pattern would obscure the underlying Hexagon imagery to an unacceptable degree. The committee's recommendation was to abandon efforts to incorporate mapping capability in the Hexagon panoramic camera.

Although the System Program Office had earlier concluded that a 12-inch stellar indexing camera was needed to satisfy Army mapping requirements, action to that end was not immediately feasible because of CIA objections. But in July Flax finally announced that Lockheed had won the satellite vehicle competition of the previous summer, and contractually covered work formally began. Final contracts were not signed until December 1967, however.

In early August 1967, following the announcement that Lockheed had won the satellite vehicle contract, the program office created four interface working groups for (1) structural and mechanical issues, (2) tracking, telemetry and command/electrical issues, (3) test and assembly coordination, and (4) operations. The working groups subsequently induced major changes in the design of Lockheed's orbital vehicle, a new command system and a single rather than a dual vehicle shroud being two of the earliest.

Late in October 1967, General Electric contracted to deliver a development test unit and six flight-qualified Mark IV Command Programmer subsystems adapted for Hexagon at a price of $7.45 million.

The Lockheed and General Electric contracts were the first to be signed in the Hexagon program--other than that covering Perkin-Elmer. The delay between program approval and contractual agreement was nearly 18 months. The basic problem was lack of agreement on detailed system specifications and production quantities. In November, for instance, the NRP Executive Committee reduced the initial Hexagon buy (deleting two planned reserve systems) and the Directorate of Defense Research and Engineering formally urged that a 12-inch (focal length) stellar-indexing camera be used in Hexagon instead of the earlier proposed 3-inch design. Dr. John Foster, director of the defense engineering agency, argued that no other expedient could satisfy Army needs.* The cost implications were

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* Although the Directorate of Defense Research and Engineering participated in general discussions of the National Reconnaissance Program at the Executive Committee level, Foster had no vote in program decisions and little influence on most. That constraint did not extend to geodesy and cartography, however. The tradition of tri-service participation in the reconnaissance effort generally gave the Navy a major role in passive electronic reconnaissance and assigned to the Army prime responsibility for mapping and charting. When the Argon program first was approved, in 1958, the Directorate of Defense Research and Engineering inherited from the Advanced Research Projects Agency both a sponsorship function and an active voice in mapping program decisions--reflected in the composition of the configuration control board for Argon. Argon had long since passed from the scene, but Army interests still were represented by the Directorate of Defense Research and

alarming, given that Hexagon was edging toward substantial price increases in several areas, but the additional weight of a 12-inch camera was yet a larger difficulty. The fundamental objection, nonetheless, was the CIA argument that Hexagon should not carry mapping equipment at all. Again, a final decision was put off.

Although a contract covering the initial lot of 10 Titan IIID boosters became effective in December 1967 (backdated to cover "black" work Martin had performed since July), problems created by the delay in starting work on the Lockheed satellite vehicle negated any progress thus implied. By the time Lockheed was legally entitled to start final design, much of the Perkin-Elmer camera system had been configured to conform to the losing General Electric spacecraft design. In particular, the Perkin-Elmer design had to be changed so that the film supply reels were oriented along the pitch axis of the vehicle rather than along the roll axis. Reconciling other aspects of the Perkin-Elmer system with the satellite vehicle forced redesign of both in December. However, the program office was finally able to let contracts for computer software, recovery parachute design and development, and communications equipment. The effect of all that was to drive budget levels from the $96.6 million

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Engineering whenever mapping programs were considered. Thus Foster was in one sense a spokesman for Army viewpoints. His access to and influence with the upper echelons of the Department of Defense made that an important consideration in decisions on new stellar-indexing and mapping systems.

annual rate of September to a $196.2 million rate by December 1967.* Most of the increase reflected booster purchase costs, but program changes of various sorts were important contributors.

Late in 1967, the stellar-indexing camera issue again surfaced. Deputy Secretary of Defense Paul Nitze, Chairman of the NRP Executive Committee, had become receptive to John Foster's advocacy of a large-camera stellar-indexing and mapping subsystem for Hexagon. Cost-factor objections to the proposal had been countered by an Army offer to contribute $1 million toward development. Even though no new camera could be readied in time for the first flight of Hexagon, and only the Army mapping agency maintained that a large camera was essential to the satisfaction of national requirements for maps and charts, the Army's arguments, and their sponsors, proved compelling. The Executive Committee had to accept Flax's assurances that no large-camera stellar-indexing and mapping system could be incorporated in early Hexagons, but development of that system continued and eventually the Committee agreed that it should be used in the seventh and all later launches. No formal contract was to be signed for another year--until November 1968--but Itek continued preliminary development activities in the interim.[32]

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* Budget levels remained very close to $200 million a year through the remainder of the development phase.

Eighteen months after program approval, Hexagon still was making only slow progress toward operational readiness. The difficulties of proceeding from conceptual design to engineering development had been sadly understated--as had the costs of that transition. Most delays had origins in delayed decisions and management disputes, but that did not diminish their effect. The CIA's reluctance to agree to software specifications and CIA efforts to acquire control of software programs caused delays in that area, for instance. Similar difficulties occurred elsewhere: a formal system performance requirements statement appeared in January 1968, after having survived a strenuous informal review the previous November, but immediately became a matter of contention between the CIA's sensor specialists and the main Hexagon program office. Lockheed finally signed a definitive contract for space vehicle development in January but was immediately obliged to propose a major vehicle redesign in order to accommodate camera-system changes made since Lockheed's design had first been submitted, some 14 months earlier. Whether the camera subsystem would be mounted by Perkin-Elmer or shipped to Lockheed for installation had not yet been decided. For that matter, still unresolved questions of camera design included decisions on the film path, the kinds and quantities of test equipment, and the scope of camera system testing to be performed once the camera section had finally been passed on to Lockheed. That Hexagon would include four recovery capsules was certain, but whether the product of stellar-indexing camera operations should be returned with the last of the four or in a separate (and smaller) capsule still was a study question as late as April 1968. Because of design uncertainties, no recovery vehicle contractor had yet been chosen. (McDonnell-Douglas had an attractive proposal in a technical sense, but the cost was unacceptably higher than for GE's less appealing shield concept.) Costs were rising, schedules were slipping, essential test articles remained undefined, and disagreements over management responsibilities repeatedly disrupted routine. Nevertheless, in April 1968 program managers agreed that 1 October 1970 was a reasonable first launch date (one both could accept) and made that, rather than mid-1968, the new program goal.

Resolution of stellar-indexing camera uncertainties* early in 1968 permitted the issuance of "go-ahead" letter contracts for recovery

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* The concept of a long-focal-length camera prevailed, but not until June was it possible to confirm the advisability of returning the film product of the stellar-indexing camera in its own separate recovery capsule. The Corona capsule eventually was adapted to that purpose.

vehicle development (to McDonnell-Douglas) late in May and for stellar-indexing camera development a month later (to Itek). Formal contracts appeared on 30 September and 15 November 1968, respectively. In May, Dr. Flax settled the who-does-what argument over camera-vehicle integration responsibilities by accepting the CIA's contention that Perkin-Elmer could do the job of installing the camera system in the vehicle assembly more effectively than could Lockheed, thus permitting disposition of several lesser questions still hinging on that fundamental issue.[33]

Fulcrum, the 1963 proposal that eventually led to Hexagon, had initially been conceived as a search system to replace Corona. Eventual approval of Hexagon development expanded that concept to include surveillance by incorporating the 1964 "Corona coverage at Gambit resolutions" statement. Between 1964 and 1968, considerable advances in reconnaissance technology had affected both Corona and Gambit; the former had become a highly cost-effective search system with remarkably good reliability, and the latter a surveillance system with a demonstrated 1.8-foot resolution capability and evident growth capability to about [redacted] "best resolution." The clandestine aspect of the Air Force Manned Orbiting Laboratory (MOL) program that also began in 1964 included a Dorian camera with nominal [redacted] capability. Several proposed unmanned camera systems with at least that resolution potential were beginning to demand attention by 1968. Further, some of the more optimistic participants in the satellite reconnaissance effort had by that time concluded that it was now feasible to undertake development of a high-resolution readout system with near-real-time capability. In the growing national uproar over the costly IndoChina War, defense budgets were becoming tighter; one consequence was that the development of expensive new satellite reconnaissance systems was becoming increasingly dependent on finding the necessary money within ceiling-limited NRP budgets. Hexagon was the single most expensive item of the 1968-1970 National Reconnaissance Program.

Starting in mid-1968, therefore, and continuing for a full year, proposals for reorientation, cutback, or cancellation of Hexagon were frequent, serious, and loud. They began routinely enough in budget bureau suggestions that Hexagon program costs were excessive and that the mission Hexagon had been designed to perform could be as well performed by other, less costly systems. That entirely legitimate issue tended to get submerged in the subsequent advocacy of particular "other" systems, partly because the McNamara tradition of proposing "alternatives" had become a fixture of the system evaluation process, partly because various groups within the satellite reconnaissance community had taken to sponsoring one particular system, and partly because any decision to cancel or reduce expenditures on Hexagon could not but enhance the prospects of some other proposal for reconnaissance satellite development and operations.

The opening of Strategic Arms Limitations Talks (SALT) with the Soviet Union further complicated orderly consideration of the future of Hexagon. Progress in the arts of satellite reconnaissance had been so rapid in the mid-1960s that it was no longer essential to couple arms limitations to the on-site inspection of strategic weapons stockpiles and installations. The Soviet Union had consistently refused that concession; pre-1968 efforts to agree on means of verifying compliance with arms limitations agreements had grounded on the inspection issue. Although neither the Soviets nor the Americans was fully prepared to specify that all needed verification and inspection could be performed by means of cameras in orbit, de facto acceptance of that premise was evident after 1968.

Once the means had been agreed upon, however informally, the details became all important. On the American side (and conceivably on the Soviet side as well), the scope and detail of coverage required to confirm compliance with arms agreements were contentious issues. Most reconnaissance systems in service and in development by 1968 had been designed to provide specialized coverage of various kinds. Systems like Corona, Gambit, Hexagon, and the several passive Elint and Comint sensor satellites could undoubtedly serve the needs of verification, but none was optimized for such an application. Optimization--which implied acceptable costs, frequency of coverage, and detail of return--could well require the development of some new system or reliance on some combination of systems not previously contemplated. Crisis reconnaissance, a troublesome subordinate requirement for a decade, could well become a dominant requirement in an era of strategic arms detente. Very high resolution might be needed to detect subtle shifts in strategic posture. Emitting systems, capable of functioning in the presence of the heavy cloud cover and poor lighting conditions that characterized most Soviet strategic missile bases, could become vital. A capability for near instantaneous recurrent coverage of selected areas might be essential. All that seemed certain was that requirements for the 1980s were uncertain and that a satellite reconnaissance system (or systems) capable of verifying Soviet compliance with arms limitation agreements must be in the American inventory in the 1970s and after. The contribution

Hexagon could make, and Hexagon costs, thus became factors in deliberations on the long-term composition of the National Reconnaissance Program.

Such issues began to concern the NRP Executive Committee during the summer of 1968. Late in that summer, Deputy Secretary of Defense Paul Nitze, alert to the increasing costs of the Hexagon program, the remarkable new capabilities being demonstrated by other reconnaissance satellites, and the potential value of Hexagon in a SALT-agreement verification setting, instructed Dr. John Foster, Director of Defense Research and Engineering, to undertake a comprehensive evaluation of Hexagon. Similar studies had been completed and reported to the Executive Committee at intervals since 1964 (although only lately had SALT been of real concern), but most had been undertaken by one or another of the several participants in the satellite reconnaissance effort (the CIA, the NRO, NPIC, DIA, and the NSA had all participated or contributed at one time or another), and Nitze wanted a fresh and entirely independent viewpoint.[34]

Cost was in no wise a new issue. But during the summer and fall of 1968 it became apparent that substantial reductions in prospective NRP budgets for fiscal years 1969 through 1973 were inevitable and that one way of offsetting them would be to cancel Hexagon. The objection, of course, was that Hexagon returns seemed essential to satisfaction of approved NRP objectives for the post-1972 period. At that point in the discussions, the Bureau of the Budget revived an earlier suggestion that the combination of Gambit-3 and an improved Corona (presumably some variant of what was generally known as the Corona J-4 proposal) would satisfy the requirement at a cost perhaps $750 million below that anticipated for Hexagon. The CIA, DIA, NPIC, and NRO responded in concert that without a complete redesign (with costs then estimated to be equal to those of completing Hexagon development), Corona could never provide search resolutions much better than about 4.5 feet--and all those agencies were agreed that search resolutions better than 3.0 feet were essential to verification of arms limitations agreements. The Bureau of the Budget rejoinder that a 1.5-foot difference in resolution could not possibly be worth the $500 million it would surely cost by 1973 had no evident effect.[35]

In November 1968 the American electorate chose Richard M. Nixon to succeed Lyndon B. Johnson as President. Nixon appointees took office in January 1969. Foster and Richard Helms, Director of Central Intelligence, were among the few senior officials to carry over from one administration to the other. Nitze was succeeded by David Packard as Deputy Secretary of Defense, and Clark Clifford, President Johnson's last Secretary of Defense, by Melvin Laird. Clifford had delegated responsibility for virtually all matters concerned with the National Reconnaissance Program to Nitze; Laird did the same for Packard, but kept closer tabs on NRP policy decisions than had Clifford. Laird's instructions from President Nixon were to reduce defense expenditures below the levels proposed by the Johnson Administration, and he did not propose to exempt the NRP from funding cutbacks. The new Director of the Bureau of the Budget, Robert P. Mayo, had received similar instructions: he found a ready advocacy of NRP funding cuts embedded in the permanent staff of the bureau.

Very shortly after taking over the budget bureau, Mayo proposed cancelling Hexagon and substituting a Corona-Gambit capability. Packard saw little merit in the idea (he had concluded that if any major reconnaissance program were to be cancelled it should be MOL-Dorian, a measure that would have about the same financial effect as a Hexagon cancellation), and for the moment Mayo received no support from the White House.[36]

Late in March, Mayo again marshalled budget bureau arguments against Hexagon and carried them to the President. On 9 April 1969, President Nixon ordered Hexagon to be cancelled and approved carrying MOL-Dorian to completion.

The rationale of the decision was extremely complex, but in essentials it derived from the evident necessity of eliminating either MOL-Dorian or Hexagon if the fiscal 1970-71 budget was to remain in balance, the apparent overlap of capability between Hexagon and Dorian in SALT terms, the impossibility of cancelling Gambit until a replacement was operational, and the lack of any other obvious reconnaissance program candidates for cancellation. Corona was so inexpensive as compared to Hexagon that its continuation into an indefinite future would have no appreciable effect on NRP budget levels, although the development of an improved Corona to serve in lieu of Hexagon might cost from $75 million to $100 million.

Both the President and his Secretary of Defense had earlier gone on record in support of the MOL program, and both had been outspoken in their criticism of the major Air Force program cancellations that marked the early years of the McNamara incumbency. That too probably was a factor in the decision; a Hexagon cancellation would go unnoticed outside the relatively small community of satellite reconnaissance specialists (and actually found favor with some in that group), while a MOL cancellation seemed certain to stir up protests in the Pentagon, in Congress, and throughout the aerospace industry.

Whatever the reasoning behind the 9 April decision, reconsideration was immediate. At Helms' urging, the President delayed action on Hexagon cancellation for two weeks. In that interval Helms and Packard made their objections known to the President, and on 21 April Mayo reversed his original stand. The three brought Laird to their way of thinking by late April. The fundamental argument they settled on (eventually presented by Mayo) was that Hexagon would provide a much better capability for validating any arms limitation agreement than MOL-Dorian. John Foster did not fully agree, but his reservations about Hexagon (derived partly from the inconclusive study he had undertaken at Nitze's urging six months earlier) and his reaffirmation of MOL requirements were both offset and counterbalanced by growing evidence of large impending cost overruns in MOL and by the surprisingly modest support of MOL provided by influential members of the House and Senate. Given the apparent temper of the Congress, it was entirely conceivable that a cutback in MOL funding would follow disclosure of imminent cost overruns in that program. Both Hexagon and MOL-Dorian might thereby suffer.

What may have been a clinching argument against MOL appeared as an independent recommendation of the Land Panel which reached the President on 6 May 1969. Dr. Land and his group favored cancelling the manned part of the MOL program, developing an unmanned high resolution satellite using Dorian-derived optics, and diverting funds saved by the MOL cancellation to a "real-time-readout" system. President Nixon was sufficiently intrigued by the potential of the readout system Dr. Land advocated to make that capability the principal reconnaissance satellite objective of his administration. To implement that decision he reversed his earlier verdict on Hexagon and ordered cancellation of MOL-Dorian. Laird publicly announced that aspect of the decision on the morning of 10 June 1969; the endorsement of Hexagon received no public notice, of course, but it was probably the more significant part.[37]

The June 1969 decision was conclusive, and before long was irreversible. To have cancelled Hexagon after the summer of 1969 would have decimated the national capability for search-satellite operations. Proposals for extending Corona production and even for stockpiling Coronas against some future need (which presumably could have included the failure of the Hexagon development program) gained an occasional hearing thereafter, but never again did they have high-level support. The National Aeronautics and Space Administration wanted Corona for possible use in Earth Resources Survey assignments and the Department of State urged retention of Corona capability against crisis reconnaissance needs, but NASA was unable to finance continued Corona production and State could not overcome arguments that Hexagon would outperform Corona in a crisis reconnaissance assignment. Enough Corona systems had been ordered to protect against a serious gap in coverage should Hexagon be delayed in development--which proved notably wise--and the development of a reasonably effective and not too costly Gambit modification (Higherboy) represented another hedge against delayed Hexagon availability. Both were stopgap measures, of course; by 1969 successful Hexagon operations in 1972 had become an integral of national reconnaissance policy.[38]

During the first two years after Hexagon program approval, incurred delays had largely arisen in uncertainties of program definition and design. Their effect had been to cause a significant slippage in program schedules. Although their advocates had represented both S-2 and Fulcrum to be fit for full system development by late 1965, not until the Spring of 1966 had a development start been approved, and not until 1968 were all of the essential elements of the Hexagon system under contract. Decisions on booster configuration, recovery vehicle configuration, the selection of a stellar indexing and mapping camera, and accommodation of the orbital vehicle to the changing design of the camera system had been delayed far longer than could reasonably have been anticipated. Long after, the chief CIA manager of reconnaissance program matters concluded that insufficient background research had been performed on Hexagon in advance of the decision to proceed with full-scale system development.*

After system definition had finally been completed, an event that was difficult to date but could most accurately be assigned to mid-1968, Hexagon began to encounter the sorts of engineering and test problems that had marked the development of all earlier photographic satellites. Gambit-1 had come closer than any other photo-satellite to meeting its schedule, and even Gambit had demonstrated disturbing operational shortcomings during its first year of operation. Corona had nearly been cancelled after a first year of flight experience dominated by mission failures, and all other photo-satellites of the 1960s had eventually succumbed to one or another of several

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* Carl Duckett, the CIA's Deputy Director, Science and Technology, suggested in a 15 July 1971 discussion of probable cost growth in a proposed new system that ". . . in the case of HEXAGON. . . we had spent little money and knew very little what we were trying to do" at the time of program approval. Although only Dr. Flax and his immediate staff seem to have expressed such misgivings while Fulcrum and S-2 were being roundly endorsed by their respective sponsors in 1965-1966, that retrospective judgment seems sound. Only the camera subsystem design seems to have been reasonably well defined at the time of Hexagon program approval in April 1966, and once engineering development got well underway even that changed significantly.[39]

major flaws. Although the Hexagon program schedule made some allowances for slippages caused by unforeseen engineering difficulties, in the end they proved to be insufficient.

The lack of an agreed software program delayed progress in operational planning until March 1969, when Flax intervened to resolve disagreements between the sensor (CIA) and system (SAFSP) program offices. Another delaying element arose from a difference of opinion involving the System Program Office and the National Photographic Interpretation Center concerning the accuracy requirement for attitude determination devices. Although for a time it appeared that some redesign of the attitude sensors might be required, in the end the problem was reduced to one of data requirements, NPIC relaxing its original demands for extreme precision. Colonel Buzard later summed up the program office viewpoint with the phrase, "if a thing is not worth doing at all, why do it well?" Nevertheless, such problems hinted at real slippages to come.

The first unrecoverable slippage of any kind was acknowledged early in 1969 (while the scheduled first launch date still was 1 October 1970); Perkin-Elmer spent an unprogrammed two and one-half months of additional work in completing and testing the first qualification model of the camera-vehicle midsection assembly. The disclosure of that misadventure had been preceded by a rather unsettling special review of Hexagon engineering work undertaken to the end of 1968; the review report highlighted 14 major and 28 lesser system faults that required prompt attention. Camera subsystem development costs increased by nearly $6 million in the first quarter of calendar 1969--a foretaste of much larger cost growth to come--and various slippages and redesign requirements forced the allocation of $5 million in additional funds to Lockheed.[40]

The CIA's Sensor Subsystem Program Office initially reacted to word of potential slippages in camera development schedules by proposing to compress and abbreviate elements of the thermal testing program, but that expedient became inadvisable when the camera section proved to be more sensitive to minor temperature variations than had been assumed earlier.

Although to that time only about two months of unrecoverable slippages in the total Hexagon program had been positively identified, and schedules had been designed to accommodate at least that much slack, in June 1969 Dr. McLucas* assigned to his principal deputy, Dr. F. Robert Naka, the task of determining the viability of the Hexagon launch schedule (which then called for first flight no later than December

* Dr. J. L. McLucas succeeded Flax as Director, National Reconnaissance Office, in April 1969.

1970). Naka's evaluation,* forwarded to members of the NRP Executive Committee on 20 June, contained carefully qualified expressions of caution.

In addition to evaluating the probability that Hexagon would be launched as scheduled, Naka estimated the degree of confidence the NRO should have that the first Hexagon mission would be successful, and looked at various ways of optimizing search mission products at least possible cost. An unavoidable parallel issue was whether Corona vehicles additional to those then on order should be purchased as a safeguard against a lapse in search coverage that might occur if Hexagon operations began appreciably later than December 1970.

Naka calculated a 95-percent probability for a first Hexagon launch no later than June 1971, rated at 75 percent the probability of a first launch by March 1971, and assigned a 50-percent probability to launch no later than January 1971. He concluded that about 75-percent

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* Dr. Naka signed and reported the findings as spokesman for a committee that included H. Plaster of the CIA's sensor project office and Colonel L. S. Norman of the NRO's Directorate of Special Projects. Although preliminary findings were forwarded to the Executive Committee in June, formal reports seem not to have been prepared until September 1969.

confidence should be assigned to the possibility of mission success on the initial flight and foresaw a 95-percent probability that at least one of the first three missions would be successful. Given those odds, he suggested that the 12 Coronas programmed for launch at about two-month intervals between June 1970 and July 1971 should be rescheduled to allow for at least two missions after July 1971, thus insuring a minimum overlap of Corona with Hexagon and providing some search coverage in the event of either a Hexagon slippage past June 1971 or mission failure. Given the existing uncertainties of Hexagon scheduling, Naka also cautioned that the need for more Coronas should be reassessed in December 1969.[41]

The Naka report, standing alone, was cause for mild uneasiness. Taken together with revised estimates of Hexagon costs in fiscal 1970, however, it prompted a serious Executive Committee discussion of the future of Hexagon as a system. Both Perkin-Elmer and Lockheed had advised program managers of potentially massive Hexagon cost growth--a particularly disheartening development at a time when other elements of the National Reconnaissance Program were also in financial distress. Part of the difficulty arose from the necessity of diverting defense dollars to the increasingly costly IndoChina War; another part derived from President Nixon's assignment of a high priority to the effort to develop a near-real-time readout system for reconnaissance satellite applications--the target date being 1976. The MOL-Dorian program had been cancelled only in June 1969, and there still was no agreement on whether ultra-high resolution or readout should receive funding priority. David Packard, chairman of the Executive Committee, asked flatly on 8 August 1969 whether there was agreement in the Committee that Hexagon development should be continued. The vote was in favor of proceeding; there was no real alternative, although various substitute means for providing search coverage in the 1970s still were being examined. CIA's Carl Duckett assured Packard that costs had been brought under control and that Perkin-Elmer, the chief offender, had promised to be attentive to the need for careful control of costs. Although the system was somewhat behind schedule, the quality of systems then in test seemed quite good, Duckett added.

In the end, the Executive Committee approved the Hexagon budget for fiscal 1970 about as submitted, merely adding a caution that the National Reconnaissance Office must keep a sharp eye and a tight hand on costs.[42]

Costs were not unrelated to schedules, of course, and in the late months of 1969 schedules were becoming almost as worrisome as costs. To maintain the required pace of progress, several contractors had resorted to double and triple shifts and the extensive use of overtime. Conduct of that sort was somewhat out of fashion by late 1969, at least for most defense procurements, but for Hexagon there seemed to be no useful alternative. In the development and production of many weapon systems, the schedule urgency attached to programs was largely artificial. Major systems had characteristically been delivered from one to three years late without significantly lessening total defense effectiveness. The customary response to development delays was to slip delivery schedules and to extend the in-service life of whatever was currently in the inventory rather than to trade money for time. Aircraft program schedules, for instance, could be restructured to offset cost increases in a given fiscal period and the worst consequence was to delay the availability of some system that probably need not meet whatever schedule had originally been established. Thus overtime generally was not encouraged for normal defense procurements, and multiple shifts usually were permitted only when some critical item like ammunition was in dangerously short supply.

But the Hexagon case was in quite another category. Satellite reconnaissance systems did not stay quietly in the weapons inventory; they were expended, regularly and inevitably. If Hexagon did not appear as scheduled, some provision would have to be made for obtaining substitute coverage of target areas--and in late 1969 the alternatives were alarmingly few. Hexagon overtime and multiple-shift work was necessary to meet schedules that were based on the planned expenditure of existing stocks of reconnaissance satellites, chiefly Corona systems. Corona J-3 could not offset Hexagon requirements, and by 1969 there was no reasonable possibility of developing an improved Corona in time to substitute it for Hexagon. Indeed, within a few months it would become impossible to order additional Corona J-3 systems in time to offset a major delay in Hexagon availability: the lead time for Corona was 18 to 24 months, which meant that systems ordered in December 1969 could not be delivered sooner than June 1971. The question of whether to spend money for Hexagon overtime and multi-shift operations or to keep Hexagon on a normal schedule and buy Corona vehicles (or the only other feasible option, Gambit systems configured for high altitude flight and artificial search capability thereby), was more academic than real. The Executive Committee had little choice.

Concern did not vanish, nor did the Committee lose sight of the problem. In October 1969, Dr. Naka again reviewed Hexagon status, and although an indicated additional slippage of at least one month had appeared since August, he recommended that the decision on an additional Corona buy be postponed until January 1970. By January there had been no significant change, so the Committee somewhat reluctantly decided to forego the option of ordering more Corona vehicles.[43]

Dr. Naka's report did not stand alone and unsupported--or supported only by classical contractor and program office optimism. In December 1969, Brigadier General W. G. King (who in August 1969 had succeeded Major General John L. Martin, Jr., as NRO head of Program A, the Directorate of Special Projects) convened a special meeting of Hexagon principals from the program office, the sensor project office, and the major contractors to reevaluate the prospect of meeting the scheduled December 1970 launch date.*

All agreed that although the schedule was getting tighter with the gradual disappearance of slack time that had earlier been provided to accommodate inevitable engineering and test difficulties, the December 1970 deadline was reasonable--but staying on schedule would require "vigorous action" by all concerned.[44]

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* Nearly seven years earlier, then-Colonel King had somewhat abruptly been named to head the Gambit program office at a time when that system was in a situation of technical, financial, and schedule crisis. A decade still earlier, he had been called on to rescue the Snark missile system after it had experienced a 300 percent cost overrun, a five-year availability slippage, and a succession of incredible technical shortfalls. He had performed admirably in both assignments. (NB: General Martin's departure was a routine reassignment after seven years with the NRO.)

Thermal control testing had, by late 1969, disclosed that the camera section was not immune to internal temperature variations of as much as 20 degrees (Centigrade), as had been intended. In practice, a variation of from three to seven degrees was as much as the camera could tolerate, and in a 60-foot vehicle exposed to variant sun angles the ambient internal temperature range was much larger. Heat had to be provided for part of the system, a modification that required adding both solar panel area and more electrical power. Recalibration and rework problems disarranged the combination camera-midbody tests at Perkin-Elmer in February and March 1970, causing Lockheed to substitute available satellite vehicle test sections for those originally scheduled to be so tested, but by adroit shifting about of test sections both contractors managed to stay reasonably close to the milestone schedule imposed by the December 1970 launch date. But that sort of test rescheduling caused expenditure of very nearly the last remaining reserves of slack time in the pre-launch test program. In early July 1970, Dr. McLucas was able to report to the NRP Executive Committee that notwithstanding ". . . the normal difficulties one can expect with major development programs," the December launch date for <u>Hexagon</u> still seemed achievable.[45]

Unhappily, even while Dr. McLucas was assembling his report to the Executive Committee the validity of his cautious optimism was eroded by events at the Perkin-Elmer plant. On 7 July, the first flight-article twin camera assembly (P-1) suffered a catastrophic failure during low temperature chamber testing. It had been scheduled for 31 July shipment to Lockheed. The extent of damage was so great that no possibility of timely repair and recalibration could realistically be entertained. On 10 July, therefore, the sensor program office confirmed the contractor's judgment that the second sensor system (P-2), originally scheduled for 5 September shipment, had to be substituted in first-flight schedules. It was conceivable that P-2 could be qualified and shipped by 26 August, but given the earlier disappearance of virtually all remaining slack time in the flight readiness schedule, there was slight prospect of meeting the 17 December 1970 first flight target date. Indeed, Dr. Naka reported to McLucas that even if the schedule were allowed to slip by three months (into March 1971), confidence in meeting the <u>new</u> flight schedule would remain low. By adopting a seven-day, three-shift operation, Lockheed conceivably could complete qualification and calibration of the combined camera-vehicle midsection assembly late in September, after which arrangements for a December launch still might possibly be made, but the effort would cost from $2 million to $3 million in additional funds for Lockheed and Perkin-Elmer efforts, and still the assurance of launch would be tiny.[46]

Although the full extent of the problem was not known at the time the NRP Executive Committee met on 17 July, the implications were plain. J. R. Schlesinger, then acting Deputy Director of the Office of Manpower and Budget, promptly resurrected the proposal to buy Corona systems to fill the search-system gap that seemed certain to develop if the Hexagon camera failure was symptomatic of a major defect. Dr. Naka, whose committee had recommended bypassing that option six months earlier, explained that the last chance to order Corona systems had lapsed the previous February. If Hexagon failed, and Corona launches continued at their planned rate, there would occur a lapse of about six months before new Corona systems could be delivered. At that time (July 1970), an 11-month overlap still existed--assuming that Hexagon could meet a June 1971 launch date, the worst possible contingency previously examined in detail and that at least one of the first three launches was successful in returning search photography. The decision that had to be made, Naka explained, was whether to push for an early launch so as to learn promptly what on-orbit problems Hexagon faced, or to complete a thorough sequence of tests in order to generate high confidence in flight success and accept the resulting schedule slippage.[47]

Although on the surface the potential for launching in December 1970 looked hopeless, the sensor project office held stubbornly to that goal for nearly a month after the failure of P-1. The chosen course had been to opt for an early launch rather than extended testing. Perkin-Elmer and Lockheed overtime costs were accepted as the price of the effort. But following arrival of the second camera payload (P-2) at Lockheed's Sunnyvale facility, major problems with the film transport mechanism again stalled the test program. Faulty platen functioning and film supply operations were simultaneously delaying qualification tests at Perkin-Elmer's Danbury (Connecticut) plant. The situation having degenerated so completely, the sensor project office conceded ". . . that they don't have a prayer of meeting the 17 December launch date."[48]

Formal acknowledgement of the inevitable launch date slippage came from General King on 15 September: "Problems principally associated with acceptance testing of the sensor subsystem. . ." had invalidated the December 1970 launch schedule. Lockheed's overtime authorization had been revoked a week earlier. King believed that if the various camera and film tracking problems encountered at Sunnyvale and Danbury were promptly solved, a March 1971 first flight might still be possible. Not until he heard King's opinion did Dr. McLucas officially advise the United States Intelligence Board that the Hexagon schedule had come thoroughly unstuck.[49]

Most of the problems proved to be electronic rather than mechanical or optical, which may have made long-term prospects seem brighter, but that did not lessen the immediate gravity of the situation. Late in September, King named select teams of specialists to review the status of sensor subsystem work and once their preliminary findings had been received sent off additional "tiger teams" to look into the state of affairs at the space vehicle and recovery vehicle plants. Their reports reinforced King's preliminary judgment: if ". . . no additional significant problems occur. . ." the first flight midsection should be ready for mating by mid-October and first launch should follow in March. Four months had been allocated for systems integration and checkout at Sunnyvale and Vandenberg.[50]

Although nothing resembling the major testing failures of July and August marred the Hexagon development program for the remainder of 1970, by January 1971 it had become apparent that "March 1971" (which had widely been interpreted to mean "about 1 March") had better be restated as April, and 9 April became the new official target date--although in private session the Executive Committee received advice from Dr. Naka that "about May 10, 1971" was a better estimate. Somewhat less inclined than in the past to accept schedule assurances at their face value, the NRP Executive Committee endorsed

Dr. McLucas' action in providing additional insurance against extended Hexagon troubles by authorizing work on a Gambit modification (Higherboy) that would permit Gambit to operate as a makeshift search system by flying at altitudes of about 525 nautical miles. At that distance, Gambit swath widths would approximate those of Corona, and resolution would be about the same. The first of three Higherboy kits ordered for insurance would be ready by November 1971 but would not be needed before April 1972, in the worst possible case. Considered as no more than Corona equivalents, they would add approximately six months to the existing overlap between Corona and Hexagon. They represented, at best, a means of offsetting the consequences of a temporary loss of search satellite capability through an extended delay in Hexagon availability. Higherboy was an expensive but expedient means for providing Corona-scope search capability, with perhaps somewhat better resolution than Corona (small lots of Coronas would cost about $20 million a system), but in no sense could Higherboy be considered a Hexagon replacement.[51]

Dr. Naka's cautious appraisal of the worth of "official" Hexagon launch schedules proved sound almost immediately. By the end of March, problems encountered in acoustic and thermal tests of the first payload-vehicle assembly caused program managers to reschedule the initial launch for "not earlier than 3 May 1971," and by April it had become apparent that the four-month allowance for payload integration and checkout should have been seven months. Late in April new delays intervened, and 20 May became the target date. Then on 26 April the program office learned that extended testing of the shutter assembly on the second and third camera payload sections had disclosed that failure was liable to occur after only 28, 000 cycles of shutter operation. Colonel Buzard sadly advised Brigadier General Lew Allen, new Program A director, that because the shutters in the payload then being prepared for launch had experienced 20, 000 and 28, 000 cyclic operations respectively, there was a high probability of shutter failure on orbit. The design, he said flatly, was marginal. He therefore proposed to delay the first launch until at least June.

Allen reacted immediately. Categorizing the possibility of on-orbit failure as "unacceptable," he halted launch preparations. Perkin-Elmer estimated that three weeks would be required to modify and retest the shutters.

The problem, when diagnosed, was almost simplistic. The shutters were of focal-plane types, with the opening and closing blades operating in separate slots in a rail and overlapping at the end of their travel. The shutter blades were .010 inches thick, and the slots .015 inches wide. Bearing surfaces on the shoes on the closing blade were .015 thick. There simply was insufficient room for both blades and bearing shoes when the blades overlapped at the end of shutter travel. The correction was simplicity itself: remove the end of the blade so that it no longer rubbed on the rail; blade failure (from that cause) thus became impossible. Accelerated tests of the modified blade assembly proved it capable of surviving 110,000 cycles of operations. But diagnosis and shutter modification (and retesting) had chewed up so much time that "about 14 June" had to become the new launch target date. (Because Hexagon payload vehicles could not be trucked over California highways on weekends, when traffic was heaviest, and because the payload would not be ready for trucking before 28 May, four additional days delay were imposed by the unfortunate coincidence of the Memorial Day weekend and the completion of payload testing at Sunnyvale.)[52]

But that was the last. Payload delivery was on schedule, pre-launch checkout was almost uneventful, and on 15 June 1971 the first Hexagon satellite went into orbit. Carrying Hexagon from program approval to first launch had taken five years rather than two and had cost rather more than twice as much as initially estimated, mostly for camera development, which cost three times as much as the CIA had anticipated,[53] but a launch had been brought off. And in the end the critical scheduling estimates provided by Dr. Robert Naka and his associates in 1969 had proved remarkably accurate: Hexagon did indeed fly in June 1971 (the "95-percent probability" date), and it did indeed function successfully (the "75-percent confidence" evaluation).

Hexagon: Initial Operations

Although first flight did not occur in October 1970, as anticipated, Hexagon operations, when they began, conformed in other respects to careful plans designed to meet that deadline. Operation of Hexagon would be as complex as the management and hardware and software problems that had proved so troublesome in the months between April 1966 program approval and June 1971 first flight. The functional and organizational interrelationships of Hexagon operations would have astonished reconnaissance program managers of the early 1960s, when verbal agreements and informal memoranda constituted the bulk of operational program documentation.

The list of organizations participating in Hexagon operations was awesome--even if only principals were counted. It included COMIREX* (the United States Intelligence Board--USIB--Committee on Imagery Requirements and Exploitations); Eastman Kodak; the

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* (Acronyms and organizational abbreviations generally have not been used on these pages, except for such often-used sets of initials as NRO, NRP, USAF, and CIA. The following brief summary of operational program participants and their responsibilities is so dominated by organizations known almost exclusively by their abbreviations that it is not feasible to continue that felicitous practice, however desirable. Some acronyms are so well entrenched in conversational usage in the intelligence community that even constant users have to stop and rummage through their memories when asked to provide the full titles of such as COMIREX, SPPF, and ICRS. The reader baffled or infuriated by bureaucratic fondness for acronyms and their verbalization may pass by this section without appreciably weakening

Global Weather Center (GWC) of the Air Force Air Weather Service; the Imagery Collection Requirements Subcommittee (ICRS) of COMIREX; the National Photographic Interpretation Center (NPIC); the Office of Special Projects (OSP), CIA, the Satellite Operations Center (SOC) of the National Reconnaissance Office (NRO); the Satellite Test Center (STC) of the Air Force Satellite Control Facility (SCF); the Sensor Subsystem Project Office (SSPO) of CIA's OSP; the System Program Office (SPO) at the NRO's Directorate of Special Projects (SAFSP); the Air Force Special Projects Production Facility (SPPF); and the U.S. Army Topographic Command (TOPOCOM). The acronyms alone were enough to engage the attention of a trained philologist.

Both the System Program Director (General Allen at the time of first launch--Colonel Buzard was Program Manager) and the CIA's Director of Reconnaissance (John Crowley) reported to Dr. Flax for purposes of managing the operational aspects of Hexagon. The System Program Office (Los Angeles) and the Sensor Subsystem Project Office (Langley, Virginia) were respectively responsible for mission operational software (computer programs) and participation in the development and analysis of the software. CIA's OSP developed

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his understanding of the Hexagon program. The section has been included in deference to the canons of historiography: some muddled scholar may some day need to know what element of jargonese referred to what organization. R.P.)

simulation and special study software, and the Satellite Operations Center participated in various aspects of software development as required.

Mission guidance for operational activities came from ICRS/COMIREX, which also provided any details of intelligence requirements not defined previously by USIB standing requirements. The Satellite Operations Center selected launch dates, orbits, and mission objectives to satisfy general intelligence requirements or such special mission requirements as might from time to time be levied. The Office of Special Projects (CIA) provided pre-mission software, and the System Program Office determined vehicle performance characteristics, established flight objectives, defined operational constraints, and provided for vehicle launch preparation and mission operations preparations.

The Satellite Test Center, in support of the System Program Office, constructed mission profiles and a software data base and performed mission software rehearsals. NPIC furnished target lists. The System Program Director exercised complete responsibility for Hexagon operations from launch through recovery. Assisted by the Sensor Subsystem Project Office, the Hexagon Operations Command Post (part of the Satellite Test Center) conducted on-orbit operations.

Global Weather Center was responsible for providing weather forecasts for each one-eighth of the full Hexagon swath width of photography for each orbital revolution, expressing the forecasts in terms of percentage probabilities that any area would be more or less than 90-percent cloud-free.

Eastman Kodak and the Special Projects Production Facility (a superbly equipped photographic processing laboratory at Westover, Massachusetts) each processed two working prints of each set of negatives. The National Photographic Interpretation Center provided preliminary readouts of the film returned by the first and third operational reentry vehicles; Eastman Kodak and the Special Projects Production Facility (with NPIC participating) did the actual film processing and distribution. TOPOCOM provided the final operational report on cloud cover during flight, the Satellite Operations Center evaluated mission accomplishments, and the System Program Director furnished a post-flight analysis of operations for all but the camera system, which was the analytical responsibility of the Sensor Subsystem Project Office.

Software capabilities resident in Hexagon included three simulation programs called CRYSPER, HAMPER and HSIM, relating respectively to sensor subsystem performance, mission performance, and camera operations. TUNITY was the name assigned to the mission targeting, command and control, and reporting program; trans-operational mission reports were mostly based on TUNITY products. The probability that mission objectives were being satisfied was calculated through use of a program called ACCOMP.[54]

Preparations for the first Hexagon launch had not gone unremarked by the press, which was scarcely surprising if only because the Titan IIID launch vehicle was so enormous (although it used the same booster core that put Gambit-3 in orbit). Oddly enough, none of the major newspapers of the country noticed the operation. Aviation Week printed a small post-launch notice that singled out Hexagon as a previously untried system but completely misstated mission and function. A feature writer for the San Jose News represented Hexagon to be "a giant super spy satellite known as 'orbiting Pueblo'. . ." and alerted local residents to watch for "the most volcanic blastoff ever witnessed on the West Coast." The imaginative writer attributed to the satellite the combined capability of being able to "photograph the whiskers on the chin of a Soviet general. . ." and "monitor whispered conversation from 115 miles in the sky"--which might have been true for some Soviet general with a waist-length beard who was sunning himself on a well-lighted black-sand beach just as Hexagon passed directly overhead, cameras operating, but was in other respects somewhat exaggerated.[55] The Air Force routinely announced the successful launch of a "Department of Defense satellite" after Hexagon went into orbit and a few newspapers printed the now-customary paragraph reporting that event, but nothing in the way of real publicity disturbed the launch.[56]

Perhaps all of the trauma and disorder fated for Hexagon had been used up in the exhausting gestation and development phases; perhaps by 1971 reconnaissance satellite development had become more a science than an art. But in any case, the launch and orbital operations of Hexagon 1201 were as nearly flawless as any first launch of the decade. Camera operations presented "only minor problems," and until the final minutes of film capsule recovery there was nothing in the mission approaching drama. The C-130 retrieving aircraft nearest the first descending capsule easily spotted the target but the pilot elected to let it fall into the ocean after observing that the parachute was badly torn and descent rate was very rapid. A helicopter crew retrieved 1201-1* from the sea less than 30 minutes later, intact and undamaged.

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* In order to limit confusion in discussions of the four-capsule Hexagon system, it seems advisable to adopt here the convention used in Hexagon mission reporting, identifying the mission by number (in the 1200 series, starting with 1201) and the mission phase and reentry vehicle by sequence of capsule use. Thus "1201-1" identifies both photography returned by the first of the four capsules to be retrieved in the first Hexagon operation and the capsule itself.

As with other untried systems, the first few Hexagon flights were primarily intended to provide data on capabilities and operational problems. In that sense, useful photography was a bonus. But unlike Gambit, the last preceding major photographic satellite system to enter the service of the National Reconnaissance Program, initial Hexagon operations were also planned to return as much overflight photography as possible. Much of the film captured images of ground targets distributed over parts of the western United States. But Hexagon carried more than 200,000 feet of 6.6-inch film, and even if the cameras had operated randomly it would have been difficult to expend 50,000 feet of film (the quantity contained in each recovery capsule) without managing to photograph some targets of interest to the intelligence community. In the case of Hexagon, of course, exposure was never random in character; camera operations were precisely calculated to provide photographs of denied areas. Dr. McLucas had his first look at the product on 22 June. He immediately advised all Hexagon program participants that it was outstanding, representative of a great technical achievement, and of remarkable value.[57]

As compared to other reconnaissance satellite first flights, Hexagon 1201 may have been relatively trouble-free, but there were operational difficulties nonetheless. Battery overheating, apparently the product of solid-rocket exhaust contamination of reflective surfaces, perturbed on-orbit control to some extent, and the parachute malfunction on 1201-1 was symptomatic of a potentially serious problem. Capsule 1201-2 also developed parachute problems, although in that instance an air catch (26 June) proved feasible nonetheless. But 1201-3, which reentered on 10 July, was another matter. All went well to the instant of main parachute deployment, but at that point a catastrophic overload developed, the parachute lines failed, and the capsule hit the ocean with such great force that the impact ruptured flotation devices. Before nearby helicopters could arrive, the capsule sank to the ocean floor some three miles below.

The battery overheating problem foiled plans to extend the first Hexagon mission to 45 days. By early July, degradation of the primary batteries threatened a shift to reserve batteries (carried on the first mission only) and there were indications that the batteries used to ignite reentry pyrotechnics were failing. When one set of pyro batteries did fail, on 14 July, Buzard had the cameras operated at every possible opportunity for the next eight hours and then recovered 1201-4 on Friday, 15 July, after Hexagon had been 31 days on orbit.

The battery problem had constrained camera operations earlier in the mission, indications of overheating being responsible for a decision to limit photography to about 15 minutes for each four orbits, a provision that was subsequently relaxed and eventually cancelled. Nevertheless, the availability of reserve batteries protected against a total failure of Hexagon 1201 if the main batteries and solar panels were to prove defective. Hexagon 1201 had been programmed for only 30 days of orbital operations, and realization of a 31-day mission represented performance marginally better than planned.

During the transfer of film take-up operations from 1201-3 to 1201-4, some undiagnosed disorder in the film transport mechanism caused two brief automatic shutdown operations, but resort to ordinary recovery measures restored the cameras to full function shortly after each incident.

On balance, Hexagon mission 1201 had to be adjudged an outstanding success. Returned photography from 1201-1 alone contained coverage of more than two-thirds of all known Soviet missile sites and one set of photography taken in one pass over Albania was sufficient to permit identification, by class and type of weaponry, of that country's entire inventory of aircraft and ships. The battery overheating defect seemed likely to be cured by battery repositioning. Film transport difficulties appeared to be of no great consequence, although when the recovered capsules were unloaded it began to appear that less film had been exposed than planned, the outcome of faulty transport mechanism operations that caused film to twist and double over itself from time to time on both sides of the platen.* But with 50,000 feet of film available for each of the four mission phases, the occasional loss of a hundred feet here and there did not seem important for a first mission.

Parachute problems were quite another matter; only one of the four recoveries (1201-4) had been free of parachute malfunctions, two of the capsules had gone into the ocean (1201-1 and 1201-3), and one had been lost altogether (1201-3). Happily, the damaged parachutes of 1201-1 and 1201-2 had both been retrieved, as had the ablative cone of 1201-2, so analysis of the problem did not have to be conducted on the strength of telemetry and photography alone.[58]

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* Some unexposed film was programmed: film rewind between camera operating phases was not scheduled for Hexagon 1201 in the interests of simplifying first-flight operating modes. Film twisting and overlapping caused the metering instruments to register more film on the take-up spools than actually reached them.

Analysis of parachute defects, and later redesign and test activities, continued for several months after 1201-4 had been retrieved. Modified parachutes were eventually provided for 1202, and a new canopy and rigging design was adopted for 1203 and later Hexagons.* The failures, it appeared, had been the products of design and testing oversight. Because tests of the parachute assembly used for 1201 had not fully explored the high-shock region of initial parachute deployment, the parachutes used for 1201 were at best marginal. That three of the four capsules had been retrieved later began to seem almost miraculous; by all odds, the ratio should have been reversed. The main parachute lines had been overstressed by a factor of about two. Discovery of that situation, and the provision of adequate parachutes, eventually contributed to a decision to delay launch of Hexagon 1202, although in fact 1201 had returned so much still undigested information that in July the head of the Defense Intelligence Agency suggested to Dr. McLucas that Corona and Gambit operations would more than satisfy intelligence needs for the moment.[59]

And Hexagon 1201 provided an opportunity no earlier reconnaissance satellite could have matched: for the first time the United States seriously attempted to retrieve a space capsule from the bottom of the Pacific Ocean.

*The redesigned parachutes were originally planned for incorporation in 1205, but schedule slippages caused by other factors eventually allowed their addition to 1203.

The capsule at issue was 1201-3, which lay at a depth of about 16,000 feet on the floor of the Pacific Ocean off the Hawaiian Islands. Capsule designers were confident that the water impact had not shattered the capsule, although it was quite likely to have been damaged and would not be water-tight.

The feasibility of recovering 1201-3 was first considered almost casually in a 27 July conversation between Dr. Naka and Carl Duckett of the CIA. Intrigued, Duckett discretely asked the Navy if the deep-submersible Trieste II, an experimental submarine of considerable versatility, could do the retrieval task. The Navy assured Duckett that the Trieste II could operate safely to depths of 20,000 feet, could quite probably manage a "hook and cable" retrieval operation, and that the precise location of the capsule could probably be established by Scripps Institute undersea survey ships then under charter to the Navy--at a cost of only $100,000. The Trieste II would be provided cost-free, if wanted.

Upon hearing the first informal suggestion that the capsule might be recovered, an NRO staff officer, Major R. A. Schow, Jr.,* asked Eastman Kodak if the film conceivably could be exploited after retrieval. The answer, surprisingly, was "yes"; the edges of the

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* U.S. Army, assigned to the NRO.

tightly rolled film would swell upon exposure to sea water, thus sealing off the center of the roll. In Eastman's judgment, a "considerable portion" of the film might survive. Because the weather over the Soviet Union had been good while the film returned by 1201-3 was being exposed, and because the film included coverage of some regions of particular interest to the intelligence community, its recovery might be highly worthwhile. D. W. Patterson, the CIA's program director for Hexagon sensor subsystems, had earlier obtained EK's assurance that the film could be safely despooled by hand. He concluded that if a search could be started by late August there would be a "good chance" of recovering useful film from 1201-3 during September.[60]

Once the informalities had been disposed of, Dr. McLucas formally asked R. A. Frosch, Assistant Secretary of the Navy (R&D), to authorize use of the Trieste II and Scripps Institute survey ships in the recovery effort. Frosch assured McLucas that the Navy would be "pleased to assist" and that the exercise would cost the NRO very little.

The effort, once begun, proved to be somewhat more trouble-some than first assumed. An initial afterthought prompted a decision to design and fabricate a special basket container with claw-like clamps rather than to make retrieval dependent on hooks, cables, and the eyebolts of the capsule. Because weakening or disintegration of the magnesium parts of the capsule would occur during exposure to seawater, an enclosing "basket" would provide greater assurance that the capsule could be brought to the surface more or less intact. Delays imposed by "basket" procurement, bringing the Trieste II to the scene, and precisely locating the capsule, delayed the start of recovery operations until winter weather arrived, in December 1971. (A start had been scheduled for late October.) But thoughts of abandoning the attempt could not realistically be entertained once it had begun. As Colonel Buzard pointed out, Soviet interest had almost surely been piqued by the unconcealable activities of such sea-bottom survey ships as the White Sands, Apache, and De Steiger, and given that the Soviets had precisely the same rights in the open Pacific as the United States, a Soviet effort to recover whatever the U.S. had been seeking was not at all inconceivable. The Soviets were known to be able to operate deep-submergence vessels at depths as great as 33,000 feet and were notoriously persistent. (A Soviet ship had then been keeping station over a sunken November-class submarine in the North Atlantic for more than 18 months, presumably to preclude any U.S. effort to recover hardware.) In such circumstances, Buzard argued, it would be foolhardy to abandon the effort to retrieve 1201-3. Should that be unavoidable, however, he suggested that the on-station ships should pretend that the recovery operation had been successful--sending congratulatory messages, tying off logistics arrangements, and otherwise presenting a bold front.

Dr. McLucas decided to persist. With the passing of bad weather in the Central Pacific in the Spring of 1972, the Trieste II returned to the scene and recommenced its deep-sea search. The survey ships reported success in locating what appeared to be capsule 1201-3 in mid-April. During the afternoon of 26 April, the Trieste II completed a two-hour submersion operation and after a search of three and one-half hours sighted first debris and then the actual capsule at a depth of 16,400 feet. Three and one-half hours of careful maneuvering preceded basket closure and the start of a cautious ascent. More than nine hours after starting its dive, the Trieste II surfaced. Unhappily the action of surface waves proved too much for the now-fragile capsule structure, which broke into pieces so small that most fell through the tines of the recovery device. Only some inconsequential bits and pieces remained.

Disappointing as the outcome may have been, it was one instance in which the death of the subject following a successful operation proved a thoroughly acceptable alternative to recovery. Nothing suggestive of U.S. reconnaissance capability remained for others to find. The eight-month effort had to be considered at least a partial success even if deterioration of the capsule had prevented full recovery: as McLucas told Frosch, the Navy had established and demonstrated "a unique capability vital to the security of the United States" that might conceivably be called into use again if the circumstances so warranted.[61]

Hexagon 1202 had initially been scheduled for launch about three months following reentry of the final capsule from 1201, but engineering modifications dictated by the performance of the first Hexagon payload were expensive of time, and the alternative of launching one of the few remaining Corona vehicles seemed preferable to a hasty patch job. In the event, assurance of a successful mission would have been lessened if battery overheating problems and the parachute malfunctions encountered during operation of Hexagon 1201 went uncorrected, and both required more effort and took longer than had initially been planned. Nor was the urgency of Hexagon coverage as pressing as had been anticipated; even though one capsule of film had been lost, the amount of film recovered from the first operation inundated photo interpreters. The notion of providing continuous coverage of the Soviet Union and Mainland China by keeping either a Gambit or a Hexagon in orbit at all times had to defer to the realities of staff and dollar resources; processing and evaluating Hexagon and Gambit film in the quantities that the two systems were capable of returning would force enlargement of the cadre of photo interpreters, a course neither the NRO budget nor NPIC training facilities could accommodate. Moreover, the concept of continuous coverage implied a capability for crisis reconnaissance rather than constant operation of orbiting reconnaissance vehicles, and systems other than Hexagon appeared to be better prospects for that assignment. (By 1971 the premise of near-real-time readout by means of an electro-optical imaging system had proceeded to a system development phase, 1976 operational availability having been approved as a schedule goal.)

What with lessened pressure for early launch of Hexagon 1202, some difficulties of system modification, and the availability of one additional Corona system for use in an emergency, it was December 1971 before Hexagon 1202 reached the launch stand. Preparations for a 21 December launch were aborted by elusive booster-system electrical problems, and correction was so lengthy that a complete revalidation of the spacecraft eventually had to be undertaken. The resulting delays caused program managers to reschedule Hexagon 1202 for a 19 January launch, a date that had to be slipped by one further day when last-minute checkout operations uncovered a minor system fault.

Hexagon 1202 went into orbit on 20 January 1972 without encountering any major problems. There proved to be no warrant for qualms about the complete reliability of the modified parachute recovery system; 1202-1 and 1202-2 reentered and were uneventfully retrieved on 26 January and 8 February respectively, just as planned. But attitude control subsystem effectiveness had begun to degenerate by early February, so flight managers reluctantly reprogrammed Hexagon 1202 for 39 rather than 45 days of operation. (Premature control gas exhaustion owing to frequent vehicle repositioning maneuvers was assumed to be the source of the difficulty.)

A much more serious problem occurred immediately following the start of camera operations for 1202-3; the film being fed through the aft camera developed a ragged tear that quickly became a film break, and for the remainder of the mission only the forward camera was operable. Capsules 1202-3 and 1202-4 reentered routinely and were recovered without further incident on 17 and 28 February respectively, but imagery was entirely monoscopic. (Worry that the reentry vehicles might be unstable because one of the two take-up spools of each was empty proved unfounded.) De-orbiting of 1202-4 eventually became dependent on the back-up recovery system ("Lifeboat") with the final exhaustion of attitude control gas on the last day of the operation, but the reserve system functioned with commendable effectiveness and no unexpected problems developed.

On the whole, the film imagery returned by Hexagon 1202 was somewhat better in technical quality than that of 1201, displaying a best resolution of about 21 inches and a "normal" resolution ranging between 30 and 33 inches. Because of poorer weather and sun angle, it contained no better detail in ground coverage, however. A variety of minor defects marred the operation, some of them the apparent consequence of having camera subsystem remain inactive on the launch stand some four weeks longer than planned, but on balance 1202 had to be counted a successful operation. The principal qualifier in that judgment was the major camera system malfunction midway through the mission, the product of film breakage. In terms of film lost or unused, 1202 and 1201 were about equal.

Diagnosis of the cause of the film failure was difficult. There appeared to be no reason to conclude that it was related to rewind operations first attempted during mission 1202. (In the interests of mission success on 1201, film had been fed through to the take-up cassettes continuously, rewind operation being bypassed. Although that operation had caused wastage, film being passed through the system while the camera was inoperative, it obviated concern for the proper functioning of the rewind mechanisms at a rate of 55 inches per second, probably the most complex elements of the Hexagon's camera system.) Inspection of recovered film suggested that some large particle of foreign matter had become enmeshed in the film transport mechanism of the aft camera, causing a puncture that quickly became a tear when tension increased during rewind and forward transport of unexposed film immediately following the start of 1202-3 events. But the diagnosis had to be tentative because there was evidence of several malfunctions in film transport. Relatively large quantities of film were twisted, overlapped, and tangled on the take-up spools. (Some sections of recovered film had to be torn loose from the spindles during despooling, being so tightly jammed between the spool hub and the spool framework that they defied ordinary removal efforts.) Part of the film damage apparently resulted from an unprogrammed spool rotation after film take-up had been transferred from one recovery capsule to the next in line.

In addition to the film break that had to be counted as the principal defect of Hexagon mission 1202, analysts cited two other major problems. One was a repetition of the thermal heating anomaly that had affected the batteries during mission 1201. Although the batteries of 1202 had been relocated to avoid heat imbalance caused by launch debris that contaminated the reflectant paint, they proved to be almost as susceptible to overheating as those of 1201. Careful control of the angle of exposure (beta angle) of the battery section to solar radiation kept any major difficulty from developing in 1202, but that requirement imposed unwanted constraints on the launch window for the Hexagon vehicle and contributed to the premature exhaustion of attitude-control gas.

The second problem was attitude control. Post-mission analysis suggested that the failure of the reaction control system late in the mission, forcing early recovery of 1202-4, had probably been caused by contaminated hydrazene. The hydrazene at Vandenberg proved, upon inspection, to be "less pure than expected." The most immediate way of correcting for the problem would be to lessen demands on the reaction control system during mission 1203 by flying at the 100-mile altitude of 1201 rather than the 82- to 85-mile altitude of mission 1202. That would somewhat adversely affect resolution potential, but it would reduce the requirements for vehicle maneuvering and improve the potential of flying a full 45-day mission.

The post-mission critique on Hexagon 1202 highlighted another problem, but one unrelated to system functioning. Midway through the operation, intelligence officials in Washington had cancelled pre-mission requirements for operations that would have completed the required annual survey of selected Soviet land areas. The change had been justified in terms of potential savings in film, given the availability of generally adequate earlier coverage of several sensitive areas, but in fact Hexagon operations were in no way constrained by film supply during 30- to 45-day missions. Program officials suggested, rather bluntly, that it was not the function of the intelligence requirements community to manage mission operations, and that it was particularly inappropriate for the Committee on Imagery Requirements and Exploitation to intervene in ongoing operations that were so heavily dependent on pre-programming.[62]

Hexagon 1203 did not go into orbit until July 1972, more than four months after the final bucket from 1202 was retrieved. The search-mission gap created by the delay was partly filled by launch of the last Corona in May and Hexagon program managers took advantage of the respite to incorporate in 1203 several system modifications that had originally been planned for later vehicles. The spacecraft and sensor system of 1203 had encountered more than the ordinary run of qualification difficulty during final tests late in 1971, but those problems were not direct contributors to the launch delay. Test indications of faulty operation in various aspects of film transport did portend similar problems on orbit, but the problems seemed to be almost basic to the complex film transport mode adopted for Hexagon. System validation tests applied to 1203 were somewhat more carefully attuned to film transport and attitude control functions than had been the case for earlier Hexagon systems, but that was no more than ordinary prudence given the difficulties actually experienced in those earlier launches.

The parachute redesign undertaken following the unhappy outcome of Hexagon 1201 capsule reentry operations reached fruition in time to permit 1203 to take advantage of it. Delays in the readiness of 1202 and 1203 permitted the incorporation of redesigned parachute systems in the recovery capsules of 1203 rather than 1205, as had been initially planned. The third Hexagon was also the first of its kind to carry P-11 signal-intelligence "piggyback" subsatellites into orbit. Problems with platen positioning and film tracking slowed final checkout of 1203, causing the launch to be put off from June to July. The space vehicle finally qualified for launch and left the factory for Vandenberg on 21 June. No serious checkout difficulties occurred thereafter, and 1203 went routinely into orbit on 7 July 1972.

Reentry vehicle 1203-1 deboosted and was recovered by air catch on 15 July after storing film from the first eight days of operation. During the next 14 days, until 1203-2 was recovered, the reaction control system experienced excessive attitude-control gas consumption. The problem became acute while film was being exposed for return in 1203-3; flight controllers eventually had to switch to the backup attitude control system. Concurrently an emergency shutdown occurred in the aft camera system, causing curtailment of stereo photography. Recalling the catastrophic failure that had marred Hexagon 1202, the program office decided to satisfy as much of the coverage requirement as possibly by using monoscopic photography.

The wisdom of that decision became obvious upon inspection of capsule 1203-3 following its 12 August retrieval. Severe film folding was the determinate cause of the stoppage in aft camera operations. The source of the problem appeared to be misalignment of film on the transport rollers. Passage of a section of folded film past the metering capstan had distorted measurements of the lengths of film being transported, causing the control mechanism to call for slow speed take-up in combination with fast film feed. The looper system (which held excess film passing through the camera section) promptly overfilled and an emergency stoppage resulted. The remedy, employed for the balance of mission 1203, was to operate the film transport system at slow speeds. But the prescription had a price: unless rewind speeds reached 55 inches per second, unexposed film passed to the take-up reels. Yet with the system operating at full speed, intermittent accordian folds occurred in the film, each more than 50 feet long. Even at slow speeds the transport system continued to double film back upon itself, but the folds averaged only about 3.5 feet in length. Before the emergency shutdown, roller misalignment had caused edge folds that in one instance extended for 1800 feet and in another affected 400 feet of film. Although it was not possible to determine precisely what sort of misalignment had caused the problem, the malfunction seemed to have occurred in the last set of cluster rollers over which the film passed before entering the take-up spool of 1203-3.

Another emergency shutdown occurred while film was being fed into 1203-4; it was cleared without great difficulty and stereo camera operations continued to the end of the mission. But hopes for a successful 65-day mission were dashed when the backup attitude control system began to use propellant at an abnormally high rate. Discretion-minded flight controllers brought 1203-4 down on 2 September, eight days sooner than programmed, but still 57 days after mission start. After film recovery had been completed, the satellite operations group began a series of attitude control experiments using the capsuleless orbiting vehicle, attempting to find the source of the control gas wastage. They were able to maintain control for another 12 days. Evaluation of telemetered data indicated that valve seats in the control gas system had somehow become so thoroughly fouled that leakage was continual.[63]

Hexagon 1204 was like its immediate predecessor in many respects, although film tracking problems were fewer. Following a 10 October 1972 launch, operations during the first phase of the mission were quite routine. Reentry vehicle 1204-1 was recovered on 21 October without incident. Early in the second phase of the flight, telemetry indicated an incipient failure of attitude control forcing temporary reliance on the backup system. A film tracking problem caused an emergency camera stoppage on 8 November, three days after 1204-2 had separated and reentered, but careful manipulation of control devices limited the shutdown to a single day and once the jam was cleared the problem vanished. Until that time the camera system had been operated in the slow-rewind mode and the vehicle under maneuvering restrictions in an effort to avoid any recurrence of the film tracking difficulties that had troubled 1203. After 9 November, both constraints were cancelled and the system operated at design film transport speeds and without pointing restraints. Excessive yaw and roll rates were recorded intermittently after 14 November, forcing another camera shutdown and another reversion to the redundant attitude control system. Capsule 1204-3 reentered on 23 November, again without incident. (The new parachute system was functioning magnificently.)

The final phase of mission 1204 proceeded without encountering major problems, although the command system gave cause for some concern on 27 November when it ignored a series of reprogramming instructions. Flight controllers disabled the offending circuitry and proceeded to the end of the flight without further difficulty. Late in the mission (after 9 December), the satellite control group began to inject payload command directions daily rather than on alternate days, as had previously been the rule. The greater frequency of command instructions permitted flight controllers to better utilize weather data in directing camera operations, thus significantly improving the quality of ground imagery. (Hexagon pictures had rather mysteriously been more degraded by cloud cover than earlier Corona pictures. That was in part the consequence of nothing more alarming than a run of bad luck in weather prediction, but it also reflected the fact that

Hexagon photographic swath widths were far wider than Corona swaths and thus recorded more clouds as well as more ground area.)

The final capsule of Hexagon 1204 reentered and was recovered on 17 December; primary mission time was 68 days, three days longer than the earlier "extended" goal. Photography was superb, characterized as the best the system could hope to produce.[64]

The fifth Hexagon mission, 1205, was distinguished by the inclusion, for the first time, of the 12-inch focal length mapping camera and a small fifth reentry vehicle to return its exposed film. Originally scheduled to be flown in the 1207, later in 1206, and finally in 1205, the mapping camera benefitted both from faster than expected progress and from the slower than expected rate of Hexagon launches. Nonetheless, the first mapping camera intended for flight failed during thermal vacuum testing early in 1972 and required complete overhaul before retesting. Shutter malfunctions also interrupted qualification testing later that year.

Hexagon 1205 had additional problems with the attitude reference module, telemetry equipment, and other specialized modules of the satellite vehicle. Delays in delivery of a flight-qualified attitude reference module provided the pad of time needed to install the mapping camera in 1205. There was no longer great pressure for an earlier launch date, the returns from the first four Hexagon missions having been sufficiently impressive to support a decision that only three such vehicles need be operated each year. (Budget pressures also contributed to the three-per-year decision.)

Thermal vacuum tests were completed on the entire satellite except for the attitude reference module by 27 November, and acoustic chamber tests by 11 December 1972. By the end of the year only the solar arrays and the attitude reference module remained to be added for flight readiness. After the attitude reference module was finally delivered, the mated satellite was shipped to Vandenberg on 21 February 1973 for a 9 March launch. As delivered, 1205 included relatively large elements of equipment originally planned for initial use on 1206, the launch schedule relaxation having provided time needed to move improved items forward in the program. (Until late January, a 15 February launch date had been scheduled.)

The mission began on schedule with a routine launch and orbital injection. A loss of telemetry data on camera temperature and pneumatic gas caused initial search camera operations to be postponed for a full day past the fifth revolution--the usual starting point. In order to minimize the potential for film transport malfunctions, modest rewind speed and scan angle constraints were maintained. The mapping camera was slated to begin operations on the eighth revolution, but its lens-cover door jammed momentarily. On the next and all but the last few orbits of 1205 the door functioned correctly, but mapping operations for the balance of the mission were restricted to targets below 50° North latitude on the descending portion of each revolution to protect against a recurrence of the temperature problem that had caused the pneumatic door activator to stick.

As in previous flights, the first mission segment was completed without major incident. Capsule 1205-1 was recovered on 21 March. Shortly thereafter, the propellant leak difficulty experienced in earlier flights became troublesome. Recovery vehicle 1205-2 was de-orbited and successfully recovered on 4 April and flight phase three began before it was necessary to switch to the redundant reaction control system, however. A yaw rate bias developed subsequent to the shift to a backup attitude control system, but mission controllers were able to use image motion compensation to overcome the smear problem thus created. The third and fourth reentry vehicles were successfully recovered on 18 April and 11 May 1973, respectively. The mapping film recovery capsule, carried in a separate compartment in the forward part of the satellite vehicle, reentered independently on 20 April.

A number of minor problems occurred with the mapping camera during the course of the flight, additional to the sticking camera door.

On four separate occasions, shutdown commands were ignored. Eventually flight controllers had to call on an alternative command system to reactivate the cameras. (Redesign of the door actuating circuitry was undertaken immediately after Hexagon 1205 completed its mission.)

About 95 percent of the mapping camera film had been successfully exposed and resolution was some 30 to 40 percent better than had been predicted. The film product of the main cameras was again of excellent quality, approaching 20 inches in "best" resolution. It seemed even to surpass the product of Hexagon 1204 in one instance (1205-1), but that was the consequence of excellent weather and lighting rather than any optical superiority.[65]

Hexagon: Program Reorganization and Product Improvement (1971-1973)

The success of Hexagon in satisfying the requirements against which the system had been developed could best be judged from the fact that as many as six missions per year had been planned while the system was in evolution, but by 1972 returns from early missions were so satisfying that launches at four-month intervals (three each year) served needs. As early as November 1971 it was apparent that Hexagon and Gambit in combination would return twice or three times as much information as the United States Intelligence Board had formally required, and both systems were susceptible of relatively modest improvements that would substantially extend their on-orbit operational lives. Hexagon, intended for 45-day operational missions, had early demonstrated 60-day capability and there were no obvious technological obstacles to flying 75-day missions. In that event, each Hexagon would perform tasks originally assumed to require 1.8 successful operations.

National Reconnaissance Program managers were not at all displeased by such trends. Hexagon had cost nearly three times as much money and twice as much time to develop as anticipated when the program was approved, and the cost of operational systems was nearly twice that planned. But the real cost of satisfying requirements for which Hexagon had been specified would approximate early predictions once 75-day missions were achievable, and few outcomes could be more satisfying. Real budget reductions could be enacted. However, it was likely that 75-day missions would overload the interpretation capability of the National Reconnaissance Program, driving costs upward in another area, a possibility that prompted David Packard, Deputy Secretary of Defense, to urge a reduction in the frequency of operating other intelligence collecting systems in order to avoid such problems.[66]

Proposals for significant improvements in various aspects of Hexagon performance entered a phase of serious discussion virtually as soon as Hexagon 1201 had completed its operations. Some of the notions first formally considered within the NRO in August 1971 involved improvements earlier proposed but temporarily tabled because of the urgency of starting Hexagon operations before the supply of Corona systems was exhausted and a gap in search coverage developed. The CIA's sensor project office had concluded by the summer of 1971 that a change in Hexagon configuration should be made effective with the nineteenth system (then planned for launch late in 1976). The spectrum of attractive, presumably achievable changes extended from a relatively modest extension of mission life to about 90 days using essentially the original camera system (though preferably simplified in details of film transport and electronics) through a major redesign leading to 145- to 180-day missions (which implied a two-per-year Hexagon requirement). Plainly, a 180-day on-orbit capability would involve, as a minimum, increasing the number of reentry capsules and enlarging film capacity. A complete camera redesign could not be excluded from consideration. The broad goal, established by Dr. McLucas, was to provide for competition in sensor subsystem procurement and to reduce the recurring costs of operating Hexagon.[67]

NRO staff officers considered the CIA's proposals to be rather more optimistic than circumstances warranted, but nonetheless the NRO budget was altered to provide for fiscal year 1973 funds to begin work.[68] The objections were not entirely on feasibility grounds, however. No requirement for missions of more than 75 days had been validated, the effect of having a near-real-time readout satellite operational had not been assessed, and as one NRO staff officer tartly put it, "hardware changes should not be funded for the sake of hardware changes. . ." Technical feasibility, argued Lieutenant Colonel S. R. Sciotto, was not a valid reason for making major system changes: timeliness, national requirements, and cost-effectiveness considerations had to be counted in the equation.[69]

Although the happy outcome of early Hexagon flights induced many senior officials to assume that a 75-day orbital life for the system was readily achievable, no such premise was valid in late 1971. General Allen cautioned Dr. McLucas that ". . . ongoing procurement actions. . . do not at present include preparations for obtaining this extended life capability." Hexagon vehicles through 1212, then on contract, were designed to satisfy 45-day mission requirements and to have 60-day-qualified components. The orbit adjust system originally built into Hexagon was design limited to 45-day operations at normal altitudes, although provisions had been made for extending to 60-day missions "when desired." The 60-day missions achieved in 1973 were made possible by increasing perigee altitude, with some loss in system resolution and with acceptance of a slightly lessened probability of successful mission completion. The absolute limit of Hexagon life, in its original configuration, was 750 camera operating cycles. (That constraint was imposed by the limited supply of pneumatics required for camera functioning.)[70]

Discussions of potential Hexagon improvements continued for more than a year after they first were proposed. By the Spring of 1973 they had progressed to the stage of a potential new camera competition, a possibility created in part by Itek's unsolicited submission of a new camera design remarkably similar in many respects to the Itek design that lost to Perkin-Elmer's Fulcrum-based proposal in 1966. Brigadier General David Bradburn, who by that time had replaced General Allen as the NRO's Director of Special Projects, urged Dr. McLucas in April to approve and fund a new panoramic camera definition study by Itek. The goal, as Bradburn saw it, should be ". . . an alternative sensor subsystem with improved performance and simplified design, and at reduced cost," that could be incorporated in the first "Block IV" Hexagon (still the nineteenth production system).

The source of the proposal was a "HEXAGON Panoramic Camera Improvements Study" prepared by Bradburn's staff in the spring of 1973. At a cost of about $1.8 million, he proposed to sponsor a technical evaluation that could conceivably lead to a formal Block IV Hexagon competition in May 1974. The new camera would incorporate a faster (f/2.0) 60-inch focal length lens than the Perkin-Elmer design, reduced film velocities at the film plane (the chief problem generator in the original Hexagon), but full compatibility with other principal elements of the existing system (film supply, telemetry, take-up section, test equipment, and vehicle design). Its principal attraction, apart from potentially better resolution arising in improved optics that permitted use of slower high-resolution film, would be to eliminate the troublesome film rewind operation designed into the original Hexagon camera.

After considering the proposal in detail and insuring that its approval would not create major funding problems, Dr. McLucas on 4 May 1973 approved starting the study. (Dr. J. R. Schlesinger, newly-installed CIA director, had informally approved the approach in the course of a 17 April discussion of Hexagon improvement potential.)[71]

A second development of mid-1973 that had considerable significance for the future of Hexagon was the transfer of camera subsystem responsibility from the CIA's Sensor Subsystem Program Office to the NRO's Program A, the West Coast Directorate of Special Projects. Proposals for that shift of authority had been informally considered two years earlier and had reached the stage of a formal plan by October 1971.

The motivation for the transfer was not obscure. On 23 September 1971, President Nixon approved a plan to develop Kennan,* a highly ambitious near-real-time readout reconnaissance satellite,

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Then known as Zaman but generally referred to as "the EOI system," for electro-optical imaging.

on a schedule that called for initial operations during 1976. Most of Kennan was to be a CIA responsibility. With limited resources for managing reconnaissance satellite development, the CIA faced a future that encompassed both the most costly and complex of ongoing reconnaissance satellites (Hexagon) and a yet more costly and complex future system (Kennan). In the circumstances, handing over Hexagon to the NRO's West Coast establishment seemed a wholly sensible course.

The plan for transferring Hexagon sensor responsibility reached Dr. McLucas on 21 October 1971, the only point of residual disagreement being whether responsibility for Hexagon 1207 through 1212 (Block II) should be reassigned on 1 July 1972 or 1 July 1973, the CIA's principal spokesman holding out for the later date.* There was no controversy about the transfer of responsibility for Block III Hexagons (1213 through 1218) or the still undefined Block IV model; all were agreed that action should be completed as rapidly as possible so that orderly planning for an improved Hexagon might proceed.[72]

Dr. McLucas chose to accept the argument for transitory CIA retention of responsibility for systems 1207 through 1212. On 29 November he assigned immediate responsibility for Hexagon 1213 and later

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* Participants in the preparation of the transfer plan were General Allen, Harold Brownman (CIA), Dr. Naka, [redacted] (NRO Comptroller), and then-Colonel Bradburn (Director of the NRO Staff).

systems to General Allen and expressed to the director of the CIA's reconnaissance programs his wish that arrangements be made for the timely transfer of systems 1207 through 1212. (Only the contracts with Perkin-Elmer were at issue; all other CIA-managed Hexagon contracts were shifted to Allen's custody at once.) Dr. McLucas hoped to complete all actions essential to the reassignment by the summer of 1973, exempting only those functions (like mission simulation and statistical prediction studies) in which the CIA had an unduplicated competence.

The formal transition plan, completed and forwarded for NRO and CIA approval in March 1972, provided very largely what Dr. McLucas had suggested in response to the initial plan the preceding October. Systems 1207 through 1212 would be transferred (to the Director, Program A--the West Coast group) effective 1 July 1973 in accordance with contractual agreements with Perkin-Elmer which were to be formalized no later than 1 September 1972. Certain specialized Hexagon-related activities of the CIA were exempted (in addition to the software work) and the CIA would retain full responsibility for Hexagon systems through 1206,* but virtually all

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* In March 1972 the flight schedule called for Hexagon 1206 to be launched in April or May 1973; various technical problems and a major revision of coverage requirements delayed that event past 1 July 1973 and 1205 became the last Hexagon to be launched in fiscal year 1973. Nevertheless, the CIA kept responsibility for 1206.

else would be captured by the shift. The CIA agreed to provide full engineering support to Program A during the transition period. Interestingly, in light of the strong feelings that had existed at the time Hexagon working relationships were first established in 1966, the transfer agreement explicitly provided for "a free exchange of information between CIA/OSP and SAFSP on all elements of the HEXAGON Program to be transferred."[73]

The Program A contract with Perkin-Elmer for systems 1207 through 1212 actually became effective on 1 December 1972 rather than 1 September, as earlier planned, but other aspects of the transfer proceeded very nearly on schedule. The overlap of CIA-Program A efforts was generally smooth and effective. The only substantial change in procedures that resulted from the transition was a shift of acceptance point for the camera systems from the Perkin-Elmer plant at Danbury, Connecticut, to the Lockheed facility at Vandenberg. The original justification for accepting camera systems at the Perkin-Elmer site had been the need for the contractor to deal directly with chamber test problems, part and component failures, and similar events, and the desire on the part of the Hexagon program office to make test qualification rather than extreme schedule urgency the prime contract incentive. As Perkin-Elmer became more familiar with space program operations, the need for the special arrangement at Danbury disappeared.*

On Friday, 29 June 1973, L. C. Dirks, the CIA's senior Hexagon-responsible official, advised General Bradburn that effective 1 July all responsibility for the camera systems for Hexagon 1207 through Hexagon 1212 was transferred to his organization. The Agency would continue to monitor the delivery and operation of 1206 (still awaiting launch), but funds transfer would be complete by 6 July 1973, and that would effectively end the CIA role in Hexagon development and operations.

On the following day, General Bradburn notified Dr. McLucas of his formal acceptance of the assignment and sent a final message to Dirks: "I congratulate you on the success of the program under your leadership and I assure you we will do our very best to continue that proud record."[74]

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* It will be recalled that the CIA arrangement with Perkin-Elmer in 1966 and 1967 was also influenced in some part by the residual distrust of the Program A staff by CIA satellite specialists, a consequence of the factionalism that had marked CIA-NRO relationships in 1964 and 1965.

NOTES ON SOURCES

1. Details of the E-5, E-6, and Corona-Mural programs are to be found in the chapters devoted to those topics.

2. See ltr, B. McMillan, DNRO, to V/Adm W. F. Raborn, Dir CIA, 3 May 65, no subj, in DNRO files.

3. Additional details of relevant Corona, E-5, E-6, M-2, J-3, and Lanyard developments are included in chapters dealing with Corona and Samos programs. The management controversies of 1963-1966 are described in Volume V, this study. See also: Memo, E.M. Purcell, Chm, Recon Panel, to DCI, Jul 63, subj: Panel for Future Satellite Reconnaissance Operations; memo, M/Gen R.E. Greer, Dir/Progm A, to DNRO, 15 Apr 63, subj: Comparison Evaluation, and encl, Report of the Findings of the Ad Hoc Group Appointed to Evaluate Potential Systems for an Improved Search Type Satellite Reconnaissance System, Apr 63; memo, E.G. Fubini, DDR&E, to USecAF, 30 Jun 64, subj: Broad Coverage System; MFR, E. Fubini, "Dictated in Mr. McCone's Presence," 13 Jan 64; memo, C.B. Clifford, Chm, FIAB, to the President, 2 May 64, subj: National Reconnaissance Program; memo, B. McMillan, DNRO, to D/SoD, 12 Jun 64, no subj, all in DNRO files.

4. Memo, A.D. Wheelon, D/Dir S&T, CIA, to DCI, 31 Aug 64, subj: Conduct of the FULCRUM Program; memo, E.G. Fubini, DDR&E, to SAFUS, 3 Jul 64, subj: Broad Coverage System; MFR, B. McMillan, DNRO, 7 Jul 64, subj: CIA Management of Satellite Projects. The SP-AS-63 episode is detailed in Vol IIB, this mss (Ch XI).

5. Ltr, C.R. Vance, D/SOD, to DCI, DNRO, 8 Jul 64, no subj; memo, A.D. Wheelon, D/Dir (S&T), CIA, to DNRO, 9 Jul 64, subj: Funding for Project FULCRUM; memo, Col J. C. Ledford, Dir/Progm B, to DNRO, 10 Jul 64, subj: Addendum to Pgm B's FY 65 Budget.

6. See ltr, McMillan to Raborn, 3 May 65; SOR Description and Preliminary Plan for a New Photographic Search and Surveillance System, 15 Oct 65, quoting USIB Reqmts Stmts of 27 Jul and 31 Jul 64; see also SAFSP Quarterly Program Review, 31 Dec 64 (hereafter cited as QPR with date).

7. For the Itek affair, see MFR, Col P.E. Worthman, 24 Feb 65; MFR, Worthman, 25 Feb 65; MFR, LtCol H.C. Howard, n/d (prob 25 Feb 65); MFR, B. McMillan, 25 Feb 65; and memo, McMillan to C. Vance, D/SOD, 25 Feb 65, no subj, all in NRO files.

8. Msg, B. McMillan, DNRO, to BGen J.L. Martin, Dir/SP, 24 Jun 65; QPR 30 Jun 65; ltr, McMillan to V/Adm W.F. Raborn, Dir CIA, 3 May 65; ltr, Raborn to C. Vance, D/SOD, 25 May 65, no subj.

9. Memo, B. McMillan, DNRO, to D/SOD and Dir/CIA, 13 Jul 65, subj: New Satellite Search/Surveillance System; memo, W.F. Raborn, DCI, to C.R. Vance, D/SOD, 20 Jul 65, no subj.

10. Agreement for Reorganization of the National Reconnaissance Program, signed by C.R. Vance, D/SOD, and W.F. Raborn, DCI, 11 Aug 65.

11. Memo, D.F. Hornig, Spec Asst to the Pres for Sci and Techn, to C.R. Vance, D/SOD, 30 Jul 65, no subj, in DNRO files. See also msg Whig 3335, BGen J.T. Stewart, Dir NRO Staff, to BGen J.L. Martin, Dir Prog A, 9 Jul 65.

12. Msg, Whig 3589, B. McMillan, DNRO, to BGen J.L. Martin, Dir Progm A, 23 Aug 65.

13. Msg, [redacted] 8568, SAFSP to SAFSM, 12 Aug 65.

14. Msg, Whig 0001, B. McMillan, DNRO, to BGen J.L. Martin, Dir/SP, 22 Sep 65; msg, Whig 0004, McMillan to Martin, 29 Sep 65.

15. Minutes, Meeting of the NRP Executive Committee (hereafter cited as NRP ExCom) on 6 Oct 65.

16. Minutes, NRP ExCom Mtg of 16 Nov 65.

17. DNRO Action Memo No. 1, 15 Oct 65 (signed by A.H. Flax, DNRO): Terms of Reference for the Project Management Task Group for the New Photographic Satellite Search and Surveillance System; NRO Actn Memo No. 2, 15 Oct 65:

Terms of Reference for the Technical Task Group. . . (as above); System Operational Requirement, Description, and Preliminary Plan for a New Satellite Photographic Search and Surveillance System, 15 Oct 56 (signed by Col D.L. Carter, chm of task grp).

18. Msg, [redacted] 9174, BGen J.L. Martin, Dir/SP, to Dr A.H. Flax, DNRO, 27 Oct 65; msg, Whig 4061, Flax to Martin, 5 Nov 65; msg, [redacted] 9273, Martin to Flax, 7 Nov 65; msg, Whig 4170, Flax to Martin, 15 Nov 65.

19. Msg, [redacted] 9416, BGen J.L. Martin, Dir/SP, to EK, 22 Nov 65.

20. Msg, Whig 4441, BGen J.T. Stewart, Dir/NRO Staff, to BGen J.L. Martin, Dir/SP, 7 Dec 65; msg, Whig 4454, Stewart to Martin, 8 Dec 65; DNRO Actn Memo No 6, 7 Dec 65; memo, Col D.L. Carter, Task Grp Chm, to A.H. Flax, DNRO, 28 Jan 66, subj: RFP for the Photographic Subsystem for a New Search/Surveillance System; QPR, 31 Mar 66.

21. Minutes, NRP ExCom Mtg of 26 Apr 66; memo, BGen J.L. Martin, Jr, Dir/SP, to DNRO, 4 Nov 65, subj: Comments on Alternative Management Arrangements for the New Photographic Search and Surveillance System (in SAFSS files).

22. Memo, A.H. Flax, DNRO, to D/Sec Def, DCI, Spec Asst to Pres for Sci and Techn, 22 Apr 66, subj: New General Search and Surveillance Satellite System; memo, Flax to BGen J.L. Martin, Dir/SP, 30 Apr 66, subj: Implementation of <u>Hexagon</u> Program.

23. See memo, Flax to D/Sec Def <u>et al</u>, 22 Apr 66, and incls, DNRO files.

24. QPR, 30 Jun 66.

25. QPR, 30 Jun 66; msg, [redacted] 1968, BGen J.L. Martin, Dir/SP to A.H. Flax, DNRO, 6 May 66; msg, Whig 5274, Flax to Martin, 13 May 66; msg, Whig 5280, Flax to Martin, 3 May 66.

26. Ltr, H.W. Paige, VPres and GenMgr, GE Miss and Space Co, to A.H. Flax, ASAF (R&D), 14 Jun 67, no subj (reviewing "points made last year"); ltr, Flax to Paige, 29 Jun 67, both in DNRO files.

27. QPR, 30 Jun 66, memo, A.H. Flax, DNRO, to Hexagon System Project Office, 25 May 66, subj: Instructions for Satellite Basic Assembly Source Selection; memo, BGen J.L. Martin, Dir/SP to Flax, 16 Jun 66, subj: Re-entry Vehicle Study for the HEXAGON System; msg, Whig 5469, Flax to Martin, 6 Jul 66; memo, Flax to Re-Entry Vehicle Source Selection Advisory Council, 6 Jul 66, subj: Instructions for Re-Entry Vehicle Source Selection Study.

28. QPR 30 Sep 66; memo, L.C. Dirks, Chmn, Sensor Subsystem Source Selection Board to DNRO, 30 Aug 66, subj: HEXAGON Sensor System Source Selection Board Recommendations; msg, DNRO to BGen J.L. Martin, Dir/SP, 11 Oct 66.

29. NRP ExCom Minutes, 17 Aug 66, 23 Nov 66, 16 Dec 66, 17 Nov 67.

30. QPR's of 30 Sep 66 and 31 Dec 66; minutes, NRP ExCom mtg of 23 Nov 66; memo, J.Q. Reber, Secy, NRP ExCom, to NRP ExCom, 9 Dec 66, subj: Agenda for NRP ExCom Meeting of 16 Dec 66.

31. QPR, 31 Mar 67; msg, A.H. Flax, DNRO to BGen J.L. Martin, Dir/SP, 21 Feb 67; QPR, 30 Jun 67; msg, Flax to Martin, 8 May 67.

32. Msg, A.H. Flax, DNRO, to BGen J.L. Martin, Dir/SP, 14 Jul 67; msg, Flax to Martin, 19 Jul 67; QPR, 30 Sep 67, 31 Dec 67, 31 Dec 68; minutes, NRP ExCom, mtgs, 17 Nov 67 and 20 Dec 67.

33. QPR, 31 Mar 68 and 30 Jun 68; msg, A.H. Flax, DNRO, to BGen J.L. Martin, Dir/SP, 20 May 68; msg, [redacted] NRO Compt, to LtCol J. McBride, SP, 10 Jun 68.

34. Minutes, NRP ExCom mtg of 20 Aug 68.

35. BoB Position Paper, "The Need for the Hexagon Photographic Satellite," Nov 68, in NRP ExCom files. (Holograph notes by A.H. Flax, DNRO, on margins of file copy.)

36. Ltr, R.P. Mayo, Dir/BoB, to R. Helms, DCI, 22 Mar 69, no subj; ltr, L.A. Bross, CIA, to J.L. McLucas, DNRO, 4 Apr 69; ltr, Mayo to R.M. Nixon, Pres, US, 21 Apr 69, subj: FY 1970 Intelligence Program Savings, with incls. See also memo, BGen R.A. Berg, Dir NRO Staff, to McLucas, 28 Apr 69, subj: BoB Paper on HEXAGON and DORIAN. (All in NRO files)

37. Memo, MGen J.T. Stewart, MOL Dir, to Gen J.C. McConnell, 12 Feb 69, subj: Briefing to the Deputy Secretary of Defense; memo, Stewart to R.C. Seamans, SecAF, 14 Mar 69, subj: Probable Presidential Budget Issues on MOL; History of the Manned Orbiting Laboratory Program, Ch XIV (by Carl Berger, Ofc of AF History), in NRO files; memo, L.A. DuBridge, Pres Sci Advisor, to Pres, 6 May 69; memo E.H. Land et al (Land Panel on Reconnaissance) to Pres, 6 May 69; interviews, Maj H.S. Coyle, 23 Mar 73, and LtCol F.L. Hofmann, 27 Mar 73, by R. Perry.

38. See Ch III, Vol I, this history for an account of the final Corona program extension proposals (1970-1971).

39. Minutes, NRP ExCom Mtg of 15 Jul 71.

40. QPRs, 30 Sep 68, 31 Dec 68, 31 Mar 69; minutes, NRP ExCom mtg of 20 Aug 68 and 13 Nov 68. The engineering review was conducted by a special committee headed by Dr A.F. Donovan of Aerospace Corp: see rpt, 15 Jan 69.

41. Memo, F.R. Naka (D/Dir NRO) to J.L. McLucas, DNRO, 4 Sep 69, subj: Report of HEXAGON Review Committee, with atchd rpt, 20 Jun 69.

42. Minutes, NRP ExCom Mtg of 8 Aug 69.

43. Rpt, Second Report of HEXAGON Review Committee, 4 Nov 69; minutes, NRP ExCom Mtg of 25 Nov 69; Third Report of HEXAGON Review Committee, 22 Jan 70; memo, F.R. Naka,

D/DNRO, to DNRO, 28 Jan 70, subj: 2nd and 3rd Reports of the HEXAGON Committee; memo, J.L. McLucas, DNRO, to NRP ExCom, 2 Feb 70, subj: Adequacy of the CORONA/HEXAGON Overlap.

44. QPR, 31 Dec 69.

45. Rpt, Director's Report to the NRP Executive Committee on FY 1970 Status, FY 1971 Program, by J.L. McLucas, DNRO, 15 Jul 70; QPRs 31 Dec 69, 31 Mar 70, 30 Jun 70.

46. Memo, F.R. Naka (D/DNRO) to J.L. McLucas, DNRO, 31 Jul 70, subj: HEXAGON.

47. Minutes, NRP ExCom Mtg of 17 Jul 70.

48. Memo, Maj R.A. Schow, Jr, NRO Staff, to Col E. Sweeney, Dir NRO Staff, 31 Aug 70, subj: HEXAGON.

49. Msg, Pilot 7104, BGen W.G. King, Dir/SP, to J.L. McLucas, DNRO, 15 Sep 70; memo, McLucas to USIB, 18 Sep 70, subj: HEXAGON Status.

50. QPR, 30 Sep 70, 31 Dec 70; msg, Pilot 7104, King to McLucas, 15 Sep 70.

51. Minutes, NRP ExCom Mtg of 29 Jan 71.

52. Msg, Pilot 7494, Col F.S. Buzard, Hexagon progm mgr, to BGen L. Allen, Dir/SP, 26 Apr 71; msg, Charge 2478, Allen to F.R. Naka, D/DNRO, et al, 27 Apr 71; memo, D.W. Patterson, Hexagon Sensor Sys Progm Dir to D/DNRO, 30 Apr 71, subj: Transmittal of Shutter Replacement Schedule.

53. See Minutes, NRP ExCom Mtg of 13 Jul 71.

54. For details of operational responsibilities and related matters, see Rpt, Hexagon Concept of Operations, prep by SOC and publ by NPIC, Sep 70.

55. San Jose News, 20 Mar 71.

56. See, for example, San Francisco Chronicle, 16 Jun 71; msg, Charge 3085, Dir/SP to NRO staff, 25 May 71; ltr, J.L. McLucas, DNRO, to R. Helms, DCI, 14 Jun 71, no subj.

57. Msg, Whig 0834, J.L. McLucas, DNRO, to Dir/SP, et al, 22 Jun 71; rpt, Report [of the DNRO] to the President's Foreign Intelligence Advisory Board on the National Reconnaissance Program, July 1, 1970 to June 30, 1971, prep by NRO staff, 1 Jul 71.

58. Msg, Charge 5457, Col F.S. Buzard, Hexagon SPO, to J. Hughes, CIA, 16 Sep 71; ltr, A. Lundahl, NPIC, to J.L. McLucas, DNRO (holograph ltr), 23 Jul 71 (incorrectly dated 1970 on original), no subj; QPRs, 30 Jun 71, 30 Sep 71; memo, LtGen D.V. Bennett, Dir DIA, to DNRO, 14 Jul 71, subj: Photographic Satellite Launch Schedule.

59. Memo, Bennett to McLucas, 14 Jul 71, QPR, 30 Sep 71, 31 Dec 71.

60. MFR, D.W. Patterson, Hexagon Sensor Subsys Prog Dir, 28 Jul 71, subj: RV-3 Recovery Planning Meeting; memo, Maj R.A. Schow, Jr, (USArmy), to J.L. McLucas, DNRO, 3 Aug 71, subj: Possible Recovery of HEXAGON Mission 1201 RV-3.

61. Interview, LtCol F.L. Hofmann, NRO Staff, by R.L. Perry, 7 Jun 73; msg, Charge 0123, Col F.S. Buzard, Hexagon Prog Dir, to Col D.D. Bradburn, Dir NRO Staff, 7 Jan 72; memo, Capt J.E. Drain (USN), NRO Staff, to J.L. McLucas, DNRO, 9 May 72, subj: Deep Sea Recovery of HEXAGON; MFR, D.W. Roth, NRO Staff, 14 Sep 71, subj: Status of Recovery Effort as of 14 September 1971; memo, J.L. McLucas, DNRO, to Asst Sec Navy (R&D), 15 May 72, subj: Deep Sea Recovery of HEXAGON Reentry Vehicle; rpt, Report to the President's Foreign Intelligence Advisory Board on the National Reconnaissance Program, July 1, 1971 to June 30, 1972 (aprox 30 Jul 72).

62. MFR, Maj C.T. Lehman, Sat Ops Center, 8 May 72, subj: Trip Report--Mission 1202 Critique; msgs, Bail 9064, Bail 9155, Bail 9206, all EK to Hexagon Progm Ofc et al, 30 Jan 72,

13 Feb 72, 21 Feb 72; minutes, NRP ExCom Mtg, 23 Nov 71; memo, Bennett to DNRO, 14 Jul 71; rpt, Director's Report to the NRP Executive Committee on Current Status and FY 72-77 Fiscal Program, prep by NRO Staff, 11 Nov 71; QPRs, 31 Dec 71, 31 Mar 72.

63. Memo, LtCol H.B. Peake, NRO Staff, to J.L. McLucas, DNRO, 21 Aug 72, subj: Aft Camera Problem; QPRS, 31 Dec 71, 31 Mar 72, 30 Jun 72, 30 Sep 72.

64. QPRs, 30 Sep 72, 31 Dec 72; MFR, LtCol H.B. Peake, NRO Staff, 18 Apr 73, subj: HEXAGON Program Review--16 April 1973.

65. QPRs, 31 Mar 72, 30 Sep 72, 31 Dec 72, 31 Mar 73 and 30 Jun 73; memo, LtCol F.L. Hofmann, NRO Staff to Col J. Shields, 22 Jan 73, no subj.

66. Minutes, NRP ExCom Meetings of 23 Nov 71, 19 Jul 72, 27 Sep 72; memo, R.E. Williamson, Lockheed, to Col L.G. Stange, Ofc Dir/Spec Proj, 16 Nov 71, subj: Dr. Sorrels Briefing on 12 Nov.

67. MFR, no sig, 15 Sep 71, subj: HEXAGON Block II, atchd to note, Maj R.A. Schow, Jr, to [redacted] NRO Compt, 16 Sep 71, no subj.

68. MFR, Schow, 15 Sep 71; note, Schow to LtCol S.R. Sciotto, NRO Staff, 16 Sep 71, no subj.

69. Informal note, LtCol S.R. Sciotto, Jr., NRO Staff, to Maj R.A. Schow, Jr, 27 Sep 71, subj: HEXAGON Block II.

70. Msgs, Charge 6963, BGen L. Allen, Jr, Dir/SP, to J.L. McLucas, DNRO, 22 Nov 71, and Pilot 3746, CIA SSPO to Dir/SP, 19 May 72.

71. Msg, Charge 2357, BGen D.D. Bradburn, Dir/SP, to J.L. McLucas, DNRO, 20 Apr 73; msg, Whig 0557, McLucas to Bradburn, 4 May 73; memo, Col J.E. Kulpa, Dir NRO Staff, to McLucas, 1 May 73, subj: HEXAGON Panoramic Camera Improvement Study.

72. Memo, M.R. Laird, SecDef, to Pres U.S., 17 Aug 71, subj: Readout Satellites; memo, H.A. Kissinger, Spec Asst to Pres, to Sec Def, et al, 23 Sep 71, no subj; memo, Col D.D. Bradburn, Dir NRO Staff, to J.L. McLucas, DNRO, 22 Oct 71, subj: Transfer of HEXAGON Sensor Subsystem Contracts from OSP to SAFSP; memo, F.R. Naka, Dep/DNRO to McLucas, 21 Oct 71, subj: Hexagon Transfer.

73. Rpt, Hexagon Transition Plan, Mar 72, prep by D.L. Haas (CIA), D.W. Patterson (CIA/SSPO), Col R.H. Krumpe (Prog A), with concurrence of H.L. Brownman (CIA/Dir Rec Progms) and approval of BGen L. Allen, Jr (Dir/Prog A); msg, Whig 1565, DNRO to Dir/CIA Recce Progms and Dir/Prog A, 29 Nov 71.

74. Msgs, Pilot 3049, L.C. Dirks, CIA, to BGen D.D. Bradburn, Dir/Prog A and J.L. McLucas, DNRO; Charge 3846, Bradburn to Dirks and McLucas, 30 Jun 73.