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CRITICAL TO US SECURITY:
THE DEVELOPMENT OF THE GAMBIT AND HEXAGON
SATELLITE RECONNAISSANCE SYSTEMS

GERALD K. HAINES

NRO HISTORIAN

1997

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Critical to US Security:

**The Development of the GAMBIT and HEXAGON Satellite
Reconnaissance Systems**

Introduction

Since the early 1960s, US policymakers have come to rely increasingly on photo-reconnaissance satellite imagery for timely and accurate intelligence. Photo-reconnaissance satellites and the information they provide have become virtually indispensable to the US Intelligence Community and its intelligence assessments. Developed, operated, and managed by the National Reconnaissance Office (NRO), these satellite systems sparked a revolution in intelligence collection. Operating in a crisis atmosphere, the NRO forged a unique working partnership with US private industry to design and build these new satellite systems. The NRO/industry partnership drove space reconnaissance technology beyond current limits. It made possible a new generation of photo-reconnaissance technologies that resulted in the acquisition of never-before-seen, detailed intelligence data for US officials.

CORONA, the first US reconnaissance satellite program ushered in this new era in intelligence. A stop gap film recovery system, CORONA focused primarily on the Soviet Union and other denied

areas. CORONA imagery provided US decision makers with vital information on Soviet weapons development, order-of-battle, and its nuclear program. During the 1960s, CORONA satellites were this nation's primary search system.¹ Covering wide swaths of the Soviet Union, CORONA cameras swept the Soviet land mass for signs of missile development and nuclear testing activity.

Although its contribution to US intelligence was "virtually immeasurable," CORONA imagery also had limitations. In 1961, for example, it could resolve no object smaller than 10-15 feet. US photointerpreters and US planners needed, and demanded, higher resolution imagery for their intelligence estimates relating to Soviet weapons systems and target identifications.

To fill this gap, DNRO, Joseph Charyk, pushed the development of a high-resolution spotting satellite system, GAMBIT. Also known as the KH-7, GAMBIT was to provide resolution of [REDACTED] two feet. After overcoming a series of developmental problems, both technical and managerial, the first GAMBIT satellite flew in July

¹Traditionally, photointerpreters divided reconnaissance photography into two categories. One was "search." It was dedicated to finding something. CORONA was a search system. Its cameras were designed to photograph large contiguous areas in a single frame of film. The second observation function was "surveillance." Once it was determined there was something of interest there, the surveillance system provided detailed information on the particular target.

1963. The returned film product whetted the appetite of US intelligence analysts for more. Although GAMBIT, a surveillance system, covered far less area than CORONA, it produced photography with a much better resolution. Objects as small as six feet could now be located and observed.

An improved GAMBIT, known as GAMBIT-3 or the KH-8, flew in 1967. Capable of stereo photography and [REDACTED] resolution, it proved highly successful replacing GAMBIT-1. The GAMBIT program eventually flew 54 missions over 20 years, concluding in 1984. It provided US officials with unique, highly detailed imagery of sensitive targets, and became a major tool for photo analysts during the Cold War.

Film-recovery payloads culminated with the development of the HEXAGON series of satellites. Approved for design and development by the United States Intelligence Board (USIB) in 1964, the CIA designed HEXAGON as both a high resolution and wide area coverage system. It was one of the largest and most complex reconnaissance satellites ever built. Known to the American public as "Big Bird," it was 10 feet in diameter and 55 feet in length. It rivaled NASA's Space Lab in size. HEXAGON featured two panoramic counterrotating optical-bar cameras and four recovery capsules (later CORONA and GAMBIT satellites carried

two). Later HEXAGONS also contained a fifth capsule to return film from a separate mapping camera. Accompanying stellar and terrain cameras in HEXAGON made it possible to extract mapping, charting, and geodetic data for the Defense Mapping Agency and other organizations of the Intelligence Community. The NRO launched twenty HEXAGON's between June 1971 and April 1986. The only failure to mar this remarkable satellite program occurred on the twentieth and last flight when the launch booster exploded above Vandenberg Air Force Base on 18 April 1986.

In the 1980s, the next generation of US photo-reconnaissance satellites (which eliminated the need for film return), replaced both GAMBIT and HEXAGON. During their years of operation, however, GAMBIT and HEXAGON proved invaluable to US policymakers. For much of the Cold War, these systems kept watch over the Soviet Union and other communist bloc areas. They proved critical to US security by providing detailed intelligence on US adversaries. Their search and surveillance capabilities also made possible arms limitation negotiations and the verification of nuclear reduction treaties.

This study traces the origins and development of the GAMBIT and HEXAGON programs. It details the technological problems, breakthroughs, and accomplishments they encountered as NRO, CIA,

Air Force, and private industry engineers, designers, and program managers, pushed the cutting edge of space reconnaissance technology. It outlines the evolving close partnership and working relationship developed between the NRO and industry in pursuing far-reaching scientific and technological goals. It also describes the bureaucratic battles among the CIA, the NRO, and the Air Force over control and management of these systems. Finally, it places the development of these unique satellite systems squarely in the crisis atmosphere of the Cold War and the constant demands of US officials for more and better pictures. It is a remarkable story.

Background

Deeply concerned over Soviet boasts about the success of their missile program and the growing "missile gap," controversy, President Dwight D. Eisenhower, despite reservations, authorized a U-2 penetration flight of the Soviet Union for 1 May 1960. The Department of State and the CIA strongly supported the decision. The intelligence objective of gathering information on the Soviet missile program was overwhelming in spite of the dangers.²

The most experienced U-2 pilot, Francis Gary Powers was selected to fly Operation GRAND SLAM from [REDACTED] to [REDACTED]. According to CIA analysts, this route offered the

²For a review of the missile gap controversy see Roy E. Licklides, "The Missile Gap Controversy," *Political Science Quarterly* 85(1970): 600-615. For a detailed review of the U-2 program see Gregory W. Pedlow and Ronald E. Welzenbach, *The Central Intelligence Agency and Overhead Reconnaissance: The U-2 and OXCART Programs 1954-1974* (CIA, 1992) (S). In August 1957, the Soviets launched a long-range ballistic missile. On 4 October 1957, they rocked US policymakers by orbiting Sputnik I (the first artificial earth satellite; it weighed 84 kg or 185 pounds) and in November 1957 the Soviet Union announced the launching of another earth satellite weighing 900 kg or 1,980 pounds. See Gerald K. Haines, *The National Reconnaissance Office, Its Origins, Creation, and Early Years* (NRO, 1997), pp. 12-13, Cargill Hall "Post-War Strategic Reconnaissance and the Genesis of Project CORONA," and Robert A. McDonald, ed., *CORONA: Between the Sun and the Earth, The First NRO Reconnaissance Eye in Space* (American Society for Photogrammetry and Remote Sensing, 1997), pp. 25-58. No U-2 operations were to be carried out after 1 May because the President did not want anything to disrupt the Paris Summit scheduled to begin 16 May 1960.

best chance of photographing suspected locations of Soviet ICBM sites. Powers first target was the Tyuratam Missile Test Range; he was then to head for Chelyabinsk, just south of Sverdlovsk. Powers never made it past Sverdlovsk. Four and a half hours into the mission, a Soviet SA-2 surface-to-air missile disabled his aircraft 70,500 feet above the Sverdlovsk area. The Soviets had succeeded in downing the United States' most advanced reconnaissance aircraft. When Eisenhower finally admitted US responsibility for the U-2 overflight, he suspended all future U-2 flights over the Soviet Union. The United States was now primarily blind regarding Soviet missile advancements.³

At the same time the U-2 was successfully overflying the Soviet Union, 1956-1960, and following the dramatic Soviet space successes in 1957 with Sputnik I and Sputnik II, President Eisenhower formally endorsed a stop-gap US satellite program in February 1958. The new CORONA project, managed jointly by the same CIA-Air Force team which had built the U-2, was to produce a satellite imaging reconnaissance system that would take pictures

³For a discussion of the shoot-down and the aftermath of the U-2 downing, see Pedlow and Welzenbach, pp. 177-187. The Soviets prepared an elaborate show trial for Powers which began on 17 August 1960. The Soviets sentenced him to 10 years in prison. On 10 February 1962, the Soviet exchanged Powers for captured Soviet spy Rudolf Abel.

from space and deorbit a capsule with film back to earth. Like the U-2, this was a bold initiative to counter the closed societies of the Sino-Soviet bloc.⁴

A string of twelve successive failures, however, threatened to end the CORONA program before it even succeeded in returning a single film capsule from space. As the failures continued to mount, Bissell and the CORONA team became frustrated. It was not like the development of the U-2 where, if something failed, the pilot, unless it was a fatal error, could usually relate what happened. With satellites, according to Bissell, "they spun out of control, burned up in the atmosphere, crashed, hopelessly lost in the ocean, or exploded. Because the whole system was destroyed on reentry, it was often impossible to retrieve it and do an assessment."⁵

Discouraged, on 10 August 1960, the CORONA team launched a diagnostic payload in an attempt to determine what was going

⁴CORONA was to be a stop-gap effort until the much larger and complex Air Force W117L Samos Satellite became operational. See Hall, pp. 42-51; Haines, pp. 14-15; and McDonald, pp. 61-74. At the same time, Eisenhower approved plans for the CIA to develop a follow-on plane for the U-2.

⁵Richard M. Bissell, Jr., with Jonathan E. Lewis and Frances T. Pudlo, *Reflections of a Cold Warrior: From Yalta to the Bay of Pigs*, (New Haven: Yale University Press, 1996) p. 137.

wrong. The launch from Vandenberg, AFB, California, was perfect, the Agena rocket sent the spacecraft into the proper orbit, and on its 17th revolution, it successfully returned to earth, the first payload from space.

Buoyed by this success, the CIA/USAF team launched a camera-equipped CORONA on 18 August. Like the earlier mission, CORONA Mission 9009 worked perfectly and deorbited its film payload on Friday, 19 August 1960, exactly 100 days after the Soviets shot down Powers and his U-2. The two recoveries did not make a successful program, however. Of the next four launches, only three went into orbit and one of these suffered a camera failure.⁶

CORONA Mission 9013, recovered on 10 December 1960, revealed Soviet construction work on its SS-6 missile sites at Plesetsk and at Yurya. Photo reconnaissance was beginning to pay off. CORONA photography obtained in June 1961 also revealed a new Soviet missile project around Leningrad. Some CIA analysts believed this new system was an anti-ballistic missile (ABM) system designed to counter US intermediate-range missiles. The John F. Kennedy administration, anxious over this new development, turned to the CIA and the CORONA program for more

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data. CORONA, however, was not able to perform the required task. Even its newest camera, the stereo KH-4, known as MURAL, was not good enough to provide technical data on the design of objects as small as the surface-to-air missile. Moreover, CORONA engineers were still grappling with keeping the satellite cameras in focus. According to the Satellite Intelligence Requirements Committee (SIRC), new US satellite systems were needed that could resolve objects as small as 6, 1.5, and 0.3 meters. CORONA cameras called only for a resolution of 6 meters. This was in accordance with its role of performing wide-area, low resolution "search" missions.'

'The Air Force had the task of developing a high-resolution "spotting" satellite.

GAMBIT

Origins of the Program

The NRO GAMBIT satellite program evolved from the Air Force's larger developmental plans for building reconnaissance satellites -- the WS-117L program in the mid 1950s. As originally envisioned, the Air Force sought to create a multi-faceted satellite observation system. Little came of these efforts, however, as the Department of Defense struggled to eliminate "non-critical" defense expenditures and the Eisenhower administration stressed a "space for peace" theme. Following the Soviet space successes of 1957, however, Defense Secretary Neil H. McElroy authorized the acceleration of WS-117L to proceed "at the maximum rate consistent with good management."⁸

Upon the urging of his civilian scientific advisors,

⁸See *. In early 1958 President Eisenhower set up a Satellite Intelligence Requirements Committee (SIRC) within the Intelligence Advisory Committee (IAC) to establish requirements for satellite reconnaissance. In July 1960, the United States Intelligence Board (USIB) (The IAC was the predecessor body to the USIB.) merged the Ad Hoc Requirements Committee (ARC), originally established by Richard Bissell as an intragovernmental unit to oversee the tasking requirements for the U-2, with SIRC to form a new unit, the Committee on Overhead Reconnaissance (COMOR). See * and William M. Leary, ed., *The Central Intelligence Agency, History and Documents* (Birmingham, Alabama: University of Alabama Press, 1984).

President Eisenhower in 1958 ordered a small part of the WS-117L program, a satellite with a returnable film capsule, be taken from the Air Force over-all program and given to the same team that had built the U-2: the CIA's Richard Bissell and the Air Force's Brig. Gen. Osmund Ritland, for quick development. CORONA was to be a stop-gap measure until the larger Air Force effort produced results.

In the aftermath of the U-2 shoot-down, the suspension of U-2 operations over the Soviet Union in May 1960, and the mounting failures of the CORONA and Samos programs, US officials urgently sought new sources of high resolution reconnaissance photography.' The imagery was critical to US national security interests.

The U-2 shoot-down triggered a series of top level meetings

'Samos originally had two planned photographic capabilities E-1 and E-2. These involved the on-orbit exposure and processing of film, translation of that imagery into an electrical signal by means of a flying-spot scanner, and transmission of the signal to earth for recomposition as a picture. E-3 was the designator for a system which substituted photosensitive electrostatic tape for film; E-4 was used to identify a proposed mapping/geodetic photographic system; E-5 was a recoverable satellite with a large recovery vehicle; and E-6 was a recoverable-film search system with several times the capability of CORONA. E-1, E-2, and E-3 were readout systems, E-5 and E-6 were film-recovery systems. Only E-1, E-2, and E-6 ever flew. See *

on the status of the Air Force's Samos programs. The Eisenhower decision to stop all aircraft overflight operations meant the loss of high-resolution observation of the Soviet Union. Even if CORONA achieved success, and at this point it had not, there was an immediate need for much better resolution than it could provide. George B. Kistiakowsky, who had succeeded James Killian as President Eisenhower's science advisor, was pessimistic about the Samos programs.

On 26 May 1960 Eisenhower directed Kistiakowsky to set up a group to advise, as quickly as possible, on the best way to expand satellite reconnaissance options. Kistiakowsky turned to James Killian, Edwin H. Land, Carl Overhage of Lincoln Laboratories, Richard M. Bissell, Jr., and Air Force Under Secretary Joseph V. Charyk. They all echoed Kistiakowsky's concerns over Samos and suggested a Department of Defense streamlined, super-CORONA program. Charyk also argued strongly for keeping the program in the Air Force. If given the chance, Charyk believed he could create a successful covert satellite program within the Air Force.

On 25 August 1960, Eisenhower approved the recommendation of the Kistiakowsky Study Group. Charyk got his wish and Samos became part of a new Air Force organization known as the Air

Force Project Office which subsequently became the Secretary of the Air Force Special Project Office (SAFSP). The new Samos project office in Los Angeles was to be housed in the same building as the new Space System Division. It would have direct access to all Air Force resources: Atlas booster; Agena spacecraft; launching site at Vandenberg AFB; tracking and control services at Sunnyvale, California; and recovery services at Oahu, Hawaii. Brig. Gen. Robert E. Greer became the first SAFSP director. He had previously been the Air Force's assistant chief of staff for guided missiles. At the same time, under a security strategy called "Raincoat," Charyk hid the sensitive space program by forbidding any publicity releases on an Air Force space project.¹⁰

Another factor that affected the GAMBIT program was the formal establishment of the National Reconnaissance Office in September 1961. Now, all national collection requirements went through the NRO and its Satellite Operations Center (SOC) located in the basement of the Pentagon. Joseph Charyk became the first Director, NRO and GAMBIT became the first full-scale venture of the new organization. Charyk assigned the GAMBIT Project to Program A (Air Force) at SAFSP. It proceeded independently from

the CORONA project and the CIA satellite effort (Program B).

GAMBIT Development

Two months earlier in March 1960 Eastman Kodak submitted proposals to the Air Force and the CIA for the development of a 77-inch (focal length) camera for satellite reconnaissance. Building on its development work for the CIA's OXCART aircraft program, Kodak suggested that the new high performance catadioptric lens camera might be suitable for satellites.¹¹

In June, Kodak proposed a 36-inch camera system to provide convergent stereo coverage of Soviet territory. Termed "Blanket," Kodak claimed the new system could be made operational in a short period of time because it was based on existing technology from the OXCART program. Kodak officials, Arthur Simmons and Herman Wagershauser, showed the proposal to Edwin H. (Din) Land, one of Eisenhower's scientific advisors. Land enthusiastically brought the proposal to the attention of Air Force Under Secretary Joseph V. Charyk. Charyk, too, was

¹¹OXCART was the next generation of manned reconnaissance aircraft. Although originally developed to overfly the Soviet Union, it never did. Improvements in Soviet radar and the SAM missile made such overflights impossible. The Air Force version of OXCART was known as the SR-71 or Blackbird.

interested. He liked the Kodak proposal, a film-only recovery scheme like CORONA with a very high-acuity, long focal-length camera. In discussion with Charyk, Kodak officials confidently projected the feasibility of providing a surveillance camera with 2- to 3-foot ground resolution with high-acuity stereo coverage.

A month later, on 20 July, Kodak offered a modified proposal which integrated the 77-inch camera with the stereo features and film recovery techniques embodied in "Blanket." It termed the new proposal "Sunset Strip" after the popular television series. This was promising technology for new orbital reconnaissance systems.

In September 1960, Charyk met with Greer, Col. Paul J. Heran (Chairman of the E-6 Source Selection Board) and Lt. Col. James Seay (Greer's procurement chief) to review proposed satellite programs. All agreed to proceed with both E-6 (which had the potential of being twice as good as CORONA) and the Kodak "Sunset Strip" proposal. Charyk directed that "Sunset Strip" be developed on a cover basis, hidden in the E-6 program. He set initial funding at [REDACTED] for R&D study funds for the balance of FY 1961. Greer named the new "black" program GAMBIT. By keeping the physical and environmental limitations of E-6 and GAMBIT compatible, it seemed possible to develop and test GAMBIT

without any outward indication that such a program existed.¹²

At the same time Charyk moved to hide the GAMBIT project, he also shielded it from the over-all Air Force Samos program, cutting out the Strategic Air Command, the Air Force Ballistic Missile Division, and the Air Force System Command. They all objected strongly to "losing" Samos. Charyk later reflected that it was extremely difficult limiting "need to know" especially when everyone believed they were working on a strategically important program. On the one hand he was telling them that Samos was extremely important and on the other that it would be drastically cut back.¹³

Since the 77-inch camera development program was well publicized, Charyk and Greer followed the earlier CORONA precedent. They terminated the Kodak study contract for "Sunset Strip" as "no longer required" and simultaneously authorized Kodak to continue the development as a covert effort. As the "Sunset Strip" activity closed and Kodak personnel nominally shifted to other Kodak projects, they actually moved into a new facility in a different building and resumed their work. In establishing the CORONA program, Bissell and Ritland followed

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much the same procedures.¹⁴

The complex, involved, security procedures for GAMBIT "cover and deception," in retrospect seem overdone. There were few challenges or threats to the system or the disclosure of GAMBIT.¹⁵

Getting Pictures

While putting the rather elaborate security system in place, both Charyk and Greer agreed that their real job was to "get pictures," the objective of the national satellite reconnaissance program. Although Charyk initially balked at Eastman Kodak's demand for a seven-percent profit margin on camera development, by January 1961, he and Kodak had reached agreement.

Greer supported Kodak. According to Greer, the fee was not excessive. He based his judgment on the U-2 camera expenses and Kodak's "unique capability." Moreover, the 25 August National Security Council directive ordered the Samos "take to be processed by the same agency that processed U-2 take" -- Eastman

Kodak. There were no alternatives.¹⁶ General Electric's Space Division was to build the orbital-control vehicle. By mid-1961, GAMBIT had evolved into a 15-foot long, five-foot diameter space vehicle.

The GAMBIT payload embodied a Maksutov f/4.0 lens (both reflecting and refracting elements) similar to an astronomical telescope with a 77-inch focal length and a clean aperture of 19.5 inches. This lens, when flown at a nominal 95 nm altitude was to produce a ground resolution, at nadir, of from 2 to 3 feet. GAMBIT was to carry 3,000 feet of 9.50-inch diameter, thin-base film through a strip camera, which would provide image-motion compensation by moving the film across the image exposure slit at the same velocity that the projected image moved over the earth. The camera would image a strip on the earth 10.6 nm wide. It possessed the capability of photographing specific targets which were off the immediate orbital track through oblique pointing. The planned weight of the total photographic system was 1,154 pounds.

The high resolution requirement for GAMBIT imposed a need for accurate orbit maintenance over a period of several days and for an ability to rotate the camera section about the vehicle's

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roll axis. The GE orbital control vehicle (OCV) was to be capable of varying the roll attitude from 0° to 45° and of performing 350 roll maneuvers at an average rate of one per second. The command system was to receive, accept or reject, and execute both real-time or stored commands.

The attitude control system was a two-axis gimballed platform on which were mounted infrared horizon scanners and an integrating gyroscope. The horizon sensors measured pitch and roll error; the gyro measured yaw error. Control movements were dependent on several jet-nozzle apertures. A set of four rocket engines, each capable of producing 50 pounds of thrust, would provide orbit maintenance.

The initial GAMBIT launch vehicle was an Atlas Agena-D. The Atlas used 123 tons of liquid oxygen and refined kerosene (RP-1) to power the booster engines -- each generating 154,500 pounds of thrust and a 57,200-pound thrust sustainer engine. The Agena-D upper stage used 13,234 pounds of fuel to power its 16,000-pound thrust engines.

After exposure, the camera's film was wound up in the recovery vehicle (RV). At the end of the mission, the RV was separated from the OCV, spun up on its axis of symmetry by a

cold-gas system, and then deboosted from orbit. Parachute deployment was to occur at 55,000 feet. The initial recovery vehicle was intended for land recovery. In fact, in October 1961, Charyk approved the use of the Wendover AFB in Utah for GAMBIT land recovery operations and the State Department opened negotiations for an additional [REDACTED] for controlling the orbital vehicle and for safeguarding the proposed land recovery process.¹⁷ At this point, both Kodak and GE appeared to be ahead of schedule in completion of their design concept. By 1 August 1961, a GAMBIT launch date in January 1963 appeared possible.

Even with progress in the GAMBIT program, by January 1962, the need for an on-orbit, high-resolution, photographic reconnaissance system was even more critical. The Samos E-5 program had been cancelled after a series of failures and CORONA was experiencing operational difficulties. DNRO Charyk, under constant pressure to get quick and effective results from the satellite reconnaissance program, wanted to accelerate the pace of GAMBIT development and improve its product. In discussions with Greer and Quentin A. Riepe, the program director for GAMBIT, however, it soon became clear serious problems remained and that

any quick fixes would seriously degrade the photography. There was general agreement that the earliest possible date for the initial launch would be May rather than February 1963.

Problems

The National Security Council (NSC) program directive in 1960 approving GAMBIT specified the development of a land recovery program. In the climate of the early CORONA program, land recovery appeared to be a useful option, less risky, more reliable, and less costly than the ocean recovery used by CORONA. Moreover, the projected weight of the GAMBIT RV would exceed the capability of the C-119 recovery aircraft. By July 1962, however, the reasons for distrusting air-sea recovery methods seemed less valid. The improving capability of the CORONA RV and the good performance of the overwater recovery system convinced Greer of the feasibility of using a CORONA-like RV on GAMBIT.

The GAMBIT RV was then 500 pounds over design weight and most of the overweight derived from complications introduced by the land recovery requirement. Over-water recovery, as developed in the CORONA program, seemed to Greer a very simple process when compared to the planned land recovery scheme. In its descent toward the ocean, a CORONA reentry vehicle could safely shed all

sorts of accessories - hatch covers and ablative cones, for example. They simply fell into the ocean and sank. A land recovery vehicle could shed nothing, lest it became a lethal projectile. Greer asked GE to do a quiet study of "gluing the DISCOVERER capsule on the front end of GAMBIT."¹⁸

Greer was attracted to the concept by the potential of major savings on weight, cost, and launch schedule. More than 600 pounds of orbital weight could be saved by going to an overwater recovery mode. Over [REDACTED] in facility funds for the Wendover range could be cut from the budget. Most importantly, with a modified CORONA RV, GAMBIT could maintain its launch schedule. After listening to the various arguments, including the GAMBIT program office which felt that the land recovery approach was still the better option, on 18 September Charyk authorized Greer to begin immediate development of a CORONA-type recovery system for GAMBIT in preparation for a June 1963 first flight date.¹⁹

The switch to a CORONA-type water recovery vehicle markedly simplified the entire GAMBIT system and probably saved the program. It did not, however, eliminate all problems. While

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work on the camera payload at Eastman Kodak continued to progress, major problems threatened the launch date schedule. The optics for GAMBIT were to be larger and lighter than any previously built for space. The [REDACTED] made the primary and stereo mirrors. Using large boules of very pure fused silica glass, [REDACTED] engineers joined the sections in an [REDACTED] fashion. The fusion operation was extremely delicate: heated too long or at too high a temperature, the structure became a molten blob, too low a temperature or too short a time prevented the parts from fusing properly. [REDACTED] shipped the large, lightweight blanks to Kodak for figuring and polishing at its special facility, [REDACTED]

Frederic Oder, director of Special Projects at Kodak and familiar with the CORONA RV from his previous work on WS-117L, favored the use of CORONA technology on GAMBIT. Kodak had originally planned to keep the film path pressurized including

²⁰Kodak set up a special unit to deal with GAMBIT. The entire project was located at [REDACTED]. Dr. Frank Hicks directed the program at Kodak. He reported to the director of Special Projects, Dr. Frederic C. E. Oder. The Special Projects organization reported to Arthur Simmons, director of research and engineering of the Apparatus and Optical Division. The GAMBIT project received the highest priority within Kodak because of its national priority. Earlier, as an Air Force officer, Oder was the original WS-117L project officer and was witting of the entire CORONA effort.

the film chute and take-up cassettes. Using his CORONA background, Oder urged the adoption of a nonpressurized film path. This simplified the process and allowed the GAMBIT film load to be accommodated in a CORONA-like RV without serious modifications.

Kodak was also having problems attaching or cementing the silica mirrors to their metal case and with the platen drive which caused the film to move irregularly over the exposure slit. Although the problems were not considered major, they added to existing pressure on delivery time and flight schedules.²¹

The Orbital Control Vehicle (OCV) development by General Electric, in its Valley Forge, Pennsylvania facility, was another story. Repeated failures in such varied experiments as the harnesses, power supplies, batteries, command systems, horizon sensors, rate gyros, environmental doors, and pyro devices, caused major cost over-runs and severely threatened delivery schedules.²²

The prevalence of cost over-runs, particularly at General Electric, the threat of new schedule slippage, and the increasing cost of the GAMBIT program greatly concerned Charyk. At the same

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time, pressures continued to increase for hard intelligence on the Soviet Union. The Cuban Missile Crisis of October 1962 added to the sense of urgency.

At a meeting with the President's Foreign Intelligence Advisory Board and the "special group" of the National Security Council, Charyk characterized GAMBIT as "imperative" and urged that the program be pressed with a "maximum sense of urgency." "No reasonable steps," Charyk argued, "should be omitted to guarantee its success at the earliest possible time." According to Charyk, GAMBIT offered the most promising approach to discovering whether or not the Soviet Union was actively preparing for war.²³

Discouraged about the rate of GAMBIT progress, Charyk suggested to Greer a management change. He wanted an exhaustive technical review of the program to locate any remaining problems.

Greer was reluctant to relieve Col. Riepe, the original program manager. Nevertheless, on 30 October 1962, Greer replaced Riepe with Col. William G. King. King had a long experience with satellite reconnaissance. He had been Samos program director in

²³See*. Most of the Samos program's photo-oriented reconnaissance had been canceled and the E-6 program was experiencing grave technical problems -- four failures in four tries.

the late 1950s and was one of the first to recognize the advantages of film recovery techniques over the technically more difficult readout systems. At the time of his appointment to head the GAMBIT program, he was serving as Greer's special plans officer.²⁴

Immediately upon taking over the GAMBIT program, King discovered that the GE adaptation of the CORONA capsule to GAMBIT was seriously off course. Greer's original intent, confirmed by Charyk, was to "glue on" the CORONA recovery vehicle. Elaborate or extensive modification of the capsule was neither intended nor desired. In the course of changing over from land recovery to air-sea recovery, however, GAMBIT officials had authorized GE to develop a recovery vehicle capable of accepting the original pressurized GAMBIT take-up cassette and film chute.²⁵ Responding to the request to convert GAMBIT to a CORONA recovery vehicle, GE

²⁴Greer's instruction to King emphasized these goals: 1) stay within budget; 2) stay on schedule; and 3) obtain one good picture. See*.

²⁵Because of rigid compartmentation of programs, only Col. Riepe in the GAMBIT program office had a working knowledge of the CORONA program. Lacking any indication that unpressurized operation was possible, (The CORONA experience with unpressurized operation had been employed successfully for two years.) GAMBIT officials assumed that the pressurization of the film cassette would have to be continued in the new recovery capsule. See*.

scaled up the CORONA capsule, making it deeper and increasing its base diameter. The result was a completely new capsule which required an extensive test program. The cost also escalated.

King suggested that the original intent of the CORONA modification be reinstated and that the rapidly expanding GE development effort be stopped. Greer, who had originally ordered that changes to the CORONA capsule should be minimal, agreed. King imposed an "absolute minimum" change policy in his instructions to GE on adopting the CORONA recovery system to GAMBIT.

At the same time, King was sorting out the technical problems with GAMBIT, Charyk and Greer decided to strengthen GAMBIT management further by transferring the program from the Space Systems Division to SAFSP. Such a move would give GAMBIT the prestige and authority of the office of the Secretary of the Air Force. This set off a fire storm in the Air Force Systems Command (AFSC). General Bernard Schriever, commander of AFSC, had been a major force in establishing the Air Force space program. Schriever believed strongly that all Air Force space activity should be under AFSC management. He made several determined but ultimately unsuccessful attempts to regain "ownership." High priority space programs would from now on

report directly to the Office of the Secretary of the Air Force.²⁶

King continued his technical review of the GAMBIT program by questioning GE's untested OCV and its attitude-control subsystem. In order to improve the probability of early GAMBIT flight successes, King and Greer suggested that the Agena, at least for the first three flights, remain connected to the OCV. The reliable Agena, while not as precise as the GAMBIT system, could provide a stabilization and control mechanism to stabilize the GAMBIT camera long enough to secure operating experience and proof of system feasibility. Flying in this "hitch-up" configuration would not allow the demonstration of GAMBIT's full capability and it would only permit near-nadir photography, but King and Greer were determined that the first GAMBIT should return at least "one good picture."

King and Greer also envisioned using a roll-joint coupling (invented for an interim high resolution satellite developed by the CIA, known as Project LANYARD and its KH-6 camera) between the spacecraft (Agena) and the camera system. Should the GE OCV prove unreliable, the introduction of the LANYARD roll-joint could stabilize and control the vehicle.

As was the case with the CORONA reentry capsule, the roll-joint technology was unknown to most GAMBIT people. Because of the high degree of security compartmentation in the reconnaissance program structure, CIA security officials were reluctant to disclose even the existence of LANYARD to GAMBIT personnel. Charyk got around this problem by "suggesting" to Greer (Greer actually drafted the suggestion.) that he contact Lockheed Corporation about the roll joint as "...he (Charyk) believed a similar idea was once proposed and possibly designed in connection with another space program." Lockheed thus delivered the finished roll joints to the GAMBIT program as though they were new items with no relationship to any other reconnaissance program.²⁷

On 14 December 1962 Greer and King proposed yet another technical innovation. The latest change advocated incorporating "Lifeboat" provisions into GAMBIT. "Lifeboat" was another CORONA originated technique. It involved providing independent reentry command circuitry (including a receiver), a separate magnetometer, and its own stabilization gas supply. All were independent of the main systems. If the primary reentry systems became inoperative, "Lifeboat" could be separately activated.

"Lifeboat" had proven its value on several occasions with CORONA.

Charyk formally approved adding "Lifeboat," "hitchup," and "roll joint" to GAMBIT on 19 December. "Lifeboat" was to be a permanent part of GAMBIT, "hitchup" was to be used on just the first four vehicles and then on a flight-by-flight basis. "Roll joint" was to be developed as an operational substitute for the OCV roll system. At the same time, in order to maintain the launch schedule, Greer and King deleted a substantial portion of the test program for GAMBIT. There was no alternative if GAMBIT was to meet its proposed schedule of June. Both knew the risk, but additional overruns or schedule slippage could put the program in danger of being cancelled.²⁸ US policymakers demanded useful intelligence images of Soviet targets.

When Charyk resigned as DNRO on 1 March 1963, Dr. Brockway McMillan of Bell Telephone Laboratories replaced him. All seemed to be proceeding well with GAMBIT. By May GAMBIT was in its first flight checkout sequence. On the afternoon of 11 May, however, a faulty valve and a deficient fuel loading sequence caused a loss of internal pressure on the Atlas 190D. The booster collapsed on the pad, dumping both the GE orbital vehicle

²⁸The CIA program LANYARD at this point had some prospect of filling the proposed GAMBIT role. See *.

and the Agena on the concrete slab. The GE vehicle was severely damaged, the Agena to a lesser degree. Surprisingly, there was no explosion or fire, although 13,000 gallons of liquid oxygen and a full load of fuel sloshed over the pad. The camera system was damaged beyond repair, a large part of the optics demolished. The GAMBIT project team worked furiously to repair the damage and keep the pre-flight checkout on schedule. Despite their efforts the original 27 June launch date slipped back to July.²⁹

First Launch

22 months and 17 days after the National Security Council decision to proceed with a covert high-resolution satellite, GAMBIT flight vehicle No.1 lifted off from its Vandenberg launching pad on 12 July 1963 at 1344, Pacific Daylight Time. For an instant during the launch, most observers experienced the horrified sense that disaster had come again to the NRO/Air Force satellite reconnaissance program. The splashing rocket exhaust of the Atlas knocked out all electrical connections to telemetry and cameras. It gave the impression of a major launch start explosion. Seconds later, however, the Atlas could be seen

²⁹Charyk resigned to become president of the newly formed Communications Satellite (Comsat) Corporation. See also *.

climbing steadily towards its launch window. Climbout, separation, and orbital injection went smoothly. Greer and King knew, however, it would be another 90 minutes before they would have proof that the bird was in a proper polar orbit. It would take another five orbits before the GAMBIT payload came to life. After another nine "working" passes, a recovery attempt would be made. There would be another wait as the capsule re-entered the earth's atmosphere, hopefully survived its passage through the upper atmosphere, arrested its descent by parachute, and was recovered.

On the fifth orbital revolution, command controllers turned on the camera for light strip exposures of 20 seconds each. On orbits eight and nine, two stereo pairs, and five, 2-second strips were exposed. A premature exhaustion of Agena stabilization gas then forced the discontinuance of camera operations. With the Agena out of fuel, "Lifeboat" became the only means of recovering the film capsule. On the eighteenth orbit, a ground station commanded "Lifeboat" and GAMBIT back toward earth. A C-119 aircraft waiting near Hawaii swept the parachuting reentry capsule out of the sky. The first GAMBIT was a success. But what about the film?

Evaluation of the recovered film, only 198 feet was exposed,

indicated an out-of-focus condition for most of the flight caused apparently by uncompensated temperature changes that affected the face of the primary mirror and by faulty image motion compensation settings. Nevertheless, the best resolution was close to 3.5 feet, the average resolution about 10 feet. It was the best photographic return ever obtained from a reconnaissance satellite.³⁰

Greer, gratified by the success of the first flight, informed King that he very much wanted "two in a row."³¹ The very success of the first flight raised Intelligence Community expectations for subsequent flights.

The second GAMBIT flight took place on 6 September 1963. All went well. During fifty-one hours on orbit, the hitched vehicle completed 34 orbits and exposed 1930 feet of film. It covered [REDACTED] intelligence targets. On the 34th revolution, the reentry vehicle was detached and successfully recovered by air catch. An analysis of the photographs recovered from the second GAMBIT showed consistently high quality until the 31st orbit. The resolution achieved during the initial portion of the flight meant the photointerpreters could distinguish such

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detail as aircraft engine nacelles, small vehicles, and even maintenance equipment. For the first time, a satellite reconnaissance camera had returned detail at levels previously obtained only from reconnaissance aircraft. Only three years after Eisenhower ordered manned reconnaissance flights over the Soviet Union discontinued, US satellites had filled the intelligence gap. First, CORONA had returned coverage of areas most U-2s could not reach or safely overfly, and now GAMBIT had returned detail not greatly inferior to that produced by U-2 cameras.³² GAMBIT imagery, however, was limited to only [REDACTED] targets and 1930 feet of film from GAMBIT's second flight. Although GAMBIT's achievements were remarkable, it did not yet provide recurring coverage of the Soviet Union. Such coverage, at resolutions much better than CORONA could provide, was still an urgent national goal.³³

McMillan, under constant pressure for more pictures, wanted future GAMBIT missions to concentrate on obtaining the best possible ground resolution over larger numbers of "denied area" targets.³⁴ McMillan informed Greer, "...the name of the game is

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specific coverage of specific, known targets with stereo photography of the best possible quality." Greer was increasingly confident GAMBIT could produce the desired results.

GAMBIT flight three of 25 October 1963 produced photography "better and more consistent than that of either of the first two missions." Imagery was the first to show identifiable figures of people on the ground -- from a distance of 90 miles. The scene was a football field in Great Falls, Montana. In one photo, a place kicker could be seen putting the football in place while the other players moved into position. In a second photo, the players had lined up, ready for the kickoff.³⁵

Despite the superb resolution, however, the first three GAMBIT flights produced little intelligence. They did, however, whet the appetite of the US Intelligence Community for more and better satellite imagery.

GAMBIT No. 6, launched on 11 March 1964, seemed to bring the program to maturity. Despite some continuing problems, GAMBIT No. 6 returned substantial quantities of highly useful intelligence data [REDACTED] targets.³⁶

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Continuing Problems

The year 1964, however, brought serious problems to the program. From May through October 1964, six GAMBIT flights produced coverage on only [REDACTED] targets. Half of the flights produced no coverage whatever. The best resolution degraded to seven feet. Despite some successes in early 1965, the GAMBIT program was seriously ill.³⁷

Maj. Gen. Robert Greer retired on 30 June. He was replaced by Brig. Gen. John L. Martin who had been chief of the NRO Staff in the Pentagon and deputy to Greer. The summer of 1965 brought key personnel changes as well. Dr. Alexander H. Flax, Assistant Secretary of the Air Force for Research and Development replaced McMillan as DNRO on 1 October. Only Col. King continued in place as project director for GAMBIT.³⁸

As Greer's deputy, Martin had a detailed knowledge of GAMBIT. He had witnessed the agonies of the early GAMBIT operations and years later recalled the emotion of "watching a bird go dead." "You simply cannot imagine," he said, "the frustration you feel when a healthy-looking GAMBIT suddenly

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became a zombie."³⁹

Shortly after assuming command, Martin faced the issue of whether or not GAMBIT No. 20 should hold to its early July flight date. Martin decided to go ahead with the previous schedule. On 12 July Martin witnessed a comprehensive failure, the Atlas booster shut down prematurely and GAMBIT No. 20 flew a 682 mile arc into the Pacific Ocean. Martin demanded immediate changes. He and King set about tightening quality control and the incentive contracting system. They subjected the GAMBIT system to new and more stringent test and inspection procedures. Despite their efforts, GAMBIT No. 21 became the third successive GAMBIT to experience catastrophic failure when the AC/DC power converter in the OCV failed, resulting in the loss of stability.⁴⁰ The Intelligence Community, increasingly dependent on high-resolution photography to determine Soviet ICBM activity expressed its major concern with the gap in detailed coverage of the Soviet program.⁴¹

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⁴¹CORONA operation continued reasonably successfully during the summer of 1965, only one major mission failure in three flights, but CORONA did not return the detail that intelligence analysts needed to interpret Soviet force status.

Martin, although under pressure to produce detailed imagery, delayed the next scheduled GAMBIT launch. He turned his attention to GE's OCV, which had, on balance, provided most of the program difficulties. Traveling to GE Philadelphia, he and King mystified GE management by requiring exclusive use of a dining room, ten tables, ten white tablecloths, and ten completed GAMBIT electronic boxes. With GE management looking on, Martin produced his own screwdriver and removed the cover-plates from the first box. He raised the box above the cloth-covered table and shook it hard. He paused to inventory the native and foreign items which fell on the table. He and King moved from table to table repeating the operation with each box. Martin concluded by stating that someone or someones had to be responsible for the debris on the table. GE management responded by revamping its organization and production and testing procedures. They were determined that GE hardware would become a quality member of the GAMBIT components family.

GE was not the only errant contractor King and Martin took to task. Lockheed and Kodak were both criticized for shipping unfinished products to Vandenberg and then attempting to complete their work in Vandenberg's Missile Assembly Building (MAB). Determined to guarantee hardware integrity, King even threatened

to close the MAB, forcing all contractors to deliver flight-ready hardware to the launch site.⁴²

Martin also made an exhaustive study of the incentive contracting in effect for the GAMBIT program. He was amazed to find that the system of rewards paid more for under-cost, on-time delivery than for high quality performance on orbit. He observed, for example, that such a set of values placed GE in position to collect a healthy bonus for providing the OCV under cost and on time despite the failure rate on orbit. To the contractor, the arrangement stressed the cost factor far more than the performance factor. The result was that GE was motivated to delete as many control and test procedures as possible in order to save money and time in producing the OCV. Taken to its logical extreme, the incentive formula could result in the delivery of a minimum cost vehicle which failed catastrophically, but, nonetheless, earned a premium for the contractors. Martin shifted the focus of the incentive system from cost to performance. Martin's new system placed the emphasis on orbital performance and provided large bonuses for on-orbit success.⁴³

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GAMBIT No. 23, launched on 8 November 1965, was the first satellite to have full benefit of the new test and inspection regime. Unfortunately, it too quickly succumbed to flaws and during its 18-revolution lifetime photographed [REDACTED] targets. The Martin-King plan for improvement in the GAMBIT program, however, continued unrelenting. It finally paid off. The next 10 flights were all qualified successes. From January to October 1966, the NRO launched GAMBIT satellites at a rate of about one per month. They routinely returned photographic intelligence of high quality, covering more than a [REDACTED] targets in each flight. "Best resolution" range from 2.5 feet [REDACTED] [REDACTED] 2.0 feet. By the third anniversary of the GAMBIT flight program, 12 July 1966, GAMBIT had extended its longevity from one to eight days on orbit; had increased the number of targets from [REDACTED] and had improved resolution from 3.5 feet to 2.00 feet. The last GAMBIT mission, No. 38 (KH-7), flew on 4 June 1967. It was replaced by the highly successful GAMBIT-3 program."

"See later discussion of GAMBIT-3.

GAMBIT-1 Summary

GAMBIT was the first operational US satellite system to return high resolution photography consistently. An Atlas-Agena booster combination launched the GAMBIT into orbit. General Electric built the orbital control vehicle which housed the camera system. Eastman Kodak developed and manufactured the camera system itself which was originally designed around a lens of 77-inch focal length, producing photographs with a ground resolution of two to three feet. GE built the recovery capsule which was adapted from the CORONA program. The first GAMBIT was launched in 12 July 1963 and flights continued until 4 June 1967 when GAMBIT-3 replaced the GAMBIT-1 system.

The Development of GAMBIT-3⁴⁵

Even before the launch of the first of the GAMBIT reconnaissance satellites in July 1963, US planners discussed the need for an even greater capability system. GAMBIT, with its two to three-foot resolution, (three to five times better than anything CORONA produced) could produce significant operational and technical details on Soviet weaponry. But, they believed, even greater intelligence on the Soviets could be obtained if the United States developed an imaging system that could return ground details of [REDACTED]. Intelligence Community analysts wanted "more."

In the early 1960s, the dominant factor in obtaining higher resolution tended to be focal length and pointing accuracy. Long lens systems created enlarged images of relatively small areas. Eastman Kodak worked on such a system with its VALLEY program. By August 1963 VALLEY research and GAMBIT-1 experience convinced many NRO officials that long focal lengths were feasible for

⁴⁵When first considered, GAMBIT-3 was informally referred to as Advanced GAMBIT, and G³, or G-Cubed. G-3 eventually became the accepted designator for the successor program, although upon the completion of the original GAMBIt program and the start of GAMBIT-3 operations that suffix was dropped and it became simply the GAMBIT program. For the sake of clarity, this study will continue to distinguish between the two systems using GAMBIT-1 for the first program and GAMBIT-3 for the follow-on.

satellite operations. In December 1963, Kodak employees, Charles P. Spoelhof and James H. Mahar, presented their ideas for an advanced GAMBIT system to DNRO Brockway McMillan and Gen. Robert Greer. Following the presentation, McMillan approved the development of an improved, higher resolution, GAMBIT program.

The crux of Kodak's proposal was a system that would exploit the pointing accuracy of GAMBIT-1 and a camera with a [REDACTED] focal length lens. Kodak engineers believed that resolution of [REDACTED] could be obtained, assuming imagery from an orbital altitude of 90 miles. Spoelhof and Mahar also proposed that the new system incorporate a "factory to pad" concept to provide greater modularity, instead of an orbital control vehicle enveloping the camera system (GAMBIT-1). They proposed using two modules, one containing the camera and the recovery vehicle, the other housing propulsion and the on-orbit initial subsystems. Kodak also incorporated the Lockheed roll-joint concept between the forward photographic payload/recovery vehicle section and the satellite-control section.⁴⁶

Kodak also planned to use a special, very-low-coefficient-of-thermal-expansion Invar (an iron-nickel alloy) for both the optical barrel and related assemblies, and a new thin-base (1.5

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mil) high-resolution film with an exposure index of 6.0. (The film was roughly three times more sensitive than the film then in use on GAMBIT-1.)

Concerned that the new program might have major problems in producing the larger optics and that the improved film could not be delivered on schedule, DNRO McMillan sponsored a host of alternative technologies. This caution was also evident in the selection of the booster. Although King and Greer favored using the Atlas and Agena booster combination, McMillan wanted an option of using the new Titan-III booster which would provide for a greater payload weight.

King and Greer worked out the remaining major elements of the GAMBIT-3 concept in January 1964. Their plan called for the entire GAMBIT-3 program to operate under the purview of the SAFSP. They called for an initial flight in July 1966. The GAMBIT-1 system would continue until GAMBIT-3 became operational.

Because of DNRO McMillan's strong interest in the Titan as a possible booster for GAMBIT-3, Greer and King tasked Lockheed in July 1964 to study Agena compatibility with the Titan-III(x). In October 1964, on the basis of the Titan III(x)-Agena study carried out by Lockheed, Greer's staff prepared cost estimates for switching from the Atlas-Agena. Consideration for making the

change included the desire to use the Titan III family of boosters for other Air Force space missions, the potential versatility and on-orbit weight-growth capability, and the likelihood that a new search system replacing CORONA would rely on Titan III boosters. Despite the fact that the Atlas was considered the standard launching vehicle for the Air Force, DNRO McMillan officially approved the switch to Titan in October 1964. Although this increased cost and caused a slippage in the initial launch date, the choice of the Titan, in hindsight, was a major improvement. It allowed future system changes with less consideration of the limited lift capacity of the Atlas.

At Lockheed, the GAMBIT-3 program came under the direction of the Space Systems Division. The program manager was Harold Huntley who reported directly to James W. Plummer, assistant general manager for Special Programs. (Plummer would become DNRO in 1974.) While Lockheed's work on the Agena modifications proceeded and never seriously threatened the planned launch date of July 1966, payload development by Eastman Kodak was behind schedule by the fall of 1964. The major problem for Kodak centered on the manufacture and mounting of the two large mirrors of GAMBIT-3 optics. The primary mirror [REDACTED] [REDACTED] in diameter and the stereo mirror [REDACTED] by

[REDACTED]. These optics were larger than those of many earth telescopes, but needed to be much lighter to operate in space. Kodak experienced several failures in attempting to manufacture the mirrors. In addition, the figuring and polishing processes were far more difficult than originally anticipated. Kodak originally estimated that each of the two mirrors would require around 800 hours of grinding, polishing, testing, and coating to finish. The early mirrors took 3,000 hours per mirror. Because of mirror-fabrication problems, Kodak was three months behind schedule. Kodak's problem was compounded by its underestimation of the needed engineering manpower. The company experienced a major shortage of technical people, apparently from an over commitment of resources. Kodak was working simultaneously on GAMBIT-1, GAMBIT-3, a lunar camera for NASA, [REDACTED] and a proposed new search system that later became the HEXAGON program.

The final determination for fabrication, fused silica with [REDACTED] construction, for the primary aspheric mirror substrate and the return to conventional polishing techniques, pushed the production schedule ahead. By January 1966 there still existed considerable doubt that the high-speed (E.I.G.), high resolution film on which GAMBIT-3 depended, would be ready for use in

initial flights. If it was not ready, the fall-back film, with an index of 3.6 and a resolution capability of 110 lines per millimeter, as against the 130 lines ASA 6.0 film would be used. It would build a certain amount of smear but there was no alternative. In fact, the new film did not become available until June 1968.

Given their experience with GAMBIT-1, Greer and King also introduced another innovative management technique. In contrast to the extensive testing at the launch site that characterized GAMBIT-1, testing that frequently brought substantial repair work in the Missile Assembly Building, Greer and King initiated a command system for GAMBIT-3, featuring an automated checkout system that allowed telemetry readout of functions. These readouts directly indicated whether or not various subsystems and components operated within acceptable limits. This automated checkout was normally performed during final assembly at Kodak and Lockheed, the principal manufacturers. The components, therefore, went directly from factory to launch pad.⁴⁷

NRO planners took no chance with the success of the first launch of GAMBIT-3. By the time of the launch, recovery operations had become rather routine, using Air Force C-130

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aircraft and Navy range ships. An NRO agreement with the US Navy provided for the Navy to support these recoveries with two such range ships. As the first GAMBIT-3 launch approached, the Navy, however, had only one ship on duty station. NRO program officers requested additional Navy support through the Office of the Commander-in-Chief, Pacific Forces (CINCPAC), which controlled all Department of Defense assets in the Pacific. CINCPAC responded that because of the Vietnam conflict, the usual recovery support could not be provided. Col. King took the issue to DNRO John McLucas. This was a serious threat to the successful completion of the mission. McLucas took up the matter with the Chief of Naval Operations (CNO), Adm. David L. McDonald, who, in turn, sent a flash precedence message to CINCPAC ordering the support. CINCPAC signaled back to SAFSP, "We don't know whom you know, but how many battleships do you want and where do you want them delivered?"⁴⁸

GAMBIT-3 Becomes Operational

On 29 July 1966 at 11:30 PDT, the first GAMBIT-3 roared off the launch pad at Vandenberg. (The initial launch had been projected nearly three years earlier for 1 July 1966.) Two hours

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later, Sunnyvale reported, "All systems appear normal." The first GAMBIT-3 performed exceptionally well. The satellite achieved a near-nominal orbit. Its mission lasted five days during which it acquired a total [REDACTED] targets of which [REDACTED] were successfully "read out."⁴⁹

The overall quality of the imagery from the first GAMBIT-3 mission was [REDACTED] better than that obtained from any GAMBIT-1 mission (a [REDACTED] best resolution as opposed to a GAMBIT-1 best of [REDACTED]).⁵⁰ Although the primary optics fell short of the design goal of [REDACTED], the intelligence provided by this mission was the highest of any reconnaissance satellite to date.

The fate of GAMBIT-1 was now sealed, although DNRO Alexander Flax was extremely reluctant to cancel any planned GAMBIT-1 launches until GAMBIT-3 actually demonstrated a consistent level of capability. Director of Central Intelligence Richard Helms, however, felt strongly that the success of GAMBIT-3 warranted cutting back GAMBIT-1 launches. The United States Intelligence Board's (USIB) Committee on Overhead Reconnaissance (COMOR)

⁴⁹The dominant cause for differences between targets programmed and targets readout in the entire GAMBIT-3 program was cloud cover. The introduction of weather satellites helped, but the problem persisted as long as cloud cover data was delayed.

⁵⁰The best GAMBIT-1 would ever achieve would be [REDACTED].

proposed, after listening to the arguments, that nine GAMBIT-1's and eight GAMBIT-3's be approved for the FY 1967 flight schedule. Contemporary launch schedules called for the launch of GAMBIT-1's at the rate of one per month. The decision to proceed with a mix of GAMBIT-1 and GAMBIT-3 was based on the perceived greater cost of the new system (GAMBIT-3), and the concern that success in all of the scheduled missions would cause the exploitation and analytical elements to be inundated with high resolution imagery. The concern was real.

During the 11-month period, July 1966 to June 1967, the very success of GAMBIT-3 created a new problem for US officials by returning huge quantities of surveillance-quality photography. The sheer volume overwhelmed US photointerpreters. The United States now had three successful satellite systems routinely returning large quantities of imagery: CORONA, GAMBIT-1, and GAMBIT-3. The Satellite Operation Center (SOC) in the Pentagon was also feeling deluged. It was barely able to cope with GAMBIT and CORONA. GAMBIT-3 made it possible, for the first time, to identify and count [REDACTED]

[REDACTED] US officials could, and did, for example, observe the rate the new [REDACTED]

Soviet-Chinese border.⁵¹

Despite the success, DNRO Flax was less than euphoric. Best resolution of [REDACTED] fell well short of the planned resolution of [REDACTED]. He, nevertheless, cancelled the final five GAMBIT-1 missions on 30 June 1967. GAMBIT-3 was to be the main surveillance satellite system. Unlike Flax, DCI Helms characterized the take from GAMBIT-3 in November 1967 as providing "extremely important intelligence."⁵² He saw it as a striking success. Flax's more cautious optimism proved prophetic.

By late 1967 the inadequacy of the GAMBIT camera system remained an unsolved problem. Despite the fact that it was better than that of GAMBIT-1, it did not obtain the [REDACTED] resolution originally specified. Some at NRO believed GAMBIT-3 would never achieve the [REDACTED] resolution for which it had been designed, much less the long coveted [REDACTED] resolution desired by photointerpreters. Improvements were on the way, however, as Kodak continued its work on improving the mirror

⁵¹See *. In September 1966 Col. King transferred to command the Air Force Satellite Control Facility. He was later promoted to the rank of brigadier general. He was replaced as director of the GAMBIT System Program Office by Col. [REDACTED]

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substitute materials and the high-speed emulsion on its ultra-thin base film. Kodak introduced its new film on the 14th GAMBIT-3 flight on 5 June 1968. By the 27th flight it exceeded all expectation.⁵³

A Chance Encounter

GAMBIT program officials strongly believed that neither the Soviets, nor any one else, knew the capability of the GAMBIT program. In 1969, however, officials held their breath as a Soviet satellite, Cosmos 264, began to make orbital adjustments, which, US engineers calculated, would bring it within 70 miles of GAMBIT-3. Eventually the two satellites passed within 15 miles of each other as NRO controllers held their breath, wondering if Cosmos was a "killer satellite."

The Block II Program

One of the major innovations in the GAMBIT-3 program was the introduction of a second recovery vehicle. It eventually became known as the Block II program. Growing national interest during the period of GAMBIT-3 development in creating a satellite capability of quick reaction to world-wide crisis situations

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drove concepts for improving GAMBIT-3. As early as January 1965, DNRO McMillan informed Secretary of Defense, Robert McNamara, of studies underway for providing GAMBIT-3 with such a capability. The CORONA program had demonstrated the feasibility and utility of using two recovery buckets. The premise behind the change was that a long-life, multiple capsule, film return system, could provide urgently required images that would be taken and returned to earth for evaluation, while at the same time continuing the satellite's routine surveillance duties.⁵⁴

Fortunately, owing mostly to McMillan's foresight, the Titan booster used for GAMBIT-3 had excess lift capability. The addition of a second reentry vehicle and more film capacity, while they greatly increased GAMBIT-3's weight, did not exceed the Titan lift capacity. Work began on the Block II series of GAMBIT-3 in late 1966. The double-bucket GAMBIT was ready by the fall of 1969. The first Block II vehicle (GAMBIT-3, no. 23) flew on 23 August 1969. After this first successful Block II flight, the program suffered a series of annoying problems, from poor orbits, to failed parachutes, to program malfunctions, which kept it from reaching its full potential.⁵⁵

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Despite the nagging problems, the resolution of GAMBIT-3 cameras continued to increase. It went from a previous best of [REDACTED]. Operational longevity also increased from ten days to 27 days. The [REDACTED], under development by Kodak for several years, was finally introduced in 1971. It brought an immediate [REDACTED] performance improvement in the camera system. With a focal length of [REDACTED] permitted GAMBIT resolution to surpass even the [REDACTED] previous best. Target coverage also increased from [REDACTED] to a normal [REDACTED] for the [REDACTED] version of GAMBIT.

A Fully Mature System

By August 1977 GAMBIT-3, with 48 vehicles flown, was a fully mature, successful satellite program. During the next seven years, GAMBIT-3 continued to steadily improve its performance. Time-on-orbit went to three to four months for each flight. Resolutions of [REDACTED] became normal. Target coverage also increased significantly. All 38 GAMBIT-1 missions photographed [REDACTED] targets. GAMBIT-3 mission no. 53 of 15 April 1983, alone acquired [REDACTED] targets. By the time of the last GAMBIT-3 flight in April 1984, GAMBIT-3 was still producing

the high quality imagery which maintained its preeminence in technical collection.⁵⁶

Summary

The CORONA program provided US policymakers, for the first time, a capability to monitor military and industrial developments over vast areas of the Soviet Union and other denied areas of the world. Although CORONA provided immeasurable contributions to national security, its resolution was not good enough to answer numerous critical intelligence questions regarding Soviet weapons development. Nor could it provide the image quality needed to provide true science and technology analysis. GAMBIT filled this gap. By the end of the program, GAMBIT routinely collected imagery of [REDACTED] ground resolved distance (GRD) or better.

GAMBIT imagery closely monitored [REDACTED]
[REDACTED]

GAMBIT imagery could identify [REDACTED]
[REDACTED]

[REDACTED] GAMBIT also provided insight [REDACTED]
[REDACTED]

⁵⁶The development of near-real time imagery systems made the GAMBIT-3 film return system obsolete.

[REDACTED]

This information was vital to US strategic planners. GAMBIT information was also used to provide [REDACTED] information. Its high resolution allowed US photointerpreters to perform [REDACTED]

[REDACTED] US policymakers and defense planners also were able, through GAMBIT imagery, [REDACTED]

[REDACTED]

The GAMBIT system proved to be an invaluable intelligence collection tool during the Cold War.

In August 1984 President Ronald Reagan emphasized GAMBIT's contribution to US intelligence in a message to DNRO Pete Aldridge:

When the GAMBIT Program commenced we were in the dawn of the space age. Technologies we now take for granted had to be invented, adapted, and refined to meet the Nation's highest intelligence information needs while exploiting the unknown and hostile medium of space. Through the years you and your team have systematically produced improved satellites providing major increases in both quantity and quality of space photography.

The technology of acquiring high quality pictures from space was perfected by the GAMBIT Program engineers; Through the years, intelligence gained from these photographs has been essential to myself, my predecessors, and others involved with international policy decisions. These photographs have greatly assisted our arms monitoring initiatives. They have also provided vital knowledge about Soviet and Communist Bloc

scientific and technological military developments, which is of paramount importance in determining our defense posture.

A generation of this Nation's youth has grown up unaware that, in large measure, their security was ensured by the dedicated work of your employees. National security interests prohibit me from rewarding you with public recognition which you so richly deserve. However, rest assured that your accomplishments and contributions are well known and appreciated at the highest levels of our Nation's government.

HEXAGON

Introduction

GAMBIT was primarily an NRO/Air Force program to develop a high-resolution "spotter-type" satellite. It caused few bureaucratic turf battles and became highly successful. Proposals for and the development of a second-generation search satellite to follow CORONA, however, became embroiled in major bureaucratic conflicts between the NRO and the CIA.

Despite the bureaucratic in-fighting, the development and operation of the HEXAGON photo-reconnaissance satellite system provided US policymakers and planners with a unique collection capability. HEXAGON's ability to cover thousands of square nautical miles with contiguous, cloud-free, high resolution imagery in a single operation, provided US intelligence users with vast amounts of intelligence information on the Soviet Union and other denied areas. It also collected unique mapping, charting, and geodesic data, large-scale contiguous imagery within specific geometric accuracies. Used in combination with the GAMBIT program, HEXAGON was of paramount importance in confirming or denying Soviet strategic weapons development and deployment. Its ability to detect quickly any new Soviet ICBM complex or mobile missile placement became invaluable to US

negotiators working on arms-limitation treaties and agreements.

Origins

In May 1963, DCI John A. McCone convened a Scientific Advisory Panel under the chairmanship of Edwin Purcell, Nobel laureate and professor of physics at Harvard University, "to determine the future role and posture of the United States Reconnaissance Program." The Purcell Panel recommended a CORONA improvement program rather than an entirely new satellite system:

We believe that an attempt to make a completely new (search) system which would provide equally wide coverage (as CORONA) with a modest improvement in resolution (5-feet, say, instead of 10-foot ground resolution) would not be a wise investment of resources.

Not entirely satisfied with the Purcell Panel recommendation, in the fall of 1963, McCone directed his Deputy Director of Science and Technology (DDS&T), Albert D. (Bud) Wheelon, to explore the requirements and possible configuration for a second generation search satellite to replace CORONA. One of the major questions confronting Wheelon and his staff was the degree of resolution needed to fulfill the various requirements of the Intelligence Community. Wheelon directed his newly created Systems Analysis Staff, headed by Jackson D. Maxey, to review the types and characteristics of United States

Intelligence Board (USIB) targets to determine the kinds of coverage needed. A detailed experiment, which included 25 National Photographic Intelligence Center (NPIC) photointerpreters, concluded that the majority of USIB targets could be properly identified using imagery with a resolution in the 0.6 to 1.2 meter (2 to 4 feet) range. Due to the cost of booster rockets, Wheelon concluded that an entirely new camera system with a longer focal length covering a large swath would have to be developed to meet such target requirements.

While Wheelon and Maxey continued to work on their study, CORONA's Performance Evaluation Team (PET) also looked at the problem. The PET investigation effort examined the possibility of "scaling up" the CORONA camera from the existing 610 mm (24-inch) lens to a one meter (40-inch) lens while maintaining the same "acuity." According to the PET report, "scaling up" could improve CORONA resolution without having to design an entirely new camera and satellite.⁵⁷

⁵⁷One way of obtaining greater resolution is to use a longer focal-length lens. The other is to improve "acuity" of the existing system by enlarging and enhancing the imagery. In the beginning of the CORONA program there were finite limitations on the size of the lens because of the weight restraints of the booster vehicle. The optimum focal length was a 610 mm refracting lens. Throughout the 14-year CORONA program, the focal length of the system never changed -- it was 610 mm for the KH-1, KH-2, KH-3, KH-4, KH-4A, and KH-4B cameras. Any increase in the focal

DNRO Brockway McMillan and his NRO staff strongly supported the Purcell Panel and PET recommendations. This sparked a growing debate between the NRO and the CIA over the development of a follow-on system to CORONA.⁵⁸

Critical of the NRO position, McCone asked for a meeting with Deputy Defense Secretary, Rosewell L. Gilpatric, to discuss the issue. On 22 October 1963, McCone and Gilpatric agreed to form a separate CIA-NRO/Air Force sponsored research group of the nation's leading optical experts to explore the issue of improving satellite photography. Chaired by Sidney Drell of Stanford University, the group met on 13 November 1963 to study image quality. The Drell group findings basically supported the CIA contention that the United States needed a new system which

length would have required a spacecraft with a larger diameter and greater payload capacity. It would have meant abandoning the heavy refracting-type lenses and developing reflecting-type systems that used mirrors and smaller lens cells. Given the limitations of the launch vehicles, the CORONA team concentrated on improving the acuity of the 610 mm system.

⁵⁸McMillan was at odds with McCone and Wheelon over a host of NRO/CIA issues. He wrote to Secretary of Defense, Robert McNamara, on 12 December 1963, that "the final price of peace with the CIA 'considering the temperament of its leaders' was at least to give the CIA *carte blanche* for development of a new search system." McMillan believed that unless something like this was done, or the CIA management changed, there would be continued obstruction to the NRO and its activity. See *.

would provide CORONA-type coverage with consistent GAMBIT-type resolution. At the same time, in order to augment these studies, Wheelon asked for additional reports from Itek and Space Technology Laboratories (STL) of the Thompson-Ramo-Wooldridge (TRW) Corporation. All seemed in agreement. A new system was needed to meet the growing requirements of the Intelligence Community for high quality imagery and expanded coverage.

Project FULCRUM

Following up these studies, in May 1964, Wheelon directed Itek and STL to prepare a joint proposal for a satellite system that could replace both CORONA and GAMBIT. The Itek-STL proposal recommended a 2,495 kg (5,500 pounds) payload containing two, counter-rotating Itek cameras in an STL three-axis stabilized spacecraft with a simple recovery system. A modified Titan II booster with no second stage, would place it directly in orbit. The camera was to be a dual Maksutov reflective system with f/3.0 lenses having a 1.5 meter (60-inch) focal length employing a corrective lens, beryllium mirror, and eggerate quartz main plate. The cameras would provide a nadir resolution from 0.8 to 1.2 meters (2.7 to 4 feet) at an altitude of 185 km (100 miles). In his memorandum recommending NRO/CIA funding for Project

FULCRUM, Wheelon suggested the program could be developed within 24 months. He also stressed the cost savings. According to Wheelon, by replacing the CORONA and GAMBIT programs, the government could save [REDACTED] by the end of FY 1969.⁵⁹

McMillan was furious. Wheelon and the CIA were contracting for satellite systems and subsystems studies without even informing the NRO, which theoretically had responsibility for all reconnaissance satellite development. Deputy Director Research and Engineering (DDR&E), Eugene Fubini, sympathetic to McMillan's position, questioned the entire FULCRUM proposal. Fubini reported that the recent CORONA missions seemed to confirm the Purcell Panel recommendations that substantial improvement in the CORONA camera results could be obtained. Over the strong objections of McMillan and Fubini, DCI McCone asked Gilpatric to direct the DNRO to establish FULCRUM as an NRO development project and assign responsibility for research, development, and operation to the CIA.

Looking for further support, McCone also asked Polaroid's Edwin H. (Din) Land to convene a panel of experts to consider the

⁵⁹Wheelon estimated that a single FULCRUM launch could return as much film as the CORONA and GAMBIT programs and cost less.

technical feasibility of the FULCRUM proposal. The group met on 26 June 1964 and issued its recommendations the same day. Land called the proposed system "extremely attractive," and "praised the ingenuity of the idea." The Land Panel also noted several problem areas but added that the system looked good enough to fund study efforts.

Armed with the Land Panel recommendation, Wheelon, on 2 July 1964, formally presented a plan to McMillan for initiating FULCRUM. After conferring with McMillan, on 8 July, Deputy Secretary of Defense, Cyrus Vance, cautiously suggested that the DNRO complete comparative studies and explore all possible alternatives before committing to the new system. He, nevertheless, authorized the CIA to pursue "design tests necessary to establish the feasibility of the proposed FULCRUM camera concept."

McCone's and Wheelon's plan went far beyond design studies. They wanted to build a strong CIA space system development and management capability. Wheelon and McCone received the backing of the USIB on 27 July 1964. The Board approved the recommendation of its Committee on Overhead Reconnaissance (COMOR) that there was an urgent need for a search and surveillance system capable of CORONA coverage and GAMBIT

resolution. This echoed Wheelon's justification for FULCRUM.⁶⁰ In August 1964, Wheelon created a Special Projects Group (SPG) within DS&T to handle all CIA satellite reconnaissance programs. He named Jackson D. Maxey FULCRUM Project Manager. (Maxey was one of several senior engineers Wheelon hired from industry.) He also brought in Leslie Dirks as project engineer. In addition, Wheelon proposed to McCone that the CIA sponsor two competitive design efforts for the film-handling system for the FULCRUM camera. At the same time, Wheelon initiated spacecraft and recovery vehicle competitions. Itek won the camera competition. General Electric (GE) became the spacecraft contractor and Avco the reentry vehicle designer. These CIA efforts touched off a bureaucratic donnybrook with the NRO and DoD that threatened the very fabric of the US National Reconnaissance Program (NRP).⁶¹

McMillan and the NRO believed Wheelon and the CIA had exceeded their authority and gone far beyond preliminary design concepts. McMillan took sharp exception to CIA's development of a spacecraft and a satellite recovery vehicle (SRV). Such development, McMillan believed, was contrary to the Third NRP Agreement that gave the NRO specific responsibility for the

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⁶¹See*.

spacecraft and SRV. McMillan protested that the CIA should limit its activity to developing the sensors carried by the satellites. McMillan requested a suspension of further CIA efforts until the situation could be considered by the ExCom.⁶²

Meanwhile, CIA officials learned that DNRO McMillan had authorized Secretary of the Air Force/Special Projects Office (SAFSP) to begin preliminary designs for a photographic payload that would include an optimal search and broad-coverage satellite system. McMillan authorized this SAFSP study in early 1964, even before the CIA's FULCRUM project. These efforts became known as S-2. Eastman Kodak and Itek completed S-2 preliminary designs by September 1964. Even after the formal approval of the CIA's FULCRUM project, McMillan approved further camera studies at Fairchild Camera and initiated studies for a new orbiting vehicle at both Lockheed and General Electric in support of S-2.⁶³

Relations between the NRO and the CIA continued to deteriorate. Even before Deputy Secretary Vance established a steering group to evaluate the most promising search and/or

⁶²The ExCom was made up the DCI, John McCone, the Secretary of Defense Robert McNamara, and the President's Scientific Advisor, See *.

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surveillance satellite and the CIA agreed to participate, cooperation between the CIA and the NRO became virtually nonexistent. When McMillan asked Wheelon to furnish a FULCRUM briefing to the steering group for "the new NRO Search /Surveillance Satellite system," Wheelon refused. He replied that "he would have to await instructions from 'his boss' before agreeing to brief the steering group as requested." Wheelon added that, "his organization was not persuaded that the steering group was a proper or good idea." "Given this attitude, the steering group accomplished little.

In this fight, McMillan and his NRO staff stood virtually alone in attempting to defend the authorities of the NRO. Secretary of Defense McNamara and most of the Defense Department were preoccupied with Vietnam. The regular, or White Air Force, totally ignored space activities. The Air Force Space Systems and Air Staff were still smarting from being excluded from most satellite developments. Even SAFSP took a limited interest. Located in Los Angeles, California, SAFSP officers concerned themselves solely with operations. They saw their role as strictly "birding" (launching and operating satellites). Future systems were not their concern. Nor was politics. They saw

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politics as strictly a function of their "Washington branch."

Moreover, coming from Bell Laboratories, McMillan had few inside connections either in Congress, the White House, or the Department of State.⁶⁵

To get around the DoD's steering group, McCone turned to Din Land and his panel of experts to evaluate FULCRUM.⁶⁶ Convening at Itek headquarters in Boston on 23 February 1965, the panel heard presentations on FULCRUM as well as the other search system studies funded by the NRO (S-2) by Eastman Kodak, Itek, and Fairchild Camera. Itek officials startled CIA officials when they announced to Land that Itek was withdrawing its support from the FULCRUM program because of disagreements with CIA over the systems specifications.⁶⁷

McCone and Wheelon had hoped and expected that the Land Panel findings would be the basis for early approval of FULCRUM

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⁶⁶ "The Panel consisted of Land, chairman, Dr. Sidney Drell, Dr. Donald Ling, Dr. James Baker, Dr. Allen Puckett, Dr. Edwin Purcell, and Dr. Joseph Shea.

⁶⁷ "CIA and Itek squabbled over the angle through which the camera system would scan. The CIA demanded a 120-degree scan. Itek officials felt this angle was too large and would seriously prejudice the FULCRUM design. See *.

by the ExCom.⁶⁸ In order to preserve FULCRUM sensor work and the momentum of the project, Wheelon quickly arranged to transfer Itek's government-funded Itek-design plans for the FULCRUM camera system to Perkin-Elmer of Norwalk, Connecticut. Perkin-Elmer had been working on a smaller back-up design for the CIA since June 1964.⁶⁹

The steadily growing hostility between the NRO and the CIA and the constant battles between Wheelon and McMillan brought the program to a near standstill. On 13 July 1965, in a report to Vance and new DCI Vice Admiral William F. Raborn, Jr., McMillan indicated he intended to select the S-2 system for a new search satellite. Upon the advice of Wheelon, Raborn countered by asking Vance to delay any decision pending the Land Panel's report. On 26 July 1965, the Land Panel finally issued its recommendation. It satisfied no one. The Panel recommended that all three camera system studies (the CIA effort at Perkin-Elmer and the NRO S-2 programs at Itek and Kodak) be funded for an

⁶⁸In fact, the Land Panel had made no recommendation on the new camera system by the time McCone resigned as DCI in April 1965. President Lyndon Johnson replaced McCone with Vice Admiral William F. Raborn, Jr.

additional three months.⁷⁰

At this point work on FULCRUM virtually came to a standstill as DCI Raborn and Deputy Secretary of Defense Vance worked out a new NRP Agreement -- the fourth. Signed on 13 August 1965, the new agreement gave the CIA responsibility for developing the optical sensor subsystem of the advanced general-search satellite (FULCRUM) and the engineering development of the spacecraft, reentry vehicles, and booster to the NRO and the Air Force. Both sides hoped this carefully crafted agreement would provide the in-coming DNRO, Alexander Flax, with the authorities and leverage to resolve the bitter, divisive debate between the NRO and the CIA over roles and responsibilities for the new satellite system. It did not.

McMillan departed the NRO on 30 September 1965, disappointed that the new agreement was less explicit in stating the authorities of the DNRO than the old agreement had been. The new agreement did not please many in the CIA either. Maxey, who headed the FULCRUM effort and was chief of the Special Projects Staff (SPS), resigned because he felt strongly that the new NRP

pact was too restrictive on the CIA.⁷¹

HEXAGON Development

Flax moved quickly to get the new system on track and mend relations with the CIA. DDCI Richard Helms also moved to develop a more cooperative relationship between the Agency and DoD. He wrote to Flax that the CIA was consolidating all CIA elements supporting the NRO into an organization headed by Huntington Sheldon, the Director of CIA Reconnaissance, and that all CIA satellite activities would be placed in a new Office of Special Projects (OSP) under John Crowley. Aiding the situation was the fact that Crowley, the new chief, and Flax got along well. Flax, in turn, established a Technical Task Group and a Project Management Task Group to study the various forms of program development and program partnership. Nevertheless, the bickering continued.⁷²

Faced with a lack of consensus on the "right" way to do the project, Flax devised his own plan for the management and

⁷¹Wheelon recruited [REDACTED] as the new FULCRUM program chief and John J. Crowley as Chief SPS. Crowley was, at the time, heading the CORONA project.

⁷²See *.

technical development of FULCRUM. On 22 April 1966, Flax submitted his plan to the ExCom for consideration and approval. Now called the HELIX program, Flax recommended a management approach that would make the CIA OSP responsible for the entire sensor subsystem and SAFSP responsible for the remaining system elements. He proposed making the Director, SAFSP, the project director for the entire system, stating that SAFSP was "the only NRP component possessing the personnel, facilities, operational resources, experience, and technical competence to be designated Special Project Director (SPD) for the new general search and surveillance satellite system." CIA officials countered that the CIA's in-house technical personnel and its relationship with the contractors built up over the years, gave it the capability of program management commensurate with that of SAFSP.⁷³

Despite continuing CIA protests, the ExCom, meeting in executive session on 26 April 1966, approved Flax's HELIX/HEXAGON program proposal as submitted.⁷⁴ Finally, more than two years after the original FULCRUM planning, the ExCom gave formal

⁷³See *.

⁷⁴The ExCom consisted of DCI Raborn, Deputy Secretary of Defense Vance and Presidential Scientific Advisor, Dr. Donald Horning.

authority for developing a new search and surveillance satellite system -- HEXAGON. Flax's compromises did not resolve all issues between the CIA and the NRO but they did reduce the "turf battles" and allowed development of HEXAGON to proceed.

The Sensor Subsystem

The CIA awarded Perkin-Elmer the contract for the design, development, and fabrication of the camera system for HEXAGON in October 1966, in a cost-plus-fixed-fee contract. Funding for the period 10 October 1966 through 30 June 1967 was [REDACTED]. Realizing that the HEXAGON contract was the largest single program ever undertaken by Perkin-Elmer, OSP chief, Crowley, traveled to Perkin-Elmer headquarters to urge the company's executives to use a new System Engineering/Technical Support (SETS) System developed by the TRW Corporation.⁷⁵ Despite Crowley's concern and special effort to warn Perkin-Elmer of the immense size of the HEXAGON project, by the end of 1966, work at Perkin-Elmer was already several weeks behind schedule. Just manning the program was a major problem. Perkin-Elmer's original

⁷⁵Total Perkin-Elmer employment in the Norwalk, Connecticut, area was 2,800 (1,350 of these in the Optical Group, of which 150 were involved with HEXAGON).

proposal called for growth from 150 to 600 people within four months and to 700 by the eighth month. This rate proved impossible to achieve, especially given the long delays in security and clearance approvals. Perkin-Elmer's lack of extensive electronic-design experience and shortage of electronic engineers also created serious problems. In addition, the general Perkin-Elmer management structure was simply inadequate for the magnitude of the HEXAGON program. In January 1967, Crowley decided the situation required drastic action. He invited the key Perkin-Elmer managers, including company president, Chester W. Nimitz, Jr. (Rear Adm. USN ret.) to CIA headquarters for a management planning session. Crowley told the Perkin-Elmer officials that he was "deeply distressed and vitally concerned" about the lack of progress and even more concerned about Perkin-Elmer's attitude toward deficiencies that had surfaced in both management and technology. Crowley's frank talk resulted in a management overhaul at Perkin-Elmer.⁷⁶

The HEXAGON sensor subsystem developed by Perkin-Elmer consisted of a two camera assembly, the film supply, and four take-ups. Located in the HEXAGON satellite mid-section, the camera assembly contained a pair of panoramic cameras mounted in

a frame. One camera looked forward on the satellite vehicle (camera A, port side) and the other looked aft (camera B, starboard side). Each camera had a 60-inch focal length, f/ 3.0 folded Wright optical system. This optical system, which contained both reflection and refracting optical elements, was mounted in an optical bar.

Perkin-Elmer's optical bar involved two, one-meter diameter tubes, each containing a 75-cm (30-inch) optically flat mirror, mounted at a 45-degree angle to reflect the ground images passing beneath the satellite and through a corrector plate, into a 91 cm (36-inch) concave main mirror at one end of the tube. Images collected in the main mirror were then focused through a hole in the flat mirror and into a compound lens, located behind the flat mirror. The compound lens then projected the images onto the film platen at the opposite end of the optical tube. As the satellite moved through space, each optical bar tube rotated about its longitudinal axis, in opposite directions. This provided a panoramic image, up to 120 inches wide. Each optical-bar was longer than the payload part of CORONA. Just to test the tubes, Perkin-Elmer built an entirely new facility at Danbury, Connecticut.⁷⁷

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Early on, Perkin Elmer had difficulties with the 91-cm main mirror. Initially, the West German firm supplied the mirror blanks, which were quartz optical surfaces fused to ceramic cores. The first blanks exhibited faults in the bonding of the face plates to the cores. These first, fused quartz, blanks were also very heavy and brittle for use in space. CIA and Perkin-Elmer engineers searched for a different material that was lighter weight, with a lower coefficient of expansion.

Beryllium, a relatively rare and lightweight metal, met all their requirements. It was one third as heavy as aluminum, had a very low coefficient of linear expansion, resisted oxidation, and was capable of being polished to a very high degree of reflectance. Its reflectivity extended beyond the visible spectrum into the infrared area, where many other mirrors failed. Unfortunately, beryllium was toxic. Inhalation of beryllium salts caused a reaction similar to chlorine poisoning.⁷⁸

Despite the hazards, Perkin-Elmer undertook a program to develop a beryllium folding mirror for the twin-60 cameras. It soon abandoned the project as too expensive and dangerous. Eventually, Perkin-Elmer decided to use a heavier but less expensive and less dangerous product produced by the [REDACTED]

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[REDACTED] known as [REDACTED]

glass has several advantages as well. It was of lightweight, almost 100 pounds less per mirror blank than fused quartz, and it had a much lower coefficient of expansion. Its cost, however, was 20 percent greater than the German blanks. HEXAGON managers reverted to the West German product.⁷⁹

The Mapping Camera Module

In order for imagery to be useful for measurement purposes (measuring distance and determining the size of objects on the ground), satellite altitude and position information needed to be recorded at the exact moment a picture was taken. In the CORONA system, this was accomplished by using a stellar-index camera, a separate unit which took pictures of both the star fields and the ground, thus allowing analysts to determine vehicle altitude and position accurately. This made it possible to prepare maps from CORONA imagery. The Defense Mapping Agency also desired a map making capability from HEXAGON imagery. In July 1968 Itek became the prime contractor for the stellar-terrain camera and GE for the RV. This was nearly 20 months after Perkin-Elmer won the contract for the main HEXAGON cameras. First launch date was

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projected for April 1970.

Itek Corporation had far less trouble with the mapping camera module than Perkin-Elmer had with the main camera. Itek developed and built a mapping camera module that contained a stellar-terrain camera with a 12-inch f/6.0 metric lens with eight elements. It used 9.5 inch film. The stellar camera, which imaged stars above sixth magnitude had two 10-inch f/ 20 systems -- one looking out each side of the module. It used 70-mm film. The GE RV was simply an improved version of the vehicle originally developed for the CORONA program, modified to accommodate the 9.5 inch and 70 mm film take-ups.⁸⁰

The Satellite Vehicle

It was not until 20 July 1967 that DNRO Flax finally approved a contractor, Lockheed, for the spacecraft. Under the leadership of program manager, Stanley I. Weiss, the general vehicle configuration for HEXAGON soon began to emerge. HEXAGON would be a satellite vehicle 10 feet in diameter and with an overall length of nearly 47 feet. One section would be devoted to the satellite control unit (the brains of HEXAGON), one to the

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sensor subsystem (the cameras), and a recovery section of four RV's. To grasp the sheer size of HEXAGON, the spacecraft weighed five times more than the CORONA payload - - 22,500 pounds compared to 4,280 pounds. It was designed to be well within the lift capabilities of the Titan III-D booster.

The spacecraft design and development experienced few major problems. In early 1971, however, Lockheed itself became involved in a serious financial imbroglio which nearly brought about the collapse of the company. Rolls-Royce Motors Ltd. of Great Britain was under contract to provide the jet engines for Lockheed's new wide-body TriStar airliner. ^{Rolls}Roll's financial collapse threatened Lockheed's promised delivery of its TriStar's to several airlines. This in turn created a cash-flow problem for Lockheed (Lockheed was already claiming heavy losses connected with its Air Force C-5A Galaxy aircraft).

In order not to delay the highly classified work then being performed by Lockheed for CORONA and HEXAGON, the firm spun off its missiles and space division. It became Lockheed Missiles and Space Company, a wholly owned subsidiary. It was, however, now protected if Lockheed found it necessary to declare bankruptcy. Eventually, the US Government provided a \$210 million loan to help Lockheed avoid bankruptcy. It, nevertheless, was a close

call for some of the United States' most closely held programs.⁸¹

Although progress on the various HEXAGON components continued, mounting cost overruns and delays brought slippage to the projected launch schedule. By late 1967, Flax and the entire Intelligence Community began to fear that further slips in the HEXAGON launch schedule might result in a period during which there would be no photo coverage of the Soviet Union.⁸²

Bickering between NRO officials and the CIA continued as well as CIA and SAFSP fought over the development of on-orbit operational control software for the system. CIA officials wanted to control the satellite from the Satellite Operations Center (SOC) in Washington, sending specific commands to the STC in California for re-transmission to the satellite. This was the system used for the CORONA program. SAFSP maintained that the complexity of the new system required that all control of the satellite be done by the Satellite Control Center (SCC) at Sunnyvale, California. In a compromise, Flax finally decided that the SOC in Washington would send a list of requirements with

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⁸²The number of CORONA vehicles was now severely limited. There were only 11 left in the barn. They could only be stretched out so far.

their priorities to the SCC where the actual target selection for a particular revolution would be made, given weather conditions and vehicle health. Although the CIA was not entirely happy with the decision, it was, nevertheless, a semi-victory for the Agency since the CIA now controlled the requirements which drove the system.⁸³

Attempts to Cancel HEXAGON

From the origins of the HEXAGON (FULCRUM) program, critics maintained that system requirements could be satisfied less expensively by improving CORONA or by using some other less sophisticated system. When the cost of HEXAGON at Perkin-Elmer alone rose dramatically in February 1968 and other contractors began showing similar cost increases, the critics intensified their efforts. In 1968, new Deputy Secretary of Defense Paul Nitze questioned the need for HEXAGON. Echoing Nitze's concerns and confronted with escalating Vietnam costs, the Bureau of the Budget (BoB) recommended that HEXAGON be cancelled in early 1968. HEXAGON was the single most expensive item in the 1968-1970 National Reconnaissance Program (NRP). As an alternative to HEXAGON, the DNRO, Flax, asked the CIA for cost estimates for

⁸³See *.

developing an Improved CORONA system. The CIA reported that an improved CORONA, without a complete redesign, (with costs estimated to be equal to those of completing HEXAGON) could never provide the search resolutions needed for verification of arms limitation agreements (resolutions of 3.0 feet or better). After reviewing the CIA estimates, [REDACTED] for 20 Improved CORONA satellites, an NRO study group recommended to the ExCom that HEXAGON be continued. The ExCom agreed and nothing came of the Bureau of the Budget's recommendation.⁸⁴

The Presidential election in November 1968 and the inauguration of Richard M. Nixon as President in January 1969 brought a series of personnel changes and another look at the HEXAGON program. Melvin Laird became Secretary of Defense and John L. McLucas, a former DDR&E and head of the MITRE Corporation, replaced Flax as DNRO. In the spring of 1969, the Bureau of the Budget renewed its recommendation to cancel

⁸⁴See *. The CIA reported that even an Improved CORONA could never provide search resolutions much better than 4.5 feet. The Budget Bureau questioned whether a 1.5 foot difference in resolution could possibly be worth the major cost it estimated it would take to complete the HEXAGON program. The decision was already made, however.

HEXAGON.⁸⁵



As Perkin-Elmer began to lay off employees in response to the Bureau of the Budget recommendation, DCI Richard Helms mounted a major effort to have HEXAGON reinstated. He called upon Roland Inlow, who had been deeply involved in planning for the Strategic Arms Limitation Talks (SALT) to study the impact of the loss of HEXAGON on arms limitations negotiations. Inlow found that all SALT proposals being made by US officials were predicated on the availability of large-scale search photography

⁸⁵The Bureau of the Budget was simply dismayed at the size of the satellite programs underway in the CIA, Air Force, and NRO.

from HEXAGON satellites.⁸⁶ Helms urged Inlow to brief James R. Schlesinger, the Bureau of the Budget's Director for International Relations, on his findings. Inlow did. Helms and Inlow also invited Schlesinger, Vice President Spiro Agnew, and DNRO McLucas for a briefing at NPIC on the HEXAGON [REDACTED] projects. After hearing the briefing, Schlesinger and Agnew recommended to President Nixon that the HEXAGON program be reinstated. On 15 June 1969, the BoB reversed its decision, [REDACTED] and reinstituted Project HEXAGON. Full-scale work resumed on the camera system at Perkin-Elmer but the cost continued to escalate.

One More Challenge for Perkin-Elmer

One of the most difficult engineering problems confronting Perkin-Elmer and CIA engineers was the challenge of moving film at very high velocities over many rollers and around sharp bends to deliver it to the focal-plane platen and then transfer it to the take-up reels in the film buckets. The high speeds and shiny surfaces created many problems, including the familiar Van de Graaff effect which had plagued CORONA. Another problem was the

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heat generated by the friction of the film as it rubbed over rubber rollers or on shiny metallic bearing surfaces. In prototype models, the film heated up, became gummy, and stuck to these surfaces

Perkin-Elmer engineers, headed by Rod Scott, attacked the film transport problem by adapting a unique air-bag (a gas-cushioned bearing surface) approach Scott had designed for the OXCART (SR-71) cameras. This method permitted moving the film through the spacecraft without it touching either rubber or metal until it reached the focal-plane platen, and then not again until it reached the take-up reel. The 168 mm film, traveling at 6.6 meters (21.6 feet) per second, left the supply spool, entered the film channel, traveled nearly four meters to the focal-plane platen, stopped to accept images from the optical-bar lenses, and moved along another 6 meters to the take-up reel. In between the film-supply reel and the platen and between the platen and the take-up reel, the film was allowed to go slack in a buffer chamber known as a "looper" so that the torque of starting and stopping would not stretch or tear it.⁸⁷

Launch

Despite the set backs, all appeared ready for a first launch on 15 June 1971. One final glitch appeared when Lockheed attempted to move the flight vehicle from Sunnyvale to Vandenberg Air Force Base for launch preparation. The State of California restricted use of the vehicle transporter (a mammoth vehicle some 14 feet high, 14 feet wide, and 70 feet long) to daylight, weekday, and non-rush hours. It was 28 May, the start of the Memorial Day weekend. The satellite could not be moved to Vandenberg until after the holiday.

The HEXAGON spacecraft itself was as big as a locomotive and 16.7 meters (55 feet) long, almost as large as NASA's Spacelab, and weighed several metric tons. It contained two giant, rotating optical-bar tubes, each with a 91 cm mirror and a camera. There were also four satellite recovery vehicles (SRV's) for returning film to earth and a 208,000 foot film supply. At 1141 PDT 15 June 1971, the first HEXAGON, sitting atop a Titan III-D missile, roared over the launch pad. *The Lompoc, California Record* reported the launch and nicknamed the satellite "Big Bird."

On 20 June 1971, during orbital revolution 82, the first film bucket separated from the satellite and reentered the

earth's atmosphere in the Hawaiian recovery area. Recovery teams sighted the capsule and its badly damaged parachute. It hit the ocean but the recovery teams got to it before it sank. The film was immediately flown to Eastman Kodak in Rochester, New York for processing. An NPIC representative at Eastman Kodak remarked after reviewing the film, "My God, we never dreamed there would be this much, this good! We'll have to revamp our entire operation to handle the stuff."⁸⁸

The second film bucket was brought back to earth on 26 June and recovery teams successfully snatched it in midair. Both the first two buckets provided extensive coverage of Soviet missile sites and other sensitive targets. The US Intelligence Community greeted the product enthusiastically. Unfortunately, when the third RV deorbited on 10 July, its main parachute failed completely and the bucket made a high-speed impact into the Pacific Ocean. It sank in several thousand meters of water before the recovery team could reach it. A recovery team snatched the fourth film bucket without incident on 16 July.

Approximately 75 percent of the photography in the three recovered film buckets was free of clouds, a considerable improvement over earlier satellite photography. This was due to

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a revolutionary new system named the HEXAGON Targeting Program (HTP). The HTP effort was a computer-based method for determining, prior to launch, the accessibility on the intended targets for each mission as well as the likelihood of their being cloud-free. The major features of the HTP included: the use of World Aeronautical Chart (WAC) divisions known as World Aeronautical Grid (WAG) cells, which were a uniform 12 by 18 nautical miles, computer routines for forecasting cloud cover, and maintaining a WAC cell climatological history. Eventually, HTP became part of a much larger NRO effort known as TUNITY. It was used in coordination with the Air Force's advanced Defense Meteorological Satellite Program and increased the efficiency of HEXAGON cameras to 90 percent.

During its 52-day mission (31 days active phase) this first HEXAGON conducted 430 photo operations and produced an average ground resolution of 3.5 feet and a best [REDACTED] target resolution of 2.3 feet. It used 175,601 feet (1,350 pounds) of film. Of this 123,601 feet (930 pounds) was recovered. In comparison, the first successful CORONA recovery (August 1960) carried 20 pounds of film. Later CORONA flights carried 40 pounds, the two-capsule version, 80 pounds. In the GAMBIT program, GAMBIT-1 carried 45 pounds of film and

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[REDACTED]

[REDACTED] 91

The fourth HEXAGON mission, no. 1204, launched on 10 October 1972, involved an extraordinary effort by CIA and NRO officials to test color film and analyze camera focus. This exercise deployed [REDACTED] targets throughout the Southwest United States to evaluate HEXAGON camera operations with color film. A 28-man team, [REDACTED] [REDACTED] cleared sites and erected and dismantled various configurations of [REDACTED] from 11 October to 17 December. [REDACTED] [REDACTED], were carefully placed along the ground trace of the HEXAGON satellite so they were photographable as the HEXAGON passed overhead. Known as ground-truthing, CIA and NRO engineers used the photographs of these targets to analyze the focus accuracy of the HEXAGON optical system. Toward the end of the mission, the team deployed specially prepared [REDACTED] film attached on to the end of the regular HEXAGON film supply.

NRO and CIA officials considered this 68-day mission highly successful.⁹²

The fifth HEXAGON flight, mission 1205, launched on 9 March 1973, was the first to carry the separate Mapping Camera System. Both the stellar and the terrain cameras functioned well during the mission. Defense Mapping Agency analysts rated the results "outstanding." Numerous small man-made features were easily detected and often identifiable; a baseball diamond, a small aircraft on a taxiway, individual homes with driveways and automobiles. This was quite remarkable for a 12-inch focal-length lens at a 92-mile altitude. The stellar photography also provided adequate star images in both magnitude and quality.⁹³

A Change in Management

When President Nixon approved the CIA proposal for a follow-on imaging system as the next photo reconnaissance system in September 1971, Carl Duckett, DDS&T, and other CIA officials, began to look for ways to ensure that the new program was properly staffed. They asked DNRO John McLucas to consolidate all aspects of the HEXAGON program under Program A (SAFSP) so

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that Program B (CIA) could concentrate on the new revolutionary system. McLucas agreed and transferred Program B responsibilities for HEXAGON to Program A. The transfer went smoothly and on 1 July 1973, General David D. Bradburn, Director SAFSP, formally assumed all responsibility for management of the HEXAGON system, wiring the CIA "we will do our very best to continue the proud record." The CIA's Office of Special Projects was now free to focus on the next generation of imagery satellites.

The HEXAGON program continued to fly with ever-improving results after the transfer. Unfortunately, the HEXAGON program ended sadly on 18 April 1986. A catastrophic Titan 34D failure, nine seconds after lift-off, terminated the 20th and final HEXAGON mission. Nevertheless, during its 13 year-life, HEXAGON proved to be an invaluable intelligence collection tool.

Summary

Despite numerous delays and large cost over-runs, HEXAGON met 70 to 80 percent of all the US Intelligence Community's surveillance requirements. A typical HEXAGON mission imaged nearly [REDACTED] targets. Considering that the Soviet Union

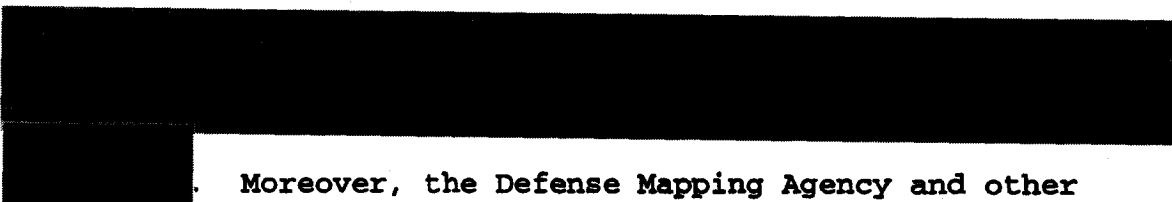
encompassed an area of almost 7 million sq. nm, the mature HEXAGON system would image about 80 percent of this area, cloud-free, on a typical mission. During its lifetime, HEXAGON played a key role in monitoring Soviet research and development, production, and deployment of strategic offensive and defensive weapons systems. It made possible the first Strategic Arms Limitation Treaty (SALT) in 1972. HEXAGON's broad area coverage capability provided US officials a high degree of confidence, that the United States could detect any new Soviet installations or activities early in the construction phase. The ability of HEXAGON to furnish high quality imagery of military installations also allowed US intelligence analysts to develop and maintain very accurate, order-of-battle information on Soviet, [REDACTED] and Chinese forces.⁹⁴ Entire Soviet military districts, for example, could, at times, be imaged on a single mission. These images provided current and accurate force-structure assessments. HEXAGON's broad area coverage provided the US analysts opportunities to monitor large-scale Soviet military exercises. In March 1979, for example, when the Soviets staged a

⁹⁴The high quality of HEXAGON imagery is often overlooked because the GAMBIT program which produced imagery of the very highest quality, overlapped HEXAGON. Nevertheless, HEXAGON was capable of meeting most Intelligence Community requirements.

major military exercise in Mongolia, in response to the Chinese attack on Vietnam, HEXAGON captured the Soviet mobilization.

HEXAGON was also tasked to provide coverage of Soviet and Chinese nuclear test sites; often providing complete coverage of these test sites often in a single image. This allowed US officials to closely monitor test preparations and assemble data on the tests themselves. HEXAGON also played a key contributing role in US economic forecasts and projections regarding the Soviet economy. During its lifetime, HEXAGON provided economic intelligence on Soviet heavy metal production, oil and natural gas exploitation, nuclear production, and conventional electrical power capacity. It also photographed Soviet grain-growing regions allowing accurate US predictions on Soviet grain production.

In addition to its coverage of the Soviet Union and China, HEXAGON produced more detailed knowledge of third world development than any system before or since. From HEXAGON, the



Moreover, the Defense Mapping Agency and other government agencies that produced maps and charts were almost solely dependent on HEXAGON for mapping source materials. Not a

NRO APPROVED FOR
RELEASE 17 September 2011

bad job for an over-sized "big bird."

Conclusion

During the heart of the Cold War, the NRO, with its CIA and Air Force components and their industry partners, designed, developed, built, and operated the GAMBIT and HEXAGON photo-reconnaissance satellite systems. The growing reality of a Soviet nuclear arsenal, the development of Soviet nuclear-tipped ICBM's, and a vigorous Soviet nuclear weapons program, combined with an increasingly complex and divisive Vietnam conflict, created a global crisis atmosphere for US policymakers during the 1960s and 1970s. A sense of extraordinary urgency swept over Washington as US officials searched for intelligence on the Soviet Union and its allies.

This crisis atmosphere drove the NRO effort to develop the next generation of search and surveillance satellites and to provide US decision makers with ever more detailed imagery. Building on the pioneer efforts and accomplishments of the CORONA program, US designers, engineers, scientists, and managers pushed photo-reconnaissance and space flight technologies to their limit in order to meet the demand for more and better photographs from space of Soviet activities. Most program officials felt the security of the United States depended upon their success.

The years of GAMBIT and HEXAGON program development were

marked by great vision, repeated disappointment and failure, and finally by extraordinary triumphs. GAMBIT, an NRO/Air Force/private industry effort strove to capture clear details of Soviet weapons activity. Under constant pressure to achieve results quickly and operating almost totally in a "black" environment, the GAMBIT program suffered from excessive compartmentation and secrecy. CORONA program development, with its successes and failures, for example, remained virtually unknown to GAMBIT officials. This resulted in duplication of effort and long delays in design and testing time. Only the introduction of CORONA technologies such as the stabilizing Agena second stage "hitchup," the state-of-the-art, Lockheed developed, roll-joint, "Lifeboat," and CORONA recovery techniques saved the early GAMBIT program from cancellation and catastrophic failure. Frustrated time and again with system problems, the GAMBIT team finally reached its goal of routinely providing US intelligence analysts with [REDACTED] resolution imagery. It was a giant step from the fuzzy, 20-30 feet resolution imagery provided by the early CORONA cameras. This imagery was even better than manned reconnaissance photography. It amazed US photointerpreters.

Overcoming technical uncertainty, GAMBIT scientists and engineers not only brought a revolution to space photography but

they made major improvements in satellite command and control systems, time on orbit, and target coverage. Its impact on US intelligence capabilities was enormous. Combined with the imagery data from CORONA and HEXAGON, GAMBIT provided the US Intelligence Community with over 90 percent of its hard data on the Soviet Union. For the first time, using GAMBIT imagery, US officials had detailed factual information and accurate mensuration data to actually develop engineering drawings on Soviet weapons capabilities. This helped US officials save billions of dollars in US weapons development alone. President Lyndon Johnson expressed his appreciation for these satellites when in early 1967 he told a meeting of American educators that these satellites "justified spending ten times what the nation had already spent on space." "Because of this reconnaissance," the President confided to the group, "I know how many missiles the enemy has." President Johnson also knew, because of GAMBIT, the approximate capabilities and state of readiness of Soviet ICBMs.

HEXAGON, like GAMBIT, was a daring technological challenge. An NRO/CIA/ industry program, HEXAGON became the ultimate film-return photo-reconnaissance satellite system. It, like GAMBIT, suffered hard times during its development stages. Not only were

there technological problems to overcome, camera and film design, reflective and refractive mirror construction, and film movement, but HEXAGON also suffered from constant bureaucratic struggles over who would control the program. The often bitter debates between the NRO and the CIA caused major delays in design and development time. This resulted in serious launch slippages and major cost overruns. Originally proposed as a cost-saving system to replace CORONA and GAMBIT, HEXAGON became the most expensive system yet build. Nevertheless, HEXAGON proved to be an extraordinary success. It had the capability of providing stereoscopic, cloud-free photography over 80 to 90 percent of the Sino-Soviet landmass on each mission. In addition, HEXAGON had the unique ability to satisfy surveillance and mapping, charting, and geodetic data requirements. HEXAGON imagery, by providing continuous direct evidence of Soviet activities, helped eliminate the surprise element for US officials and increased the Intelligence Community's and US policymakers confidence in the overall intelligence product. It provided the hard data for analysis. It also provided assurance to US leaders negotiating arms limitation agreements with the Soviets.

GAMBIT and HEXAGON proved to be of paramount importance to US policymakers. With these systems, US officials had detailed

information on Soviet strategic weapons development and deployment. Any new Soviet ICBM complex or development, such as mobile missile deployment, was quickly detected. Soviet construction of antiballistic (ABM) sites, nuclear submarines, aircraft, and naval vessels, and Soviet ballistic missile launchings were all carefully monitored by GAMBIT and HEXAGON. Conceived and built under a crisis situation, these systems stretched space technologies and ultimately performed well beyond their initial expectations. They were truly, "Critical to US Security."

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