VOLUME FOUR

PREFACE

This is the fourth volume in the history of the National Reconnaissance Program (NRP) imaging satellite systems. The first volume, completed in November 1987, related the story of CORONA, the world's first successful satellite imaging system.. CORONA flew more than 145 missions in slightly more than 11 years, from 1960 into 1972. In 1963, it was supplemented by the first of the high-resolution imaging systems, GAMBIT. The second volume of the NRP history, published in August 1988, chronicles GAMBIT, which operated until 1984. The third volume, published in 1992, describes HEXAGON, the improved search imaging system which flew 19 missions between 1971 and 1986.

This is the story of an incredibly sophisticated, complex and successful imaging program known at various times in its life as ZAMAN, KENNEN, [redacted] From its first launch in December 1976, [redacted] providing the Intelligence and Mapping Communities with high quality target and area coverage imagery.

WHY WAS ZAMAN/KENNEN/[redacted] SUCCESSFUL ?

Why was this program successful, in the face of great adversity in both technological challenges and political atmosphere? In talking to a great many knowledgeable people, both in government and in industry, one theme comes through loudly and clearly: harmony!!! Government/industry relations in NRO programs have always been both good and unique. The need for security and the widely-held belief that everyone is working for a common good has always served the NRP well. In the case of the [redacted] program, this belief was enhanced by teamwork and professionalism at nearly unbelievable levels. Every corporation whose staff was interviewed, each participating government official, every member of the Program Office: all independently averred that the people who produced this system were superbly motivated, technically adept, managed by unusually clear-thinking people and performed brilliantly. There were bumps, as will be pointed out in later chapters, but even the rough spots were often overcome in unique fashion. Throughout the many interviews, the prevalent theme was the quality of the people involved in the Program.

The government operated the program with a small staff (compared to any other government program of this or any size). Consider that all of the early technology development was done by Les Dirks and a handful of engineers. The Program Office did not exceed 40 people until the Ground Station construction got underway. Charlie Roth, once he was named as the first Program Manager, insisted on complete candor and honesty among both his people and the contractors. There was never any withholding of data between the Program Office and the responsible industry team. Roth and Dirks held their personnel to an extremely high level of performance: they didn't hesitate to replace people who failed to meet their expectations. To a person, those in the Program Office believed unfailingly in what they were doing. Bureaucracy was held to an absolute minimum and each person in the Program Office knew exactly what he or she was expected to do. Charlie had a simple credo: schedule, budget, performance and he stuck to it religiously.

The industry counterparts to the Program Office also had a sense of mission. Managers were given wide latitude by their corporate bosses to do what was necessary to do this job. In many cases, this meant ignoring company rules and policies: a move that was terminal to those who might attempt such things in other venues, but which got those in the Z/K/[redacted] program promoted and, in some cases, brought their companies fame and not a little income. Time after time, industry members of this team related how much they truly cared for the government members of this effort; the uniform competence of the Program Office: the pleasure and sense of accomplishment they got out of the blood, sweat and tears that they put into this job. The apparent truth coming from this program was that it was a combination of the right people, with the right job to do, at the correct time; with sufficient funds to do the job.

The efforts to chronicle this program turned up literally tens of people who were anxious to discuss their role, even though in many cases it was 20 years ago, and they had gone on to do other things in their respective careers.

In researching the material for this history we were particularly well-supported by the staff of the current [redacted] Program Office, the NRO Staff, [redacted] and a myriad of individuals in each of these, and other, firms and organizations. We have elsewhere in this volume chronicled those individuals who graciously agreed to be interviewed, many of whom are in retirement and who gave so willingly of their time and energy to relate their particular role in this incredible story. Unfortunately, there were a number of key people whose input we were not able to obtain before their demise.

This volume, as were the previous three, was initially envisioned by Mr. Jimmie D. Hill, Deputy Director, NRO. To Mr. Hill and everyone involved in making this undertaking possible, our most sincere appreciation for the opportunity to be able to chronicle this great story.

THE HEROES

In assessing the success of the ZAMAN/KENNEN/[redacted] program, four individuals names rise above the thousands of talented, dedicated people who made this program possible: Edwin Land, Carl Duckett, Leslie Dirks, and Charles Roth. Land for his vision and insistence in high places that EOI was the technology of choice; Duckett for his persistence and salesmanship in convincing high-level decision makers that ZAMAN should be built; Dirks for his intellectual and technical brilliance in developing the technology necessary for an EOI system and seeing it through to launch, and Roth for his unparalleled competence as the Program Manager. Those four, if given the opportunity, would certainly demur , avowing that others were more deserving than they; few can argue with their being selected for this honor.

This volume should be dedicated to these four men. It is, however, with great pride and humility that the authors dedicate this work to the un-named hundreds and thousands of people, in government and private industry, who can forever be proud of having produced an incredible addition to our nations' security, the [redacted] Imaging System.

CHAPTER ONE

THE FORERUNNERS OF NEAR-REAL-TIME (PAST IS PROLOGUE)

In the world of the 1950s, the early roots of the US space program were formed. The Cold War was in full swing, the war in Korea was past history, the Soviet Union was our primary military and political focus and President Eisenhower was in office. We were faced with what came to be called the Bomber Gap and the Missile Gap; both occasioned by a huge lack of intelligence on what precisely was happening in the USSR. The US had embarked on a high-altitude aircraft reconnaissance program in 1956, with the first U-2 flights over denied territory. Imagery from that program, while welcome,was spotty: it, in fact, allowed analysts to dismiss the Bomber Gap and it provided some data on the fledgling Soviet missile and space program. Visionaries of the 1940s and early 50s had foretold of the use of space vehicles for reconnaissance,as technology allowed the development of such craft. A RAND study in 1951 had established the specifications for a reconnaissance satellite which would return TV-like images to an earth ground station, when such technology became available. The emphasis within the US military was on the development of weapons systems to deliver nuclear warheads to the Soviet Union. Programs to develop missiles like the TITAN, ATLAS and THOR were receiving the highest priority in funding and facilities. Although the President had authorized the beginnings of a space reconnaissance effort in early 1957, the priority was very low. The Air Force, which had primary responsibility for reconnaissance from space, was focusing its efforts on developing the ability to deliver nuclear warheads through space, especially in the form of ICBMs.

This state of affairs was to take a dramatic turn in October 1957, with the successful launch and orbit of Sputnik. Suddenly, space reconnaissance moved up the ladder to be equal to, and in some cases exceed, the urgency associated with missiles development. NSC Action Memo 1846, 22 Jan 58, directed DoD to give priority to development of a reconnaissance satellite. (1)

PIONEERS IN SPACE RECONAISSANCE - what is this supposed to caption?

(TECHNOLOGY COMES IN A RUSH)

CORONA

The initial space reconnaisance program of the U.S. Government was started in the 1955 time-frame and operated under the uninspiring codename of Weapon System 117L, or WS-117L as it was more popularly known. It was an ambitious Air Force program to build a constellation of satellites including what some might call Near-Real-Time, film-return, scientific and SIGINT variations. It was given, or popularly acquired, the name SAMOS; a name which would continue to exist in the space world until about 1964. In late 1957, President Eisenhower made a decision to split the film-return satellite part of SAMOS away from the main program. The film-return imaging satellite, which became known as CORONA, was given to CIA for technical development, procurement, cover and security. As it was a joint project, the Air Force was to provide the launch services and provide some of the cover for the project. SAMOS was to continue as an overt program; it never successfully returned a significant amount of imagery from space, and was quietly cancelled in 1964. There was a basic conviction within the SAFSP staff at that time that CORONA was, at best, only a stop-gap; readout SAMOS was the ultimate goal.(2) This was further reinforced by a comment by George Kistiakowsky, Science Advisor to the President "They" (AFBMD) believe that "readout"/SAMOS is much more promising than "recovery SAMOS". (3)

CORONA was given the "white world" name of DISCOVERER, a name which most Americans recall. There were 12 consecutive failures to launch, orbit and retrieve a film capsule from space during 1959 and 1960. Some made it to orbit, while others did not. Some were lost on orbit or during re-entry. Discoverer XIII, carrying a diagnostic payload in an attempt to gather data on why the previous ones failed, flew what is reported to be a perfect mission: launch, 17 orbits, and a recovery from the surface of the Pacific Ocean on 10 August 1960. Discoverer XIV, a week later, was launched with a photographic payload, Mission 9009; it flew a nominal one day mission, ejected its film capsule which was ocean-recovered, and the US space photo-reconnaissance program had begun. It was 19 August 1960. 9009 flew 17 orbits, 8 of them over the Sino-Soviet landmass and acquired 1.5 million square nautical miles of area, more than all of the U-2 missions combined. There had been a four month gap in coverage of the USSR since Gary Power's shootdown; either a coincidence or great good fortune.

CORONA was to enjoy an amazingly successful journey through nearly 150 missions (145 launches), terminating in 1972. Utilizing five increasingly complex and improved camera systems (KH-1, 2, 3, 4a and 4b), typical mission lives lengthened from one day at the beginning to more than 23 days at program termination. It represented an evolutionary process for a program which at its inception was considered a 'stop gap' for the more sophisticated Near-Real-Time part of the SAMOS effort. A low resolution (3-25 feet) system, it routinely acquired wide-area coverage of the Eurasian landmass as well as other parts of the world of interest to intelligence analysts and policy-makers. Imagery from CORONA disproved the missile gap and contributed to the elimination of the bomber gap, both factors in governmental debate in the mid-1960s. CORONA imagery was used to locate all of the Soviet strategic missile facilities deployed up through mid-1971, when HEXAGON began operations. For more details on the WS-117L program, we refer you to The CORONA Story, the first volume of the NRO Histories.(4)

In the years when CORONA was flying and GAMBIT and HEXAGON were being developed, two additional NRP imaging programs (ARGON and LANYARD) were conceived, built, launched, and discontinued.. Both were relatively conservative approaches to problems which were amenable to satellite imagery solutions: one intelligence and the other directed toward acquiring mapping imagery.

ARGON

Work had begun in 1959, in the CORONA Program Office, to develop a dedicated mapping satellite. The requirement had originated in the Army Map Service and was being further advocated by the Defense Intelligence Agency. Known by its Byeman codename of ARGON, its camera system was given the designator KH-5 (5). Apparently, both the Army and DIA had hoped to be able to build and operate this dedicated mapsat outside the auspices of the NRO, but such was not to be. Twelve ARGON launches were attempted, six and a partial seventh were successful in the time-frame 1961-1964. A proposed follow-on, codenamed VAULT/TOMAS, was never pursued and the program to build and operate dedicated mapping vehicles was cancelled in 1964 (6). The only other operational satellite mapping camera flown on NRO systems was a mapping sub-system operated on a number of HEXAGON vehicles,(SV

5-16) although there were stellar and terrain cameras on many of the CORONA satellites which were used for mapping purposes.

LANYARD

The LANYARD program, actually a modified CORONA spacecraft equipped with an E-5 SAMOS camera, was a crash project to get high-resolution imagery of an area near Tallinn (near Leningrad) which was suspected of being a Soviet ABM site under construction. Because of the greater weight of the LANYARD spacecraft, it used the Thrust-augmented Thor booster, rather than the Atlas of the CORONA program. The TAT, as the Thor was known, was later used to launch improved versions of CORONA. There were three launches of LANYARD, numbered 8001, 8002, and 8003, in 1963: two failed completely and the third failed after 32 hours in operation. The film was recovered, but contained no images of the Tallinn site. The program was cancelled by the DNRO after the first successful GAMBIT launch in the Fall of 1963 (7).

GAMBIT

The early GAMBIT spacecraft were built by General Electric; subsequently larger ones by Lockheed, with all cameras by Eastman Kodak.

The nation's first successful attempt to radically improve the resolution of its imagery reconnaissance satellites lay in the GAMBIT imaging vehicle, with its KH-7 camera system. ~~Built by Lockheed, with the imaging payload provided by General Electric,~~ the GAMBIT spacecraft was launched by a Titan II, a modified ICBM. Evolving through several years, the GAMBIT system received a new camera system, the KH-8, in 1966. This program was to last through 54 spacecraft and was best known for the very high-resolution imagery that it produced. By the time that the program had run its course in 1984, it was routinely providing imagery in the range of [redacted] ground resolution(best was on the order of [redacted] For more data on GAMBIT, see Volume 2 of the NRO series, The GAMBIT Story.(8)

HEXAGON

While CORONA was enjoying a very successful lifetime, most people associated with the imaging reconnaissance programs realized that increases in area covered and, more importantly, increased resolution were needed. Technology in camera systems and in improvements in launch weight capabilities had moved impressively forward toward the mid- late 1960s. The need for medium resolution coupled with increased synoptic area coverage were identified as being critical to arms control measures then under consideration. The US and the USSR were making progress in negotiations for controlling certain strategic arms. These resulted in an evolutionary imaging system known as HEXAGON. Originally proposed by CIA in 1964, as project FULCRUM, it was described as having "CORONA type coverage with GAMBIT type resolution." (9) Ground resolution improved to the order of 18 inches from the 25 feet obtained on CORONA mission 9009, and area coverage at these dramatically improved resolutions went up by several factors. Whereas the swath width of CORONA was on the order of 75 miles, HEXAGON had the capability to image 150 miles either side of the ground track. HEXAGON also eventually carried over 300,000 feet of ultra, ultra-thin base film and enjoyed one or more 300 day missions. It's KH-9 camera system was revolutionary in terms of the complexity of the camera system, the film mechanism, and the huge size of the spacecraft. Over a period of 15 years, starting in 1971, HEXAGON operated 19 spacecraft out of 19 launches. Unfortunately the twentieth vehicle in the series was lost in April, 1986, when the booster exploded a few seconds after liftoff. For more data on the HEXAGON program, you are referred to the third volume in the NRO series, THE HEXAGON STORY. (10)

PLUSES AND MINUSES

When taken in context, CORONA, HEXAGON and GAMBIT were all tremendously successful programs. They were to propell the United States into a position of unquestioned supremacy in space reconnaissance. The Soviet Union, the only country with a viable space reconnaissance capability even in the 1990s, remained consistently 10 years behind the US. Space reconnaissance provided the US Intelligence Community with irreplaceable data on denied areas of the world on a regular, predictable basis with ever-increasing levels of quality. However, they all had similar shortcomings:

Spacecraft were not continuously on orbit. Many world crises took place when no imager was on orbit. Even when there were spacecraft on orbit, their revisit time was on the order of days: not adequate to support crises.

The imagery was days to months old when received at NPIC and the other exploitation facilities.

Film buckets had to be ejected, caught over the Pacific, transported to Rochester, N.Y. for processing, and then shipped to Washington for interpretation.

Derived information was largely historical in terms of providing military, political or economic intelligence.

Until the advent of the Defense Meterological Support Program, large percentages of film return system imagery were cloud-covered.

Because of their low-earth orbits, the film-return systems required frequent orbit adjusts, to prevent them from re-entering the atmosphere before their film had been exposed and the re-entry capsules ejected. Nominal perigee over the USSR was on the order of 78-80 nautical miles (NM) for GAMBIT; 92-93NM for HEXAGON; and about 115-120NM for CORONA. Orbit adjustments, or "drag makeup", consumed significant amounts of propellant; propellant which had to be carried into space as part of the launch vehicle. In the early days, consumables were traded for film payload, often resulting in fewer days on orbit than might otherwise have been the case.

The film return systems also suffered from some degree of access limitations due to orbital constraints. The inclinations usually resulted in revisit times of 3 to 7 days. As events were beginning to show, these constraints were becoming untenable and efforts needed to be made to address them.

EVENTS DRIVE TECHNOLOGY

Events of the mid-to-late 1960s piled up convincing evidence that the film-return satellite systems were not responsive enough to contribute significantly to current intelligence needs. The Cuban Missile Crisis of 1962, the Arab-Isreali War of 1967 and the Soviet invasion of Czechoslovakia of 1968, served as good examples of the lack of contribution of these very expensive reconnaissance systems to the needs of the policy-makers. Pressures to seek ways to speed up the acquisition and reporting of imagery-derived information were building. Expensive launches, competition for pads at VAFB, the cost of designing and building satellites all contributed to these pressures.

1965 had seen the onset of another Air Force attempt at a revolutionary approach to space reconnaissance when development began on the Manned Orbiting Laboratory with its KH-10 camera. The MOL program had many facets besides the "black" photo reconnaissance mission. It was to be a military man-in-space program, based largely on the SKYLAB spacecraft. General Electric had the prime contract and Eastman Kodak was to provide the cameras. The reconnaissance mission was given the Byeman codeword DORIAN.

Check this: I think the prime for MOL was MacDAC and GE was prime for Payload.

The need to satisfy policy-makers and the resulting intelligence requirements for more timely information gave rise in the late 1960s to two parallel approaches to near-real-time (NRT) imagery: Film Readout GAMBIT (FROG) and ZAMAN, an Electro-Optical Imaging System. FROG was an evolutionary refinement of the Air Force GAMBIT program, while ZAMAN was an entirely new, revolutionary concept being developed by CIA.

CHAPTER TWO

REAL-TIME RECONNAISSANCE NEED
(More, Better, Sooner)

By the mid-1960s, it was becoming increasingly clear to everyone in the national reconnaissance effort that providing more timely imagery-derived data was mandatory. While it was true that satellite days-on-orbit were increasing and quantities and quality of imagery was forging ahead in good measure, the Intelligence Community and its principal consumer, the White House, were becoming increasingly strident in their clamor for current information.

CORONA was an extremely reliable area-search vehicle, while the relatively new GAMBIT was impressing everyone with its high-quality imagery of foreign weapons and installations. HEXAGON was well along in its development into a fine medium-resolution area-search system. It was to first fly in space in mid-1971. The major shortcoming of all of the film-return systems was the delay in getting the information from the sensing platform to the ultimate user. Absolutely first-rate imagery tended to lose its luster while encapsulated in a spacecraft high above earth. Marvelous pictures from space became pages in the historical data base of a current-intelligence analyst at Langley or Omaha.

The concept of sending imagery from a spacecraft to the ground in a short period of time was not new nor novel in the mid-1960s. In fact, a Rand study in the late 1940s had espoused such a concept. Several efforts in the 1950s and early 1960s had tried to bring this concept to fruition; all to no avail. There were good and sufficient reasons; the booster capabilities of the then fledgling ICBM programs had serious weight limitations, stabilized spacecraft were only just becoming a reality, the resolution of rudimentary TV cameras were not sufficient for intelligence purposes, the technical problems of transmitting large quantities of data from spacecraft to ground receiving stations were seemingly insurmountable, and converting the data to useable film for viewing had probably not been addressed.

EARLY ATTEMPTS AT NEAR REAL TIME
(Technology Whose Time Had Not Arrived)

In 1951, RAND, continuing its studies in overhead photo reconnaissance, defined the technical characteristics of a reconnaissance satellite which would relay television pictures from the spacecraft to ground receiving stations. (11) By 1955, with development work on THOR, ATLAS, and TITAN boosters underway, the idea of placing imaging payloads in space became more credible.(12) Work was initiated at Wright Field, Ohio, on a project known as WS-117L; which by 1956 had been transferred to the Air Force Western Development Division(WDD) in Los Angeles. Also being developed by WDD at the same time were the nations fledgling ICBMs and they clearly enjoyed higher priority than did a reconnaissance program.

October 1957, saw a change in emphasis on the value of space reconnaissance. With the orbiting of SPUTNIK, WS-117L was divided: the film-return satellite later known as CORONA was separated from the more grandiose and multi-faceted SAMOS/SENTRY program and was covertly given to the Central Intelligence Agency for development. (13). The portions of the WS-117L program which involved imagery were twofold: what was called "Read-out SAMOS" and "Film-return SAMOS".

CORONA was to become the nations first successful space imaging system, while SAMOS suffered repeated failures and was eventually cancelled.

Thus, Air Force efforts to design and perfect some form of real-time or near-real-time imaging from space carried on from 1956 through 1964, with little success. Concurrently, Les Dirks in the Office of Special Projects, CIA had begun a low-level effort in the early 1960s to investigate the technology necessary to build and operate a covert, near-real-time imaging system. The original emphasis was on building a covert satellite which could be placed in an undetectable orbit, to be called into use in time of crisis. Called ZOSTER, the effort was pursued for a very short period of time before those involved came to the conclusion that the covert aspects of the project were less and less feasible, but the aspects of near-real-time imaging looked like they were very feasible and , moreover, most desireable. Dirks, with engineers Frank Eliot, Emanuel (Manny) Goldstein, and Norbert Crookston, proceeded with a whole series of small [redacted] contracts with various aerospace companies to pursue technology issues related to NRT. These efforts were primarily directed at using media other than film for imaging and transmitting the images to earth. Among those media investigated were vidicon tubes (similar to those used in TV cameras), a reusable plastic medium, a tape storage camera (under development by SAFSP) that used a photo-cathode and silicon-based tape and several solid-state, light-sensitive devices. All of these came to be lumped under the rubicon of Electro-Optical Imaging (EOI).

ZOSTER was replaced by the codeword ZAMAN in 1965 and the CIA efforts at developing a near-real-time imaging system were contained under that codeword until the prime contracts for the eventual system were let; at which time (Jan 1972) the codeword was changed to KENNEN. During this five year period, contracts for various elements of the EOI technology were pursued at companies like [redacted] By 1965, the total funds for ZAMAN reached the [redacted] level. The OSP/CIA contingent devoted to managing this effort amounted to four engineers and scientists formed into the Advanced Developments Branch of the Design and Analysis Division, still under the leadership of Les Dirks.

As it became obvious that NRT was the way of the imaging future, the Air Force Office of Special Projects began to look at ways of modifying its highly-successful, high-resolution GAMBIT imaging satellite in order to transmit its pictures to earth. This effort became known as FROG, for Film Readout GAMBIT. FROG and ZAMAN were to compete for the NRT system selection until 1971, when ZAMAN was finally selected. More about that competition and selection later.

A NEW PLAYER IN NRO PROGRAMS

Two Intelligence Community reports in the later 1960s gave a considerable boost to the EOI/NRT fortunes. William Tidwell, Chairman of COMOR (the predecessor of COMIREX) headed a study in late 1966, which concluded that existing and future film-return satellites could not provide the timely data now being demanded, and recommended the development of a NRT system. This report, completed in August, 1967, was sent by the USIB to the NRO for comment in Febuary 1968. It would not receive a reply until more than a year later and, at that, received an evaluation from the NRO which was less than enthusiastic. In the meantime, Roland Inlow, CIA member of Comirex, and John Hughes of DIA were named by DCI Richard Helms to do a study on how the Intelligence Community went about establishing its imagery requirements. It examined such questions as who decides on the allocation of resources; what is a reasonable revisit time; can like intelligence problems be merged into "problem sets" for collection and exploitation; can statistical methods be used to sample targets; and what effect would daily imagery collection have on the Nations imagery analysis organizations. One conclusion of this study was to develop a computerized method of handling collection and exploitation requirements, now known to the IMINT community as CAMS, the COMIREX Automated Management System. CAMS has ultimately grown into CAMS II and , in the early to mid-1990s, will be supplanted by RMS or Requirements Management System. The Inlow Study, as this effort was popularly known, made the assumption that the ZAMAN EOI system would eventually be built to replace the existing and plannned film-return systems. Of the NRT systems under consideration, it had the greatest potential capacity. The study used three scenarios to demonstrate how a NRT system might perform in contrast to the film-return systems actually in use at the time: the Cuban Missile Crisis of 1962; the Arab-Israeli War of 1967; and the USSR invasion of Czechoslovakia of 1968.

With the results of this and other studies and under the uncertainties of the Salt Treaty negotiations then underway, the USIB, on 29 July 1969, approved a requirement for a near-real-time system. It correctly did not specify which NRT system it preferred. (14)

Ultimately, any Near-Real Time system developed and flown would have to have good resolution in order to supplant GAMBIT and have broad area coverage in order to replace HEXAGON. Neither requirement was specified in the original statements of need, but the realities of the budget environment would force both of these events. The system built would eventually prove capable of replacing its earlier kin, although not to the complete satisfaction of everyone.

Themes

- A TRADITION OF EXCELLENCE

- A COMMITMENT TO EXCELLENCE

TOP SECRET

The ZAMAN/KENNEN [redacted] program has long had a motto, or series of mottos, which contained very direct references to excellence. The use of this term probably started with Bob Kohler, an engineer on the program in the early days; later he rose to be the Program Director and then to Director, OD&E. Kohler, something of a maverick in government service, was above all other things a superb people motivator and a super salesman. If he is responsible for the focus on excellence, he probably was motivated by at least two reasons.

First, CIA and OD&E have been commited since the days of Les Dirks' initial investigations into NRT technology to produce the finest imaging system possible. This has been reflected in almost every detail of the development and history of the system. Secondly, the succession of high-level managers of this program have steadfastly maintained an extremely high state of morale among the many hundreds of people who have worked on ZAMAN/KENNEN [redacted]

The first program director, Charles Roth, used a brief, straight-forward philosophy which he expressed as simply "Budget, Schedule, Performance". Charlie is reported to have had a two-drawer safe in his office; the bottom drawer of which contained a sign which said, "Things to do after the first launch." (Ref interview with Jimmie Hill and comments at 20th anniversary party by Marty Faga) Every good idea on how to improve the system went into that drawer and was eventually considered, but not until after the first vehicle was flying. In Roth's words, there was nothing else which guided the efforts of all involved in the development of the program.This genuine, long-lasting commitment to the myriad tasks involved in more than 20 years of the program have let to numerous kudos.

One gentleman in a position to be knowledgeable of all NRO programs, Mr. Jimmie Hill, has summed up his feelings by stating that Z/K [redacted] has been the best-run program that he has seen in more than 25 years of NRO experience (interview 23 Sep 91)

Thus was born, and continues to this day, a commitment on the part of those who work on this program, to provide the finest in imagery intelligence..

TOP SECRET

WORKING PAPERS

HANDLE VIA BYEMAN CONTROL SYSTEM ONLY

CHAPTER THREE

TECHNOLOGY INVESTMENTS
(Cautious Progress Takes Place)

The Early Years

Records indicate that interest in "real-time/near-real-time" imaging in 1963 was based on a need for crisis indications[1]. A task force, made up of personnel from the DDS&T Systems Analysis Staff and the DDI's Office of Current Intelligence, developed six requirements[15] which proved to be an accurate precursor for the subsequent COMIREX/OSP System Requirements Document produced in 1969.

- Primary targets of concern were in the USSR.
- Overhead photography would be required.
- Number of targets could be limited to 250.
- In the event of a hostile threat, ground resolution of 1.5 meters (5 ft) would be needed.
- Frequent coverage of sample targets was more important than full coverage less often.
- Because the information was perishable, the time between collection and analysis would be critical.

The initial USIB concern of 1963 with satellite vulnerability did not have an impact on requirements until after the start of system acquisition in 1972 when Dr Teller reviewed the program and concluded that some action was necessary. It was decided [redacted]

The 1964 ZOSTER concept developed by DDS&T Bud Wheelon proposed a system concept study for a satellite capable of a maximum of 150 indicator targets per day with direct readout [redacted] DNRO McMillan instead directed the Zoster emphasis on "readout and rapid communication of high resolution pictures"[16].

Contracts were let by DDS&T's Jack Maxey which after eight months produced no specific conclusions and the work was relegated to a "development planning" effort under D&AD Chief Leslie C. Dirks. By 1965, the work evolved to a technology program for Electro-Optical Imaging (EOI) with emphasis on: the sensor, a data storage technique, and a data transmission plan. At the same time, modest efforts were directed to optics, attitude control (for the spacecraft), image reconstruction (from solid state detectors), programmable satellite computers and overall system concepts including ground station requirements. Surveys were made of existing and projected capabilities in other government agencies such as DARPA and NASA and in a broad spectrum of contractors.

D&AD in-house work confirmed the sensor as the key to achieving the required resolution of [redacted] 5 feet GRD (Ground Resolved Distance) required by COMIREX and demonstrated by the DDS&T work with the CORONA, GAMBIT and HEXAGON programs. In 1965, [redacted] and subsequently [redacted] began development of solid state linear arrays of solid state photo sensitive detectors. [redacted] proposed a photo sensitive plastic material known as Screened Thermoplastic Xerography (STX) which gave good promise for high resolution photography and development work was supported by D&AD. The other promising sensor which had already demonstrated its ability to provide good resolution was the [redacted] videcon, a photocathode tube operating over (then "wideband") data links both on the ground and from aircraft. The size of the available videcon tubes was limited to a 1" format which was insufficient to produce useful image sizes from space so contract work was initiated to evaluate the ability to increase the size to the 2" to 4" regions. Small contract and in-house efforts were devoted to other sensors such as an [redacted] avalanche diodes and large area photo cathode surfaces. Considerable effort was devoted to candidate storage media and attention focused on tape recorders which had already demonstrated satellite capability to record and playback several tens of MHz of analog electronic signals. The need to handle hundreds of megabits of digital data led to technology efforts at many recorder companies principally [redacted] The requirement for recovery and reconstruction of the data on the ground was pursued by the same companies as well as by [redacted]

[redacted] and others. The evidence from these technology efforts indicated that both from the feasibility and desirability standpoint, the wideband image data should be brought directly to the ground via a Relay Satellite. Examination of optics, attitude control and satellite computer capabilities for an imaging satellite identified these areas as requiring technology work to demonstrate that an EOI system for near real time reconnaissance could be developed with reasonable risk. Potential System Contractors were briefed and evaluated to support the integration of technology study results and to establish a basis for development of an overall system plan. Among the candidate prime contractors were [redacted] Initial studies were largely contractor funded and Les Dirks staff carried out the key tasks of integrating all the data from them as well as the technology results. Work on large optics concepts at [redacted] guided imaging satellite concepts and supported sensor technology, image quality and image reconstruction studies.

A continuing dialogue was carried out with the various elements of the CIA/DDI, DIA, and DoD with direction from the NRO and oversight from the USIB, PFIAB, PSAC and NSC staff. The Land Panel early on provided valuable guidance while other groups such as the Fubini Panel were primarily critics and the source of capability questions. By the end of 1967, D&AD's work was very encouraging overall and the Intel Community -sponsored Tidwell study produced definitive requirements (resolution 2.5 feet, images to decision makers within a few hours) and concluded that "development of a visible imaging system should be accorded priority"[17].

The Pace Increases

A series of events in the late 1960's resulted in focusing technology efforts and development of a system concept documented in Les Dirks "Application of Electro-Optical Technology to Satellite Reconnaissance",. 15 May 1968 [18] That report, popularly called the "Dirks Blue Book", was a 58 page masterpiece which foresaw the ZAMAN/KENNEN [redacted] Program with impressive clarity and comprehensiveness. It summarized the key technologies, forecast results, defined a system architecture and even presented cost projections which were quite accurate, for the time. Other key factors were DCI Helms and DDS&T Duckett's support, the DNRO McLucas' decision to increase ZAMAN funding, the Land Panel's strong support for solid state transducer sensors and the cancellation of DORIAN (MOL) in June 1969.

Since the EOI approach required conversion of digital electrical signals to film a major effort was undertaken in 1969/1970 to demonstrate the process and establish credibility in the quality of the images. An Image Process Laboratory (IPL) was established at [redacted] while an Image Chain Analysis (ICA) Program was started at [redacted] Initial experiments at the IPL used simulated data from the various transducer contractors while the ICA team undertook a theoretical evaluation of the process based on Les Dirks Signal to Noise Equation[19] tracing the electrical signal from the light impinging on the optics, to the detectors in the focal plane, thru the communications links to the ground Laser Image Recorder (LIR) and finally, onto the film for the photo interpreter. The use of Ground Sample Distance (GSD) and its relationship to the community-used Ground Resolved Distance (GRD) and to NIIRS was new to the community and it was recognized that significant effort was necessary to prove it acceptable. The D&AD ZAMAN group led by Charley Roth established working interfaces with NPIC following management arrangements by DOSP John Crowley and D&AD Chief Les Dirks. The NPIC personnel, Paul Mattox and Paul Reed, were assigned full time to the ZAMAN Project and provided invaluable help guiding the establishment of criteria and requirements for the IPL and ICA. Meanwhile, solid state transducer efforts were maturing and the availability of working chips led to the ~~connection~~ conviction ? that more significant demonstrations of EOI imaging were required. [redacted] Msrs. Mattox and Reed assisted in the development of qualitative relationships between GSD and GRD and definitive requirements for GSD as it applied to intelligence problems and Photo Interpreters (PI's) use of NIIRS ratings. Intelligence Analysts and members of the community were briefed on the product and assisted in evaluating utility of the imagery to help guide the engineering definition of the system. Correlation of the PI's evaluations with the optics, solid state transducers, comm link, LIR and film design and actual performance data from the technology programs established a firm basis for EOI imagery and the validity of GSD parameters. The [redacted] results also gave invaluable engineering guidance such as confirmation that electrical bias worked, demonstration of haze backout, proof that image motion compensation was not required and confirmation of system signal to noise performance and predictions. Several potential prime contract bidders set up "image laboratories" to operate solid state transducer chips provided by the Zaman Project Office. Their experiments enabled them to understand and confirm Imaging Satellite (IS) requirements and specifications for stability and tracking (expressed as a percentage of pitch of the detectors for example), agility (the speed to move from one target to another) and thermal control.

Technology efforts from the early 60's had progressed significantly by 1969 and at the same time new programs were started as needs were identified. One of the key technology efforts was development by [redacted] of a film for the EOI LIR's. It was important that minimal loss of quality occurred as the laser spot, representing the point imaged on the ground, exposed the film to be used by the PI. These were unique requirements and [redacted] photoscientists worked hard to produce a film with maximum resolution (high modulation transfer function MTF) at very short exposure times and very low light levels. The results were excellent and the film for the final step in the Image Chain was subsequently produced by [redacted] in the large quantities required.

A great deal of attention was of course focused on the transducer efforts. In house as well as candidate I/S contractor evaluations of an STX based system were not very encouraging. Although the material demonstrated very good sensitivity in laboratory experiments, little progress was made towards repeatable quality, usable size materials. The construction of the transducer was very complex: multiple layers being required to make up the device. On a 1/8 to 1/16 inch thick glass plate was added a thin metallic layer which served as an electrical ground. On top of this was a metallic screen which contained about 300 parallel lines per millimeter. The next layer consisted of a light-sensitive, photoconductive material. This was then coated with a thin outer layer of thermoplastic, which formed the surface of the device. (20) In addition, designs of a transport mechanism, a readout device and an "erase" station quickly showed that the subsystem would be complex, heavy and have questionable reliability. The material would have had to be in platens approximately 8" square and after exposure moved to a very high accuracy (tens of angstroms) light and Photo Multiplier Tube (PMT) scanner to convert the deformations representing the image to a data stream for transmittal to the ground. The erase station would have had to be a carefully controlled heat source which would return the material to its original un-deformed state. Little or no data was available to indicate a good estimate of a practical number of life cycles. Due to the incredible complexity of the device and the promising nature of some of the other technologies, STX work was dropped in favor of other approaches.

Work with the [redacted] videcons confirmed that the signal to noise characteristics were adequate for the job but progress from the 1" to 2" or larger format was slow. In outward appearance, the vidicon resembled the picture tube of a five-inch oscilloscope. It was about two feet in length and less than a foot in diameter.The tube had a glass faceplate with a photosensitive surface and an electron gun which read out the image from the faceplate and converted it to an electrical signal. Following exposure, a replica of the image existed on the tube face in the form of an electic charge pattern. The pattern must be converted into a video signal. After the entire tube face has been scanned by an electron beam, the surface was erased and prepared for the next image. Exposure time for the videcon was about the same as for photographic film (hundredths of a second) , while readout time ran in the five to ten second range. Erasing the tube required three to five seconds. In order to acquire ground areas of three by three nautical miles, it would have been necessary to either develop larger tubes or to group tubes together. Work was underway to try both solutions. The vidicon appeared to primarily be an interim solution because of its limitations. (21) The division of [redacted] doing the videcon work was more interested in commercial applications and other products and even the 2" to 4" format would have required multiple tubes in the focal plane to reach satisfactory frame (image) sizes for the intelligence user. In addition the high power required by the videcon was unattractive from the viewpoint of reliability. Efforts to develop this device were reduced and finally terminated as the solid state devices matured.

The solid-state array was a grouping of solid state detectors, arranged in the image plane of the optical system. The detectors are placed in a line which is perpendicular to the satellite velocity vector, thus the array is at right angles to the satellite ground track. In operation, the amount of light falling on each element of the array is converted to an electical signal, which is sampled and either recorded or transmitted to the ground. The array can be pictured as scanning the ground in the cross-track direction as the satellite moves along its path. Resolution in the cross-track direction is determined by the spacing of the individual elements in the array. In-track resolution is determined, in part, by how often each element is sampled.(22)

With a large input of money from the NRP in November 1968, OSP entered into contracts with [redacted] to design and build test arrays of solid-state transducers which could be used in both the lab and in aircraft tests.

[redacted] was the first of the solid state candidate contractors to make a working array. It was called a "quasi linear" array since the photo sensitive areas were in two horizontal rows to achieve a solid line of image samples. The results were exciting because they confirmed signal to noise and sensitivity calculations done earlier by Frank Eliot and Les Dirks. At this time linear response of the photo diodes was achieved by illuminating them with a low light level which activated the photo sensitive area. Dirks, Roth and Eliot recognized the numerous difficulties associated with a long life, spectrally pure, light source and devoted much effort to developing a different approach. [redacted] was more interested in other programs and [redacted] became distracted by ambitions in the commercial computer market while the Program Office found great interest and potential at [redacted] Initial results from these two contractors were so encouraging that other solid state devices such as avalanche diodes and photo cathode surfaces were abandoned. The [redacted] design involved highly sensitive phototransistors packaged in [redacted] element modules. The [redacted] arrays exhibited an excellent mechanical and thermal design, but suffered from what was known as "popcorn noise". [redacted] was working with photodiodes in [redacted] modules. Although the design of the [redacted] detector was ~~not as good~~ less elegant than as [redacted] ~~they were~~ it was quieter .(23) Both [redacted] rather quickly achieved contiguous or linear detector arrays and both laboratory and [redacted] test confirmed promising performance. Data from the tests, the ICA work and NPIC quality assessments were used to arrive at a viable sampling scheme which would permit use of an achievable [redacted] data link*. Device yield remained as a significant challenge and both [redacted] were tasked to produce and test 250 chips. The specifications, generated by the ZAMAN Project Office, were definitive and verified by the previous limited number of chips produced. Preliminary designs called for [redacted] detectors with from 25 to 100 detectors per chip with the chips assembled in groups of five to ten on modules holding the amplifiers and other related electrical components and circuitry. By this time, the contractors were able to provide an electrical bias which gave immediate linear response and eliminated the need for the illumination of the array by an on-board light source.

Based on Les Dirks May 1968 report[24], popularly called the Blue Book, the ZAMAN Project Group developed parametric relationships between data rate, image quality, optics size, detector sensitivity, spacecraft parameters (weight, size power) and cost. This served to bound the areas of interest for a system meeting the System Requirements Document developed in conjunction with COMIREX.. It was clear early on that large [redacted] diameter primary mirror) optics were desirable if not essential. The largest space type mirror produced at that time was the 72" primary for Dorian (MOL) and there was considerable doubt that a [redacted] parabolic, high quality [redacted] wavelength) light weight (<3000 lbs) mirror could be built. However, in depth studies of optical systems concluded that a [redacted] (combined with a maneuvering spacecraft) was the best solution and that a spacecraft altitude of about 300 miles was very desirable. Evaluation of the launch vehicle options and the probable TDPS characteristics led to a maximum useable primary diameter of [redacted] was placed under contract, and subsequently also [redacted] to build a [redacted] primary.

[redacted] and had invested a considerable amount of money and effort into facilities in [redacted] DNRO McLucas directed that [redacted] be included in the ZAMAN competition. Detailed evaluations of potentially available light weight mirror blanks came down to ULE glass, egg crate structures from Corning or CERVIT glass, milled blanks from Owens Illinois. Corning's design was selected as being most acceptable and the blank mirrors were GFE'd to [redacted] produced [redacted] wave, light weight mirrors in 1970/1971 despite predictions from authoritative sources (such as Fubini and Dr Meinel) that an inordinate time would be required or even that it could be done. The optical system work was carried out in parallel to support development of a firm spacecraft concept as well as to contribute necessary data to the IPL and ICA. Prior to system acquisition, [redacted] was selected to produce the optical system and was presented to the prime contractors as a directed Associate Contractor. In addition, important problems such as methods for calibrating the transducer and Altitude Control System (ACS) requirements were analyzed and design data for system and segment specifications were generated. [redacted]

Dirks' Blue Book identified [redacted]

[redacted] the requirements for an on-board computer capable of storing predetermined commands, inertial reference information from the spacecraft sensors, ground tracking ephemeris data and real-time commands were defined. Specifications were prepared and bids requested from companies including [redacted] submitted the winning proposal and began work to develop an engineering model to support subsequent system tests and to later be the I/S ACS supplier for system acquisition.

During this period, the ZAMAN Program Office developed a comprehensive Work Breakdown Schedule(WBS) and a System Segment concept which included all the elements necessary to develop an EOI System, deliver the product to the user, conduct the initial photo interpretation and distribute the product to the community.

The segments and their top level WBS were:

1.0 System Engineering (SE), System Integration (SI), and System Documentation
2.0 Imaging Satellite (I/S)
3.0 Receiving Facility (R/F)
4.0 Operating Facility (O/F)
5.0 Processing Facility (P/F)
6.0 Optics Subsystem (O/S)
7.0 Relay Satellite (R/S)
8.0 Ground Station [redacted]
9.0 National Photographic Interpretation Center (NPIC)
10.0 Intelligence Community (IC)
11.0 Global Weather Central (GWC)
12.0 Terrestrial Communications (T/C)

As other "segments" were identified, they were added; [redacted] The segments were broken down for cost, schedule and technical tracking to the third level for ZAMAN Program Office use and to lower levels as required at contractors. A document tree was developed to include specifications and Interface Control

Documents (ICD's) for each Segment and for subsystems within the segments. The initial documents were generated by the ZPO as part of an overall Program Plan.

Both discouraging results from tape recorder technology work and the desirability of real time return of the image data led to a decision to prove the necessary technology capabilities for a wide band data link [redacted] from the I/S to the ground via an R/S. Arrangements were made by Program B management with DNRO McLucas to assume direction of an AF [redacted] which became the [redacted] (the White World name for the [redacted] Satellite Program). [redacted] let technology contracts for Wide band Travelling Wave Tubes (TWT's) to [redacted] antennas to [redacted] and numerous component developments such as mixers and amplifiers at companies like [redacted]

A number of concepts for returning the image data to a central processing facility were examined. One envisioned a series of ground stations located in parts of the world which would be visible to the Imaging Satellite as it passed over targets of interest; the data would be downlinked from the spacecraft and then forwarded to the Continental US. This idea limited the access of the imager to about one-third of the Northern Hemisphere and depended on continued good relations with whichever countries the ground stations were located in. The political limitations, cost of multiple ground stations and the restricted access of the satellite all made that option unattractive. The most viable solution was to have several relay satellites through which the image data could be sent to a central US-based processing facility. This, of course, was the course chosen. (25)

Initial R/S concepts were explored informally with candidate bidders such s [redacted] The ZPO carried out work on related issues including wideband data encryption, frequency allocations (from the FCC), frequency standards (from NBS) and an end to end quadra phase, [redacted] data link laboratory demonstration at [redacted]

Work on ground data processing and handling was emphasized with engineering model ground tape recorders underway at [redacted] a Laser Image Recorder (LIR) demonstration model at [redacted] data stream processing hardware brass-board at [redacted] films and (visicous) film processing including subframe array assembly at [redacted] and Ground Station specifications by the ZPO.

Ready for System Definition

By 1970, the Executive Branch, the Land Panel, the NRO, House and Senate cleared individuals and the community support for EOI was such that it was decided to prepare a Development Plan for EOI which would field a system with IOC in 1975/1976. Using the plans and specifications developed during the technology and study phases, a comprehensive system was laid out. Segments 1 through 4 were grouped as candidates for one prime contractor. Segment 5 was determined to be an Associate Contractor status as well as the Optical Subsystem (O/S) which clearly was to be [redacted] Segment 7, the R/S, was to be [redacted] managed by ZPO. Segments 8 through 12 were to be ZPO/Government managed. The Ground Station location selection process was initiated with key requirements established such as available support services (power, water, fire fighting etc.) proximity to [redacted] security (both physical and comm downlink footprint). System requirements for the ground station were derived from each of the other segments.

Selections were made in key subsystem areas. One of the most important was the transducer (TDPS). Fabrication and testing of the devices at [redacted] went essentially as planned while two disturbing problems emerged at [redacted] The first one was an inability to make the chips on schedule - a difficulty which appeared to be tractable to increased effort. The second problem was indication of a random noise source in the signal output. After vigorous efforts by [redacted] and the ZAMAN Project Office, it was determined that the source was "burst" noise. No known method of eliminating the noise could be found and although it did not make the devices useless, they could not meet specification nor could a simple method for correcting the data corrupted by the noise be found. The [redacted] device was selected for the EOI transducer (transducer data processor subsystem - TDPS), and contract work to design a flight TDPS was initiated. This contract continued through the System Definition Phase and [redacted] supported all the prime bidders until source selection was complete at which time they became a directed subcontractor. Not only had [redacted] demonstrated its unique capability to build the high performance [redacted] Optical subsystem but specifications and ICD's had been generated for [redacted] become a directed Associate Contractor to the candidate bidders for segments 1 through 4 as well as to provide the ground station film and film processing. The results of the [redacted] tests a[redacted] and the contractor proposals were so encouraging that it was decided to select [redacted] and designate them as a directed supplier to the I/S. [redacted] was also designated as a directed supplier for the I/S ACS computer and various general purpose computer suppliers such as [redacted] were evaluated for the ground station computational requirements as well as for development support at Segments 2, 4 and 5.

These decisions and actions set the stage for initiation of System Acquisition.

CHAPTER FOUR

COMPETING CONCEPTS
(To Each His Own)

From the earliest days of space reconnaissance development; probably dating from the budding fantasies of those forward-thinking pioneers, the desire to have pictures sent to earth in some form of rapid fashion was the ultimate goal. In fact, it was the principal focus of the SAMOS/SENTRY(WS-117L) System for the many years that it was fruitlessly pursued.

In the late 1950s, through the mid-1960s, SAMOS went through three different read-out system concepts and three cameras.(26) Technology simply would not support large-scale development of read-out technology and, further, the Intelligence Community did not press for urgent development of the capability. As world events, such as those previously discussed, produced more interest among Intelligence consumers for the more-timely receipt of imagery from space. Even in the mid to late 1960s, the Intelligence Community ran hot and cold on the need, probably in reaction, or lack thereof, to the appeals of the policy-makers. USIB and COMOR seemed to be at the forefront of the vacillation, but Dr. Edwin Land began to press in the late 1960s for progress on near-real-time delivery of imagery. He specifically supported electro-optical imagery, while others advocated less radical technology. The two principal imagery satellite developers in the NRO, OD&E and SAFSP, each began to strongly advocate the technologies being pursued in their respective organizations.

PROGRAM A
(Evolve, Yet Move Forward)

SP was at that time flying the very successful GAMBIT system, even then developing the GAMBIT-3 (sometimes called the GAMBIT CUBED). As the Community, and others, began to more stridently express a desire for a capability for near-real-time, Program A proposed a modification to GAMBIT which rapidly acquired the nickname FROG (Film-Readout GAMBIT).

At the same time, Les Dirks in Program B was well-along in a technology development effort to support the contention that EOI was a viable way of returning images from space in a timely manner.

These two efforts were to spark what probably has been the most intense competition ever undertaken in the space reconnaissance environs of the US Government. Both programs certainly believed that their own approach had the highest likelihood of achieving success and they certainly expended prodigious amounts of energy in pursuing their technologies. First, FROG will be described and then will follow a description of the early efforts of the EOI development.

FROG
(Build On What's Proven)

Film-Readout GAMBIT employed the technology developed in the E-1 and E-2 camera systems of the SAMOS project. In this system a "bi-mat" technique was used to develop the exposed film on-board the imaging satellite. The exposed film was processed by pressing it against a web containing developer and fixer chemicals. The developed film was then scanned by a line-scan lens, a photo-multiplier tube and a video signal amplifier. The film was optically scanned, converted to an analogue signal and the resultant signal downlinked to a ground station, where it would be reconstituted into hard-copy images. (27)

The bi-mat technology had been successfully operated on one flight in the SAMOS series, but the results were somewhat discouraging. The experiment had produced imagery in the 100 foot range of resolution and the data transmission rates had been too low to allow significant numbers of images to be sent from one satellite revolution. (28)

- FROG was evolutionary; building on proven imaging technology.
- It was a modification of an operational system.
- It had the drawback that it carried expendibles such as film, and chemicals.

• Program A emphasized that it could be built for less than a from-the-ground-up system and in less time.

• Because of doubts among key officials, like David Packard, Eugene Fubini, and John McLucas, that EOI technology was ~~still not~~ proven, there were decisions made in early and mid-1971 to keep working on FROG, with an eye to orbiting an "interim" NRT capability.

• Al Flax, DNRO, urged in March 1969, that if the "Community wanted an expedited NRT program, it would have to be FROG. (29) COMIREX left the decision up to the NRO, because it was felt that the NRO was the proper place to determine the feasibility of performing an indications/warning task; a principal driver of NRT imaging.

There were other complications which led to significant vacillation in the quest to build FROG (and ZAMAN, for that matter); the on-going SALT negotiations had not settled on whether higher resolution (than FROG) or quick response were to be accorded priority. Also, project DORIAN the black portion of the MOL, had consumed large amounts of money for optics work at Eastman Kodak; work which competed with read-out for money. DORIAN was cancelled in 1969, and the money previously allocated to EK for optics work on the KH-10 camera was now divided between Programs A and B for continuation of optics work at EK. The investment of NRO money at Kodak was simply too great to even consider any other optical contractor at this time.

In July 1969, USIB approved a requirement for a Near-Real-Time System. Following closely behind this decision was an NRO EXCOM meeting on 15 August 1969, at which the competing technologies were debated at some length. DNRO McLucas favored a read-out technology development program but urged that no specific approach be selected pending further advances in technology. CIA's position was that a program needed to be established by January 1970, with sufficient funds allocated to begin system definition. Deputy SECDEF Packard offered a compromise which was ultimately accepted: a more rapid technology and analysis program than offered by McLucas with a task force appointed to report on the status of film read-out technology, electro-optical imaging and tape-storage system. The latter was a favorite of DDRE John Foster, who believed it less expensive and would require smaller optics than EOI, yet give equivalent results. Program A had been pursuing the tape-storage concept for some time. (30).

There is ample evidence that nearly everyone in positions of responsibility and knowledge, both in and out of government, believed that EOI was the imaging technology of the future, Virtually no one brought forth the argument that the effort should not be pursued. The degree to which individuals believed that the technology was at hand varied immensely. Dr. Edwin Land was firmly convinced that EOI could safely and wisely be funded and developed in 1969. He was joined in this estimate by Richard Garwin of IBM and Sydney Drell of Stanford University. Eugene Fubini, John Foster and David Packard of DoD generally believed that the EOI technology development had not progressed to the point where questions about its reliability and orbit-lifetime could be firmly answered. In the NRO, Dr. McLucas apparently felt that none of the NRT proposals were sufficiently developed to enable him to back one. Within CIA's Program B, Les Dirks, Carl Duckett, and Richard Helms were convinced that EOI was ready to go into system definition. The Special Projects Office in Los Angeles was equally confident that FROG offered the quickest path to an"interim" NRT capability.

COMMUNITY STUDIES
(New Players In NRP Projects)

While the two NRO programs were moving ahead with technology development, there were several studies performed in the Intelligence Community which were to have considerable influence over the selection of a NRT system. In the Fall of 1966, CIA suggested to USIB that a study be conducted on whether or not a real-time readout system would contribute significantly to the indications and warning capability of the US. DCI Helms agreed to this approach and directed that an ad hoc group be established under the leadership of William Tidwell, Chairman of COMOR. This group was formedly in November, 1966. However, before it could really get significant underway, the NRO EXCOM decided to reduce the level of effort on the FROG system. (31) The Tidwell study went on and concluded in August, 1967. Among its conclusions were three basic demands for an NRT system:

- Nadir resolution of 2.5 feet
- Capable of sampling target categories on a daily basis

• Capable of delivering information to decision-makers within a few hours of sensing(32) Helms sent the report to the DNRO, Al Flax on 14 February 1968. It was to be 13 months before a less than favorable reply was received.

The second study of note, which was directed at the impacts of a NRT system on a different part of the Intelligence Community, was undertaken. The Inlow Study, named for the gentleman from CIA who actually co-chaired it, looked at the impact of NRT on the analytical side of Intelligence. This may have marked the watershed of attention being paid to other aspects of the Community than just collection organizations. In the days of the 1990s, when the Community looks at all aspects of a new collection system, we tend to forget that such attention has not always been the case.

The Inlow effort was initiated by Richard Helms, in response to a PFIAB (President's Foreign Intelligence Advisory Board) concern that the prodigious amounts of money being spent in 1969 on reconnaissance systems was too large. Mr. Helms didn't think so, but agreed to have the question studied. He ordered a group formed to examine the impacts of a NRT system on the intelligence production and analysis processes. Roland Inlow, then deputy director of the Office of Strategic Research (the Agency's military intelligence analysis group) and the CIA member of COMIREX (the successor of COMOR) was named to head the study. It was a precedent-setting study in that it considered facets of intelligence which had never previously been considered in the development of a reconnaissance system: computer-assisted targeting of the satellites, ground processing, image interpretation, analytical organizations, and dissemination of imagery and data to user organizations. While previous consideration had been given to indications and warning functions of NRT, the Inlow Study broadened its scope to include crisis and fast-breaking events, target surveillance, current intelligence, support to military operations and the monitoring of strategic arms or disarmament pacts. (33)

Inlow also used three recent crises to illustrate how a NRT system might work. Given the prevailing climate in early 1969, (EXCOM having reduced FROG), the group assumed that ZAMAN would be the system built. (35).

Cuba, Oct/Nov 62 - showed how a communications mixup resulted in a CORONA vehicle not being tasked and the crisis being over before its next access.

Arab-Israeli War, 1967 - CORONA look angles were too poor and imagery was of no value for bomb damage assessment of Israeli airstrikes.

Czechoslovakia, August 1968 - CORONA filmed the pre-invasion military buildup, but the film arrived at NPIC several days after the invasion had take place.

The Inlow group report so impressed Helms that he had the study briefed to USIB, then named Inlow to succeed Tidwell at COMIREX.

CIA STUDY ON NRT IMPACT ON INTELLIGENCE PRODUCTION AND PROCESSES
(We'll Get How Much, How Often?)

In early to mid-1969, CIAs Intelligence Directorate conducted a study on the impact that a Near-Real-Time imaging system might have on the "other" side of the Intelligence house-the interpreters and analysts. This study, quite naturally, used the EOI system then under development by Les Dirks of OSP as a model for the study. Remember,that at this time the FROG system had been reduced to little more than an R&D effort.

The study resulted in a rather lengthy document, and came to the following conclusions:(36)

- Urged that USIB issue an initial statement of requirement for a NRT system.

- NRT will significantly improve current reporting, crisis reporting, event analysis, and some areas of indications/warning (particularly tactical forces). (37)

- NRT will permit a more aggressive use of imagery in dealing with day-to-day analytical problems.

- A NRT system should be capable of [redacted] images per day, would probably still need high resolution of GAMBIT and the area coverage of HEXAGON. (38)

- A major advantage of NRT will be an orderly and routine flow of imagery to support stable processing, analysis and reporting throughout the Intelligence Community.(39)

- Urged that a NRT system be planned and executed in terms of a total system concept--not separate pieces. (40)

- System characteristics desired in a NRT system:

    - 2 to 3 foot resolution at nadir be capable of accessing all COMIREX targets at least 3 to 4 times per week.

    - image footprint on the ground of 3 by 3 nautical miles capable of [redacted] frames per day, with a stereo capability

DECISIONS, DECISIONS, DECISIONS
(USIB Vacillation on NRT in 1971)

In the late 1970-early 1971 time frame, a general concensus developed in the Intelligence Community that a NRT crisis-response satellite capability was needed in order to provide adequate indications and warning data on the Soviet Union. Enough USIB members believed in this need that agitation surfaced which called for an interim effort, given that ZAMAN would not likely be in operation before 1975. One of the chief agitators turned out to be the Secretary of State, Wm. Rogers, who strongly argued for a NRT capability before the end of 1974: a date which curiously coincided with the end of President Nixon's term of office.(41) This led the NRO EXCOM to resurrect the FROG program in the Spring of 1971. (42)

This shifted the emphasis towards an interim crisis-response capability in FROG and seemed to demote the NRT ZAMAN proagram. There was a considerable body of belief in the NRO, particularly in Program B, that building and flying FROG would so dilute funding for ZAMAN as to presage its eventual demise. In the summer of 1971, Intelligence Community imagery users had even begun to form task forces to prepare to receive FROG imagery. (43)

These folks had not reckoned with the persuasive abilities of the CIA Deputy Director for Science and Technology, Carl Duckett. Nor, apparently, had they truly appreciated the technical achievements of Les Dirks and his small group of engineers in the ZAMAN Program Office. Duckett had a friend in court in the person of Senator Carl Ellender of Louisiana, Chairman of the Senate Appropriations Committee. Senator Ellender and Congressman Mahon, his House of Representatives counterpart, had been staunch supporters of the EOI program. Mr. Duckett visited Senator Ellender's office in late Summer, 1971, accompanied only by William Woodruff, Ellender's Legislative Assistant. Apparently, Duckett outlined the advantages of EOI over FROG and played on Senator Ellender's pride in having backed EOI in the budget process. The upshot of the sessions was Ellender's charge to Woodruff to the effect "write the White House and tell them that we are only going to fund one system; my system" (44) During this same time, or soon thereafter, Dr. Henry Kissinger, National Security Advisor to President Nixon, had a private briefing from Syd Drell and Richard Garwin on the true status of the EOI technology and the relative merits of EOI vs FROG. We are not privy to what else may have transpired behind the scenes in the White House or on Capitol Hill, but we do have for posterity the 23 September 1971 memo signed by Dr. Kissinger, announcing in very brief language that the President had decided to proceed with the development of the EOI System. It has been suggested that Duckett may have drafted the 23 September memo. (45).

ZOSTER
(Covert Isn't Necessarily Better)

In 1965, at about the same time that the FULCRUM/HEXAGON project was underway, the USIB became concerned that US reconnaissance satellites were becoming vulnerable to a Soviet ASAT threat. There was a prevailing opinion in DoD, not shared in CIA, that the so-called Tallinn missile system (later known as the SA-5) had an

ASAT capability. This caused a USIB-directed study, called ZOSTER, to be initiated. CIAs Offices of Scientific Intelligence and Special Projects contributed analysts and engineers to ZOSTER, which originally set out to investigate the feasibility of building a covert imaging satellite: one launched in secrecy; maintained in a high, non-detectable orbit; which could be lowered and used in the event of a crisis.

As work on ZOSTER progressed, it became obvious to all that a covert satellite was probably not either feasible from a covert standpoint nor was it necessary. Rather, it was felt that time and money should be spent on developing an indications and warning system; something that could provide data on military buildups and hostile actions much more rapidly than could the then-current film-return systems.. The results of ZOSTER turned the attention of OSP engineers to investigations of means of acquiring satellite imagery other than on +conventional film. (46)

THE LAND PANEL REPORT
(Go For EOI)

The National Reconnaissance Panel to the President's Science Advisor, a distinguished group of scientists who were acknowledged experts in the reconnaissance field, met a number of times to discuss the merits of both the FROG and EOI technologies. Chaired by Dr. Edwin Land (better known as Din), the Panel issued a key report on July 14, 1971, offering their judgements as to the relative merits of the two competing programs. For purposes of clarity, the report will be quoted extensively:(47)

• EOI will have a best nadir GSD of [redacted] duration.FROG will have a best nadir GRD of 24", but could be operated for a limited time at an altitude which would provide 12" GRD. (editors note: there has never been a completely satisfactory means of equating GSD, Ground Sampled Distance, with GRD, Ground Resolved Distance, although many have tried. However, for purposes of this history, these measures were considered to be essentially equivalent at the time.)

- EOI [redacted] GSD was judged clearly superior to the best G3 (usually stated as [redacted] GRD), while EOI [redacted] GSD was judged somewhat inferior to the best of G3.

- EOI will have many more accesses at GSD [redacted] than does the present G3, at GRD of 14" and can therefore replace G3. EOI can provide multiple views of the same structure from a range of angles on a single pass.FROG, limited to roll only, cannot.

Near nadir, FROG has very little capability to monitor lines of communication. At large obliquity, FROG has greater LOC coverage, but at substantial sacrifice in resolution. EOI. even in its original framing mode, can acquire coverage of a minimum of 60 miles per pass. In the stripping mode, some 450 miles of typical LOC can be covered per pass.

EOI gives [redacted] with imagery available [redacted] FROG with the planned continental US sites will have a 12-hour delay after photographing European Russia, the Suez, or Eastern Europe. EOI images of these regions at local noon (5 A.M. Washington time) can be available for a full day's review by US leadership, with resultant tasking of the next days's take. A 12-hour delay in return of imagery would lead to a 2-day cycle if the system were to serve directly the needs of Government leaders.

While EOI has demonstrated the performance of the developmental items which have been exposed to critical appraisal for at least the last 2 years, there are certain tasks remaining to be accomplished:

- Adequate thermal control of the detector array
- Choice of the optimum means of continuous calibration of each detector.
- Demonstration of the vehicle stabilization achievable with the redundant [redacted]

We are confident that this work can be performed successfull on the required time scale.

On the other hand, FROG will require the development or adaptation of many techniques and pieces of equipment new to the program and to the contractors:

- Bimat processing with 1 year life, involving thermal control to 1 degree C with acuracy at 0 degree C.

- Laser scanner-film guide

- Roll joint modifications

- Zero-g propellant requirement

- Flexible solar cell array

- In general, the many systems responsible for raising the number of "relay-driver pairs" from 220 in the G system to 760 in the proposed FROG.

These capabilities appear possible of achievement, but our experience with analogous development programs causes us to regard the successful achievement of all these capabilities on schedule as a substantial risk.

We conclude that the risk associated with FROG on the stated schedule may well be greater than that associated with EOI on its schedule with operational capability one year later.

We believe that EOI design will not benefit from operational experience of FROG because such experience will not be available to any significant extent until mid-1975 and to delay the EOI procurement until then would postpone EOI operation to 1978 or 1979.

Our comparisons show the performance of FROG to substantially inferior to that of EOI. The operation of FROG would only be an interim program. The longer EOI is delayed, the longer we will be denied the much superior EOI product, but we shall eventually develop the EOI system. The question is not whether we spend [redacted] to build FROG to fly end 1973 o[redacted] to fly EOI end 1974. The question is whether it is worth [redacted] additional to have an inferior product one year sooner and with what we regard as probable resulting delay of the superior capability.

The Panel believes that recent decisions have been based on two misconceptions:

- that EOI and FROG are sufficiently similar in performance that the two are alternates.

- that the risk in developing FROG is substantially less than that in building EOI.

The Panel is unanimous in its judgement that the FROG program has the higher risk.

Members of the panel signing the report were:

- Edwin H. Land
- James G. Baker
- Sidney D. Drell
- R.L. Garwin
- M.L. Goldberger
- Don Ling
- A. Puckett
- Joseph Shea

There is inadequate documentation available at this writing to ascertain just what the reactions of various officials was on the publication of the Land Panel Report. It is evident that Mr. Packard was not convinced that the optimism of the Panel was well-founded. He still apparently harbored doubts as to the maturity of key technologies in ZAMAN and wanted to proceed slowly in the development of the EOI program. It is equally likely that Packard was being urged by some in DoD to move in the direction of acquiring an interim read-out capability. The idea that some real-time imagery in the near term is better than a lot of real-time imagery in the far-term was certainly prevalent in this time.

There is extant a draft memo, prepared by the President's Science Adviser, Edward E. David, Jr., for the signatures of Helms and Packard, which lays the decision on choosing between FROG and EOI squarely in the lap of President Nixon. It provided four options;(48)

- Procure FROG now for launch in early 1974, delay EOI for two years so that the first EOI wioulded be launched in 1978.

- Procure FROG now for launch in early 1974 and in December 1971, procure EOI for launch in 1976.

- Procure EOI only for launch in1976

• Procure EOI only in a shorter time frame by undertaking a riskier, crash program.

We do not have any firm evidence that this memo actually made it to the President or, if it did, what form it took.

With the 23 September 1971, memo FROG was dead; never to be resurrected.