INNOVATIONS & INNOVATORS

OF THE NATIONAL RECONNAISSANCE OFFICE

1961 - 2021

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CENTER FOR THE STUDY OF
NATIONAL RECONNAISSANCE

MAY 2023

CENTER FOR THE STUDY OF NATIONAL RECONNAISSANCE

The Center for the Study of National Reconnaissance (CSNR) is an independent National Reconnaissance Office (NRO) research body reporting to the Director/Business Plans and Operations Directorate, NRO. The CSNR's primary objective is to advance national reconnaissance and make available to NRO leadership the analytic framework and historical context to make effective policy and programmatic decisions. The CSNR accomplishes its mission by promoting the study, dialogue, and understanding of the discipline, practice, and history of national reconnaissance. The CSNR studies the past, analyzes the present, and searches for lessons for the future.

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A NOTE TO THE READERS

The National Reconnaissance Office was established on 6 September 1961, uniting Central Intelligence Agency and Department of Defense reconnaissance satellite programs into a single agency. In the six decades that have passed, the NRO has accomplished innovations in many areas driven by a unique class of innovators. Some of the nation's best minds have labored to give the U.S. strategic and tactical advantages in protecting the nation from the vantage point of space. Additionally, the development of NRO systems also contributed to broader U.S. space programs and the advancement of commercial activities.

To commemorate the National Reconnaissance Office's 60th Anniversary in 2021, the staff of the NRO's Center for the Study of National Reconnaissance (CSNR) wrote a compilation of highlights celebrating various aspects of NRO history which we called "I&Is." The effort identified 60 "Innovations" developed by the NRO and 60 "Innovators" that have been involved with the NRO over the years — one specific example for each year of the NRO's existence and most of which are included in this publication.

The I&Is were released to the workforce periodically throughout the year, as the NRO celebrated its 60th anniversary. This publication is simply an effort to consolidate those highlights in one place for the ease of retrieval and education of all. The I&Is are short and general in nature, but each should contain enough information to inform the general reader, as well as to provide clues on where to find additional information for the advanced researcher.

We would like to note to the reader the parameters that defined this project. We are only highlighting unclassified accomplishments. This compilation was not intended to be a "Top 60" list, since many of the NRO's innovations are still highly classified and cannot yet be shared with the public. We also made no effort to "rank" the lists, since the innovations are in different areas — ranging from groundbreaking technological discoveries to innovative management practices to development of new ways of thinking — and any systemic criteria we chose to do so would be problematic. In addition, some of the innovations we included are still not fully declassified, and we can only consider the information that has been released, which in some cases is minimal.

The I&Is that we included are grouped into several different categories for organizational purposes only and for ease of the reader. Each report stands on its own, so while the reader will occasionally notice some duplication of information, it merely shows the interconnectivity of many of the NRO's programs and activities. No I&I is any more or less important than any other with no bias toward placement within the overall publication. Not all innovators or innovations were included because of classification and project limitations.

We hope that the reader will find this publication both compelling and informative. More information can always be found on the CSNR's "History and Studies" page of the NRO.gov website.

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INNOVATIONS

NRO CULTURE

NRO CULTURE

Ultimately any organization that is highly innovative depends on developing, sustaining, and refreshing a culture that enables innovation. During its 60 years in existence, the National Reconnaissance Office (NRO) invented and nurtured a culture of innovation resting on six key pillars.

NATIONAL SECURITY IMPERATIVE

The reason for the NRO's existence arises from protecting the citizens of the United States from nefarious acts carried out against the U.S. and its citizens. The NRO was established as the threat of nuclear annihilation accelerated. In just over a decade before the establishment of the NRO in 1961, the Soviet Union became a nuclear power and engaged in the advancement of weapons systems that could deliver nuclear weapons to the United States with little warning. Throughout the first years of the Cold War between the U.S. and the USSR, the U.S. had little means to understand the development of those systems. With limited access to the USSR, the U.S. developed space reconnaissance systems to peer over the Iron Curtain and understand the extent to which Soviet nuclear weapons systems threatened the very existence of the nation.

The national security imperative born of the Cold War drove the National Reconnaissance Office to identify threats from Intercontinental Ballistic Missiles, Anti-Ballistic Missile systems, Strategic Long Range bombers, and the like to understand the strategic threat environment. In its second decade, the NRO expanded capabilities to understand international crises with timely and responsive technical collection. This capability allowed the U.S. to respond more rapidly to a crisis, as well as carry out activities to circumvent emerging crises.

More recently, the NRO has taken up new national security imperatives such as providing technical intelligence to those countering terrorism and to warfighters defending U.S. interests abroad. The NRO continues to develop highly innovative and technologically flexible collection systems to respond to new threats to U.S. national security and the safety of U.S. citizens and residents.

RISK-TAKING AND TOLERANCE

Just over a year before the NRO was established, the U.S. had recovered its first imagery from space. This effort did not come without significant risk-taking and tolerance. The U.S. attempted launches of Corona imagery collection satellites 13 times before the first mission was declared a success. More than a year and a half elapsed between the first attempt and the first success of the program, yet Corona program personnel steadfastly dedicated themselves to improving the Corona system. This level of persistence in face of doing something that had never been done before established an early cultural hallmark for the NRO of taking and tolerating risk.

Over the 60 years that the NRO has been in existence, its approach to risk management has afforded opportunities to develop dozens of new technologies and avenues for using space as a vantage point for technical intelligence collection. The NRO has consistently sought the most exquisite solutions that are technologically viable but also pushing the bounds of technology. Risk as a cultural hallmark of the NRO remains essential to the organization's success.

EMBRACING OPPORTUNITY

The use of space for intelligence collection emerged as a promising approach 15 years prior to the establishment of the NRO. It was only with the establishment of the NRO that the opportunities to collect intelligence from space grew into a fully integrated constellation of imagery, signals collection, and communications satellites. Along the way, the NRO embraced several technological opportunities including development of electro-optical and radar imagery, communications satellites, large data processing systems, and advanced signals collection systems. Each key technology provided the opportunity to embrace potential for better and more responsive intelligence collection.

The NRO has also consistently embraced management opportunities. With flexibilities arising from CIA authorities, the NRO engaged in novel acquisition approaches. The organization also embraced unique approaches to protect the secrecy of satellite systems. Systems integration and engineering emerged as key processes for advancing the nation's use of space for intelligence collection using NRO's satellites. The NRO avoided adhering to established policies and processes in favor of embracing new that would advance the organization's mission.

INDUSTRIAL PARTNERSHIPS

From its earliest days, the NRO has depended on the leading technology companies of U.S. industry to develop complex space systems. This unique industrial partnership is a key characteristic of the NRO culture. Industrial partners in the early years brought unsolicited solutions to intelligence collection challenges faced by the U.S. In developing systems, industrial and government employees worked together to develop new satellite systems in relationships of trust and respect.

Industrial employees continue to serve as essential members of the NRO community. They often work large portions of their careers on NRO projects. They bring fresh perspectives to the challenges of developing, launching, and operating space reconnaissance systems. In many instances, NRO employees from the space industrial base provide the "institutional memory" that is so important to successful organizations. Since its 40th anniversary, the NRO has recognized pioneers of national reconnaissance for their trailblazing contributions to development of NRO systems. The vast majority of those pioneers have been employed by industrial partners—a fact that confirms the importance of the industrial partnership in the cultural environment of the NRO.

CONNECTED LEADERSHIP

The NRO is one of the few organizations in the Federal Government where almost all employees have personal interaction with senior NRO leadership. Most employees assigned to work at the NRO can engage directly with the NRO Director. The DNRO does not have a security team or staff entourage that separates the director from the workforce. Most NRO directors and other senior leadership establish working relationships at all levels of the organization.

Historically, the NRO has been a "flat" organization with relatively few layers in its organizational structure. Additionally, most employees assigned to or working for the NRO have significant responsibilities given their grade levels. The structural efficiencies of the NRO organization allow for rich and rewarding experiences and interactions between multiple levels of the organization.

DEDICATED WORKFORCE

Above all else, the NRO culture is defined by a workforce that is dedicated to each other and to the success of NRO programs. In the early days of the NRO, those assigned to the organization worked long hours and days to develop the newest of technologies. Over the years, that work ethic has continued apace with significant devotion of NRO team members to organizational success. Launches at the NRO remain events that unify the workforce and afford mutual celebration of success. During the 40th anniversary of the NRO, banners read "One Team—Revolutionizing Space." These many years later, the dedication of this "One Team" of those working at the NRO should not be under-appreciated. The NRO workforce has grown and changed over the past 60 years, but it has retained one common feature, and that is dedication to *Supra Et Ultra*—together going "Above and Beyond" to protect the United States and its citizens and residents.

INNOVATIONS

GEOINT

IMAGERY FROM SPACE

BACKGROUND

In July 1955, the Soviet Union staged a deception that set the course for the United States to successfully obtain imagery from space. In 1954, Aviation Week reported that the Soviets had developed the Myasishchev M-4, or Bison bomber as it became known in the West. At the 1955 Aviation Day air-show held at Tushino Airfield northwest of Moscow, the Soviets carried out a highly effective deception operation. Knowing that western military attaches would attend the show, the Soviets flew 10 Bison bombers to impress the crowd. Unknown to those in attendance, the same 10 Bison bombers flew a second time over the crowd, followed by eight additional bombers. Thus, it appeared the Soviets had produced in a year's time a total of 28 bombers rather than the 18 they actually possessed—nearly a 30 percent difference. Based on the deception, the United States estimated that the Soviets would produce 800 bombers by 1960, a rate that would provide the Soviets with greater long-range bomber capability than the United States.

THE NEED FOR IMAGERY FROM SPACE

Although skeptical that the Soviets were capable of building more bombers than the United States, President Dwight Eisenhower did not have definitive intelligence to dispel the "bomber gap" in favor of the Soviets. He had approved the development of the U-2 in 1954, a jet-powered aircraft that could fly at speeds and altitudes that would evade Soviet air defenses. It proved to be just the resource needed to obtain definitive evidence of Soviet bomber production capabilities. On 9 July 1956, the U-2 obtained an image of an airfield near Leningrad with 30 Bison bombers. Subsequent U-2 imagery of other Soviet airfields confirmed the Bison bombers were limited to just that single base. The imagery served as conclusive intelligence for a new estimate that affirmed the United States maintained the advantage in the production of long-range bombers.

By the 1960 presidential election, two events took place that again raised concerns about the Soviets out-pacing the U.S. in strategic nuclear capabilities, this time the production of nuclear missiles. The first event occurred on 4 October 1957, when the Soviet Union launched the first man-made satellite known as Sputnik 1. Although the Soviets had publicly touted their efforts to launch a satellite, they surprised the world with the launch. Troubling to many was the realization that if the Soviets could launch an object into space, they could potentially launch a nuclear weapon against the U.S. or its other adversaries. The second event was the downing of Francis Gary Powers' U-2 over the Soviet Union on 1 May 1960. The downing of that flight led President Eisenhower to cancel all future overflights of the Soviet Union, briefly leaving the U.S. without one of its most reliable intelligence sources.

FIRST STEPS

However, the U.S. had already made a critical commitment to create a new intelligence collection system in 1954, the development of a satellite. The program, eventually known as Satellite Missile Observation System (Samos), got off to a slow start, but was accelerated after the Sputnik launch. In February 1958, President Eisenhower approved rapid development of an imagery satellite branching off the Samos program. After 13 unsuccessful launch efforts beginning in January 1959, the Corona satellite successfully returned imagery from space in August 1960. It was just in time to fill the void left by the cancellation of U-2 flights over the Soviet Union.

Corona was designed to take images of broad areas of the Soviet Union and other denied areas of the world of concern to U.S. policymakers. By the time of Corona's first successful launch, the United States was in the depths of the 1960 presidential election between Richard Nixon and John F. Kennedy. Kennedy alleged that the Soviets were out-pacing the U.S. in nuclear missile production while on President Eisenhower and Vice-President Nixon's watch. Just prior to Election Day, Corona had in just a few short weeks obtained enough imagery to dispel Kennedy's allegations of a missile gap. However, Corona was one the U.S.'s most closely guarded secrets and Eisenhower did not release evidence to dispel Kennedy's claims during the heated presidential election. The satellite imagery intelligence capability was too sensitive to reveal, even in a race for the U.S. presidency.

THE EVOLUTION OF SATELLITE IMAGERY SYSTEMS

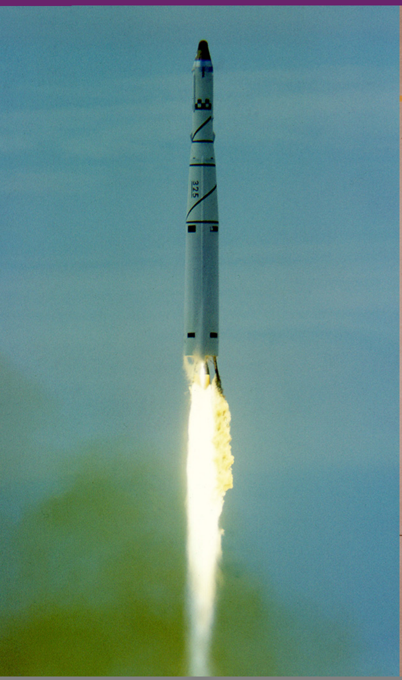
The Corona system, developed jointly by the CIA and Air Force, first could obtain images of objects about 40 feet in size, and by the end of the program, that capability improved to obtaining images from space of objects about six feet in size. Corona became an important source of collecting intelligence on issues of concern to U.S. officials such as adversaries' missiles, aircraft, naval vessels, and military installations. By 1971, the U.S. launched a follow-on satellite to Corona known as the Hexagon. Hexagon was one of the U.S.'s largest reconnaissance satellites, approximately the size of a train locomotive, with about 250 times more imaging capacity than the first Corona. It showed a vast improvement over Corona's imagery resolution with the ability to identify objects from space of about 1.5 feet in size.

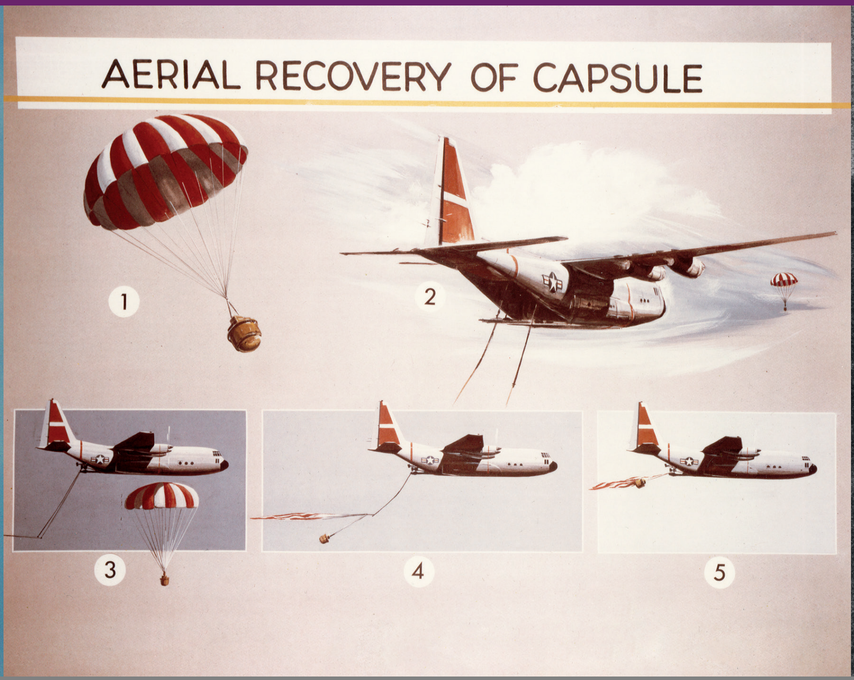
While Corona and Hexagon were excellent for identifying large objects from space to detect the capabilities of the U.S.'s adversaries, more detailed imagery granularity was needed. To that end, the NRO developed a high-resolution satellite, known as Gambit, to pinpoint specific qualities and characteristics of objects of interest. Launched first in 1963, the Gambit photoreconnaissance satellite could initially capture images of objects about 4 feet in size. Gambit's resolution improved to capturing objects about 2 feet in size when, in 1966, it was replaced by an improved Gambit-3 system. The Gambit-3 system evolved throughout its lifespan until its last launch in 1984. By then, the Gambit had the ability to image objects smaller than one foot in size. The combination of the broad area search satellites with the high-resolution satellites like Gambit allowed the U.S. to identify not only increases in Soviet weapons systems, but also technological improvements they were making to those systems.

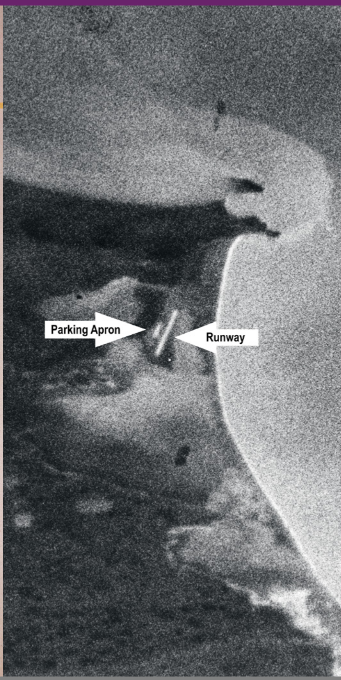
The NRO spearheaded additional satellite reconnaissance capabilities that were key innovations for intelligence collection from space. For instance, in 1964, NRO launched an experimental satellite, known as Quill, which proved radar data could be processed into images. This established a foundation for the U.S. to image areas of concern where U.S. adversaries often used techniques and actions to disguise their capabilities or activities.

In 1976, the NRO's first electro-optical satellite, known as Kennen, was launched. Kennen produced the first digital images, rather than film-return images used on earlier satellites that had to be returned to Earth and processed. Kennen allowed the U.S. to capture images in "near real-time" rather than waiting days and weeks to process images from the earlier film return systems. With Kennen, the NRO provided an intelligence collection system that provided more timely intelligence for the President, senior policymakers, military commanders, and eventually the warfighter, starting in the 1990s and the Gulf Wars. Kennen also provided early investment in digital photography—a capability now used by most Americans every day. NRO has been, and continues to be, one of the original pioneers in the design and development of satellite technology and innovation.

CORONA





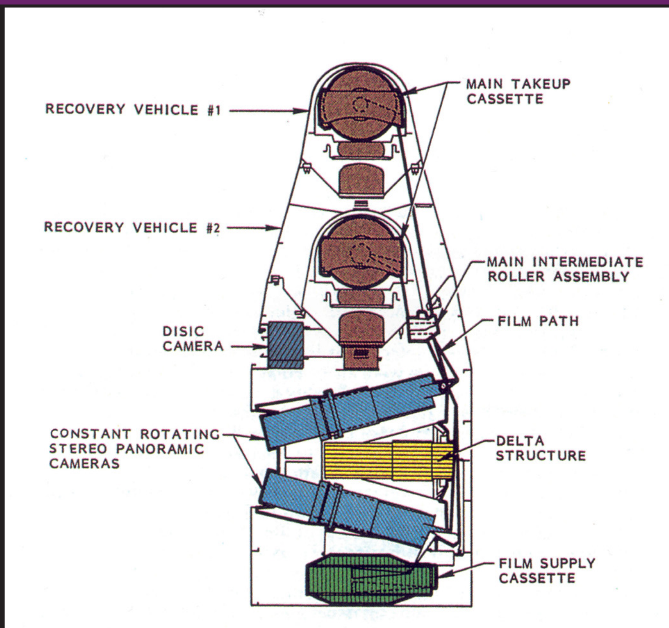


ORIGINS OF PHOTORECONNAISSANCE

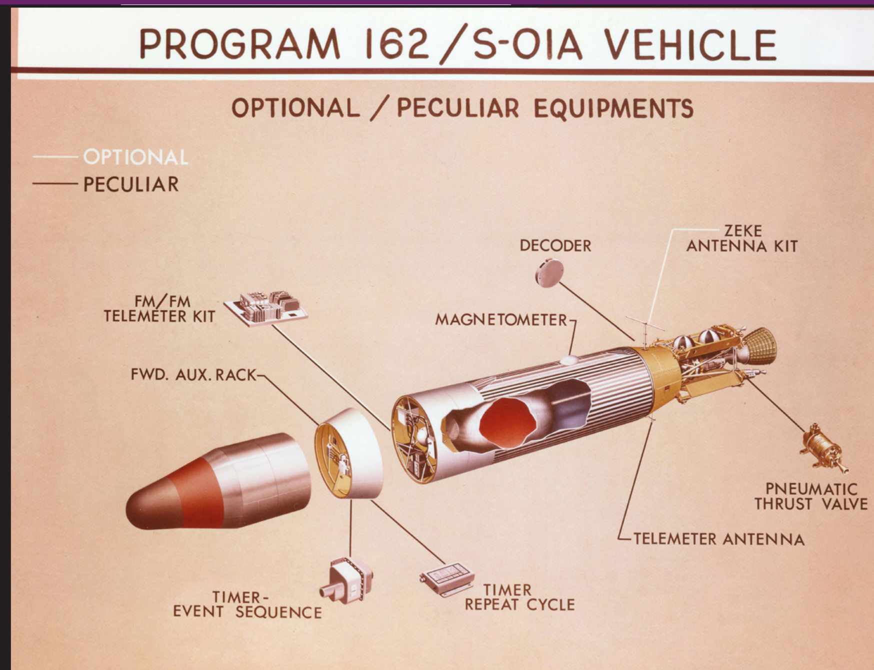
Following World War II, the United States identified the need for photoreconnaissance capabilities that could penetrate denied areas in the Soviet Union, Eastern Europe, and Asia. To that end, in February 1958, President Eisenhower endorsed the Corona project. Developed by the CIA and Air Force, Corona was a satellite imaging reconnaissance system that took pictures from space as it passed over denied territories like the Soviet Union. To obtain the images, the satellite would periodically "deorbit" and drop a film capsule, which was picked up in mid-air by a C-119 aircraft for transport back to CIA's National Photographic Interpretation Center (NPIC). Unlike its predecessors, the U-2 reconnaissance plane and the A-12 supersonic aircraft, Corona operated with far less risk since imagery was acquired from space. After Corona's first launch in 1960 until the program's retirement in 1972, the U.S. Intelligence Community (IC) refined photoreconnaissance under the program, which had an unprecedented impact on IC collection and national security policy.

PHOTORECONNAISSANCE SYSTEM ENHANCEMENTS

Corona operated for a little more than a decade, but it acquired photographic coverage of 750 square nautical miles of the Earth's surface and its early years were marked with rapid advancements. Between August 1960 - 1963, Corona went from a single camera system that produced a limited imagery resolution of 25 to 45 feet to a twin panoramic camera system that produced imagery with a resolution of 6 to 10 feet. Imagery users referred to Corona reconnaissance satellites by a Key Hole (KH) designator assigned to each new camera system as its capabilities were enhanced over time--starting with KH-1, KH-2, and so on. Notably, the KH-4 camera systems were the first to provide stereoscopic imagery, which allowed the IC to significantly increase collection content. The 30 degree convergent angle for stereo photography enabled measuring vertical and horizontal dimensions of the Earth's surface, which improved overall system dynamic balance and expanding mission durations.

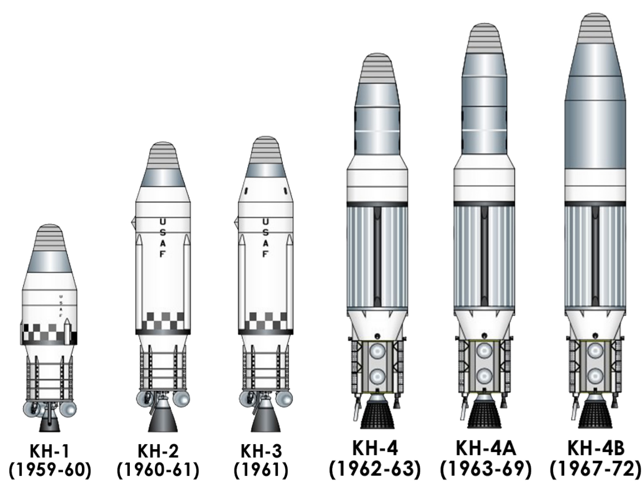


Major Components of the J-3 System



CONTRIBUTIONS TO NATIONAL SECURITY

The Corona program was operational from 1960 to 1972 and was instrumental in identifying military activities of interest to U.S. policymakers. As the only operational imaging-reconnaissance satellite until the launch of Gambit-1 in 1963, Corona imaged multiple targets in hostile areas yielding invaluable intelligence on Soviet targets. Corona identified and imaged all Soviet medium-range, intermediate-range, and intercontinental ballistic missile launching complexes. With Corona's imagery, analysts dispelled the myth that the U.S. lagged behind the USSR in missile production – the so called "missile gap." Using Corona imagery, analysts were also able to identify the main Soviet construction site for ballistic-missile-carrying submarines at Severodvinsk. The Corona program propelled the United States into an unparalleled position of dominance in photoreconnaissance capabilities that ultimately helped the U.S. win the Cold War. In 1995, President Clinton declassified the Corona program.

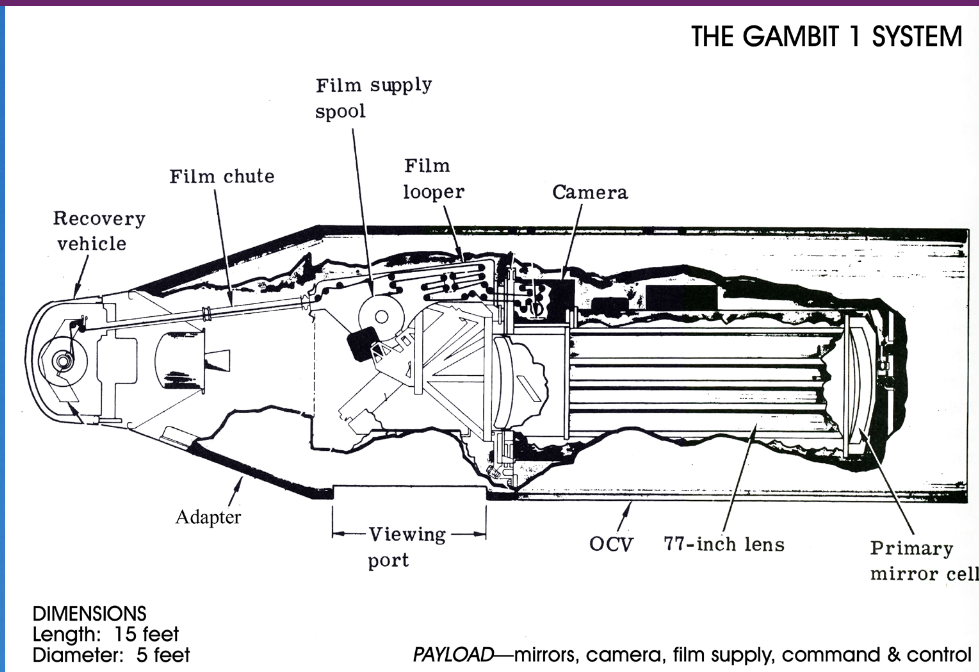


CORONA'S KH EVOLUTION

1959 – 1961: KH-1, KH-2, KH-3
Lens: 24-inch focal length
Film Length: 1,200 to 5,000 Feet
Image Resolution: 20 - 40 Feet
One Film Recovery Capsule

1961 – 1972: KH-4, KH-4A, KH-4B
Lens: 24-inch focal length
Film Length: 5,000 to 48,000 Feet
Image Resolution: 6 to 10 Feet
One or Two Film Recovery Capsules

GAMBIT 1 (KH-7)



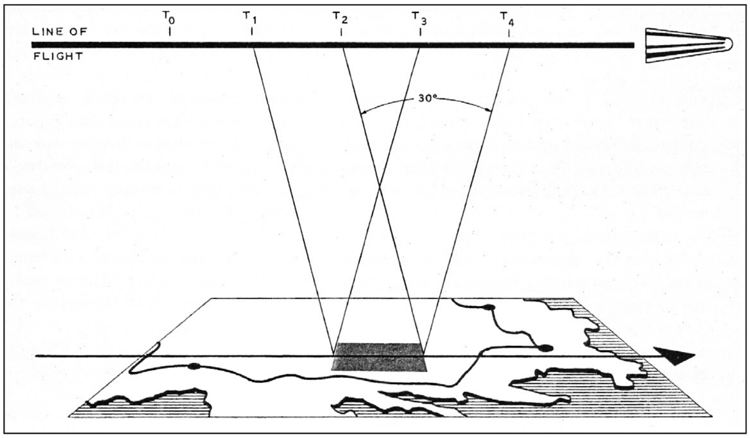
ORIGINS OF PHOTORECONNAISSANCE

Following World War II, the United States developed new photoreconnaissance capabilities to penetrate the denied areas in the Soviet Union, Eastern Europe, and Asia. President Eisenhower directed the Central Intelligence Agency to develop the U-2 reconnaissance plane, and later the more innovative supersonic A-12, in order to improve the nation's photoreconnaissance capabilities. He also directed the CIA to develop, in conjunction with the U.S. Air Force, the nation's first photoreconnaissance satellite, codenamed Corona. First launched in 1960, Corona operated with much less risk than photoreconnaissance aircraft and searched broad areas to capture incredibly valuable imagery while orbiting high above the Earth. These air and space platforms propelled the United States into an unparalleled position of dominance in photoreconnaissance capabilities that helped the U.S. win the Cold War.

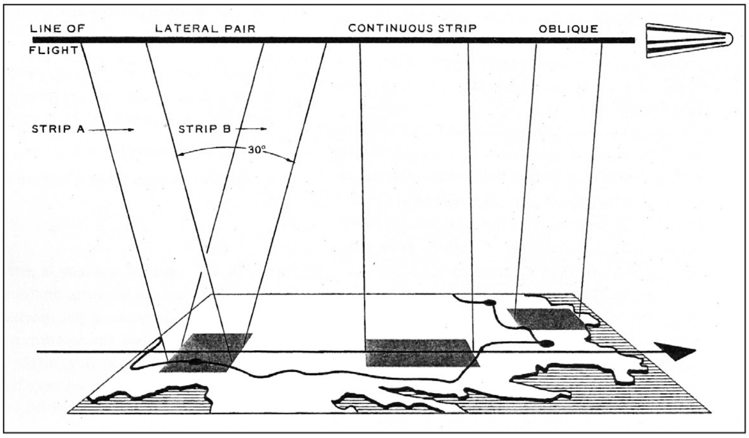
INTELLIGENCE NEED FOR PHOTORECONNAISSANCE

Although Corona provided the capability to search large areas from space, the U.S. still lacked high-resolution imagery. Approximately one year after the first launch of Corona, the National Reconnaissance Office began development of its first high-resolution satellite program, codenamed Gambit. The first Gambit system, launched in 1963, was equipped with the KH-7 camera system that included a 77-inch focal length camera for providing specific information on scientific and technical capabilities that threatened the nation. Intelligence users often characterized this capability as surveillance, allowing the United States to track the advancement of Soviet and others' capabilities. Over time, the Gambit program evolved into a second generation system.

Eastman Kodak Corporation provided an unsolicited proposal, named Sunset Strip, in the summer of 1960 to the Department of Defense program under the direction of Dr. Joseph Charyk, who would later become a Director of the National Reconnaissance Office. Kodak was already involved in the U.S. Air Force's Samos satellite program to develop reconnaissance satellites including photoreconnaissance satellites. After review, Dr. Charyk and other senior leaders found the proposal promising and initiated development of



STEREO OPERATION SCHEMATIC.



OPERATING MODES KH-7 CAMERA SYSTEM.

a high resolution satellite within a year of the initial success of the Corona photoreconnaissance satellite. By the time the NRO was formed in September 1961, the satellite was under development in the Air Force's Program A, now housed at the NRO. Less than two years later the Gambit satellite, named after an opening move in chess, provided the United States its first high-resolution imagery from space.

The United States depended on these search and surveillance satellites to understand the capabilities, intentions, and advancements of those who opposed the United States during the Cold War. Together they became America's essential eyes in space.

Gambit 1 provided the U.S. with close-in surveillance from July 1963 - June 1967

PROGRAM FACTS

Missions: 38 (28 successes)
Average Mission Life: 6.6 days
Imaging Days: 1-8.1 days
Altitude: 60-150 nautical miles
Roll Control: attitude control gas
Payload Weight: 1,154 lbs
Image Retrieval: Film Return Capsule

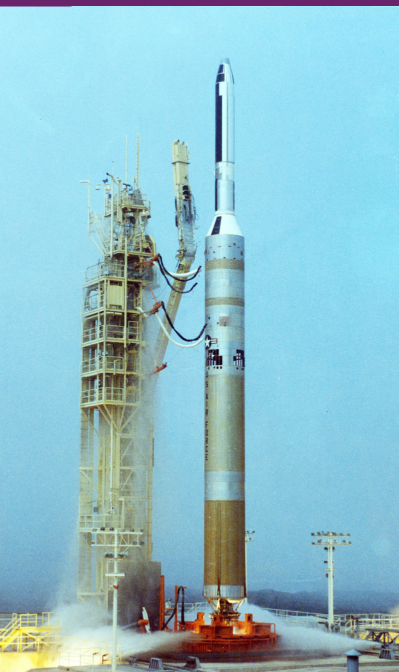
OPTICS/IMAGING

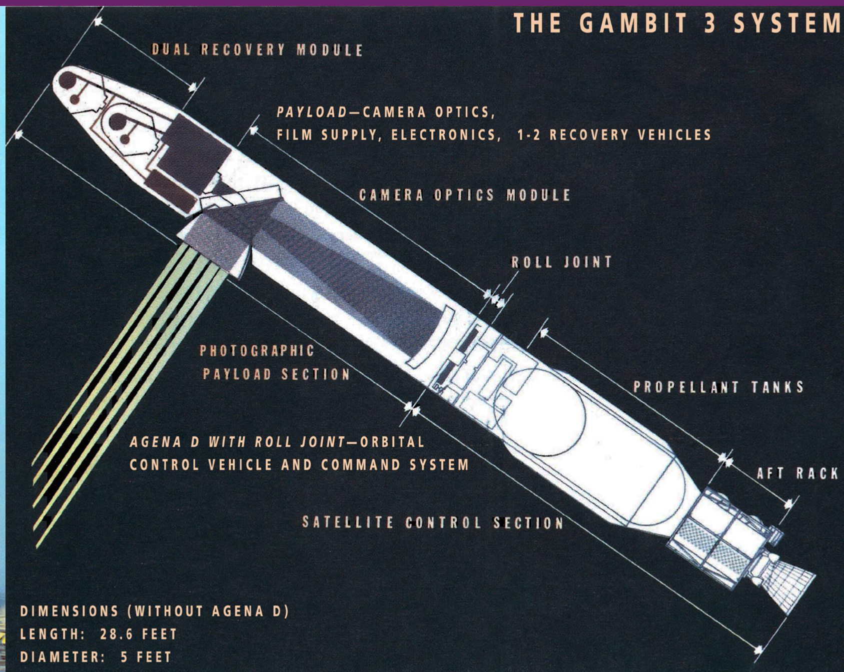
Aperture: 19.5 inches
Focal Length: 77 inches
Camera Developer: Eastman Kodak
Lens: f/4.0
Image Resolution: 3-2 feet
Film Length: 3,000 feet
Film Width: 9.46 inches

ADVANCEMENTS

Thin film permitted longer missions. The roll capability and stereo cameras enabled increased target acquisition and gave images a three-dimensional quality.

GAMBIT 3 (KH-8)





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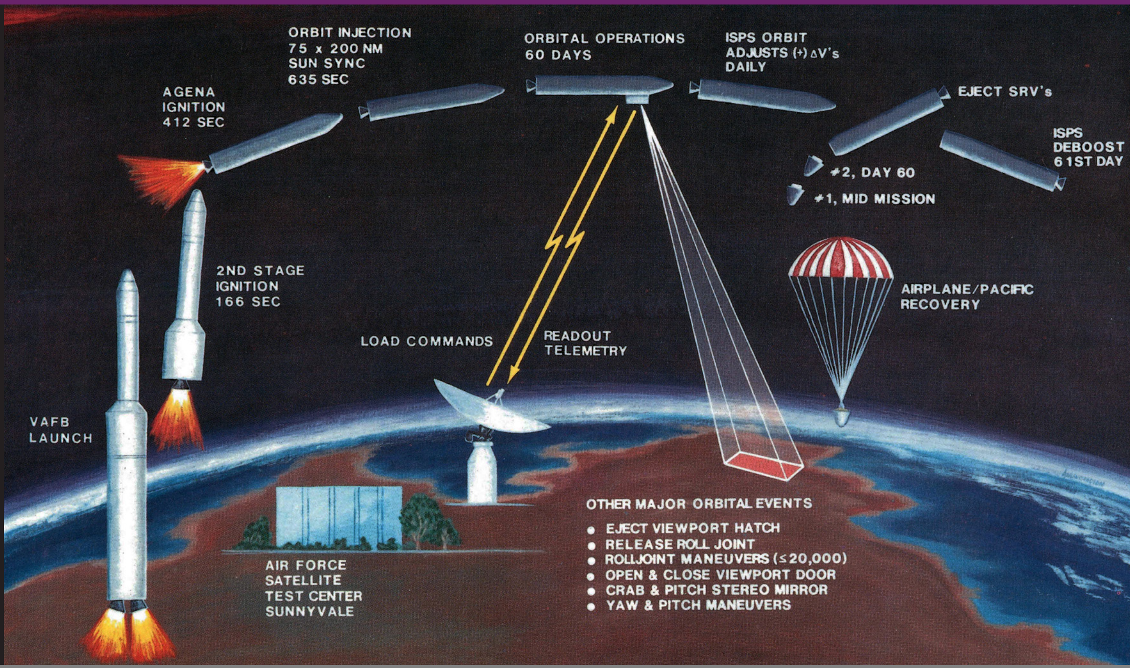
Kodak had proposed four generations of Gambit satellites. The NRO's Air Force Program A, responsible for Gambit development, determined that the second generation did not provide significantly improved capabilities. Foregoing the second generation, Program A leadership opted for developing the third proposed generation, or Gambit 3, that would eventually allow the U.S. to obtain images from space of objects less than one foot in size. The fourth proposed Gambit generation required technological advances that were not possible at the time it was considered and therefore not pursued by the NRO's Program A.



LAUNCH, OPERATION, AND RECOVERY SEQUENCE FOR GAMBIT 3
Film-return photo-reconnaissance satellites returned the exposed film to Earth from space in a bucket with a heat shield designed to withstand the entry through Earth's atmosphere.

The second generation Gambit 3 photoreconnaissance satellite was equipped with the KH-8 camera system that included a 175- inch focal length camera. The system was first launched in 1966 and provided the U.S. with exquisite surveillance capabilities from space for nearly two decades.

The United States depended on these search and surveillance satellites to understand the capabilities, intentions, and advancements of those who opposed the United States during the Cold War. Together they became America's essential eyes in space.

PROGRAM FACTS

Missions: 54 (50 successes)
Average Mission Life: 31 days
Imaging Days: 5-126 days
Altitude: 65-90 nautical miles
Roll Control: mechanical roll joint
Payload Weight: 4,130 lbs
Image Retrieval: Film Return Capsule

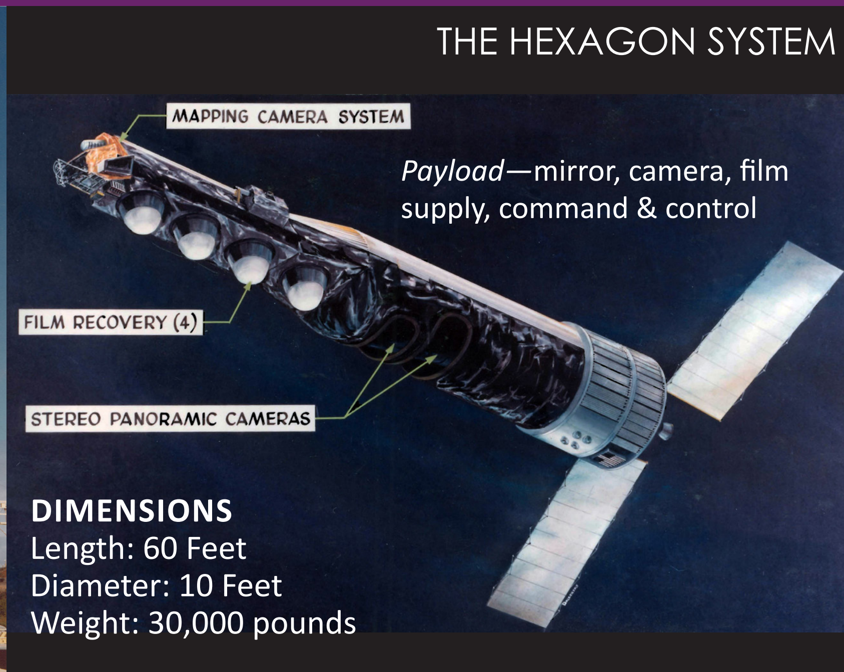
OPTICS/IMAGING

Aperture: 43.5 inches
Focal Length: 175 inches
Camera Developer: Eastman Kodak
Lens: f/4.09
Image Resolution: better than 2 feet
Film Length: up to 12,241 feet
Film Width: 5 inches and 9 inches

ADVANCEMENTS

The roll joint integrated with the attitude control resulted in extremely stable body rates, zero settling times, and improved expendables management—significantly increasing the number of targets it acquired.

HEXAGON (KH-9)



ORIGINS OF PHOTORECONNAISSANCE

Following World War II, the United States developed new photoreconnaissance capabilities to penetrate the denied areas in the Soviet Union, Eastern Europe, and Asia. President Eisenhower directed the Central Intelligence Agency to develop the U-2 reconnaissance plane, and later the more innovative supersonic A-12, in order to improve the nation's photoreconnaissance capabilities. He also directed the CIA to develop, in conjunction with the U.S. Air Force, the nation's first photoreconnaissance satellite, codenamed Corona. First launched in 1960, Corona operated with much less risk than photoreconnaissance aircraft and searched broad areas to capture incredibly valuable imagery while orbiting high above the Earth. These air and space platforms propelled the United States into an unparalleled position of dominance in photoreconnaissance capabilities that helped the U.S. win the Cold War.

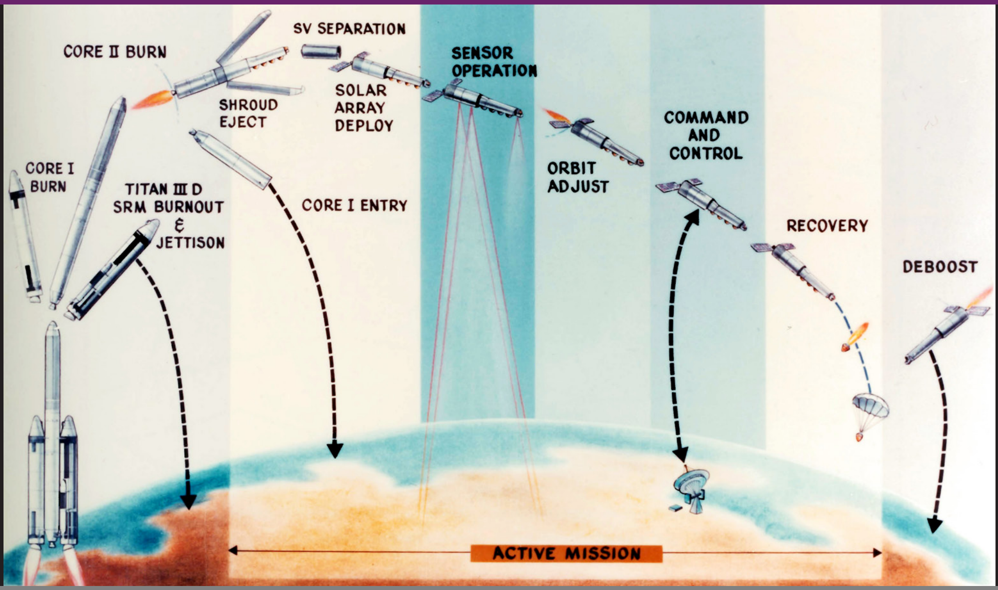
INTELLIGENCE NEED FOR PHOTORECONNAISSANCE

Although Corona provided the capability to search large areas from space, the U.S. still lacked high-resolution imagery. Approximately one year after the first launch of Corona, the National Reconnaissance Office began development of its first high-resolution satellite program, codenamed Gambit, first launched in 1963.

By the end of the 1960s, the CIA explored the development of a satellite that could obtain both wide area search imagery and high-resolution imagery under their Fulcrum program. If successful, the new satellite would replace both the Corona and Gambit satellites. The program was transferred to the NRO's Program B responsible for CIA satellite development efforts and renamed Hexagon. Although the Hexagon satellite provided significantly improved search capabilities, it did not match the high-resolution imagery capabilities of Gambit.

The NRO launched the first Hexagon satellite in 1971 to improve upon Corona's capability to search broad and wide denied areas for threats to the United States. The system sometimes carried a mapping camera to aid in U.S. military war planning.

The United States depended on these search and surveillance satellites to understand the capabilities, intentions, and advancements of those who opposed the United States during the Cold War. Together they became America's essential eyes in space.



LAUNCH, OPERATION, AND RECOVERY SEQUENCE FOR HEXAGON
After a parachute slows the bucket's decent, an airplane would capture the bucket mid-air.

Hexagon provided the U.S. with impressive broad-area search & mapping capabilities from June 1971 - April 1986

PROGRAM FACTS

Missions: 20, 12 with the MCS (19 successes)
Average Mission Life: 124-day average
Imaging Days: 31-270 days
Altitude: 80-370 nautical miles
Roll Control: attitude control gas
Payload Weight: 7,375 lbs
Image Retrieval: Film Return Capsule
Program Coverage: 877 million square miles

PANORAMIC OPTICS/IMAGING

Aperture: 20 inches
Focal Length: 60 inches
Camera Developer: Perkin-Elmer
Lens: f/3.0
Image Resolution: 2-3 feet
Film Length: 320,000 ft (60 miles)
Film Width: 6.6 inches

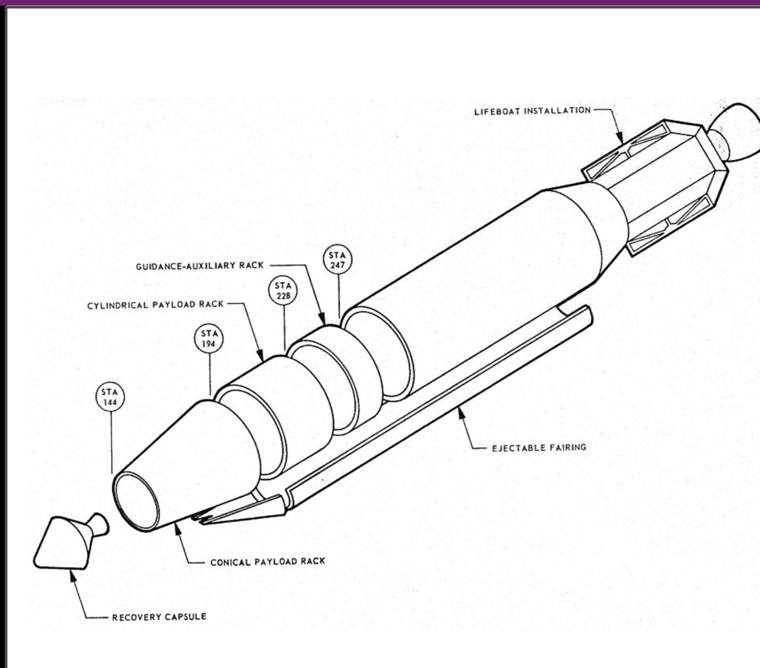
MAPPING OPTICS/IMAGING

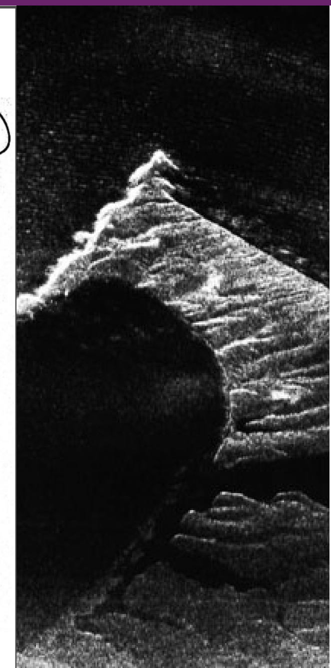
Camera Developer: Itek
Lens: f/6
Focal Length: 12 inches
Image Resolution: 30-35 feet

ADVANCEMENTS

Hexagon, with its multiple recovery buckets and extended mission life, moved the U.S. closer to achieving continuous space imaging capability. Hexagon's primary panoramic camera provided improved search coverage and resolution. Hexagon's mapping camera provided global geodetic positioning, accurate point locations for military operations, and data for military targeting.

QUILL





ORIGINS OF QUILL

Despite the successes of the Corona and Gambit programs, they suffered some significant limitations. They could not obtain imagery at night or in poor weather conditions. Because both Corona and Gambit imagery was obtained via capsule returned from space, imagery from the systems could not be obtained quickly. The NRO was searching for solutions to those limitations. One of those was data transfer from orbit, which had proven successful with Sigint satellites such as GRAB.

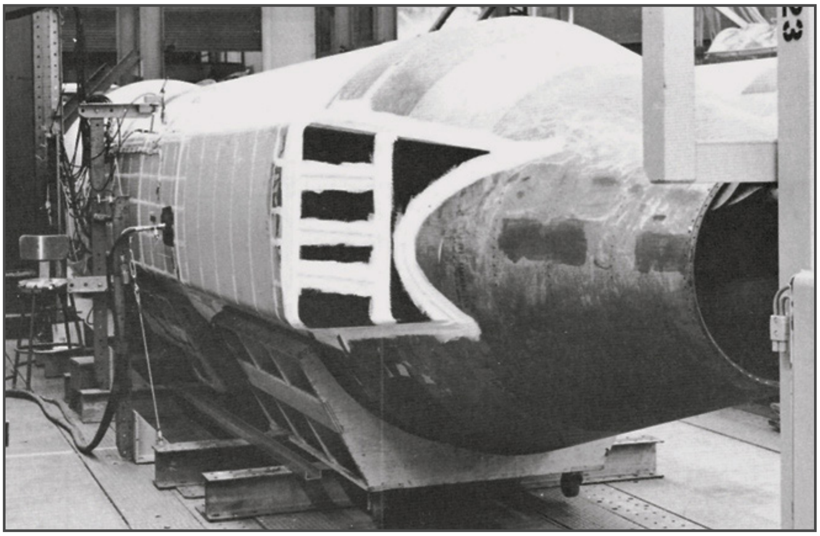
The other was the use of radar returns for manipulation into imagery, which the Army and Air Force had proven as a successful imagery approach using airborne platforms. Radar returns could travel through bad weather and night. Quill was born under these conditions in 1962.

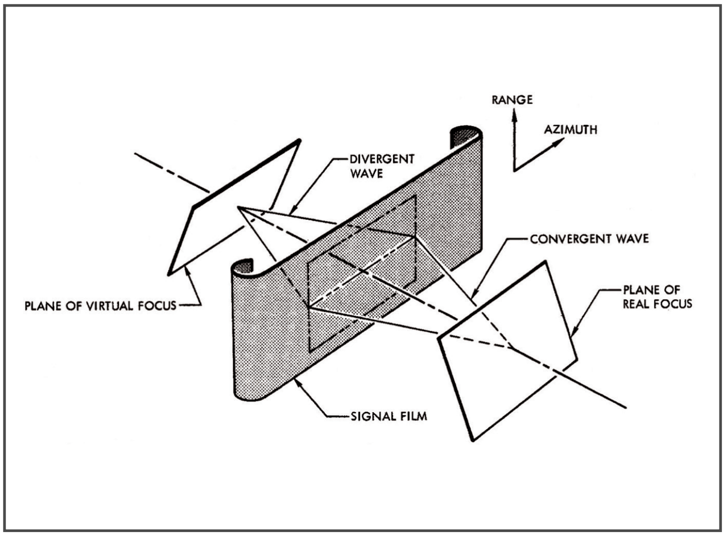
Major David Bradburn was assigned as the Quill Program Director. Bradburn worked diligently with Goodyear Aerospace and Lockheed Missiles and Space Companies to develop the Quill system. They were able to modify a number of existing radar and space vehicle components to integrate the system, saving time and money. By 21 December 1964 NRO launched the first and only Quill, and the launch was highly successful.

All the systems worked as planned. Quill was unique in that imagery would be derived from both film de-orbited from the space vehicle, using a Corona film-return system, and a radar data downlink that would be processed to create imagery on the ground. The two sources would then be compared for effectiveness. The first launch and operation of the satellite was so successful that a second launch was deferred indefinitely.

INTELLIGENCE NEED FOR QUILL

Quill was a trailblazer. The program demonstrated that the NRO could take existing sensor technology, modify it for use in space, marry it with other specialized hardware for national reconnaissance programs, and demonstrate the potential for new intelligence collection. Quill blazed the trail in technologies that could collect images day or night and through cloud cover. Quill was also run by then-Major David Bradburn, who would go on to become a senior leader of the NRO and major contributor to other successful program efforts at the NRO. The then-young NRO needed a program that could be turned quickly from concept to operation, and Quill blazed that trail leaving a stronger, more confident NRO.





QUILL

Experimental Radar Satellite - December 1964
Manufacturer: Lockheed & Goodyear

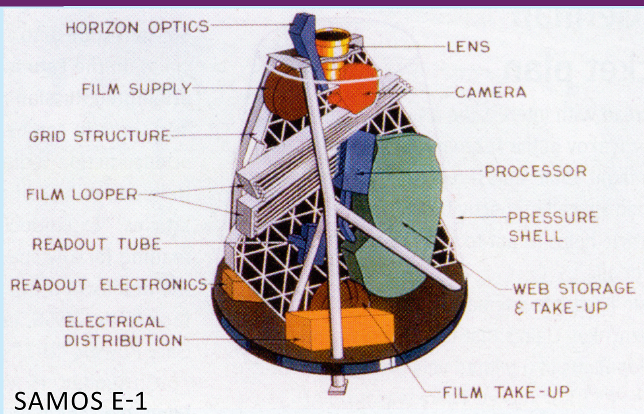
On 21 December 1964, the first and only Quill satellite launched on a thrust-augmented Thor booster and an Agena upper-stage from Vandenberg. Quill's experimental mission would last only 96 hours. During that time the KP-II radar would operate no more than five minutes per orbit, and for no more than three orbits in succession. Three silver-zinc batteries powered the unit, providing a maximum of 80 minutes of synthetic aperture radar (SAR) collection. These parameters would allow the vehicle to achieve its mission goals. Vandenberg was equipped with video display monitors to determine if Quill was operating and transmitting properly. During Quill's seventh orbit, Vandenberg tracking station personnel began to receive radar returns on its monitors, declaring Quill operational. The data returned from Quill proved that radar imagery could be collected from space, and NRO determined a second experimental mission was not needed. Although the Quill experiment was a success, it would be several decades before radar satellites became part of NRO's satellite constellation.

The proven flight package of a thrust-augmented Thor booster and an Agena D upper stage would carry Quill KP-II radar into space. Lockheed engineers expected the Agena to provide sufficient stability for its integrated KP-II payload to function effectively. This allowed them to opt for the simple solution of flush-mounting the radar antenna onto the Agena's outer surface. The 15-foot antenna occupied nearly the entire right side of the Agena, protruding about 2.5 inches from its surface once covered by a protective fairing.

ADVANCEMENTS

The Quill experimental radar imaging satellite was the first space-based system to use SAR to determine if radar could acquire ground images through clouds and in darkness. The SAR for this proof-of-concept satellite was developed as a way for the Air Force to assess post-strike damage in the event of a nuclear war. The technology was "off-the-shelf," adapted from a pulsed Doppler system being developed for a USAF reconnaissance aircraft.

KENNEN



SAMOS E-1


SAMOS E-2 LAUNCH


KENNEN LAUNCH - 1976

CRISIS DECISION-MAKING AND SPACE IMAGERY

Following the successful capture of imagery from space in 1960, the U.S. President and other leaders of the nation became increasingly dependent on space imagery for making key decisions. The early U.S. photoreconnaissance satellites, Corona and Gambit, shared common weaknesses with respect to supporting making decisions during international crises: both relied on film-return systems that meant captured imagery, at best, would be in the hands of decisionmakers within days of a crisis breaking out; and, both conducted relatively short, expendables-limited missions that required frequent launches, potentially leaving the U.S. with no satellite orbiting to obtain imagery as the crisis unfolded. The Strategic Air Command (SAC), in particular, was interested in rapid response imagery to assess escalating tensions that might lead to a nuclear weapons exchange with the Soviets. Thus the U.S. faced a daunting challenge in the late 1960s to develop a reliable near real-time imagery system.

CRISES RESPONSE PROVES INADEQUATE

Perhaps the first call for quicker photoreconnaissance from space arose from the 1962 Cuban Missile Crisis. The NRO orbited Corona systems near the end of September 1962 and the beginning of November that same year. Neither system could provide imagery during the October crisis. Another example was the Soviet invasion of Czechoslovakia in the fall of 1968, where a NRO satellite did obtain relevant imagery of Soviet troops massing on the Czech border, but the imagery was not available until the crisis was over and the imagery's relevance was overcome by events. Out of frustration over his inability to obtain clear intelligence on the placement of Soviet weapons systems in the Suez Canal zone during 1970, President Richard Nixon pressed for obtaining near real-time imagery from space. His administration was focused on limiting Soviet presence in the area, but had no reliable, time-sensitive source of intelligence on the Soviet activity. Near real-time imagery from space would address that issue.

EARLY NEAR REAL-TIME IMAGERY DEVELOPMENT

When the U.S. established the nation's first reconnaissance satellite development program that would eventually be known as Samos in 1956, program leaders proposed film-return satellite designs that would bear fruit in the Corona, Gambit, and Hexagon satellite systems. Samos program managers also pursued a film readout design, proposed by Eastman Kodak Company, which would provide imagery in a matter of hours, instead of the days and weeks required for the early film-return systems. The systems, known as E-1 and E-2, would rely on an on-orbit chemical photo development process—somewhat like the instant photography process that would become a commercial success for the Polaroid Corporation. Once the images were developed on orbit, an image scanner would scan the image and transmit segments of the image to ground stations where the image would be processed.

The system faced a number of daunting challenges given late 1950s and early 1960s technology. First, the chemical photo development process was new by earth-bound standards and was even more complicated in the vacuum of space. Second, the mechanics of developing an image and then scanning it in space required a very complex machine. Third, there was very limited storage and bandwidth for transmitting an image during the narrow windows when a satellite was within range of a ground station. The efforts to obtain space imagery using the film readout system proved too daunting, and the National Reconnaissance Office cancelled the film readout program elements after a single on-orbit operation of the E-1 proved the feasibility of the innovative technology, but also its limitations. The NRO turned its attention to improving film-return systems.

PERSISTENCE OF FILM READOUT TECHNOLOGY

The Samos film readout technology inherited by the NRO persisted despite the program's cancellation due to requirements from National Aeronautics and Space Administration (NASA) and the U.S.' efforts to send astronauts to the Moon by the end of the 1960s. One key requirement for successfully landing Apollo program astronauts on the Moon was detailed imagery of the Moon's surface. The Soviets had successfully imaged the back side of the Moon in 1959 using technology similar to the E-1 film readout system.

In 1963, NASA solicited proposals for a lunar imagery system that could image the Moon's surface to identify appropriate landing sites for Apollo program astronauts. Boeing Corporation partnered with Eastman Kodak for their proposal. The Boeing/Kodak proposal relied on the film development system used in the Samos E-1 system. NASA's source selection board judged the Boeing/Kodak proposal superior to the other four proposals primarily because its semi-dry chemical development process was less vulnerable in the vacuum of space compared to wet chemical processes proposed by the competitors. The Samos-based innovative film development process was incorporated into NASA's Lunar Imager system that successfully returned lunar images, helping to enable Apollo landings.

In July 1963, NRO's Program A successfully orbited the Gambit high-resolution imagery satellite. Gambit served as a companion to Corona. Whereas Corona obtained images of areas and objects of intelligence interest, the Gambit system imaged those areas and objects at high resolution to obtain intelligence specifics. Gambit eventually obtained imagery of objects and characteristics smaller than one foot in size, giving the U.S. a tremendous intelligence advantage in better understanding developments in the closed Soviet Union.

A number of crises prompted U.S. leaders to ask if satellite imagery was or could be available to assist in crisis decision making. In most cases, the NRO could not provide imagery quickly enough to support decision making during emergencies. The requests, though, prompted Program A officers to think of innovations to provide near real-time imagery that could assist in crisis decisions. They continued to investigate potential improvements in film readout technology first proven in the Samos program. More importantly, Program A officers advocated marrying such technology with the innovative high-resolution Gambit optical system. Such a marriage would significantly advance U.S. crisis management capability through timely high-resolution imagery. Program A called the system Film Readout Gambit or FROG.

KENNEN: THE NEAR REAL-TIME IMAGERY SOLUTION

In 1968, the CIA's Program B at the NRO began development of a highly innovative approach for obtaining imagery from space. Rather than relying on film at all, the Program B engineers pursued development of a digital optical system. Earlier proposals for putting a video camera in space preceded Program B's thinking on non-film based imagery systems. Their approach was highly unique and required a completely new kind of camera system—one not even developed for use on Earth at the time.

Program B's approach required a number of technological breakthroughs for the system to work. The first was the optical system itself. CIA pursued the first two types of new digital technology: a photo diode array and a photo transistor array. Either approach would avoid many of the pitfalls of depending on film-based systems in space and would open the possibility of reducing the time to obtain space imagery from weeks and days to hours and minutes. Both approaches required major technological breakthroughs to achieve revolutionary near real-time imagery capability from space.

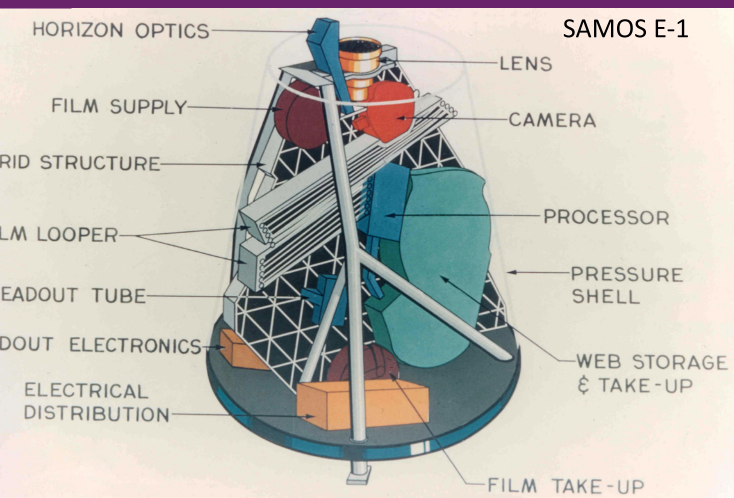
Another significant innovation advanced by Program B was the introduction of relay satellites to assist in transferring the image from the imagery satellite to the ground station, where it could be processed and exploited. Previous approaches to more rapid imagery from space had been hampered by the short time in field of view of ground stations. The relay satellite solved this problem, as it was placed in a geosynchronous orbit within the constant field of view of the ground station.

Program B developed the program concept so that by the early 1970s they were confident to invest in the new innovative digital imagery program. Program A continued to advocate for their FROG system, arguing that it was less risky and could be procured more quickly. Elements of the Department of Defense, CIA, and Office of Management and Budget debated the merits of both programs. Eventually, both choices were presented to President Richard M. Nixon, and he approved the Program B proposal, which would be known as Kennen, on 23 September 1971. The name Kennen was chosen by NRO Deputy Director Bob Naka adopting the German verb "to know" as the program name.

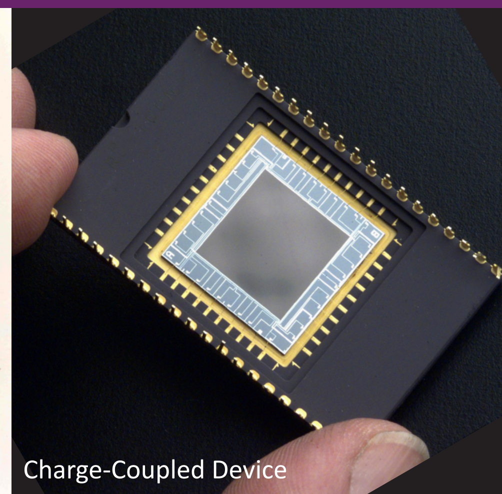
Nixon approved the program with the understanding that it would provide imagery by the end of what he hoped would be his second presidential term in 1976. Program B did launch the first Kennen satellite in December 1976, but the first imagery was delivered to newly inaugurated President Jimmy Carter at his first intelligence briefing after being sworn in as President in January 1977.

Program B's initial efforts established a foundation for development and adoption of the optical systems' charge-coupled device (CCD), a completely new technology for imagery. The charge-coupled device would evolve further for commercial use in digital video cameras and other commercial applications after the NRO's heavy investment in CCD technology. A new era of digital photography began.

DIGITAL IMAGERY



SAMOS E-1


Charge-Coupled Device


Kennan Launch - Dec 1976

EARLY U.S. ELECTRONIC SPACE IMAGERY EFFORTS

The Air Force's satellite reconnaissance efforts originated from the WS-117L program, which was created in 1954 by the Air Research and Development Command. One of the programs started in WS-117L was the Samos project, which began development of satellites with both Imint and Sigint payloads and investigated both film-based and electronic imagery systems. In late 1957, it was decided that technology for imagery transmission was still years away, and the film-based system was much closer to being realized. The two projects were separated, and the film-based project was broken away into what soon became the Corona program, which started returning imagery to Earth three years later.

Meanwhile, scientists and engineers continued to work on electronic imagery with Samos. They developed an analog system, called the E-1, that worked but had significant shortcomings that proved too insurmountable to be used in an intelligence satellite. Early studies showed the time needed to transmit the images to Earth was the main impediment to making it useful for a satellite orbiting the planet.

APOLLO PROGRAM AND ELECTRONIC SPACE IMAGERY

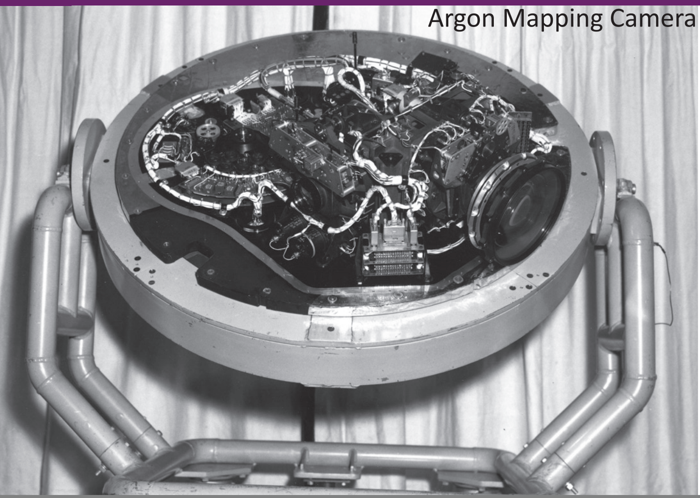
In the 1960s, when NASA began planning for their Lunar Orbiter to map the Moon's surface for landing sites for the Apollo program, the NRO allowed Eastman-Kodak to propose a candidate for the NASA program using the E-1 system that was developed for the NRO. Although the Kodak proposal was the most expensive candidate, it had proven technology and so was chosen by NASA because the other proposals all required testing and would take far longer, with success not guaranteed. The Lunar Orbiter succeeded in mapping 90% of the Moon's surface, enabling NASA to choose the best landing sites for its missions. Without the NRO's help, Neil Armstrong's "one giant leap" may have been delayed, and President Kennedy's call to visit the Moon before the end of the 1960s may not have been fulfilled.

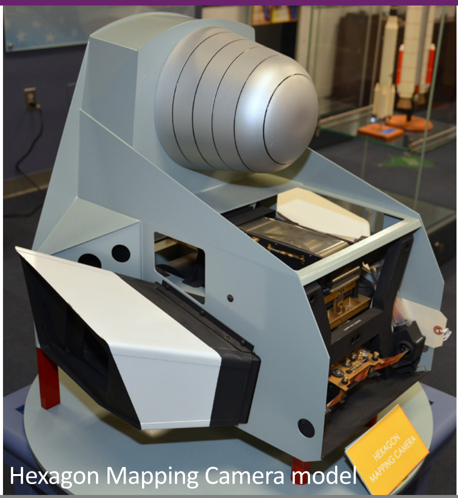
WHY WE USE IT

Still, an intelligence satellite orbiting the Earth needed a much faster data transmission rate than was provided by the analog E-1 camera system, and that could not be realized until digital imagery systems were developed. Actual "digital" imaging had been around since the 1920s, but the process was cumbersome and time consuming. The NRO continued its research, and using both in-house advances and data from the private sector, such as the invention of the charge-coupled device in 1969 by scientists at Bell Labs, the technology soon reached a tipping point. By 1971, all of the pieces had been put into place, and in September, President Nixon authorized the commencement of the NRO's electro-optical imagery program, which would eventually produce the KH-11 Kennen satellite.

It would be another five years of long, hard nights and weekends for NRO engineers, but in December 1976, the NRO finally launched the world's first electro-optical imagery intelligence satellite, and imagery's Digital Revolution began. On 20 January 1977, the day on which Jimmy Carter was inaugurated President, the KH-11 Kennen satellite became operational and beamed the world's first near real-time intelligence imagery to Earth, much to the chagrin of President Ford, who had hoped to get the first image before he left office, consistent with Richard Nixon's desire to see the satellite operate by the end of what would have been his second presidential term. Since that day, the NRO has continued to make groundbreaking advances and has produced significantly better imagery satellites time and again. The digital electro-optical imagery satellite system continues to be a key component in the NRO constellation and will continue to be for decades to come.

MAPPING CAMERAS


Argon Mapping Camera


Hexagon Mapping Camera model


Hexagon Mapping Camera image

In the early 1960s when U.S. satellite activity was taking shape and the NRO was formed, it quickly became apparent that imagery needed for strategic intelligence purposes and imagery needed for mapping requirements were not always compatible. At the time Corona first orbited, the U.S. military was still heavily dependent on captured World War II-era German maps for planning defenses against the Soviet Union. Those maps were both imprecise and incomplete. The military needed new imagery to update their maps, but strategic planners had more pressing concerns, such as the number of bombers and nuclear missiles the Soviets had in their inventory.

While the development of reconnaissance satellites had the utmost priority with U.S. decision makers, the country could not afford to have multiple programs trying to build basically the same type of system; that was precisely one of the reasons the NRO was formed in the first place. With this in mind, the NRO recognized that satellite vehicles could be configured for different collection purposes, so they could accomplish different missions without developing an entirely different system.

ARGON

The Air Force developed their own mapping and charting system, designated the E-4, in the Samos program. While a few working E-4 cameras were eventually built, none ever flew because of a lack of rockets to launch them into orbit, which were distributed to programs with higher priorities. Meanwhile, the NRO worked with the Army on the Argon project that incorporated a mapping camera into the Corona satellite platform to provide imagery for improving mapping capabilities. Integrating a new capability into an existing platform demonstrated the integration philosophy of the NRO.

Argon operations were not really part of the Corona program but generally were treated as such because of equipment and operational similarities. To perform its cartographic function, Argon flew much higher than Corona and used a much shorter (3-inch focal length) lens and a different camera mechanism, but in most outward respects, it was indistinguishable from a Corona-C or C′ camera. Between 1961 and the end of 1964, 13 Argon launches were attempted. Six missions were counted as successful to some degree, and the remainder failed completely, most of which were attributed to launcher failures. Notably, six of the first seven mission attempts failed, but only one failure occurred (on 26 April 1963) in six launches during the last two years of Argon operations.

In 1964, Corona engineers began developing the DISIC camera—which had a three-inch focal length lens—that provided a star-calibration capability that was largely unaffected by the orientation of the orbital vehicle. The earlier stellar indexing system had become ineffective whenever the main camera was positioned so that the stellar camera looked toward the sun; in DISIC, one camera was always pointed at least 90 degrees away from the sun. The incorporation of DISIC in combination with a variety of other improvements in camera precision effectively created a mapping capability in Corona J-3 that finally obviated any need for flying dedicated mapping missions. With the addition of DISIC to the Corona system, the requirement for additional Argon missions or a successor to Argon vanished.

HEXAGON

First launched in 1971, the Hexagon system was the replacement for Corona, which could not be appreciably improved without major system restructuring and enhancements. Since the expected benefits of an improved Corona were not that significant, the NRO decided to instead start from scratch and develop a brand new search system to take full advantage of the advancements that had been made in satellite and launcher technology over the previous decade. The result was a significantly improved system, both in terms of size and capabilities. The new "Big Bird" satellite was as big as a bus, could carry 10 times the film load of Corona, and could stay in orbit for up to nine months.

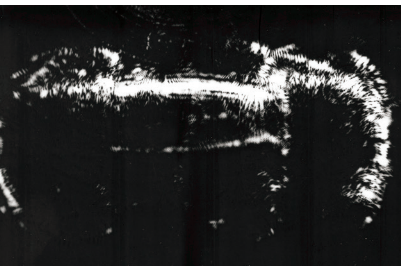
Being the replacement for Corona meant that Hexagon was the natural vehicle to carry the next government mapping camera. The first four Hexagon satellites flew with just their reconnaissance cameras aboard, while the new mapping camera was being developed. But the next eight Hexagon vehicles all carried the Hexagon Mapping Camera (MCS). The MCS did not fly on the last four Hexagon missions.

One of the most significant improvements over the Corona system was that because of the size of the Hexagon flight vehicle, engineers were able to incorporate the MCS into the standard mission vehicle without removing any of the basic components. The extra MCS cameras and film load could be attached to the Hexagon vehicle without any reduction in Hexagon performance. Therefore, the MCS was able to fly along with the Hexagon's reconnaissance cameras/film, so those flights could accomplish both missions. This was a complete departure from the Corona program, where the Argon system had to replace the Corona cameras to fly. The Hexagon MCS was also so reliable that it never caused any malfunction or delay in the Hexagon's primary reconnaissance mission.

Over the course of eight flights, the MCS collected 48,000 feet of highly accurate mapping film covering about 104 million square nautical miles. The MCS provided better than a four-fold improvement in accuracy, and more than a ten-fold improvement in resolution, over the previous best KH-5 (Argon) mapping camera. This data provided far better geographic positioning and elevation information for the nation's mapping community, allowing them to produce more and better maps and targeting data for tactical and strategic weapon systems.

Hexagon flew 19 successful missions from June 1971 through October 1984. The 20th and final Hexagon mission was launched on 18 April 1986, but it experienced a booster malfunction nine seconds into flight and was destroyed, becoming the only unsuccessful Hexagon mission. The Hexagon MCS was declassified along with the Hexagon and Gambit programs by DNRO Bruce Carlson for the NRO 50th anniversary celebration on 17 September 2011.

RADAR IMAGERY

BEGINNING THE TRADECRAFT

Radio Detection and Ranging (RADAR) was developed in the early 20th century from theoretical work and basic experiments of Scottish and German scientists from the late 19th century. Many countries began to seriously investigate the principle in the 1930s, and most of the major participants in the Second World War had some form of usable radar system. Many historians credit radar as the single most important ingredient in the Allied victory in the Battle of Britain in 1940.

INVESTIGATING A NEW DISCIPLINE

However, static radars can only measure signals and cannot "paint a picture." Radar imagery can only be produced by collecting returns along a path by a moving radar. So it was many years before radars could be made small and mobile enough to produce radar imagery. In April 1960, the U.S. Army unveiled pictures of American cities taken at night and through clouds using a synthetic aperture radar system mounted in a small aircraft (SAR is a scientific technique that simulates a much larger receiving antenna, which improves the resolution of the resulting radar "picture," making it possible to put radars in aircraft and satellites). This emerging technology was receiving significant interest from people and organizations involved in reconnaissance activities. The Air Force was particularly interested to see if this technology could be used to provide usable post-strike damage assessments without having to wait for appropriate conditions for optical sensors.

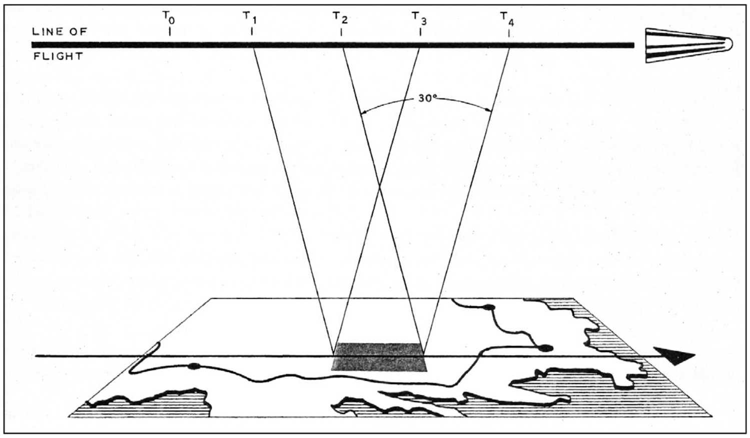
QUILL

In late 1962, DNRO Joseph Charyk designated Maj David D. Bradburn (who would later become a Major General and head of NRO's Program A) to lead a project named Quill to determine if collection of usable SAR imagery from satellites was feasible. Using "off-the-shelf" equipment and technology, Bradburn was able to quickly and efficiently get the program off the ground. Quill collected radar returns on tape spooled in the satellite, while also transmitting the data back to collection sites on Earth. The first (and only) Quill launch occurred on 21 December 1964. The satellite worked so well that a second planned launch was cancelled, since all of the program's objectives had been met during the first launch.

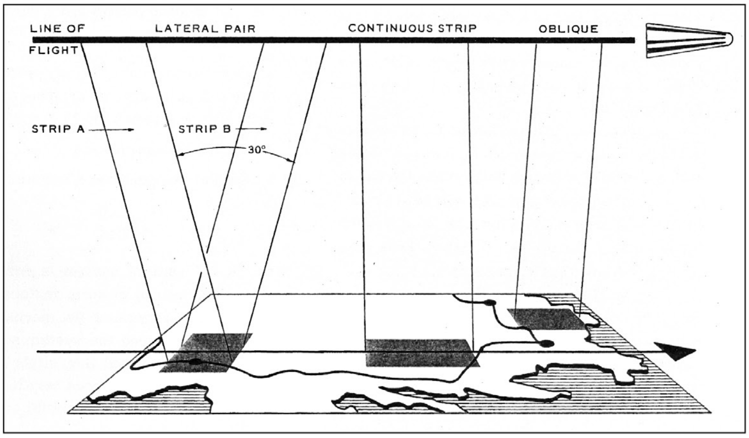
THE PATH FORWARD

In the final evaluation of the experiment, it was found that usable SAR imagery could indeed be collected from satellites. However, the resolution of the Quill imagery was relatively poor, and it did not provide the necessary intelligence needed to justify a new satellite system. While the NRO moved on to more pressing needs, it never forgot about radar imagery, and its engineers and scientists continued to explore this new technology. It would be many years before the Intelligence Community would be able to build a usable radar satellite with sufficient resolution; it was not until 9 June 2008 that the DNI declassified the fact that the U.S. operated an effective radar satellite reconnaissance system.

STEREO IMAGERY



STEREO OPERATION SCHEMATIC.



OPERATING MODES KH-7 CAMERA SYSTEM.

IT IS ALL IN THE VIEW

Stereo imagery is the result of taking two images of the same spot from slightly different locations, resulting in slightly different perspectives, and viewing each of those images separately with each of your eyes or viewing a combined picture with special goggles/glasses. The resulting view gives depth to the scene and a 3D perspective, and it gives the viewer a much more detailed view of the scene, allowing the viewer to see things that could be missed from simply viewing a single image because imagery is a two-dimensional representation of a three-dimensional space. For non-imagery analysts, the most common experience of stereo viewing is watching a 3D movie or using virtual reality goggles.

WHAT IT PROVIDES

Viewing imagery in stereo provides the ability to perceive height and depth in remotely sensed data. NRO tasking software determines the correct acquisition parameters for stereo imagery with math models that ensure the proper differential perspectives of the two images. Taken from orbit, the aim points must be precise; otherwise the resulting stereo pair would not register properly and would appear blurry.

WHY WE USE IT

In the Intelligence Community, NRO-provided stereo imagery has been used for decades by imagery analysts to differentiate fine details in a scene. It is particularly useful for identifying and analyzing tall, thin objects, such as antennas and towers, and also in analyzing very small objects that provide little detail in a 2D perspective. Cartographers and geospatial analysts use stereo imagery to produce maps and digital elevation models. Stereo imagery has the added benefit of producing very accurate positional measurements required for certain operational applications.

In the early days, exploitation of stereo images was a difficult, haphazard technique of physically aligning the hard-copy images below a special viewing tool that had to be constantly adjusted to look at different points on the images. With today's advanced computers, softcopy exploitation is much more easily achieved, although the process takes a great deal of computer power and memory.

WHO ELSE USES IT

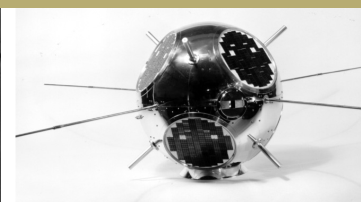
In the private sector, stereo imaging has proliferated into many new areas in the last two decades. Stereo imaging is used in art, education, medicine, scientific/engineering research, space exploration, and of course, entertainment. It is used by doctors to view inner parts of a body before surgery. It is used extensively by eye doctors for both diagnosis and treatments. It was used by NASA in the Mars Exploration Rover missions. Today's nascent virtual reality business is built on stereoscopic imaging principles, and everyone expects that business to boom as the technology matures. It may be years before we can all play the chess game that Chewbacca and C-3PO played in Star Wars (which was more holography than stereo imagery, though the concepts are similar), but those days will be with us before we know it.

INNOVATIONS

SIGINT

GRAB

SIGNALS COLLECTION HUT



BACKGROUND

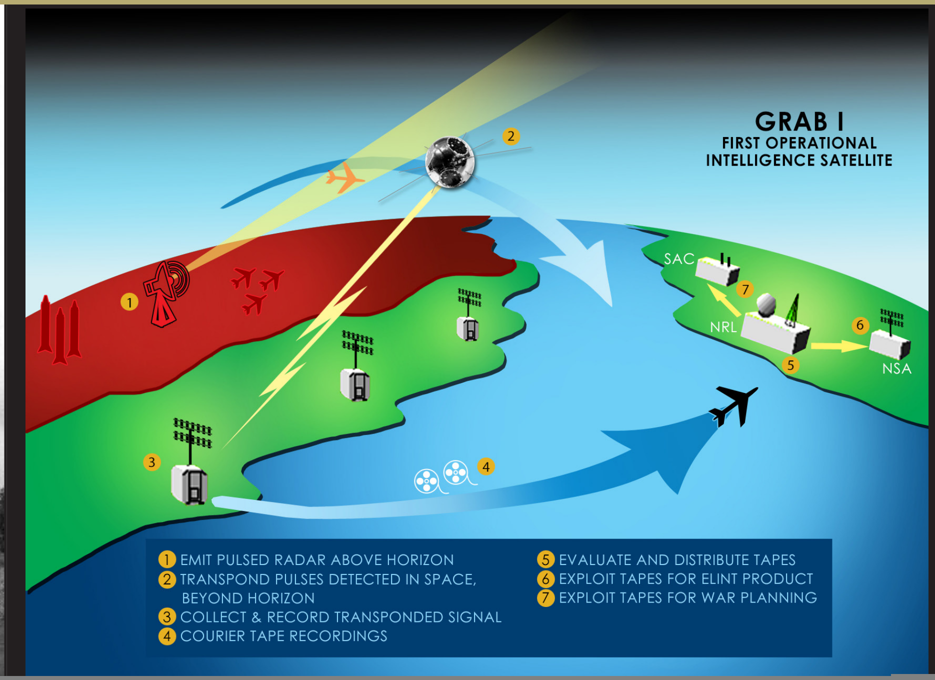
In March 1958, Reid Mayo, an engineer at the Naval Research Laboratory (NRL), passing time while stuck in a restaurant during a Pennsylvania snowstorm, came up with the novel idea of mounting a periscope-radar detector on a Vanguard-like satellite. After returning to Washington, Mayo pitched his idea to NRL's electronic countermeasures chief and shortly thereafter the concept was approved by the Director of Naval Intelligence, and the Galactic Radiation and Background (GRAB) project became a reality. In August 1959, President Eisenhower formally approved Mayo's project, which by then became classified with the code name "Tattletale."

NAMES CAN BE MISLEADING

The GRAB satellite was a cover name that portrayed the program's purpose as a research project measuring radiation in space. In fact, the GRAB satellite was equipped with scientific instruments and a receiver that could detect pulsed-radar signals emitting from Soviet air defense systems. The intelligence yielded from GRAB played a vital role in U.S. national security at the height of the Cold War. While GRAB was the first electronics intelligence (Elint) satellite to be launched into space by the U.S., it only operated from 1960-1962. However, Poppy, GRAB's successor, operated from 1962-1977. The Director of CIA (D/CIA) authorized limited declassification of GRAB in 1998. In 2004, the D/CIA declassified limited facts about Poppy's existence.

UNWANTED INTERNATIONAL CONTROVERSY LEADS TO ACTION

On 1 May 1960 when Frances Gary Powers' U-2 high-altitude reconnaissance aircraft was shot down over the Soviet Union, President Eisenhower cancelled all U-2 flights over the region. Four days after the U-2 was shot down, President Eisenhower approved the first GRAB launch. GRAB was successfully launched into orbit on 22 June 1960 from Cape Canaveral, Florida on a Thor Able-Star rocket. NRL attempted four additional GRAB missions between 1960 and 1962, but only one was successful. However, lessons learned from GRAB's two successful launches were foundational to the development of its first cousin and successor, Poppy (sometimes referred to back then as the polar flower in the sky).



HOW GRAB WORKED

GRAB satellites featured Elint antennas that provided reception of radar signals. A larger and separate turnstile antenna received ground commands, telemetry, and Elint data. When terrestrial radar emitted pulsed-radar signals above the horizon, GRAB satellites collected each radar pulse signal in a specified bandwidth and transmitted a corresponding signal to an NRL control ground hut within its field of view. The hut's antenna masts contained two upper bays of 10-element yagi antennas that received telemetry (108 MHz) and four lower bays of 10- element yagi antennas that transmitted commands and received Elint (139 MHz). Personnel at the ground control huts then recorded data from GRAB and dispatched tapes with that data, initially to NRL, and then to National Security Agency (NSA) and the AF Strategic Air Command. NSA and SAC then exploited the data to develop technical intelligence about Soviet radar. As mentioned, only two of GRAB's five launches were successful, and the program was realigned under the newly-formed NRO.

SATELLITE PROGRAMS ALIGNED UNDER NRO

When NRO opened its doors on 6 September 1961, its charter was to manage the newly created National Reconnaissance Program (NRP), which consisted of all consolidated satellite and overflight reconnaissance projects for the IC. Consequently, in 1962, NRL's Elint satellite activities were realigned under NRO as were CIA and Air Force space programs. These projects became known as NRO's alphabet programs. Program A represented the Air Force, Program B represented the CIA, and Program C represented Navy programs, including GRAB and Poppy. Under Program C, the Navy continued NRL's Elint satellite collection with the enhanced Poppy, GRAB's successor. The GRAB-2 program was terminated in August 1962, and on 13 December 1962 the Air Force used a Thor Agena-D launch vehicle, to carry Poppy 1 into orbit from Vandenberg Air Force Base in California.

GRAB AND POPPY LASTING LEGACY

Early NRO Elint satellite programs were a critical element of U.S. technical reconnaissance operations during the 1960s into the 1970s. Before development of these systems, technical intelligence about Soviet air defenses was limited to airborne and ground-based collection platforms that could only access radar site data from less than 200 miles. GRAB's lasting contribution was demonstrating that Soviet air defense networks had far more radars than SAC knew about, prompting SAC to change their offensive strategy for fighting nuclear war. Collections from GRAB, and later Poppy, supported a wide range of other intelligence applications as well. For example, they provided SAC not only with detailed information about Soviet air defense equipment and locations but provided valuable ocean surveillance data to Naval operational commanders. When GRAB and Poppy data were combined with Corona's satellite images, a more complete picture emerged about Soviet military capabilities, which supported military and senior policymakers with making informed decisions. GRAB and Poppy innovations have and will continue to impact development of increasingly sophisticated capabilities into the 21st century, which are needed today more than ever.

ADVANCEMENTS

GRAB satellites featured Elint antennas that provided reception of radar signals. A larger and separate turnstile antenna received commands, transmitted telemetry, and transmitted Elint data.

The National Security Agency and Strategic Air Command exploited the data to develop technical intelligence about Soviet Radar.

GRAB

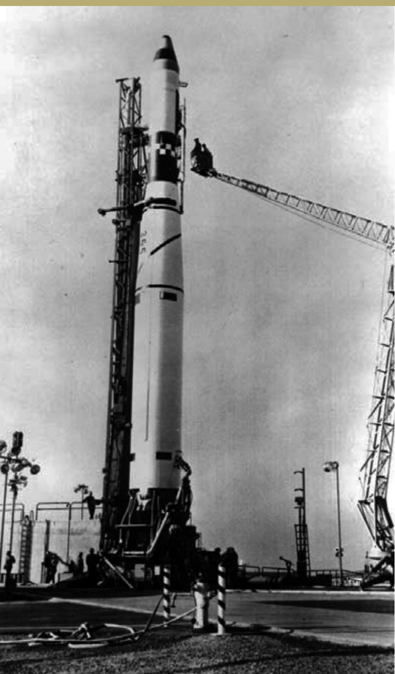
Successful Missions: 2
Size: 20 inches in diameter
Codename: Tattletale
Objective: Collect Elint

GRAB MISSIONS:

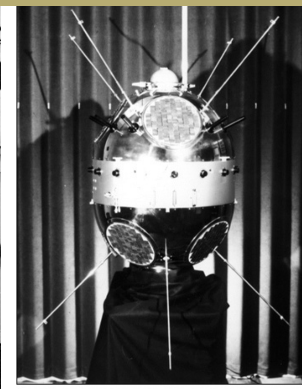
LAUNCHES

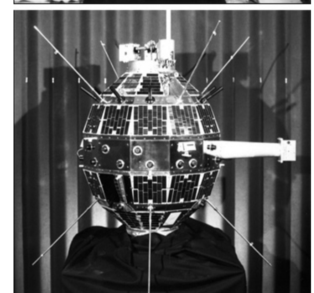
GRAB 1	22 JUN 1960	THOR ABLE STAR
	30 NOV 1960	THOR ABLE STAR (FAILED)
GRAB 2	29 JUN 1961	THOR ABLE STAR
	24 JAN 1962	THOR ABLE STAR (FAILED)
	26 APR 1962	SCOUT (FAILED)

POPPY



SIGNALS RECEIVING CONSOLE





ORIGINS OF SIGNALS INTELLIGENCE

The Galactic Radiation and Background electronic signals intelligence satellite was the world's first successful reconnaissance satellite.

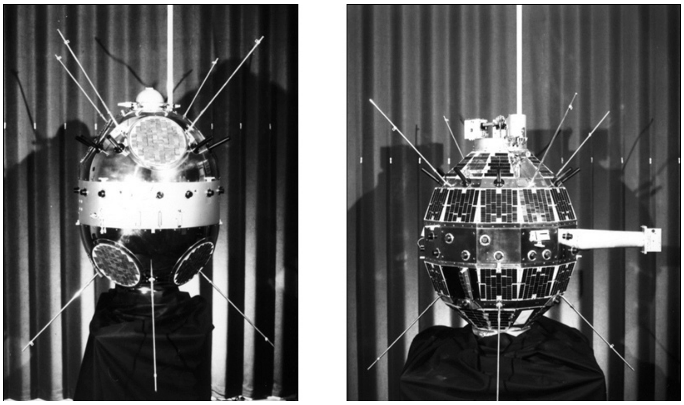
The Poppy reconnaissance satellite was GRAB's successor. In 1962 the Naval Research Laboratory, by then part of NRO's Program C, developed this larger and more advanced satellite. The NRL launched the first Poppy satellite on 13 December of 1962, and the Poppy program completed seven missions. The NRL launched the last Poppy mission on 14 December 1971.

EVOLUTION OF POPPY

The initial Poppy mission succeeded, as did all six additional missions. The Air Force used three versions of the Thor Agena booster for Poppy: Thor Agena-D for Poppy 1, 2, 4, and 5; a Thrust-Augmented-Thor (TAT) Agena-D for Poppy 3; and the Thorad (also know as Long-Tank Thrust-Augmented Thor) Agena-D for Poppy 6 and 7.

The first Poppy missions featured a stretched spherical satellite design, initially 20 x 24 inches (at 55 pounds), which ultimately became 24 x 32 inches (at 129 pounds).

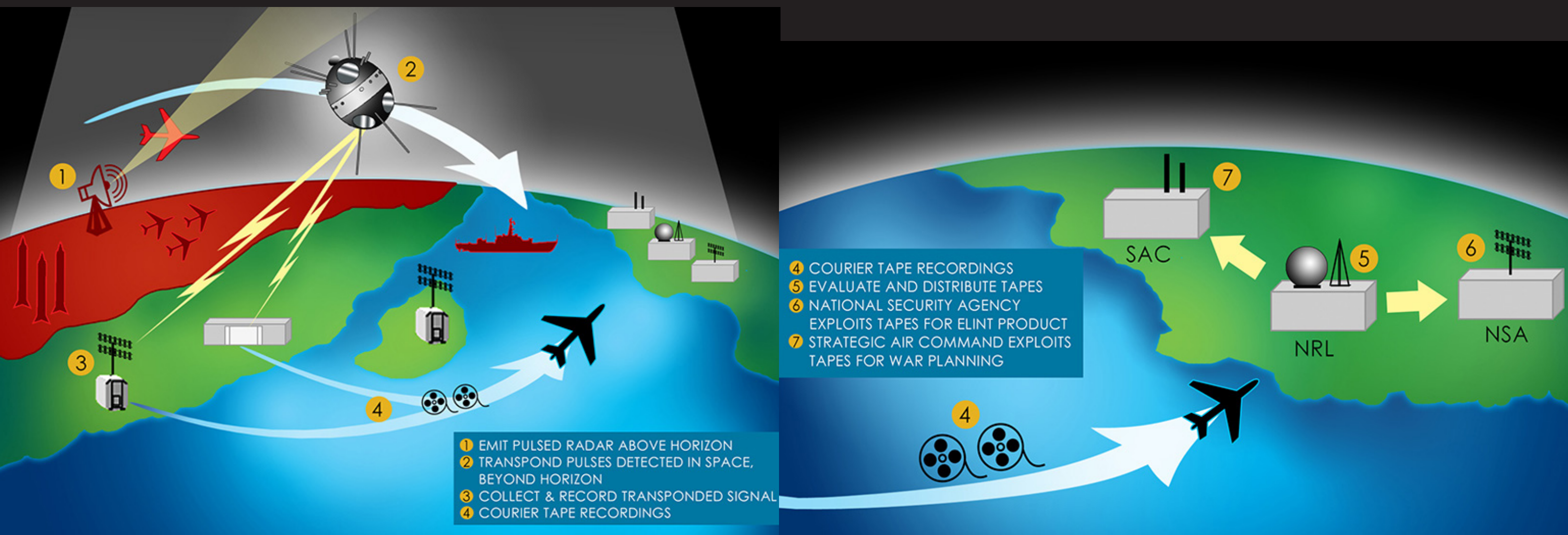
Poppy also featured a 12-sided multiface design, initially 27 x 32 inches (at 162 pounds), which ultimately became 27 x 34 inches (at 282 pounds).



Two Poppy designs—stretched sphere (left); multiface (right)

INTELLIGENCE NEED FOR SIGNALS COLLECTION

Intelligence derived from data that Poppy collected went to support a wide range of intelligence applications. It provided cues to the location and capabilities of radar sites within the Soviet Union; it provided SAC with characteristics and locations of air defense equipment to support building the U.S. Single Integrated Operations Plan (SIOP)13; it provided ocean



surveillance information to Navy operational commanders; and, with data from the Corona imaging reconnaissance satellite, it provided a more complete picture of the Soviet military threat. We can credit these systems with helping the U.S. win the Cold War. At the same time they extended their impact into the future, as they laid the foundation for future national reconnaissance capabilities. The NRO's 21st-century Sigint reconnaissance capabilities grew out of GRAB and Poppy innovations in the 1960s and 1970s.

From the relatively safe distance of 600 miles above the Earth, Poppy intercepted Elint signals from radar sites throughout the Soviet Union. The threat of Soviet hostile action limited U.S. airborne and ground-based platforms to collecting signals from radar sites to only 200 miles inside Soviet territory.

ADVANCEMENTS

Poppy added ocean surveillance capabilities. During 1965-67, Program C phased out the earlier receiving and control huts used for GRAB; the program also upgraded data quality by installing equipment in buildings provided by host installations. This upgrade also augmented manual analysis in the field.

POPPY
1962 - 1977

Successful Missions: 7

Size: 20X24(stretched spherical)
24X32 (multifaced)

POPPY MISSIONS
LAUNCHES

Poppy 1	13 Dec 1962	THOR/AGENA D
Poppy 2	15 June 1963	THOR/AGENA D
Poppy 3	11 Jan 1964	THRUST-AUGMENTED-THOR/AGENA D
Poppy 4	9 March 1965	THOR/AGENA D
Poppy 5	31 May 1967	THOR/AGENA D
Poppy 6	30 Sept 1969	THORAD/AGENA D
Poppy 7	14 Dec 1971	THORAD/AGENA D

ABM SYSTEM TESTING DETECTION


Nixon and Brezhnev Sign The Anti-Ballistic Missile Treaty.


ABM Testing Facility
Sary Shagan- Soviet Union

FROM A HOT TO COLD WAR

The United States' nuclear bombing and destruction of Hiroshima and Nagasaki in Japan brought to close a global hot war, yet started a global cold war. The United States underestimated the pace with which nuclear weapons would be developed by the Soviet Union. In order to assure that the Soviet Union would be unsuccessful in carrying out a surprise nuclear weapons attack, the U.S. invested heavily in a number of weapons systems. One of those was an anti-ballistic missile (ABM) system designed to shoot down incoming intercontinental missiles from the USSR. The USSR, unsurprisingly, countered with development of their own ABM system, raising the potential for a successful nuclear strike against the United States. Consequently, the U.S. turned to national reconnaissance systems to understand the development and deployment of Soviet ABM systems and to increase the odds of preventing the global Cold War from turning hot.

NUCLEAR WEAPONS SYSTEMS DEVELOPMENT AND DETECTION

After the United States' Manhattan nuclear weapons development program successfully produced the bombs that destroyed Hiroshima and Nagasaki, nascent U.S. intelligence reporting concluded the Soviet Union was unlikely to develop a successful nuclear weapon before 1953, but could possibly develop one as early as 1950. The United States was surprised when their nuclear detection program confirmed the Soviets' first successful atomic weapon test, which occurred on 3 September 1949. The Soviet Union was also surprised 20 days later when President Truman announced to the world the Soviets' successful test, believing they could hide a successful nuclear weapons test.

The United States had wisely decided to develop a system for detecting foreign nuclear detonations, growing out of their own research efforts to identify and track nuclear fallout from their own weapons testing. In 1947, then Army Chief of Staff, General Dwight D. Eisenhower, designated the Army Air Corps—soon to be the U.S. Air Force—to develop a system to pick up indications of nuclear fallout at high altitudes. Shortly after the successful Soviet test, U.S. military aircraft captured nuclear fallout through this detection system, operated by U.S. Air Force. Early in the Cold War, the United States understood the importance and difficulty of developing systems to track the development of Soviet nuclear weapons in a highly closed society.

U.S. ABM DEVELOPMENT

At the same time as developing nuclear testing detection capability, the U.S. also engaged in the development of a weapons system that could be used to destroy nuclear weapons before they reached the U.S., eventually known as an anti-ballistic missile system. In 1950, the U.S. began testing the Nike Ajax, designed to launch from the ground with command guidance for tracking incoming aircraft for intercept and destruction. This critical capability, would allow the U.S. to destroy the most likely means of delivering a nuclear weapon in the early days of the Cold War. The Ajax system was followed by the Nike Hercules system that also used command guidance, but could intercept targets 150,000 feet away—three times the distance of the Ajax system.

By the mid-1950s, the United States faced an emerging threat from newly developed Soviet intercontinental ballistic missiles (ICBMs). During 1955 and 1956, the U.S. carried out intensive ABM technology studies. The studies led the U.S. to award a contract to Western Electric, Bell Labs, and Douglas Aircraft to develop a new ABM system known as Nike Zeus to intercept ICBMs. Following the Soviet Union's successful launch of their Sputnik satellite in October 1957, the program took on new urgency. Nike Zeus utilized radar to identify and track ICBMs and used computers to assign specific ABM batteries to strike against targeted ICBMs. Before Nike Zeus could be deployed, the U.S. determined through system tests and studies that the system could not effectively counter a Soviet attack using multiple ICBMs and decoys.

The U.S. remained resolved in developing an ABM system and began development of what would be known as the Safeguard system by the time Richard Nixon became president in 1969. The new system utilized a phased array radar. The Safeguard system incorporated fixed antennas with electronic beam steering at U.S. ABM sites. Two different ABMs were developed under the program. Spartan missiles were to be launched first for farther out ICBM interception, and Sprint ABMs would be used for ICBMs that were closer to their intended targets. Under the Nixon administration, the system was intended to protect offensive nuclear weapons sites in Montana and North Dakota.

SOVIET AND CHINESE ABM SYSTEM DEVELOPMENT

Beginning in the late 1950s, the Soviets began testing missiles that could intercept weapons delivery vehicles at their missile testing facility at Sary Shagan. In 1961, they successfully intercepted one of their own missiles launched from their facility at Kapustin Yar.

By 1962, the Soviets began constructing their own ABM system to intercept U.S. ICBMs in the event of a nuclear attack. The system depended on radar facilities to identify incoming targets and track those targets for attack by Soviet ABMs. The U.S. nicknamed the radar facilities as "Dog House" because of their A-frame shape. Those facilities were latter supplemented by "Cat House" radar facilities, as well as "Hen House" radar facilities around the periphery of the Soviet Union to provide early warning. The ABM system was developed to protect Moscow against nuclear attack.

Like the U.S., the Soviets developed ABMs that were intended to intercept missiles at long range and short range—the Galosh and Gazelle missiles respectively. Also like the U.S., the Soviet ABM system could not handle the large number of targets that would likely be launched in a full-scale nuclear exchange. The rapid proliferation of nuclear warheads exceeded advancements in ABM system capabilities.

Prompted by U.S. and Soviet nuclear weapons and ABM systems development, in 1964, the People's Republic of China (PRC) initiated their own ABM system. They eventually undertook development and testing of the Fanji ABMs. The Chinese also developed ground radar tracking stations for early warning of a nuclear attack. In addition, the PRC undertook development of the XianFeng anti-missile gun. Although ambitious, these programs were canceled by 1977 after the death of PRC Chairman Mao Tse Tung.

ANTI-BALLISTIC MISSILE TREATY

The United States and the Soviet Union both recognized the limitations of ABM systems as rapid development of nuclear weapons systems occurred on both sides. The pace was amplified by the development of multiple nuclear warheads that could be launched using a single ICBM. As a result of these realities, in 1972 President Nixon and Soviet Premier Brezhnev signed an anti-ballistic missile treaty. The treaty allowed both sides to protect one ABM site and one site for weapons system command and control. As a consequence, the U.S. dismantled its Montana ABM missile system site and later decided not to deploy an ABM system to defend Washington, D.C.

This left only the site in North Dakota where U.S. ABM system development continued. The site became operational in 1974, but the U.S. Congress rejected the utility of an ABM system and discontinued funding the North Dakota site. It closed in 1976.

The Soviet Union continued to build and maintain an ABM system to defend Moscow against attack. ABM system development continued after the Soviet Union collapsed in 1991.

THE ROLE OF RECONNAISSANCE SATELLITES IN ABM MONITORING

One critical element of any arms control treaty is the ability of each party of the treaty to verify the other parties' compliance. Such was the case for the U.S. and the USSR with respect to the ABM treaty. The treaty specified a new term, "National Technical Means," to be used to verify treaty compliance. When the treaty was signed in 1972, the United States' reconnaissance satellites developed and operated by the NRO remained highly classified. For the United States, "National Technical Means" meant NRO satellites. It would not be until 1978 that the U.S. acknowledged the existence of reconnaissance satellites and until 1992 that the U.S. would acknowledge the existence of the NRO. Despite the lack of public acknowledgment, the highly innovative and capable NRO reconnaissance satellite architecture served as the primary means for ABM treaty verification, as well as assessments of the threat posed by Soviet ABM system development from the early stages of their development.

GEOLOCATION FROM SPACE
FOUNDATION FOR GLOBAL POSITIONING SYSTEM


GPS - NAVSTAR

GEOLOCATION IN THE 21ST CENTURY

In the 21st century, satellite geolocation is ubiquitous, woven into the fabric of everyday life for billions of people worldwide. Individuals have apps on their phones, tablets, watches, and in their cars, capable of determining their precise position on the Earth, of providing a directed route to a selected destination, even warning of upcoming obstacles like heavy traffic or road construction. What has made this possible is the Global Positioning System (GPS), a constellation of more than 30 satellites, together with comparable systems in Europe and Asia. Given its widespread adoption and everyday influence, it can be easy to forget that this technological innovation is a very recent phenomenon that made obsolete the natural observation methods humans had used for centuries. Where once ship captains used stars in the sky and dead reckoning techniques to calculate where they were at sea, the modern traveler links to human-made celestial bodies—orbiting satellites with ultra-precise atomic clocks—to obtain much more accurate and reliable location information. Although most knowledgeable users today know that this technology was once the exclusive province of military and intelligence organizations, many remain unaware of the role the National Reconnaissance Office and other organizations played in developing it. The story of using space-based systems for geolocation is a great example of how American technological innovations originally pursued for supporting military forewarning and national security policymaking, were later transferred to the private sector as the foundation for innumerable, related innovations, e.g., self-driving cars or steps-counting fitness bands and myriad other civilian and commercial applications.

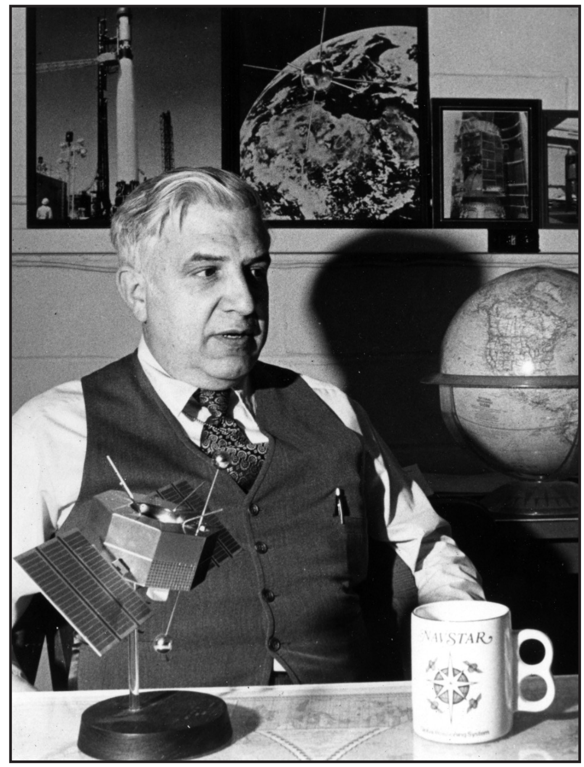
During the Cold War, the Soviet Union's obsession with secrecy and systemic suppression of even the most trivial details about life behind the Iron Curtain, made extremely challenging the gathering of intelligence by traditional means. Soviet security services concealed progress of their country's post-WWII nuclear weapons program—and penetration by its spies—so well that their first successful atomic detonation in 1949 shocked Western intelligence experts who had forecast that the USSR was still years away from obtaining "the bomb." The arms race that ensued—four years later to the month, the Soviets countered another American weapons development success, the testing of a hydrogen bomb, by exploding their own powerful fusion weapon—produced further uncertainty and instability. Knowing the Soviets' military intentions and capabilities, particularly its strategic missile numbers and strength, became a paramount concern. Were conflict to break out, the U.S. military response needed to be immediate, reliable, and, above all, accurate, which required knowing where and what to target for annihilation. Unfortunately, given the lack of intelligence in the 1950s, and the vast interior of the USSR, it was difficult to know even where to begin to look. To provide military commands and national policymakers better information, the U.S. Intelligence Community proposed overhead reconnaissance missions, first through conducting aerial overflights of denied territory, and later by launching and operating satellites. Beginning in 1956, U-2 high-altitude reconnaissance aircraft missions began to pull back the curtain, revealing previously unknown military installations, missile launch facilities, and dispelling the myth of the "bomber gap." But it would be the advent of space-based systems that would enable the U.S. to really penetrate Soviet secrecy and collect the vital information that removed uncertainty, lessened tensions, and allowed the Cold War to remain "cold." In time, satellites would also provide military leaders with the capability to geolocate enemy combatants and weapons systems to perform precision air and missile strikes.

Ironically, the earliest satellite geolocation method may have been conceptualized partly in response to the Soviet launch of Sputnik-1. In tracking the tiny satellite's radio signals, scientists at Johns Hopkins' Applied Physics Laboratory noted that signal frequency increased as the vehicle approached and decreased as it moved farther away, an illustration of the Doppler Effect. The scientists extrapolated that a satellite could be tracked from the ground by measuring the frequency of emitted radio signals, and conversely, one could determine the location of the unit receiving that signal by knowing its distance from the satellite. This realization led to the first operational, satellite-based, geo-positioning system, the U.S. Navy's Transit program, begun in 1958. Transit was not a true navigation system, but instead a positioning system for fixed objects, initially designed to meet the Navy's need for accurately locating Polaris submarines at sea by updating shipboard inertial navigation systems. When Transit became fully operational in January 1965, submarine or ship navigators could measure the Doppler shift in a Transit satellite's radio transmissions during the 15 minutes it took to travel from horizon to horizon to calculate their sub or shipboard receiver's position on Earth. In 1967, the Transit system was made available as a broad ocean navigation system for civilian ships, by which time the NRO and Department of Defense had further advanced space-based geolocation on other programs.

On 22 June 1960, the Naval Research Laboratory, site of what became NRO Program C, put into orbit the U.S.'s first successful reconnaissance satellite, GRAB, launched as a "piggybacked" payload aboard the Transit 2A satellite. Throughout the 1960s and into the early 1970s, the NRO's low-earth orbiting, signals intelligence (Sigint) collecting satellites GRAB, and the even more successful follow-on system Poppy, used high gain antennas to intercept signal pulses from Soviet radar equipment and then transponded corresponding signals to receiving huts. Once processed, the signals provided analysts cues to the location, strength, and number of radar sets trying to detect oncoming U.S. strategic bombers. Although not accurate by GPS standards, the geolocation method used with early Sigint satellites was geometric reconstruction using the direction of arrival of a signal at a single intercepting satellite whose location and orientation was accurately known. Later the NRO would discover how to use a different method to achieve much more precise location information. In addition to providing Strategic Air Command critical flight route data to support building the Single Integrated Operations Plan, Poppy satellites provided ocean surveillance info to Navy operations commanders, and in combo with imagery satellites, gave a more complete picture of the Soviet military threat.

As the NRO satellite constellation grew and evolved over the succeeding decades to comprise many longer duration mission payloads operating in multiple orbital types (e.g., low earth, geosynchronous, sun-synchronous, highly elliptical, etc.), it continued to redefine state-of-the-art in remote sensing technology in ways that exponentially increased the intelligence windfall. Pioneering NRO engineers discovered novel ways of exploiting signal externals measurements to greatly improve tracking and geolocation of missiles by reconstructing their altitude. This led to the first demonstrated geolocation capability from space using methods tried previously with aircraft, but thought to be unworkable with satellites. Precision timing was needed, and for that, the NRO employed cesium clocks, an innovation that would be critical to the success of GPS. Though it took a few years for space-based geolocation breakthroughs to be fully exploited, eventually satellite enhancements and refined techniques made measurements more accurate, and space-based geolocation remains at the forefront of a variety of intelligence applications.

Also known by its formal program name, NAVSTAR, GPS took more than two decades to mature from concept to fully operational, and the program office built upon technologies and satellite geopositioning techniques discovered and honed by NRL, NRO, and the Aerospace Corporation, to name a few. Of these contributors, the NRO Program C connection to GPS's development is least well known. As previously noted, Program C was headquartered at NRL, but it was far from the only activity there. Founded at the suggestion of Thomas Edison to create an organization to house a "repository" of technical capability, NRL began foundational work on a precise, all-weather, real-time, global navigation system independently of Aerospace's more touted efforts, and well before the consolidated NAVSTAR program. Two key NRL contributions to the GPS program were development of precision cesium and rubidium atomic clocks, which had to be improved 100 fold for use in satellites, and the use of refurbished Atlas F launch vehicles to boost the payloads into orbit. At the forefront were two brilliant engineers, Roger L. Easton, considered by many to be the “Father of GPS,” and Peter G. Wilhelm, a Pioneer of National Reconnaissance and technical director and lead engineer for 74 satellites over his 50-year career at NRL. In 1964, Easton began research and experiments to demonstrate his idea for instantaneous satellite navigation using passive ranging and a constellation of satellites containing high-precision, atomic clocks and operating in a circular orbit. Easton called his system TIMATION (time-navigation). By 1967, he was ready to prove his concept through an initial satellite launch. Here the connection to NRO Program C becomes clearer.



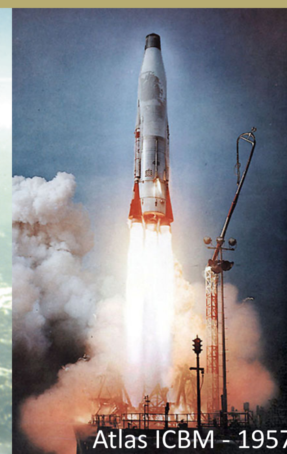
Roger L. Easton

Wilhelm—but not Easton—was actively working NRO satellites for Program C, and had developed the radio transmitters and receivers for GRAB. In the same year that Easton began his Timation work, NRL promoted Wilhelm to lead all of its satellite programs, including those being funded by the National Reconnaissance Program. So when the time came to launch the first two of Easton’s Timation satellites, Timation-I on 31 May 1967, and Timation-II on 30 September 1969, Wilhelm arranged to have those satellites launched—as GRAB had been—in “piggyback” mode atop NRO satellites Poppy 5 and Poppy 6. These were the first demonstrations of what became the GPS navigation concept from space, the first of four experimental satellites that Easton had developed. Even after the Air Force, along with Aerospace, established a GPS program office in 1972, it was Easton’s Navigation Technology Satellite-2 (NTS-2; the first had launched in 1974), launched in 1977, that became the first satellite in the NAVSTAR GPS.


Peter G. Wilhelm

Wilhelm’s hand can also be seen in the decision to use the Atlas booster—specially modified—for the NTS launches, rather than the more expensive Thor/Agena D combination employed for the Timation launches. Wilhelm conceived the idea of an Atlas combined with two solid rockets with no onboard guidance, which were used to transfer the satellites to GPS’s 10,000+nm orbit, a concept he called “arrow.” Wilhelm proposed this new, lower cost launch concept to Director, NRO John McLucas in 1972. Being able to affordably launch a 24-satellite constellation to become fully operational was key to gaining GPS program approvals, and the approach was used on the first 13 launches.

ICBM DEVELOPMENT DETECTION



Atlas ICBM - 1957

Corona KH-4 Image

IDEOLOGICAL DIVIDE OF THE COLD WAR

If the victorious Western allies of World War II believed that the defeat of Nazi Germany and Imperial Japan would bring about a new era of global harmony, free from conflict, in which smaller nations could exercise political autonomy, they soon discovered they were mistaken. In Europe, erstwhile ally USSR took little time reneging on most commitments pledged by Stalin at the Yalta Conference in February 1945. Germany itself would be occupied for the foreseeable future, and was divided ideologically into East and West amongst four nations as agreed, but the Soviet leader also had paid lip service to a postwar principle of allowing free elections in eastern European states liberated from Nazi forces (i.e., Czechoslovakia, Poland, Romania, Hungary, and Bulgaria). The Red Army's overwhelming presence in those countries, however, ensured that the USSR could instead facilitate the installation of puppet regimes, in effect obtaining for Moscow not simply a sphere of influence over Eastern Europe, but by the early 1950s, political domination behind an "Iron Curtain." Meanwhile in China, after decades of civil war, the Chinese communists emerged victorious in October 1949, mere weeks after the USSR had detonated an atomic bomb, ending the U.S. monopoly of nuclear weapons. Less than a year later, North Korean forces invaded South Korea, equipped with Soviet weapons and with China's encouragement. Observing all these developments, Winston Churchill entitled the last book of his Second World War memoirs Triumph and Tragedy because, he wrote, "the overwhelming victory of the Grand Alliance has failed so far to bring general peace to our anxious world."

INFORMATION GAP IN DENIED AREAS

With the nuclear arms race begun and the Cold War intensified, Western governments became increasingly uneasy about the growing military threat from the closed society of the USSR and Communist Bloc. Never mind a lack of timely, reliable data on military capabilities and intentions, the West had difficulty obtaining propaganda-free information on simple, everyday events within the Soviet sphere. The Communist countries of the 1950s erected at their borders checkpoints that were constantly patrolled by military forces. It was a world composed of single-party, totalitarian governments, whose ruthless, disciplined, and formidable security forces rigidly controlled the flow of information, and imposed suspicion and fear upon their populations to ensure their docile compliance, if not active cooperation in exposing supposed enemies of the state. This made intelligence collection through traditional human espionage in these so-called "denied areas" extremely difficult and highly dangerous. But strategic reconnaissance systems, until 1956 comprised of specially adapted camera-carrying aircraft and aerial balloons, also proved of limited value. Western leaders were left with fragmentary information, all of which seemed to indicate, at worst, warlike intentions, and at best, a Soviet strategy of destabilizing governments throughout the world to extend the Communist power base beyond Eastern Europe. The U.S. developed the innovative U-2 high-altitude, reconnaissance aircraft in just eight months after Presidential approval, and beginning on 4 July 1956, conducted periodic overflights of the interior of the Soviet Union. Although a tremendous success—U-2 imagery conclusively refuted intelligence estimates of a significant Soviet advantage in long-range bomber production—the U-2 program highlighted inherent limitations even with high-altitude aircraft reconnaissance: relatively infrequent missions, narrow imaging passes that excluded large swaths of territory, and vulnerability to countermeasures. On 1 May 1960, Francis Gary Powers, piloting the U.S.'s 24th mission over the USSR, was shot down by surface-to-air missiles, and President Eisenhower terminated all future overflights of the Soviet Union. A new reconnaissance capability was needed, and, fortunately, one was not long in coming.

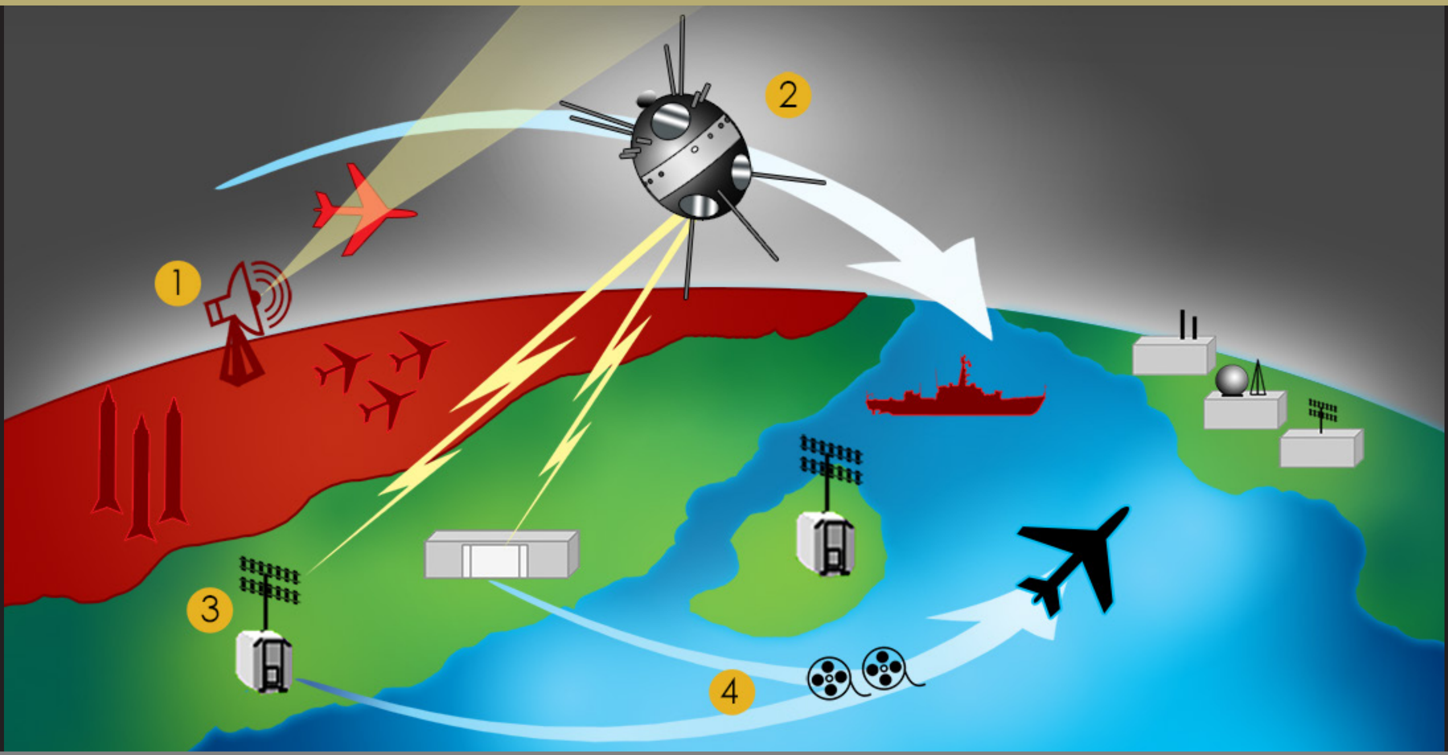
A NEW KIND OF INTELLIGENCE PROVIDES HIGH CONFIDENCE UNDERSTANDING

Even while the U-2 flights were ongoing, the Soviet Union had upstaged the U.S. on two space-related developments: intercontinental ballistic missiles and space satellites. When America tested its Atlas ICBM in July 1957, the missile only rose about 5,000 feet before plunging back to Earth. A month later, the Soviets announced that they had successfully tested an ICBM, although the U.S. could not confirm the story's veracity. On 4 October 1957, the Soviets removed all doubt by launching the first man-made satellite, Sputnik 1, which the world tracked as it orbited the Earth. Troubling to many was the realization that if the Soviets could develop ICBMs powerful enough to launch an object into space, they could potentially equip similar missiles with nuclear warheads to launch a devastating attack. And because of the lack of solid evidence to the contrary, these fears received outsized attention. Thus, the 1960 presidential election became, in part, a referendum on concerns about the Soviets outpacing the U.S. in strategic nuclear capabilities — this time the production of nuclear missiles rather than bombers. Democrat candidate John F. Kennedy assailed the Eisenhower administration, including then sitting Vice-President and opposing Republican candidate Richard Nixon, for its failure to prevent this "missile gap" from developing. What the candidates did not know when the campaign began—and could not reveal even after they became aware of it—was that the U.S. had successfully developed a new capability that eventually would provide high confidence understanding of Soviet ICBM development and completely transform national reconnaissance: signals and imagery satellites.

CORONA AND SUCCESSORS' CONTRIBUTION TO ICBM DETECTION AND TREATY VERIFICATION

The launch of the GRAB signals intelligence satellite on 22 June 1960, followed by the launch of the Corona photoreconnaissance satellite on 18 August 1960, revolutionized intelligence collection of denied areas. Going forward, U.S. policymakers could at last be confident of both the accuracy and scope of intelligence assessments of Soviet strategic capabilities, not least because of an improved ability of "negation," or verifying the absence of activity. CIA and Air Force elements, after 6 September 1961 as components of the NRO, would operate Corona satellites, with steadily improving camera technology and collection capabilities, for 145 missions spanning nearly 12 years. The system's broad-area, panoramic imagery made possible the identification of all Soviet medium-range, intermediate-range, and ICBM launching complexes, definitively dispelling fears that the U.S. lagged behind in missile production. After June 1963, Corona would conduct search missions in conjunction with the Gambit imagery satellite system's high-resolution, narrow-field-of-view mission to provide close-look information. Through repeated coverage of areas of concern and a coordinated search process that involved close cooperation among satellite operational units, photo interpreters, and all-source analysis components, the NRO programs enabled compilation of a huge database of newly identified installations and activities: ICBM sites, air defense sites, nuclear development and test facilities, shipyards, airfields, communication sites, military bases, manufacturing and agricultural activity, etc. By the middle of the 1960s, the U.S. and its allies were assured that they knew the scale and pace of Soviet ICBM deployment within narrow limits. Past areas of uncertainty, such as "where" and "how many," no longer caused concern and were replaced by questions of detailed characteristics for delivery systems. The dramatic reduction in the number of intelligence surprises paved the way for the initiation of strategic arms limitation talks between Washington and Moscow, for which area-coverage imagery provided by Corona (and starting in June 1971 by Corona's successor, Hexagon) would be indispensable for monitoring resulting treaty provisions. Indeed, verification of compliance through use of imagery satellite systems—termed "national technical means" to obscure specifics about still-classified programs—provided leaders of both countries with the confidence that permitted them to sign the Strategic Arms Limitation Treaty on 26 May 1972.

SHIP TRACKING (OCEAN SURVEILLANCE)



1 Emit pulsed radar above horizon
2 Transpond pulses detected in space, beyond horizon
3 Collect & Record transponded signal
4 Courier tape recordings

The earliest U.S. reconnaissance satellites began operation when there were many strategic intelligence gaps, and their express purpose was to provide American leadership visual and electronic access to the vast landmass of the USSR, the major Cold War adversary. Space-based photoreconnaissance and signals interception missions quickly proved adept at acquiring the data to find and locate objects of interest, catalogue significant activities, and confirm the absence of activity. By the mid-1960s, satellite reconnaissance had reduced the number of intelligence surprises, and the U.S. and Western Allies were becoming increasingly confident that, for example, they knew the scale and pace of Soviet ballistic missile deployment within narrow limits. But a new threat was emerging: the USSR had begun to build up a large and formidable navy. From its Baltic and Black Sea shipyards, the Soviet Union accelerated development and production of combatant and auxiliary ships, including new cruisers, frigates, and destroyers armed with guided missiles; cruisers carrying missile-equipped helicopters; and nuclear submarines armed with ballistic missiles. This rising world-class fleet was soon deployed around the globe, particularly in waters adjacent to non-aligned nations. Although the U.S. Navy monitored its movements as closely as it dared from its own surface vessels while carefully avoiding causing a diplomatic incident, reconnaissance satellites offered far greater potential for closing this new intelligence gap through collecting imagery and signals to establish a database on the USSR naval order of battle and its activities. It was only a matter of time before ocean surveillance—i.e., tracking ships—became a satellite collection mission requirement.

The U.S. Intelligence Board (USIB) issued formally documented satellite mission requirements, which in the formative years of space-based reconnaissance tended to reflect the needs of whichever military or intelligence organization would be using the information. For example, Air Force Strategic Air Command wanted details on Soviet targets, data on radars and anti-aircraft weapons, and exact locations of Soviet defensive installations, so it could plan aircraft penetration routes. The CIA was additionally interested in, and tasked to produce, intelligence estimates on Soviet technology, military numbers and capabilities, and economic indicators. As more was learned of the USSR's naval buildup, the U.S. Navy wanted to determine the threat from Soviet surface ships and submarines. The Soviet navy had doubled its activity in the Mediterranean Sea in 1967, and a Navy Space Program Review concluded that the Department of the Navy must move boldly to translate space policy to fleet needs. This had not been a priority until then, and more than a decade into the Space Age, the only operational U.S. satellite-based system that directly supported its fleet was the Navy Navigation Satellite System, more popularly known as Transit. But Transit was older, limited technology used as a positioning system for fixed objects, when the ship tracking problem required a system capable of detecting and tracking mobile threat radars. Fortunately, NRO systems' advancements to satellite collection, geo-positioning capabilities, and increased sensitivity now enabled space mission planners to consider incorporating ship tracking requirements, which could provide insight into Soviet military intentions, as well as their economic and diplomatic activities. Rear Admiral Leonard, who commanded a carrier division and was interested in tracking missile-equipped Soviet ships at sea, submitted a request through the Chief of Naval Operations for "the conduct of tests by the NRO to evaluate satellite use for passive detection, classification and localization of ships at sea."

One prime candidate to perform this mission was the NRO's electronic intelligence satellite system, Poppy,* developed by Program C at the Naval Research Laboratory and operated by the NRO from 1962 until the late 1970s. Poppy used high-gain antennas to intercept signal pulses from Soviet radar equipment and then transponded corresponding signals to receiving huts. Once processed, the signals provided analysts cues to the location, strength, and number of radar sets the Soviets could employ to detect oncoming U.S. strategic bombers. With early Sigint satellites like GRAB and Poppy, NRO engineers initially used a geolocation method based on geometric reconstruction. But they later discovered novel ways of exploiting signal externals measurements to greatly improve tracking and geolocation of missiles by reconstructing their altitude, leading to the first demonstrated geolocation capability from space.

As the NRO evolved the system through successive enhancements, low-earth-orbiting Poppy proved best at intercepting ship-based radars, which were sometimes on for only a few fleeting moments because of the deception tactics used by Soviet ship captains to avoid detection. In 1970, the USIB added electronic-order-of-battle production and ocean surveillance to Poppy mission guidance. With consequent upgrades to receiving stations, the Poppy program became an interim ocean surveillance system, while continuing also to provide Strategic Air Command critical flight route data to support building the Single Integrated Operations Plan and performing anti-ballistic missile search and general search missions to give Navy operations commanders and Intelligence Community decision-makers a more complete picture of the Soviet military threat. The success of the Poppy system also paved the way for the NRO, in conjunction with its mission partner, the National Security Agency, and the Navy, to sponsor development of a more advanced successor system dedicated to monitoring the threats manifested by an expanding, worldwide, blue-water Soviet Navy. With the establishment of offices for Tactical Exploitation for National Capabilities (TENCAP) in the military services, the NRO was able to provide not only direct support regarding enemy warships, merchant ships, and land-based emitters to the fleet, but also operational Elint support to the Army and Air Force.

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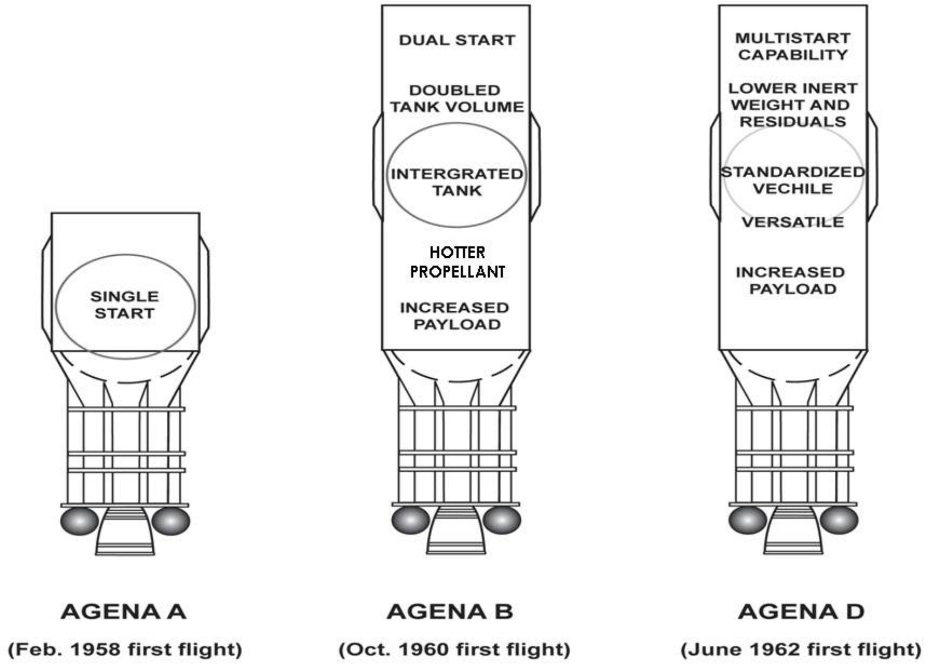
* The Poppy system had evolved from GRAB, the very first national reconnaissance satellite, which on 22 June 1960 launched as a "piggybacked" payload aboard the Transit 2A satellite.

INNOVATIONS

SPACE ENTERPRISE

AGENA



FOUNDATION OF SPACE RECONNAISSANCE

In 1946, the U.S. Army Air Force placed a requirement for Project RAND to study the technical feasibility of orbiting artificial satellites, which eventually became the Air Force's Advanced Reconnaissance System or Weapon System 117L (WS-117L). After numerous bids, on 29 October 1956, Lockheed Aircraft Corporation (which had teamed with Eastman-Kodak) was awarded the prime contract for the liquid-propellant Agena booster-satellite developed for the WS-117L program. The contract had three operational components: Samos (named after a Greek Island), was the pioneer version that was a near real-time photographic reconnaissance system; Ferret, an advanced version, was an electronic signals collector; and Midas, a surveillance version, was an infrared system that was capable of serving as an early warning missile system by detecting heat from missile launches.

An integral part of each of these systems was a general purpose vehicle that provided two critical functions. First, the vehicle served as a second-stage booster to place a variety of probe and satellite payloads into stable orbits after the Atlas Intercontinental Ballistic Missile first-stage boosters burned out. Second, once in orbit, the upper stage of the Agena vehicle served as the satellite control section by supporting the electrical power, three-axis attitude control for stability and pointing, and communications for both command and control of the payload functions and downlink telemetry for both satellite health and mission data.

SAMOS AND AGENA

In each of its three Samos missions, the Agena vehicle was required to support payloads with varying requirements. For example, the Samos' imaging payload could point off-axis to a limited degree to photograph targets that were not directly below the satellite, but to the outer periphery. Midas' infrared scanners rotated around the pointing axis to view the horizon looking for missile launches. Ferret was slightly different in that it was a signals collection antennae attached to the Samos on the front of the satellite to have an unobstructed view of the Earth below.

Samos finally launched on 11 October 1960, but the first launch failed to reach orbit. Later launches proved there was an issue with transmission capability that limited the downlink speed, which made this ineffective as an operational reconnaissance system. Midas first launched its two developmental missions in 1960 from Cape Canaveral while waiting on the completion of launch pads at Vandenberg Air Force Base in California.

Discoverer 14 Agena Spacecraft

Lunar Orbiter Launch
Agena D
10 Aug 1966

CORONA AND AGENA

As the program schedule for WS-117L slipped, there was a need for an interim photograph system using the Agena with a smaller Thor Intermediate Range Ballistic Missile as the first stage booster. Lockheed urged the adaptation of the WS-117L upper stage to the Thor missile as the first step in the program acceleration. This version was initially powered by the Bell XRM-81 rocket engine, originally designed for a B-58 Hustler bomber program, hence the name Thor-Hustler. Later this upper stage was called the Agena, and it was used for Discoverer, the cover name for the Corona program.

Unlike WS-117L, Corona required the Agena vehicle to fly with its long axis parallel to the ground so that the panoramic camera system could image a swath from one side of the flight path to the other. Since it also had a film re-entry capsule that had to be ejected from the Agena, the vehicle would maneuver to a 60 degree downward position to provide the proper re-entry sequence and recovery. The Agena was equipped with body-mounted roll and pitch position gyroscopes updated by the horizon sensor. The attitude control system would allow the camera to point accurately and have low roll and pitch blur rates needed for the Itek camera to deliver a resolution of about 20 feet. The Corona systems had to pass over the Soviet Union at latitudes higher than could be covered by launches from Cape Canaveral in Florida. The need for polar launches, greater security, and frequent launches to test new ballistic missile designs led to the establishment of Corona launch platforms at Vandenberg in California.

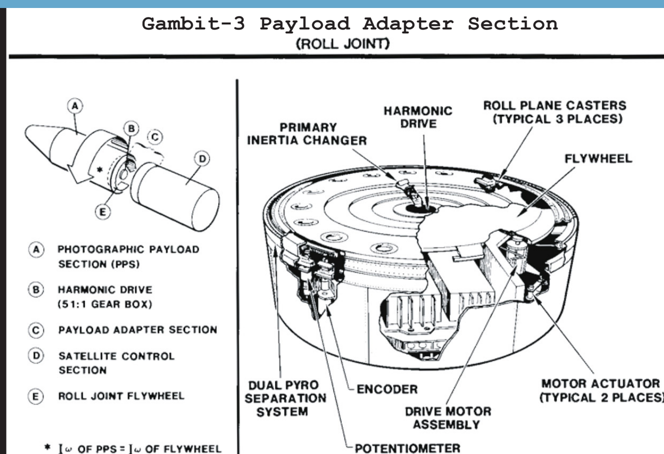
GAMBIT AND AGENA

NRO developed the Gambit satellite to provide high-resolution pointed target imagery. The Gambit-1 was designed to fly on the Atlas Agena booster. Its first flight was on July 1963, and there was a total of 38 missions. However Gambit-3, or Gambit-cubed, was flown on the Titan booster because it required a greater lift capability than the Atlas was able to provide.

Over the 28 years and 362 missions of the Agena program between 1959 and 1987, there were three basic models of the Agena vehicle flown called Agena A, B, and D. The Agena vehicle also provided other support to civil space programs including NASA. Programs like Ranger provided images of the lunar surface, and Mariner was a series of interplanetary spacecraft to investigate Mars, Venus, and Mercury. Gemini Agena Target Vehicles launched between October 1965 and November 1966 to develop and practice space rendezvous and docking techniques. The last NASA Agena flight was Nimbus 4 in 1970, and the last Agena flight was in 1987.

CONTROL MOMENT GYROSCOPES


Dirks




Hexagon Panoramic Camera Image

The groundbreaking technical achievements of the NRO's early film-return photoreconnaissance satellites – Corona, Gambit, and Hexagon – and their imagery collection were major intelligence contributors that ensured America's national security during the Cold War. However, the distribution of imagery from these satellites to analysts could take several weeks. There were also times when film-return satellites were not in orbit, and the satellites were limited in the ability to image ample intelligence targets on a daily basis. These limitations revealed a potential threat to U.S. security and demonstrated the need for an imagery satellite that could deliver intelligence in near real-time (NRT), be in orbit continuously, and image intelligence targets daily.

SATELLITE STABILITY AND NEAR REAL-TIME IMAGERY

Exploration of an NRT imagery satellite began in the early 1960s. In 1963, the CIA began funding Zoster (later renamed Zaman and then Kennen) program studies, led by Leslie Dirks, considered the father of near real-time satellites. These studies focused on the development of an electro-optical imaging (EOI) NRT system. By 1968, Dirks' team had identified a number of requirements for potential NRT satellites, which were compiled in the Application of Electro-Optical Technology to Satellite Reconnaissance study, known as "Dirks' Blue Book." It was this study that identified Control Moment Gyroscopes (CMGs) for use in the attitude control system* of NRT satellites. The attitude control would allow for the maneuvering of an NRT satellite that would need to orbit continuously and image select intelligence targets daily.

*Attitude is stabilized by yaw (nose left to right movement), pitch (nose up and down movement), and roll (rotation left and right of the nose).

President Nixon approved the Central Intelligence Agency to begin development of the Kennen NRT satellite system on 23 September 1971.

Kennen's acquisition of intelligence targets differed from earlier film-return satellites. Gambit-3 had a roll-joint, allowing limited side-to-side imaging, while Hexagon had panoramic cameras and did not need to roll. Film-return satellites controlled attitude by either firing low-precision, life-limited, liquid-fueled reaction control thrusters or utilizing agility-limited reaction wheel assemblies. Because of their low earth orbits, film-return satellites required frequent orbit adjustments to prevent prematurely re-entering Earth's atmosphere before the complete payload had been used. These orbit adjustments consumed large amounts of propellant, which had to be carried as part of the launch vehicle. These consumables came at the expense of film payloads, and they sometimes limited days in orbit. As there had not been a maneuvering spacecraft of the anticipated size of Kennen with a life span of more than a year, CMGs would provide the attitude control that would enable Kennen's success.

DEVELOPMENT OF CONTROL MOMENT GYROSCOPES

The NRO chose an industrial partner to develop Kennen's CMGs. The launch configuration of the first Kennen satellite used six individual CMGs, allowing the satellite maximum maneuverability and the ability to point in any direction at any intelligence target. Developing the CMG required precision design in electro-magnetics, high-speed bearings, lubrications, exquisite balancing, and advanced control algorithms that pushed the capabilities of existing onboard spacecraft computers. Early Kennen missions using CMGs were not without problems. The components inside these devices spin at considerable speed, so minor imperfections would cause catastrophic failure to a spacecraft. Even with precise balance, CMGs are one of the largest sources of vibration on spacecraft and, left unchecked, would interfere with payload operations. An NRO Pioneer developed a novel and groundbreaking vibration isolation technology to lessen CMG vibration and reduce the impact on payload performance. Several NRO programs have used this technology to isolate payloads from a variety of disturbance sources.

The CMGs provided the innovative technology that integrated the best of previous capabilities to develop larger, more agile satellites with improved pointing performance and longer mission life. These highly complex electro-mechanical systems enabled NRO satellites to accomplish their essential missions for national security from the 1970s into the 21st century.

CUBESATS

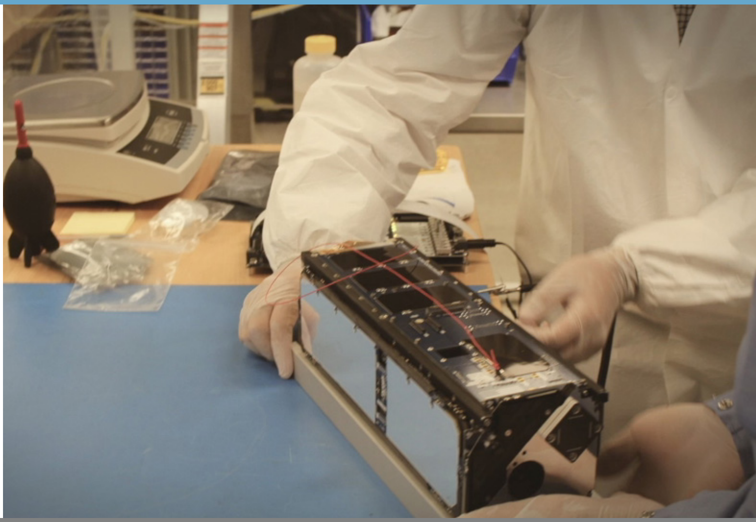

When U.S. satellite programs began in the late 1950s, satellites always started small due to the limited launch capacity of rockets used to carry the satellites into orbit. The world's first reconnaissance satellite, the Galactic Radiation and Background, an electronic intelligence satellite launched in June 1960, weighed a mere 55 pounds. As U.S. launcher technology advanced and became capable of carrying larger and heavy payloads, engineers began creating more capable satellites, which naturally became bigger and heavier. By 1971, the NRO launched the Hexagon film-return satellite, which was as large as a locomotive and weighed approximately 16,000 pounds. But as satellites got larger and more capable, they also naturally became more expensive and took longer to replace. As the nation's satellite constellation matured, it became evident that there was a need for smaller satellites to compliment the larger ones being placed in orbit, both as a time and cost savings measure and also as a survivability measure.

RIDE ALONGS

In the 1980s, the NRO began experimenting in the utility of smaller satellites. By the 1980s, interest grew in small satellites. The NRO began experimenting in the utility of smaller satellites. NASA too renewed their interest in small satellite launch efforts. The agency created its Gateway Special Program (GAS), a Space Shuttle rideshare program available for scientific and commercial use and open to educational institutions and business interest (foreign and domestic). These small payloads weighed less than 200 pounds and traveled on a space-available basis.

In the 2000s, NRO used small satellites for testing the viability of new technologies in space environments. These satellites could go from the planning stage to launch quickly and at a great cost savings because of their reduced size and weight. Rapid Pathfinder and the CubeSat program are two examples of small satellite technology pioneered by NRO's Advanced Systems & Technology Directorate (AS&T).

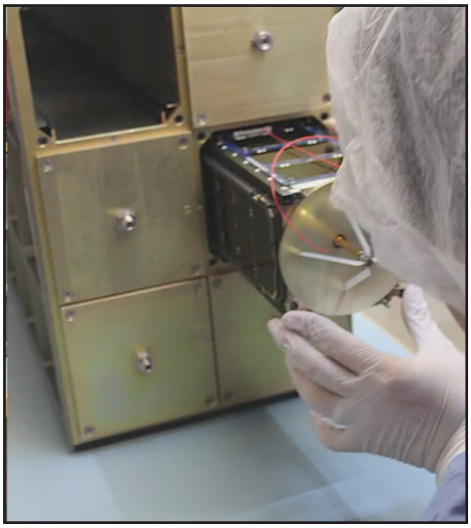
Rapid Pathfinder was an experimental technology testbed spacecraft developed by AS&T that launched on NROL-66 from Vandenberg Air Force Base on 6 February 2011 aboard a Minotaur 1 launch vehicle. Rapid Pathfinder's mission was to validate new research and development technologies and to demonstrate that the NRO could launch advanced technologies quickly and at a reduced cost. It was less expensive and smaller than most satellite vehicles, and it carried two advanced technology payloads. The AS&T brought Rapid Pathfinder from design to launch in just two years.



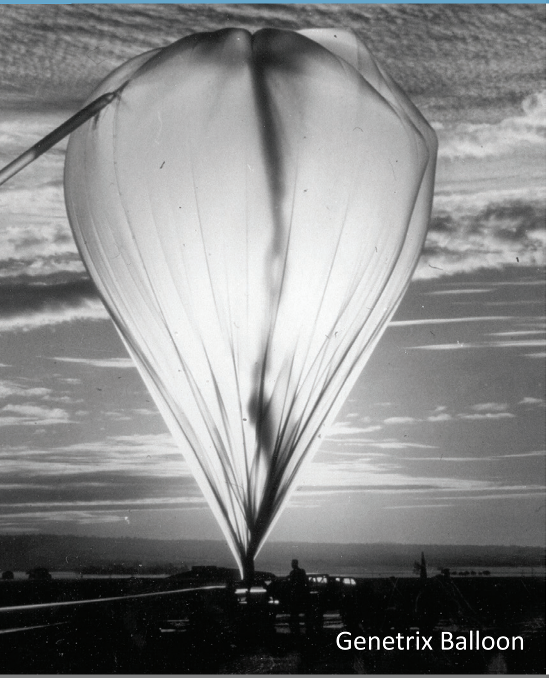
SMALL SATELLITES

CubeSats are nano-satellites developed, launched, and controlled at a fraction of the cost of a typical operating platform. CubeSats typically weigh between one and five kilograms. They are beneficial in reducing the risk of larger programs because of their low cost and rapid development cycle. California Polytechnic State University (Cal Poly) and Stanford University designed and developed the CubeSat concept in 1999. The first NRO CubeSat rideshare, OUTSat (Operationally Unique Technologies Satellite), took place in 2012 onboard NROL-36.

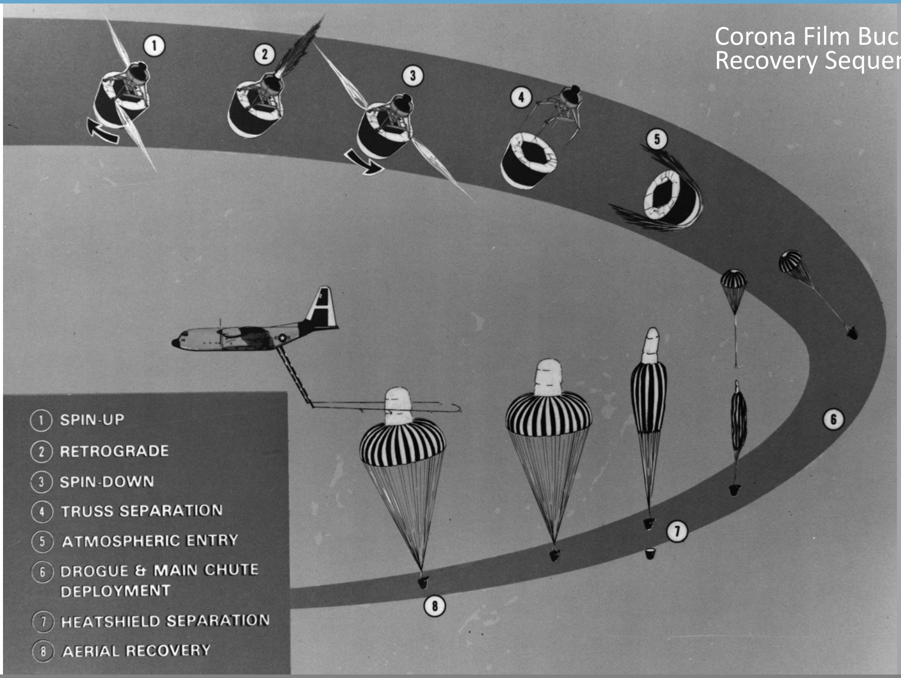
The NRO, NASA, and other government agencies recognize the utility of CubeSats and engage universities, service academies, laboratories, and industry to advance the state of practice. These small satellites are an important pioneering research effort that provide early evaluation of new technologies and test their survivability and performance in space environments. Today, NRO can easily test new technologies for a small fraction of the time and cost of previous development programs. Additionally, by teaming with other researchers and organizations, the NRO can provide rideshare on its launches and benefit from the cost savings and technology sharing with these various "hitchhikers."



FILM RETURN



Genetrix Balloon



Corona Film Bucket Recovery Sequence

LAYING THE FOUNDATION

When people are asked about the first film-based intelligence satellite, they invariably think of the Corona program, and rightly so. However, that program would not have been as successful if not for the experience gained from an earlier film-return reconnaissance effort called Genetrix.

On 10 January 1956, the Air Force launched the first of what would eventually be 516 high-altitude balloons released from Europe and Turkey that were designed to sail over Eastern Europe, the Soviet Union, and China, taking pictures at intervals along the way. The balloons were then caught in midair, after they had passed hostile territory and floated out over the Pacific Ocean, by Air Force crews flying C-119 aircraft. While simple in concept, the planners failed to take into consideration one small detail—Mother Nature. After launch, the balloons were at the whim of high-altitude wind currents, which were not well understood in 1956. Most flew too far south to be of use, and many blew far off course and were lost. After a couple weeks, Soviet fighter pilots realized that at dawn, the balloons had floated to a lower altitude due to the cooler night air and could be shot down. Of the 516 balloons launched, only 46 were recovered, and only 34 succeeded in returning useful imagery. The program was cancelled by President Eisenhower after only a month because of Soviet protests. However, the mid-air recovery experience gained by the Air Force flight crews in training and actual operations proved invaluable when they were recalled two years later for the Corona program.

CORONA

President Eisenhower approved the Corona program in February 1958. The design called for a film-based camera system to be launched into orbit, to take pictures as it passed over denied areas, to collect the film in a bucket at the tip of the satellite, and when all of the film had been exposed, to release the bucket back into the Earth's atmosphere to be caught midair as it descended toward the ocean. All nine pilots who had worked in the Genetrix program were called back in June 1958 to form the core of a new Air Force squadron, the 6593rd Test Squadron (Special), which would be assigned to retrieve the Corona film buckets and their precious cargo.

One key difference related to retrieving film canisters existed between the Genetrix and Corona programs. While the difference in the weights between the Genetrix film gondolas and the Corona buckets was significant and created problems of their own, they were easily overcome. The key difference was the speed and angle at which the two objects were recovered. The Genetrix gondolas floated along under a balloon at relatively slow speeds and constant altitudes.

Flight crew from 6593rd Test Squadron - Edwards AFB - 1958

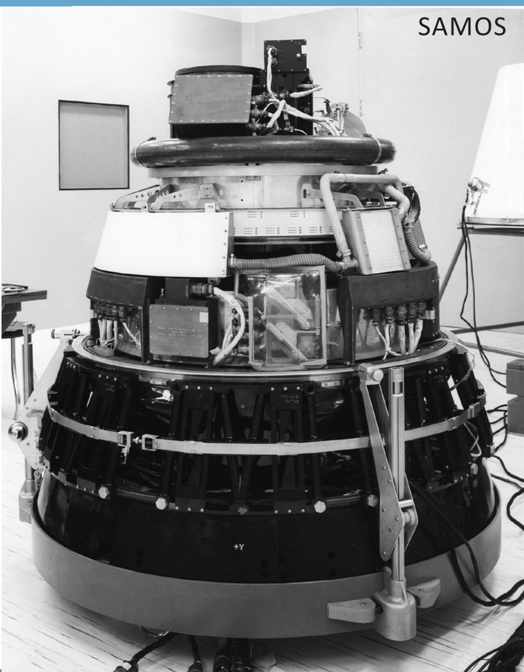
In contrast, the Corona bucket fell back to Earth under a parachute. To catch a falling parachute without overflying it or having it get caught in the moving parts of the aircraft was easier said than done. The pilots, crews, and program engineers spent over two years perfecting and practicing the concepts needed to make the safe capture of falling Corona buckets a reality. The pilots and crews spent the entire Genetrix program and first year of the Corona program flying C-119J aircraft; but in 1961, they began to phase the JC-130 four-engine aircraft into their operations as it became available, providing them greater endurance and safety as they flew above the Pacific Ocean.

On 19 August 1960, Capt Harold E. Mitchell and the crew of *Pelican 9* completed the first successful capture of an object from space returning to Earth after they snagged the film bucket from Corona 14 about 300 miles southwest of Hawaii. In the next 12 years, the “Star Catchers” of the 6593rd retrieved 158 film buckets from Corona missions, culminating on 31 May 1972 when Capt Donald G. Hard caught the second recovery bucket from Corona 145, the final Corona mission. After that mission, the 6593rd Test Squadron (Special) was deactivated, and their personnel and equipment were assigned to the 6594th Test Group, which continued the tradition and retrieved the film buckets from 79 successful Gambit missions and 19 successful Hexagon missions through 1984.

LIKE THE FOTOMAT

After 26 years and hundreds of successful recoveries, film return as an aspect of national reconnaissance eventually became obsolete. With the deployment of a near real-time imagery system in 1976, film return satellites had become slow and redundant. The 20th and last Hexagon mission in 1986 was the last film-based satellite launched by the NRO, and film return for national reconnaissance slowly migrated into the history books.

INTEGRATED SYSTEMS



BACKGROUND

When people think of satellites in space, they usually imagine that satellites operate independently and perform a single function. In the earliest days of satellite development, that was typically the case. However, the NRO early in its development of satellites recognized that every satellite vehicle provided a potential means for orbiting more than a single collection function. Given the significant costs of launching a satellite, the NRO built satellites that utilized full lift capacity for each rocket by incorporating, in some cases, additional collection systems. Today those satellites are identified as multi-mission vehicles, an approach to satellite development that the NRO trailblazed. Additionally, the NRO recognized that multiple satellites should act in concert, where possible, and developed the concept of integrated space architecture. Finally, the NRO moved away from single satellite system ground architecture to a more fully integrated ground architecture supporting the integrated orbiting architecture.

SAMOS

The nation's first reconnaissance satellite program, Samos, embraced the notion of a multi-sensor satellite. The primary imagery system carried a 36-inch lens for photoreconnaissance collection, but there were also plans for extra sensors to collect other types of imagery. Additionally, Samos was designed to include signals collection satellites that could collect both analog and digital signals. Samos satellites were envisioned as flying in a single architecture utilizing an integrated ground architecture.

CORONA AFTRACK

When the NRO declassified the Corona program, one capability remained classified for many more years. The first recovery was a test vehicle and did not carry film. Instead it carried a U.S. flag to confirm the return of an object from space. What the NRO kept classified is that Corona mission was an operational mission. It carried a signals collection sensor on the rear of the Agena control vehicle that confirmed the Soviet Union could track U.S. satellites. Additional Corona vehicles would not only capture intelligence imagery, but also carry similar integrated signals collection sensors. Because of the location of the sensor, the program was codenamed AFTRACK.

CORONA AND MAPPING CAPABILITIES

The NRO also recognized that satellite vehicles could be configured for different collection purposes. An early problem that the NRO addressed was the collection of imagery that would enable better mapping in support of military operations. At the time Corona first orbited, the U.S. military was still heavily dependent on German maps captured from World War II for planning defenses against the Soviet Union. Those maps were both imprecise and incomplete. The Air Force envisioned a mapping and charting system named the E-4 Mapping Satellite. Alternatively, the Corona program cooperated on the Argon project that incorporated a mapping camera into the Corona satellite platform to provide imagery for improving mapping capabilities. Again, integrating a new capability into an existing platform further demonstrated the integration philosophy of the NRO.

GAMBIT AND HEXAGON

Like with the Corona program, the NRO did not reveal all aspects of the Gambit and Hexagon programs with their initial declassification. By the time the Gambit and Hexagon vehicles were successfully developed, launch capabilities had significantly improved since the early Corona launches. With improved launch capabilities, the NRO could launch heavier payloads into space, which offered more integration opportunities. Both Gambit and Hexagon vehicles carried passenger payloads—usually signals collections satellites—that typically detached from the primary imagery vehicle. In some cases, however, they remained attached to the primary imagery vehicle, collecting signals in a low earth orbit.

First the Corona, and later the Hexagon vehicles served as companions to Gambit vehicles. Corona and the follow-on Hexagon program collected images of broad areas of interest allowing the U.S. to identify areas and objects of interest. The NRO then carried out Gambit missions to surveil those areas and objects with much higher resolution which provided significant intelligence details. The broad area search capabilities of Corona and Hexagon satellites integrated with the high resolution surveillance capabilities of Gambit provided an efficient and effective means for better understanding the capabilities of the Soviet Union and other adversaries during the Cold War.

Similar to flexibility offered by Corona, Hexagon allowed for much improved mapping imagery. Twelve of the 19 successful Hexagon satellite launches included a mapping camera system. The mapping camera had a separate optical system, film supply, and recovery vehicle. It was attached to the Hexagon vehicle and allowed collection of broad area search imagery and mapping imagery at the same time, again demonstrating the NRO's space system integration philosophy.

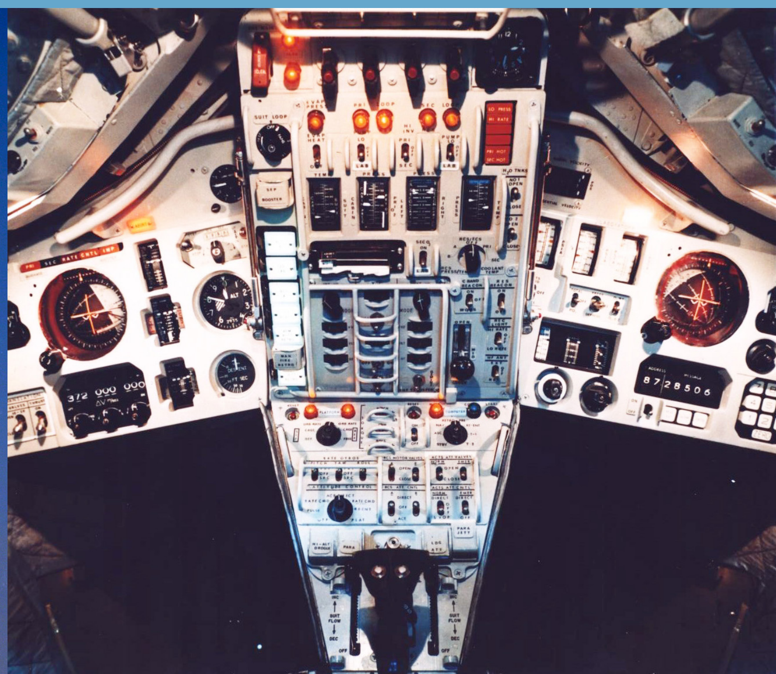
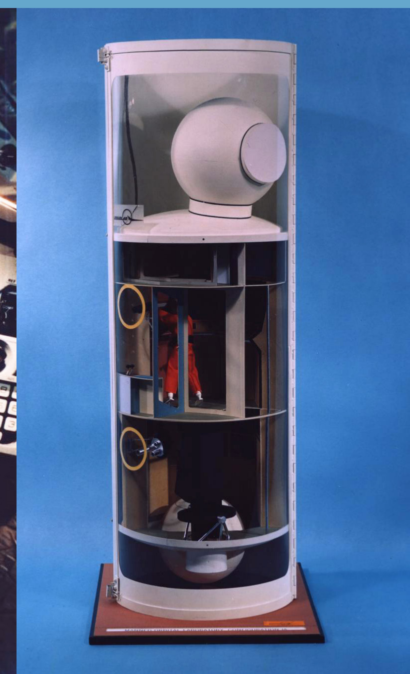
KENNEN

In 1976, the NRO launched its first electro-optical satellite known as Kennen. The Kennen satellite depended on a relay satellite in order to transmit imagery in near real-time. The use of a relay satellite further advanced NRO efforts to integrate satellites into a unified architecture.

A MATURE INTEGRATION PHILOSOPHY

The integration philosophy continues today with the NRO efforts to incorporate multiple sensors into an integrated architecture of satellites. This longstanding integration approach developed by the NRO consistently improved the efficiency of NRO satellite development and the effectiveness of satellites in low-earth, geosynchronous, and highly elliptical orbits. As the NRO improved satellite integration efforts, it has also improved the integration of ground stations. On both fronts, the NRO's integrated architecture provides robust and resilient intelligence collection capabilities necessary to maintain the U.S.'s national security in a very uncertain world.

MOL

A PRESIDENTIAL DECISION

President Lyndon Baines Johnson was not afraid to embrace government programs that might bring about significant change if successful. On 25 August 1965, he announced the following to the American Public:

> *At the suggestion of Vice President Humphrey and members of the Space Council, as well as Defense Secretary McNamara, I am today instructing the Department of Defense to immediately proceed with the development of a Manned Orbiting Laboratory. This program will bring us new knowledge about what man is able to do in space. It will enable us to relate that ability to the defense of America. It will develop technology and equipment which will help advance manned and unmanned space flights. And it will make it possible to perform their new and rewarding experiments with that technology and equipment.*

The Manned Orbiting Laboratory, or MOL as it was known, promised to use space for the first time as a manned reconnaissance vantage point. If successful, the program could dramatically change the way the United States collected intelligence on its adversaries, including the nation's main foe, the Soviet Union.

THE DORIAN PROGRAM

In the early 1960s the Air Force began efforts to put Air Force members into space by developing the Manned Orbiting Laboratory. The Air Force described the MOL program as follows in its initial December 1963 press release announcing the project:

> *The MOL program, which will consist of an orbiting pressurized cylinder approximately the size of a small house trailer, will increase the Defense Department effort to determine military usefulness of man in space...MOL will be designed so that astronauts can move about freely in it without a space suit and conduct observations and experiments in the laboratory over a period of up to a month.*

The U.S. Air Force described the MOL program as a less expensive option that would allow the Air Force to "conduct military experiments involving manned use of equipment and instrumentation in orbit and, if desired by NASA, for scientific and civilian purposes." From the beginning of the program, however, U.S. officials questioned the need for the MOL in addition to the U.S.'s civilian space program.

Unbeknownst to the public, the MOL program included a highly secret set of experiments and capabilities to gain intelligence from space. Information about MOL's secret planned capabilities was strictly protected under a security compartment known as Dorian. The capabilities developed under the Dorian project would result in the United States using the MOL as a manned reconnaissance station in space, collecting both imagery and signals intelligence. If achieved, the MOL would allow the U.S. to overcome the limitations of the already successful Corona and Gambit satellite reconnaissance programs.

The Dorian camera system was developed by Eastman Kodak, the same company that developed the high-resolution camera system used on the Gambit photoreconnaissance satellite. The Dorian camera system would have some unique capabilities. First, it had a longer focal length and other improvements, permitting better resolution than the first generation of Gambit satellites. Second, the camera system would be used after MOL crew members used a spotting scope system to determine whether or not targets were clear for imagery. Third, imagery targeting priorities could more readily be changed to meet unexpected imagery opportunities. And fourth, the MOL crew members would be trained to repair the Dorian system in the event that there were malfunctions preventing successful imaging. Together, these capabilities mitigated the shortcomings of the Corona and Gambit photoreconnaissance satellites.

MOL CHALLENGES

The resources devoted to the Vietnam War, the War on Poverty, and the Apollo program competed with the resources needed for the MOL project. Additionally, the NRO had already demonstrated that space could be used successfully as a reconnaissance platform through the Corona, Gambit, Grab, and Poppy satellite programs. At the time MOL was proposed, the NRO already had plans for a more powerful high-resolution Gambit program and the CIA was in the early stages of developing a satellite to supersede the Corona program, and they hoped, the Gambit program too. That program evolved into the NRO's Hexagon program. The Hexagon program was designed to carry an immense film load, allowing it to stay on orbit for six months or more. It would also carry an improved targeting system. It promised versatility that called into question MOL's necessity. Eventually, Hexagon and the improved Gambit-3 system would suffice in the Nixon administration's view, leading to the MOL's termination in June 1969.

MOL Crew Members

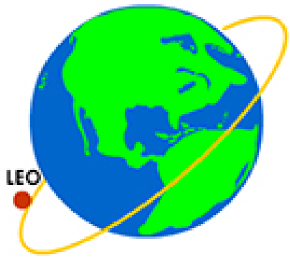
THE MOL PROGRAM LEGACY

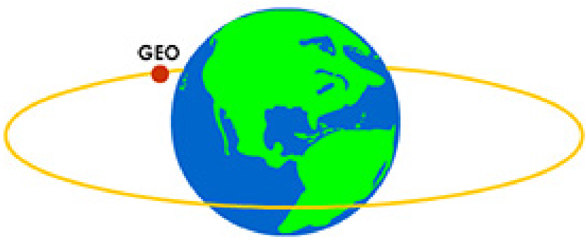
Because of the MOL program size, complexity, and time in existence, it consumed many millions of dollars in funding before termination. This begs the question of what if anything did the United States gain from the program? There were significant legacy contributions from the program. The first and foremost significant contribution was the leadership that came from the MOL crew members trained under the program. Seven of those crew members were accepted into NASA's astronaut program. At NASA they would either command or pilot the Space Shuttle. Of those, one would eventually lead NASA as the agency's Administrator, another would command NASA's Cape Canaveral launch facility, and others would lead elements of the NASA space program. Yet another would go on to lead the U.S.'s Strategic Defense Initiative. Another would serve as Vice Chairman of the Joint Chiefs of Staff. Many would also play important roles in corporations supporting national defense and space programs. Other engineers, scientists, and staff would play key roles in other national reconnaissance programs, drawing on their experiences and insights gained from the MOL program.

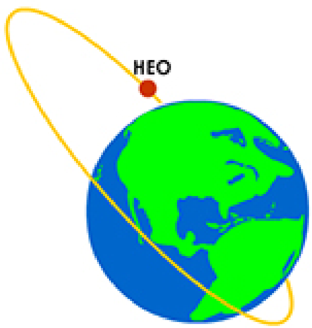
The MOL program would also make important contributions to national reconnaissance and space exploration programs. The Dorian camera system was to be preserved and studied for possible incorporation into the Hexagon program. One of the options for reducing costs of the MOL program was a series of unmanned missions. Those missions would carry multiple film return capsules in a configuration that closely resembled the configuration eventually developed for the Hexagon program. The MOL program also included a segmented mirror technology that was eventually used in a domestic space observatory. Segmented mirrors offered additional advances in space exploration with MOL advancing this important technology.

Finally, MOL helped advance the technology and science necessary for longer space missions. For example, the MOL program required its crew members to travel through a narrow tube or tunnel from the Gemini capsule to the laboratory section once the vehicle was on orbit. This in turn required a flexible space suit—more so than what NASA had developed at the time. The advancements in space suits under the MOL program were transferred to NASA. MOL also included proposals for more than one space module being launched and then linked on orbit. This concept would be critical for the development of today's multi-module space craft on orbit such as the International Space Station. The research and technology developed under the MOL program for sustaining crew members on orbit was also transferred to NASA, undoubtedly aiding NASA's advancements in manned space flight.

MULTIPLE ORBITS







The NRO has acknowledged that it flies satellites in three types of orbits: Low Earth Orbit (LEO), Highly Elliptical Orbit (HEO), and Geosynchronous Orbit (GEO).

LOW EARTH ORBIT (LEO)

The NRO's first satellites, the GRAB Elint satellites and the film-return photoreconnaissance satellites of the Corona program, flew in LEO. Subsequent programs including Poppy, Gambit, and Hexagon, likewise flew in this orbit. Satellites in LEO fly relatively close to the Earth's surface, up to 2,000 km in altitude. In LEO, orbital periods are short – often completing a pass over the Earth in just 90 minutes. In general, LEO satellites can make up to 16 complete passes in a day, but they must, by definition, make at least 11.25 passes. Satellites in LEO fly at high velocity, averaging around 7.8 km/second. Due to their close proximity to Earth, LEO satellites offer a limited field of view and are only able to communicate with small portions of the Earth at a time. Therefore, most satellites in LEO require a network or constellation in order to provide continuous coverage. In low altitude, satellite life expectancy remains low due to atmospheric drag (an important factor that has historically precluded flying satellites below 300 km), and they require periodic reboosting in order to maintain a stable orbit.

Within the LEO orbit, there are several subsets based on inclination and altitude. The Equatorial Low Earth Orbit (ELEO) indicates an orbit with a low inclination to the equator, offering rapid revisit times. Conversely, with a high inclination rate, Polar Orbits offer satellite passes above or nearly above both poles. In recent years, more objects have begun flying in Very-low Low Earth Orbit (VLEO). These objects require new and developing technologies to combat the significant atmospheric drag and maintain orbit, and yet remain economically sustainable.

Despite any limitations of the LEO orbit, it lends itself to manned missions and more accessible servicing. It is the most common orbit for reconnaissance satellites and all other man-made objects. The International Space Station flies around 330 km above the Earth's surface; the Chinese Tiangong Space Station, launched in April 2021, orbits between 340 and 450 km; and the Hubble Space telescope orbits at about 540 km. Unlike most communication satellites, a series of satellites operated by Iridium Communications operates in LEO at about 780 km. And finally, remote sensing satellites often fly around 800 km and near polar inclination.

The United States Strategic Command (USSTRATCOM) currently tracks more than 8,500 objects that are larger than 10 cm in LEO. Because it is the preferred, oldest, and most accessible orbit, LEO is becoming crowded, putting objects at risk of catastrophic collisions.

HIGHLY ELLIPTICAL ORBIT (HEO)

Objects that experience a much higher high point (or apogee) than its low point (or perigee) are flying in a Highly Elliptical Orbit. The most common type of HEO is the Molniya orbit, "lightning" in Russian. From their latitude, the Russians found that it required too much energy to launch communications satellites into Geosynchronous Orbit, as many other nations were doing in the 1960s. So in 1965, Russia began launching into HEO, making them the original user of the orbit. Russia continued to launch their series of Molniya satellites, both military and communications, until 2004. Objects in a Molniya orbit make two full passes over Earth in a day, flying in a highly inclined orbit, and are generally marked by an Argument of Perigee at the Southern Hemisphere. Given the nature of the orbit, satellites slow as they approach and descend from apogee, offering long-dwell collection opportunities. Objects in Molniya orbit are near apogee for about 11 of their 12-hour orbit time, ideal for coverage around the North Pole and for space-based ballistic missile early warning systems. Marked by high apogees, satellites in HEO are under far more severe solar and lunar gravitational terms than satellites in LEO, requiring high-precision modeling in the orbital mechanics of a HEO satellite.

A much lesser-known type of HEO, the Tundra orbit, similar in characteristics to Molniya, offers only one pass over Earth per day. With only one pass, satellites in Tundra are near apogee for about 16 hours of their 24-hour orbit. The only known user of the Tundra orbit is Sirius Satellite Radio, which operated satellites in Tundra from 2000 to 2017. Communication satellites fly predominantly in HEO.

GEOSYNCHRONOUS ORBIT (GEO)

Unlike satellites in LEO, satellites in GEO fly at high altitude – around 35,790 km above the Earth's surface. At such a distance, satellites in GEO follow the Earth's rotation and sidereal day, marked by an orbital period of just 3 minutes and 56 seconds shy of 24 hours. The orbit was first described by Herman Potcnik in 1929, although it wasn't until 1945 when the British science fiction author, Arthur C. Clarke, first popularized the idea of the orbit in his paper, "Extra-Terrestrial Relays- Can Rocket Stations Give Worldwide Radio Coverage?" GEO is sometimes referred to as the Clarke Orbit. Designed by Harold Rosen at Hughes Aircraft, in 1964, Syncom 3 became the first satellite successfully placed in GEO. It transmitted the summer Olympics from Japan to the United States

A geostationary orbit, a type of geosynchronous orbit marked by zero degrees of inclination and zero eccentricity, remains over the same spot on the Earth's equator at all times. From such a high altitude, satellites in geostationary orbit can offer a large, constant view of the same spot on Earth – making this orbit a favorite for weather and communications satellites.

An inclined geosynchronous orbit (IGSO) is geosynchronous but not geostationary. At an incline other than zero degrees, the ground track of a satellite in IGSO can vary from a straight line of longitude around the equator to a non-symmetric analemma (or figure-8).

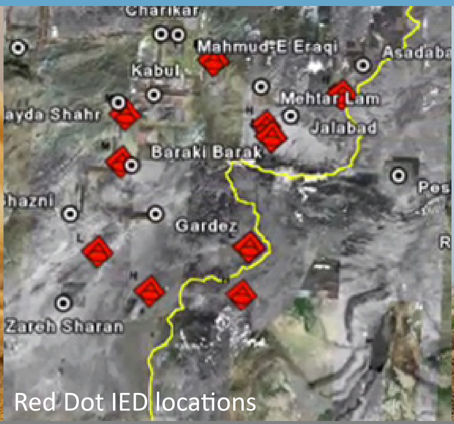
Satellites that fly in GEO include INMARSAT, a fleet of 11 telecommunications satellites operated by the International Mobile Satellite Organization, an international telecommunications company founded in 1979. The Thuraya Satellite Telecommunications Company, a regional mobile satellite system that covers 110 countries across the Indian subcontinent, the Middle East, Central Asia, North and Central Africa, and Europe, likewise operates two satellites in GEO. Intelsat also flies in GEO.

Because all satellites in GEO must occupy the same ring above the equator, there are a limited number of slots available for satellites. The International Communications Union addresses and navigates disputes over accessibility to the available GEO slots.

NRO IS EVERYWHERE

The three types or orbits are all distinctly different from each other. Each offers particular advantages, as well as disadvantages. The type of satellite usually determines the orbit, since the satellite's mission will be benefited by a certain orbit, while the orbit's detriments can be lessened or nullified based on the mission and target(s). The NRO has declared that it uses all three orbit types in its constellation.

RED DOT



Red Dot IED locations

The NRO has played a key role in operations against al-Qa'ida and other terrorist organizations, as well as U.S.-led military operations against insurgencies in Iraq and Afghanistan. These adversaries often operate as dispersed, clandestine networks, hiding in isolated, rugged locales like the Afghan-Pakistan border, or in hostile ungoverned regions of Somalia or Yemen. These adversaries are successful in their use of technology, and a favored weapon is the improvised explosive device (IED).

THE HIDDEN THREAT

Cheap and easy to construct, IEDs allow lightly armed and barely trained militants to engage with deadly consequences against the well-equipped and highly-trained troops of U.S. and coalition forces. IEDs tip the balance in an asymmetric conflict by enabling insurgents to inflict mass casualties without exposing themselves. The unpredictable, combat-avoiding nature of IED attacks are what makes them so effective. In the past, IEDs slowed the mobility of U.S. troops while time-consuming sweeps for concealed devices were conducted. In the early days of the Global War on Terror, the only defense against IED attacks was equipment such as radios, metal detectors, electronic counter-measure systems, and robots.

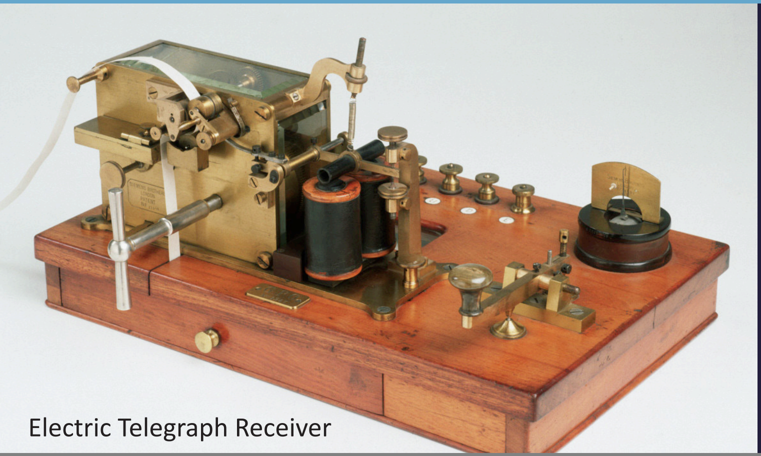
IEDs are one of the most lethal weapons available to terrorists and enemy combatants, as they are not only simple to build and deploy, but also virtually undetectable, and they frequently produce high casualty counts. The Defense Manpower Data Center reported that from 7 October 2001 through 16 September 2006, IEDs caused about half of all the American casualties in Iraq, and about 30% of combat casualties in Afghanistan. Separately, a U.S. Government Accountability Office report stated that between January 2007 and February 2018, approximately 9,000 IED incidents were targeted against U.S. and allied military forces in Iraq and Afghanistan, resulting in about 23,000 casualties.

THE NRO DEPLOYS RED DOT

One of the most successful efforts to date in countering the IED threat faced by U.S. and Coalition Forces is the RED DOT program. Developed by the NRO and initially deployed to Iraq in early 2010, and later to Afghanistan, the program leverages information from multiple intelligence sources to provide an integrated IED risk situational picture that is delivered directly to the warfighter in harm's way. It works by monitoring roadways for the electronic signals produced by the transmitters used to trigger the explosives, and within minutes, combines those signals with other intelligence streams, terrestrial sensors, and imagery to narrow the IED location to an accuracy within a few meters. It then sends the information directly to the tactical user on the ground, indicating where the possible IEDs may wait ahead, thus enabling the troops to avoid the area and ultimately remove the IED from the battlefield.

It takes an incredible amount of skillful integration of signals and imaging satellite intelligence with other source inputs in order to display, quite literally and within minutes of receipt, a red dot on the computer display in the vehicle on the ground. That dot identifies, in near real-time, the probable location of deadly IEDs. Former DNRO Bruce Carlson said, "It's incredibly difficult to take a picture someplace and fuse it with signals intelligence that you might have a million different pieces of." However, the one thing that is certain is that RED DOT saves lives by providing the integrated information needed to avoid and successfully remove hundreds of IEDs from the battlefield every year.

RELAY SATELLITE DEVELOPMENT



Electric Telegraph Receiver

Traveling Wave Tube Amplifier

GAME-CHANGING INTELLIGENCE COLLECTION INNOVATION

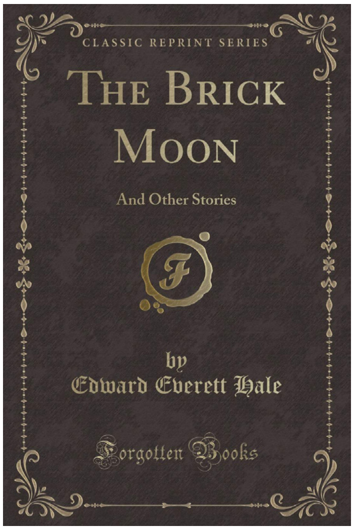
The NRO's implementation of communications relay satellites enabled near real-time return of high-resolution, digital reconnaissance imagery, among the most important intelligence collection innovations in the organization's history. The first relays served as integral components of the Kennen electro-optical imaging satellite system. Beginning in January 1977 when Kennen became operational, the relay satellites formed the space segment downlinking collected digital data to a receiving mission ground station, which converted it into hard copy imagery. This game-changing capability provided the U.S. an immediate technological edge and intelligence advantage in conducting diplomatic and military actions. For the first time in history, decisionmakers in Washington could obtain digital imagery within hours of collection or tasking, allowing the monitoring of an emerging or ongoing crisis happening nearly anywhere in the world. The Kennen system also ushered in a new era of tactical responsiveness for military commanders, who could use the high-quality, time-sensitive imagery for planning, targeting, and executing missions. Development of relay satellites, which NRO needed four years to complete, made instantaneous downlinking possible by solving the line-of-sight and weather problems that since ancient times had limited long distance communications methods, ranging from smoke or light signals to semaphore and even radio telegraphy.

QUEST FOR LONG DISTANCE COMMUNICATIONS LINKS

The first long-distance communication method that overcame these problems and promised to provide timely messaging was the electric telegraph. Long distance communication links were established by the laying of network cables along the bottom of oceans, which provided telegraphic messaging capability, first between England and Europe in 1850, and later between Europe and North America in 1866.* By the early 20th century, the telephone and wireless communications began to supplant the telegraph; early wireless systems, in particular, transmitted in frequency ranges below 30 MHz that reflected signals off the ionosphere and the Earth's surface to follow the curvature of the planet, providing unlimited range. All these innovations greatly improved and accelerated long-distance communications, but as radio frequencies above 100 MHz began to be used, the old problem resurfaced: higher frequency waves were not reflected back, but simply traveled into space, meaning that transmissions could only be received when the transmitter and receiver were in line of sight of each other. The solution for integrating higher frequencies into global communications would require a space-based system, but few had thought seriously about this problem yet. One early fantastical concept, as online

*In 1858, the Atlantic Telegraph Company, a joint Anglo-American venture, had successfully laid cable along the ocean floor stretching from Valentia, Ireland to Heart's Content, Newfoundland. Unfortunately, the cable was already in deteriorated condition before installation, and further damage caused by sending higher than necessary voltage through the line caused the communications link to fail after only three weeks. It would take eight years, during which time engineers continued to refine cable construction, until the Atlantic Telegraph Company laid a reliable cable, and transatlantic telegraph service could truly begin.

Encyclopedia Britannica notes, appears in American author Edward Everett Hale's 1870 short story, "The Brick Moon," which features signal communications between people on the Earth and others residing on a primitive space station. In the story, a group of men decides that having a second moon would be enormously beneficial to navigation, so they build a structure 200 feet in diameter, made of bricks, and launch it into space. Once in orbit, the "Brick Moon" satellite transmits Morse code signals to navigators by having people jumping up and down on the satellite's surface. Imaginative, perhaps, but clearly lacking understanding of what a later writer would call "the peculiarities of the ionosphere."



EXTRATERRESTRIAL RELAYS

That writer was Arthur C. Clarke, who was destined to become an enormously popular science fiction author and essayist. In 1945, Clarke—who was then an unknown Royal Air Force Officer—began ruminating on the limitations of long-distance communication and the possibilities for using satellites to provide a true broadcast service over the whole globe. In a Wireless World article published that October, Clarke postulated that artificial satellites in 24-hour orbits (i.e., moving at the same speed as the Earth's rotation, thus remaining in a fixed position relative to a point on Earth, eventually called geostationary orbit) could intercept radio signals, amplify them, and retransmit to other relay satellites or ground receivers. By placing three such satellites 120 degrees apart, Clarke calculated his extraterrestrial relays constellation could provide television and microwave coverage to the entire planet. Although it did not garner much immediate attention, Clarke's concept was essentially correct and pointed toward a future of space-based communications. Moreover, although not stated, relay satellites would prove critical to addressing the bedeviling line-of-sight delays that would occur with still-nascent orbiting sensor payloads, which could not downlink data to the Earth without being in clear view of a ground station. The result is significant time lag between when sensor data is collected and when it is finally received by the processing station. A constellation of two or more relay satellites compensate for this by working in tandem to continuously transfer data and command instructions to and from the ground. The operations of relay satellites have been compared to their namesake racers in track and field: like runners carrying and passing off batons on a relay team, the individual satellites hand off data to the next satellite to carry it on the next leg of its journey.

Fortunately, technology was not dependent upon Clarke's readership. The same year his article appeared, the U.S. Army Signal Corps reflected radar pulses off the Moon back to a terrestrial antenna. John R. Pierce of AT&T's Bell Laboratories expanded upon Clarke's ideas by suggesting the use of a space communications "mirror" in conjunction with a medium orbit "repeater" and a 24-hour orbit "repeater." By the end of the 1950s, Navy stations on both U.S. coasts and at Pacific sites transmitted messages, including facsimiles, using "lunar bounce." Working for NASA, Pierce's Bell Labs team developed the first active relay Telstar 1, which transmitted live television images between North America and Europe in 1962. Another influential engineer, Harold Rosen, led a Hughes Aircraft Company team in launching the first satellite into a geosynchronous orbit, Syncom 2, as well as the first geostationary orbit satellite, Syncom 3. Similar technological developments paved the way for NRO's implementation of its relay satellite system.

PIONEERING CONCEPT AHEAD OF TECHNOLOGICAL READINESS

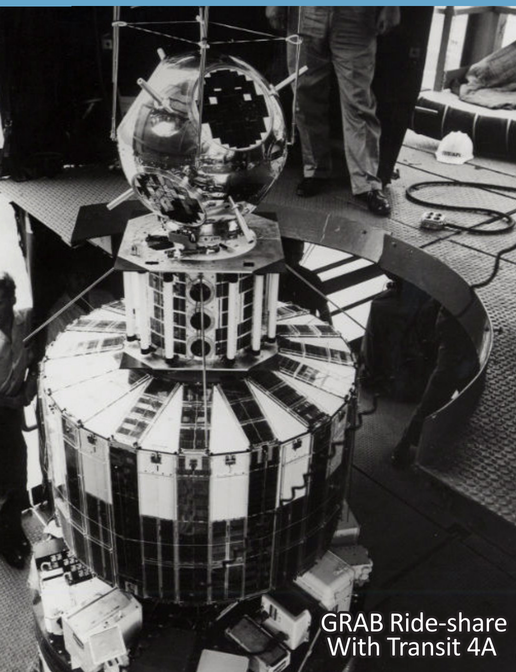
Developing systems capable of providing timely data to warn of an imminent attack had been a principal national reconnaissance objective in the first U.S. satellite program, the Air Force's WS-117L begun in the late 1950s and contracted to Lockheed. Also encompassing plans for a family of systems to collect electronic and infrared intelligence, the WS-117L program's primary photoreconnaissance satellites consisted of systems employing both film-readout, which provided more timely data return, and film-return technologies, which promised greater image resolution and ground coverage potential. The former were developed under the Sentry (later renamed Samos) program, and though electronically scanning film negatives and transmitting the data to the ground was indeed more timely, the technological state-of-the-art limited scanning capacity and degraded image resolution. This left the latter, separated from WS-117L and developed covertly under the Corona program, to become the first operational photoreconnaissance system. The tremendous success of Corona—the NRO launched and operated Corona satellites for 12 years, continually improving cameras and extending mission duration—particularly its innovative film-recovery method, ensured that it became the blueprint for two successor film-return systems, Gambit and Hexagon, that further advanced space reconnaissance technology. Still, the need for a near real-time capability persisted as, too often, returned imagery that was found to contain time-sensitive information became available only after effective follow-up action could be taken. One frequently cited example occurred in August 1968, when Corona imagery revealing an impending Soviet invasion of Czechoslovakia was returned from space, processed, exploited, analyzed, and delivered to President Johnson's office more than a week after Warsaw Pact troops had largely suppressed the "Prague Spring." Confronted with a fait accompli—not to mention evolving policies crafted to lessen East-West tensions and NATO allies opposed to military intervention in the Soviet sphere of influence—all the President could do was cancel a scheduled U.S. - U.S.S.R. summit and issue a toothless diplomatic protest.

By the late 1960s, NRO Program B was already studying major technologies and subsystems needed for an EOI satellite system that would meet the requirements for a near real-time indications and warning capability. The envisioned system's primary method for image recovery was expected to be relay satellites, and though some additional technology development would be required, the NRO contemplated building relays that closely resembled communications satellites then under development. In particular, Intelsat-3, an American communications satellite developed by TRW and used to relay commercial global telecommunications, including live TV, was considered a close approximation to what NRO would require for its relays, albeit with less demanding specifications. Thus, study teams at that time did not consider this essential component to the EOI system to pose daunting engineering challenges. This assumption proved to be overly optimistic. As events unfolded following President Nixon's approval on 23 September 1971 to proceed with development and acquisition of the revolutionary EOI system, the NRO discovered there are always unexpected challenges when an organization redefines state-of-the-art.

MAXIMIZING PROGRAM MANAGEMENT EFFECTIVENESS TO ACHIEVE THE CRITICAL LINK

After the relay satellite contract award to Hughes Corporation one year later, the NRO scientists and engineers set about designing and building first-of-its-kind hardware. To meet challenges, NRO engineers adopted and adapted existing commercial components where possible. Enabling the relay satellites to operate in conjunction imagery satellites was another challenge absent in the use of commercial communication satellites system. Finally, the choice of orbit was critical, and NRO sought inspiration from Clarke's hypothesis from some 30 years earlier. For the other issues, the NRO team worked round-the-clock to overcome many challenges in getting the spacecraft ready for launch, to include compiling test procedures from scratch. In the months leading up to the first launch, the prime contractor took the unprecedented step of assigning its chief engineer—later named a Pioneer of National Reconnaissance—to work full-time to ensure complete mission success. In the end, the NRO launched the relay satellites on-time and without significant cost overrun. The new architecture eliminated the country's dependence on film-return systems and provided a persistent global information perspective that supported decision-making on emerging crises.

RIDE-SHARE LAUNCH


GRAB Ride-share With Transit 4A


Space Shuttle


CubeSats


NROL-36

NRO has innovated by exploring and exploiting ways to launch its satellites. Rideshare launches are a key example of its innovative approaches. In essence, ride-sharing connects passengers with available transportation. A secondary payload, or "ride-share," is a smaller-sized payload that is transported to orbit on a launch vehicle supplied by or for the entity associated with the primary payload. Typically, the primary payload dictates the specific requirements for launch and the launch-vehicle interface. In return, the ride-share gets into orbit at a substantially reduced price.

EARLY NRO RIDE-SHARING

Ride-sharing is not a new concept for the NRO. The idea of launching more than one payload together dates back to NRO's very beginnings. The first electronic intelligence satellites were small, and launch procedures were rather fluid. Two or three satellites might be stacked and then joined together in what was called a "piggyback" launch, sending the main satellite and one or more auxiliaries together into orbit. After reaching orbit, the payloads typically would separate to perform their individual missions.

Galactic Radiation and Background 1 was the first operational U.S. intelligence satellite. It accompanied the first U.S. Navy navigation satellite, which was called Transit 1B, as a covert piggyback payload. Then, as in more recent times, the organization with the main payload determined the launch schedule. On 22 June 1960, the two satellites launched together from Cape Canaveral, Florida, using a Thor-Able-Star booster. Although details including GRAB 1's name and Elint mission remained classified, the news media celebrated this first U.S. dual launch as an important space accomplishment. GRAB 2, the next successful Elint satellite, launched on 29 June 1961. It was piggybacked with the Transit 4A satellite and a satellite designed by Dr. James Van Allen of the University of Iowa to study the radiation belts around the Earth. That was the first successful launch of three satellites together.

As the NRO began to develop larger and more complex satellites that in turn required powerful boosters, the opportunity arose for it to host secondary payloads systematically. The NRO's Program A operated an experimental program to collect Soviet radar information in which smaller payloads were attached to a rack on the rear or "aft" section of the Agena satellite vehicle for launch. This configuration received the very logical program name "AFTRACK." The first AFTRACK experiment, SOCTOP, successfully launched along with a Corona satellite on 10 August 1960. Subsequent AFTRACK experiments had imaginative names that included TAKI, GRAPE JUICE, NEW HAMPSHIRE, PLYMOUTH ROCK, WILD BILL, and OPPORKNOCKITY. The last AFTRACK ride-share, DONKEY, launched on 24 July 1967.

Sigint "Proof of Concept" subsatellites flew as aft-rack "hitchhikers" on Corona, Poppy, and other launches. Other secondary payloads were the Sigint Project platforms. These Program 11 (P-11) subsatellites detached from the primary satellite and proceeded with their missions. Designed to be longer lived than the AFTRACK experiments, these were bona fide subsatellites with their own propulsion systems.

NRO AND THE SPACE SHUTTLE

For a period of time, all NRO and DoD payloads were directed to launch solely via the Space Transportation System, more commonly known as the Space Shuttle. In fact, plans to use the shuttle to launch the very large Hexagon system dictated the dimensions of the Space Shuttle's cargo bay. The relationship between the NRO and NASA was complicated. Disasters in the 1980s, including the loss of the *Challenger* and an explosion that damaged a planned shuttle launch site, were serious setbacks. In the end, the actual number of NRO payloads that launched via shuttle missions was limited. The NRO instead chose to develop unmanned launch systems that were more reliable, flexible, and less costly.

RIDE-SHARING TODAY

The term "ride-sharing" became extremely popular in the early 21st century. In the launch arena, the NRO led the way with its CubeSat program. It was a creative approach to launch and operate nanosatellites on orbit at a lower cost, and in a quicker time frame, than traditional NRO programs. This allowed the NRO and a variety of mission partners that included NASA to launch experimental CubeSat satellites that explored new questions and enabled rapid innovation. Small, containerized, modular, and boasting standard interfaces, CubeSats are designed to reach space by hitchhiking as secondary payloads. Ride-sharing got small, low-cost satellites on orbit very quickly.

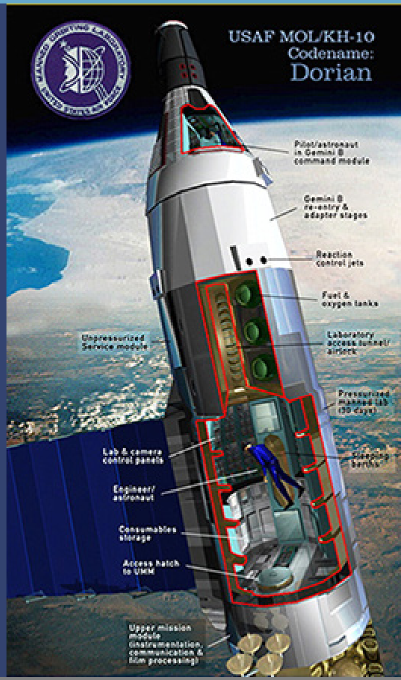
On 13 September 2012, the NRO launched its first ride share mission, NROL-36. The Atlas V rocket boosted the main payload along with 11 CubeSats in the extra capacity bulkhead. These small modular CubeSats had been developed by labs and other organizations to research such topics as maritime shipping container tracking and space weather.

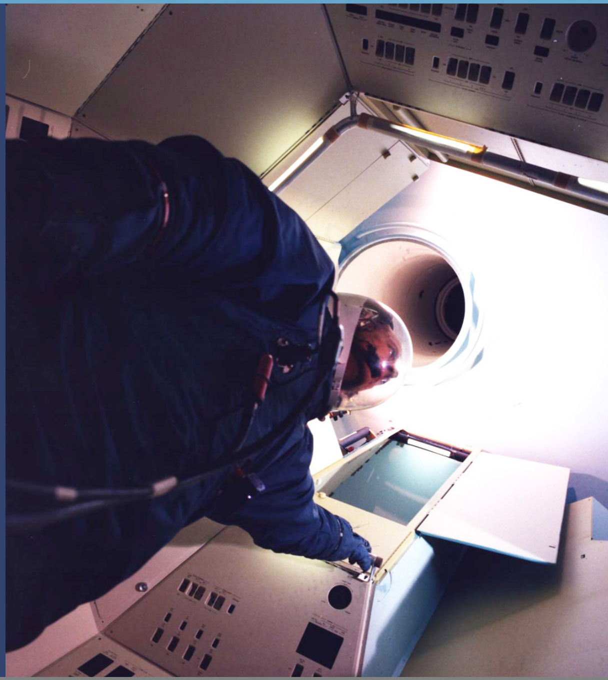
The costs of developing a CubeSat, and of securing a launch slot for it on a larger mission, are substantially lower than single-purpose launches. Reaching orbit as a ride-share allows CubeSat missions to take on more risk with the potential for substantial rewards on investment. Another key factor fueling the success of ride-sharing at the NRO was the development of inexpensive deployment systems to propel the ride-shares into space after the primary payload deployed.

The NRO CubeSat Program Office accepted cutting edge ride-share payloads from government, academia, and industry. NRO Director Betty Sapp praised ride-sharing in 2013, saying that "[w]e have long recognized that there are benefits and efficiencies to be gained through the ride-share in space launch. These benefits include opportunities to conduct scientific research and demonstrate and apply emerging technologies through the use of small satellites."

Originally a process just for government-sponsored launches, ride-sharing quickly is becoming ubiquitous. The advent of nanosatellites and the expansion of commercial launch providers helped fuel the growth of ride-share launches. Thanks in no small part to the NRO's ride-share innovations, sending a small payload into space may eventually become as easy as shipping a package with a delivery company.

SPACE-BASED LAB





MANNED ORBITING LABORATORY HISTORY

Originally conceived in 1962 and publicly announced in 1965, the Manned Orbiting Laboratory program was a joint NRO-Air Force project designed as a 30-day mission to send reconnaissance-trained military men into space. Once in orbit, the astronauts were to transfer from their Gemini capsule into the laboratory vehicle via a hatch cut into the Gemini's heat shield. There, the astronauts would spend the next 30 days in a shirt-sleeve environment, performing experiments and taking reconnaissance photos of Earth - avoiding disruptive weather conditions and responding to changing national security concerns.

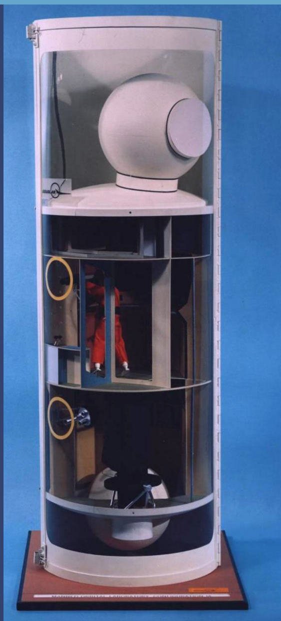
Upon completion of the MOL mission, the crew was to climb back through the hatch and into the Gemini capsule, detach from the laboratory, and return to Earth in the Gemini. The remaining MOL hardware - the entire laboratory vehicle - would become space refuse. Unfortunately, the system was not designed to allow for a rendezvous with a later crew.

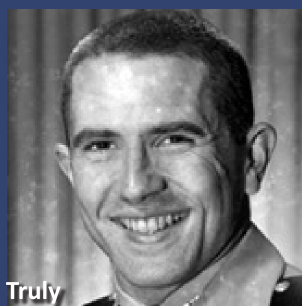
Although the program was cancelled in 1969 before it ever flew, it prompted the design and building of several important pieces of technology that went on to benefit the space community for years to come. In response to the program's cancellation, an ad hoc group chaired by MOL technical director Michael Yarymovych and tasked with finding national benefit from the program remarked, "In this regard, an unmeasurable but real benefit of the program is the expansion of manned spaceflight know-how across a broad segment of industry and Government."

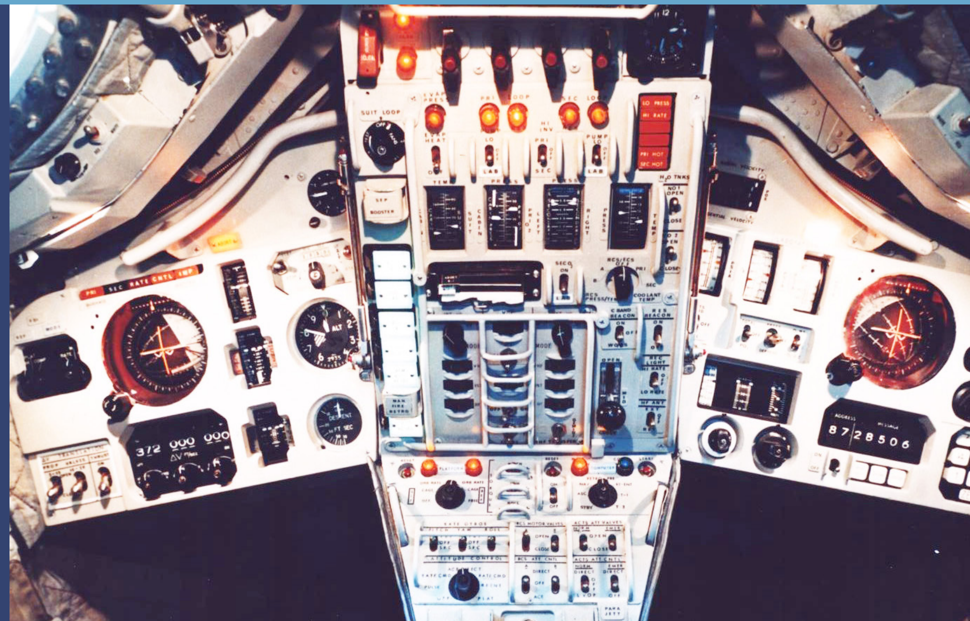
MOL VEHICLE DESCRIPTION

The MOL's Space-Based Lab was composed of a Laboratory Module mated with a Mission Payload System Segment (MPSS). The Laboratory Module was 10 feet in diameter and 19 feet long - the most spacious design for any American spacecraft at the time. It was to be the crew's mission support during the 30-day orbital flight phase. At 1,000-cubic feet, the pressurized compartment was designed to allow for a shirt-sleeve environment for the two-man crew, working and living without constantly wearing their space suits. It was also to provide a living area for the longest anticipated spaceflight to date.

The Laboratory Module was divided into two octagonal workspaces, housing eight bays each. The bays were designed to provide room for storage units, environmental control system equipment, the environmental control system controls, hygiene/waste compartment, a biochemical test console and work station, large experiment airlocks, a glove box for handling liquids, a motion chair to determine mass of crew members during flight, two performance test







panels, a physiology test console, a full-body exercise device, emergency oxygen masks, viewport and instrument panel, and the main spacecraft control station. The module would also be home to beds, spacesuits, food, and water stores to support the astronauts for 30 days.

Within the Laboratory Module, the two-man crew was to conduct their primary function of attaining high resolution, useful reconnaissance photos. Over the life of the program, two MOL astronauts, Lachlan Macleay and Richard Truly, worked to design a targeting software package to make use of man in the program. Using two targeting telescopes, the MOL astronauts would be able to look ahead to planned targets, assess the weather and viability of the target, and vote on which targets to prioritize. The targeting telescopes and photographic equipment were located in the MPSS, while the workstations were housed in the Laboratory Module.

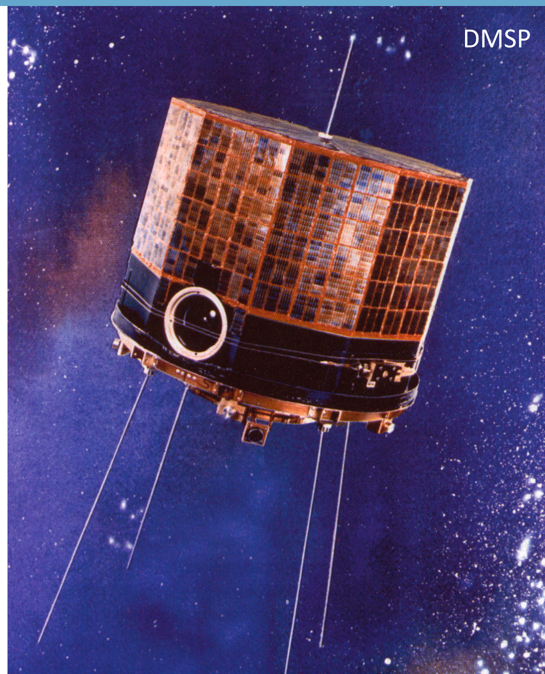
The MPSS was designed to house the photographic system and subsystems necessary for control and dynamics. It was an unpressurized module 10 feet in diameter and 37 feet long. It housed the acquisition and tracking scopes, communication equipment, film processing, and all other equipment required to maintain system functions. Mated with the Laboratory Module, it created the complete Laboratory Vehicle.

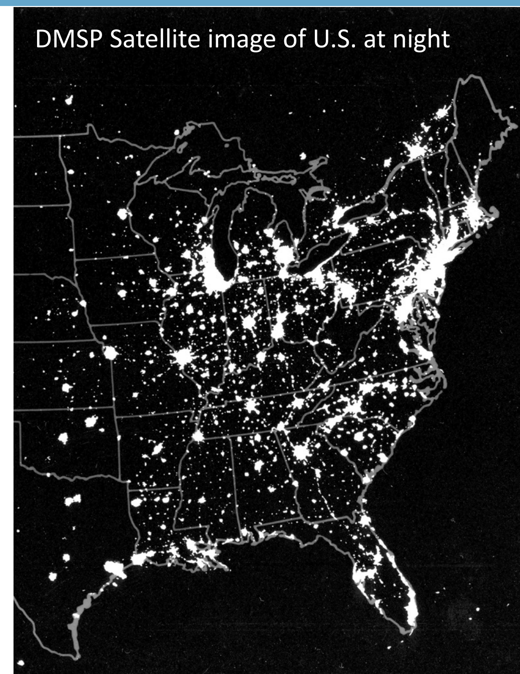
MOL LEGACY

When the program was cancelled in June 1969, officials made the decision to transfer all crew-related equipment, as well as the Gemini, to NASA. It was a prolonged transfer process, but NASA was in possession of all manned system components, including the Laboratory Module Simulator and the Mission Simulator, by the end of 1973. The MOL's waste management system eventually flew on Skylab, and several other pieces of MOL equipment contributed to the NASA Earth Science research program. Additionally, MOL's acquisition and tracking system, which became the centerpiece of the program, as well as the mission development simulator, contributed to the success of NASA's earth sensing program. Although the program's cancellation was a disappointment to many involved, pieces of MOL undoubtedly contributed to a variety of space-related missions across government and industry in the decades that followed.

WEATHER SATELLITES


TIROS Launch


DMSP


DMSP Satellite image of U.S. at night

BACKGROUND

In the mid-1950s, the RAND Corporation warned U.S. Air Force officials that accurate and timely meteorological forecasts depended on cloud-free photography, prompting the establishment of the DMSP program to support the joint CIA and Air Force program. The Corona satellite was first launched in 1960. Corona satellites took photographs from space enabling the U.S. to both monitor meteorological forecasts and track threat activity in denied areas like the Soviet Union. Though Corona's photoreconnaissance capability was remarkable for the time, in the early days its imagery was difficult to interpret and expensive to process in a timely way. The Corona program operated from 1960-1972 and was the U.S.'s first photoreconnaissance satellite and foundational to the development of satellites designed for meteorological purposes.

TELEVISION INFRARED OBSERVATIONAL SATELLITE (TIROS-1)

On 1 April 1960, a satellite designed by the Radio Corporation of America (RCA) and launched by NASA became America's first weather satellite. While TIROS-1 only operated for 78 days, the program demonstrated that cloud cover and weather patterns could accurately be monitored from space—in contrast to blurry images obtained from Corona's early missions in 1960-1961. In April 1961, after an interdepartmental study on weather satellites concluded, NASA was chartered to establish requirements for the development of meteorological satellites for the Department of Commerce and DoD under the umbrella of the National Operational Meteorological Satellite Program (NOMSS). This program, many believed, would avoid duplication of effort and produce at less cost a single satellite system to meet civil and military weather forecasting needs, including National Reconnaissance Program's requirements. TIROS 1 then became the model for subsequent civilian and military meteorological satellites.

DEFENSE METEOROLOGICAL SATELLITE PROGRAM (DMSP)

In July of 1961, at the height of the Cold War, Joseph Charyk, Under Secretary of the Air Force and NRO Director, became concerned that NOMSS was designed mainly for civil programs, which did not always align with NRO's classified mission requirements. For that reason, Charyk authorized the development of four "Earth-referenced" wheel-mode weather satellites to be launched using NASA's Scout boosters as an "interim" solution for NRO. In tandem, DMSP under NRO established the technology and flight operations for polar orbiting, low-altitude national weather satellite systems administered by the National Oceanic and Atmospheric Administration (NOAA). In the following months, NRO-DMSP funded weather satellites incorporated many improved features and performed so well that they later became the model and were adopted for all U.S. civil and military low-altitude meteorological satellites.

POLAR ORBITING SATELLITES: There are two polar orbiting satellites in north-south orbits that observe the same spot of Earth twice daily, once during the day and once at night. Polar orbiting satellites provide imagery and atmospheric soundings of temperature and moisture data over the entire Earth. These satellites offer the advantage of operating closer to Earth (about 520 miles above the surface), providing detailed imagery, and excellent views of the polar regions.

GEOSTATIONARY SATELLITES: Unlike polar orbiting satellites, geostationary satellites orbit at a much higher altitude of 22,236 miles above the Earth's surface, are positioned over the equator, and orbit around the Earth once every 24 hours. The satellite appears stationary relative to Earth allowing it to hover continuously over one position of Earth's surface. Because they stay above a fixed area on the surface, geostationary satellites provide a constant vigil for atmospheric "triggers" for severe weather conditions like tornadoes or hurricanes.

NRO'S TIROS DESIGN

TIROS was a 100-pound satellite shaped like a 10-sided polyhedron, 23-inches across and 21-inches high. A spinning motion, introduced when first launched into orbit produced around 12 revolutions per minute by small spin rockets. The spin axis was maintained perpendicular to the orbit plane by torqueing the satellite against the Earth's magnetic field; the force then created a direct-current loop around the satellite's perimeter. A ground command station would then direct the electric current to flow in the desired direction to generate the torque. The few NASA officials who knew about TIROS viewed the joint NRO-Air Force program as a no-risk test case of an "Earth-referenced" wheel-mode weather satellite.

DMSP SUCCESS

By mid-1965, NRO's "interim" weather satellites operated like a formal military space program. By then the DMSP provided the NRP with daily coverage over Eurasia and other territories using two polar orbit, sun-synchronous weather satellites. The program not only addressed the requirement to secretly surveil remote territories with excellent results but accomplished the mission at half the annual cost of NOMSS. In fact, DMSP pioneered weather satellite technology so well that the Department of Commerce embraced the initial DMSP wheel-mode Block 1 satellite, the TIROS Operational System (TOS), as an interim polar-orbiting weather satellite.

DMSP GROWING PAINS

Despite NRO's advances in meteorological technology, only five DMSP satellites were launched from May 1962 through September 1963 and several launches failed due to defective Scout rocket boosters. The first polar-orbiting satellite, viewed by the DMSP as a test, was a standard four-stage Scout booster carrying an NRO GRAB satellite, launched from Vandenberg Air Force Base. The test launch on 25 April 1962, ended in a Scout booster failure within sight of the ground station. The Scout booster failed again on 23 May when the vehicle self-destructed. The next DMSP launch on 23 August 1962 was a success though the ground-control team at first failed to track the weather satellite. By January 1964, the Scout boosters were replaced with Thor-Agena boosters and four DMSP satellites were successfully launched into orbit providing the NRP all of the meteorological data they needed. Despite setbacks, after DMSP acquired the Thor/Burner combinations in the ensuing months and years, they achieved an 86 percent launch success rate.

DMSP Block 1 Launch, 19 Jan 1964

DMSP Block 5D1, 11 SEPT 1976

SUCCESS WITH A PRICE

The DMSP-TOS under NRO became operational within 24 months and demonstrated impressive technical performance for strategic and tactical applications. Considering its cost and performance in the mid-1960s under NRP's umbrella, Commerce leaders told NASA they would adopt the DMSP wheel-mode spacecraft in place of NOAA's Nimbus weather satellite, to be used as the standard for low-altitude, polar-orbiting meteorological applications. That decision was formalized in the mid-1970s when the latest DMSP Block 5D, three axis-stabilized spacecraft was selected for civil programs. This prompted the declassification of the DMSP program in 1973. The choice to adopt a central satellite program to leverage related requirements for civil and military missions once again glossed over the national security aspects of why NRO leaders established the DMSP to begin with.

NASA POLAR-ORBITING ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

In May 1994, DoD, Commerce, and NASA released the NPOESS implementation plan endorsed by President William Clinton. The plan created an Integrated Program Office that developed, acquired, and operated all NPOESS systems. The NPOESS was comprised of senior officials from consolidated agencies to ensure requirements from each combined former organization were responsibly maintained under different elements of the NPOESS. NOAA was given oversight for the merged systems, including satellites on orbit and public representing the program to the civil and international communities. The DoD became responsible for contracting, acquiring, and launching new meteorological satellites. Reminiscent of the division of labor in 1961 that produced Nimbus, NASA assumed responsibility for development and acquisition of new cost-effective technologies related to the merged meteorological programs. DMSP's great success under NRO's stewardship skyrocketed the advancement of meteorological satellite technology for the nation, but also led to its termination. Nevertheless, NRO's significant contributions to weather satellite technology for both civil and military mission requirements cannot be overstated.

INNOVATIONS

RECONNAISSANCE

D-21 DRONE

D-21 Drone

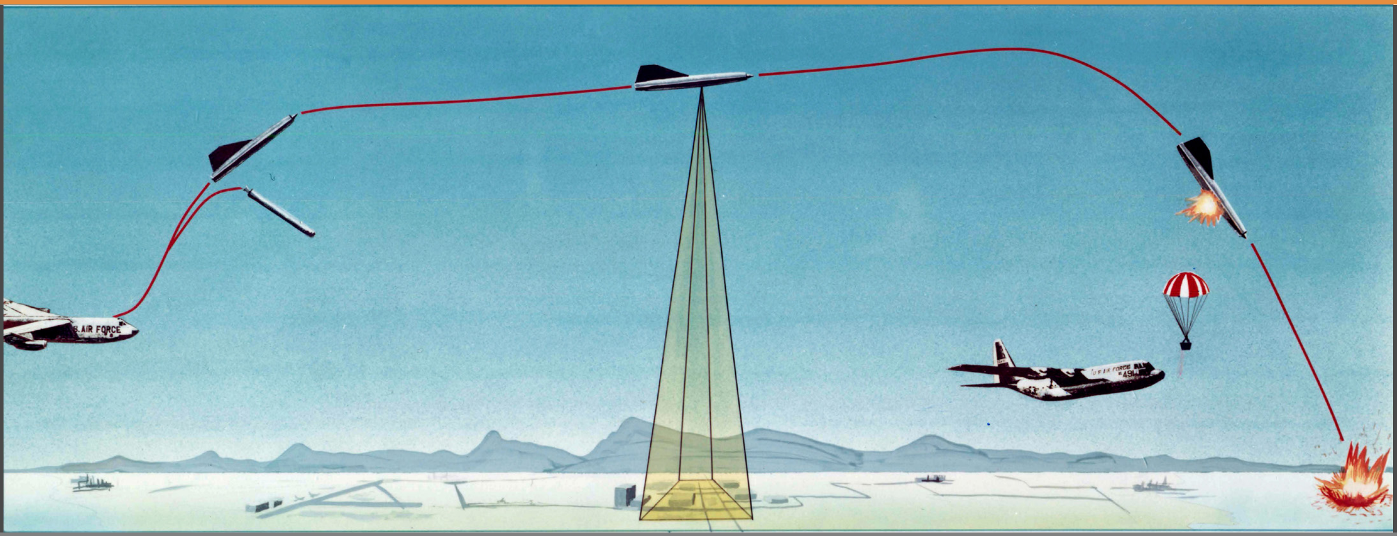
Drone Photo of Phoenix, AZ

D-21 DRONE

Decades before the advent of military and commercial unmanned aerial vehicles (UAVs), the NRO engineered, produced, demonstrated, and operationally tested a highly advanced, unpiloted, supersonic reconnaissance aircraft with unbelievable characteristics. This reconnaissance drone flew at speeds over Mach 3.3 at an altitude over 90,000 feet, and the NRO designed it using low radar observable technologies, suggestive of 21st century stealth technology. During the middle of the 20th century, the NRO and others had been conducting limited experimentation with drones, but it was the NRO's Program D that began experimenting with the development of the D-21 drone. The D-21 validated that unpiloted aircraft were possible and could have a role in reconnaissance. The NRO's work in the middle of the 20th century had anticipated what was to come, the proliferation of UAVs in the 21st century.

In October 1962, CIA authorized the Skunk Works, Lockheed's experimental engineering division, to study the feasibility of modifying the A-12 reconnaissance aircraft to carry and deploy a reconnaissance drone for unmanned overflight of denied areas. The mothership, renamed the M-21 to avoid confusion with the A-12, was fitted with a second seat for a launch control officer (LCO) for the drone, called the D-21. The M-21 Drone Program ended in 1966 after a crash that killed LCO Ray Torick. The Skunk Works built 38 drones.

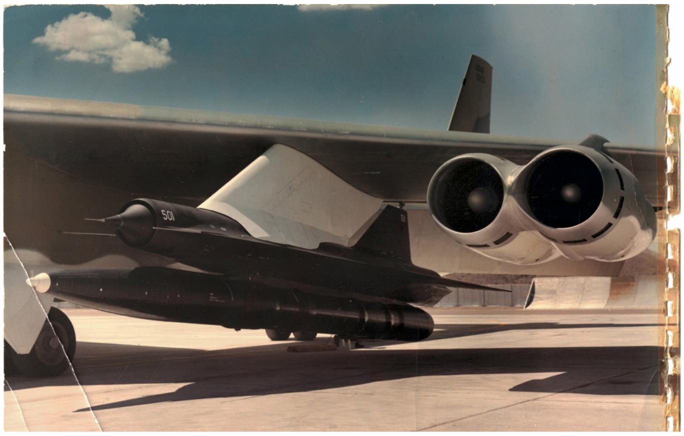
From 1969 to 1971, the Air Force began using B-52s to launch some of the remaining drones against Chinese targets. The drones, re-designated as D-21B, flew four missions; none were completely successful. After the program was cancelled, one of the spare D-21B airframes (#538) was stored in California and then moved to the Aircraft Maintenance and Regeneration Center ("Boneyard") at Davis Monthan AFB near Tucson, AZ. In the 1990s, Warner Robbins AFB displayed and stored #538 until 2017, when it was transferred to the NRO. Eventually, the NRO entered into a loan agreement with the Southern Museum of Flight in Birmingham, Alabama. The museum restored and began displaying #538 in November 2018.



DESIGN SPECIFICATIONS:

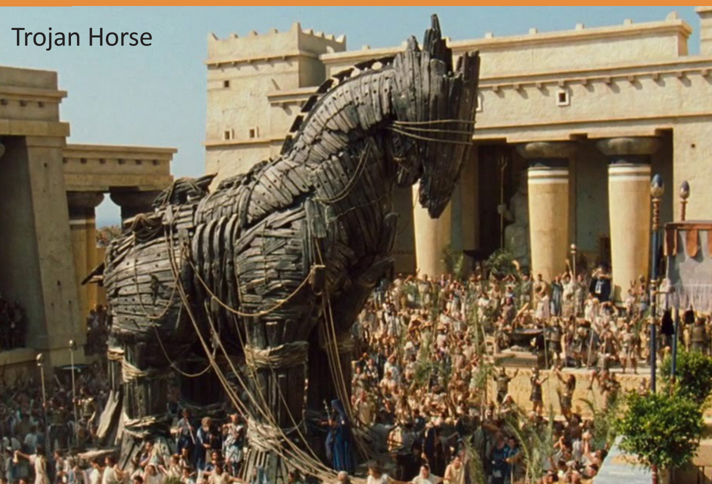
Construction:	Titanium with small radar cross section
Dimensions:	Length—514.27 in Wing Span—288.90 in Height—85 in
Weight:	11,000 pounds, gross
Propulsion:	Marquardt Ramjet Solid propellant rocket booster
Performance:	Speed—Mach 3.25 Altitude—80,000 to 95,000 feet Range—3,000nm
Payload:	Hycon Frame camera (24" fl) Coverage: 28nm X 3020nm
Resolution:	1.5'

Mission Code Names: TAGBOARD (D-21)
SENIOR BOWL (D-21B)



B-52 with two D-21B drones under wings at top is a close up of D-21B on wing of a B-52.

DENIAL AND DECEPTION


Trojan Horse


Inflatable Tank

MYTHICAL DENIAL AND DECEPTION

Virgil in his *Aeneid* recounts the story of the Greeks carrying out a grand deception to defeat the city of Troy. The Trojans managed to stave off defeat for many years. After those many years, the leaders of the Greeks, as Virgil reports, decided to construct a large wooden horse to facilitate their deception—the horse was the emblem of Troy. After building the horse, the Greeks staged what looked like a retreat by sea, leaving the horse for capture by the Trojans. Assuming the Trojans would take their victory prize into the city, the Greeks hid a force inside the wooden horse. Consistent with their expectations, the Trojans seize the horse as a victory prize. Despite the warnings of the Trojan priest Laocoon to not seize the horse and bring it into the city, the Trojans did so. The Greek force waited until nightfall, then left the horse and opened the gates of the city. Troy fell to the Greeks and the war ended.

The story of the Trojan horse has traversed time to now symbolize acts of deception. Deception in conflict is a constant. The Cold War between the United States and the Soviet Union was no different. Deception and denial of truth and facts to hide activities are key strategies in waging war.

DENIAL AND DECEPTION IN WAR

There are many well-known deceptions in war. For example, the success of Allied troops against German forces occupying the shores of France during D-day was greatly enhanced by deception. The Allies created a fictional army to deceive the Germans into thinking that an attack to retake France would occur at other beaches than where Allied forces landed. To make the fictional army seem believable, the allies used inflatable devices to appear as tanks, trucks, and other equipment that would be necessary to support an army. With the inflatables in place in England, the Germans flew over and photographed the fake equipment, further enhancing the deception. When the Allied troops did attack on D-Day, the Germans remained convinced the attacks were a diversion from the real attack that would occur elsewhere on the French coast and with a more powerful force. The Germans held troops in reserve for the attack that never came, allowing Allied success on D-Day.

THE USSR AND DENIAL AND DECEPTION

The Soviet Union adopted a military strategy of denial and deception developed by the Tsarist Army in the early 20th century where an army deception school developed the doctrine. The formal doctrine became known as maskirovka, meaning either disguise or masking.

As the Cold War progressed, the Soviets relied on denial and deception frequently. One of the earliest deceptions was carried out between 1954 and 1955. By the mid-1950s the U.S. had developed long-range bombers that could be used to carry out a nuclear attack against the Soviet Union. The Soviets did not have a similar capability, but wanted the world to believe they did. In winter 1954, Aviation Week carried a story describing the Soviets' development of their own long-range jet powered bomber, the Myasishchev M-4 Molot, or hammer in Russian. The bomber was designated Bison by the West, and made its first appearance at the 1954 May Day celebrations in Moscow.

WEATHER
Forecast for Tucson: Clear, little change.
Temperatures
Yesterday: HIGH 85 LOW 51
Year Ago: HIGH 81 LOW 55
U. S. Weather Bureau

The Arizona Daily Star

★ An Independent NEWSpaper Printing The News Impartially ★

FINAL EDITION
TEN CENTS

VOL. 121 NO. 296 TUCSON, ARIZONA, TUESDAY MORNING, OCTOBER 23, 1962 THIRTY PAGES

U.S. BEGINS BLOCKADE OF CUBA; GRIM WARNING ISSUED TO RUSSIA

Himalayan Battling Worsens

New Front Opened By Chinese Reds

The President And Cuba

(An Editorial)

The distinctive feature of President Kennedy's address to the nation concerning the development of intermediate and long-range missile sites in Cuba, is that it represents a determined and uncompromising effort to persuade the Soviet Union to abandon its military threat in Cuba.

Air Force, Navy Men Hopping

Planes And Warships Busy In Florida Area

President Says Soviet Lied, Castro Missile Bases For Offense

Washington, Oct. 22 (AP)—President Kennedy put into effect

Each year, the Soviets staged a large military air show at the Tushino airfield near Moscow. At the 1955 show, the Soviets knew that western military attaches would attend the show. Building on what was already known about the M-4, the Soviets flew 10 bombers in a dramatic display. Nine then quickly turned around out of site of the observers and were joined by eight more bombers. This left the impression that the Soviets had produced 28 bombers in a year, instead of 18, or at a third higher rate than they actually produced the bombers. Based on this observation, U.S. military analysts concluded that the Soviets would outpace U.S. strategic bomber production by the early 1960s, creating a "bomber gap" between the two adversaries. Word of the analysis became public knowledge, creating a furor in political and military circles.

In October 1962, U.S. U-2 overflights of Cuba captured telltale signatures of Soviet nuclear weapons placement in Cuba. The Soviets carried out a number of deceptions to get the missiles and many thousands of troops into Cuba to build and maintain the missile launch facilities. For example, the name chosen for the operation led western analysts to believe that the activity was being carried out in an artic location versus the warm Caribbean climate. The missiles and equipment were covered with shrouds to hide them from any aerial observation of the ships carrying them. The ships were unloaded at multiple ports in Cuba, making it difficult to observe the massive amount of material and personnel moved into Cuba. Just weeks before the U.S. discovered the Cuban missile deception, the Soviet Union's ambassador assured the U.S. Attorney General and brother of the U.S. President that no troops or offensive weapons were or would be placed in Cuba by the Soviets. Even after the discovery of the emplacements, the Soviet Union went to great lengths to deny their existence despite conclusive imagery intelligence disclosed to other world leaders and the public.

In August 1968, the Soviet Union led an invasion of Warsaw Pact member Czechoslovakia to remove a government that was pursuing very liberal reforms, threatening what counted for Communist orthodoxy at the time. For example, the Soviets ordered Warsaw Pact troops to remain in barracks and also remove material that led the Czech leadership to believe there was not an imminent outside threat. Instead, the Soviet Union and other Warsaw Pact nations were able to move troops and supplies to the Czech border in advance of the rapid and overwhelming invasion of Czechoslovakia. The surprise allowed the Soviet Union to depose the more liberal government and replace it with a government that would toe the Soviet line.

U.S. RESPONSE TO SOVIET DENIAL AND DECEPTION IN THE COLD WAR

The U.S. invested significant resources into developing sophisticated technological means to understand the true intentions of the Soviet Union and unmask their deceptions. The U-2 played an early and important role in this effort. For example, the U-2 captured an image of a Soviet airfield that displayed their entire M-4 Bison bomber fleet. There were far fewer aircraft than the Tushino deception had led U.S. military analysts to believe existed. Concrete intelligence dismissed the "bomber gap."

After the 1957 launch of the Soviets' Sputnik satellite, many in the U.S. grew very concerned that the Soviet Union was outpacing the U.S. in the development of ballistic missiles—missiles that could deliver nuclear bombs to the U.S. By August 1960, the U.S. successfully launched a Corona satellite that set the course for the U.S. to obtain concrete intelligence dispelling such a "missile gap" existed. By fall 1960, the Corona imaging capability countered Soviet efforts to leave the impression they were outpacing the U.S.

In September 1961, the Kennedy administration established the National Reconnaissance Office to develop even more sophisticated reconnaissance satellites to counter Soviet denial and deception. The first photoreconnaissance satellite launched by the newly formed NRO was the 1963 Gambit high-resolution satellite. The Gambit program would eventually produce a second-generation satellite that could capture images of objects smaller than one foot in size. This level of resolution made it much more difficult for the Soviet Union to carry out denial and deception activities.

In 1964, the NRO developed a satellite specifically to test technology that could directly challenge denial and deception activities. The program, known as Quill, was to launch an experimental satellite that would test whether or not radar from space could be processed into images. The Quill experiment confirmed radar could be used to obtain imagery from space—a capability that would allow the United States to obtain reconnaissance imagery under conditions used by the Soviet Union to disguise and obscure their strategic and tactical activities.

To gain greater persistence, the NRO developed a large satellite, Hexagon, that carried 60 miles of film stock. Hexagon allowed the U.S. to repeatedly capture imagery of the Soviet Union and other areas of concern using its broad area coverage cameras. Hexagon's repeated and persistent imagery made it much harder for the Soviets to carry out denial and deception activities.

While the U.S. was developing photoreconnaissance satellites, it was also developing signals collection satellites. The world's first reconnaissance satellite was an experimental satellite known as GRAB. It proved to be highly successful, giving the U.S. the most comprehensive understanding of Soviet radar capabilities to date—an understanding necessary to carry out a nuclear counterattack by evading those radars. After GRAB began collection of signals from space, the U.S. launched many other experimental Sigint satellites, demonstrating means to collect communications signals, as well as signals associated with Soviet military equipment, launch vehicles, and other systems that posed a threat to the U.S. They lifted the veil further, exposing true Soviet intentions and capabilities.

By 1976, the NRO launched the first electro-optical satellite, known as Kennen, which could collect imagery in near real-time and remain in orbit much longer than the film return systems. With this enhanced capability, the Soviet Union had even less flexibility in carrying out denial and deception activities given the increased persistence of U.S. imagery collection capability.

Although little can be said of more recent NRO capabilities for countering U.S. adversaries' denial and deception activities, the earlier declassified history demonstrates a regular and ever more sophisticated capability of the NRO to collect intelligence countering denial and deception. The innovation of the NRO and the innovators who pressed the best technology into service provided formidable means for countering denial and deception—a responsibility that continues today.

(THE *Morning* KANSAS CITY STAR)

The Kansas City Times

VOL. 125. NO. 254. ★ ★ ★ KANSAS CITY, TUESDAY, OCTOBER 23, 196[illegible]—32 PAGES. ★ ★ ★ PRICE 7 CENTS.

U. S. CLAMPS NAVAL RING ON CUBA

Declaring That There Has Been "Unmistakable Evidence" in the Last Week That the Soviet Is Developing Offensive Missile Sites on Island, Kennedy Sets Up Full Sea Blockade.

THE FRONT PAGES OF LONDON NEWSPAPERS show the reaction of the British press to President Kennedy's speech. The difference in London and Washington time has the Daily Herald calling the speech "Kennedy's Midnight Bombshell"—(Wirephoto by cable from London).

ALL AMERICAS IN RANGE

Retaliatory Response Promised Moscow if Any Nuclear Missile Is Fired on Any Nation in Hemisphere.

Washington (AP)—President Kennedy proclaimed a U. S. naval blockade against Cuba last night, saying the Soviets have started to turn Cuba into an offensive military base capable of raining nuclear destruction on all the Americas.

Speaking grimly to the nation in a suddenly called radio-TV broadcast, Kennedy said the United States would wreak "a full retaliatory response upon the Soviet Union" if any nuclear missile is fired on any nation in this hemisphere.

Kennedy reported that within the last week the United States has received "unmistakable evidence" that—contrary to Soviet assurances—nuclear-type, long-range missile sites and atomic-capable Soviet jet bombers are being established in Cuba.

Sites Would Be Vulnerable.

Kennedy uttered what seemed an implied warning that the United States may have to bomb offensive sites in Cuba if the build-up continues. He put it this way:

"Should these offensive military preparations continue, thus increasing the threat to the hemisphere, further action will be justified. I have directed the armed forces to prepare for any eventualities; and I trust that, in the interest of both the Cuban people and the Soviet technicians at these sites, the hazards to all concerned of continuing this threat will be recognized."

And the President cautioned the Soviets that, if they react by aggression somewhere else in the world, they "will be met with determination."

"Any hostile move anywhere in the world against the safety and freedom of peoples to whom we are committed—including in particular the brave people of West Berlin—will be met by whatever action is needed," he said.

As Initial Action Only.

He emphasized, both in his prepared text and in his delivery, that the steps he was ordering now were only "initial" ones.

Even before the President finished speaking, U. S. Ambassador Adlai E. Stevenson requested an urgent meeting of the U. N. Security Council to seek the withdrawal of offensive weapons from Cuba. Stevenson

MILITARY OFFICIALS PAUSED OUTSIDE THE DOOR of President Kennedy's office yesterday after a conference with the chief executive. Left to right: Gen. Earle Wheeler, Army chief of staff; Gen. Curtis LeMay, Air Force chief of staff; Admiral George Anderson, chief of naval operations; Cyrus Vance, secretary of the Army, and Capt. Tazewell Shepard, jr., presidential naval aide—(Wirephoto).

J.F.K. REPORT IS A JOLT

Disclosure of Soviet-Built Missile Bases in Cuba by the President Is Called a "Shock to the Civilized World" by Britain.

BONN WITH HIM

President's Determination in Handling the Situation Is Welcomed.

MAY REVISE A STAND

Canada, Which Has Been Trading With Castro, to Make a Study.

J.F.K. Gives Up Speeches

BRITISH PLEDGE TO ASSIST INDIA

Communist China Is Accused of Aggression in Border Dispute.

READY TO PARLEY ANEW

Peiping Says It Would Try Again for Peaceful Settlement.

THE WEATHER—FAIR.

ROCKETS POINT TO U. S.

Aerial Photographs Taken in Recent Days Over Cuba Reveal Ballistic Missiles Are on Launchers and Facing Toward Our Mainland.

SPOT RED JETS

Pictures Show an Assembly of Bombers Near an Airfield.

PLANE TYPE A SECRET

Pentagon Simply Describes Craft as of Reconnaissance Class.

All of Cuba's Forces Are Called Up

Send More Marines.

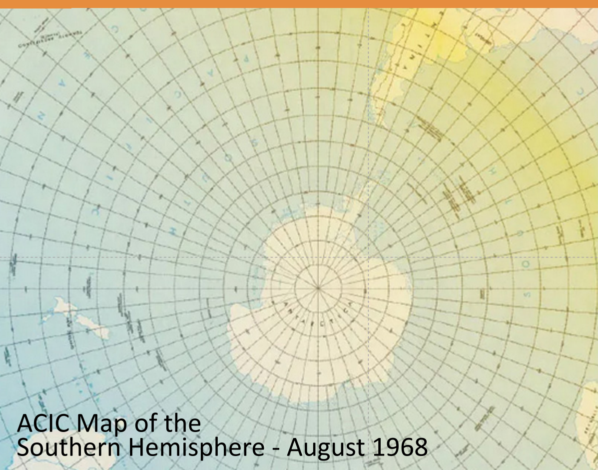
KEEP ON ALERT

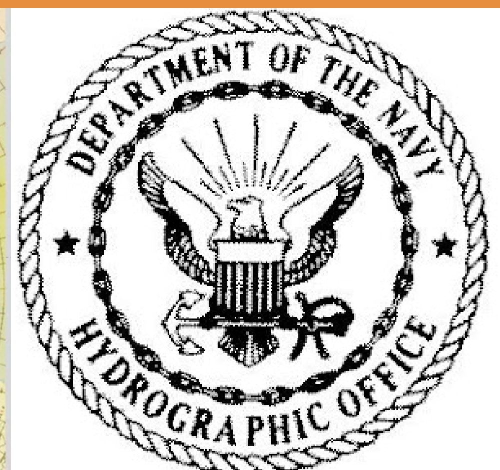
U. S. Is Prepared for More Crises Over Action on Cuba.

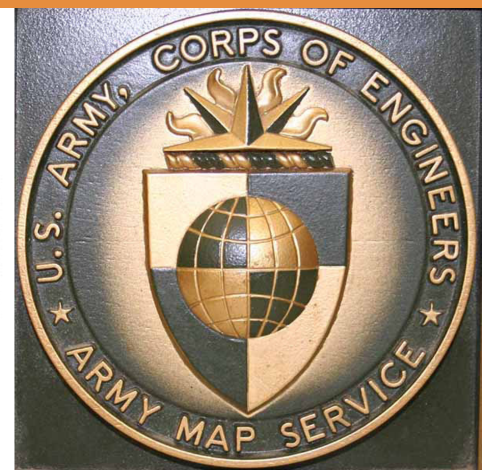
READY FOR RED MOVES

Procedures Set Up for Checking Ships Going to Castro.

GEODETIC DATABASES


ACIC Map of the Southern Hemisphere - August 1968





In the 1960s, the Intelligence Community faced two distinctly different mapping situations — the lack of mapping data of the Soviet Union and the relatively good mapping data of the United States. The imagery collected by two NRO satellite systems—Corona (operational life 1960-72) and Argon (1961-64)—revolutionized U.S. mapmaking activities concerning features on the Earth's surface and eventually led to the development of technical applications for a geodetic database framework. The task for mapmakers was to find a technical solution to compile the imagery data into that geodetic database. Three military mapping organizations would take on the technological challenge of mapping the Soviet Union: the Air Force Aeronautical Chart and Information Center (ACIC) in St. Louis, MO, and the Army Map Service (AMS) and Navy Hydrographic Office (NHO), both in the Washington, D.C. Metro Area. Federal civil agencies would take on the challenge of updating U.S. maps.

MAPPING THE USSR — MILITARY MAPPING AGENCIES

During the 1950s, a "Cartographic Iron Curtain" prevented the U.S. from creating accurate maps of the Soviet Union. The lack of basic maps of the USSR existed before the Cold War. Large areas of the country had never been mapped, and during the Cold War, several roadblocks made mapping the USSR difficult. The closed Soviet society kept strict controls on and added distortions to all detailed mapping data, and there was a concerted deception program directed at foreigners who used generalized maps released by the Soviet Union.

Corona and Argon imagery provided the key to break through the USSR's Cartographic Iron Curtain. Corona's higher resolution imagery yielded detailed information, and Argon's low resolution provided essential data for improving the accuracy of the geodetic framework. Intensive technical efforts of the U.S. military mapping organizations and integration of the satellite imagery armed the three military mapping agencies with the tools to build a geodetic framework of the Soviet Union. Each organization would take on different aspects of the obstacles to mapping the country.

The Air Force Aeronautical Chart and Information Center focused on the development of a worldwide geodetic network. Its program focused on analysis, integration, and triangulation used in orbital positions of the Corona and Argon spacecraft at the time of imaging to obtain a steadily increasing geodetic accuracy that was critical in supporting bombing and missile targeting in the event of U.S. - Soviet hostilities. Corona's wide - area coverage capabilities enabled production of air navigation charts, which were important for potential targeting areas.

The Army Map Service exploited satellite imagery to produce more reliable depictions of all ground features of the USSR, a difficult and time-consuming project. The objective was to cover the entire USSR landmass, supplemented by areas of high interest and larger scales for major cities. To achieve this, a crash program produced hypsometric maps (with contour and elevation data) and planimetric maps (without terrain elevation).

Due to an aggressive Soviet threat, the Army Chief of Staff for Intelligence and the CIA developed a joint mapping program — the Special Intelligence Graphic (SIG) — to help reduce production times. SIG data responded to military and intelligence requirements. The AMS concentrated on the basic map framework, and the CIA Directorate of Intelligence provided research assistance in identifying and annotating manmade features. A prototype map sheet of Stalingrad was used to test the joint production program. The success of the prototype led to mapping the entire USSR and, eventually, to mapping China and adjacent areas in Eurasia.

The Navy Hydrographic Office had a smaller role in the exploitation of satellite imagery. However, the NHO was able to use Corona and Argon imagery to update its nautical charts around the world.

The work of these agencies was key to producing reliable maps, charts, and geodetic data to meet needs on the Soviet Bloc, as well as navigation chart requirements on a worldwide basis. Completed in just a decade, the accurate mapping database covered the entire Soviet landmass (almost one-sixth of the Earth's land surface) and was vital to the National Technical Means used to enter arms control agreements between the U.S. and Soviet Union.

MAPPING THE U.S. – FEDERAL CIVIL AGENCIES

Use of Corona imagery began in the late 1960s with an initiative by President Johnson's Science Advisor to test the value of overhead satellite imagery for U.S. civil purposes. The U.S. Geological Survey opened a classified facility for access to civil agencies to exploit the Corona imagery for various mapping, research, and other production programs.

The use of satellite imagery for domestic purposes would have a different focus, but was no less urgent, than mapping the Soviet Union. Accurate maps of the U.S. were available and the basic geodetic control framework existed, but they were outdated. What did not exist was the technology needed to create more detailed large-scale maps. These updated U.S. maps were needed, due to the postwar expansion of urban core areas and expanding suburbs, and the extensive construction of interstates and highways. The Department of Agriculture's Forest Service updated its maps of national forest lands, and the National Oceanic and Atmospheric Administration corrected and updated its nautical and aeronautical charts. The Environmental Protection Agency used Corona imagery to find areas impacted by pollution.

CONCLUSION

Within a decade, the U.S. had mapped the USSR at a medium scale and laid the groundwork for the future of U.S. mapmaking activities. These early mapping activities met critical national security needs, as well as civil domestic requirements. Success would have been unreachable without the expertise of specialists in photointerpretation, photogrammetry, geodetic science, and Russian language skills, as well as enormous investments in research and development of unique production equipment, all supported by complex computer programs. The concerted effort from the three military organizations to create an accurate geodetic database largely from NRO satellite imagery led to changes in the organizational structure of the U.S. military mapmaking organizations. The consolidation of the three mapping agencies, first begun as early as the 1970s, would eventually produce today's National Geospatial-Intelligence Agency (NGA).

STEALTH AIRCRAFT


U-2


SR-71


D-21


A-12

BANDITS IN THE NIGHT

In the early morning hours of 20 December 1989, two F-117A Nighthawk stealth fighters each dropped single 2,000-pound Mark 84 bombs onto Rio Hato Airfield, 120 km southwest of Panama City, in the opening hours of the U.S. invasion of Panama. This was the first use of stealth aircraft in combat, six years after the F-117A was declared operational, and more than a decade since the decision had been made to build the world's first stealth combat aircraft. However, that decision would never have been made had it not been for significant advances in stealth technology developed by Lockheed Martin and the NRO.

TRYING TO HIDE THE U-2

In 1956, despite assurances from his senior intelligence advisors that the U-2 would be virtually undetectable to the Soviets, President Eisenhower was upset when he learned that Soviet early warning radars had tracked the first U-2 flights over the Soviet Union. Eisenhower ordered a temporary halt to U-2 flights, and designers got busy trying to find ways to reduce the radar cross section (RCS) of the U-2 airframe. Later that year, engineers installed fiberglass rods to the non-moving parts of the wings and surrounded the airframe with a small-gauge wire with precisely spaced ferrite beads. The wire and beads were supposed to capture incoming 70-MHz radar pulses and either trap them in the loop or weaken them so much that they would not register as a valid radar return. A second approach, tested in early 1958, involved the use of plastic material containing a printed circuit designed to absorb radar pulses in the 65- to 85-MHz range glued to outside parts of the fuselage. Although these approaches had some success, they did not protect against radars outside of that narrow range of frequencies. More importantly, they degraded the performance of the aircraft, forcing it to fly at a lower altitude and even causing some engine problems, one of which resulted in the death of a Lockheed test pilot. However, the concepts were not lost, and the idea of adding radar-absorbing material to the outside of the aircraft's fuselage proved to be an effective strategy used later with the F-117A and many future stealth aircraft.

SHIELDING THE OXCART

In late 1957, an advisory committee selected to choose a design for a replacement of the U-2 was formed by Dr. Richard Bissell, the CIA's U-2 project manager and soon-to-be co-Director of NRO. In contrast to the U-2, design of the A-12 centered as much on a minimal RCS as it did on aircraft performance. Over the next two years, Lockheed and Convair submitted proposal after proposal, but all were rejected. In August 1959, the committee finally chose the latest Lockheed design (the A-12), based as much on Lockheed's history with the U-2 program, as on their design of the A-12. However, the committee was still not happy with the level of RCS exposure in the proposed design and required Lockheed to reduce it even further before a full contract was awarded.

Clarence "Kelly" Johnson, the Lockheed mastermind behind the U-2 and A-12 designs, incorporated several ingenious technologies to reduce the RCS of the A-12, such as a continuously curving airframe, a fore-body with tightly slanted edges called chines, engine housings (nacelles) located mid-wing, canted rudders, and nonmetallic parts. A cesium fuel additive was added to reduce the radar detectability of the afterburner plume. To reduce radar reflections, the two canted rudders were fabricated from laminated nonmetallic materials—the first time these materials were used to build an aircraft. Later, the production aircraft was painted with a radar-absorbent coating of ferrite particles in a plastic binder. There was little difference in the RCS design between the A-12 and SR-71, other than the SR-71 was larger with a more prominent nose and body chines. However, while the SR-71 was larger and presented a bigger radar target, it also carried a number of electronic countermeasure systems that the A-12 did not have, which greatly enhanced SR-71 electronic defenses.

D-21 DRONE

Began in the early 1960s by NRO's Program D, the D-21 was a ramjet-powered pilot-less drone designed to be launched from the back of a modified A-12 and fly even higher and faster than the A-12. After a fateful accident involving one of the modified A-12s, the design was altered to be launched from under the wing of a modified B-52, which was less dangerous to the carrier aircraft. The D-21 drone incorporated many design features of the A-12, including the use of non-metallic components and insulated fuel propulsion parts to help reduce infrared detection. However, after several test flight failures and the drone's mission becoming less essential, the program was cancelled in 1971.

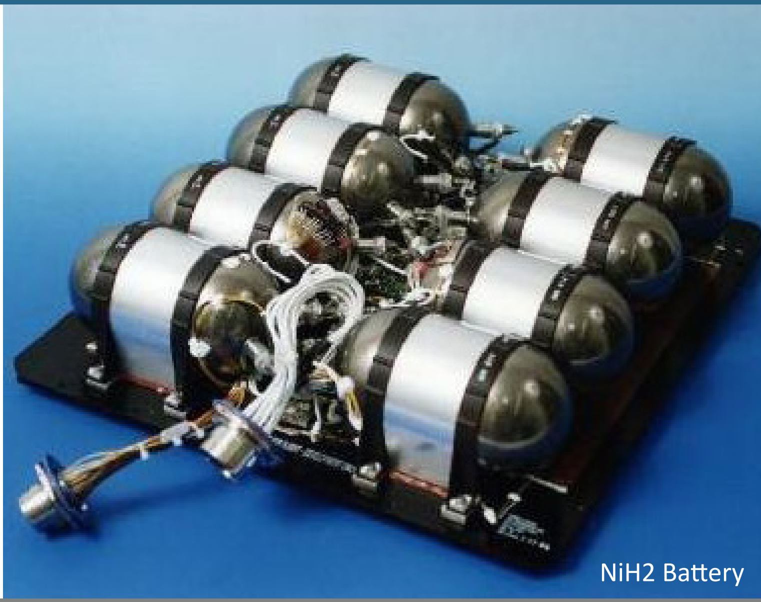
LONG-TERM BENEFITS

Although much of the work that NRO and Lockheed carried out in the 1960s saw few operational results, it was not wasted effort. Although the A-12 was identified and fired at a few times over North Vietnam in its short operational history, it did successfully complete some missions where it was not detected. More importantly, the seeds of research that the engineers planted in the 1960s finally bloomed in the 1980s, when many of their designs were successfully incorporated into the world's first stealth combat aircraft. Today's stealth aircraft continue to utilize the ideas of advanced structural designs, composite components, radar absorbent paints, and diffused exhaust vents. Even the Space Shuttle applied the concept of heat absorbing tiles to diffuse the intense heat of re-entry which, while not a stealth concept, originated from the idea of applying radar-absorbing materials to an aircraft. As with many NRO scientific breakthroughs, many of these design elements are still being utilized today, long after the mission they were designed for has ended, to benefit additional NRO programs, U.S. national security, and the American people.

INNOVATIONS

COMMERCIAL APPLICATIONS

BATTERY DEVELOPMENT



NiH2 Battery

EARLY BATTERY TECHNOLOGY

At the turn of the 20th century, batteries first emerged as a source of energy to power new tools and devices invented in the early industrial era. Alkaline electrolyte batteries promised early commercial application. By the 1930s and 1940s new alkaline batteries such as zinc–silver oxide and zinc–mercuric oxide alkaline batteries significantly improved battery performance. In the latter half of the 20th century, new advances and materials resulted in smaller and more powerful batteries for use in portable equipment. The more recent development of batteries using lithium, nickel-hydrogen, and nickel–metal hydride have opened new applications in commercial markets such as electric vehicles, cell phones, and computers, as well as applications in spacecraft.

ORIGINS OF POWERED SATELLITES

Science fiction writer Arthur C. Clarke may have been the first to propose the basic idea of a satellite and its varied uses. Even before World War II was over, Clarke speculated how one might use the German V-2 as a satellite launch vehicle. In the February 1945 edition of Wireless World Clarke wrote,

> A rocket which can reach a speed of 8 km/sec parallel to the earth's surface would continue to circle it forever in a closed orbit; it would become an 'artificial satellite'.... It would thus be possible to have a hundred-weight of instruments circling the earth perpetually outside the limits of the atmosphere and broadcasting information as long as the batteries lasted. Since the rocket would be in brilliant sunshine for half the time, the operating period might be indefinitely prolonged by the use of thermocouples and photo-electronic elements.

Clarke anticipated the idea of using geosynchronous satellites for receiving and retransmitting radio signals from space—the basic concept for both a communications satellite and a satellite for collecting Sigint. He observed that

> An 'artificial satellite' at the correct distance from the earth would make one revolution every 24 hours; i.e., it would remain stationary above the same spot and would be within optical range of nearly half the earth's surface. Three repeater stations, 120 degrees apart in the correct orbit, could give television and microwave coverage to the entire planet.

BATTERY USE IN SATELLITES

Long-time battery manufacturer Saft explains,

> On satellites, batteries are used to provide power at "night," when the satellite passes behind the Earth and is no longer illuminated by the Sun. In the "day" phase, energy is produced by solar panels, which recharge the batteries. Using the power of the sun in this way is very important because it gives the batteries a long operating life. Batteries designed for space must meet a unique set of demands: they must be reliable, have an operating life of more than 20 years, and be able to withstand extreme temperatures and radiation. They must also be strong enough to survive launch vibrations, landing impact, and other physical shocks.

Early NRO satellites had relatively short design lives of a few days' or weeks' duration. This allowed the satellites to carry batteries that sustained the mission of the satellite. As NRO satellites became more sophisticated, they required rechargeable battery systems, frequently relying on solar cells to recharge the battery. Low earth orbit satellites are shadowed by the Earth requiring battery power. Satellites in other orbits also experience "eclipse periods" requiring battery power.

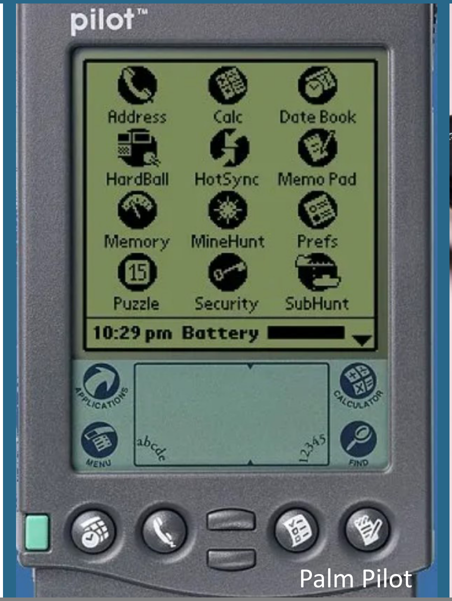
As with all satellites, batteries for NRO satellites are designed considering a number of factors including battery capacity and voltage, discharge and charge rates, and methods of charging. Launch stresses and the space operational environment present a number of factors for battery design including temperature fluctuations, vibration, and shock stresses.

NRO INVESTMENT IN BATTERY TECHNOLOGY

The NRO has done research on many space power storage and control projects through the years. Nickel-cadmium (NiCd) space batteries, which had been the standard for many years, largely moved to nickel-hydrogen (NiH2) batteries because of pioneering work by the NRO. The NiH2 single pressure vessel (SPV) battery was developed at Johnson Controls by the NRO. This battery was also used widely on commercial spacecraft, including IRIDIUM for example. Additionally, the NRO has supported research on NiMH (Nickel Metal Hydride) batteries for space application. The NRO has supported development of Lithium technology batteries for use in space applications that are used widely in everything from cellular phones to other computing devices.

CELLPHONE DEVELOPMENT

1980s Cellphone



Palm Pilot

COMMUNICATING ON THE GO

Occasionally an older movie will show a scene where an actor is in a car and picks up a telephone handset—similar to what would have been in homes and offices at the time—and speaks to another person. These early communication devices were not cell phones; instead they were powerful two way radios often used by first responders and fleets such as taxi services. They are known as 0G or Zero Generation mobile networks. The first generation developed using cellular technology or towers that covered a geographic area close enough to another coverage area—or cell—that the signal could be handed from one cell to the next during travel. By the end of the 1970s, the first mobile cellular network appeared in Japan, followed by European and U.S. cellular networks in the early to mid-1980s. These 1G or first generation cell phones worked on limited analog signal networks and were very costly.

By the early 1990s, cellular companies began constructing networks using digital signals. European providers developed the Global System for Mobile Communications or GSM standard. The use of a common standard marked the beginning of the 2G era. By the mid-1990s, Qualcomm offered Code Division Multiple Access or CDMA as a communication standard that offered more efficient use of cellular bandwidth. Roughly a decade later, providers upgraded their systems to 3G standards that enabled not only communication using cell phones, but early availability of information search and retrieval. By the end of the 2000s, 4G technology enabled greater access to the World Wide Web necessitated by growing use of the internet for multiple activities and services. And then a decade later, 5G technology promised more capacity and speed for cellular users who are highly dependent upon mobile devices for communication, social interaction, and commerce.

SMARTPHONES BECOME ESSENTIAL

Recognizing that technology enabled mobile devices to do more than allow users to call and text, engineers developed phones that could carry out a number of additional functions. An IBM engineer developed the first such device, the Simon Personal Communicator, sold by BellSouth beginning in 1994. At the same time cell phones were emerging as consumer products; companies like Palm Inc. created Personal Digital Assistants that allowed users to maintain calendars, address books, To Do lists, and other functions for life at home and at the office. Finally, companies like Apple developed digital products like the iPod for storing and playing music and other media.

Mobile device manufacturers recognized the benefits of combining the functions of cellphones, PDAs, and portable media players into a single device. The earliest of these products were developed by companies such as Nokia and Ericsson who dominated the manufacturing of cellphones in the late 1990s and early 2000s. The introduction of

3G technology fueled the development of such devices. Research in Motion introduced their Blackberry mobile device in 2002 that allowed users to email, send wireless faxes, and browse the internet. Blackberry would evolve as the dominant device for such purposes in the 2000s.

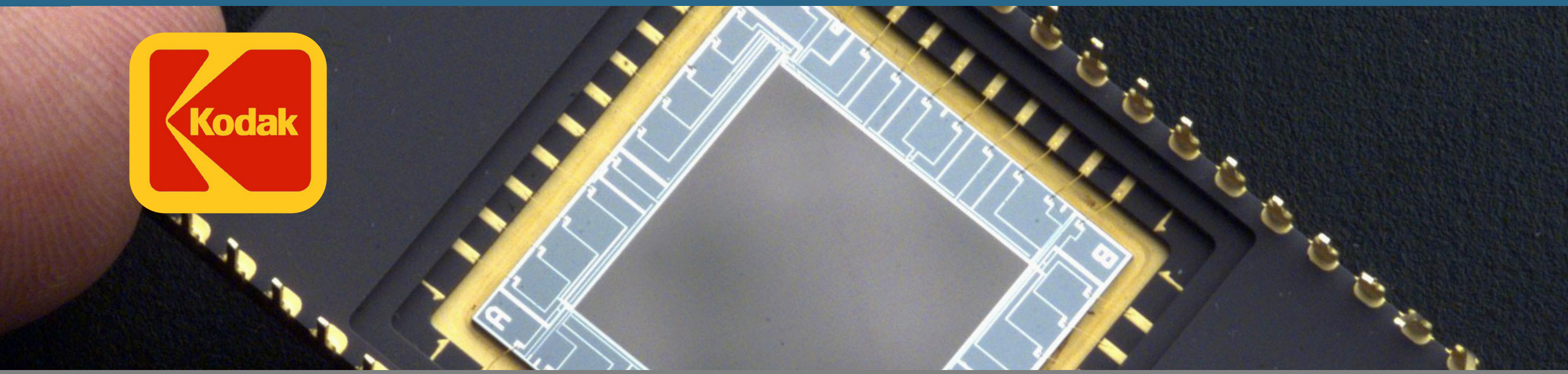
In 2007, Apple Corporation's Steve Jobs introduced the first Apple iPhone that redefined mobile devices. The iPhone had a touchscreen, eliminating physical keyboards used by other devices. It also included a camera for taking photographs, music storage and playback, and personal planning capabilities found in other mobile devices. Shortly after the release of the iPhone, Apple unveiled the App Store where users could purchase applications for use on their devices. Apple would continue to refine the iPhone series, making it one of the dominant manufacturers of smartphones today.

Other companies recognized that mobile devices would become essential to everyday lives of consumers. In 2003, software engineers established the Android Corporation for developing an operating system for mobile devices. After struggling, Google purchased the company in 2005, forming the foundation for Google to enter the mobile device marketplace. Using the open source Linux operating system as the foundation, Google released the Android mobile operating system in 2007 for use by cell phone manufacturers, with the first commercial device using the system released in 2008. Unlike Apple, Android did not initially release its own hardware, only doing so in 2011. Although consumers were slow to adopt Android in the early years, the operating system became dominant within a decade. Others who developed mobile operating systems prior to Android, such as Microsoft and Research in Motion, ceased developing their systems in favor of Google's Android.

THE NRO AND CELLPHONE TECHNOLOGY

Today's cellphone is more than a device to make calls on the go. It is a navigation device, camera, media player, productivity device, research device, activity tracker, multi-platform communication device, and much more. The NRO has nurtured many of the technologies that are integrated into the cellphone. Because of intelligence needs, the NRO was an early developer of databases and technology to locate objects and locations on Earth with precision. The NRO invested in the development of high density batteries that could be recharged multiple times. The organization pursued the development of signals that could carry information in a more efficient manor to enhance use of available bandwidth. The NRO developed a major digital camera system for use in space that fundamentally altered the capture, processing, and use of digital images. Recognizing that touchscreen technology enhances the use of technology products, the NRO invested in early development of touchscreens. These and other investments have spurred along an industrial base that continues to refine consumer products like the smartphone—altering the way people go on about their daily lives.

CHARGE-COUPLED DEVICE



HUMAN QUEST FOR IMAGERY

From their earliest days, humans have captured images of their world as they knew it. Early in 2021, archeologists announced that they had identified the oldest drawing to date in a cave on the remote Indonesian island of Sulawesi. The image was first found by a doctoral student in 2017 and dated back to 45,500 years ago. The image was a life-sized picture of a pig.

In the millennia since, human imaging has progressed from drawings and carvings largely preserved in caves to paintings, portraits, and photographs housed in museum galleries. In accordance with this progression, those who create images have developed tools that increased the complexity and accurate capture of the image's subject. Sophisticated and advanced satellite imagery has been a direct beneficiary of human progress in image capture.

ORIGINS OF PHOTOGRAPHY

Most discussions of the origin of photography acknowledge that the word is derived from the Greek *photos* or light, and *graphein* or to draw. The origins of capturing images reside in early efforts to cast light to produce images. For instance, the use of a camera obscura to cast an image from outside a room onto a wall inside the room using a small hole or lens can possibly be traced back more than two millennia. Early efforts in using materials to capture images such as Heinrich Schulze using salts and sunlight or Nicephore Niepce using bitumen and lavender oil to copy drawings are examples.

Louis-Jacques-Mande Daguerre, collaborating with Niepce, created the first images that would be recognized as photographs. He created the daguerreotype by first discovering a process using iodized silver to capture an image on glass and then using a sodium solution to fix the image on the glass. Others such as Hercules Florence and William Henry Fox Talbot worked on processes to fix images to paper.

By the mid-1800s, the daguerreotype became a global means for capturing and preserving images. Talbot continued to refine his efforts to preserve images on paper. Richard Leach Maddox developed a process for capturing images on a "dry plate" or one that used a gelatin mixture instead of liquid to capture images. By the end of the 19th century, photography became more common and convenient because of these advancements.

Just prior to the turn of the 20th century, George Eastman invented first a paper-based film and then a celluloid film base. This, in conjunction with the Kodak cameras he developed, opened the world to widespread photography. The introduction of 35mm film for photography in the early 20th century further enhanced use of cameras by a wider segment of the world's population—a trend that would continue until the end of the 20th century.

PHOTOGRAPHY FROM SPACE

During the early years of the Cold War between the United States and the Soviet Union, the U.S. faced great difficulty in understanding the actual military threat from the USSR. Because the Soviet Union closed its borders and heavily controlled movements of foreign nationals who visited, the U.S. could not depend on human sources for intelligence. The 1957 launch of the Soviets' Sputnik satellite demonstrated launch capability that could be used to fire a nuclear-armed missile against the United States.

In order to gain insight into Soviet military capabilities, the U.S. turned to developing technology for obtaining intelligence. A mainstay of this emerging capability was the development of satellites for collecting imagery using space-based cameras.

In August 1960, the U.S. obtained its first imagery of the Soviet Union using a Corona photoreconnaissance satellite. Within months, the Corona satellites confirmed the U.S. maintained an advantage in the number of nuclear-armed intercontinental missiles. This opened up a critical source of intelligence for the United States.

The Corona satellite captured images on film. Once the film supply was exhausted, the captured images were returned to Earth in film return vehicles. Eastman Kodak processed the film at a special facility, providing the Central Intelligence Agency this new critical source of information. In 1963, the Gambit photoreconnaissance satellite joined Corona, taking high-resolution images of specific areas identified from Corona's broad area search capability. In 1971, the Corona system was further supplemented and later replaced by the film return Hexagon system that carried significantly more film and thereby had more capability.

CRISIS IMAGERY NEED

While Corona, Gambit, and Hexagon proved highly effective for obtaining insight into Soviet strategic weapons capabilities, they were less useful for managing U.S. responses to international crises. None of these systems were on-orbit continuously, and they could not be launched rapidly in response to a crisis. Additionally, the film from the systems was not returned for days or weeks, leaving them unable to provide timely intelligence.

The United States needed a new imaging technology for crisis imagery—one that was not available commercially. In 1969, two Bell Labs scientists, Willard Boyle and George Smith, were engaged in developing better computer memory by sequencing metal oxide semiconductor (MOS) capacitors. They found that radiation disrupted the MOS capacitors in series for memory, but their sensitivity to light radiation turned out to establish a basis for capturing a digital image.

Boyle and Smith assembled the MOS array and discovered that the device was sensitive to light photons and that they could scan the electron charge taken up by the capacitors associated with light. By scanning this array, they could create a camera that produced digital images. By 1971, they produced a camera sensor using this approach, which became known as a charge-coupled device. The world now had a cutting-edge possibility for capturing digital images.

DIGITAL IMAGERY FROM SPACE

At the same time Boyle and Smith were developing the CCD, the National Reconnaissance Office was searching for a solution for obtaining crisis imagery. In the late 1960s, the Air Force program at the NRO proposed to scan the film on the Gambit vehicle before deorbiting it and transmitting those images back to Earth. The U.S. had attempted scan readout from space in the early 1960s, but the technology failed to work as needed. The NRO also explored the possibility of always having film-return systems ready to launch quickly to obtain crisis imagery. This approach was very costly.

Engineers and scientists in the CIA program at the NRO followed the developments in digital photography. They saw the emerging digital technology, such as photo transistors, photo diodes, and the CCD, as potential solutions for building a satellite optical system that could obtain imagery from space. The NRO established a new program office to develop an electrical optical satellite, known as Kennen, using one of these technologies. One bidder proposed using photo transistors while another proposed using photo diode arrays to capture digital images from space. Eventually the Kennen program leadership utilized the existing technology before later adoption of CCDs to improve imaging quality.

Back on Earth, CCDs would emerge by the early 1980s as a key technology for digital photography. Several companies worked on improvements to and commercial applications for CCDs. Fairchild Semiconductor developed by the mid-1970s a CCD for potential commercial use. Integrating that CCD, Kodak developed the first still camera in 1975. Kodak would wait nearly 20 years before introducing a commercial camera using CCDs. As the century turned, major camera manufacturers developed cameras to take digital images, many using the CCD.

The NRO's Kennen system first orbited in 1976. It opened a new era in imaging capture. By 1986, the NRO stopped using film return systems and became fully dependent upon digital imagery enabled by CCDs. Although at least a decade ahead of commercial CCD use, the NRO's investment in CCD technology provided considerable resources for advancing digital image capture. The innovation of the NRO in image capture technology opened new possibilities for recording important events in human history—a human quest that goes back at least 45,000 years.

CHANGE DETECTION

CORONA BASELINE

In August 1960, the U.S.'s first successful photoreconnaissance satellite, Corona, opened new opportunities to visually detect changes in intelligence targets. Corona's first intelligence image captured the USSR's Mys Shmidta air base on the extreme northeast coast of that large nation, just 400 miles distant from Nome, Alaska. The air base was one of a group constructed by the Soviets in 1954 for use by long-range bombers capable of nuclear attack on the United States. Understanding developments and changes at Mys Shmidta and other airbases was critical to assess the USSR's advancements in nuclear first-strike capabilities.

With the establishment of the NRO in 1961, the United States continued to develop more capable imagery systems, such as the Gambit high-resolution photoreconnaissance satellite that enhanced intelligence analysts' ability to detect changes in locations such as Mys Shmidta. These earliest examples of change detection efforts, illustrate the new capability that emerged from the U.S.'s first successes in obtaining overhead intelligence.

THE MYSTERY OF THE "CASPIAN SEA MONSTER"

Often imagery analysts would uncover objects captured by NRO satellites that had no immediate explanation. On one occasion, an analyst discovered a mysterious, large craft in an image of the Caspian Sea shoreline. It appeared to be an aircraft with stubbed wings, new to the Soviet arsenal. Intelligence nicknamed the craft the "Caspian Sea Monster," and for many years, the NRO imaged this location to figure out what it was designed to do, using Corona and Gambit satellites, as well as Corona's successor, Hexagon.

After noting changes, analysts were able to conclude it was a large hydrofoil, a cross between a boat and plane designed by the Soviets to fly a few meters above the sea's surface. It could carry massive numbers of men or amounts of material at nearly 300 miles an hour. For several years, it was the largest aircraft in the world. Applying change detection to the imagery allowed the U.S. to assess its capabilities and the threat it posed.

THE NRO AND MAMMOGRAPHY

In the 1990s, the medical community in the United States reached out to the National Reconnaissance Office with a critical question: Is there anything you are doing with space imagery that could improve mammography? Mr. Frank Calvelli, who went on to serve as the NRO's Principal Deputy Director, provided a presentation at a 1994 conference on new frontiers in breast cancer imagery and early detection. In his briefing, he explained that NRO technologies could improve mammography in the following areas:

- Change Detection
- Automatic Target Recognition
- Soft Copy Exploitation Systems
- High Resolution Softcopy Displays

The same tools that helped us understand over time Mys Shmidta and the Caspian Sea monster could be shared with the medical community. The sharing of this toolbox improved the quality of mammography and, as a consequence, has helped in the fight against breast cancer.

COMMUNICATIONS


Teletype Machine


Fax Machine

STU-II Secure Phone

In 1961, the NRO was formed as one of the most secret and compartmented programs in the entire U.S. Government. But how does an organization that requires a verified need-to-know before you even learn its name communicate between offices located across the country using 1960s' technology? It required a small, highly capable, innovative cabal of communicators with the money and priority to create evolutionary breakthroughs, while hiding in the shadows, even from people who thought they were cleared for the nation's highest secrets.

SMALL TEAM, BIG JOB

When the NRO was created, it consisted of personnel in three different states and Washington, D.C., and with personnel at several different locations within those states. The job of getting all those personnel to work together for a common mission was the responsibility of the NRO Director and the NRO Staff, located in an unmarked suite (Room 4C-1000) in the Pentagon. The 44-person NRO Staff had a squad-sized communications team whose responsibility was to ensure that all the various programs and detachments could communicate with each other, regardless if they worked on another floor or in a different state.

The line organization began as a 12-person detachment commanded by an Air Force captain but eventually evolved into Squadrons, Groups, and finally into a single Air Force Communications Wing of over 1,000 military and contractor personnel, with a substantial operating budget. It developed and fielded leading edge advances in secure voice and message handling, facsimile capabilities, and secure tactical dissemination systems. It also enabled the NRO to be the earliest national security adopter of commercial long-line services and at the forefront in the secure application of new digital applications, internet services, and email. Many of these NRO-led capabilities were subsequently adopted by the DoD and other government organizations, such as the White House Communications Agency, the State Department, and other government agencies.

WHAT'S A FAX MACHINE?

The initial 4C-1000 communications team of 12 Air Force communicators operated a special communications center, providing classified and unclassified communications services. Initially, the NRO relied on messages sent by teletype from communications center to communications center. "Comm centers" were established at Byeman facilities. The key component of the NRO Communications infrastructure during this period was the Special Operations Communications network or SOCOM. It was based on the standard Air Force hard-copy messaging system but with unique security keying for the NRO. Secure voice communications were serviced by the DoD's Automatic Secure Voice Communications network (AUTOSEVOCOM). Facsimile was connected through the secure voice line to provide very low-rate but secure support, particularly for small facilities not serviced by SOCOM.

In the mid- to late 1970s, NRO communicators worked closely with NSA to help fund and expedite the development of advanced technology devices, such as the Secure Telephone Unit (STU)-I and STU-II. They also contracted for development of new lightweight fax machines to operate with the STU devices to provide improved capability. The combination of secure voice and secure facsimile provided essential communications capability to smaller contractors and NRO outposts, as well as the ability to establish temporary operating sites.

One of the major accomplishments during this period was the development and stand-up of the Defense Dissemination System (DDS), which enabled near real-time imagery to flow to operational users worldwide. A new dedicated squadron that was established to support this effort included operational testing, as well as 24-hour-a-day operations.

MOVING TO THE FUTURE

The 1980s was the beginning of a revolution in communications, and the NRO was at the forefront in adopting new technologies. NRO communicators were early adopters of new high-speed long lines and satellite links that were becoming commercially available. They pioneered the development and installation of a high speed, totally integrated digital switch. This was the first operational CONUS-wide digital switch within the government that integrated both secure voice and computer data traffic, and it served thousands of subscribers.

They adapted the secure red phone system, then in use by the NRO and based initially on STU-II and then STU-III technology, to the much higher bandwidths enabled by the broadband lines and digital switches to provide a greatly improved secure voice and facsimile capability for the NRO.

By the mid-1980s, the requirement for NRO secure tactical communications had grown to the point that field users wanted more and quicker data services. The NRO communications team developed and fielded a highly portable, lightweight satellite terminal that would operate on the Defense Satellite Communications System (DSCS). This was a huge success and was adopted for use by the White House Communications Agency and also, in different variants, by the Services, the Unified and Specified commands, and the commercial communication satellites used by news organizations.

The NRO started beta testing secure email in the mid-1980s. At first, it was hosted as an application on the SOCOM computers, so it was limited to sites that hosted a SOCOM relay. Users accessed their email account via remote computer terminals hard-wired to SOCOM computers. As the commercial markets grew, the email applications were ported to desktop computers by 1990.

Today, the Communications Systems Directorate (COMM) provides end-to-end secure IT and transport services throughout the NRO enterprise and to foreign mission partners. Using state-of-the-art technology to provide satellite communications and internal cyber capabilities, COMM works with all NRO directorates and across all missions to protect and advance the strategic advantage that overhead reconnaissance provides for the security of our nation and allies.

LIGHT WEIGHT FILM

When the CIA began developing the U-2 reconnaissance aircraft in the mid-1950s, it needed a supplier of aircraft film that could meet its needs while keeping the whole process secret. So in 1955, the CIA approached Dr. Albert Chapman, president of the nation's leading film producer, the Eastman Kodak Company. Realizing the importance of the request and foreseeing a lucrative potential relationship, Chapman quickly persuaded the Kodak board of directors to agree to work with the Agency, beginning a more than 40-year relationship that would outlast the Cold War.

Aerial reconnaissance is almost as old as the airplane itself. Yet in the 1950s, the technology was not very advanced, up until then, most requirements were simply to identify large objects (industries, bombing targets, armies on the move, etc.) But the mission of the U-2 was much different, and the limitations imposed on the aircraft's sensors were much more stringent. Kodak would have to come up with revolutionary new ideas to provide the needed film for the U-2's cameras.

By the U-2's first operational flight in June 1960, the company had developed the revolutionary Kodak Special Plus X Aerial Aerographic film on .0052-inch (5.2 mil) acetate base. This film was significantly lighter than most aerial films at that time and helped Lockheed save the weight necessary to reach their target altitude of 70,000+ feet.

THE MOVE TO SPACE

When planning was initiated for the move to space with the first photoreconnaissance satellite, Corona, the government again turned to Kodak. During testing, it became apparent that the production process used for the Kodak aerial film was incompatible with a space environment, and the acetate base lost structural integrity. Aware of a new material invented by DuPont called polyethylene terephthalate (PET), or Mylar, Kodak purchased a licensing agreement from DuPont to permit Kodak to manufacture the PET with the provision that Kodak limit its use to films in photographic applications. Kodak called its new film base "ESTAR."

The ESTAR base was both compatible with a space environment as well as being significantly thinner than their previous acetate base. Measuring just .004 inches (4 mils)-thick, the ESTAR base allowed Kodak to produce smaller and lighter rolls of film to meet the strict size/weight limitations needed for space flight. The world's first photoreconnaissance satellite, Discoverer (Corona) XIV, flew on 18 August 1960, and carried a film load limited to ten pounds of 70mm-wide SO-102 film (approximately 3000 feet).

While they originally produced ESTAR base with a thickness of just 4 mils, there was the potential for producing even thinner film bases. As manufacturing techniques improved, it became possible to reduce the ESTAR base thickness to .0025 inches (2.5 mils), identified as ESTAR Thin Base film. Because the thinner base permitted a larger film payload for the same weight, all Corona flights after 1962 used this ESTAR Thin Base film.

By the late 1960s when Gambit was launching and Hexagon was under development, technological improvements allowed Kodak to produce even thinner films, the .0015-inch (1.5 mil) ESTAR, known as ESTAR Ultra-Thin Base (UTB) and the 1.2 mil ESTAR, known as ESTAR Ultra-Ultra-Thin Base (UUTB). Both of these film types flew on both Gambit and Hexagon flights. By the end of the Hexagon program, fully loaded Hexagon satellites were launched carrying 320,000 feet of film, more than 100 times the film load of that first Corona satellite, just 25 years earlier.

THE WORKFORCE

In the early days of the U-2 program, the core production operation in Kodak's Bridgehead program was comprised of approximately 50 highly trained operators, technicians, and engineers. In the 1960s, as the Corona program came on-line and the scope of production support became better defined, staffing grew to 100-130 personnel. By 1975, the total complement of all Bridgehead operations and support reached its highest level of 535 personnel. Despite all of that, there were no known security breaches about Kodak involvement in the U.S. film return satellite infrastructure throughout the program, and Kodak's involvement did not become public knowledge until the Corona program was declassified in 1995.

Kodak Black & White Film Types Used in the Corona Program

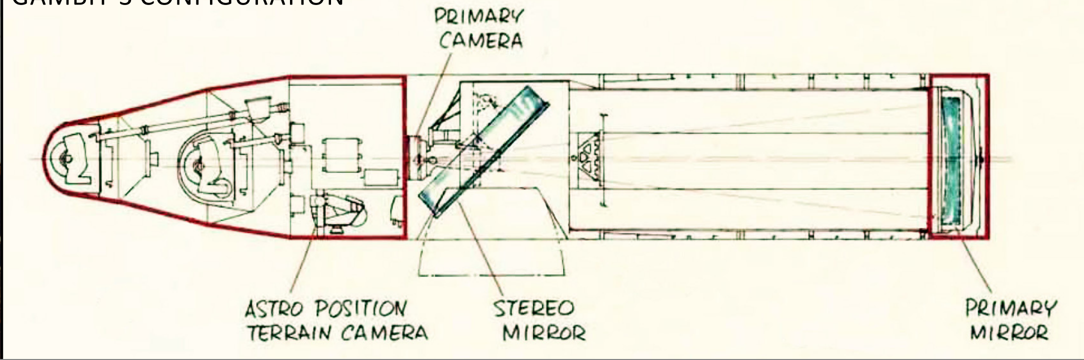
This chart identifies the film types carried as the principal film load in the various KH systems. On occasion shorter lengths of color films or B&W infra-red films were spliced into the film roll for evaluation and/or as an aid in image exploitation.

DESIGNATION	KH-1	KH-2	KH-3	KH-4	KH-4A	KH-4B
TIME PERIOD	'59-'60	'60-'61	'59-'62	'62-63	'63-69	67-72
CAMERA MFGR.	FCIC*	FCIC*	Itek**	Itek**	Itek**	Itek**
CAMERA DESIGNATION	C	C'	C'''	?	J	J-3
LENS	f/5	f/5	f/3.5	f/3.5	f/3.5	f/3.5
MODE	Mono	Mono	Mono	Stereo	Stereo	Stereo
RV	1	1	1	1	2	2
FILM WIDTH	70mm	70mm	70mm	70mm	70mm	70mm
BASE TYPE	Acetate	Acetate	Acetate/Estar	Estar	Estar	Estar
BASE THICKNESS	5.2 mil	5.2 mil	5.2mil/2 ½ mil	2 ½ mil	2 ½ mil	2 ½ mil
FILM CODE	SO-1153	SO-1153	SO-132	SO-132	3414	3414

* Fairchild Camera and Instrument Corporation
**Itek Corporation

LIGHT WEIGHT OPTICS

GAMBIT-3 CONFIGURATION



In mid-1963, about the time of the first Gambit satellite launch, the need for even higher photo resolution than that provided by the country's first high-resolution reconnaissance satellite was emerging. Intelligence analysts and engineers began to envision the benefits of better resolution than even the new Gambit systems could provide. However, engineering considerations with the original Gambit satellites hampered some basic areas for improvement. From a photographic payload point of view, the original Gambit configuration was non-optimal in a number of ways: redundant structural elements, thermal management subsystems, and power-distribution gear consumed more than their fair share of space and weight. These duplicated systems were crowding out possible growth elements such as larger optics, more film, and other life-extending expendables. The new Gambit-3 (aka Gambit-cubed) system was born out of these considerations. In terms of optics, those proposed for Gambit-3 were to be larger and lighter than any previously built for space use. The primary mirror was 44 inches in diameter, and the stereo mirror was a 58-inch by 46-inch ellipse. These optics were larger than those of many terrestrial telescopes, but they were required to be much lighter in weight, with optical figure accuracy at least as demanding.

BLANK MIRROR ASSEMBLY

The initial step in the production of light weight optics was to assemble the primary and stereo mirrors as "blanks" (unground and unpolished mirrors) with their support structure. The blanks were manufactured by the Corning Glass Company for Eastman Kodak. Using large boules of very pure fused (amorphous) silica glass, face and back plates were cut, as were the interior pieces, which were thin, notched, quasi-rectangular plates joined in an "egg-crate" fashion. The mirrors were assembled with the back plate supporting the egg-crate section, surrounded by side plates, with the to-be-finished face plate on top. This assembly was then placed in a large furnace where it was heated just to the melting point of silica, at which point the various pieces were fused to each other. The fusion operation was delicate: heating for too long or at too high a temperature would make the intended structure a partially molten blob, while too low a temperature or too short a time would prevent the parts from fusing sufficiently to provide structural integrity. After the fusion step, various tests were conducted to determine the percent of intended fusion that had actually taken place and to establish the geometry of any voids. After some early failures, these large, lightweight blanks were successfully manufactured by Corning and shipped to Eastman Kodak for figuring and polishing.

MIRROR POLISHING

To perform the polishing work, Eastman Kodak prepared a special facility where new, large grinding and polishing machines were built. Well-proven techniques were used, and success was largely a question of scale, as well as proper concern for the fact that the structure being ground and polished was more delicate than the usual piece of solid glass. An integral part of the figuring and polishing step was the need for repeated testing to ensure achievement of the desired optical figure. The optical figure-error budget required that the spherical primary and flat stereo mirrors be accurate to a root-mean-square value of one-thirtieth of the wavelength of light, as well as a peak-to-peak value of the same magnitude. The grinding and polishing process was initially fraught with difficulties, chief of which was the excessive time that it took to complete each mirror to get to the desired accuracy. Eastman Kodak originally estimated that each mirror would require about 800 hours of grinding, polishing, testing, and coating from the raw blank to the finished product. However, the process ran as high as 3,000 hours per mirror and initially put the system behind schedule. Eventually, Eastman Kodak was able to reduce the production time, and the program was back on track. By 1964, Eastman Kodak had progressed to where it had developed sound techniques for manufacturing the large, but lightweight optics. The first Gambit-3 launched in 1966 and provided image resolution about twice as good as the original Gambit systems.

PROCESSING OF LARGE DATASETS

MISSION IMPERATIVE

The NRO has been on the cutting edge of processing data and finding new solutions to handle large capacity datasets since its inception in the early 1960s. From recording telemetry data onto magnetic tapes, to processing of film returned from space, to today's processing of near real-time data, a massive amount of data pours into the NRO every day. The structuring and dissemination of large datasets is critical. To meet this challenge, the NRO utilizes integrated architecture that brings together data from all sensors in ways that refine products, streamline delivery, and create more value-added content for policymakers, analysts, warfighters, and other mission partners.

EARLY DATA ACQUISITION

Processing large datasets originated from data acquisition of early electronic intelligence search and technical collection satellites GRAB and Poppy. These Elint satellites targeted the Soviet Union's air defenses using radar pulse signals in specified bandwidths, and they transmitted corresponding signals to radio receiving and control ground huts within their fields of view. Cryptologic elements of the Army, Navy, and Air Force then coded, converted, and recorded this radio telemetry data onto magnetic tapes. Couriers carried magnetic tape recordings back to the Naval Research Laboratory, where technicians evaluated, duplicated, and forwarded the data to National Security Agency and the Air Force Strategic Air Command for analysis and further processing.

Advances in Elint satellite technology increased the volume and density of radar intercept data, overwhelming then-existing analytical capabilities. This stimulated development of computer-aided approaches at the NSA, NRL, and SAC. Such innovations led to increased volume, accuracy, and timeliness of reports on weapons systems. Intelligence collected from early Elint satellites supported a wide range of intelligence applications, helping the U.S. win the Cold War and laying the foundation for future Sigint and Geoint reconnaissance capabilities.

EXPLOITATION AND DISSEMINATION

NRO launched a series of successful film-recovery photoreconnaissance satellites—Corona, Gambit, and Hexagon—in the 1960s and 70s. Corona alone collected more than 860,000 images of the Earth's surface between 1960 and 1972, and Gambit and Hexagon were even more prolific. These satellite systems acquired photographs with telescopic camera systems and loaded the exposed film into recovery capsules. The exposed film was delivered to Kodak/Bridgehead for image processing and on to photo-interpretation analysts for evaluation. NRO partnered with Kodak/Bridgehead to manage the high volume of imagery collected, which led to innovations in improved black and white film processing techniques and advances in duplicating the original film negatives for exploitation and analysis. These images were used for reconnaissance and to produce maps for U.S. intelligence agencies. The success of these satellite programs created an appetite and dependency on satellite photoreconnaissance and led to a desire for increased volume and quality, as well as decreased time to receive imagery. In the film return era, it could take up to several weeks between target acquisition and exploitation of the imagery by the Intelligence Community.

ADVANCES IN SATELLITE TECHNOLOGY INCREASE DATA COLLECTION AND PROCESSING

Enter Kennen, the world's first high-resolution electro-optical satellite. Launched in 1976, Kennen made imagery available to analysts so quickly the process is called "near real-time." Unlike film-return systems, Kennen electronically down-linked its imagery in near real-time, providing a relatively steady stream of digital imagery to analysts after collection and processing. The NRO created from whole cloth new processes and infrastructure to process this new type of imagery.

As NRO's satellites became more sophisticated, the data stream grew in velocity, volume, and variety, and it overwhelmed established capabilities to process and disseminate information. Data acquisition became more critical, and the equipment needed to evolve to perform advance manipulation of this data. New techniques were developed to turn digital data into imagery for exploitation in support of intelligence analysis. The imagery needed to be processed, searched, retrieved, disseminated, and achieved in ways that had not been possible before. This required moving beyond the use of more traditional light tables to new technology.

During this same period, supercomputing capabilities were emerging in the United States. New computing technology provided greater efficacy in running complex simulations and mining unrelated large datasets allowing for more analysis and less searching. The NRO was able to leverage cutting edge computing technologies to meet the challenge of maximizing the exponential growth in imagery data collection from the Kennen program.

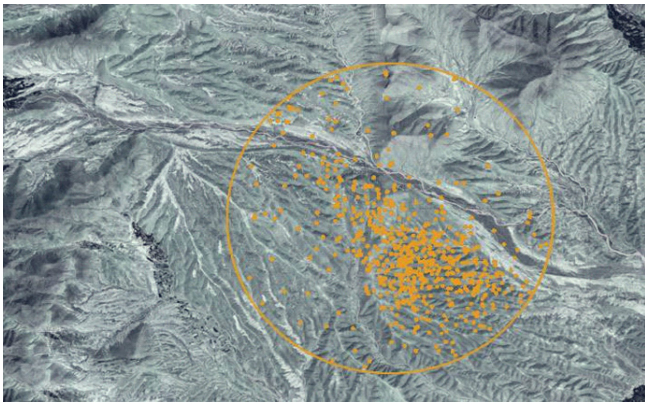
LAYING THE FOUNDATION FOR DATA SCIENCE

Advancements in space reconnaissance programs presented numerous challenges to processing large datasets for faster transmission of timely intelligence to policymakers, intelligence consumers, and warfighters. Solutions were needed. In 2008, the NRO established the Ground Enterprise Directorate (GED) as an infrastructure to deliver big data automation, speed, machine learning, and advanced sense-making necessary to optimize the value of overhead intelligence. Through micro-second timing, near real-time relays and processing, raw data is converted by individual sensors and receivers into millions of usable intelligence products on a global basis every day. It is now routinely feasible for analysts and managers throughout the Intelligence and user Community to obtain, on demand, positive intelligence in response to immediate needs. Through such accomplishments, NRO helped to lay the foundation of what today is called "data science."

SUPPORT TO WARFIGHTERS

The speed at which the warfighter is able to collect, process, analyze, and understand data directly impacts mission success. By the 1980s, NRO's improved technology applied in space and on Earth opened the way to using near real-time overhead intelligence for tactical support of military forces. With an expanding arsenal of sensing capabilities, multi-intelligence fusion methods, and a commitment to collaboration across communities, NRO systems and secure networks have ensured the timely delivery of accurate, insightful, life-saving intelligence (including real-time identification, detection, localization, and tracking of contacts of interest) to combat commands.

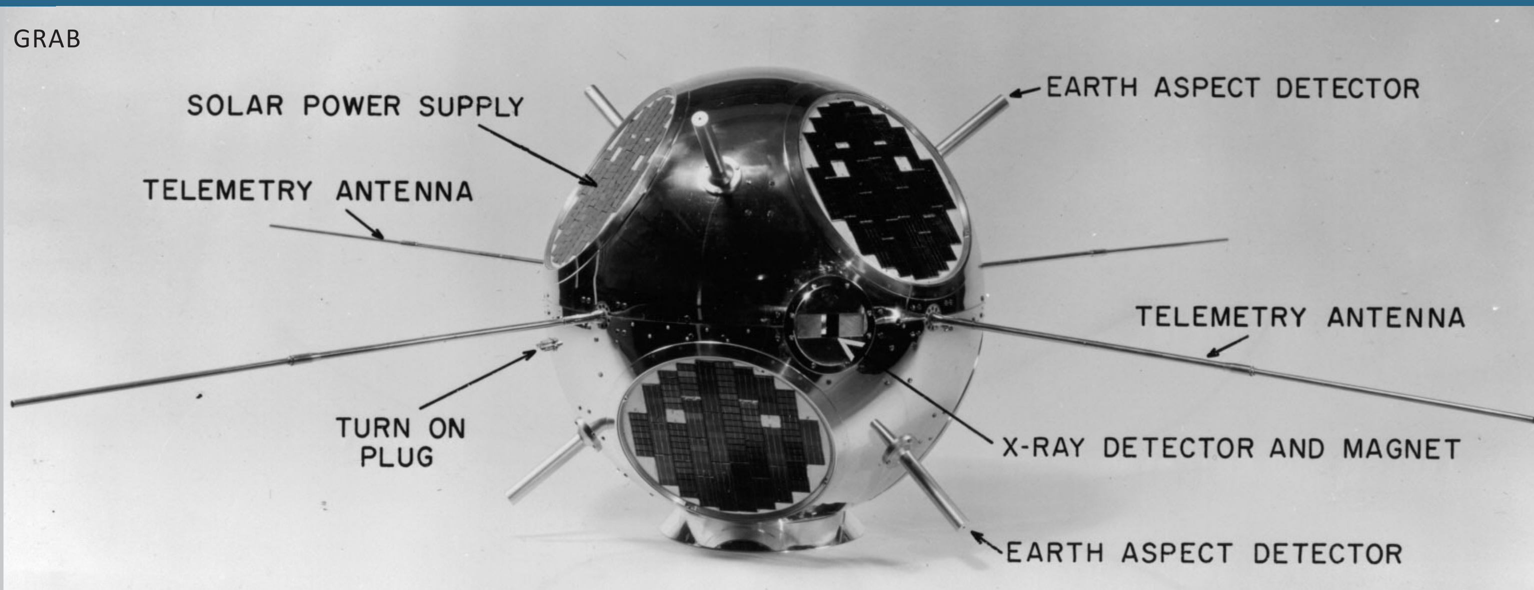
One example is the use of displayed visualization of large volumes of multi-source data to detect changes that reflect patterns of human activity. These geospatial patterns, when temporally displayed, are not only valuable for military mission planning, but also for battlefield forensics. When the geospatial display, which can render millions of data elements, is given temporal motion (i.e., reflect the changes over time), trends emerge that suggest specific activities, such as communications patterns, that can explain battlefield activities.



Millions of data elements from multi-intelligence Sources as temporally and geospatially displayed on an overhead Image. (Source: Unidentified overhead image; courtesy of CSNR Reference Collection.)

SOLAR CELL TECHNOLOGY

GRAB



THE SPACE RACE

After the October 1957 launch of the Soviet Union's Sputnik satellite—its only purpose was to emit radio pulses to make its presence known to the world—the United States' focus intensified on launching a satellite into space. In January 1958, the U.S. successfully launched the Explorer satellite. The satellite's payload carried a cosmic ray detection sensor to assess the radiation environment around the Earth, leading to confirmation of the Van Allen radiation belt theory. Both the Sputnik 1 and Explorer 1 satellites were powered by batteries. Sputnik operated for three weeks before its batteries discharged. The more elegantly designed Explorer satellite transmitted scientific data for nearly four months until its batteries discharged.

POWER FOR LONGER MISSIONS

The United States recognized that a sustainable power source was necessary to carry out longer satellite missions—one option being development of better batteries and the other incorporation of solar cells to power satellites. The U.S., and the NRO in particular, invested in both technologies to prolong on-orbit operations.

The Naval Research Laboratory, out of which one of the NRO's signals collection satellite programs would emerge, was the first organization to incorporate solar cells to power a satellite. NRL's Vanguard satellite, launched in March 1958, was designed to assess radiation effects on space vehicles and also use radio signals to provide geodesic information on the Earth. The satellite carried mercury batteries to power the satellite, but was also the first satellite to incorporate solar cells as a power source. The success of solar cells on the Vanguard I satellite prompted their use on other satellite vehicles.

FIRST SOLAR-POWERED RECONNAISSANCE SATELLITE

In addition to developing the Vanguard satellites, the NRL undertook a classified signals collection satellite development program in the same timeframe. The project was called the Galactic Radiation and Background satellite or GRAB. To cover the true nature of the satellite, NRL indicated it would carry experimental sensors to better understand radiation in space. GRAB's true purpose was to capture Soviet radar returns to better understand their air defenses. GRAB became the nation's first successful operational reconnaissance satellite when it launched in June 1960.

Drawing on NRL's early expertise in solar cell use in powering satellites, engineers designed GRAB to be powered by both batteries and solar cells. With the establishment of the NRO in 1961, the Kennedy administration included NRL's signals collection satellite program in the new organization. As part of the NRO's Program C, NRL engineers developed a follow-on satellite to GRAB named Poppy. Like the Vanguard and GRAB satellites, Program C satellite developers designed the satellites to include solar cells for power. In a very innovative approach to using solar cells on a satellite, Program C engineers designed later Poppy satellites to be covered with solar cells on almost all of their exteriors. This later generation vehicle was known as the Multi-Faced Poppy satellite.

EVOLUTION OF POWER FOR IMAGERY SATELLITES

By the 1960s, solar cells became a power source for most earth orbiting satellites and probes launched to better understand the solar system. The NRO's early imagery satellites were powered by the Agena control vehicle carrying battery cells, later supplemented by solar cells. The Agena vehicle was originally designed as a boost vehicle for placing satellites into proper orbits. As used by the NRO, it not only served that purpose, but also served as an orbital control and support vehicle for the imagery optical payloads for both the Corona and Gambit systems.

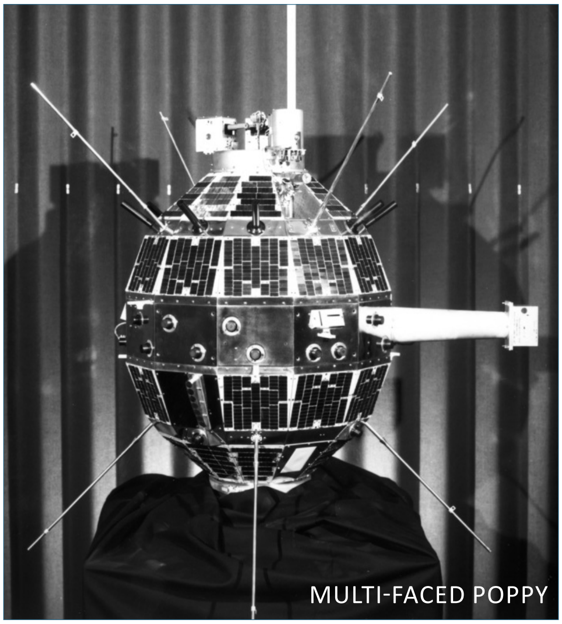
One of the significant limitations of both the Corona and Gambit systems was that they carried film supplies, and in early versions, only a single film return capsule. As a result, the missions ranged from a few days to a few weeks, at most, before the film was exposed and returned to Earth for processing and exploitation. Since the early Corona missions were short, battery power proved adequate for supporting early imagery collection satellites. With the development of dual return vehicles first on Corona and later on Gambit, the NRO's satellites required a battery and solar-cell-powered Agena.

The NRO's CIA component, Program B, undertook an ambitious program in the mid-1960s to develop a large imagery satellite that could obtain imagery for several months. The program was named Hexagon, a satellite the size of a locomotive, carrying 60 miles of film, and four film-return capsules. To power the satellite and recharge its batteries, the Hexagon vehicle included two large solar arrays on the aft of the vehicle. The arrays incorporated state-of-the-art solar cells and provided the necessary power for the large satellite and its much longer mission life compared to the earlier photoreconnaissance satellites launched by the NRO.

SOLAR CELL DEVELOPMENT CONTINUES

In 1976, the NRO launched the first Kennen imagery satellite, designed to obtain electro-optical images in near real-time. This advancement not only allowed for much longer mission operations for imagery satellites but also required sustainable power from solar cells while on orbit. As with developments in imagery collection capability, the NRO developed more advanced signals collection satellites that also required improved power sources. The NRO continued to invest in solar cell development to enable advances in satellite vehicles and their improved capabilities.

In particular, the NRO pushed gallium arsenide (GaAs) solar cell development with multi-junctions and exotic layering of materials. These cells are now used extensively on commercial spacecraft. However, GaAs solar cells were more expensive to manufacture and are known to be more brittle than traditional silicon materials, and thus the panel materials when constructed have to be appropriately heavier – a downside in launching satellites. The NRO supported development of high-efficiency silicon solar cells resulting in efficiency improvements that reached 17% efficiency. Solar cell designs of these types are also prevalent now in the industry. Additionally the NRO supported development of indium phosphide (InP) solar cells, achieving 18% efficiency and more radiation hardening than with GaAs solar cells.



MULTI-FACED POPPY

INNOVATIONS

COLLABORATIONS

A-12/SR-71


A-12


SR-71

In 1956, CIA pilots began flying the U-2 reconnaissance aircraft over denied territory. Although President Eisenhower had been assured that it would not be detectable by Soviet radars, the Soviets were able to track U-2 aircraft from the very first flight. Clarence “Kelly” Johnson, Lockheed’s genius aircraft designer of the U-2, estimated that his aircraft would have only two years to operate before the Soviets could shoot it down. While it actually took four years before the Soviets shot down Francis Gary Powers’ U-2 on 1 May 1960, the CIA and Lockheed did not wait to start developing the U-2’s replacement. The CIA approached industry experts as early as 1956 to begin development of what became the A-12 and the Air Force’s version, the SR-71, which was originally operated under the NRO’s Program D.

OXCART

The CIA began Project Gusto to develop the follow-on to the U-2 in 1956. For three years, the Agency worked with aircraft designers, eventually settling on Lockheed’s A-12 design for an aircraft that could cruise at Mach 3.2 and fly above 91,000 feet, with minimal radar cross section. A contract was signed in February 1960 for a dozen A-12 aircraft, and the program was renamed Oxcart.

REVOLUTIONARY INNOVATION

The A-12 was so far ahead of its time, it was more of a revolution than an evolution in design. Kelly Johnson said, “It makes no sense to just take this one or two steps ahead, because we’d be buying only a couple of years before the Russians would be able to nail us again….I want us to come up with an airplane that can rule the skies for a decade or more.” It was designed to fly four times faster and three miles higher than the U-2. For that, Johnson had to do things that had literally never been done before. Steel was too heavy, and aluminum was not strong enough to withstand the heat caused from the friction of flying more than three times the speed of sound. For 90% of the airframe, Johnson used a titanium alloy, some of which had to be covertly imported from the Soviet Union. Due to its strength, engineers had to develop new tools to machine and shape the metal. Things such as the water used to rinse the metal and the wrenches used to tighten bolts were changed because minuscule traces of residue left during maintenance would cause parts to fail when subjected to extreme heat in flight. The other 10% of the airframe, mostly on leading edges and engine inlets, was made of advanced composite materials to absorb/deflect both heat and radar pulses to reduce the RCS.

Normal jet fuel would explode when subjected to the heat experienced in the fuel tanks of the A-12, so a new fuel called JP-7 was invented. Synthetic lubricants that could work at extreme temperatures were invented, but at room temperature the lubricants were nearly solid, so they had to be heated before each flight. The fuel tanks leaked because no sealant was ever developed that was both impervious to chemical effects caused by the fuel, and elastic enough to expand/contract as the tanks heated and cooled. A “leak rate” of between 5 and 60 drops per minute was considered acceptable. When the A-12 was about to take flight, it was given only enough fuel to get airborne. It then rendezvoused with a

KC-135, topped off its tanks, and climbed to operating altitude, where the metal expanded and the leaks stopped. Perhaps the greatest innovation of the aircraft was the engine cones. A pair of retractable, spike-shaped cones protruded from the engine inlets to decelerate, compress, and superheat incoming air. Without the spikes, the J-58 engines would have produced only about 20 percent of the power the A-12 needed.

To save weight, Lockheed declined to pressurize the aircraft and decided to use a flight suit to protect the pilots from the pressure affects at altitude, as well as both the heat inside the cockpit and the extreme cold that would result if forced to bail out at extreme altitude. Perkin-Elmer developed a new camera system to work under severe design constraints. Corning Glass Works spent three years and $2 million to design a new camera window that would not distort from the 400-degree difference between the inside of the aircraft and the outside portion being subjected to the extreme friction of Mach 3.0 flight.

FLIGHT PERFORMANCE

The A-12's first flight was 25 April 1962, and it set numerous "unofficial" world records during flight tests that still hold today. In 1965, A-12s reached peak speed and altitude of Mach 3.29 (over 2,200 mph) and 90,000 feet. These records are "unofficial" because the A-12 was classified, so the Air Force's version holds the official records, even though its performance was inferior to the A-12's.

SR-71

While the CIA was testing the A-12, the Air Force was developing its own variants, the YF-12A interceptor and the SR-71 reconnaissance version. Both Air Force variants were two-seat aircraft to allow for a co-pilot to handle additional weapons or sensors. Because of this, the single-seat A-12s were both smaller and lighter than the Air Force models, allowing the A-12 to fly higher and faster. While the A-12 was concerned primarily with photo acquisition, the Air Force version would carry several other sensors that could collect much more data. The SR-71 carried two TEOC cameras, as well as several additional sensors – Operational Objective, Terrain, and Infrared Cameras, Side Looking Radar, and an Elint package. These additional sensors provided greater flexibility and a greater mission profile, part of the reason the SR-71 survived after the A-12 was cancelled. The YF-12A never advanced past the prototype phase.

OPERATIONS

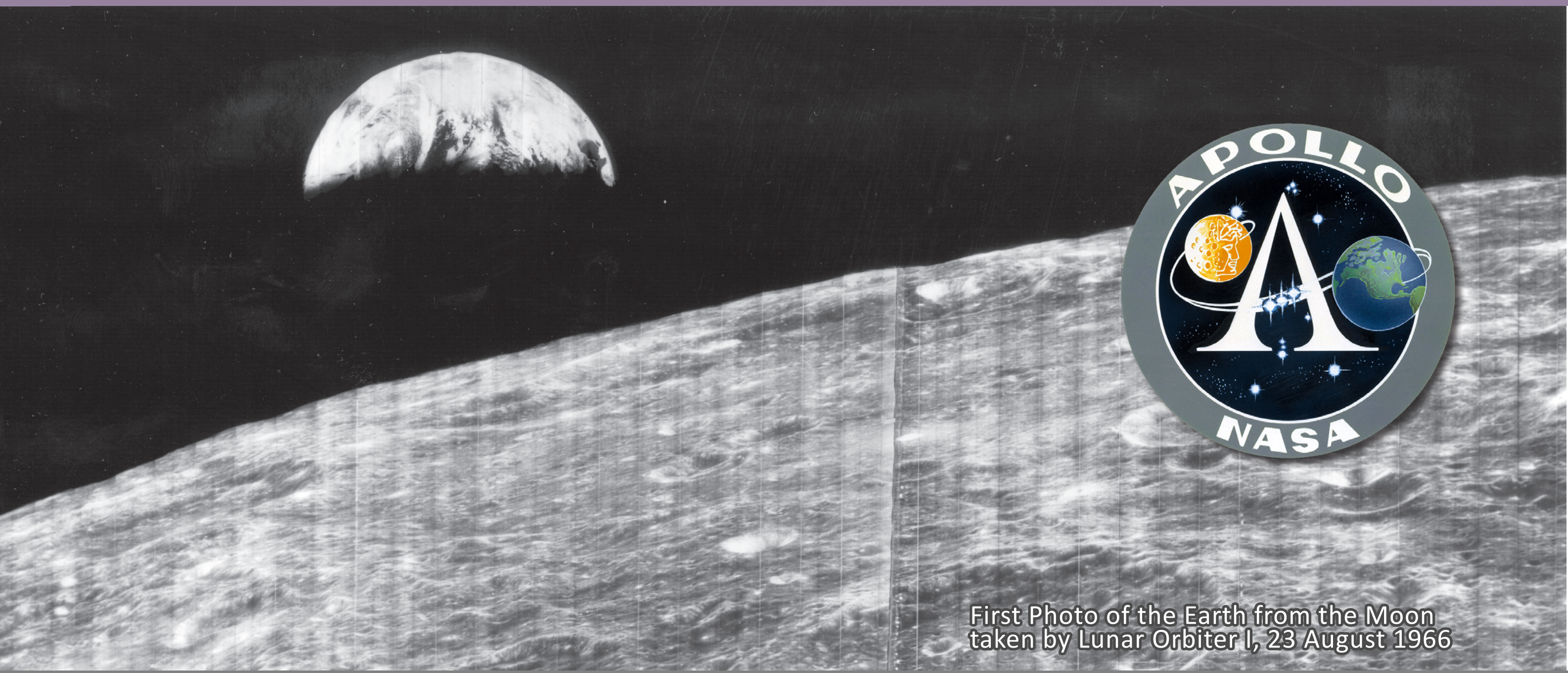
Although the A-12 was capable of conducting remarkable feats by the early 1960s and it was officially declared "operational" in late 1965, the A-12 was without a mission, due to domestic and international political issues. It had already been decided to never again fly manned aircraft over the Soviet Union – the mission the A-12 had been designed for – so many people debated whether it was prudent to have two similar fleets being flown by both the CIA and the Air Force. It was not until May 1967, when policymakers became concerned about undetected surface-to-surface missiles in North Vietnam, that the A-12 finally flew its first mission, mainly because the SR-71 was not yet operational. Over the next nine months, Operation BLACK SHIELD conducted 26 missions over South East Asia and three over North Korea. The A-12 program was then cancelled. The Air Force operated the SR-71 as part of NRO's Program D from 1968 up to 1974, when Program D was cancelled and all reconnaissance aircraft were transferred to the operational Air Force; the Air Force continued to fly the SR-71 until 1999.

WHAT IS IN A NAME?

The A-12 has been known by many names. The "A-12" moniker comes from the actual design of Kelly Johnson, who assigned Archangel-1 to his first design. Archangel was chosen because the plane was the follow-on to the U-2, which had been designated Angel by Lockheed. After numerous modifications, testing, and follow-on designs, the final decision landed on the 12th version of the design, or the Archangel-12, which then became the A-12. The term Oxcart was the CIA project code name, chosen from a random list, that also became synonymous with the aircraft itself. Once flight testing began, Lockheed unofficially changed the name to Cygnus, after the Swan star constellation. Pilots preferred the name Cygnus because no self-respecting jet pilot wanted to be known as someone who flew an Oxcart.

The term Blackbird refers only to the A-12's Air Force cousin, the SR-71. Sometimes confused with A-11, the A-11 was simply a counter-intelligence attempt used during the Presidential announcement of the existence of the aircraft. The prototype "A-11" was merely a YF-12A that was used in the official world speed/altitude record trials. Interestingly, the Air Force's version was initially named the RS-71, or Reconnaissance/Strike-71. However, during its public unveiling, President Johnson transposed the letters and called it the SR-71. Rather than correct the President, Air Force officials created a new Strategic Reconnaissance (SR) category and renamed the aircraft.

APOLLO PROGRAM SUPPORT



First Photo of the Earth from the Moon taken by Lunar Orbiter I, 23 August 1966

U.S. CALL TO SPACE

When President John F. Kennedy stood in front of a crowd in Houston, TX in 1962 for his "We choose to go to the Moon" speech and implored the nation to support the Apollo Program to send a man to the Moon before the decade was out, the NRO was less than a year old. Few people even knew of the NRO's existence, and even fewer could foresee that the NRO would get involved in the endeavor. But the NRO did indeed assist the National Aeronautics and Space Administration in getting Apollo 11 to the Moon, as well as getting Neil Armstrong, Buzz Aldrin, and Michael Collins safely back to Earth.

When NASA was created, it was charted as a purely civilian agency with no military ties and only peaceful scientific goals. Some questioned whether working with a classified federal intelligence agency was ethically, and even legally, allowed. However, because the "fact of" the NRO was kept classified until 1992, the story of NRO's relationship with NASA was kept secret for decades.

When the NRO was formed in 1961, one of the programs it absorbed was the Air Force's Samos project, a satellite program that was investigating both imagery and signals intelligence collection systems. The Samos E-1 was a Kodak-developed camera that was a near real-time analog film readout system that took photographs, scanned them, and then transmitted them to ground stations on Earth. However, the system was too slow to be utilized in a low-orbit intelligence satellite. Because of this, Dr. Joseph V. Charyk cancelled the Samos imaging project soon after becoming the Director of the newly formed NRO.

NRO IMAGING CONTRIBUTIONS TO NASA

In 1963, NASA requested bids for a satellite that could map the Moon, looking for suitable landing sites for the upcoming Apollo flights. Trying to recoup their investment in the E-1, Kodak requested permission to enter the competition, and NRO approved the request. Although their proposal was the most expensive entry, it was the only candidate with proven technology, and NASA chose the Kodak bid. The Lunar Orbiter program flew five man-made satellites to Earth's only natural satellite, mapping 90% of the Moon's surface and beaming the images back to Earth, thus becoming man's first near real-time imaging satellite. Without the NRO's help, Neil Armstrong's "one giant leap" may have been delayed, and JFK's call to visit the Moon before the end of the 1960s may not have been fulfilled.

Meanwhile, NRO offered NASA its most advanced high-resolution KH-7 imagery system from the Gambit program, in case NASA needed higher resolution imagery than the Lunar Orbiter could provide. The origin of the camera was hidden under NRO's Upward program. Kodak built the system and would provide NASA hardware for advanced imaging. The system was designed to launch on an Apollo spacecraft and to be operated by Apollo astronauts. However, the Lunar Orbiter imagery of the Moon proved sufficient to identify safe landing spots, so NRO and NASA discontinued development of the Upward lunar imaging system.

CRITICAL SUPPORT TO APOLLO 11 SUCCESS

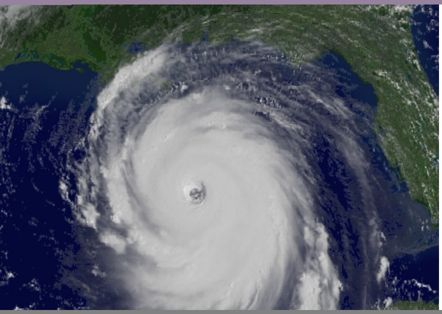
But the NRO's contribution to the Apollo program did not end there. In July 1969, Captain Hank Brandli was an Air Force meteorologist assigned to the NRO in Hawaii. He used data from the NRO's Defense Meteorological Satellite Program to estimate weather over drop zones in the Pacific Ocean used by the Air Force (the "StarCatchers") to recover Corona film buckets and to ensure film drops occurred only on days with good weather over those drop zones. He could accurately estimate weather over the drop zones up to five days in advance—an unheard of capability in the late 1960s. The problem was the Corona program, and the DMSP's relationship to it, was so highly classified, the StarCatchers' Group commander was the only other person in the Group cleared for both programs.

The day after Neil Armstrong leapt onto the Moon, Capt Brandli had evidence from the DMSP satellite that told him a major tropical storm would be over the spot in the Pacific Ocean where the Apollo astronauts were scheduled to splash down on 24 July. If that happened, the parachute used by the astronauts would be ripped to shreds, their capsule would plummet into the ocean, and the astronauts would be killed on contact—not exactly the ending for their historic mission that NASA was envisioning.

Brandli had to act. But the DMSP and its technology were so highly classified, nobody at NASA was cleared, so he could not tell NASA that their astronauts were in danger of being killed after successfully making their way all the way to the Moon and back. With just 72 hours to change history, Brandli discovered that the U.S. Navy was in charge of forecasting weather for NASA. So Brandli contacted the DoD chief weather officer, Navy Captain Willard (Sam) Houston, Jr., at the Fleet Weather Center in Pearl Harbor. Although Houston was not cleared for the Corona program, he was cleared for the DMSP. Brandli showed him the photos and convinced him of the danger. Now all Houston had to do was convince Rear Admiral Donald C. Davis, the commander of the naval forces tasked with the Apollo 11 recovery—all without being able to tell him where his information was coming from because RADM Davis was not cleared for the DMSP.

Due to the extremely short timeline, RADM Davis had to reroute the entire USS *Hornet* task force to a new splashdown area 215 nautical miles to the northeast before he received official orders to do so, a career-ending decision if he was wrong, especially since President Richard Nixon was scheduled to fly to the *Hornet* to greet the returning astronauts. He also had to convince NASA to alter its flight plan so their recovery capsule landed in the right area. As it turned out, Capt Brandli's forecast was spot-on, and the astronauts splashed down in nice calm seas to the relief of everyone. Capt Houston received a Navy Commendation medal for his efforts that he could not talk about until Corona was declassified in 1995, and Capt Brandli received a visit from DNRO John McLucas and DDNRO Robert Naka, who congratulated him for his impressive work and extraordinary effort.

CIVIL APPLICATIONS OF NRO INNOVATIONS



TOWARD CIVIL USE OF CLASSIFIED INTELLIGENCE

The Civil Applications Committee (CAC) is an interagency committee that coordinates and oversees the Federal civil use of data acquired by U.S. National and Commercial Imagery Systems. The idea for the establishment of the CAC arose in the 1960s when the Corona imagery satellites began to return large quantities of photography of the Earth. Could National Reconnaissance Program satellite imagery be used for U.S. civil applications? In 1966 the NASM 156 committee recommended, and the U.S. Intelligence Board approved, granting a limited number of Top Secret clearances to employees and consultants of various civil agencies to permit their review of reconnaissance satellite photography.

In early 1967, Presidential Science Advisor Donald F. Hornig, with the approval of the DCI and Secretary of Defense, authorized a study of selected satellite imagery by the Departments of Agriculture, Interior, and Commerce, along with the Agency for International Development and NASA. “Project Argo” sought to determine satellite imagery’s usefulness for economic, social, and natural resource surveys. The group of resource experts issued a four-volume report in March 1968, concluding that existing imagery would be of considerable value in archaeological, glacial, hydrological, geological, and agricultural studies; forestry management, surveys of land use, and natural disasters; and mapping and urban area analyses; among other uses. In 1969, a special facility operated by the U.S. Geological Survey was established in the Washington, D.C. area to support the use of classified remote sensing data by Federal civilian agencies. An Argo Steering Committee representing relevant Federal departments and agencies was subsequently formed to consolidate their data requirements and submit them to the appropriate components of the IC for NRP tasking. A charter for this group was issued in 1970.

PRESIDENTIAL MANDATE

These early actions led to a 1975 Executive Order from President Ford establishing the Civil Applications Committee, a central body that would be provided classified overhead imagery for civil purposes. Initially, representatives of the Departments of Commerce, Interior, and Agriculture, as well as the Environmental Protection Agency, and the Agency for International Development (USAID) were selected to exploit satellite imagery for unique civil requirements. Only domestic imagery of national disasters (e.g., floods, drought, and famine), with the exception of USAID, would be made available to the member agencies. The Intelligence Community’s Committee on Imagery Requirements and Exploitation (COMIREX) ensured the CAC members adhered to national imagery security policies in the use of authorized imagery. The NRO has been an associate CAC member since 1993.

CIVIL APPLICATIONS TODAY

Today, CAC-sponsored activities include a broad range of science and remote sensing applications and research central to CAC member missions. Examples include monitoring volcanoes, sea ice, and glaciers; detecting and tracking wildfires; supporting emergency response to natural disasters, such as hurricanes, earthquakes, and floods; and monitoring invasive species, ecosystems, and global climate change. Headquartered at the U.S. Geological Service National Civil Applications Center (NCAC) in Reston, VA, the CAC oversees and facilitates “civilian agencies’ use of classified and commercial systems and coordinates the incorporation of photography, derived data, and technology in the performance of domestic civilian functions....” In cooperation with the USGS National Civil Applications Program, the CAC coordinates collection and certifies that requested data is properly used. The CAC also supports remote sensing research and development activities at USGS facilities, such as the National Civil Applications Center, where exploitation tools are available to CAC scientists and analysts.

CAC MEMBERSHIP

PRINCIPAL:

Department of the Interior/United States Geological Survey – Chair
Army Corps of Engineers
Coast Guard
Department of Agriculture/Vice Chair
Department of Commerce
Department of Health and Human Services
Department of Transportation
Environmental Protection Agency
Federal Emergency Management Agency
National Aeronautics and Space Administration
National Science Foundation
Tennessee Valley Authority

ASSOCIATE:

Defense Intelligence Agency
Department of Energy
Department of Homeland Security
Department of State
National Geospatial-Intelligence Agency
National Guard Bureau
National Reconnaissance Office

EX OFFICIO:

National System for Geospatial Intelligence
Office of the Director of National Intelligence
Office of the President of the United States

CLIMATE CHANGE

image credit: coolgeography.co.uk

The original mission of the National Reconnaissance Office was to obtain satellite reconnaissance photos, as needed by U.S. Government leadership, to evaluate and monitor the potential threats of Soviet missile activity. Over the course of its 60-year existence, the NRO's mission has evolved significantly. In the decades since its creation, the work accomplished by the NRO has influenced developments, not only within the classified world of the Intelligence Community, but also in the unclassified arenas of space exploration, agriculture, meteorology, communications, medicine, technology, and climate change. For example, NRO capabilities assisted with the assessment of damage from the 2004 tsunami in Southeast Asia and of Hurricane Katrina in 2005, and has helped save lives by supporting the responders that fight wildfires in the American West. Today, multiple civilian agencies use NRO overhead systems to, among other things, assess and predict climate change, study crop production, map habitats of endangered species, respond to natural disasters, and track geological and glacial change.

DECLASSIFICATION OF NRO IMAGERY

Early NRO imagery collection, obtained by the space-based reconnaissance systems of the 1960s and early 1970s, was driven mostly by the need to confirm purported developments in Soviet strategic missile capabilities. At the time, the photos were also used to produce maps and charts for the Department of Defense and other U.S. Government classified mapping programs.

In the early 1990s, a Classification Review Task Force, led by the Central Imagery Office, examined imagery security policy and the utility of satellite photo reconnaissance imagery for public purposes. The Task Force evaluated the associated national security risks, in the post-Cold War era, of releasing the 1960s reconnaissance photos to the rest of the U.S. Government and the public. It was concluded that the value of the images, to the study and analysis of climate change, was more significant than the continued protection of mostly obsolete technology and the identification of early targets of reconnaissance missions. The Task Force then made recommendations to the White House to declassify the imagery.

In February 1995, President Clinton signed Executive Order 12951, "Release of Imagery Acquired by Space-Based National Intelligence Reconnaissance Systems," which directed the declassification of imagery obtained by the Corona, Argon, and Lanyard photoreconnaissance missions. The order resulted in the declassification of more than 800,000 images collected by these satellites between 1960 and 1972.

IMPACT

Prior to the declassification of the reconnaissance images, environmentalists were limited by the imagery provided by the Landsat system, which became operational in 1972, but had poorer image quality than the earlier NRO programs. The release of the previously classified archive of reconnaissance photos, covering the previous 12 years (1960-1972), provided an additional basis for the systematic and comprehensive coverage of the Earth's surface to scientists and environmental researchers. The images acquired by the NRO's earliest reconnaissance satellites (Corona, Argon, and Lanyard), allowed environmentalists to establish a 1960s baseline, not available by any other means, to assess environmental changes and provided significant contributions to the analysis and understanding of global environmental processes. Subsequent declassification of the NRO's Gambit and Hexagon programs and associated imagery further enlarged the imagery data available for climate change analysis.

NRO'S FIELD REPRESENTATIVES

BACKGROUND

The NRO Field Representative (FR) program traces some of its institutional roots back to NRO's Program C (Navy), which trained and deployed technical support representatives to provide on-site support to U.S. Naval operations. The FR programs were initially managed by Program C, but transitioned along with several other programmatic elements, to become the Operational Support Office (OSO) in 1990. Following NRO's 1992 disestablishment of Programs A, B, and C—OSO became the primary office responsible for customer interface and dissemination of NRO data. With consolidation of NRO into an integrated organization, NRO's operational support expanded to a diverse customer base, particularly after the Gulf Wars, which included senior policymakers and IC stakeholders.

INTEGRATION OF SYSTEMS, PERSONNEL, AND CONCEPTS

The success of today's NRO FRs can be attributed to the fact that they were, from the inception of Program C, an integral component of a culture that had an exceptional understanding of NRO systems' data and end user needs. When the NRO co-located technically smart line officers and expert enlisted technicians who understood the Navy's operational environment with competent Naval Research Laboratory engineers, the resulting collaboration produced imaginative ways to capture, exploit, and disseminate satellite collection to operational users, which in the Program C era, was the Naval Fleet.

APPLICATION OF TECHNICAL EXPERTISE AND COMPETENCE HELPED END USERS UNDERSTAND THE DATA

Forward-deployed FRs possess the expertise and dedication that has been, and will continue to be, pivotal in helping consumers understand NRO systems and data, while relaying user feedback to senior management regarding the need for new or enhanced techniques, tools, and procedures. Drawing from the procedures and culture of Program C, NRO FRs helped resolve vexing technical support challenges by providing the warfighter and IC elements with training and education on systems and content to prototype new applications to meet mission priorities.

COMBINING STREAMLINED DIRECTION WITH ENGINEERING EXPERTISE SERVED AS A TIMELESS SUPPORT MODEL

When NRO adapted its dynamic organizational culture to combine streamlined, operationally focused, single-chain of command direction with engineering expertise, it became a model for forward-deployed technical support that remains relevant, insightful, and even inspirational to current and future NRO operational support personnel.

NAVAL LEADERSHIP CHANGES THE GAME

In the 1980s thorough 1990s, the Navy was determined to validate the then-revolutionary premise of real-time, spaced-based FR support to operations. The concept was predicated on three principles:

- Rapidly deploy automated tools to process vast quantities of data from satellite systems.
- Provide in-depth analysis of that data to optimize its utility in the field.
- Provide education and training to aid deployed users with an understanding of how satellite data could be applied to their missions.

Underwriting the cultures from the 1960s through the 1990's Program C, along with the NRO's 1990-2005 Deputy Director for Military Support/OSO eras, was a marriage of operational focus and institutional support. The modus operandi was simple and direct: be willing to take risks, use failure as an opportunity to learn, employ sound engineering program management practices, and minimize bureaucratic overhead.

The post-Desert Shield/Desert Storm NRO Directors from Martin Faga (1989-1993) through Keith Hall (1996-2001) saw the international landscape changing; after the Gulf Wars ended and with global terrorism on the rise, they were determined to make NRO's satellite data readily available to tactical warfighters. They rightly foresaw an emerging, large military customer base whose tactical needs for NRO data far exceeded DoD's strategic needs for targeting and planning. Moreover, NRO still had to accommodate the IC's need for satellite reconnaissance to make long-range estimates related to threats in hostile and denied areas. Yet, in spite of this clear understanding of the value of NRO data, as often happens during periods of change and re-organization, inadvertent mistakes occur with shifting leadership priorities, which sometimes adversely impact mission focus.

TODAY'S FIELD REPRESENTATIVE

The role of a well-trained and knowledgeable NRO FR on site to help explain and illustrate innovative ways to use satellite collection to those less familiar cannot be overstated. As the nation moves towards an integrated Space Force, there may well be calls to eliminate forward-deployed NRO FR operational support thinking it a relic of a bygone era. However, NRO FRs' unique technical and operational expertise continue to be an essential means of imparting knowledge to DoD and IC consumers of satellite collection worldwide to aid IC partners with meeting critical mission needs.

IDEX WORKSTATION

ANALYZING IMAGERY

Prior to the NRO's Kennen electro-optical satellite, intelligence imagery was copied on a film base for imagery analysts to review for intelligence exploitation purposes. Analysts used devices known as light tables to illuminate film in order to magnify and view the detailed images under viewing scopes. In the early days of the Kennen program, digital images were copied in a similar "hardcopy" fashion. Recognizing that finding a way to view the processed digital images without this step would speed and improve analysis, the NRO, CIA, and Defense Intelligence Agency collaborated on a more innovative means for soft-copy imagery exploitation.

EXPLOITING DIGITAL IMAGERY

The Committee on Imagery Requirements and Exploitation highlighted growing funding requirements for systems to analyze soft-copy imagery obtained from Kennen. Representatives from CIA and DIA chaired a subcommittee to recommend an Intelligence Community solution to these requirements. The subcommittee identified the requirements for soft-copy exploitation across the larger community, as well as a review of the technology possible. Under these circumstances, the first-generation IDEX I (Image Data Exploitation) workstation was built by E-Systems. Only ten first generation IDEX I workstations were deployed from 1981 to 1991.

As digital technology advanced, so did the opportunity to develop a more capable workstation for use across the Intelligence and Defense Communities. As a result, the IDEX II emerged as the workstation for imagery analysts to review digital imagery. One of those stations was transferred to the National Air and Space Museum in 2005 for display. The museum described the significance of the workstation as follows:

> From 1991-2003, U.S. intelligence agencies used Lockheed's Image Data Exploitation (IDEX) II system to analyze digital imagery returned from photoreconnaissance satellites and aircraft. There were about 100 IDEX IIs deployed at DoD and intelligence agency locations around the world. They were used to analyze mostly high-interest targets and images that needed enhancing, such as haze removal and contrast and brightness manipulation to fully exploit the data. The other digital imagery was run off in hard copy to be analyzed on light tables. The DoD and intelligence agencies replaced IDEX II with commercial hardware and programs, which enabled them to analyze virtually all the digital imagery on computers and thus retire the light tables.
>
> The IDEX systems permitted the enhancement of imagery to achieve more complete and precise analyses. They also made the storage, retrieval, and dissemination of imagery much easier and quicker. A color monitor is on the left, and a high-resolution black and white monitor is on the right. The goggles enabled the imagery analyst to view images stereoscopically.

The highly innovative IDEX II enabled analysts to better utilize imagery in understanding and answering complex intelligence questions. The innovators who designed the workstations pressed into service the most cutting edge technology of the time, consistent with the established pattern of NRO innovation.

NRO & IC



NRO'S MISSION

In the 21st century, NRO is one of 17 U.S. intelligence agencies operating under the egis of the Director of National Intelligence. NRO designs, launches, and operates America's reconnaissance satellites to collect vital information in support of all IC mission partners worldwide.

BACKGROUND

NRO's relationship with DoD, CIA, and NSC to highlight but a few key relationships dates to the 1950s. In 1954, President Eisenhower in coordination with his National Security Council (NSC) staff, requested that a panel of scientific experts be assembled to study threats against the U.S. to prepare in the event of a surprise attack. This team, the Technological Capabilities Panel (TCP), determined that the U.S. needed to increase the timeliness of information collected for actionable CIA intelligence estimates. Following TCP recommendations, Eisenhower commissioned Lockheed Missile and Space Company to build the first U-2 reconnaissance aircraft. The U-2, also known as the Dragon Lady, was a single-jet engine, high-altitude reconnaissance aircraft operated by the U.S. Air Force. The Dragon Lady provided day and night, high-altitude (70,000 feet or 21,300 meters) all-weather intelligence gathering. U-2 became a critical asset during the Cold War when information related to Soviet activities was difficult at best to come by.

To avoid escalating tensions from U.S. overflights over the Soviet Union, the TCP recommended using CIA's special authorities to streamline contracting processes using "unvouchered" funds to build the U-2. By bringing CIA into the development of this large technical collection system, it enabled the U.S. to classify reconnaissance missions over the Soviet Union since CIA manned those flights. From Eisenhower's perspective, "If . . . the United States flies over Russia . . . it is an act of war . . . and I don't want any part of it." The first U-2 mission was flown 4 July 1956 and 23 missions were accomplished until 1 May 1960 when CIA pilot Francis Gary Powers was shot down by a Soviet missile near Yekaterinburg. So began the complex relationship between DoD and the IC with what became the NRO a little more than a month later.

NRO'S ESTABLISHMENT

On 25 August 1960, President Eisenhower greeted top science advisors prior to a meeting with the NSC. Edwin Land, Polaroid Corporation's CEO and James Killian, President of the Massachusetts Institute of Technology, proposed that a national office responsible for the design, acquisition, and operation of reconnaissance satellites be established. At that NSC meeting, President Eisenhower formally gave his stamp of approval to establish the NRO.

UNRAVELING THREADS

The NRO consolidated under its umbrella what the media described as a series of "technologically fragmented collection systems" evolving from interagency turf wars. Competition centered around the Satellite Missile Observation System, championed by the Air Force and CIA, who competed for control of America's powerful space domain. Moreover, NASA's Discoverer program, which also served as cover for the Corona program, was perceived by the Air Force to be yet another intrusion into its air domain. Moreover, the Air Force still had not fully recovered from CIA's (albeit mandated requirement) to assume authority over U-2 flights. Thus, by 1960, the Air Force was determined to hold on to Samos at all costs. However, events like shooting down Frances Gary Powers and CIA's Discoverer 14 becoming the first satellite to have its film capsule snatched mid-air, led to an extensive review of Samos and other space programs. What became known as the Samos Panel concluded that the tangled space programs were management problems, not always hardware problems.

IC SPACE PROGRAMS REALIGNED UNDER NRO

To accommodate political sensitivities, the Air Force Undersecretary became the new Director of NRO (and continues to serve in a top tiered leadership role today). The Air Force was given responsibility for launching and controlling satellites and recovering capsules as they were ejected from orbit. A senior CIA officer was assigned as the Deputy Director of NRO. Since CIA was the nation's preeminent foreign intelligence gathering organization, it was also given responsibility for developing satellites in coordination with NRO and Air Force leaders. The intent was to leverage interagency expertise for optimal mission performance. Naval reconnaissance also became a less controversial but equally important element of NRO.

U.S. NAVY (USN)

The National Underwater Reconnaissance Office (NURO) is sometimes referred to as NRO's "hidden younger brother." NURO was established in 1969 and became a liaison office for the USN and CIA to manage underwater reconnaissance. NURO used "special project submarines" like USS *Seawolf* and USS *Parche* deep inside Soviet waters to monitor naval communications, including their bases and sound signatures. NURO is a little-known agency and its existence remained a secret until 1998.

THREE DECADES OF SUCCESS

The loose construct of disparate IC space programs remained under NRO's umbrella for three decades until the end of the Cold War. Some describe the early years of NRO's history as the Golden Years, particularly since the lion's share of the U.S. defense budget went to NRO. However, what was perceived as NRO's inflated budget is really a misnomer since most of NRO's budget was, and continues to be, used to build satellite capabilities in support of IC mission partners. Consequently, the NRO and IC have been inextricably linked from a technological and intelligence collection standpoint from its inception.

THE END OF THE COLD WAR AND A CHANGING WORLD

The collapse of the Soviet Union in 1991 and the end of the Cold War resulted in vast changes to NRO and how it supported the IC. U.S. defense expenditures were drastically cut to correspond with what was perceived to be a safer world. In that context, NRO was forced to adapt to close Congressional scrutiny, who openly and often, questioned the value and relevance of many national reconnaissance programs. This was in stark contrast to the past era when NRO enjoyed strong Congressional and senior policymaker support. The end result of these Congressional inquiries, was a drastic reduction in NRO's funding. This unprecedented cut adversely impacted many overhead space programs responsible for monitoring and targeting, what the IC knew to be, ongoing threats from U.S. adversaries. Reduced funding also negatively impacted existing satellite constellation maintenance, along with research and development innovations, all developed to support mission partners and U.S. national security.

NRO FUNDS DECREASE, SATELLITE RECONNAISSANCE DEMAND INCREASES

In the 1990s, IC officials and NRO appealed to Congress—and the American public after NRO's existence was acknowledged in 1992—that overhead reconnaissance needs were not declining, they were growing. Though most Cold War threats to the U.S. had disappeared in the monolithic sense, new dangers emerged like international terrorism as well as political instability fomenting from newly independent states formerly a part of the Soviet Union. At the same time, IC intelligence collection needs increased dramatically for a range of issues, including battlefield support, monitoring treaty compliance, weapons proliferation, narcotics trafficking, and environmental concerns to highlight the most pressing requirements. After the Cold War ended, demands for NRO's overhead surveillance increased more rapidly than at any other time in NRO's history at a time when funding was reduced the most.

NRO IN THE 20TH AND 21ST CENTURIES

The need for NRO's satellite reconnaissance increased exponentially before, during, and after the Gulf Wars, but after 11 September 2001 with the rise of global terrorism demand skyrocketed. As new threats constantly emerged, the need for timely satellite reconnaissance collection increased based on NRO's long history of working with IC partners developing innovations to meet dynamic mission goals. NRO continues to support IC partners everyday by diligently working behind the scenes, to design and create advanced, groundbreaking technologies to meet the needs of an ever-changing and more dangerous world. Today's NRO demonstrates the same commitment and innovation that President Eisenhower envisioned on 25 August 1960—60 years later.

OVERSEAS PARTNERSHIPS

One early difficulty the NRO faced in successfully operating reconnaissance satellites was the timely, regular, and secure operation and control of those space vehicles. The first reconnaissance satellites operated in a low-earth orbit, affording relatively brief opportunities to communicate with them directly from secure tracking stations within the United States. To enhance reconnaissance satellite operation, the NRO needed to install more tracking stations around the globe, which required U.S. leaders to negotiate assistance and partnerships with other nations. Those interactions formed the foundation for an NRO presence and overseas partnerships that continue today.

AIR FORCE SATELLITE CONTROL NETWORK

Beginning with the development of the Samos reconnaissance satellites in the late 1950s, U.S. program managers recognized that optimal satellite control would depend on a global network of stations. Those stations would provide tracking, telemetry, command and control support functions for satellite operations. The U.S. Air Force established the Air Force Satellite Control Network (AFSCN) for this purpose.

The first reconnaissance satellite to depend on AFSCN was Corona. The Air Force established network stations in many domestic U.S. locations including California, Colorado, and New Hampshire, as well as overseas in Hawaii and Guam. Because control from U.S. states and territories was limited, AFSCN stations were also constructed in foreign overseas locations including Greenland, England, Diego Garcia, and the Seychelles. Australia would also provide a remote tracking station, further enlarging the footprint for satellite control.

GALACTIC RADIATION AND BACKGROUND SATELLITE

The Galactic Radiation and Background satellite was the first operational U.S. intelligence satellite. The project formally began as a U.S. Navy Elint satellite system in 1959, launched its first satellite in June 1960, and the satellite operated successfully until August 1962. Its mission was to obtain information on Soviet air defense radars inside the country that could not be observed by Air Force and Navy ferret aircraft flying Elint missions along accessible borders in Europe and the western Pacific.

GRAB was controlled by a series of Earth Satellite Vehicle (ESV) huts deployed worldwide. Ground station equipment was installed inside these self-contained transportable shelters. These were lightweight, aluminum structures designed for worldwide service conditions. Transportable by helicopter, aircraft, truck, rail, or ship, the huts were shipped to various worldwide locations as essentially stand-alone facilities. Those sites were often around the periphery of the USSR in Europe, Asia, and Africa.

EXPANDING REMOTE TRACKING STATION LOCATIONS

Following the success of the Corona photoreconnaissance satellite program, the NRO established the Gambit satellite program to obtain high-resolution imagery of sites of interest identified by Corona satellites. Later the NRO would establish the Hexagon program to succeed Corona's search of broad areas of the globe mission, as well as to provide imagery for more precise mapping. Additional tracking stations supported Corona, Gambit, and Hexagon from Alaska and Christmas Island.

The increased number of remote tracking stations reduced risks associated with operation of NRO satellites and provided increased assurance of reliable collection of intelligence from space. Overseas partnerships with the nations that allowed the operation of these stations were essential to the success of NRO satellite programs.

KEY PARTNERSHIPS TODAY

Today, the NRO has a presence at the Joint Defence Facility Pine Gap, Australia, and the Royal Air Force Base Menwith Hill, United Kingdom, to coordinate with allies on national security issues. The NRO supports joint missions at these locations through the provision of technical systems and shared research and development. The NRO's participation is achieved with the consent of the host governments and contributes to the national security of the countries involved.

The NRO routinely collects intelligence for U.S. military operations, and in today's environment this support is more likely to be "multi-INT," combining overhead intelligence with other data. The NRO's workforce today thus includes personnel from throughout the Intelligence Community; for example, NSA and NGA personnel are often assigned to NRO facilities. Similarly, because U.S. forces are most likely required to operate as members of a coalition, the NRO workforce also includes representatives from the United Kingdom, Australia, Canada, and New Zealand. NRO personnel themselves today more frequently deploy "downrange" with more than 40 people typically deployed in combat theaters.

THE SPACE SHUTTLE AND THE NRO


Gemini


Faget with Shuttle Model


Discovery

Following the unparalleled success of the Apollo lunar program, NASA overcame major obstacles to operate the Space Transportation System (STS), a reusable launch vehicle more commonly known as the Space Shuttle. The National Reconnaissance Office's satellites would fundamentally alter initial designs for the Shuttle. The NRO's influence on the Shuttle program resulted in a more capable vehicle for meeting not only the NRO's requirements, but also requirements for the International Space Station.

ORIGINS OF THE SPACE SHUTTLE

From its earliest days, NASA sought a reusable space vehicle. The Air Force set out first to actually build a reusable space vehicle with its DynaSoar program. The DynaSoar vehicle was designed to be boosted into space on a rocket, with the manned vehicle returning to Earth at the end of each mission. The Air Force and NASA also explored the development of lifting body vehicles to be carried on a rocket or another aircraft to high altitudes before detaching and, then under their own power, obtaining space orbit. As the United States entered the 1960s, attention turned from reusable vehicles to single-use rockets and return capsules for NASA's manned spaceflight programs—first Mercury and Gemini, and later Apollo.

By the mid-1960s, NASA began again to focus on development of a reusable space vehicle. As NASA looked beyond the manned space flights to the Moon, they focused on developing an orbiting laboratory for sustained human presence in space. In conjunction with that focus, NASA explored options for regular missions to and from the space laboratory, including transport of supplies and crew members. Consequently, a reusable launch vehicle system seemed as potentially the most technologically sound system for crew and supply transport on a regular basis.

EARLY SPACE SHUTTLE DESIGNS

In 1968, NASA established a Space Shuttle Task Group to explore the feasibility of a reusable launch vehicle and commissioned studies for what they deemed the Integral Launch and Reentry Vehicle (ILRV). Four companies responded to the call for studies—General Dynamics, Lockheed, McDonnell Douglas, and North American Rockwell. By July 1969, based on the solicited studies, the Task Group concluded an ILRV should support a space station in low earth orbit, launch and retrieve satellites, service and maintain satellites on orbit, and deliver propellant and necessary stages to extend mission life of other programs, as well as serve as orbiting vehicle to fulfill other space science needs.

Early design proposals built on earlier efforts to boost a reusable launch vehicle using a lifting body. NASA engineer, Max Faget, who provided critical designs for Mercury, Gemini, and Apollo capsules, proposed a two-stage configuration with a large booster to carry the shuttle vehicle to orbit and then a powered shuttle to maneuver in space. Both of Faget's vehicles included a straight wing design. The proposed payload for the shuttle vehicle was 45 feet by 14 Feet that could deliver 45,000-pound payloads.

ACCOMMODATING THE NRO

NASA recognized that for the reusable vehicle to be fully successful, it would need to not only support NASA missions but also all U.S. space launch missions. The costs of building and operating the shuttle system could then be spread across more missions, reducing the average cost for each mission. With President Nixon's 1972 decision to build the shuttle came the decision to use it for all U.S. Government space launch activities. Accordingly, NASA had to develop a vehicle that could boost the nation's largest satellites into space.

In 1971, the USAF launched into space a new generation of NRO's classified satellites. This new generation was the biggest vehicle launched up to that point, requiring a newly configured Titan III vehicle with two solid boosters strapped to the main launch vehicle. The local press, not knowing the true nature of the vehicle, named it "Big Bird." The classified name was Hexagon—an enormous locomotive-sized vehicle that carried 60 miles of film to image large areas of the Earth's surface. To meet requirements for launching Hexagon, NASA would need to accommodate Hexagon's 60-foot length in a shuttle cargo bay.

On behalf of the NRO, the Air Force levied requirements for a shuttle vehicle that included a larger 60 x 15 foot cargo bay, a launch capacity of 65,000 lbs, and the capacity to fly a longer cross range upon return from orbit. The bay and lift requirements were necessary to lift the Hexagon vehicle into space. The cross range requirement was necessary to assure vehicles could return to Vandenberg Air Force Base in California to launch imagery collection satellites into a necessary polar orbit. Such launches were achieved more efficiently from Vandenberg.

NASA responded by modifying the shuttle's design to carry the NRO's 60-foot-long Hexagon imagery satellite. To accommodate the cross range requirements, NASA agreed to the delta wing shape of design eventually used on the shuttle system. Finally, NASA included solid boosters in the design to increase its lift capacity to 65,000 lbs.

THE SHUTTLE AND THE INTERNATIONAL SPACE STATION

The Space Shuttle—or Space Transportation System as NASA formally named it—did not carry a Hexagon vehicle. A new generation of electro-optical satellites, known as Kennen, were first launched in 1976. By presidential order, all Department of Defense satellites—including the NRO's—were slated to transition for launch on the shuttle, but the soon-to be discontinued Hexagon vehicles continued to be launched on Titan boosters, with the last Hexagon launch in 1986. After the 1986 *Challenger* explosion, the Air Force obtained authority to discontinue using the shuttle for NRO and other launches. A small number of NRO satellites eventually were launched using the shuttle because they could be launched more efficiently using the shuttle rather than redesigning them for launch on a rocket booster.

Following the success of NASA's 1973 Skylab, NASA remained committed to launching and orbiting a long-term space laboratory. NASA's follow-on Freedom program envisioned a modular space station with segments carried by the shuttle to assemble a much larger space station. The shuttle was also to carry supplies to the station, as well as transport crew members to and from the station. By the mid-1980s, the European and Japanese space programs joined NASA with combined efforts to build the new space station. In 1993, following the very successful Mir space station, Russia agreed to join the development of the new space station, which became known as the International Space Station. The Space Shuttle eventually docked with the Mir station in 1995. In 1998, the shuttle carried out the first of 37 missions to the International Space Station.

The requirements to carry NRO satellites and innovations developed to meet those requirements made the Space Shuttle a more capable vehicle, enabling it to support the International Space Station. It had the cross-range to land on both coasts of the U.S. It also had a much larger payload bay and lift capability that would prove essential to the building and supplying of the International Space Station. The NRO's cutting edge satellites required the most advanced launch capabilities, as the shuttle was under design. Such innovation carried over into the Space Shuttle program, resulting in the most sophisticated space vehicle and launch system ever developed.

INNOVATIONS

MANAGEMENT

BATTLE'S LAWS

Bissell Ritland

Col. Battle

LAW AND ORDER

"Battle's Laws" were the precepts of Colonel C. Lee Battle, Jr., the Air Force director of the Discoverer/Corona program that produced the world's first photoreconnaissance satellite. Battle guided day-to-day USAF management of Corona, working alongside Brig Gen Osmond Ritland and CIA Project Manager Richard Bissell, reprising his role from U-2 development. The principles by which Battle ran his program office emphasized a streamlined approach that began with selecting a small group of talented contractors, relying on their technical recommendations, demanding quality performance, focusing on mission accomplishment, and avoiding unnecessary paperwork. There were techniques for interaction with many industrial base contractors and government agencies, and for technical advancement, which reflected variants of hard lessons learned and implemented on aerial reconnaissance programs (e.g., U-2 or Genetrix) and early space launches. Over time Battle compiled his "doctrine of the laws and principles of program management," and the success of the seminal Corona program likely ensured that his guidelines were readily accepted and adapted to subsequent national reconnaissance programs.

At the heart of "Battle's Laws" were proven management practices such as maintaining close working relationships between the program office and contractors, applying strong systems engineering to perform rigorous analysis and rapid fault correction, and throughout the development process, limiting bureaucracy: "Keep the program office small;" "Cut out all unnecessary paperwork;" and "Don't over-communicate with higher headquarters." In ensuing years, NRO program offices refined these practices to create an environment that nurtured innovation and facilitated rapid development.

PIONEERING WORK

In 2000, the NRO recognized Col Lee Battle, Jr. as a Pioneer of National Reconnaissance, crediting "Battle's Laws" with establishing standards for subsequent programs developed by NRO. In accepting this highest recognition, Battle commented "I am pleased to leave behind a legacy that still can contribute to the improvement of our national reconnaissance capability."

The complete list of "Battle's Laws," as compiled by Colonel Battle in two annexes:

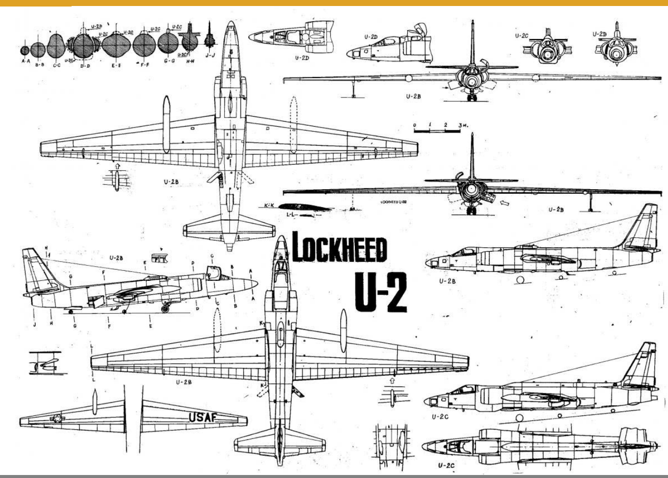
Annex 1 - Battle's Laws (5 September 1961)

1. Keep the program office small and quick reacting.
2. Exercise extreme care in selecting people, then rely heavily on their personal abilities.
3. Make the greatest possible use of supporting organizations. You have to make unreasonable demands to make sure of this support.
4. Cut out all unnecessary paperwork.
5. Control the contractor by personal contact. Each person in the program office has a particular set of contractor contacts.
6. Hit all flight and checkout failures hard. A fault uncorrected now will come back to haunt you.
7. Rely strongly on contractor technical recommendations once the program office has performed its function of making sure the contractor has given the problem sufficient effort.
8. Don't over-communicate with higher headquarters.
9. Don't make a federal case if your fiscal budget seems too low. These matters usually take care of themselves.
10. Don't look back; history never repeats itself.

Annex 2 – Principles of Program Management

1. Be schedule-oriented.
   a. If you don't start that way, you will end up that way anyhow.
   b. Haste does not make as much waste as foot-dragging in this business.
   c. Decision time is critical.
   d. A tight schedule avoids letting anyone off the hook.
   e. Early launch testing shortens time to fix.
   f. Only in the program office does schedule motivation exist.
2. A good program office is oriented to the technical side of the problem. Don't kid yourself—the program payoffs come with results. That means when it works.
3. Recognize the contractor's role and live with it.
   a. The contractor is in the driver's seat, technically speaking.
   b. At the same time, make sure you hold the contractor fully responsible.
   c. The program office concentrates on evaluating the amount of effort and quality of people, and on problems you think are important.
4. The direct personal involvement of all program office members is vital.
   a. The Program Director must be held personally responsible for all aspects. (This automatically becomes the case).
   b. In turn, the Program Director holds individuals under him in same status, etc.
5. (Corollary to 4) The Program Office must remain small. Parkinson can kill you.
6. (Corollary to 5) Use all of the other offices you can. Apply principle 4 to this. Always make unreasonable demands.
7. Never ask for help, you might get it.
8. Comply promptly with all report requirements in the most meager fashion that will pass inspection.
9. (Restatement of 8) Don't over-communicate with higher headquarters.
10. Financially, it is the same story. You have to live with the contractor. Never let him get behind in keeping a finger on his status. Incurring unpredicted overruns is bad, but overrunning without knowing is disastrous.
11. Troubles: hit them hard and instantly.
    a. Unfixed troubles will bite you again.
    b. There is no such thing as a random failure.
    c. Personnel mistakes are far more frequent than design defects.
12. System integration is very important.
13. Insist that all principles herein apply to all contractor activities.
14. Don't generate paperwork. There are plenty of people willing to do this for you.
15. Committees are the world's most useless activity. Avoid "let's-have-a-meeting-ers" like you avoid poison.
    a. They never accomplished anything.
    b. There is always some individual who has the responsibility for doing what the committee thinks it is doing.
16. Management surveys are punitive. Recognize it and employ them (if ever) accordingly.
17. Examine closely the tie between the Home Office and the field. There's many a slip here.

STREAMLINED PROCUREMENT




Bissell


Corona

A decades-long challenge and source of frustration for many government program managers is the often excessive timeline associated with requirements definition, source selection, contract award, and final delivery of a product or service. This is a process that, for some highly technical development programs and large dollar value procurements, can take years. The federal procurement process has a long history, dating back to at least the 1950s, of being heavily burdened with excessive levels of bureaucracy, administrative red tape, extensive management review, and frequent Congressional intervention.

The NRO has typically used unique acquisition processes to accomplish its mission. It is simultaneously an intelligence, defense, and space organization with the benefit of operating within a blend of authorities from across those arenas. When the NRO was first established, it functioned within a framework that streamlined the organizational and operational management functions with the goal of maximizing program success by minimizing the number of individuals involved in the review and decisionmaking apparatus. The framework provided many benefits, some of which were: budgetary flexibility, shortened management and decision chains, strict internal review with limited external oversight, and streamlined procurement processes.

Early on, one of the principal benefits available to the NRO, was the use of authorities contained within the CIA Act of 1949, which granted the Director of Central Intelligence the power to spend federal money, "without regard to the provision of law and regulations relating to the expenditures of government funds…such expenditures to be accounted for solely on the certification of the director." Consequently, the CIA seldom used competitive bidding for highly sensitive projects. It also used management techniques that were not available to other government agencies and which permitted the CIA to hold a tight rein on paperwork and cost overruns.

THE U-2:
IDEA TO TEST FLIGHT IN 8 MONTHS

In November 1954, President Eisenhower approved the U-2 aircraft project. In order to build the high-altitude spy aircraft quickly, a pioneering partnership between the CIA, the Air Force, and the private sector was established; and the use of CIA's special authorities regarding unvouchered funds and streamlined contracting methods was approved. Known as Project Aquatone, and directed by Richard M. Bissell Jr., then Special Assistant for Planning and Coordination at the CIA, this confederation of civilian and military interests overcame significant technological challenges, ideological differences, and bureaucratic barriers that led to Lockheed building the first U-2 aircraft in just eight months. The U-2 program was a streamlined procurement success story in two primary areas: one, it demonstrated rapid and prompt development of the plane and its subsystems; and two, it achieved its project goals under budget. The success of the U-2 program was also one of organization – the U-2 program had also established an organizational precedent, managerial model, and pattern of working relationships that would influence the successful development of the Corona satellites, as well as the A-12 aircraft program.

CORONA:
CONCEPT TO OPERATIONAL SPACECRAFT IN TWO YEARS

Corona was remarkable from a management perspective. From the time President Eisenhower approved the concept, it took only two years to design and build an operational spacecraft. This was an amazing feat when one considers the fact that no one knew if such a scheme – one of launching a camera into space to obtain photographs of intelligence value – could possibly work. It had never been done before, but after the experience and success with the U-2 program, Bissell and others relied on the same management principles to get results.

CORONA TIMELINE:

- President Eisenhower endorsed the Corona concept in February 1958;
- DCI Dulles approved funding in April 1958;
- the first test flight took place in January 1959, but failed;
- the first space-based reconnaissance photo was returned in August 1960.

Corona demonstrated that in order to be successful with technology, especially when challenged by unclear and baffling obstacles, there needs to be an existing, strong, industrial base backed by in-depth research and development. Corona's success was dependent on an innovative management approach that looked to success and avoided bureaucratic pitfalls. Corona's organizational framework was simple, and its interactions were informal. The success of using a streamlined approach was reflected in the speed and efficiency with which decisions were made and actions completed. Fundamentally, people were given a job and empowered to do it, and their cooperation was informal without bureaucratic layers. In the end, Corona created a legacy for managing spaceborne reconnaissance in the form of the National Reconnaissance Office.

THE 1990s – A TRANSITIONAL PERIOD

Throughout the first half of its history, the NRO generally did not follow traditional Defense Department procurement procedures for acquisitions, but rather used streamlined approaches that it had developed for Corona and its associated reconnaissance programs. Those special business practices and streamlined procurement processes were not unique to the early NRO, as other programs of extreme urgency and national importance, such as the Manhattan Project, Polaris, and the F-117 Stealth Fighter, also used these special practices. It is clear that the streamlined processes and minimization of bureaucracy, were important to the success of the NRO and were key to helping the United States win the Cold War.

However, by the late 1980s and early 1990s, a fundamental shift was occurring within the NRO acquisition cycles as programs were becoming increasingly immersed in the normal, highly bureaucratic, government processes. Direct and personal involvement in the success of NRO programs by the President and his senior advisors was beginning to wane. This led to constrained budgets during a time period of increasing national security threats and challenges, while demands on NRO systems were stressing their capabilities.

The 1990s marked a period of significant transition for the NRO. The Cold War was over, different intelligence priorities were emerging, and the information age was taking hold. In September 1992, the government declassified the "fact of" the NRO's existence, and in December 1992 DNRO Martin Faga reorganized the organization away from the alphabet program offices (Programs A, B, and C), to the "INT structure" aligning the organization along functional lines.

In the mid-1990s, the NRO also found itself navigating the fallout of two major controversies: one, the construction of the Westfields Headquarters building and two, the forward funding issue. In partial reaction to the controversies, the NRO was required to adopt DoD-style acquisition practices. But the transition to a heavy DoD acquisition style, was also a result of systems that were more expensive, developmentally complex, and integrated with users who were highly dependent on NRO products and an industrial base and partners that were downsizing. However, the DoD acquisition procedures, which were appropriate for building hundreds of aircraft or buying large quantities of munitions, seemed a poor fit for an organization expected to deliver new systems on a regular basis – each offering new capabilities – and containing significant inherent risks. The procedures and experience required for an agile and innovative development organization are, by necessity, very different from those expected of a reliable deliverer of critical infrastructure.

The passage of the Federal Acquisition Streamlining Act of 1994, enacted across the Federal Government, recognized the benefits of streamlined procurement, with the goals of lowering procurement barriers and removing the unnecessary levels of bureaucratic review and approvals; however, this act brought little benefit to the NRO. The Act generally promoted the purchase of commercial off-the-shelf items, the use of fixed price contracts, and established a modest low dollar value threshold ($100,000) to the procurements to which the streamlined procedures would apply – none of which meshed well with highly technical, one-of-a-kind, and expensive satellite development efforts undertaken by the NRO.

INCREMENTAL AND RESERVE FUNDING

The acquisition of complex systems, such as the intelligence satellites developed, launched, and operated by the NRO in the years following its founding, required the use of flexible budgeting and acquisition funding options that differed from normally recognized and accepted Federal Government financial practices at the time. Unlike the remainder of the Intelligence Community, the NRO had a highly specialized and unique space mission that required expensive satellites, all of them evaluated, developed, acquired, launched, and operated by a team of exceptionally skilled technical personnel from private industry, academia, the military services, and the Intelligence Community.

Two funding practices that were, and continue to be, particularly helpful to the NRO's satellite acquisition activities were incremental funding and reserve funding.

- Incremental funding is the provision or recording of budgetary resources for a program or project based on obligations estimated to be incurred within a fiscal year when such budgetary resources are provided for only part of the estimated cost of the acquisition. In short, incremental funding spreads the anticipated costs of an effort or acquisition over multiple years, rather than funding all program costs upfront in the first year.

- Reserve funding (also known as Budgetary Reserve) permits portions of budgetary resources to be set aside, under authorities contained in the Anti-Deficiency Act, solely to provide for contingencies or to effect savings. In other words, reserve funding creates a set of funds for use against future unknown contingencies that, when needed, can be easily tapped into without the normal budgetary reprogramming exercises or the need to wait for the next appropriation cycle.

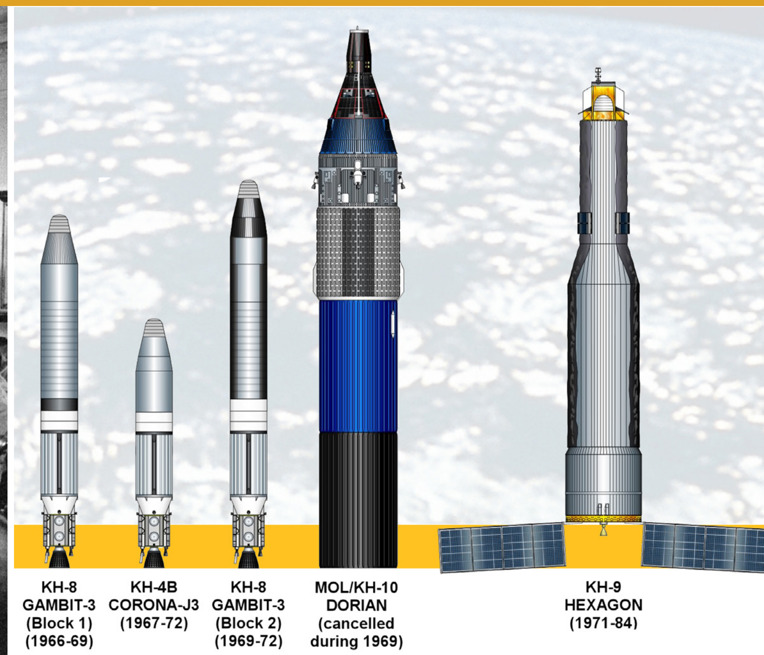
From the very beginning of the National Reconnaissance Program, flexibility was built into the NRO budgeting and acquisition systems so that program managers had the decision authority, rapid decision timelines, and reserve funding needed to initiate alternatives and take corrective actions when primary approaches were not progressing the programs as expected. Normal funding and acquisition procedures that applied elsewhere in the Department of Defense and Federal Government were never forced upon the NRO. This flexibility was intentional, and by design, given the necessary secretive world in which the NRO's budget was formulated and included in a publicly available Federal Government budget.

This sometimes led to controversies, such as when forward funding practices were first disclosed in the media in July 1995. Members of Congress, who were not aware of the accounting practices and some of whom, prior to 1992, were not aware of the existence of the NRO, were outraged at the reports that $1.7 billion, an amount which was later revised upward to $3.7 billion, had been carried forward, and this led to accusations that NRO officials had intentionally misled Congress and the Director of Central Intelligence. Such budget and accounting practices were not illegal; nor were they attempts, as many critics claimed, to create slush funds for inappropriate or unapproved purposes. It was a necessary process and worked well to bring our intelligence and reconnaissance satellites to full operation.

But while the use of reserve funding became controversial by the 1990s, it was essential to NRO's success. This flexibility proved crucial in 1986, for example, after an NRO payload exploded at Vandenberg (80 days after the *Challenger* disaster) and the debris not only damaged the SLC-4E launch platform, but it also damaged the -4W pad downrange. The accident left a gaping hole in West Coast launch capability, with the critical launch of an essential new satellite scheduled in six months. The NRO applied reserve funds to repair both launch pads, enabling the autumn launch to proceed on schedule. Without this flexibility, the timely launch would not have been possible.

SECURITY COVER STORIES


Corona Capsule presented to Eisenhower and Media at White House



When the National Reconnaissance Office was established by agreement between the Department of Defense and Central Intelligence Agency, there was no public announcement. No director was acknowledged to the public. No signs were placed on the exterior of any building acknowledging the existence of the new reconnaissance satellite organization. The establishment of NRO, its purpose, and those assigned to the organization remained classified. Instead, elements of the new organization remained geographically placed with their parent organizations—the CIA, Air Force, and Navy. Until the NRO's declassification more than 30 years later, the NRO would remain shrouded in secrecy.

GALACTIC RADIATION AND BACKGROUND SATELLITE

The first successfully launched reconnaissance satellite was the Galactic Radiation and Background satellite, developed by the Naval Research Laboratory. Since satellite launches themselves cannot be hidden, the U.S. developed cover stories to keep the satellites' true purposes obscured. Efforts to keep the true capabilities of GRAB were aided by the unique circumstances it was launched under. The GRAB satellite shared a launch with the Navy's Transit satellite on June 22 June 1960. This was the first known launch of two satellites on the same vehicle—a feature that reduced focus on GRAB. Other Transit satellites had already been launched by the Navy, allowing for naval vessels to obtain more precise details of their locations. For GRAB, the Navy reported publicly that the satellite would measure levels of solar radiation as it orbited the Earth, hence its name.

GRAB's true purpose was to determine whether or not the Soviet Union's radar systems could be detected from space. The concept was largely developed beginning in 1958 by NRL's Reid Mayo, based on similar systems he developed for Navy submarines. The GRAB satellite was extremely successful, not only identifying the existence of Soviet radar systems, but also types and locations of those systems. The satellite would remain classified until June 1998, when its true purpose was revealed as part of the NRL's 75th anniversary.

CORONA

Shortly after GRAB's successful launch, the U.S. successfully orbited and obtained its first imagery from space using the Corona satellite. Jointly developed by the CIA and Air Force, security officers went to great lengths to obscure Corona's true purpose. To the public, Corona was known as the Discoverer satellite. The Department of Defense carried out the public affairs responsibility for the program and described the satellite program as a test program to better understand how humans might survive in space or as a biomedical experimental system. They also explained that several launches would be conducted carrying sensors and live animals to better understand the space environment. Since the Corona vehicle had to return imagery from space using a return capsule, the program needed an appropriate cover story for the return of the capsules. The public affairs staff explained that the return capsules would bring back sensors and information necessary to assess the success of the experiments. The program even went so far as to carry mice into space and build chimpanzee pens at Vandenberg Air Force Base to further the biomedical cover story.

The cover story was further strengthened after the recovery of the first capsule by the Navy on the surface of the Pacific Ocean. That capsule carried a U.S. flag, which was promptly flown to Washington, D.C. where the press was invited to see President Eisenhower accept the flag. When the first imagery was captured in a return capsule by the Air Force, the air crew that captured the capsule was feted in Washington, D.C. and appeared on national television programs, and the crew members were made available for local parades and other local events across the nation. The focus on these elements of the program reduced the focus on the true nature of the system.

Corona's true purpose was to obtain images of the vast Soviet land mass. With the outbreak of the Cold War, the U.S. had very limited means to understand emerging threats from the Soviet Union. Human sources were virtually non-existent. The U.S. lost critical collection capability when its U-2 reconnaissance aircraft was downed over the USSR in May 1960. By the time Corona first returned imagery from space in August 1960, it emerged as the key technical collection system for understanding threats, such as those from the Soviet Union's Intercontinental Ballistic Missile program. Eventually the Corona program would discontinue telling the public that it was carrying out biomedical experiments. Instead, no details were released concerning the nature of Corona launches—an approach that continued until the last launch in 1972. Twenty-three years later, the NRO declassified the true purposes of the Corona program in 1995.

GAMBIT

While the Corona system was highly effective at gathering imagery of broad areas, it could not provide insight into details of objects found in the imagery. As a consequence, the NRO developed a companion satellite that could image objects of interest in high resolution, known as the Gambit satellite. The first Gambit satellite was launched in 1963, and like Corona, it obtained images on film that were returned to Earth. Gambit security was carried out using a very interesting approach. Rather than create a cover story, the Air Force instead initially acknowledged the program and then publicly announced its cancellation. They then decided to hide the program in plain sight by developing the satellite vehicles without acknowledgment, instead depending on the much larger publicly acknowledged Samos reconnaissance satellite program to obscure the existence of the Gambit program. The approach was to neither acknowledge nor obscure the Gambit program, leaving interested uncleared parties to believe the Gambit vehicles were really Samos vehicles.

With the cancellation of most elements of the Samos program before Gambit had an opportunity to orbit, the Air Force decided to seek better cover for the program. By 1961, the program's director, Brig Gen Robert Greer, decided to use a "null program" approach. The concept was to reveal virtually nothing to uncleared parties other than the existence of the program--with no acknowledgment of the program's origin or purpose. Such an approach allowed for more open procurement of elements, like launch boosters. When President John F. Kennedy became aware of the program, he ordered it to be completely classified, and Gambit moved into the Byeman security control system established for satellite reconnaissance programs.

HEXAGON

The CIA pursued a program to combine the search of broad areas carried out by Corona with surveillance of target details of interest by Gambit into a single satellite vehicle. To do so, the CIA program at the NRO developed a satellite the size of a locomotive with very sophisticated mechanical systems. The new imagery satellite, named Hexagon, required a newly configured launch vehicle using a Titan core and strap-on boosters. When the first vehicle was prepared for launch in 1971, the local press could not help but take notice of its size. One newspaper named the new satellite "Big Bird," a name that remained with the program for many years. By the time Hexagon launched, the NRO controlled its programs within the Byeman security control system. At that time, no public information was released on what organization was responsible for launches or the purpose of the satellite. This security approach would remain in place until 1996, after the existence of the NRO was declassified in 1992 and launches from the organization could be acknowledged. The NRO declassified the Hexagon and Gambit programs as part of its 50th anniversary in 2011.

THE NRO AND NASA

The NRO's cutting edge technology has found its way to NASA from time to time. The earliest example is the transfer of technology developed under the Samos program to NASA for use in imaging the Moon. Because of the distance of the Moon from Earth, NASA needed a means to obtain imagery other than the return of film to the Earth. As part of the Samos program, Eastman Kodak developed a system that allowed film to be developed on orbit, scanned on orbit, and then transmitted to Earth electronically. The NRO quietly gave Kodak permission to transfer the technology, which allowed NASA to successfully launch and operate the Lunar Orbiter for imaging the Moon. This significantly assisted NASA in meeting President Kennedy's goal to land a U.S. astronaut on the Moon before the end of the 1960s. The NRO and NASA cooperated on development of other technology, including a more advanced lunar imaging camera and the requirements for the capabilities of the Space Shuttle. Both organizations succeeded in their partnership, despite nearly opposite policies for public insight into their programs and security practices.

MANNED ORBITING LABORATORY

In the late 1960s, the Air Force undertook a massive manned space program known as the Manned Orbiting Laboratory. In 1965, President Johnson announced publicly that the Air Force would develop and operate the MOL, noting the knowledge would contribute to "the defense of America." This would be accomplished, the President noted, through development of new technology to advance unmanned and manned space flight and perform experiments with new and rewarding technology. The USAF identified 59 experiments to be carried out by MOL astronauts. They did not, however, identify the primary purpose of the MOL program, which was manned operation of a reconnaissance camera code-named Dorian, developed by the NRO and based on a Gambit camera design. The premise of the imagery program from MOL was that astronauts could assure better imagery by avoiding coverage attempts in bad weather, better spotting of imagery targets, and the potential for initial readout on orbit. President Nixon cancelled the program in 1969, and with its declassification by the NRO in 2015, the primary purpose of the program was finally revealed.

DECLASSIFICATION OF THE NRO

The existence of the NRO remained classified for more than 30 years. During those decades, inadvertent and purposeful disclosures gradually eroded the carefully crafted efforts to keep NRO activities secret. The first press disclosure occurred in 1971, followed by an inadvertent Congressional disclosure in 1973. By 1978, President Carter publicly acknowledged for the first time that the U.S. collected imagery using reconnaissance satellites. By the mid-1980s, full-scale press accounts revealed significant details about the NRO. By the end of the Cold War, in conjunction with the erosion of the cover story protecting the existence of the NRO, the CIA and DoD decided to acknowledge the NRO's existence in 1992. This was done through a DoD press release that acknowledged the NRO's existence, its current director, and its general mission to carry out space reconnaissance. This announcement accomplished one of the largest cover rollbacks in the nation's history and opened the NRO to a new era in its history of continually providing highly classified and exquisite intelligence from satellites in space.

LEAN SIX SIGMA/BALDRIGE

Baldrige

WHAT ARE LEAN SIX SIGMA AND THE BALDRIGE CRITERIA?

"Lean Six Sigma" (LSS) is a customer-focused strategy for business process improvement to increase efficiency and effectiveness. In this model, as process quality improves, there should be fewer and fewer errors. In statistics, the Greek lowercase letter sigma, "σ," represents one standard deviation from the mean of a population or probability distribution for an outcome. A "Six Sigma" process is one that is free of defects up to the sixth standard deviation from the mean; this would mean no more than 3.4 "defects" per million opportunities when delivering a product or service to customers. In other words, Six Sigma aims for 99.99966 percent efficiency and effectiveness.

"Lean" focuses on ways to eliminate waste in terms of time, talent, and other corporate assets. A Lean Six Sigma approach is a data-driven, well-balanced, and organized way to save money and produce better products and services for customers.

The five key principles of LSS to improve an existing business process:

- Define the process improvement goals that are consistent with customer demands and enterprise strategy.
- Measure the current process, and collect relevant data for future comparison.
- Analyze to verify relationships and to determine the true "root" cause.
- Improve or optimize the process based upon the analytical findings.
- Control to ensure that any variances are corrected before they result in defects. A control plan is used to implement and monitor the new process.

There are also LSS techniques to create defect-free new products or processes.

The **Baldrige National Quality Program** encourages performance excellence within organizations. This honor is named after Malcolm Baldrige Jr., who was a U.S. Secretary of Commerce, and a widely known proponent of quality management.

LEAN SIX SIGMA AND BALDRIGE AT THE NRO

The NRO Directorate of Management Services and Operations' (MS&O) former director, Brian Malone, instituted the use of Lean Six Sigma and the Baldrige Performance Excellence Criteria to improve its support activities and as a key part of its operating model. MS&O's mission is to deliver integrated service and support solutions to ensure NRO mission success. Using LSS and the Baldrige

Criteria allows MS&O to deliver very high-quality customer service, both to the headquarters personnel, as well as to the global enterprise. In this way, Baldrige and LSS were part of the maturation of the NRO's support services.

The use of both LSS and Baldrige complemented each other, since they both helped drive performance excellence at the NRO. The very exacting and extensive Baldrige award criteria were useful tools for MS&O to assess quality of its services. Both were used to assess the organization, and to continuously improve its process performance. MS&O hired people with extensive LSS and Baldrige experience to be expert coaches. MS&O personnel—after taking the required training to achieve increasing levels of proficiency designated as LSS Yellow Belts, Green Belts, or Black Belts—employed their skills to complete formal process improvement projects. As the MS&O workforce grew more comfortable with LSS and how it improved processes and customer satisfaction, a number of MS&O workers proactively found small, less formal solutions that staved off bigger problems.

EXAMPLES OF APPLICATIONS

According to Mr. Malone, who was the Director of MS&O from 2001 to 2013, MS&O used LSS and the Baldrige Criteria as ways to facilitate performance excellence. He described the Baldrige Criteria as "a model," rather than an end in and of itself. The goal was not to win the award, but to use it as an exemplar to make the organization the best it could be in terms of people, processes, customer service, and "to guide us to be the best" in government while also helping people. Closely linked was the strong emphasis on strategic planning as "part of the fabric" of the organization on a day-to-day basis, rather than just an annual event.

One example Malone cited was portfolio management. Managers for various NRO facilities met periodically to rank all facilities' projects from first to last or "1-n" in terms of funding necessity. The default impulse for managers might be to rank their own projects automatically as most important, which could stalemate the process. Instead, they were challenged to become familiar with each other's unique situations, and to make strong data-driven decisions. Eventually, they were able to work together to prioritize projects based on what was most necessary overall.

The NRO was the first agency in the IC to receive a national award for having attained the national Baldrige Criteria for Performance Excellence. In May 2013, the U.S. Senate Productivity and Quality Awards (SPQA) Program for Virginia and Washington, D.C. was awarded to NRO's Media Service Center (MSC). This award was the culmination of a ten-year MSC effort to put the performance excellence framework into practice in a creative media production environment. MSC had completed extensive LSS training, had increased customer satisfaction levels, had decreased product "defects," and had expanded its products and services within the NRO, and also to mission partners across the IC. MS&O consciously had never made it a stated objective to win the Baldrige award. However, it wasn't surprising when MSC took on the challenge to do all that was necessary—first just to complete the extensive application process, and ultimately to win the award. MS&O leaders saw the award as confirming the excellence that had been in place for many years.

The legacy of MS&O's adoption of Lean Six Sigma and the Baldrige Criteria is the directorate's ongoing dedication to high-quality customer service and support.

NRO WESTFIELDS CAMPUS

BACKGROUND

On 11 January 2021, the Westfields Campus, the headquarters of the NRO in Chantilly, Virginia, celebrated its 25th Anniversary. The concept of Westfields first came about based on the Geiger-Kelly study commissioned by Director of NRO Edward "Pete" Aldridge, Jr. in the mid-1980s. The goal of the study was to examine the feasibility of restructuring NRO by consolidating all program elements under one roof. When the study was completed in 1989, the new DNRO Martin Faga began to implement the study's recommendations. This initially meant leasing a temporary building to centrally locate all NRO program elements, including the Air Force reconnaissance office (Program A), the CIA satellite office (Program B), and the Navy (Program C) satellite campuses. However, the ultimate goal was to construct a permanent headquarters, to house the entire NRO workforce, though Westfields' existence would be classified.

THE CONCEPT OF WESTFIELDS

Building NRO's new classified headquarters was a massive undertaking. To start the creative process of designing the building, then Acting DNRO Jimmie Hill tapped Roger Marsh, a CIA careerist, to lead the project. On 15 January 1992, Marsh became the first Director of NRO's newly formed Management Services & Operations office. The creation of MS&O allowed NRO to have their own support services, which meant they no longer had to rely on the CIA, the Air Force, or the Navy to fulfill those needs.

According to Marsh, Hill's criteria was that the building be close to Washington, D.C. and close to an airport for contractors, other agencies, or government officials to travel to without undue inconvenience or lengthy transport requirements. Marsh drew a 25-mile circle around the Pentagon and determined that any land within the vicinity would work. Marsh also considered the impact of moving a large workforce to an area they were not familiar with, as well as the impact the move would have on housing, schools, and local transportation. The Westfields concept expanded more by the day.

KEEPING SECRET

Since the building's existence was classified, Marsh had to work out a plan to maintain cover. Marsh used Coldwell Banker as the real estate agent, under cover of CISCO, then a subsidiary of Rockwell International and later Boeing, as part of the shield for keeping NRO's secret. For security purposes, extra land was purchased to ensure that NRO's classified activities were concealed from public scrutiny and curious observers. Accordingly, 68 acres of prime real estate in Chantilly, Virginia was purchased from Long & Foster for $25 million. Davis and Dewbury were hired as architects and engineers along with the contract giant Hazel. After a competitive process, Hyman was hired to build three towers, which ultimately expanded into four, which became the core structure of Westfields. Turner Construction was engaged to design the interior of the building. After clearing the site, Hazel, an environmentally conscious company, replanted 1500-2000 trees to surround the building perimeter, which made it environmentally friendly with an added layer of security.

TROUBLE BREWING

Initial construction efforts went well, but trouble was on the horizon due to increased Congressional and public scrutiny. In years past, NRO received the lion's share of the defense budget to build innovative satellite technology for U.S. national security purposes. However, when the Cold War ended, funding that had previously flowed to NRO without question, started to dry up. Since the Cold War was over, defense spending was no longer viewed as a top national priority by policymakers or the public. While this change in mindset was taking place and Congress was advocating for transparency, NRO was building a $350 million dollar top secret complex that no one could talk about. With that context, the construction of Westfields became a major controversy. On 8 August 1994, the Senate Select Committee on Intelligence (SSCI) Chair, Dennis DeConcini, and Vice Chair, John Warner, sent a letter to Congress expressing shock over Westfields' price tag and cost to taxpayers, as if they were not briefed on the project.

VINDICATION

In an interesting twist, the House Permanent Select Committee on Intelligence (HPSCI) Chair, Larry Combest, confirmed that his staff was aware of Westfields' cost, that they were briefed, and that it was "an open and shut case." A joint review by DoD and the CIA also found that NRO officials did not mislead Congress and provided them with cost data as requested. Moreover, the review found that Congress had actually approved the purchase of property for the new NRO headquarters before construction began. They further conceded that the cost of a building on Westfields' scale was in line with what one would expect for a project that size. The report, however, did claim that NRO did not follow IC budgeting guidelines, but in NRO's defense, they operated from a set of rules enacted prior to Congressional changes.

STILL STANDING

Though Westfields was declassified in September 1992, the construction project itself remained classified until August 1994 when President Clinton authorized its declassification. The majestic Westfields campus still stands tall among the mature trees that Hazel so thoughtfully planted 25 years ago. Those who walk the halls of Westfields today often feel a sense of pride for the building and for the technological feats that have taken place inside its doors. In 2005, Roger Marsh was lauded for his work on Westfields and recognized as an NRO Pioneer. Happy birthday not only to NRO for 60 years of outstanding service to the country, but happy birthday to Westfields, which provides a secure and comfortable environment for the men and women who work there to carry out their duties in service to the nation.

4C-1000 SEVEN TENETS

1. Focus on threat-based need
2. Adhere to short timelines
3. Maintain resource stability in staffing and funding
4. Rely on small, streamlined, breakaway, collaborative team
5. Employ strong systems engineering & program management
6. Adapt and draw from the latest advances in technology and concepts of operation
7. Establish a short chain of command & avoid bureaucracy

NRO MANAGEMENT PHILOSOPHY: 4C-1000 SEVEN TENETS (7 TENETS)*

One key enabler of NRO innovation was the management philosophy that guided its program offices. The NRO was organized and operated from its outset according to foundational principles that have proven remarkably effective in fostering an environment conducive to creativity and rapid technology development. We call these principles the 4C-1000 7 Tenets, and they include precepts such as focus on a threat-based need, establish a short chain of command for decisionmaking, and avoid bureaucracy (see complete list above). Taken together, the 7 Tenets encompassed an experience-driven, best-practices-following development and acquisition approach that shaped an environment for creativity and innovation, resulting in revolutionary changes in overhead reconnaissance during the Cold War—a remarkable paradigm that played a critical role in bringing the Cold War to a peaceful end.

BACKGROUND

The 7 Tenets evolved from practices of the Central Intelligence Agency in its development of the U-2 reconnaissance aircraft, practices of the Naval Research Laboratory in its development of GRAB, the first signals intelligence satellite, and practices of CIA and the U.S. Air Force in their joint development of Corona, the first photoreconnaissance satellite. By the end of 1960, these three seminal programs had produced revolutionary reconnaissance capabilities in support of U.S. national security. So when the Department of Defense and CIA on 06 September 1961 signed the memo establishing a "National Reconnaissance Program" with a covert NRO exercising direct control over all program elements, it seemed only appropriate that they wrote into the agreement a management structure and implementation guidelines that built upon those successful program models. In ensuing years, the NRO program offices focused and refined the practices to create an environment that nurtured creativity and innovation within an appropriate infrastructure that facilitated a rapid development pace.

To briefly illustrate how the 7 Tenets contributed to innovative NRO technology, we will review management practices on CIA's U-2 development—the model that early satellite programs Corona and GRAB followed that developed the 7 Tenets within the NRO Program Office structure—and three successive NRO imagery satellite programs: Gambit, Hexagon, and Kennen.

RICHARD BISSELL AND U-2 PROGRAM MANAGEMENT

Under the management of Richard Bissell, a joint CIA and Air Force program team delivered the innovative U-2 aircraft in just eight months following Presidential approval. The organizational structure and managerial model that Bissell and his team followed and the lessons learned from the U-2 program served as the foundation for the NRO to develop its 7 Tenets and apply them on later imagery and signals intelligence satellite programs like Corona, Poppy, Gambit, Hexagon, and Kennen. The intelligence requirement that ultimately produced the U-2 design reflected an adherence to the first Tenet: "Focus on threat-based need" (T1). The collaborative government-contractor team was motivated by a sense of national emergency to respond to

* Why "4C-1000" Tenets? 4C-1000 was the NRO Staff office's location in the Pentagon, Room 4C-1000. For more than 30 years after its establishment, the NRO's very existence remained a highly classified secret, with even cleared personnel who possessed a valid need-to-know refraining from using the office's name or initials in open channels. Thus whenever an official referenced "4C-1000," witting individuals understood that it meant the NRO Staff Office and pertained to classified national reconnaissance space activities.

the threat posed by a hostile, nuclear-armed Soviet Union, about whose strategic capabilities the U.S. possessed a dearth of reliable intelligence. Bissell formed a "small…breakaway, collaborative team" (T4) that partnered with Col. Osmund Ritland's USAF and Kelly Johnson's streamlined Lockheed Skunk Works teams, integrating short chains-of-command, cutting through procurement red tape (T7), and making rapid decisions to achieve exceptional project execution. Bissell and Johnson oversaw informal work environments that encouraged a culture of taking risks, voicing criticisms without fear of retribution, and adhering to what seemed like impossibly short timelines (T2). The result was an aircraft that flew at an altitude of 72,000 feet, too high for fighter jets to intercept and beyond the reach of known surface-to-air missiles, and with an operating range of 2,950 miles. For four years between June 1956 and May 1960, the U.S. operated this technologically advanced reconnaissance asset over the vast, denied interior of the Soviet Union to provide timely and precise targeting data and expose the "bomber gap" as a myth.

MANAGEMENT PHILOSOPHY ON CORONA AND EMERGENCE OF THE 7 TENETS

The spectacular success of the U-2 project convinced officials to virtually replicate the small, breakaway, collaborative team approach on the first U.S. reconnaissance satellite programs, GRAB and Corona, with similarly impressive results. On 22 June 1960, the U.S. launched GRAB as the world's first reconnaissance satellite, just two years after conception; and 30 months after approval, the Corona program was conducting operational missions that would continue for 12 years from August 1960 to May 1972. Bissell again served as the first CIA project manager on Corona, responsible for payload, mission, and image exploitation, and Ritland again managed Air Force support. They were joined by Colonel Lee Battle, who guided day-to-day USAF management. Battle's management style closely resembled Bissell's in selecting and cultivating a small group of talented engineers, demanding quality performance, focusing on mission and avoiding busywork, and relying on the contractor's technical recommendations. Battle summarized his principles as "Battle's Laws" (see NRO Innovators "Battle's Laws") that, together with Bissell's philosophy, Kelly Johnson's Skunk Works processes, and the management style of the NRO's program offices, evolved over time into the 7 Tenets.

STRONG SYSTEMS ENGINEERING AND RESOURCE STABILITY IN GAMBIT AND HEXAGON PROGRAMS

The NRO continued to refine and apply the 7 Tenets on subsequent satellite programs, including Gambit, a high-resolution, surveillance imaging system, and Hexagon, the technologically advanced follow-on to Corona and inheritor of the broad-area search and mapping mission. Together these satellites—which operated, in Gambit's case, from 1963 to 1984 in two variants, and in Hexagon's case, from 1971 to 1984—provided four U.S. Presidents with sufficient knowledge of the strategic threat that they were willing to enter into arms control agreements with the Soviet Union. Achieving success on these highly complex programs involved a thorough application of the 7 Tenets principles already mentioned, to which NRO program offices added a rigorous, top-down systems engineering approach (T5) that uniquely conceptualized and integrated all program elements—spacecraft subsystems, camera optics, film, and ground control components—in a "factory-to-launchpad" strategy. This implementation of a lesson learned from experience on Corona entailed integrating separate components and conducting systems tests and fixing problems at the factory, which enabled the contractor team to ship a completely assembled, flight-ready satellite to the launch base, greatly decreasing pre-launch timelines at the pad (T2). Many organizations might have struggled with reimagining their processes. But the NRO had by then developed a superb cadre of experienced government and contractor managers and engineers, a result of maintaining resource stability (T3) in staffing — retaining the best and brightest over a program's lifetime and beyond, and funding — capitalizing on the White House and Congress's commitment to national security imperatives. By the time the NRO began developing Hexagon, the 7 Tenets were engrained into the program offices, and success on this most challenging of NRO developments to that time is perhaps the best testament to that philosophy's effectiveness. Despite the fact that Hexagon was the largest satellite the U.S. had attempted to lift into space—a dauntingly complex mechanical device of many moving parts that represented a huge technological leap forward—CIA's NRO Program B completed development in only 36 months.

ADAPT AND DRAW FROM THE LATEST ADVANCES IN TECHNOLOGY: KENNEN AND NEAR REAL-TIME IMAGERY

The NRO's application of the 7 Tenets might be said to have reached its apex with national reconnaissance satellite programs from the mid-1970s until the early 1990s. This was an era of very large, highly sophisticated spacecraft and sensor development. Perhaps none represented a more revolutionary transformation than NRO's development of the Kennen electro-optical imaging satellite, which launched in December 1976. Kennen provided the U.S. with uncontested technological and tactical advantage, moving from reliance on the delayed-recovery, film-based photoreconnaissance systems then operating (i.e., Gambit and Hexagon) to an EOI digital imaging system capability. The NRO engineers—again under direction of Program B—developed this next-generation system in only five years, and as with earlier programs, the NRO's experiences on Kennen serve as a model demonstrating the impact and value of the 7 Tenets. One Tenet is especially relevant: "Adapt and draw from the latest advances in technology" (T6). During Kennen's development, the program office aggressively took advantage of advancing technology implied in Moore's Law, which stipulated that the number of electronic components that could be placed on a given area of a microchip was roughly doubling every two years, with the resultant proliferation of electronics. Kennen heralded the beginning of the digital age.

The NRO's application of the 7 Tenets has been, and continues to be, fundamental to successful, innovative, timely, and transformative advancements in national reconnaissance. Over the years, the NRO has drawn on these Tenets to consistently make system enhancements that have increased its capabilities, expanded its mission, and increased its responsiveness to an ever-growing user base, and the country is more secure because of it.

INNOVATORS

FOUNDERS & PIONEERS

THE NRO FOUNDERS

THE NRO FOUNDERS

By the end of the Eisenhower administration, a handful of foresighted individuals recognized the importance of combining government satellite efforts into a single U.S. intelligence organization that would become the National Reconnaissance Office. Although many hands helped to establish the NRO in September 1961, it was not until 2000, when the Director of the NRO, Keith Hall, formally recognized ten individuals as Founders of the NRO, as part of the NRO's 40th Anniversary Commemoration. They were recognized for "their wise advice and counsel [that] persuaded decision-makers that a national policy of peacetime strategic reconnaissance could, and would, succeed." In 2013, then-Director of the NRO Betty Sapp recognized one additional person as a Founder because of that individual's similar contributions to sustaining the NRO from its earlier days to positioning for the successes of today.

William O. Baker, PhD - A physical chemist and signals intelligence expert at AT&T Bell Laboratories, Dr. William Baker was instrumental in shaping the course of signals intelligence, communications, and encryption/decryption technology for national reconnaissance. He served as a scientific counselor to the NSA, CIA, USN, and NRO on overhead and earth-based reconnaissance systems. He was a member of presidential boards and advised Presidents Eisenhower, Reagan, and Bush on intelligence matters. Baker would rise to become president of Bell Labs.

Merton E. Davies - An engineer, reconnaissance systems designer, imagery interpreter, and space cartographer, Mr. Merton Davies made substantial contributions to all early USAF reconnaissance studies and planning. He invented the Spin-Pan camera and collaborated in design and development of the Corona film-return satellite. Employed by the RAND Corporation, he served on advisory panels that established reconnaissance requirements, and advised on the merits of competing reconnaissance systems. Davies earned notoriety for his contributions to planetary exploration.

Sidney D. Drell, PhD - A theoretical physicist at Stanford University, Dr. Sidney Drell served in several intelligence advisory roles for the U.S. President. He served as a key scientific advisor to the CIA and to the Senate Select Committee on Intelligence where he was instrumental in securing approval for and support of several NRO special projects. A distinguished scientist at Stanford University, Drell became one of the foremost experts in the United States on Nuclear Arms Control.

Richard L. Garwin, PhD - A physicist and student of Enrico Fermi, Dr. Richard Garwin chaired presidential advisory panels on military aircraft and anti-submarine and naval warfare, and he advised the U.S. President on intelligence aspects of these programs. He served as a key advisor to the CIA on the development of national reconnaissance satellites, where he established standards and found solutions for electromechanical design of modern long-life spacecraft. He championed electro-optical imaging, heavily influencing the presidential decision to develop the NRO's near real-time imagery satellites. Garwin designed the U.S.'s first hydrogen bomb and remains a foremost expert on nuclear weapons.

Jimmie D. Hill - The longest serving second-in-command of the NRO, Mr. Jimmie Hill built the foundation for the post-Cold War NRO. After receiving his commission in the U.S. Air Force, Mr. Hill began working in classified NRO programs for both the Air Force and CIA elements at the NRO. After retiring from the Air Force, he continued to serve in senior leadership of the NRO. He rose to become second-in-command of the NRO and served in that role for 14 years. Through his leadership, Mr. Hill helped position the NRO to transform from a Cold War-focused intelligence organization to an organization focused on countering more diverse and complex post-Cold War threats to the United States.

Amron H. Katz - A physicist involved in lens and camera design for aerial systems, Mr. Amron Katz performed the first experimental simulation of electro-optical imaging by a reconnaissance satellite. At RAND Corporation he co-directed a project on peacetime overflight reconnaissance, and co-proposed film recovery satellites as an alternative to on-orbit film readout satellites, establishing the basis for the Corona satellite program approved by President Eisenhower. Katz would continue to be the U.S.'s preeminent expert in the use of airborne and satellite imagery systems for nuclear weapons systems verification.

James R. Killian, PhD - While President of the Massachusetts Institute of Technology, Dr. James Killian chaired the Technological Capabilities Panel for President Eisenhower that recommended developing the U-2 and reconnaissance satellites. He served as President Eisenhower's scientific advisor, making key recommendations on the development of the nation's earliest reconnaissance satellite programs. He shaped key agreements between the CIA and Department of Defense that laid the foundation for the establishment of the NRO. Killian would also become an advocate for public funding for television, leading to the establishment of the Corporation for Public Broadcasting Service.

Edwin H. Land, PhD - Edwin Land was Polaroid CEO and chairman of a presidential sub-committee on intelligence and technology. He was an imagery intelligence expert and scientific counselor to Presidents Eisenhower, Kennedy, Johnson, and Nixon. He advised the CIA on new intelligence satellite systems and improvements to existing ones. He played a key role in the presidential decision to proceed with the development of the NRO's near real-time electro optical imagery satellite, Kennen. Land was an accomplished scientist and inventor, holding a significant number of patents for his inventions.

Frank W. Lehan - An electrical engineer, Mr. Frank Lehan was a presidential advisor and also advised the NRO and CIA on overhead reconnaissance systems. He was instrumental in the decision to proceed with an important signals intelligence satellite system and contributed to the reflector design for that system. Lehan would co-found a space systems company, serve as a U.S. Department of Transportation official, and serve as a consultant on numerous Federal Government programs.

William J. Perry, PhD - A mathematician, Dr. William J. Perry served in the U.S. Army where he became involved in signals intelligence collection and subsequently advised NSA and CIA on communications and on intercepting and evaluating Soviet missile telemetry. He chaired a CIA advisory panel on all U.S. signals satellite collection systems. He later served as Under Secretary of Defense for Research and Engineering and as Secretary of Defense.

Edward M. Purcell, PhD - Harvard Nobel Laureate and radar expert, Dr. Edward Purcell worked on all early high-altitude overhead reconnaissance projects including the U-2, A-12, and SR-71. He made substantial contributions to the design of new materials for these aircraft that significantly reduced their visibility to radar systems. His efforts also contributed to the production of Have Blue, the F-117, B-2, and other U.S. special projects. He chaired a panel that selected the Hexagon film recovery follow-on reconnaissance system. In addition to his work in physics, Purcell also made significant contributions to astronomy.

NRO & US PRESIDENTS

Pearl Harbor, World War II, the Cold War, nuclear threats, the space race, and terrorism are just some key events that shaped the world in the 20th and 21st centuries. These events also determined how U.S. presidents promoted and championed satellite reconnaissance technology to provide the Intelligence Community with the most sophisticated capabilities to counter threats to U.S. national security.

DWIGHT D. EISENHOWER

During President Eisenhower's administration, satellite reconnaissance emerged as a critical U.S. intelligence asset. In 1953, a report published by James Killian, President Eisenhower's science advisor, warned that more timely intelligence was essential to maintain battlefield advantage and defend against potential attacks against the U.S. Determined to avoid another Pearl Harbor and counter threats from the Soviet Union, Eisenhower approved the development of several reconnaissance technologies to gain deeper understanding of our adversary's capabilities. The CIA and Air Force jointly developed two innovative reconnaissance assets: a high-altitude reconnaissance aircraft, the U-2, and a film-return imaging reconnaissance satellite, Corona. The U-2 overflights, which began on 4 July 1956, paid immediate dividends when the overflights revealed that the Soviets had fewer nuclear bombers than the U.S. had anticipated. In May 1960, the U-2 was grounded after Frances Gary Powers' plane was shot down midflight over the Soviet Union. By August 1960, the first successful Corona imagery film return system was launched, further validating that the Soviets had not outpaced the U.S. in the nuclear missiles domain. During the same period the Naval Research Laboratory developed, and then launched on 22 June 1960, the world's first signals intelligence satellite, the GRAB. These remarkable advances in national reconnaissance were vital to the acquisition of intelligence in denied areas about Soviet weapons capabilities during the Cold War.

JOHN F. KENNEDY

During President Kennedy's administration, national reconnaissance continued to evolve. On 6 September 1961, the administration consolidated all high-altitude aerial reconnaissance overflight programs and satellite reconnaissance programs at the CIA, the Air Force, and the NRL under the new and highly secretive, National Reconnaissance Office. Building on the earlier successes of the U-2, GRAB, and Corona, the CIA, the Air Force, and the NRL, now under NRO's umbrella, significantly enhanced satellite reconnaissance collection capabilities to advance national security goals. During President Kennedy's tenure other advances in reconnaissance technology included: the first test flight of the A-12 Oxcart (CIA's supersonic reconnaissance aircraft), development of the Poppy signals intelligence satellite (an enhanced version of GRAB), and the launch of Gambit-1 film-return system—featuring high resolution imagery. Kennedy's belief that the U.S. lagged behind the Soviets in weapons capabilities was also dispelled—as confirmed by intelligence collection from the Corona.

Images from Left: Eisenhower and SecDef Thomas Gates 10 February 1960 Cape Canaveral, Kennedy viewing the corona capsule 1961, Carter using a imagery light table.

LYNDON B. JOHNSON

During President Johnson's administration satellite reconnaissance capabilities expanded as information yielded from space collection provided senior policymakers and military leaders with situational awareness and operational advantages. Improvements were made to existing reconnaissance capabilities such as the development of the SR-71 Blackbird supersonic photo reconnaissance aircraft (the Air Force's version of CIA's A-12 Oxcart). Gambit-3 also emerged in 1967 making it possible to view images from space that were less than one foot in size. NRO continued to experiment with new ways to collect intelligence from space with the development of the Quill synthetic aperture radar and the Manned Orbiting Laboratory satellites. While the Quill system, developed by the Air Force in 1964, had only limited success, it served as a model for building future radar imaging satellites. In 1965, President Johnson announced the Air Force's MOL program. Although the program was cancelled in 1969, technical advances derived from the MOL such as segmented mirrors, flexible space suits, and multi-modular spacecraft contributed to the success of future space programs.

RICHARD M. NIXON

During President Nixon's administration, NRO made significant advances in the field of imagery satellite reconnaissance with an enhanced ability to conduct broad-area search of large land areas. The growing confidence in U.S. satellite capabilities to monitor Soviet military activities prompted the U.S. to engage with Russia in 1969 on the Strategic Arms Limitations Talks (SALT-I). On 23 September 1971, National Security Advisor Henry Kissinger informed the NRO that President Nixon approved the development of an electro-optical imagery collection satellite. The satellite, known as Kennen, provided the U.S. its first near real-time imagery after its launch in 1976. This decision by President Nixon moved the NRO into a new generation of imagery collection. The value of monitoring Soviet military activities from space became readily apparent in May 1972 when President Nixon and General Secretary Brezhnev signed the Anti-Ballistic Missile Treaty and the Interim Agreement on strategic offensive arms. Confidence to sign the agreement came from knowledge of a space reconnaissance capability. A key element in the agreement was that both countries could use "national technical means," i.e., reconnaissance satellites, to ensure treaty compliance.

GERALD R. FORD

During the abbreviated two and a half years of President Ford's administration, national reconnaissance became an expected resource for national security, and its products were becoming a presence in the civilian sector. National reconnaissance now would be seen as having a multifaceted role—monitoring threats from foreign adversaries and supporting domestic civilian goals. On 18 February 1976, Ford formally acknowledged the NRO as part of the IC and began to make reforms that would shape the IC and NRO's future activities. With growing confidence in satellite reconnaissance's ability to monitor Soviet threats, President Ford and the Soviet Union, in November 1974, began the next phase of arms reduction negotiations—SALT II. Ford formed the Civil Applications Committee in 1975 to evaluate potential uses of satellite imagery for civilian purposes. Subsequently, the NRO began to share declassified elements of its imagery capabilities with civilian government agencies on a more regular basis.

JAMES E. CARTER

President Carter's administration continued with arms reduction negotiations (SALT II) with the Soviet Union, and NRO introduced the next generation of imagery satellites to monitor treaties and ongoing national security threats. To reassure policymakers about the U.S.'s ability to monitor treaty agreements, Carter publicly acknowledged the "fact of" photoreconnaissance satellites in 1978. The initial announcement was released in a White House memorandum and then Carter spoke about it publicly during a speech at Cape Canaveral—acknowledging that photoreconnaissance is one of the "national technical means" used to ensure Soviet compliance with the arms control agreement. On 20 January 1977, the NRO declared the Kennen electro-optical system delivering near real-time imagery to IC consumers operational. These satellites provided what the film-return photoreconnaissance satellites Gambit and Hexagon could not—almost immediate imagery of intelligence targets and world events that affected U.S. security and policy. President Carter's presidency was overshadowed by the Iranian hostage crisis when Iranian students captured 66 U.S. embassy personnel in November 1979.

THE COLD WAR WINDS DOWN – NEW CHALLENGES IN A CHANGING WORLD

RONALD W. REAGAN

President Reagan's administration mandated several new launch vehicle directives which further defined roles and responsibilities of the IC, as political shifts in relations with the Soviet Union and the retirement of film-return satellites changed the international landscape. Among the directives signed was the designation of the Space Shuttle as the primary launch vehicle for all U.S. government space missions. The NRO was justifiably concerned about reliance on a single launch system due to the production delays in the shuttle's initial operating capability. The two-year delay in the shuttle returning to operation after the *Challenger* tragedy underscored the potential impact on NRO's mission. The NRO reached a compromise that committed NRO satellites to launch from the shuttle, but also allowed the NRO to maintain "complimentary launch systems" to ensure its continued access to space for national security purposes. President Reagan's Executive Order 12333, built on the Church Committee's report, further defined the IC's roles, activities, and guidelines to curb the excesses outlined in the report. In 1986, all first generation of imagery satellites were retired and electro-optical, near real-time satellites, like the Kennen, became the wave of the future into the 21st century under subsequent administrations.

GEORGE H. W. BUSH/WILLIAM J. CLINTON

As the Cold War melted and the world moved into a new era, Presidents Bush and Clinton began to navigate the transformation of the IC into a new paradigm of greater transparency and partnerships, while trying to adjust to new types of threats. In 1992, President Bush authorized the NRO to reorganize along functional lines, and Congress later allocated money for the Office to relocate most of its personnel to one location. Later that year, the Administration declassified the NRO and opened it up to greater public partnerships, as well as greater scrutiny. In the mid-1990s, President Clinton made two decisions that would have transformational effects on the IC, and NRO in particular. In 1995, he declared for the first time that IC support to military forces would be a priority, even over national strategic intelligence issues, when those forces are deployed. In 1994-95, Clinton set the course for U.S. satellite development for the next several decades by opening up the commercial space market to American companies, knowing that a commercial imagery market would exist whether or not the U.S. participated. He also increased IC transparency by declassifying the Cold War-era Corona, Argon, and Lanyard imagery systems, soon followed by the declassification of the "fact of" Sigint and Masint collection (1996) and the GRAB satellite (1998). This effort set the course for the later declassifications of Poppy (2004), Quill (2009), Gambit and Hexagon (2011), and MOL/Dorian (2015).

TWENTY-FIRST CENTURY: KEY INNOVATIONS AND PRESIDENTIAL SUPPORT

As the U.S. emerged from World War II directly into a Cold War with the Soviet Union, national security threats of the 1950s and 1960s created a sense of urgency to quickly build a national reconnaissance capability to prevent another war. This required direct Presidential involvement, and in President Eisenhower there was a willingness to enable brilliant engineers to build the new technologies to collect intelligence to solve new and emerging national security issues. This more direct Presidential involvement continued throughout the Cold War, but slowly began to change as Congressional oversight increased and cabinet officers assumed more decisionmaking authority for overhead systems development and acquisition. As the Cold War ended, the IC and NRO responded to new national security threats. The Middle East conflicts in the 1990s and the 11 September 2001 terrorist attacks shifted focus to new challenges faced by the IC. Mature late 20th and early 21st century satellite systems provided a robust architecture for responding to these emerging intelligence challenges of the 21st century.

NRO'S FIRST PIONEER CLASS

The First Pioneer Day: On 27 September 2000, as part of its 40th Anniversary celebration, the NRO held its inaugural induction ceremony of a new recognition program—the Pioneers of National Reconnaissance. Director of the NRO Keith Hall hosted "Pioneer Day" in the four-year-old Westfields Headquarters facility in Chantilly. Along the walls of the first-floor corridor of Tower 4, the NRO affixed plaques honoring 46 individuals who made lasting and significant contributions to national reconnaissance, and DNRO Hall dedicated the display as Pioneer Hall. With the 2002 Pioneer Day celebration (the 2001 event had to be postponed after the 9/11 attacks), the NRO began a tradition of annually recognizing selected individuals whose contributions had changed the direction and scope of the discipline of national reconnaissance, and upon whose scientific, technical, and engineering achievements the NRO was built.

In 1995, the CIA declassified the legacy Corona program—the genesis of photoreconnaissance satellites—and recognized many contributing individuals. When Hall became DNRO in 1996, he set about recognizing historical NRO leadership, including Program Office directors, the NRO's legacy components. At one such ceremony, former DNRO Hans Mark recommended identifying and celebrating "the people who did the real work," namely, the national reconnaissance pioneers. Hall subsequently directed his Office of Policy director and the Director of the Center for the Study of National Reconnaissance to develop an approach for a pioneer recognition program, which resulted in the appointment of an independent selection board representative of the NRO's civilian, military, and industry heritage. The board was charged with identifying and selecting 40 Pioneers—one for each year since the first successful Corona mission on 18 August 1960—but in the end, the board recommended 46 individuals for enshrinement:

The Pioneers of National Reconnaissance (2000 Inaugural Class)

James G. Baker, PhD

Career in National Reconnaissance: 1940-1972

A Harvard astronomer, Dr. James Baker designed most of the lenses and many of the cameras used in aerial overflights of "denied territory," enabling the success of the U.S. peacetime strategic reconnaissance policy.

C. Lee Battle, Jr., Colonel, USAF (Ret)

Career in National Reconnaissance: 1958-1963

Colonel Lee Battle directed the government-contractor team that produced, launched, and operated Corona, the world's first satellite film-recovery system.

John T. Bennett

Career in National Reconnaissance: 1965-1982

TRW's chief engineer in support of Program B, Mr. John Bennett conceived the spacecraft design, including the reflectors, used in signals intelligence satellite systems.

John W. Browning, Colonel, USAF (Ret)

Career in National Reconnaissance: 1967-1975

Colonel John Browning directed a key signals intelligence satellite project for Program A, managing its first launch and operations.

Jon H. Bryson, Colonel, USAF (Ret)

Career in National Reconnaissance: 1966-1992

Colonel Jon Bryson directed the development, acquisition, and operation of a Program A signals intelligence satellite system that handled rapidly increasing data rates.

A. Roy Burks

Career in National Reconnaissance: 1965-1995

Mr. Roy Burks served as CIA Technical Director of the Program B Corona Program, successfully integrating Air Force, CIA, and contractor development teams.

Frank S. Buzard, Colonel, USAF (Ret)

Career in National Reconnaissance: 1960-1972

Colonel Frank Buzard was the system program director for the Hexagon broad-area search and surveillance satellite, described then as "the most complex electro-mechanical device ever placed in orbit," yielding a record number of consecutive successes.

Cornelius W. "Connie" Chambers

Career in National Reconnaissance: 1962-1994

Mr. Cornelius Chambers, as a contractor with Lockheed, contributed flight "protective measures" adopted for use on most NRO satellites, thus developing a novel approach to on-board fault detection.

John O. Copley, Colonel, USAF (Ret)

Career in National Reconnaissance: 1958-1975

Colonel John Copley guided the development of Program A signals intelligence satellites from the earliest experiments to the later constellations that provided broader coverage.

Robert H. Crotser

Career in National Reconnaissance: 1960-1990

As Lockheed's business manager for the Kennen electro-optical imaging satellite, Mr. Robert Crotser wrote the handbook on cost and schedule management that remains a standard reference in spacecraft acquisition.

John J. Crowley

Career in National Reconnaissance: 1965-1975

Mr. John Crowley served as CIA Chief of Program B's Office of Special Projects, and he is credited with establishing a true partnership between the CIA and Defense Department elements of the NRO.

James C. de Broekert

Career in National Reconnaissance: 1960-2000

Mr. James de Broekert, a contractor with Advent Systems, Inc., contributed key payload designs for several of Program A's first-generation signals intelligence satellites.

Gary S. Geyer, Colonel, USAF (Ret)

Career in National Reconnaissance: 1971-1999

Colonel Gary Geyer's work resulted in notable improvements in signals intelligence collection, data processing, and dissemination that enabled the product to reach military and civil users in near real-time.

Thomas O. Haig, Colonel, USAF (Ret)

Career in National Reconnaissance: 1961-1965

In 1961, Lt Col Thomas Haig led the Defense Meteorological Satellite Program team that developed an operational, polar-orbiting meteorological satellite, its launch vehicle, and associated ground command and control stations.

Frederick H. Kaufman

Career in National Reconnaissance: 1964-1991

Mr. Frederick Kaufman directed the TRW team that produced two important Program B signals intelligence satellites, including the first communications cross-link system in space.

Robert J. Kohler

Career in National Reconnaissance: 1967-1987

A CIA photographic specialist, Mr. Robert Kohler introduced photographic edge measurement and edge sharpening tools used to evaluate and enhance overhead imagery.

Ellis E. Lapin

Career in National Reconnaissance: 1962-1967

Mr. Ellis Lapin managed the Aerospace Corporation's system design and engineering efforts for Program A imaging satellites, improving flight operations by nearly doubling functional on-orbit time.

Lloyd K. Lauderdale, PhD

Career in National Reconnaissance: 1963-1984

Dr. Lloyd Lauderdale was Program Manager for the CIA Program B team that developed an advanced signals intelligence satellite from concept through first launch.

Richard S. Leghorn, Colonel, USAF (Ret)

Career in National Reconnaissance: 1946–1961

Colonel Richard Leghorn articulated the concept of peacetime strategic reconnaissance in 1946 as a means to forestall surprise attack, and founded the Itek Corporation that produced lenses for the Corona and other cameras.

Walter J. Levison

Career in National Reconnaissance: 1942-1975

Mr. Walter Levison, with the Itek Corporation, designed the camera for the Genetrix overflight program, the camera for the WS-461L overflight program, and its panoramic variant for Corona satellites.

Howard O. Lorenzen

Career in National Reconnaissance: 1957-1973

An early advocate of signals intelligence satellites, Mr. Howard Lorenzen directed the development of GRAB, the nation's first such program, at the Naval Research Laboratory.

Frank J. Madden

Career in National Reconnaissance: 1960-1975

As chief engineer of the Itek Corporation's camera systems development program, Mr. Frank Madden directed the design, test, and production of the Corona cameras and its improved versions.

James T. Mannen, Colonel, USAF (Ret)

Career in National Reconnaissance: 1971-1993

As director of a vital imagery satellite program, Colonel James Mannen introduced procedures that improved target tasking and significantly increased ground resolution and on-orbit system reliability.

Paul W. Mayhew, PhD

Career in National Reconnaissance: 1964–1992

Dr. Paul Mayhew served as TRW's payload project manager and system engineer for two unprecedented signals intelligence satellite systems.

Reid D. Mayo

Career in National Reconnaissance: 1957-1981

Mr. Reid Mayo conceived and designed the first Navy signals intelligence satellite, GRAB/Dyno, at the Naval Research Laboratory, and later served as project engineer and technical director of Program C.

James E. Morgan
Career in National Reconnaissance: 1966-1992

An early Navy champion of electronic intelligence satellite tactical support to military operations, Mr. James Morgan developed the target tasking and data dissemination architectures for key Program C systems.

Mark N. Morton
Career in National Reconnaissance: 1958-1970

Mr. Mark Morton directed GE's Reentry Systems Division that designed, fabricated, and tested the re-entry capsules used in the Corona film-return satellite and in subsequent satellite reconnaissance programs.

Alden V. Munson, Jr.
Career in National Reconnaissance: 1967-1994

Mr. Alden Munson, a contractor with the Aerospace Corporation and TRW, conceived and developed a fully automatic electronic intelligence system that directly supported U.S. military forces in the field.

Charles L. Murphy, Colonel, USAF (Ret)
Career in National Reconnaissance: 1958-1964

Colonel Charles Murphy served as the first field technical director of the Corona Advanced Projects Integration Facility, the main link to the Intelligence Community.

Frederic C.E. "Fritz" Oder, Colonel, USAF (Ret)
Career in National Reconnaissance: 1956-1984

In the late 1950s, Colonel Frederic Oder directed the nation's first reconnaissance satellite enterprise, the USAF WS-117L (later Samos) Program, continuing his career with Lockheed and Eastman Kodak.

John Parangosky
Career in National Reconnaissance: 1954-1965

Mr. John Parangosky, a key contributor to the U-2 and A-12 Programs, served as Chief of the CIA Development Staff on the Corona Program.

Julius P. "Val" Peline, PhD
Career in National Reconnaissance: 1960–1988

Dr. Julius Peline served as Lockheed's system test director and program manager for a key imagery intelligence satellite program.

Robert M. Powell
Career in National Reconnaissance: 1959–1975

Mr. Robert Powell, Lockheed's program manager for a key high-resolution satellite reconnaissance program, devised a novel orbital maneuver that greatly extended the lifetimes of satellites in orbit.

Edward H. Reese
Career in National Reconnaissance: 1962-2000

Mr. Edward Reese, GE's program technical director, led the development of the ground data system that integrated hardware and software to process digital imagery from electro-optical imaging satellites.

Osmond J. "Ozzie" Ritland, Major General, USAF (Ret)
Career in National Reconnaissance: 1954-1965

As the Air Force manager of the U-2 program, General Osmond Ritland developed the service infrastructure that made early overflights of the USSR possible.

Lee W. Roberts, Colonel, USAF (Ret)
Career in National Reconnaissance: 1971-1977

Colonel Lee Roberts directed improvements in the Gambit-3 satellite reconnaissance effort that produced high-resolution imagery of the Earth's surface.

Charles R. "Charlie" Roth
Career in National Reconnaissance: 1966-1988

Mr. Charles Roth served as the CIA manager in Program B for the government-industry team that produced Kennen, the first electro-optical imaging reconnaissance satellite system.

Robert W. "Rob" Roy, Colonel, USAF
Career in National Reconnaissance: 1958–1964

Colonel Robert Roy directed NRO launch operations at Vandenberg AFB at a time when these activities increased dramatically.

Charles P. Spoelhof
Career in National Reconnaissance: 1954-1985

Mr. Charles Spoelhof, an Eastman Kodak official, collaborated on the design of the U-2, A-12, and Samos cameras, and directed efforts that led to the application of thin-based Mylar film in NRO reconnaissance satellites.

Forrest H. Stieg
Career in National Reconnaissance: 1971–2000

Mr. Forrest Stieg, a CIA engineer and spacecraft operations specialist in Program B, devised a process for selecting an optimum orbit that balanced signals collection with vehicle longevity.

Marvin S. Stone, PhD
Career in National Reconnaissance: 1968-1988

Dr. Marvin Stone served as a TRW payload systems engineer and project manager on Program B electronic intelligence satellite programs.

Don F. Tang
Career in National Reconnaissance: 1960-1995

Mr. Don Tang, as a Lockheed spacecraft engineer in Program A, established a "collection scale" for determining what signals could be technically collected at affordable costs.

Albert D. "Bud" Wheelon, PhD
Career in National Reconnaissance: 1962-1966

The first director of the CIA's Directorate of Science and Technology, Dr. Albert Wheelon was responsible for U-2 overflights and development of Oxcart and three major satellite reconnaissance systems.

Peter G. Wilhelm
Career in National Reconnaissance: 1959-2000

As the chief spacecraft engineer at the Naval Research Laboratory, Mr. Peter Wilhelm invented new techniques and devices that added capabilities and improved performance of signals intelligence satellites.

Roy H. Worthington, Colonel, USAF
Career in National Reconnaissance: 1962–1968

Colonel Roy Worthington, Deputy Commander of the 6594th Aerospace Test Wing, directed the integration and launch of some 200 satellites from the Western Test Range.

Robert W. Yundt, Colonel, USAF
Career in National Reconnaissance: 1964-1974

Colonel Robert Yundt directed the Signals Intelligence Project Office in Program A, introducing a new, long-lived, multi-purpose signals intelligence satellite.

NRO'S 2001 PIONEER CLASS

2001 PIONEER CLASS:
Lt Gen Donald L. Cromer, USAF (Ret) (left),
A.J. "Tony" Iorillo (not pictured),
Vincent Rose (right), and
John Walton (not pictured).

Lieutenant General Donald L. Cromer, USAF (Ret)

Career in National Reconnaissance: 1970 – 1998

Then-Colonel Cromer directed the design, development, and acquisition of a new imaging satellite system that became a critical part of U.S. national reconnaissance. His work led to vital new imaging capabilities, and his efforts in this and other NRO programs were critical to the evolution of NRO systems.

A.J. (Tony) Iorillo

Career in National Reconnaissance: 1965 – 1994

Mr. Iorillo conceived a new concept in spacecraft control and operation, which became a fundamental design for many NRO spacecraft. He also was a leader in the Hughes design and development effort that fielded the critical, near real-time optical-imagery-transmission relay system. He guided corporate and government-funded research efforts on critical technologies that produced significant advances in national reconnaissance capabilities. His efforts contributed to the successful achievement of a challenging and important vision: near real-time optical imaging, with data relayed directly from space to a ground processing system.

Vincent Rose

Career in National Reconnaissance: 1957 – 2001

Mr. Rose of the Naval Research Laboratory designed the first Elint payload used in Sigint reconnaissance satellites. His achievements enabled the earliest receivers to collect radar emissions across broad frequency ranges that produced "horizon to horizon" area coverage capabilities. His exceptional designs gave the U.S. its first space reconnaissance collection success, and he contributed to the development of advanced Elint receivers, antennas, and associated elements for four decades.

John Walton

Career in National Reconnaissance: 1970 - 1991

Mr. Walton, the system integrator for the first near real-time electro-optical reconnaissance satellite, made possible the combined, successful operation of the earth and space-based program elements. His revolutionary management and acquisition methodology has been applied in other NRO programs.

NRO'S 2002 PIONEER CLASS

2002 PIONEER CLASS:

Lee M. Hammarstrom, Col Robert L. Paulson, USAF (Ret), Dr. Vance D. Coffman.

Vance D. Coffman

Career in National Reconnaissance: 1971 – 2018

Dr. Vance D. Coffman's technical and management skills were instrumental in developing and initiating on-orbit operations of the first near real-time electro-optical imaging satellite system. From 1971-1984, he served at Lockheed Missiles and Space Company (later incorporated into Lockheed Martin Corporation) as the program's controls design engineer, attitude control system manager, Chief Systems Engineer, and finally Program Manager. Coffman led the development of a new satellite attitude control capability needed to provide major improvements in producing large quantities of geographically accurate, highly detailed maps from satellite-collected images.

Lee M. Hammarstrom

Career in National Reconnaissance: 1962 – 2002

For more than 40 years, Mr. Lee M. Hammarstrom enhanced and extended the reach of U.S. near real-time satellite intelligence collection, processing, and data dissemination capabilities. His concepts and developments for satellite, ground station, and processing systems greatly improved the accuracy, timeliness, and volume of NRO Elint products. Hammarstrom worked in various positions in Program C for HRB-Singer and the Naval Research Laboratory from 1964-1990. He served as the key conceiver and system integrator for a Program C Elint satellite system, and greatly improved Program C Elint ground stations. He served as the head of the NRO's Technology Office, and the NRO's Chief Scientist.

Colonel Robert L. Paulson, USAF (Ret)

Career in National Reconnaissance: 1973 – 1989

Colonel Robert L. Paulson served as the Air Force Program Manager for an Imint satellite system, directing its development, launch, and initialization. The success of this program is the result of his dynamic management of resources and technical knowledge. He saved the program from cancellation during a time of technical, schedule, and funding problems. He then successfully led his program office and operations team through the critical design, development, and testing of the system, and developed its complex ground architecture.

NRO'S 2003 PIONEER CLASS

2003 PIONEER CLASS:
Col David Raspet, USAF (Ret), Dr. James W. Stoner, Carl L. Ferdensi, Jr., Charles C. Tevis (deceased)

Carl L. Ferdensi, Jr.

Career in National Reconnaissance: 1976 – 2017

Mr. Carl L. Ferdensi, Jr., devised algorithms and computer processing techniques in the late 1970s and early 1980s for foreign instrumentation signals intelligence (Fisint) data. His pioneering work led to dramatic improvements in telemetry collection. The accuracy of the data enabled national and military decisionmakers to make informed decisions about Soviet military capabilities.

Colonel David Raspet, USAF (Ret)

Career in National Reconnaissance: 1966 – 2010

Colonel David Raspet pioneered advanced methods of integrating spacecraft into launch vehicles, and he provided crucial leadership in the management of national reconnaissance systems. His innovative approaches to spacecraft design and integration during the 1970s ensured the sustained operation of reconnaissance satellites and the continuous flow of technical intelligence to national and military decisionmakers.

James W. Stoner, Ph.D.

Career in National Reconnaissance: 1970 - 2012

Dr. James W. Stoner pioneered techniques for near real-time processing of electronic intelligence signals in the 1970s. He developed essential algorithms, supervised software engineering, and implemented ground station procedures to process large volumes of data in support of global military operations. His work made possible rapid digital processing and dissemination of data that continues to meet critical requirements of military users.

Charles C. Tevis

Career in National Reconnaissance: 1954 - 1994

Mr. Charles C. Tevis, in the late 1950s, was a pioneering advocate at the NSA for space-based signals intelligence collection. His advocacy for using satellites to collect telemetry from foreign strategic weapons systems resulted in the deployment of several space-based Sigint collection systems. In the late 1960s, Mr. Tevis also was instrumental in founding the Defense Special Missile & Astronautics Center (DEFSMAC) that analyzed signals intelligence at a single location. This made integrated intelligence available to senior national and military policymakers.

NRO'S 2004 PIONEER CLASS

2004 PIONEER CLASS:

Robert G. Kaemmerer, M. Sam Araki, James W. McAnally, Lt Col Harvey Cohen, USAF (Ret) (not pictured)

M. Sam Araki

Career in National Reconnaissance: 1958 - 2002

Mr. M. Sam Araki pioneered at Lockheed Missiles and Space Company the development of the world's first stabilized space platform, Agena, which the NRO used most notably for the highly successful Corona Imint system. Mr. Araki researched and corrected the problems associated with seven of Corona's initial 12 failures. Corona's long-term success was dependent on Agena, which inserted the payload into orbit, maintained its stability throughout the photographic mission, and correctly positioned the recovery capsule for re-entry. Mr. Araki's contributions resulted in a stabilized space platform that the NRO used during the 1960s for a majority of its space-based Sigint and Imint systems.

Lt Col Harvey Cohen, USAF (Ret)

Career in National Reconnaissance: 1982 - 2000

Lt Col Harvey Cohen pioneered for Program A from 1964 to 1984 innovative NRO security practices and procedures that were instrumental in the success of Program A's Cold War Space Systems. These innovative information safeguard procedures, and the associated policy framework, provided the essential security to protect sensitive reconnaissance technology. Mr. Cohen's work significantly contributed to keeping the NRO collection systems covert during this Cold War period of high security concerns.

Robert G. Kaemmerer

Career in National Reconnaissance: 1966 – Present

Mr. Robert G. Kaemmerer pioneered at TRW the development of the most sophisticated family of intelligence satellite systems of the Cold War. Mr. Kaemmerer provided critical leadership for the teams that developed numerous space-based programs. His contributions continued to be reflected in nearly every facet of the NRO's geo-synchronous and highly elliptical orbit Sigint systems developed during the early 21st century.

James W. McAnally

Career in National Reconnaissance: 1976 – 1997

Mr. James W. McAnally pioneered at Martin Marietta development of a new satellite reconnaissance system capable of producing imagery essential for a wide range of operations. His technical expertise, program management skills, and overall leadership provided the nation with vital capabilities crucial to the national security. The system provided unique and critical intelligence information during the Cold War and into the Global War on Terrorism.

NRO'S 2005 PIONEER CLASS

2005 PIONEER CLASS:
Wayne L. Proffitt, Roger C. Marsh, Edward A. Miller, Ph.D, Robert E. Eisenhauer.

Robert E. Eisenhauer

Career in National Reconnaissance: 1962 – 2000

Mr. Robert E. Eisenhauer pioneered the techniques that led to precise time-of-arrival signal recovery and digitization and encryption of data for 1960s-era NRO Program C satellite systems. He further developed these systems to achieve high-speed, real-time, on-board integration, synchronization, and processing of Sigint data from multiple satellites. These techniques completely changed wide-area Sigint reconnaissance technology and dramatically improved the accuracy and dissemination timeliness of satellite intelligence products through the present day.

Roger C. Marsh

Career in National Reconnaissance: 1971 – 2001

Mr. Roger C. Marsh pioneered a methodology by which it was possible to construct, operate, and manage an organization shrouded in secrecy utilizing open source methods. He successfully applied his considerable analytical, management, and organizational skills to the challenge of consolidating and collocating a far-flung operation into the present NRO headquarters in Chantilly, Virginia. Mr. Marsh delivered a modern facility that incorporated state-of-the-art security features on schedule and within budget. As director of the Management, Services, and Operations Office, he administered all support services, including facilities development and operation, headquarters security, human and personnel resources, information management, logistics, and employee assistance programs.

Edward A. Miller, PhD

Career in National Reconnaissance: 1959 – 1968

Dr. Edward A. Miller pioneered the design, construction, deployment, and operation of the first man-made object to be recovered from earth orbit – the Corona Satellite Recovery Vehicle. Dr. Miller and his team developed the first satellite-based photographic capability that replaced techniques no longer effective. His success with the Corona satellite recovery vehicle provided critical intelligence during the Cold War.

Wayne L. Proffitt

Career in National Reconnaissance: 1966 – 2002

Mr. Wayne L. Proffitt pioneered the design of the mechanism that enabled satellites to point the communications dish at the relay satellite and maintain continuous contact while imaging. In his long tenure as Program Director at Lockheed Martin, Mr. Proffitt overcame many complex engineering obstacles. His contributions included the delivery of capabilities that extended satellite operational lifetimes, enabling the NRO to satisfy mission requirements.

NRO'S 2006 PIONEER CLASS

2006 PIONEER CLASS:

Dr. David L. Klinger, Mr. Ingard M. Clausen, Ms. Jane A. Wood, Mr. Fred V. Hellrich

Ingard M. Clausen

Career in National Reconnaissance: 1957 – 1960, 1964 – 1968

Mr. Ingard M. Clausen pioneered the preliminary design and development of the satellite re-entry vehicle, which became the world's first man-made object successfully recovered from earth orbit. He managed the Discoverer/Corona program from its inception until 1959. His contributions to the field of rocketry and engineering laid the groundwork for the Corona system's ability to endure the harsh environment of space and withstand the heat of re-entry into the Earth's atmosphere. The first recovery from orbit occurred less than eight months after turnover of the program from Mr. Clausen.

Fred V. Hellrich

Career in National Reconnaissance: 1965 – 2022

Mr. Fred V. Hellrich pioneered the architecture, design, development, deployment, and integration of the first digital computer system to process satellite Elint data at remote ground stations. This new technology allowed for the transmission and collection of compressed data, dramatically reducing the time required to process from weeks to minutes. His innovations provided a revolutionary improvement in the productivity, accuracy, and timeliness of electronic intelligence product and near real-time reporting to the tactical user.

David L. Klinger, Ph.D

Career in National Reconnaissance: 1967 – Present

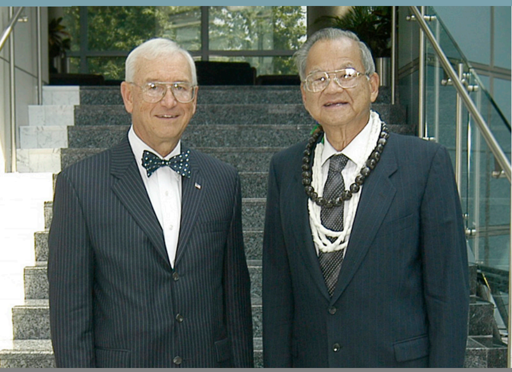
Dr. David L. Klinger pioneered the development, manufacturing, test, and deployment of a new technology that substantially enhanced the ability of the NRO to collect overhead intelligence. He and his team designed, built, and brought on line new manufacturing and test facilities in parallel with the technology development. He also conceived and developed new processing techniques and a star catalog required for accurate geo-location of intelligence targets.

Jane A. Wood

Career in National Reconnaissance: 1969 – 1992

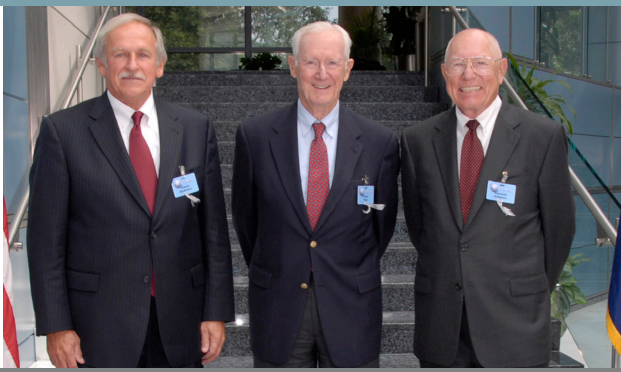
Ms. Jane A. Wood pioneered the development of a budget and accounting system that accurately tracked expenditures for many of the most sophisticated U.S. space assets. She was preeminent in the national reconnaissance fiscal world in the development of reliable budgets for complex satellite programs, establishing an environment of financial stability that furthered the growth of reconnaissance capability. Ms. Wood provided more than 23 years of outstanding service to the discipline of national reconnaissance.

NRO'S 2007-2008 PIONEER CLASSES



2007 PIONEER CLASS:
Dr. Paul G. Kaminski, Sun Yet Wong

2008 PIONEER CLASS:
Howard G. Brotherton, Hilliard W. Paige, Sr., Col Raymond E. Anderson, USAF (Ret)



2007 PIONEER CLASS

Paul G. Kaminski, PhD

Career in National Reconnaissance: 1971 – 1976

Dr. Paul G. Kaminski pioneered the development of a new type of NRO reconnaissance satellite system. He employed aircraft to demonstrate the feasibility of operating the new sensor from space. Moreover, he introduced innovative exploitation tools for analysts, enhancing their ability to exploit information from this complex system. Dr. Kaminski's contributions greatly enhanced intelligence capabilities vital to national security.

Sun Yet Wong

Career in National Reconnaissance: 1959 - 2015

Mr. Sun Yet Wong pioneered new technologies that improved the effectiveness of NRO satellite systems. He was instrumental in the development of STARDYNE, which enabled the NRO to better analyze complex spacecrafts and special payloads. He introduced the use of synthetic lubricants to stabilize and extend the life of Control Moment Gyroscopes. His contributions increased NRO satellite uniqueness, performances, reliability and promoted timely launches while reducing cost, thereby having a direct impact to the security of the United States and the world.

2008 PIONEER CLASS

Colonel Raymond E. Anderson, USAF (Ret)

Career in National Reconnaissance: 1966 - 2020

Col Raymond E. Anderson pioneered the use of solid-state recorders in reconnaissance satellites to extend their operational life spans. His insight led to a complete transition throughout the aerospace industry from mechanical tape to solid state recorders. His contributions brought about a generation of satellites that continue to provide intelligence essential to U.S. national security.

Howard G. Brotherton

Career in National Reconnaissance: 1969 - 2007

Mr. Howard G. Brotherton pioneered advances in satellite technology that enhanced mission success for multiple reconnaissance programs. Mr. Brotherton's contributions enabled an evolution in momentum management and developed techniques that advanced the state of automation for critical missions. His work on several Imint satellite systems provided valuable information to the Intelligence Community.

Hilliard W. Paige, Sr.

Career in National Reconnaissance: 1956 – 1970

Mr. Hilliard W. Paige, Sr. pioneered the concept of using ICBM re-entry technology for the recovery of reconnaissance film capsules from space, and recognized the need for both a three-axis stabilized camera platform and a protective heat shield. Mr. Paige's work was instrumental in the development of the Corona program and the successful recovery of the first reconnaissance images from earth orbit.

NRO'S 2009-2010 PIONEER CLASSES

2009 PIONEER CLASS:
Lacy G. Cook, Michael F. Maguire,
Dr. James P. Campbell (deceased)

2010 PIONEER CLASS:

Robert H. Dumais, Brig Gen Jack A. Gibbs, USAF (Ret) (not pictured), Col Richard J. Randazzo, USAF (Ret) (not pictured)

2009 PIONEER CLASS

James. P. Campbell, PhD

Career in National Reconnaissance: 1970 – 1998

Dr. James P. Campbell pioneered the early conceptual studies and analysis, which resulted in a new, innovative operational imaging reconnaissance capability. He provided the technical excellence and management leadership required to ensure the successful development, test, launch, and deployment of the highly reliable spacecraft and ground processing system. He made key technical improvements that far extended the operational life of the spacecraft to periods unprecedented in space-based national reconnaissance.

Lacy G. Cook

Career in National Reconnaissance: 1980 – Present

Mr. Lacy G. Cook pioneered the development and application of unique technology to add new capability to an existing NRO satellite. Mr. Cook's novel design allowed for the new capability to fit into the vehicle's limited space. His innovative approach provided national policymakers with unprecedented capability and solved highly complex technical challenges.

Michael F. Maguire

Career in National Reconnaissance: 1960 – 1979

Mr. Michael F. Maguire pioneered one of the last film-based reconnaissance systems used by the National Reconnaissance Office. Pushing the state of the art during the design and development phases of acquisition, Mr. Maguire's efforts and leadership resulted in a truly invaluable national asset in reconnaissance and one that the nation's leaders relied on heavily in their policy decisions. The resulting imaging satellites brought greater reliability and operational longevity to the national reconnaissance space constellation.

2010 PIONEER CLASS

Robert H. Dumais

Career in National Reconnaissance: 1960 – 2006

Mr. Robert H. Dumais pioneered the intelligence utility of an innovative capability for an imaging satellite system. This led to the subsequent design of a new subsystem on an existing imaging satellite that greatly improved the quality of imagery products from space.

Brig Gen Jack A. Gibbs, USAF (Ret)

Career in National Reconnaissance: 1956 – 1958

Brig Gen Jack A. Gibbs helped pioneer the application of innovative techniques to U-2 operations. His contributions resulted in the effective use of high-altitude airborne reconnaissance for intelligence collection over denied areas during the Cold War.

Col Richard J. Randazzo, USAF (Ret)

Career in National Reconnaissance: 1964 to 1986

Col Richard J. Randazzo pioneered the introduction and application of new operational techniques for NRO imaging systems. His countless engineering studies and demonstrations, followed by implementation of his designs, resulted in improved satisfaction of mission requirements and increased coverage of high-priority targets. Col Randazzo made a profound contribution to the acquisition and operation by all NRO imaging systems from 1964 to 1986.

NRO'S 2011 PIONEER CLASS

2011 PIONEER CLASS:
Col Joseph E. Eash III, USAF (Ret), Dr. John Shipley, Richard C. Van Wagoner, Dr. Thomas A. Brackey, Dr. Michael N. Parker

Thomas A. Brackey, PhD

Career in National Reconnaissance: 1969 – Present

Dr. Thomas Brackey pioneered critical breakthroughs, including first-of-a-kind hardware, in space-based communications technology and operational concepts that enabled near real-time collection and dissemination of data.

Col Joseph J. Eash III, USAF (Ret)

Career in National Reconnaissance: 1979 – 1987

Col Joseph Eash III pioneered the application of special innovative technologies to the NRO overhead reconnaissance mission. In his position as Chief of the NRO's "Special Staff," Col Eash led the way in the development of new, highly sensitive NRO missions for both aircraft and satellite systems.

Michael N. Parker, PhD

Career in National Reconnaissance: 1968 – Present

Dr. Michael Parker pioneered tracking and geolocation techniques based on precision signal externals measurements. In the 1970s, he developed missile tracking techniques that directly supported arms limitation treaty negotiations. He also demonstrated a first-time geolocation capability from space, a technology now at the heart of signals intelligence.

John Shipley, PhD

Career in National Reconnaissance: 1980 – Present

Dr. John Shipley pioneered the concept development, architectural approach, and initial system definition that led to the successful development of a revolutionary NRO collection asset. His unique beam-forming design led to proven on-orbit performance and critical collections that have exceeded expectations.

Richard C. Van Wagoner

Career in National Reconnaissance: 1979 – 2022

Mr. Richard Van Wagoner pioneered antenna and system design and the evaluation of system performance critical to the successful execution of the NRO Sigint mission. His ground-breaking development of innovative technology has resulted in the high quality Sigint collection now available to the Intelligence and DoD Communities.

NRO'S 2012-2013 PIONEER CLASSES

2012 PIONEER CLASS:
Dr. Robert P. O'Donnell

2013 PIONEER CLASS:
William G. Montgomery,
Dr. Donald N. Simkins

2012 PIONEER CLASS

Robert P. O'Donnell, PhD

Career in National Reconnaissance: 1972 – Present

Dr. Robert P. O'Donnell pioneered the development of unique, complex precision structures and mechanisms that enabled dramatic breakthroughs in the ability to collect critically important signals and imagery intelligence from space. He developed analysis and simulation techniques which made possible the precision pointing and flexible structure deployment and control of a new generation of collection satellites.

2013 PIONEER CLASS

William G. Montgomery

Career in National Reconnaissance: 1968 – 1992

Mr. William G. Montgomery pioneered precision control and pointing accuracies for a new generation national system that enhanced volume, resolution, and accuracy in imagery intelligence collection for the U.S. Government. He also led the application of precision sensing and control instruments and advanced systems engineering methods to balance performance contributions from multiple space and ground segments.

Donald N. Simkins, PhD

Career in National Reconnaissance: 1975 – Present

Dr. Donald N. Simkins pioneered the development of processing techniques that allowed the dramatic advancement of geo-location algorithms. His accomplishments include the first precise model of the signal path, long-term coherency, and automated techniques that expanded and improved the collection, exploitation and display of target information.

NRO'S 2014-2015 PIONEER CLASSES

2014 PIONEER CLASS:

Thomas C. "Chris" Fitzsimmons,
John R. Stavlo

2015 PIONEER CLASS:

L. Porter Davis

2014 PIONEER CLASS

Thomas C. "Chris" Fitzsimmons

Career in National Reconnaissance: 1966 – 1998

Mr. Thomas C. "Chris" Fitzsimmons pioneered the development, production, and test of lightweight optical and structural components that eliminated a significant amount of weight from the large aperture, heavy optical subsystem used in the nation's electro-optical imagery reconnaissance satellites, with no reduction in image quality. The technological breakthroughs and processes he pioneered are the key enablers of our currently flying high-resolution EO collection capabilities and remain in practice today.

John R. Stavlo

Career in National Reconnaissance: 1978 – 2007

Mr. John R. Stavlo pioneered the design and implementation of a first-of-a-kind precision pointing and tracking control system. To overcome the challenge of extending conventional attitude control concepts and development tools, he devised an innovative solution involving simulations with high-fidelity dynamic models and test beds with engineering model hardware operating in a closed loop mode. Mr. Stavlo's design and techniques represent a quantum leap in Sigint collection sensitivity.

2015 PIONEER CLASS

L. Porter Davis

Career in National Reconnaissance: 1963 - 2012

Mr. Porter Davis, during the mid-1960s, pioneered the development of control moment gyros for maneuvering and controlling the attitude of large spacecraft. The CMGs provided the NRO with innovative technology that led to the development of more agile satellites, affording increased collection capacity, with improved pointing performance and longer mission life. These highly complex electro-mechanical systems enabled NRO satellites to accomplish their essential missions for the nation.

NRO'S 2016-2017 PIONEER CLASSES

2016 PIONEER CLASS:

Thomas R. Reinehr

2017 PIONEER CLASS:

Timothy J. Barnes

2016 PIONEER CLASS

Thomas R. Reinehr

Career in National Reconnaissance: 1992 – 2000

In the 1990s–2000, Mr. Thomas R. Reinehr pioneered the development of concepts and algorithms, the "Reinehr Combiner," and other operational processing solutions that advanced the development of generations of imaging systems. These innovative technologies enabled vital missions to provide tactical warfighters, and strategic decisionmakers, with expanded imagery intelligence to address evolving threats.

2017 PIONEER CLASS

Timothy J. Barnes

Career in National Reconnaissance: 1983 - 2017

In the late 1990s Mr. Timothy J. Barnes pioneered geolocation bias-correction methods of profound and lasting effect on NRO's national and tactical missions. These groundbreaking, technical advancements improved precision geolocation performance by an order of magnitude and remain foundational to NRO geolocation systems today.

NRO'S 2018-2019 PIONEER CLASSES

2018 PIONEER CLASS:
Edward Mahen, Jr.

2019 PIONEER CLASS:
Carol A. Staubach

2018 PIONEER CLASS

Edward Mahen, Jr.

Career in National Reconnaissance: 1998 – 2021

Mr. Edward Mahen pioneered the development of a revolutionary new reconnaissance satellite and supporting infrastructure that significantly enhanced and strengthened national security over the past decade. This program enabled the National Reconnaissance Office to better counter its most critical threats and broadened the NRO's spatial, spectral, and temporal capabilities.

2019 PIONEER CLASS

Carol A. Staubach

Career in National Reconnaissance: 1988 – 2019

Ms. Carol Staubach pioneered the future of overhead reconnaissance by modernizing the NRO's Sigint ground architecture, delivering unprecedented intelligence capabilities and the blueprint followed by others for the future NRO Enterprise. She overcame social, fiscal, international, and technical challenges changing the course of the NRO forever.

NRO'S 2020-2021 PIONEER CLASSES

2020 PIONEER CLASS:
Dr. Michael Price,
Mr. Rod J. Dallaire

2021 PIONEER CLASS:
Mr. Paul S. Demshur
Dr. Kerry D. Rines

2020 PIONEER CLASS

Rod J. Dallaire

Career in National Reconnaissance: 1964 – 1992

Mr. Rod J. Dallaire pioneered radar payload designs, discovered hardware failures that saved satellites, and invented numerous ground processing techniques that significantly improved image quality. Additionally, he led technology improvement programs that transitioned cutting-edge software and hardware to system program offices for integration into on-orbit satellite flight programs.

Michael Price, PhD

Career in National Reconnaissance: 1973 – 2020

Dr. Michael Price pioneered targeting-level geolocation accuracy for near real-time Elint processors using combined data from NRO spacecraft. His work on bias estimation and removal has improved many of the NRO's overhead Sigint systems in operations today.

2021 PIONEER CLASS

Paul S. Demshur

Career in National Reconnaissance: 1981 - 2022

Mr. Paul S. Demshur pioneered the framework for the revolutionary re-architecture of the Low Earth Orbit Signals Intelligence Systems Acquisition Directorate (SIGINT) mission, combining multiple legacy systems into more capable multi-mission platforms. He pioneered ground-breaking technologies that greatly improved national reconnaissance intelligence collection and made enduring, time-tested contributions to the SIGINT mission spanning 40 years.

Kerry D. Rines

Career in National Reconnaissance: 1981 - 2019

Dr. Kerry D. Rines pioneered the end-to-end design of the high altitude Signals Intelligence Systems Acquisition Directorate architecture through an innovative, full-lifecycle approach. His system design and multi-mission concepts of operations satisfied critical, dynamic, and complex national security requirements. Dr. Rines' architecture and processes are the basis of current NRO capabilities and form the foundation for future excellence across intelligence domains and acquisition directorates.

TECHNOLOGICAL CAPABILITIES PANEL

LEFT PHOTO: Unknown witness, James R. Killian, President Eisenhower and Sherman Adams in 1957.

RIGHT PHOTO: Edwin C. Land.

THE PRESIDENTIAL PANEL THAT MADE A DIFFERENCE

Often presidentially appointed panels in the United States do not seem to make much of a difference. The Technological Capabilities Panel appointed in 1954 to advise President Dwight D. Eisenhower is the exception. President Eisenhower faced a unique tension in his own viewpoint on how to govern. On one hand, he was perhaps second only to Washington as the President with the most military experience. On the other hand, he was keenly aware how proponents of military defense could quickly seek more resources than were necessary to defend the nation. This tension was further complicated by the escalating threat from the Soviet Union at a much faster pace than most analysts had judged. The key to balancing the tension and addressing the threat in Eisenhower's mind was the harnessing of emerging technologies in defense of the nation.

In 1950 President Truman established the White House's Office of Defense Mobilization whose purpose was to coordinate all wartime mobilization activities. This powerful organization also created a Scientific Advisory Committee in 1951, which focused on emerging technology for use in U.S. defenses. By the time Eisenhower took office, the science board members were increasingly frustrated by the lack of notice of their recommendations and insights. With Eisenhower in office, he turned to Massachusetts Institute of Technology (MIT) President James R. Killian to solicit insight from U.S. scientists on how best to utilize their expertise in improving technological use in U.S. defenses. Killian convened a group of east coast SAC members in the spring of 1954. That group made a recommendation to Eisenhower that a group of scientists take up the question of how to use technology to counter the greatest threat to the U.S. at the time—the threat of a surprise nuclear attack on the U.S. by the Soviet Union. Eisenhower accepted the recommendation by the SAC to establish a Technological Capabilities Panel. Eisenhower appointed Killian to lead the Panel.

TECHNOLOGICAL CAPABILITIES PANEL

Killian wasted no time in recruiting some of the best technological experts in the nation to serve the Panel. For the steering committee he included the chair of SAC, Lee DuBridge. Joining them were retired Air Force General James H. Doolittle, James B. Fisk from Bell Laboratories, inventor and businessman Robert C. Sprague, and military historian James P. Baxter. Killian and the committee members designated three areas for review: (1) nuclear defense capabilities, (2) offensive nuclear strike capabilities, and (3) intelligence capabilities. These sub-panels were respectively chaired by Leland J. Haworth from Brookhaven National Laboratory, Marshall G. Halloway of Los Alamos National Laboratory, and Edwin C. Land, President and CEO of Polaroid Corporation. Altogether some 42 of the nation's best scientists, engineers, and technologists supported TCP activities from the fall of 1954 to the spring of 1955. On 17 March 1955, the Panel leadership presented their findings to Eisenhower.

To frame their findings, the Panel identified four time-frames for discussing the nuclear threat. The first time-frame was from the report findings in 1955 for as long as two years in the future characterized by both the U.S. and the Soviets being able to mount surprise nuclear attacks but neither side to decisively win a nuclear exchange. The second time-frame began as early as 1956 lasting as long as 1960 during which the Panel concluded the U.S. would develop a significant nuclear weapons edge over the Soviet Union. The third time-frame would begin as early as 1958 but no later than 1960 when the Soviet Union would obtain larger nuclear weapons and long-range bombers to strike the U.S., but with the U.S. still maintaining greater strategic ability. The fourth timeframe would eventually develop in which the U.S. and the Soviet Union would be able to destroy each other—the era of mutual assured destruction that eventually shaped much Cold War maneuvering between the U.S. and the Soviets.

The members supporting the Panel strongly recommended key technological advancements in each of the three areas of concern: offensive nuclear weapon development, defenses against nuclear attack, and meaningful intelligence capabilities to pierce the closed borders and societies of the Soviet Union.

TCP RECOMMENDATIONS

The Technological Capabilities Panel made a significant number of recommendations. With respect to offensive nuclear weapons capabilities, they recommended that the U.S. continue to invest in strategic long-range nuclear bombers. The Panel saw the bombers as the cornerstone for the U.S. to carry out an attack over the Soviet Union. They recommended that the Strategic Air Command receive resources necessary to keep airborne capability as the primary means to carry out an attack. However, the Panel recognized that airborne capability was not enough. They recommended that the U.S. also develop land-based intermediate range nuclear missiles, as well as intercontinental nuclear missiles for use in a nuclear attack. Moreover, the Panel also recommended the development of sea-based nuclear weapons. The TCP recommendations served as the foundation for the architecture built by the U.S. with nuclear weapons deployable at any time from land, sea, and air—or what would become known as the nuclear triad.

The TCP made a number of recommendations to develop missile warning capabilities. Much like their recommendations that led to the nuclear triad, they also recommended that the U.S. deploy missile warning systems terrestrially and in space. The Panel also listed a number of key technologies that the U.S. should invest in to allow the development of these new defensive and warning systems.

The intelligence sub-panel, chaired by Land concluded:

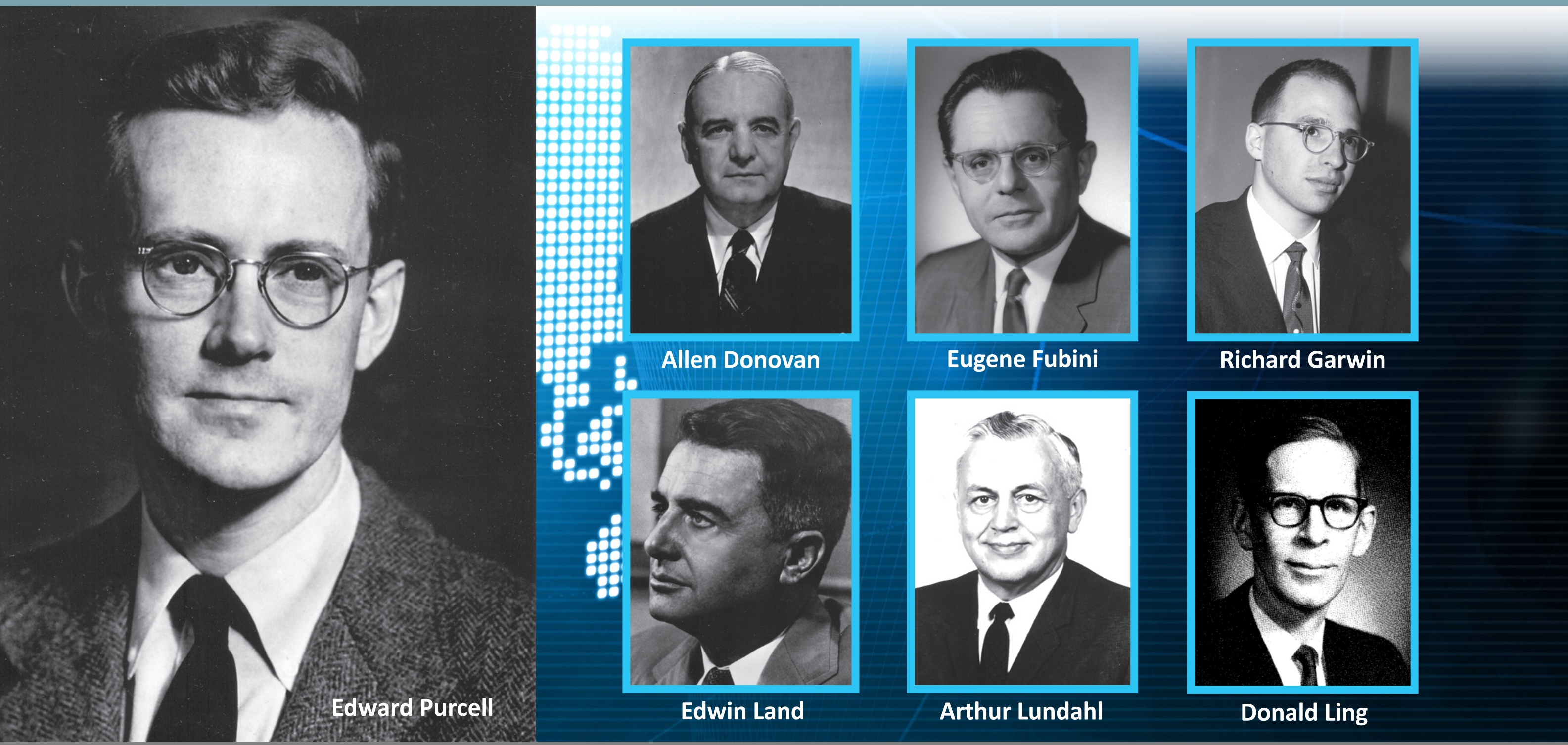
> We must find ways to increase the number of hard facts upon which our intelligence estimates are based, to provide better strategic warning, to minimize surprise in the kind of attack, and to reduce the danger of gross overestimation or gross underestimation of the threat. To this end, we recommend adoption of a vigorous program for the extensive use, in many intelligence procedures, of the most advanced knowledge in science and technology.

Land's sub-panel recommended two types of key technology. The first was the development of an aircraft that could rapidly fly over the Soviet Union at high altitudes and rapid speed, eventually known as the U-2. Both capabilities would allow the aircraft to elude both Soviet air- and ground-based air defenses. Additionally, the aircraft design incorporated features to reduce its radar profile. Land and his Panel members also recommended the use of an imagery camera system, developed by NRO Pioneer and Harvard Professor James G. Baker that included the latest optical technology for capturing imagery using such an aircraft. The U-2 would provide key intelligence that settled the questions of Soviet strategic bomber production capability in the beginning of the program. The U-2 continues to fly today, making valuable contributions to the U.S.'s defenses.

The second recommendation made by Land's Panel was the development of reconnaissance satellites. This recommendation set the foundation for the U.S.'s first reconnaissance satellite program that would eventually be known as the Samos program. Out of it grew the Corona program, which provided the U.S. its first space-based imagery in the late summer of 1960. With that imagery, the Corona program immediately provided intelligence confirming the U.S. maintained an advantage in the development of ICBMs. The Corona program would endure for a dozen years under the management of the NRO for the majority of that time. It served as the cornerstone for the NRO's imagery programs.

The TCP also proved that scientific advisory could help the Federal Government in confronting some of its most daunting problems. Eventually the Defense Department would establish a decades-long program to seek scientific advice on its most pressing challenges. Eisenhower's White House would eventually appoint Killian as the first presidential science advisor, a role that would prove essential for reaching key decisions on other NRO programs in the decades ahead.

THE PURCELL PANEL PRECEDENT



PHOTORECONNAISSANCE AT A CROSSROADS

In the early 1960s, the United States developed two photoreconnaissance satellites that complemented each other, providing the nation robust technical collection capability. With the launch of these systems, policymakers were at a crossroads with respect to what direction to move to develop even better collection capability. To decide which path to pursue, those policymakers turned to world-class scientists and engineers for recommendations. This was a course similar to the earlier 1950s Technological Capabilities Panel engineers and scientist members, whose recommendations influenced the development of the early photoreconnaissance programs.

The nation's efforts to develop its first photoreconnaissance satellite, Corona, were a direct result of recommendations made by the TCP. In 1960, the year Corona first successfully launched, many of the same panel members, now functioning as the Special Panel on Satellite Reconnaissance, recommended that the United States discontinue electronic readout satellites in favor of film return satellites with much higher resolution than Corona was producing. This panel was chaired by the White House Science Advisor, James Killian, and Polaroid Corporation's CEO, Edwin "Din" Land. Edward Purcell was a committee member, as he had been on the earlier TCP. By 1963, the U.S. had developed and launched the high-resolution Gambit film-return photoreconnaissance satellite, and operating it together with Corona, provided policymakers their primary means for assessing the Soviet Union's growing nuclear weapons capability. But now the U.S. had reached a crossroads on the best path forward for continuing to improve satellite reconnaissance capabilities.

PURCELL PANEL ESTABLISHED

The National Reconnaissance Office was established by agreement between the U.S. Department of Defense and the Central Intelligence Agency on 6 September 1961 to consolidate satellite reconnaissance programs under a single agency. However, NRO satellite program offices maintained strong ties to their parent organizations at the Defense Department and CIA.

In spring 1963, recognizing the importance of satellite reconnaissance to intelligence assessments, Director of Central Intelligence, John McCone, directed the establishment of a panel to review future capabilities and prospects for improving U.S. satellite reconnaissance. The CIA selected Edward Purcell, who had won the 1952 Nobel Prize for Physics, to lead the panel. The Purcell Panel was the first prominent group to provide recommendations on satellite reconnaissance after the establishment of the NRO. Panel members also included Allen Donovan, Eugene Fubini, Richard Garwin, Edwin Land, Donald Ling, and Arthur Lundahl.

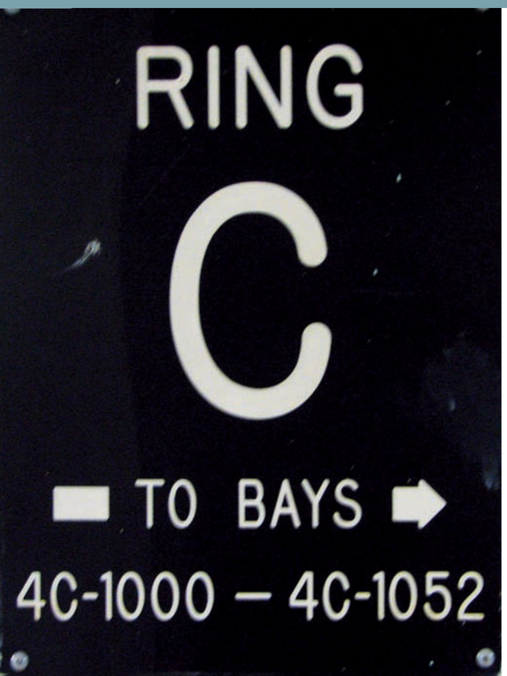
The Panel issued its report on 3 July 1963. Panel members concluded that the current satellite programs were very promising and should continue. They also concluded that "technological possibilities for growth in the direction of higher resolution systems are extremely promising" and that "[t]he eventual goal of ground resolution approaching one foot is not too high for optical photography to aim at." The Panel did not see the likelihood of a film-readout system operating successfully given technological constraints. The Panel also commended the management of photoreconnaissance satellite programs and recommended that the current management structure stay in place.

The Purcell Panel's recommendations encouraged CIA scientists and engineers to pursue an ambitious satellite that would obtain both the broad area coverage capabilities of the Corona satellite and the high-resolution capabilities of the Gambit satellite. CIA established the Fulcrum program to develop such a satellite. When the CIA program at the NRO assumed control of the effort, the satellite was eventually renamed Hexagon. Although its best resolution was a respectable 1.6 feet, it could not improve upon the Gambit satellite's capabilities. It did, however, serve as a hearty replacement for the soon-to-be-retired Corona program beginning in 1971.

EXPERT PANELS CONTINUE

The Purcell Panel was the first, but certainly not the last, of many expert panels convened by the NRO to consider the future of satellite reconnaissance. Shortly after the Purcell Panel reported, a committee of optical experts headed by the highly respected physicist Sidney Drell considered the question of measurement and improvements of satellite imagery resolution. Other panels would consider the best mix of Sigint satellites in geosynchronous, low earth, and highly elliptical orbits. And expert panels were not only consulted on satellite technology issues. Later panels convened to determine whether or not the NRO itself should remain classified and whether its organizational structure needed to change. After the conclusion of the Cold War with the Soviet Union, several panels would review the effectiveness of the NRO and make recommendations for how it could meet future challenges. These panels often included individuals like Killian, Land, Purcell, and Drell. Their reviews and recommendations helped the NRO fulfill its responsibilities to retain innovation as the mainstay of the efforts that have driven 60 years of organizational success.

NRO (4C-1000) STAFF



WHAT IS IN A NAME

The first NRO Director, Joseph Charyk, created Programs A, B, and C in 1962, which consisted primarily of personnel from the Air Force (California), the CIA (Virginia), and the Navy (Maryland). As the Under Secretary of the Air Force, Dr. Charyk was located in the Pentagon, and he had to run the NRO, even though the vast majority of its personnel worked in other locations. In order to help manage this new, complex, and highly secretive organization, Dr. Charyk utilized a very small staff in the Pentagon, located mostly on the 4th Floor, Concourse C, Suite 1000. Not only was 4C-1000 the office location of the NRO Staff, but the nomenclature of "4C-1000" became synonymous with the Staff and was often used interchangeably to identify people who worked on the Staff, since the mere mention of the NRO name remained classified until 1992.

WHAT MADE IT DIFFERENT

Throughout its 30-year existence, there were a number of themes that always characterized the NRO Staff. The Staff was always small, never numbering more than about 70 personnel. In 1961, President Eisenhower emphasized the need to remain a small, agile organization by mandating that anyone who was to be cleared for knowledge of the NRO had to have a "must know" requirement to do their job. This applied not only to the personnel brought in to work at the NRO, but also to any government officials that needed access to intelligence derived from NRO sources. This requirement to remain small meant that the NRO Staff had to rely on individuals capable of doing multiple jobs at all different levels of government. This enabled the NRO Staff to typically "punch above their weight," a euphemism used to describe typical mid-level NRO officers regularly dealing with much more senior military and civilian authorities. NRO officers of Captain, Major, and Lieutenant Colonel rank often briefed and worked closely with flag-level military officers, Congressmen, and Cabinet-level government officials. Due to the lack of management levels in the NRO, Staff personnel had great autonomy and authority to make decisions and get things accomplished, and senior NRO decisionmakers (the DNRO, DDNRO, and Staff Director) often relied on the expertise and knowledge of their Staff members. NRO seniors were able to make this work because they always had the highest priority to hand-pick the people they brought in to work on the Staff from the best and the brightest that the military and the CIA had to offer.


First NRO Staff

WHAT IT DID

While the NRO Staff had a common name, their workload was far from usual. Although the Staff was not located with the Program Offices that were building satellites, they had to represent the Offices to Washington-area authorities and then relay the orders from Washington back to the Offices, which often chafed at the interference and second-guessing of bureaucrats telling them how to do their jobs. The Staff also had to play referee to sometimes acrimonious internal squabbles between the Program Offices. Staff personnel were responsible for creating, implementing, and enforcing security controls not only for the NRO, but government-wide. The Staff was involved in setting government policies regarding satellite intelligence—not only coordinating with multiple agencies, but often actually writing Presidential Directives, Executive Orders, and other high-level decision memoranda. The Staff prepared the annual NRO Budget request and defended it in front of Congress. The Staff coordinated between the Program Offices building satellites and contractor launch companies building the boosters to carry those satellites into space. During its first 15 years, Staff personnel manned the Satellite Operations Center, which operated the satellites in orbit. Staff members also managed the Air Force communications team that built, maintained, and operated the secure communications infrastructure, that enabled NRO offices to talk to each other and with other cleared government officials and organizations, as well as systems to control NRO satellites in space.

WHAT HAPPENED TO IT

By the early 1990s, after the First Gulf War and the fall of the Soviet Union, the NRO was facing a new world, and change was in the air. After several studies and commissions, DNRO Martin Faga enacted a reorganization which disbanded the 30-year-old Programs A, B, and C, and created a new "INT-based" NRO. In 1992, Mr. Faga began to reorganize the NRO based on intelligence disciplines and to collocate most NRO offices in one central location in northern Virginia, enabling the agency to eliminate much unnecessary competition and duplication of effort. In the process, the Staff was merged into the new organization, and the NRO Staff formally came to a close in 1992 when the last Staff Director, Brig Gen Donald Walker, departed the NRO.

INNOVATORS

PEOPLE

NRO DIRECTORS

Dr. Christopher J. Scolese

Director NRO
1 Aug 2019 – Present
USN

Ms. Betty J. Sapp

Director NRO
6 Jul 2012 – 2 April 2019
USAF

Mr. Bruce A. Carlson

Director NRO
12 Jun 2009 – 6 Jul 2012
USAF

Mr. Scott F. Large

Director NRO
19 Oct 2007 – 18 Apr 2009

Dr. Donald M. Kerr

Director NRO
26 Jul 2005 – 04 Oct 2007

ORIGINS

From 1960 until 1962, Joseph V. Charyk, then Under Secretary of the Air Force, worked closely with the Central Intelligence Agency's Richard M. Bissell, Jr., to consolidate CIA, Air Force, and Navy satellite reconnaissance programs to form a new overhead reconnaissance organization. Charyk and Bissell were appointed co-directors of the new organization, the National Reconnaissance Office, on 6 September 1961. Together they initiated streamlined acquisition practices for aerial and satellite reconnaissance programs, and developed a strategy for peacetime reconnaissance of denied areas.

TENURE

The average tenure of a DNRO is approximately three years. Richard Bissell served the shortest term of about seven months. Edward Aldridge served the longest term of just over seven years, while Betty Sapp served just three months short of seven years.

DUAL APPOINTMENTS

Seven of the DNROs served a dual appointment as both NRO Director and Under Secretary of the Air Force. They include Joseph Charyk, Brockway McMillan, John McLucus, James Plummer, Hans Mark, Edward Aldridge, and Peter Teets. Five DNROs also served concurrent appointments as an Assistant Secretary of the Air Force including Alexander Flax, Robert Hermann, Martin Faga, Jeffrey Harris, and Keith Hall. Beginning with Donald Kerr, DNROs have not served in a concurrent Air Force capacity.

Edward Aldridge, after serving nearly five years as an Under Secretary, served the remainder of his tenure as Secretary of the Air Force. John McLucas was appointed as Secretary of the Air Force after serving as DNRO. Thomas Reed was the Secretary of the Air Force during his entire tenure as DNRO. Richard Bissell held a joint position as co-Director of the NRO and the CIA Deputy Director for Plans.

PRIOR EXPERIENCE

DNROs historically have come from a mix of military, government, and private industry backgrounds. Directors such as Joseph Charyk, Brockway McMillan, Alexander Flax, John McLucas, Thomas Reed, Edward Aldridge, and Martin Faga, shifted between private industry and government service, most in the fields of space research or development. James Plummer was the first DNRO to come directly from private industry after working as a senior manager for Lockheed Missiles and Space. Peter Teets also came to the NRO with a similar background as Plummer, having served as president of Lockheed Martin. Several DNROs worked primarily in government service before their appointments including Hans Mark, Robert Hermann, Jeffrey Harris, Keith Hall, Donald Kerr, Scott Large, and Christopher Scolese. Bruce Carlson was a General in the Air Force before retiring in 2009 and serving for a brief stint as a defense industry consultant. Nine other DNROs served in the military. Nine DNROs held doctorate degrees. Mr. Hall, Mr. Large and Ms. Sapp also served as Deputy Director or Principal Deputy Director of the NRO before serving as Director of the organization. The current DNRO, Christopher Scolese, served over 30 years with NASA, retiring as the director of the Goddard Space Flight Center to take over the helm at the NRO.

POST SERVICE

After serving as the DNRO, the majority of these officials continued to serve on boards, committees, and panels dedicated to national security and space technology issues. Often those who previously spent time in the private sector, like Joseph Charyk, Richard Bissell, Brockway McMillan, James Plummer, Martin Faga and Edward Aldridge, returned to upper-level management positions in corporations. Others, like Donald Kerr, continued in government service when he was appointed the Deputy Director of National Intelligence in 2007. Bruce Carlson left the NRO to assume a full time leadership position in his church.

Mr. Peter B. Teets

Director NRO
13 Dec 2001 – 25 Mar 2005
Under Secretary Air Force
13 Dec 2001 – 25 Mar 2005

Mr. Keith R. Hall

Director NRO
28 Mar 1997 – 13 Dec 2001
Asst. Secretary Air Force
28 Mar 1997 – 13 Dec 2001
USA

Mr. Jeffrey K. Harris

Director NRO
9 May 1994 – 26 Feb 1996
Asst. Secretary Air Force
9 May 1994 – 26 Feb 1996

Mr. Martin C. Faga

Director NRO
28 Sep 1989 – 5 Mar 1993
Asst. Secretary Air Force
28 Sep 1989 – 5 Mar 1993
USAF

Mr. Edward C. Aldridge, Jr.

Director NRO
3 Aug 1981 – 16 Dec 1988
Under Secretary Air Force
3 Aug 1981 – 8 Jun 1986
Secretary Air Force
9 Jun 1986 – 16 Dec 1988

Dr. Robert J. Hermann

Director NRO
8 Oct 1979 – 2 Aug 1981
Asst. Secretary Air Force
8 Oct 1979 – 2 Aug 1981
USAF

Dr. Hans M. Mark

Director NRO
3 Aug 1977 – 8 Oct 1979
Under Secretary Air Force
3 Aug 1977 – 8 Oct 1979

Mr. Thomas C. Reed

Director NRO
9 Aug 1976 – 7 Apr 1977
Secretary Air Force
9 Aug 1976 – 7 Apr 1977
USAF

Mr. James W. Plummer

Director NRO
21 Dec 1973 – 28 Jun 1976
Under Secretary Air Force
21 Dec 1973 – 28 Jun 1976
USN

Dr. John L. McLucas

Director NRO
17 Mar 1969 – 20 Dec 1973
Under Secretary Air Force
17 Mar 1969 – 20 Dec 1973
USN

Dr. Alexander H. Flax

Director NRO
1 Oct 1965 – 17 Mar 1969
Asst. Secretary Air Force
1 Oct 1965 – 17 Mar 1969

Dr. Brockway McMillan

Director NRO
1 Mar 1963 – 1 Oct 1965
Under Secretary Air Force
1 Mar 1963 – 1 Oct 1965
USN

Dr. Joseph V. Charyk

Director NRO
1 Mar 1962 – 28 Feb 1963
Co-Director NRO
6 Sep 1961 – 28 Feb 1962
Under Secretary Air Force
28 Jan 1960 – 1 Mar 1963

Dr. Richard M. Bissell, Jr.

Co-Director NRO
6 Sep 1961 – 28 Feb 1962
CIA Deputy Director Plans
1 Jan 1959 – 28 Feb 1962

NRO PRINCIPAL DEPUTY DIRECTORS

Dr. Troy Meink

2020 - Present

Mr. Frank Calvelli

2012 - 2020

Ms. Betty Sapp

2009 - 2012

Mr. Ralph S. Haller

2008 - 2009

Mr. Scott F. Large

2007

Mr. Dennis D. Fitzgerald

2001 - 2007

Mr. David A. Kier

1997 - 2001

ORIGINS

When the National Reconnaissance Office was established by agreement between the Central Intelligence Agency and Department of Defense on 6 September 1961, the agreement specified no Deputy Director. This was largely due to the fact that Joseph V. Charyk from the DoD and Richard M. Bissell Jr. from the CIA were named as co-Directors. When Bissell left government service in early 1962, the NRO was left without a second-in-command until the naming of Eugene P. Kiefer as the first Deputy Director, NRO (DDNRO) in the fall of 1963. In between, the CIA and DoD renegotiated the terms for managing the NRO with agreements in the spring of 1962 and again in the spring of 1963. The 1962 agreement included no Deputy Director, instead specifying that the CIA's Deputy Director of Research would represent CIA interests in the new organization, but without a formal organizational role. The 1963 agreement resolved the leadership question about sharing control of the NRO between the CIA and DoD. Both organizations agreed that future Directors of the NRO would be appointed by the DoD, with a Deputy Director appointed by the CIA—an agreement that has held since. In 2006, the DoD agreed to appoint a flag officer to serve in senior leadership as the Deputy Director of the NRO. The previous position for the CIA-appointed Deputy Director was re-designated as the Principal Deputy Director of the NRO (PDDNRO), who is second-in-command.

TENURE

Jimmie D. Hill was the longest serving Deputy NRO Director, serving nearly 14 years. Hill also served as acting Director twice with nearly two years in that role—longer service than six DNROs. The second longest serving second-in-command was Frank Calvelli, who served just over eight years in the role. Three individuals served less than 18 months—Keith R. Hall, Scott F. Large, and Betty J. Sapp—with each leaving the position to become DNRO. Kiefer had the shortest tenure of anyone in the position who did not leave to become DNRO.

PRIOR EXPERIENCE

Those who served in the DDNRO/PDDNRO positions came with very diverse experiences. Nine of the individuals served in the military, including the Air Force, Army, and Navy. While serving in the military, most had experience in intelligence collection programs.

The DDNRO/PDDNROs have had extensive educational training. James Q. Reber, F. Robert Naka, Charles W. Cook, and Troy E. Meink all held PhDs, with Hall holding an honorary PhD. Nearly all others obtained master's level training. Individuals obtained their education from universities such as Harvard, University of Chicago, George Washington University, and The American University.

Prior to serving as the DDNRO/PDDNRO, many individuals served in other federal departments. For example, Reber worked at the State Department; Robert D. Singel at the Commerce Department; David Kier at NASA; Hall at Office of Management and Budget (OMB), and Cook, Naka, and Donald L. Haas at the Defense Department. Others worked in private industry such as Naka at Lincoln Labs; Cook at North American Aviation; Haas at Martin Marietta; and Dennis Fitzgerald at Sperry Gyroscope. Hall also worked as a Congressional staff member.

Prior to their appointments, both Sapp and Meink served as Deputy Undersecretaries at the Department of Defense.

EXPERIENCE AT THE CIA AND NRO

Prior to becoming DDNRO/PDDNRO, several individuals served in leadership positions at the CIA Directorate of Science and Technology including Kiefer, Reber, Haas, Fitzgerald, Large, and Calvelli. Hall served on the Director of Central Intelligence's Community Management Staff. For many of those, their service also included heading the career service of CIA employees assigned to the NRO.

Several DDNRO/PDDNROs led directorates at the NRO. Fitzgerald led the SIGINT Directorate; Large the IMINT Directorate; Sapp the Business, Plans, and Operations Directorate; and Meink both SIGINT and IMINT Directorates. Ralph S. Haller also served as Chief Operating Officer of the NRO.

While serving as DDNRO/PDDNRO, Naka, Cook, and Hill also served as Deputy Undersecretaries of the Air Force for Space Systems. Kier and Large served as Principal Deputy Assistant Secretaries of the Air Force for Space.

POST NRO EXPERIENCE

Four DDNRO/PDDNROs continued in government service, including the three who became DNRO. Reber continued his government service chairing the nation's Signals Intelligence Committee. The other DDNRO/PDDNROs retired from government service, with several taking positions at corporations such as Raytheon, Lockheed Corporation, GTE, and Booz Allen Hamilton. Others served as consultants and board members for companies working on space systems.

Mr. Keith R. Hall

1996 - 1997

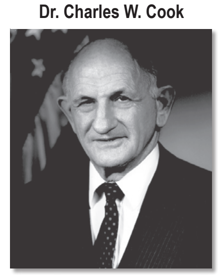
Mr. Jimmie D. Hill

1982 - 1996

Mr. Donald L. Haas

1979 - 1982

Dr. Charles W. Cook



1975 - 1979

Mr. Robert D. Singel

1972 - 1974

Dr. F. Robert Naka

1969 - 1972

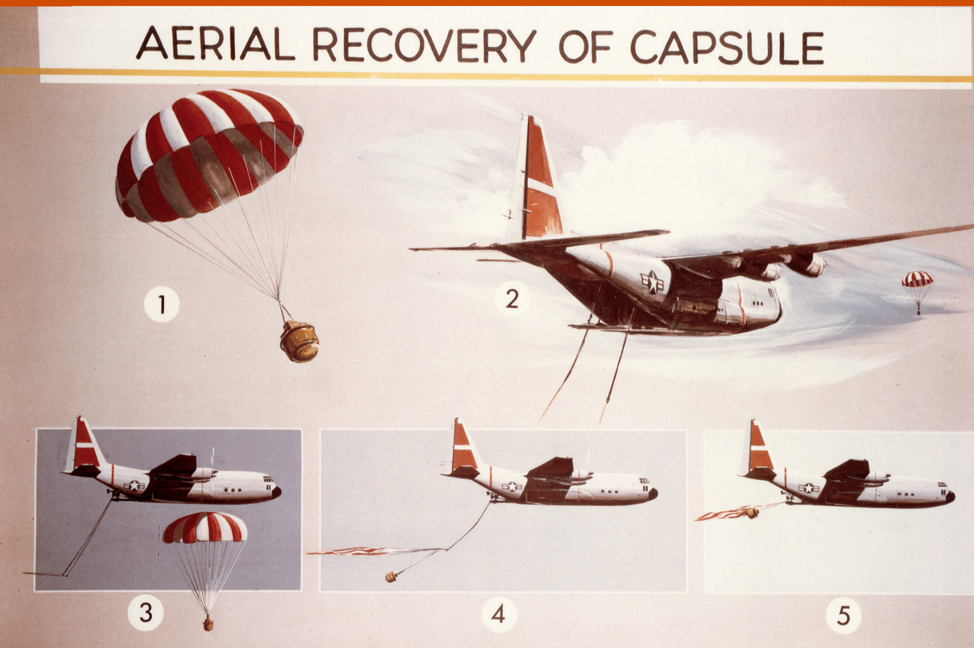
Mr. James Q. Reber

1965 - 1969

Mr. Eugene P. Kiefer

1963 - 1965

STARCATCHERS




6593d Test Squadron Patch

For 12 years, from 1960 to 1972, specially-trained, enthusiastic airmen retrieved falling stars from space. Digital satellite imagery technology was not yet available, so retrieving reconnaissance film capsules midair was the best way for the United States to receive accurate and critical reconnaissance information. It was a seemingly impossible task. But through talent, skill, and untold hours of practice, the StarCatchers facilitated the Discoverer/Corona program, providing vital strategic intelligence to the U.S. and altering the course of the Cold War.

A SPECIAL SQUADRON

The Air Force's 6593rd Test Squadron (Special) used their experience to meet the demands of this new space program and recover Corona's film capsules. Flying modified C-119J and JC-130 cargo aircraft, ten-member crews worked together to hook the falling film canisters as they returned from orbit. Crews were comprised of the commander and co-pilot, navigator, flight engineer, four-man teams of loadmasters (two on each side of the aircraft), winch operator, and aerial photographer. Every member was vital. The crews were assigned to stay together, so they got to know each other quite well during their tours. Occasionally, changes were made to cover for missing crew members, and those opportunities allowed for crews to learn from each other, as well as build camaraderie across the unit. They were a large but close group.

CATCH A FALLING STAR

This was a groundbreaking program, and the squadron represented the Air Force's best. The initial nine pilots (Jim Brewton, Tom Hines, Lynwood "Lindy" Mason, Jim McCullough, Harold E. Mitchell, Ed Mosher, Warren Schensted, Larry Shinnick, and Jack R. Wilson) all joined the program from the Genetrix project - a program that launched reconnaissance balloons over the Soviet Union, then retrieved them midair out over the Pacific. These pilots were specifically chosen for their experience. In addition to the pilots, a number of enlisted recovery personnel joined the Discoverer program from Genetrix. For some crew members who joined the program without the Genetrix experience, the entire concept was shocking and unbelievable.

Capsule recovery occurred over the open ocean, miles from Hawaii. Given that challenge, navigators joined the program from the Military Airlift Command, ensuring that they had over-water navigation experience. Although experience was important, many crewmen were very young. A2C Daniel Hill was the youngest member of the "Pelican 9" crew that caught the Discoverer 14 capsule. The first successful catch of a Discoverer bucket occurred the day after his 21st birthday.

The crews were talented and young, so it is not surprising that they could be boastful and competitive. There was widespread betting, bragging, and needling. It was a

dangerous job, and crew members were daring. But they also relied on each other, developing deep trust in their fellow crewmen. Despite the risk, no one was ever seriously injured or lost. Recovery was a complicated task, and it required teamwork and a serious attention to detail.

Even more than talent and experience, practice made the program a success. Crews began training together long before they ever flew over the Pacific, waiting for a falling capsule. It was an intensive and arduous training regimen, and crews were required to make at least one to two recoveries per week—more when they were preparing for a specific mission. But many of the crewmembers later recalled a deep love of the job, never tiring of it or all the practice.

Publicly, the Discoverer program was acknowledged as a scientific and experimental satellite program. Due to the open nature of the recoveries, the goal was to disclose as much information about them as possible. But the Corona program, or the classified reconnaissance mission of the program, was known to only the officers on the crews. Although most crewmen were unaware of the true mission of the operation, everyone knew that it was a priority program. And those who did know about the reconnaissance mission felt the weight of it, the significance for both the U.S. and the broader world.

A SPOTLIGHT ON A BLACK PROGRAM

Following the first successful catch on 19 August 1960, the "Pelican 9" crew who recovered the Discoverer 14 capsule went on a publicity tour across the U.S. After facing one of the biggest disappointments of their careers when they missed the Discoverer 13 catch the week before, that same crew described palpable enthusiasm after Discoverer 14. They were treated like celebrities, featured on NBC's "Today Show" and "The Ed Sullivan Show." They were treated to banquets, hometown parades, and speaking engagements. Later successes, given the security constraints of the program, were celebrated more quietly with recovery parties on base.

With time, the 6593rd came to be known as a plum assignment. Although not everyone was privy to the exact nature of it, everyone knew it was important. And being stationed in Hawaii definitely was not a downside. It was a thrilling program.

After 158 successful recoveries, on 31 May 1972, Corona 145 was the last capsule recovered. Piloted by Capt. Donald G. Hard, the final catch marked the end of a remarkably successful program. For 12 years, 10-man crews of young, eager, talented, and ambitious airmen flew over wide swaths of the Pacific Ocean, hoping to catch a falling star.

For further information, see CSNR's *CORONA Star Catchers*.

MOL ASTRONAUTS

A number of incidents in the early Cold War years - from the 1948 Arab-Israeli War to the 1962 Bay of Pigs incident - highlighted the importance of adaptable reconnaissance collection. But how could the United States answer these unexpected reconnaissance needs in a moment of crisis? In 1963, the Department of Defense announced the Air Force's Manned Orbiting Laboratory program, and a military man in space became the answer.

The program was conceived to send military men, trained in space reconnaissance, into space aboard the MOL. Divided into functional segments, the Gemini B capsule would provide crew support, protection, and transportation; the laboratory module would serve as crew and mission support during the orbital flight phase; and the Mission Payload System Segment was the photographic system designed to provide photographs of a superior resolution at an altitude of 80 nautical miles. For 30 days, the crew would orbit the Earth, performing experiments - the unclassified justification for the program–but in reality tasking MOL's camera system to respond to weather on Earth and any unexpected reconnaissance needs was the true, classified purpose of the program. Rather than wasted photographs on cloudy sites or missed information relating to current crises, the MOL pilots would ensure the most effective use of MOL's camera system and limited film supply.

From 1965-67, in three separate groups, the Air Force announced 17 individuals selected to fly as MOL "pilots." They endured grueling physicals and extensive testing before they were chosen. From the time of their selection until the moment of cancellation, these impressive individuals trained for spaceflight in addition to perfecting the design and mission of MOL:

A graduate of MIT and successful Air Force pilot, **James A. Abrahamson** (Group 3) began work on his first space program - the VELA Nuclear Detection Satellite Program - in 1961. He served two tours in Southeast Asia before attending the Aerospace Research Pilot School (ARPS). Like most of his fellow MOL pilots, Abrahamson was selected for MOL directly from ARPS. Following MOL, Abrahamson held a number of prominent positions, including Associate Administrator for the Space Shuttle program at NASA. In 1984, President Reagan named Abrahamson the first director of the Strategic Defense Initiative (SDI), also known as the "Star Wars" program. Following his retirement from the military in 1989, Abrahamson found further success in the private sector.

Michael J. Adams (Group 1) graduated from MIT prior to attending the Experimental Test Pilot School at Edwards Air Force Base and the ARPS. After only a few months in the MOL program, Adams was invited to join the X-15 program. On 15 November 1967, Adams was killed in a tragic accident in that program.

MOL GROUP 1 ASTRONAUTS. From left to right: Adams, Crews, Finley, Lawyer, Macleay, Neubeck, Taylor, Truly.

Karol J. Bobko (Group 2) was a member of the first graduating class of the Air Force Academy. Following flight training, he spent five years flying fighters, and hoping to one day get into space. He graduated from ARPS just prior to his MOL selection. Upon MOL's cancellation, Bobko transferred to NASA where he eventually flew on three shuttle missions. In 1988, Bobko retired from NASA and the Air Force, continuing his work on spaceflight in the private sector.

Albert H. Crews, Jr. (Group 1) was the oldest of the first group. After graduating from the Air Force Institute of Technology and the ARPS, Crews joined the DynaSoar program and was officially transferred to MOL when DynaSoar was cancelled. After the MOL program, Crews transferred to the NASA Flight Crew Directorate, flying a number of experimental aircraft including the "Super Guppy" outsize cargo transport. He retired in 1994, but he still regales audiences with tales of his career.

Although MOL was an Air Force program, **Robert L. Crippen** (Group 2) was a Naval Aviator, graduating in aerospace engineering before attending the Navy's Aviation Officer Candidate School. He served as an attack pilot for two years, then attended ARPS. With offers from both NASA and MOL, Crippen chose the MOL program, feeling his chances of flying in space were higher with that program. When MOL was cancelled, Crippen transferred to NASA where he eventually flew on four shuttle missions. From 1992-95, Crippen served as Director of the Kennedy Space Center.

John L. Finley (Group 1) was also a Navy man. He joined the MOL program out of the ARPS, but he requested a transfer back to the operational Navy in April 1968 when he became frustrated with the program's many delays. For the next 12 years, Finley was stationed in a number of locations, from Vietnam to Hawaii. He retired from the Navy in 1980, then enjoyed a successful career in the private sector.

C. Gordon Fullerton (Group 2) joined the Air Force after graduating from CalTech with both his bachelor's and master's degrees in mechanical engineering. He attended flight school, flew for the Air Force for five years, and attended ARPS before he was selected for MOL. Upon the program's cancellation, Fullerton transferred to NASA where he eventually flew on three shuttle missions. After his astronaut career, he worked as a research test pilot before his retirement in 2007.

Henry W. Hartsfield (Group 2) began his Air Force career in ROTC at Auburn University where he studied physics. He was stationed in Germany prior to attending ARPS, and from there he was selected for MOL. Following MOL, Hartsfield transferred to NASA where he flew on three shuttle missions. Hartsfield stayed with NASA until 1998, at which point he was named vice president of aerospace engineering services at Raytheon, retiring in 2005.

MOL GROUP 2 ASTRONAUTS. From left to right: Overmyer, Hartsfield, Crippen, Bobko, Fullerton.

Although **Robert T. Herres** (Group 3) attended the Naval Academy, he chose to serve in the Air Force. Prior to attending ARPS and his MOL selection, he was stationed in the U.S. and Germany, earned master's degrees in electrical engineering and public administration, and he graduated from the Air Command Staff College. After MOL's cancellation, Herres returned to the Flight Test Center at Edwards AFB. He commanded a number of units before he was named commander in chief of the North American Aerospace Defense Command (NORAD) and Aerospace Defense Command, and commander of the Air Force Space Command. In 1984, he became the first commander-in-chief of the United States Space Command. In 1987, Herres was appointed as the first Vice-Chairman of the Joint Chiefs of Staff. After retiring from the military, he served as chairman and CEO of USAA Group.

Robert H. Lawrence, Jr. (Group 3) was the first selected African-American astronaut. He earned his PhD in chemistry and served as an Air Force pilot, stationed for a time in Germany, before he attended ARPS. On 8 December 1967 at age 32, only six months after his MOL selection, he was killed in a tragic F-104 aircraft crash. He was the instructor pilot, teaching his trainee the steep-descent glide landing technique. When the aircraft hit the ground too hard, Lawrence ejected to the side and was killed instantly.

Richard E. Lawyer (Group 1), a passionate outdoorsman whom his colleagues nicknamed "the great white hunter," graduated from the Air Force Fighter Weapons School, served two tours in Vietnam, and graduated from ARPS before he was selected for MOL. Lawyer retired from the Air Force in 1982, and he spent his retirement flying experimental spacecraft for private companies.

Lachlan Macleay (Group 1) graduated from the Naval Academy, but he took an Air Force commission in 1954. Macleay attended the Test Pilot School and ARPS, served a tour in Korea, and flew reconnaissance aircraft before he was selected for MOL. After MOL, Macleay served a combat tour in Vietnam, among other assignments, before he retired from the Air Force in 1978 and joined the private sector.

Francis G. Neubeck (Group 1) was also a Naval Academy graduate who elected to join the Air Force. He was stationed at Eglin Air Force Base as a flight instructor, and he attended both the Air Force's Test Pilot School and ARPS prior to his MOL selection. After MOL, Neubeck continued his Air Force career, serving a combat tour in Southeast Asia and as vice commander at the Tactical Air Warfare Center at Eglin Air Force Base. He retired from the Air Force in 1986, allowing him to pursue his interests in writing and politics.

MOL GROUP 3 ASTRONAUTS. From left to right: Herres, Lawrence, Peterson, Abrahamson.

Robert F. Overmyer (Group 2) was the only Marine Corps member selected for MOL. He completed his Navy flight training and served with the Marine Attack Squadron before graduating with his master's degree in aeronautics. From ARPS, he was selected for MOL. Overmyer joined NASA after MOL's cancellation, flying on two shuttle missions. He was a lead investigator following the *Challenger* disaster, then retired from both NASA and the Marine Corps in 1986.

Donald H. Peterson (Group 3) was a West Point graduate who chose to join the Air Force. He served as an Air Training Command instructor and military training officer, then earned his master's degree in nuclear engineering. He served as a nuclear systems analyst and fighter pilot before attending ARPS and joining MOL. After the program's cancellation, Peterson transferred to NASA, where he eventually flew on the Space Shuttle with his fellow MOL pilot, Karol Bobko. He retired from NASA in 1984, although he stayed active in the industry.

Prior to his selection, **James M. Taylor** (Group 1) studied electrical engineering and served as a flight test engineer. He then graduated from the Air Force Test Pilot School, as well as ARPS. After MOL was cancelled, Taylor returned to the Test Pilot School, this time as an instructor. He was killed in a tragic T-38 accident there in 1970.

Like Crippen and Finley, **Richard H. Truly** (Group 1) was a Naval Aviator. After graduating from college in aeronautical engineering, he attended flight training and ARPS, where he was an instructor at the time of his MOL selection. When the program was cancelled, Truly transferred to NASA where he flew in space on three shuttle missions. He then served as the commander of the Naval Space Command before returning to NASA, where he served as Associate Administrator for Space Flight following the *Challenger* disaster. From 1989-92, Truly served as NASA's eighth Administrator.

A-12 PILOTS

From 1956-59, the CIA and Lockheed worked together to design a replacement for the U-2 reconnaissance aircraft. A contract was signed in February 1960 for a dozen A-12s—less than three months before the Soviets shot down Francis Gary Powers' U-2. The A-12 flew for the first time on 25 April 1962. During flight testing, the A-12 set numerous "unofficial" world records for top speed and altitude that still hold today. The records are "unofficial" because the aircraft was classified, so the Air Force's version (the SR-71) holds those records, even though its performance was inferior to the A-12's. The pilots of the A-12 blazed a path for those who would later fly the SR-71 under NRO's Program D. Two of the A-12 pilots would also eventually go on to fly the SR-71.

THE MISSION

Although the A-12 was capable of conducting remarkable feats by the early 1960s, and it was officially declared "operational" in late 1965, the A-12 found itself without a mission, due mainly to domestic and international political issues. It was not until May 1967, when policymakers became fearful of undetected surface-to-surface missiles in North Vietnam, that the A-12 finally was released to do its job. Over the next nine months, Operation BLACK SHIELD conducted 26 missions over SE Asia and succeeded in photographing North Vietnam's air defense network, key military and economic targets, and war-related activities, ostensibly as part of NRO's Program D, which was in charge of all national airborne reconnaissance efforts. Near the end of the operation, North Korea seized the USS *Pueblo*, sparking an international incident. Fearing the outbreak of a second Korean War, the A-12 was quickly assigned three missions over North Korea, where its collection revealed that the North Koreans were not mobilizing for war.

THE PILOTS

Since the A-12's futuristic design enabled it to go beyond anything any aircraft had previously accomplished, the pilots that "drove" the A-12 had to be exceptional at their craft. These pilots were literally "the best of the best." The Air Force searched its inventory of pilots to identify candidates who were then tested and screened in physical, medical, and psychological categories. Testing was so secret that neither the candidates, nor their commanders, were informed of why they were being tested. Once qualified, the pilots had to agree to join the program without being told what it entailed. At first, only five pilots agreed to join, so later a second testing effort had to be conducted to identify six more pilots.

*A-12 pilots and managers: from left to right, **Ronald J. "Jack" Layton**, **Dennis B. Sullivan**, **Mele Vojvodich Jr**, Barrett, **Jack W. Weeks**, **Kenneth B. Collins**, Walter L. Ray, Brig Gen Ledford, Skliar, Perkins, Holbury, Kelly, and squadron commander Col. Slater, not in picture Frank Murray.*

Of the 11 pilots chosen, three left the program before the aircraft became operational, and one was assigned to develop an Air Force variant and never flew operationally. One pilot, Walter L. Ray, crashed and died during flight testing, leaving six pilots who eventually flew the A-12 under operational conditions:

COL KENNETH B. COLLINS

Ken Collins joined the Air Force in 1950 and began flying reconnaissance aircraft in 1952. For eight years, he flew missions around the world, including 118 combat missions in Korea. He joined the A-12 program in 1960 and flew the aircraft for the first time in 1963. He conducted six missions over North Vietnam in 1967-68. After the A-12 was cancelled, Collins returned to the Air Force, flew the SR-71, and became a Squadron and deputy Wing commander. He retired in 1980 as Deputy Chief of Intelligence for the 15th Air Force.

COL RONALD J. "JACK" LAYTON

Jack Layton enlisted in 1950 and later got his pilot's wings, flying various fighters all over the U.S. for eight years before his selection to the program in 1960. He deployed to Okinawa for Operation BLACK SHIELD and flew five combat missions over SE Asia and one over North Korea. On 4 January 1968, Layton became just the second A-12 pilot to be shot at, after the North Vietnamese launched multiple SA-2 missiles at his aircraft, all of which missed. On 6 May 1968, Layton flew the A-12's third mission over North Korea, which turned out to be the program's last combat mission. After the A-12, Layton spent six years testing SR-71s and YF-12s for the Air Force and NASA before retiring in 1974.

LT COL FRANCIS J. "FRANK" MURRAY

Frank Murray enlisted in the Air Force in 1948 and got his pilot's wings four years later. For the next 11 years, he flew various fighters all over the world. In 1963, he was chosen to join the A-12 program, not as a Project Pilot but as a chase plane pilot. Three years later, after some of the original A-12 pilots left the program, he was asked to become an A-12 pilot. Murray flew three combat missions over North Vietnam and one over North Korea. Murray was the last pilot ever to fly an A-12 aircraft, after he flew the last aircraft from the A-12 base in Nevada to Lockheed's storage facility in Palmdale, CA. After the A-12, Murray returned to the Air Force, flew 67 combat missions in an A-1 Skyraider in SE Asia, and retired in 1977.

BRIG GEN DENNIS B. SULLIVAN

Dennis Sullivan graduated from Annapolis in 1950 and took a commission with the Air Force. For 13 years, he flew fighters all over the world, including 100 combat missions in Korea. Joining the A-12 program in 1963, Sullivan flew three combat missions over North Vietnam. On 28 October 1967, Sullivan became the first A-12 pilot to be fired upon when the North Vietnamese launched a single SA-2 at him above Hanoi. Two days later, he again came under fire when at least six SA-2s were fired. He reported seeing at least three detonations, and post-flight inspection revealed a small piece of shrapnel in the aircraft's wing, the only combat damage the A-12 ever received. In 1968, Sullivan returned to the Air Force for 15 more years, eventually becoming commander of NORAD's Cheyenne Mountain Complex.

MAJ GEN MELE VOJVODICH JR.

Mele Vojvodich enlisted in the Army Air Force in 1947, earned his wings in 1950, and flew fighters and reconnaissance aircraft all over the world, including 125 combat missions in Korea. Joining the A-12 program in 1963, he flew five combat missions over SE Asia, including the very first mission on 31 May 1967. After the A-12 program's cancellation, he served in the Air Force for another 15 years, and flew 135 additional F-4 combat missions in SE Asia. He retired in 1983.

CAPT JACK W. WEEKS

Jack Weeks was commissioned through ROTC in 1955 and spent the first eight years of his career as a fighter pilot and instructor. He joined the A-12 program in 1963 and flew five combat missions. His fifth mission was the first flown over North Korea, finding the *Pueblo* and collecting data showing that the North Koreans were not preparing for war. On 4 June 1968, after the program had been terminated, Weeks became the second A-12 fatality when his plane disappeared over the Pacific while on a checkout flight, for an engine replacement, as he prepared to fly back to the U.S. from Okinawa.

NRO CADRE

ORIGINS OF PERSONNEL ASSIGNMENTS

When the NRO was formed in 1961, the agency was set up as a joint organization run by the CIA and the DoD. President Eisenhower envisioned a new separate organization to run all of the government's strategic reconnaissance operations because he did not want any one group to have overall command and be able to exert undue influence. The Office was created by combining already-existing elements from different organizations, rather than a new organization built from scrap. Because of this unique structure, the NRO was reliant upon other organizations for employee talent and expertise.

The NRO did have the ability to retain some key personnel for long parts of their careers, but those personnel were always reliant on their home organizations for promotions and career advancement. Invariably, most personnel would eventually move back to their home organizations at some point. The early NRO was struggling to retain talented personnel and replace those who had moved on to other opportunities in the CIA and DoD. As the years went by and technological improvements continued to evolve, losing trained personnel at the end of their rotations became much more of a problem, and training new replacements became harder and more time-consuming.

ESTABLISHING THE NRO CADRE

On 11 August 2014, DNRO Betty J. Sapp requested "authority to establish a permanent cadre of DoD civilian positions in the NRO." The NRO established the Workforce Stability Initiative that would "create a more predictable and stable workforce, while maintaining the diversity that has been a core strength through the NRO's entire history." The Initiative stated that it was important for the NRO DoD Cadre to create a sense of stability that would foster the "NRO culture, maintain program expertise and build an innovative intelligence acquisition corp." In order to do that, one of the Initiative's key components was that the new Cadre would be comprised of mostly Air Force and Navy civilian personnel assigned to the NRO.

On 6 March 2015, Secretary of Defense Ashton Carter signed a memorandum titled "Request for Permanent Cadre in the National Reconnaissance Office." The directive stated that the "initial permanent DoD civilian cadre shall be established through a transfer of function of the FY 2015 authorized positions currently held by the U.S. Air Force and the U.S. Navy that support the NRO." Essentially, about 400 positions were turned into cadre positions under the helm of the DNRO. Instead of those 400 employees transferring back to their military service after their four-year assignment was over, those 400 civilians employees could now stay on at the NRO for as long as they wished, retaining well-developed and expensive experience. Soon after, the CIA established the Office of Space Reconnaissance (OSR) in the DS&T to be the home of most CIA personnel assigned to the NRO. This also allowed CIA employees at the NRO to be able to build their career without having to depart the NRO to pursue better opportunities around the Agency.

BUILDING THE CADRE

On 30 June 2015, Mr. Michael Hale was appointed the first Executive Director of the NRO Cadre and Defense Civilian Intelligence Personnel System head of component by DNRO Sapp. On 2 September 2015, the first NRO DoD Cadre Orientation day took place, welcoming the first group of NRO Cadre employees to begin building a dedicated and permanent civilian workforce able to meet the unique mission challenges of the NRO.

In May 2017, the NRO Cadre established a career field management structure to hire and develop a workforce with the knowledge, skill, and experience required to continually sustain and advance mission capabilities. The Career Field is set up into an organizational structure that allows the NRO Cadre leaders to organize their workforce into groups of Cadre members whose skills are aligned with the same mission-focused functional areas. Each Cadre member is assigned to one of six career fields: Acquisition Program Management, Contracts, Financial Management, Mission Support, Security or Technical. Each Career Field is headed by a Career Field Manager, who is a senior designated government representative who sets the Career Field's standards and partners with the NRO's Office of Human Resources to support recruitment, hiring, retention, and training needs.

NRO AFFINITY GROUPS

The Federal Government uses special resources dedicated to prevent or address discrimination in hiring and employment practices. The Civil Rights Act of 1964 was a landmark civil rights and labor law that outlaws discrimination based on race, color, religion, sex, national origin, and later, sexual orientation and gender identity. Executive Order 11246 signed by President Lyndon B. Johnson on 24 September 1965 established requirements for non-discriminatory practices in hiring and employment on the part of U.S. Government contractors. These directives helped to establish the foundation for Special Emphasis Programs (SEPs). The SEPs concentrate on the enhancement of employment and advancement opportunities for minorities, women, and people with disabilities.

On 18 August 2011, President Barack Obama signed Executive Order 13583 that stated "we are at our best when we draw on the talents of all parts of our society, and our greatest accomplishments are achieved when diverse perspectives are brought to bear to overcome our greatest challenges." The EO called on each Federal entity to develop a Diversity & Inclusion Strategic Plan. In April 2012, in response to the Executive Order, the DNRO wrote:

> The Office of Equal Employment Opportunity and Diversity Management (OEEO & DM) performed a comprehensive review of the new EO and developed a strategy to meet its intent. After determining the recommendations developed through the Corporate Decision Process, I authorize Director, OEEO & DM, using exhibit resources, to realign diversity management functions, allowing greater focus on implementing new EO requirements.

SUPPORT AT THE NRO

The NRO Employee Resource Groups (ERGs) were created from the SEPs and are managed by the Office of Equality & Inclusion (OE&I) under the guidelines provided by NRO and Department of Defense. The ERGs operate under the OE&I oversight and fall under the greater umbrella of the SEP. The Director, OE&I has delegated authority for the programs to the C/Inclusion Program (IP) who works with SEP managers to ensure that the programs are working and protected groups are represented. An ERG charter was created for the ERGs and stakeholders to understand expectations and their roles/responsibilities.

The NRO emphasizes that "the IP cultivates an inclusive work culture and creating an environment that reflects and capitalizes on the rich diversity of the workforce. To this end, the IP works to foster collaboration, flexibility, and fairness and leverages diversity throughout the Enterprise. This ensures that all individuals are able to participate and contribute to their full potential. The NRO IP also observes federally mandated programs through its ERGs and provides cultural awareness and education to everyone through special observances held throughout the year. Participation in the IP initiatives is open to all NRO personnel." ERG representatives from the Directorates and Offices (D's & O's) are used to provide information, guidance, and assistance to managers and supervisors in the implementation of corporate initiatives to promote diversity and inclusion. Cross-collaboration with the ERGs is highly encouraged to promote and maximize initiatives that will enhance career opportunities, career development, and cultural awareness.

NRO RESOURCES

At the NRO, the following ERGs and national program partnerships are supported by the Director's OE&I:

African American Diversity Network (AADN)

Federal Women's Program (FWP)

Khalfani (NRO chapter of Blacks In Government)

LGBTQ+ Inclusion For Everyone (LIFE)

NRO Asian Pacific American Network (NAPAN)

NRO 3D Network: Deaf-Disabilities-Diversity (3D)

NRO Hispanic Advisory Network (NHAN)

NRO Native American Network (NNAN)

The mission of ERGs is to support diversity and inclusion in the NRO workforce through education and career development in alignment with the NRO Diversity and Inclusion Strategic Plan. The strategy allows the ERGs to communicate issues that influence advancement of its constituency into leadership positions directly to the inclusion program. It promotes recruitment, career development, professional career planning and retention for employees and increased overall awareness of and participation in the ERGs to the workforce.

INNOVATORS

NRO ORGANIZATIONS

ALPHABETIC PROGRAM OFFICES: NRO PROGRAM A

ALPHABETIC PROGRAM OFFICES

Before it was an acknowledged organization, the NRO from 1961 to 1992 managed satellite and overhead reconnaissance system acquisition and development through several independently directed offices: Program A, Program B, Program C, and for 12 years, Program D. Colloquially called the "alphabetic Program Offices," these elements did not appear on any unit organizational charts outside of NRO channels, even under such non-descript names. The program offices were aligned with larger, external "parent" organizations that provided plausible cover for their covert projects, and from which they drew staffing and human resources support. The parent organizations included the U.S. Air Force (USAF), the Central Intelligence Agency (CIA), and the U.S. Navy. These three organizations, supported by a growing industrial base, laid claim to leadership roles during space's genesis in the 1950s through their technological developments and pioneering experiments, paired with streamlined contracting that facilitated rapid acquisition and development. Some examples of these breakthroughs include ballistic missile development that produced launch vehicles, satellite studies that led to spin-stabilized spacecraft, camera design and testing that resulted in extreme altitude, high-acuity lenses housed in camera bodies able to withstand the inhospitable space environment, and security systems.

Geographically separated from one another, the Program Offices developed strong cultural identities shaped by the ethos and traditions of their parent organizations, a close connection to users of their systems within those same organizations, and the career paths available to long-serving office personnel. Program directors functioned as Chief Operating Officers having complete management control over their national reconnaissance program-funded projects, in a framework that encouraged competition—particularly between Programs A and B —to propose, and then acquire and develop, the best technical solution to the nation's overhead intelligence problems. This competitive environment attracted the best talent, encouraged innovation, and contributed to breathtaking technological advancements in satellite and aircraft reconnaissance systems.

PROGRAM A

Program A comprised satellite reconnaissance activities conducted by the NRO through utilization of Department of the Air Force resources and managed by an office with the overt designation of Secretary of the Air Force for Special Projects (SAFSP), headquartered in El Segundo, California. As an additional security precaution, SAFSP personnel were furnished with additional duty assignments within their units, which allowed them to openly complete actions necessary to accomplish the compartmented work of the NRP. This arrangement mirrored how the NRO obscured the presence of its Staff Office within the Pentagon, located in room 4C-1000 under the unassuming name of the Office of Space Systems.

In keeping with a staffing policy recommending "carefully selected personnel of the highest qualifications," Program A's directors were flag rank Air Force officers who spent their entire careers in space and reconnaissance fields, and the element's workforce consisted of top scientific and engineering minds drawn from the military, private industry, and civilian government. The Air Force element within Program A also provided base facilities, and integrated, launched, and often operated on-orbit satellites for other agencies and programs.

Program A developed the first high-resolution imagery reconnaissance satellites under the Gambit program, first featuring the KH-7 camera system first launched on 12 July 1963 and later incorporating the much improved KH-8 camera in the more advanced Gambit 3 system the NRO operated until 1984. In 1973, Program A assumed management responsibilities for the NRO's broad area search and surveillance satellites that had been developed by Program B under the Hexagon program. Program A was also responsible for several early signals intelligence satellites in low, geosynchronous, and highly elliptical orbits. Additionally, Program A successfully developed and launched in 1964 the U.S.'s first radar imagery satellite—the experimental Quill satellite.

On 31 December 1992, the NRO consolidated its operations and formally dissolved the alphabetic program offices to replace them with a new organizational structure featuring functionally aligned directorates.

NRO PROGRAM A DIRECTORS, 1962 - 1992

Brig Gen Robert E. Greer, USAF

Director
23 July 1962 –
30 June 1965

Brig Gen John L. Martin, USAF

Director
1 July 1965 –
31 July 1969

Brig Gen William G. King, USAF

Director
1 August 1969 –
31 March 1971

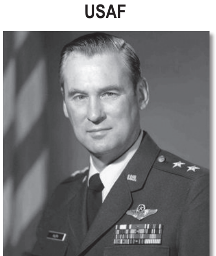
Maj Gen Lew Allen, Jr., USAF

Director
1 April 1971 –
21 January 1973

Brig Gen David D. Bradburn, USAF

Director
22 January 1973 –
31 July 1975

Brig Gen John E. Kulpa, USAF



Director
1 August 1975 –
19 January 1983

Brig Gen Ralph H. Jacobson, USAF

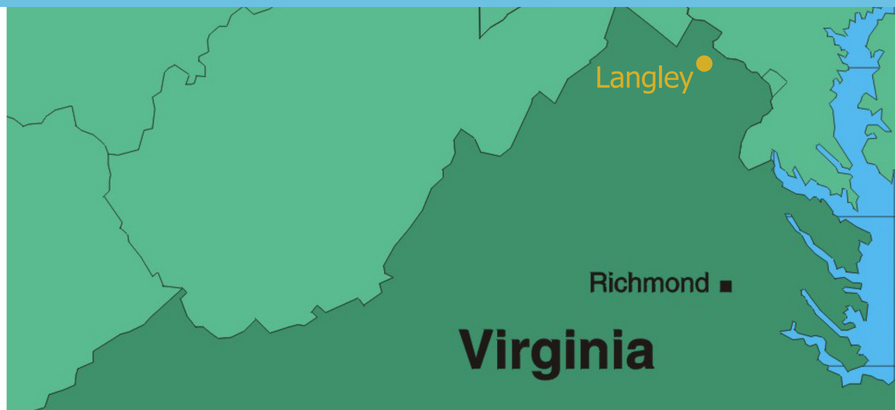
Director
20 January 1983 –
19 February 1987

Brig Gen Nathan J. Lindsay, USAF

Director
20 February 1987 –
31 December 1992

ALPHABETIC PROGRAM OFFICES: NRO PROGRAM B


Bissell




Wheelon

ALPHABETIC PROGRAM OFFICES

Before it was an acknowledged organization, the NRO from 1961 to 1992 managed satellite and overhead reconnaissance system acquisition and development through several independently directed offices: Program A, Program B, Program C, and for 12 years, Program D. Colloquially called the "alphabetic Program Offices," these elements did not appear on any unit organizational charts outside of NRO channels, even under such non-descript names. The program offices were aligned with larger, external "parent" organizations that provided plausible cover for their covert projects, and from which they drew staffing and human resources support. The parent organizations included the U.S. Air Force, the Central Intelligence Agency, and the U.S. Navy. These three organizations, supported by a growing industrial base, laid claim to leadership roles during space's genesis in the 1950s through their tehnological developments and pioneering experiments, paired with streamlined contracting that facilitated rapid acquisition and development. Some examples of these breakthroughs include ballistic missile development that produced launch vehicles, satellite studies that led to spin-stabilized spacecraft, camera design and testing that resulted in extreme altitude, high-acuity lenses housed in camera bodies able to withstand the inhospitable space environment, and security systems.

Geographically separated from one another, the Program Offices developed strong cultural identities shaped by the ethos and traditions of their parent organizations, a close connection to users of their systems within those same organizations, and the career paths available to long-serving office personnel. Program directors functioned as Chief Operating Officers having complete management control over their national reconnaissance program-funded projects, in a framework that encouraged competition—particularly between Programs A and B —to propose, and then acquire and develop, the best technical solution to the nation's overhead intelligence problems. This competitive environment attracted the best talent, encouraged innovation, and contributed to breathtaking technological advancements in satellite and aircraft reconnaissance systems.

PROGRAM B

Program B managed and directed satellite reconnaissance programs utilizing CIA resources. Its headquarters were in the northern Virginia suburb of Langley. The creation of a CIA-managed office for NRP activities was the natural outgrowth of overhead reconnaissance projects initiated by the Agency's Development Project Staff, formed originally for development of the U-2 reconnaissance aircraft under direction of DCI Special Assistant Richard Bissell, and later also used to develop the reconnaissance equipment for Corona satellites. As CIA's Deputy Director for Plans, Bissell thus became the de facto head of Agency-managed national reconnaissance projects, leading to his being named first co-director of the NRO. When CIA later subdivided the office into Plans and Research, it named Dr. Herbert Scoville, Jr. as Deputy Director of Research, with responsibility for managing Program B's portfolio. Over the years, Program B's directors concurrently served within the Agency as directors of the Office of Development and Engineering within the larger CIA Directorate of Science and Technology, which the Agency established in 1963 under future Pioneer of National Reconnaissance Albert "Bud" Wheelon. Directors of OD&E also served as the career service head for CIA personnel assigned to the NRO.

Before the NRO was established, the CIA elements that would become Program B developed Corona. Program B would go on to develop its successor, the broad-area search and surveillance satellite system known as Hexagon, as well as a major Sigint satellite system operating in geosynchronous orbit, and the very first electro-optical imaging satellite known as Kennen, capable of returning digital imagery in near real-time.

On 31 December 1992, the NRO consolidated its operations and formally dissolved the alphabetic program offices to replace them with a new organizational structure featuring functionally aligned directorates.

NRO PROGRAM B DIRECTORS, 1962 - 1992

Dr. Herbert Scoville, Jr.

Director
1 March 1962 –
14 June 1963

Brig Gen Jack C. Ledford, USAF

Director
12 August 1963 –
27 September 1965

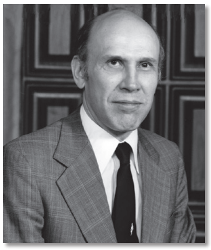
Mr. Huntington D. Sheldon

Director
27 September 1965 –
13 January 1967

Mr. Carl E. Duckett

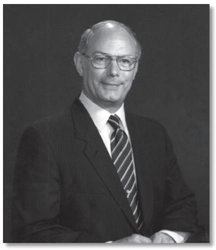
Director
14 January 1967 –
28 May 1976

Mr. Leslie C. Dirks



Director
6 June 1976 –
2 July 1982

Mr. R. Evans Hineman



Director
3 July 1982 –
28 August 1989

Mr. Julian Caballero, Jr.

Director
28 August 1989 –
31 December 1992

ALPHABETIC PROGRAM OFFICES: NRO PROGRAM C

NAVAL RESEARCH LABORATORY - 1960

ALPHABETIC PROGRAM OFFICES

Before it was an acknowledged organization, the NRO from 1961 to 1992 managed satellite and overhead reconnaissance system acquisition and development through several independently directed offices: Program A, Program B, Program C, and for 12 years, Program D. Colloquially called the "alphabetic Program Offices," these elements did not appear on any unit organizational charts outside of NRO channels, even under such non-descript names. The program offices were aligned with larger, external "parent" organizations that provided plausible cover for their covert projects, and from which they drew staffing and human resources support. The parent organizations included the U.S. Air Force, the Central Intelligence Agency, and the U.S. Navy. These three organizations, supported by a growing industrial base, laid claim to leadership roles during space's genesis in the 1950s through their technological developments and pioneering experiments, paired with streamlined contracting that facilitated rapid acquisition and development. Some examples of these breakthroughs include ballistic missile development that produced launch vehicles, satellite studies that led to spin-stabilized spacecraft, camera design and testing that resulted in extreme altitude, high-acuity lenses housed in camera bodies able to withstand the inhospitable space environment, and security systems.

Geographically separated from one another, the Program Offices developed strong cultural identities shaped by the ethos and traditions of their parent organizations, a close connection to users of their systems within those same organizations, and the career paths available to long-serving office personnel. Program directors functioned as Chief Operating Officers having complete management control over their National Reconnaissance program-funded projects, in a framework that encouraged competition—particularly between Programs A and B —to propose, and then acquire and develop, the best technical solution to the nation's overhead intelligence problems. This competitive environment attracted the best talent, encouraged innovation, and contributed to breathtaking technological advancements in satellite and aircraft reconnaissance systems.

PROGRAM C

Ten months after its creation, the NRO was continuing to refine its organizational structure. Chartered by the Executive Branch as a joint CIA and USAF agency, the NRO on 23 July 1962 established a third independent satellite program office designated Program C. Program C was the USN satellite reconnaissance element within the NRO and funded by the NRP. Located in Washington, D.C. and bordering Maryland areas, its members were assigned to the Technical Operations Group comprising individuals from the Naval Research Laboratory, PME-106, SPAWAR, the USN Electronics Command, and the Naval Security Group. Like Program A's directors, its leadership was drawn from Navy flag and staff officers with many years of experience in their fields. Some had been decorated combat veterans in the Second World War, Korean War, and Vietnam War before becoming Program C directors.

The smallest by workforce size—and budget share—of the three longest serving NRO Program Offices, Program C developed signals intelligence satellites that supported a wide range of intelligence applications. Before there even was an NRO or Program C, NRL succeeded in launching the nation's very first reconnaissance satellite, GRAB, on 22 June 1960. By the time of the 23 July 1962 organizational decision, the USN satellite reconnaissance element was well on its way to producing GRAB's successor, Poppy, which Program C launched on 13 December 1962 and operated until the mid-1970s, when the program again produced a more advanced successor signals intelligence satellite.

On 31 December 1992, the NRO consolidated its operations and formally dissolved the alphabetic program offices to replace them with a new organizational structure featuring functionally aligned directorates.

NRO PROGRAM C DIRECTORS, 1962 - 1992

RADM Vernon L. Lowrance, USN

Director
23 July 1962 –
19 June 1963

RADM Rufus L. Taylor, USN

Director
19 June 1963 –
14 June 1966

RADM Eugene B. Fluckey, USN

Director
8 July 1966 –
30 January 1968

RADM Frederick J. Harlfinger II, USN

Director
10 September 1968 –
4 January 1971

RADM Robert K. Geiger, USN

Director
5 January 1971 –
23 July 1975

CAPT Robert T. Darcy, USN

Director
24 July 1975 –
30 June 1977

RADM Grover M. Yowell, USN

Director
1 July 1977 –
29 August 1981

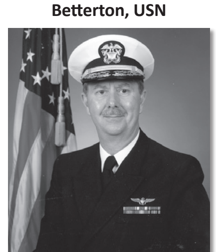
CAPT Lee Roy Patterson, USN

Director
31 August 1981 –
10 September 1982

RADM Dennis M. Brooks, USN

Director
4 October 1982 –
19 March 1985

RADM Thomas C. Betterton, USN

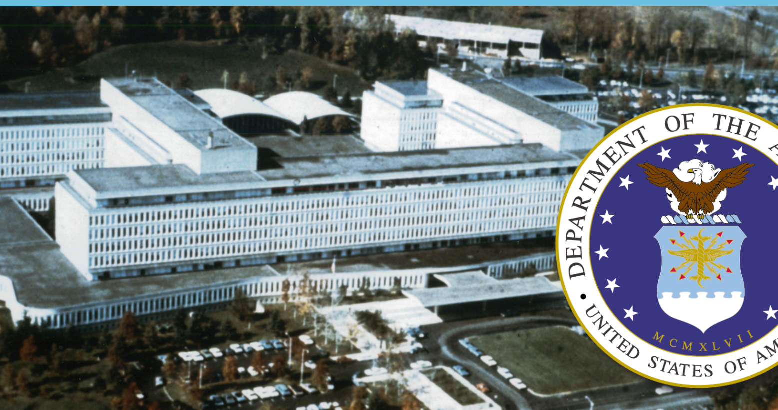


Director
20 March 1985 –
31 January 1992

RADM Jay W. Sprague, USN

Director
31 January 1992 –
31 December 1992

ALPHABETIC PROGRAM OFFICES: NRO PROGRAM D



U-2

EARLY COLD WAR U.S. AIRBORNE RECONNAISSANCE

The Soviets' successful nuclear bomb test in 1949 propelled the USSR forward as a major world power. If other actions had not, the Soviet Union's support of North Korea's surprise invasion of South Korea on 25 June 1950 confirmed the USSR posed a growing threat to the security of the United States. From an intelligence standpoint, the USSR maintained a distinct advantage over the U.S. because the Soviet Union tightly controlled its borders and travel of the few foreign nationals allowed in the country. The U.S. faced a daunting challenge in gaining intelligence from human sources within the USSR. Such sources were nearly non-existent compared to the many human sources for the USSR who could travel freely in the U.S. and gain intelligence on U.S. military capabilities.

The Korean War changed this Cold War dynamic. The emboldened U.S. President Harry Truman recognized the U.S. and its allies needed to obtain insight into the growing military capabilities of the Soviet Union and its allies. In 1950, President Truman formally authorized overflights of the Soviet Union. Previous overflights as well as flights along the border of the Soviet Union had provided useful intelligence. He also struck an agreement with British Prime Minister Clement Atlee for both nations to cooperate with conducting overflights. When Winston Churchill returned as Prime Minister in 1951, he wholeheartedly stuck with the agreement.

When the Korean War concluded under President Dwight Eisenhower, he remained committed to overflights of the Soviet Union and other areas where the U.S. was denied access. He went even a step further in 1954 and approved the CIA funding a Lockheed project to build a high altitude aircraft, the U-2, specifically to overfly the Soviet Union. During a summit meeting with the leaders of the USSR, the United Kingdom, and France, Eisenhower proposed allowing agreed-upon flights so each side understood the capabilities of the other ("Open Skies")—a proposal soundly rejected by the USSR.

With the downing of the U-2 piloted by Francis Gary Powers in May 1960, President Eisenhower suspended overflights of the Soviet Union. After two years of trying to launch a successful imagery satellite, the U.S. was near reaching the goal of having an imagery satellite in space. Later that summer, this new system would help fill the intelligence gap left with the suspension of the U-2 flights.

SUPERSONIC AIRBORNE RECONNAISSANCE

Although the U-2 had flown less than two years, in late 1957 the CIA initiated efforts to develop a replacement for it. For the new aircraft, the CIA again turned to Lockheed Aircraft Corporation's "Skunk Works" led by Kelly Johnson who designed the U-2. The CIA program for the new aircraft was named Oxcart, with the aircraft designated as the A-12, designed to have a low radar profile to avoid Soviet detection. The A-12 first flew in April 1962. It would go on to set altitude and airspeed records of 90,000 ft and Mach 3.29 respectively. Because of advances in Soviet air defenses and NRO satellite development, the U.S. did not use the A-12 for overflights of the Soviet Union. It did carry out 26 missions in 1967 over Southeast Asia, but was retired shortly thereafter in favor of the sister aircraft built for the U.S. Air Force.


U-2 Photo of Soviet-made Nuclear Missiles in Cuba


SR-71


D-21 Drone

The success of the A-12 program encouraged the Air Force to pursue development of a similar aircraft, known as the SR-71 Blackbird. The SR-71 became operational in 1968. It was slightly larger than the A-12 due to carrying more sensors, as well as a co-pilot to assist in the operation of the aircraft. The procurement of the SR-71 required close cooperation between the Air Force and CIA, cooperation that was facilitated by the NRO.

NRO'S PROGRAM D

Culture, mission, and other differences between the CIA and the Air Force required an effective liaison. By 1962, that liaison effort was led by Col Leo P. Geary who was assigned to the NRO by the Air Force to oversee the operation of reconnaissance aircraft. Within the NRO, Col Geary was appointed director of what was known as NRO Program D. The other NRO Programs A, B, and C housed the satellite development efforts of the Air Force, the CIA, and the Navy respectively. Program D officers needed to work in both the military and clandestine intelligence worlds. Because the NRO was a highly classified organization, Program D was listed as part of the U.S. Air Force's Inspector General's Office, although it did not carry out any OIG functions.

Col Geary and his Program D officers worked with CIA and Lockheed on the early efforts to begin development of the SR-71. With the establishment of this relationship, Program D assumed responsibility for the procurement of the SR-71 aircraft. The secrecy, streamlined procurement procedures, and management approaches of the NRO made it a preferable organization for the acquisition of the SR-71 for the Air Force.

In the early 1960s, the CIA also began development of a supersonic unmanned reconnaissance vehicle, or drone, to be flown on a modified A-12 and then launched to overfly denied areas. By 1963, the NRO Director assigned Program D to assume development of the drone, known as the D-21. The CIA, however, resisted the transfer of the program, but eventually relented after determining CIA collection requirements could better be fulfilled with other sources and systems. Program D assumed responsibility for the D-21 program in 1964. Over the next several years, Program D officers worked to bring the D-21 into operation. After a handful of minimally successful test flights, the NRO cancelled the program in favor of significantly more capable satellite collection.

Program D also played a critical role in the management of the U-2 aircraft. After the May 1960 downing of the U-2 over the Soviet Union, the United States discontinued overflights of the USSR. However, the U-2 was a highly effective resource for collecting intelligence over areas where less sophisticated air defense systems existed, such as China and the Soviet Union's ally in the western hemisphere, Cuba. As a result, the Air Force desired U-2 aircraft for their own use. Like with the SR-71 procurement, the Air Force and CIA benefited from NRO's Program D in obtaining control of U-2 aircraft.

The U-2 demonstrated its value as an intelligence collector when it imaged Soviet-made nuclear missiles placed in Cuba in October 1962. After the crisis resolved, the control of U-2 aircraft shifted partially to the Air Force. The CIA maintained operational control of U-2 flights over Cuba, and other flights were operationally controlled by the Air Force through the good offices of NRO's Program D.

The CIA was equally dependent on Program D for operation of both the A-12 and U-2. While the CIA had its own test facilities for the development of reconnaissance aircraft, it did not maintain air bases from where the aircraft could be operated. Program D facilitated Air Force logistical and locational support of CIA airborne reconnaissance requirements.

Program D played a final critical role at the NRO. The NRO's satellites were fabricated in locations away from launch facilities at Vandenberg Air Force Base in California and at Cape Canaveral in Florida. In order to get satellites to the launch facilities, the NRO programs needed Air Force air transport support. Program D again served as the liaison between Air Force transport elements and the programs at the NRO to accomplish this very vital support.

Eventually, Program D closed in 1974, due to a number of factors. First, the CIA found that satellite reconnaissance met intelligence collection needs over Cuba and no longer needed operational control of U-2s. Second, the Air Force conducted SR-71 reconnaissance missions that were exclusively in support of military operations and successfully received approval for total control of the SR-71 program. Third, with the cancellation of the D-21 program, Program D had no unique intelligence collection program underway. Finally, the NRO recognized that it could work directly with Air Force transport elements to shuttle satellite vehicles from factory to launch locations.

In the 12 years that Program D operated, it provided innovative approaches that bridged significant gaps between the challenges of maintaining the high secrecy surrounding NRO programs, while depending on the more observable activities of the U.S. Air Force. Program D played a critical role in transitioning airborne reconnaissance fully to the Air Force, and it facilitated critical relationships between CIA and the Air Force. It also enabled the critical transportation of national reconnaissance satellites for successful launches. Program D closed with a proud record of innovations and innovators who accomplished these very important mission objectives.

NRO PROGRAM D DIRECTORS, 1962 - 1992

Brig Gen Leo P. Geary, USAF

Director
2 May 1962 –
15 July 1966

Col Clason B. Saunders, USAF

Director
15 July 1966 –
31 October 1967

Col Frank W. Hartley, Jr., USAF

Director
1 November 1967 –
30 June 1972

Col Bernard L. Bailey, USAF

Director
21 July 1972 –
1 October 1974

AS&T DIRECTORATE

NRO STAFF OFFICE MANAGEMENT

When the National Reconnaissance Office was established in 1961, the co-Directors of the NRO, Joseph Charyk and Richard Bissell, were supported by a small staff of fewer than two dozen at the Pentagon. Many of the staff members had worked with Charyk when he was appointed as an Undersecretary of the Air Force. Drawn mostly from the ranks of Air Force officers, the staff remained very small in the first decades of the NRO. The staff had responsibility for not only directly supporting senior NRO leadership, but also coordinating issues between the Air Force, CIA, and Navy reconnaissance programs housed under the NRO. NRO staff members also supported budgeting, procurement, security, personnel, legislative liaison, communications, launch, technology assessment, and communications policy development for systems that linked the NRO programs together. The staff would also provide studies, plans, and analysis for charting the future of the NRO.

MAJOR NRO REORGANIZATION

After many years of consideration and study, the Department of Defense and CIA agreed the structure of the NRO needed to change. In 1992, the Air Force, CIA, and Navy programs at the NRO were reorganized along functional lines by establishing individual directorates for large programs in signals collection, imagery collection, communications, and later, advanced technology development. Other directorates and offices were established to take over the NRO staff's responsibilities, a staff that never grew to more than about 70 people in the first 30 years of the NRO. That major restructuring established the organizational backbone that supports the mission of the NRO today.

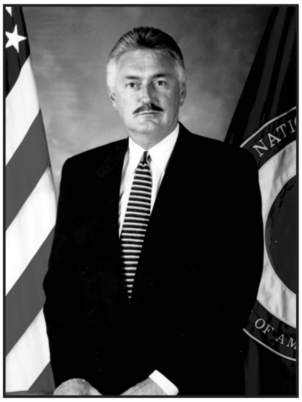
ADVANCED SYSTEMS AND TECHNOLOGY DIRECTORATE FORMED

The Advanced Systems and Technology Directorate was formed in 31 March 1997 as the fourth major directorate in the NRO after the 1992 reorganization. The new director, Bob Pattishall, was charged with establishing an aggressive, customer-focused research and development program to provide advanced technologies for global satellite reconnaissance. Since that time, AS&T has continually developed boundary-breaking innovative technological solutions and products to the NRO and IC.

Today, AS&T develops technology to enable a responsive, problem-centric, multi-INT architecture by investing in advanced technologies, applied research, and capability demonstration pathfinders. AS&T is inventing the NRO future by transforming what exists and discovering what does not.

The AS&T Strategy focuses on delivering the critical capabilities needed to achieve the NRO strategic goals and Architecture After Next. AS&T develops high-risk, high-reward technologies and capabilities for transition into the operational baseline.

DIRECTORS OF AS&T



Mr. Bob Pattishall
March 1997 - February 2000

Ms. Carol Staubach
February 2000 - October 2001

Maj Gen Craig Weston
October 2001 - June 2002

Brig Gen Bob Latiff
June 2002 - November 2003

Dr. Pete Rustan
November 2003 - January 2008

Mr. Jim Arnold
January 2008 - June 2010

Mr. Bob Brodowski
August 2010 - November 2015

Dr. Susan E. Durham
November 2015 - April 2022

BUSINESS PLANS AND OPERATIONS

John Nelson
1995 - 1998
First ROM Director

Misty Tullar
2017 - present
BPO Director

NRO STAFF OFFICE MANAGEMENT

When the National Reconnaissance Office was established in 1961, the co-Directors of the NRO, Joseph Charyk and Richard Bissell, were supported by a small staff of fewer than two dozen at the Pentagon. Many of the staff members had worked with Charyk when he was appointed as an Undersecretary of the Air Force. Drawn mostly from the ranks of Air Force officers, the staff remained very small in the first decades of the NRO. The staff had responsibility for not only directly supporting senior NRO leadership, but also coordinating issues between the Air Force, CIA, and Navy reconnaissance programs housed under the NRO. NRO staff members also supported budgeting, procurement, security, personnel, legislative liaison, communications, launch, technology assessment, and communications policy development for systems that linked the NRO programs together. The staff would also provide studies, plans, and analysis for charting the future of the NRO.

MAJOR NRO REORGANIZATION

After many years of consideration and study, the Department of Defense and CIA agreed the structure of the NRO needed to change. In 1992, the Air Force, CIA, and Navy programs at the NRO were reorganized along functional lines by establishing individual directorates for large programs in signals collection, imagery collection, communications, and later, advanced technology development. Other directorates and offices were established to take over the NRO staff's responsibilities, a staff that never grew to more than 100 people in the first 30 years of the NRO. That major restructuring established the organizational backbone that supports the mission of the NRO today.

EARLY FINANCIAL MANAGEMENT AT THE NRO

In the early days of the NRO, the alphabetic programs managed their own financial accounting and management. In the mid-1990s as the NRO established functional directorates, the addition of the Office of Resource Oversight and Management (ROM) allowed the NRO to meet customer needs in a more cost-effective and efficient manner. This was done in part because it became apparent that the reorganization and collocation of the NRO programs into functional directorates exposed serious inconsistencies and differences in financial accounting and management used previously in the alphabetic programs.

MAJOR NRO REORGANIZATION

On 15 October 1995, ROM was established to serve as a focal point for all NRO financial, budgetary, programmatic, and legislative matters, as well as strengthening internal resource management functions. Mr. John Nelson served as its first director. ROM improved both internal budgetary control and its external interactions with Congress and their constituent intelligence and financial committees. ROM developed a comprehensive financial accounting, contracting, and disbursement system, and it was also responsible for frequent audits and reviews of major programs reported to Congress and other federal agencies and departments. ROM played a major role with Congress, handling legislative liaison, as well as preparation of the annual budget and executing funding initiatives for NRO systems.

ESTABLISHMENT AND EVOLUTION OF BPO

In 2003, ROM became the Business Plans and Operations Directorate (BPO). Both ROM's and BPO's organizational structure changed after their establishment. For instance, the Office of Contracts and the Office of Strategic Planning joined the directorate. Later, many of the NRO's support functions, including BPO, combined into a short-lived Directorate of Administration in the mid-2000s. By the time BPO became an independent directorate again in 2006, the directorate expanded to include the Office of Policy, which included the Center for the Study of National Reconnaissance. BPO also saw the Office of Public Affairs join Legislative Affairs within a single BPO office. In the early 2010s, BPO evolved further with the Office of Contracts and the Office of Policy realigning to directly report to the DNRO.

BPO TODAY

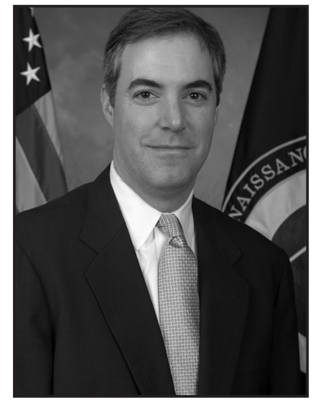
Today, BPO advances the NRO mission through premier resource management and strategic communication solutions that ensure accountability and transparency in the development, acquisition, and operation of an agile and resilient NRO Enterprise. BPO creates, implements, and manages sound financial policies, provides cost-estimating support, develops budget submissions, performs accounting responsibilities, supplies integrated financial systems, conducts financial performance and internal control management, supports travel services, and provides total personnel management support to enterprise-wide financial management staff.

The BPO oversees NRO strategic communications, conducts public affairs, provides Congressional liaisons and effective communications counsel, and provides historical insight and analytical framework to NRO Leaders. It is primarily responsible for:

- Annual NRO National Intelligence Program budget build and monitoring of the annual DoD Military Intelligence Program build;
- Annual Intelligence Program and Budget Submission for the ODNI;
- Annual Congressional Budget Justification Book for Congress;
- NRO Communications Strategy and supporting products, including NRO overview briefing, NRO reference publications and communications campaigns;
- Annual NRO Financial Report, enabling the thirteenth consecutive clean audit;
- Documentation of NRO's history and publication of analytical assessments; and,
- Identification, accession, and preservation of national reconnaissance artifacts.

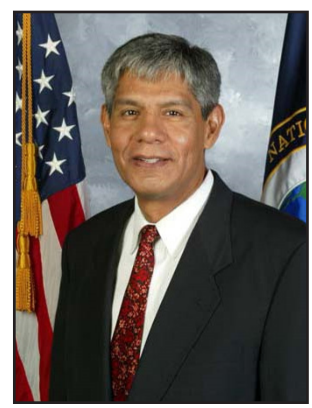
DIRECTORS OF ROM AND BPO

Mary Corrado
1998 - 1999



Vincent Dennis
1999 - 2004

Betty Sapp
2004 - 2007



Benjamin Gimeno
2007 - 2011

Jim Martin
2011 - 2013

Todd Peckins
2013 - 2016

COMM DIRECTORATE

NRO STAFF OFFICE MANAGEMENT

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ESTABLISHMENT OF COMM DIRECTORATE

DNRO Martin Faga initiated the major restructuring in early 1992 to create an NRO structure more responsible to "INT-based" functionality and to eliminate unnecessary redundancy and internal competition. The SIGINT directorate incorporated all personnel and programs involved in signals intelligence, and the Imint directorate became responsible for acquiring and operating satellites that collect electro-optical imagery. The Communications Systems Directorate (COMM) was set up to be responsible for the NRO's information technology and communications systems. COMM was also given the added responsibility of security for both space-based and ground-based communications used by military forces, the Intelligence Community, and other government users.

In 2014, DNRO Betty Sapp consolidated COMM with the Business Information Technology Enterprise Services Center and officially "double-hatted" the D/COMM with the Chief Information Officer (CIO) title and duties. The key drivers for this consolidation included eliminating organizational seams affecting Information Assurance and NRO's transition to the Intelligence Community IT Enterprise; accelerating IT service delivery; and consolidating and optimizing NRO IT functions. Increased clarity, simplified execution, and improved agility for NRO's IT initiatives would be among the benefits resulting from this consolidation. Terry Duncan took over in September as the first D/COMM to also hold the title of CIO.

Today, the COMM mission is to provide end-to-end, secure IT and transport services for the NRO and mission partners. In accomplishing this mission, COMM directly contributes to achieving the NRO mission of protecting and advancing the strategic advantage that overhead reconnaissance provides for the security of our nation and allies.

DIRECTORS OF COMM

Brig Gen Thomas J. Scanlan, Jr., USAF
January 1993- July 1995

Brig. Gen. Howard J. Mitchell, USAF
July 1995 - August 1998

Rear Adm. Rand H. Fisher, USN
February 1999- August 2004

RADM Victor C. See
August 2004 - December 2008

Andrew Cox
January 2009 - July 2011

Mr. Terry S. Duncan
September 2011 - June 2017

Mr. John M. Hood
November 2017 - Present

GROUND ENTERPRISE DIRECTORATE

EARLY MANAGEMENT OF THE NRO

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ESTABLISHMENT OF THE GROUND ENTERPRISE DIRECTORATE

The Ground Enterprise Directorate was established on March 31, 2008, as part of a multi-year NRO reorganization effort. During a 2008 Congressional presentation, DNRO Scott Large articulated the rationale for standing up GED:

> Through ongoing algorithm development and processing improvements, we are providing quick-turnaround solutions to urgent user needs. This makes it clear that our most flexible "system" is not in space, but on the ground. Therefore, the key is to build a functional flexibility on our satellites which enables us to be operationally responsive on the ground. Responsive ground-based solutions are critical to the continued success of NRO systems against our Nation's most daunting adversaries.
>
> Recognizing the importance of the ground element to the entire NRO system architecture, one significant and foundational step in response to the strategic framework, was the stand-up of the Ground Enterprise Directorate (GED). The GED is responsible for delivering an integrated ground architecture that is more automated, scalable, and responsive to pressing intelligence problems, and based on multi-intelligence, ground system-of-systems modern architecture. Standing up the GED, was the first vital step to ensuring effective, flexible, seamless overhead solutions to our customers' needs across the IC and DoD, and to ensure that we have processes and systems that enable collection orchestration, timely cross-cueing, and advanced processing that maximizes overhead value.

A key goal for this new directorate was to create a common services layer across the entire NRO Ground Enterprise (NGE). An integrated and more "horizontal" ground enterprise would minimize stovepiping while maximizing data resources and data access.

GED TODAY

In its first years, GED innovated across the board and prepared for GED's first official acquisition, known as Block 1. GED also enhanced the operational baseline for new satellites, sensors, and targets. GED's second major acquisition was the Future Ground Architecture (FGA) which transitioned ground capabilities to a more Application Service Provider based construct that separated the software from the hardware through a series of frameworks that host the mission applications in a plug-and-play fashion. FGA facilitated the move to multi-site and cloud-based hosting, while delivering new mission capabilities for collection orchestration, multiple intelligence and activity-based intelligence support. GED has scaled automation, change detection, data fusion, and sense-making, for more timely processing and multi-INT integration across the NRO's Geoint and Sigint disciplines. FGA 2.0, the acquisition programs that are building upon FGA foundation, are even more adaptive, resilient, scalable, fast, data-centric, and user focused through even more use of automation, machine learning, and artificial intelligence.

GED also provides timely Overhead-based global situational awareness to users including those in the Intelligence Community and Department of Defense.

Through GED's actions, the NRO has shifted from static, single-sensor collections to dynamic, multi-sensor solutions in response to complex intelligence problems. The NRO Ground Enterprise provides timely, value-added critical information to users worldwide through innovative solutions based on Agile software development practices and modern acquisition techniques to accelerate the delivery of mission. GED helps mission partners and customers access and utilize the most valuable overhead intelligence from the constantly expanding constellation and volumes of data. Today, GED turns user needs into useable intelligence by providing the satellite control, scheduling, relays, processing, advanced product generation, and global situational awareness for all NRO overhead systems. As GED "advances deep learning, artificial intelligence, data centricity and analytics into operations," the evolution of the NRO's integrated ground enterprise continues. NRO Ground is truly the "brains" behind the Nation's "eyes" and "ears".

DIRECTORS OF GED

Dr. Pete Rustan
February 2008 - September 2009

Ms. Jan Janssen
September 2009 - September 2012

Mr. Mike Hale
January 2013 - December 2016

Ms. Darlene Minick
January 2017 - present

GEOINT DIRECTORATE

NRO STAFF OFFICE MANAGEMENT

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ESTABLISHMENT OF IMINT DIRECTORATE

DNRO Martin Faga initiated the major restructuring in early 1992 to create an NRO structure more responsible to "INT-based" functionality and to eliminate unnecessary redundancy and internal competition. The SIGINT directorate incorporated all personnel and programs involved in signals Intelligence, and the COMM directorate became responsible for all NRO information technology and communication systems, as well as security for all satellite and ground-based communications. The Imagery Intelligence Systems Acquisition and Operations Directorate (IMINT) was formed with all personnel responsible for acquiring and operating satellites that collected electro-optical imagery. The three new directorates stood up on 1 January 1993.

IMINT EVOLVES TO GEOINT

On 17 April 2017, then-DNRO Betty Sapp announced that the Imagery Intelligence Systems Acquisition Directorate would become the Geospatial Systems Acquisition Directorate (GEOINT).

She explained the basis for the decision reflecting the directorate's evolving innovation:

> The name "IMINT" was apt when panchromatic imagery was our primary product. However, "IMINT" does much more than that today, and will do even more in the future. The new name more accurately reflects today's performance and our plan for tomorrow.
>
> The term geospatial intelligence is defined in law as "imagery, imagery intelligence, and geospatial information," used to describe, assess, and visually depict features and geographically referenced activities on the Earth. The new name aptly reflects the evolution of our overhead collection capabilities from panchromatic images, to providing increasingly rich geospatial information. It also better conveys our close partnership with the National Geospatial Intelligence Agency.

Today's GEOINT directorate defines its mission as, "Delivering innovative, resilient, and responsive overhead GEOINT." The GEOINT vision is to give U.S. adversaries "No way to hide." To fulfill both its mission and vision, GEOINT continues the 60 years' long delivery of the world's most innovative overhead collection systems to obtain geospatial intelligence.

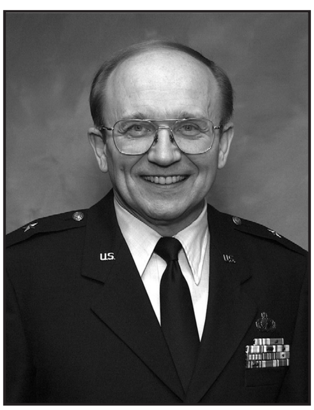
DIRECTORS OF GEOINT

Mr. Julian Caballero, Jr.
January 1993 – October 1993

Mr. Edmund H. Nowinski
October 1993 – July 1995

Mr. Robert H. Dumais
July 1995 – October 1996

Brig Gen Robert Larned, USAF
November 1996 – November 1998



Brig Gen Joseph B. Sovey, USAF
November 1998 – May 2001

Ms. Carol A. Staubach
August 2001 – July 2003

Mr. Scott F. Large
July 2003 – November 2006

Mr. Ralph S. Haller
January 2007 –January 2008

Ms. Darlene R. Minick
July 2008 - January 2017

Dr. Troy E. Meink
April 2017 – October 2020

Dr. Darrell Zimbelman
December 2020 - Present

MISSION INTEGRATION DIRECTORATE

EARLY MANAGEMENT OF THE NRO

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ESTABLISHMENT OF THE MISSION INTEGRATION DIRECTORATE

In 2013, the Mission Support Directorate was renamed the Mission Integration Directorate (MID), culminating an evolution of operational support entities and name changes that began decades earlier. With significant improvements to NRO's overhead constellation and data dissemination technologies by the late 1970s, the focus of national reconnaissance collection expanded to include targets of concern for deployed military forces. A concurrent, gradual lifting of security classification barriers permitted an increased flow of space-based intelligence products directly to the battlefield. The military services created offices for Tactical Exploitation of National Capability to leverage national systems in support of tactical forces. In 1980, the Secretary of Defense created the Defense Space Reconnaissance Program (DSRP) as a funding repository for DoD to modify systems to meet military requirements, develop and acquire systems through NRO processes for military use, and develop or acquire capabilities to assure dissemination of satellite-derived information to military forces. In 1994, the SecDef and Director of Central Intelligence agreed to place all space acquisition into the National Foreign Intelligence Program (NFIP), but DSRP retained a research budget of $50-60 million for technology improvements to assist the military in using space assets through training and exercise support.

Optimizing NRO for direct military support. In 1990, the Geiger-Kelly study determined that military forces had an insufficient understanding of NRO systems and that NRO needed to improve its responsiveness to the military. Thus, NRO incorporated support to the military as a higher priority and created a new Deputy Director for Military Support (DDMS) position held by a General/Flag officer. The DDMS served as third in the organization's chain, enjoyed full SecDef support, and served as a member of the Joint Staff. Accordingly, numerous automated tools and field manuals were created specifically to train military staff on how to request, process, and disseminate NRO data to the field. The DDMS's link to the Joint Staff provided needed insight into the military's operational requirements, so operations support was designed and customized to meet warfighter needs. In 1992, DNRO Martin Faga assigned the mission of directly interfacing with the military to the Operational Support Office in NRO Program C.

With the dissolution of the NRO Program Offices, and the recognition by the Jeremiah Panel—another study board put together to analyze and recommend how the NRO could best serve the nation—that operational users and demand for satellite coverage of the battlespace was only going to increase, DNRO Keith Hall in 1996 created a Deputy Director for National Support (DDNS) position to look after the interests of other agencies requiring NRO's unique collection capabilities. In the years following the 9/11 attacks, another sea change occurred in the Intelligence Community, including the creation of the Office of the Director of National Intelligence. The NRO, under Director Don Kerr, signed new agreements with the Air Force and CIA that created a military Deputy Director of the NRO position, to be filled by an Air Force two-star general, which would replace the DDMS as third in command at the NRO. The second in command, the formerly CIA-staffed deputy director position, was then designated Principal Deputy Director. Citing redundancy, DNRO Kerr disestablished OSO, DDMS, and DDNS, combining the latter two's responsibilities into a new Deputy Director for Mission Support office, effective 01 July 2006. Starting 01 October 2009, the DDMS was renamed Mission Support Directorate, and finally, in February 2013, MSD became MID.

The NRO's Mission Integration Directorate provides integrated intelligence products and services to end-users across the Intelligence Community, Department of Defense, Civil, and Law Enforcement communities. Since its inception, MID's purpose has been to rapidly meet the needs of NRO partners worldwide by developing and delivering solutions for timely and actionable intelligence, and applying new technologies to increase end-user effectiveness.

DIRECTORS OF MID

Blake Bowman
June 2018 – Current

Randal Barber
January 2012 – June 2018

MISSION SUPPORT DIRECTORATE DIRECTOR

Pete Rustan
July 2009 – August 2011

DEPUTY DIRECTOR FOR MISSION SUPPORT

Art Zuehlke, Jr.
January 2012 – January 2013

Pete Rustan
08 – 30 September 2009

BG Jeffrey Horne, USA
6 April 2007 – July 2009

Brig Gen Floyd Carpenter, USAF
July 2006 – 5 April 2007

DEPUTY DIRECTOR FOR MILITARY SUPPORT

Brig Gen Floyd Carpenter, USAF
June 2005 – June 2006

Brig Gen Irving L. Halter, Jr., USAF
January 2003 – June 2005

Brig Gen William M. Fraser III, USAF
December 2000 – November 2002

Brig Gen Thomas F. Crawford, USAF
June 1999 – December 2000

RADM Richard J. Nibe, Jr., USN
September 1997 – April 1999

Brig Gen David E. Baker, USAF
January 1996 – September 1997

DEPUTY DIRECTOR FOR MILITARY SUPPORT (continued)

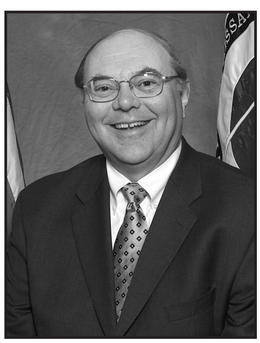
RADM Joseph J. Dantone, Jr., USN
April 1994 – January 1996

RADM Daniel P. March, USN
March 1992 – March 1994

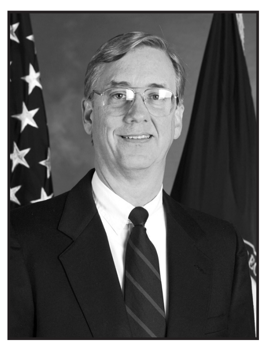
RADM Dennis M. Brooks, USN
August 1990 – January 1992

DEPUTY DIRECTOR FOR NATIONAL SUPPORT

Mary Sturtevant
June 2004 – June 2006



John A. Lauder
March 2001 – June 2004



Thomas W. Conroy
November 1998 – March 2001

Michael F. Munson
October 1996 – November 1998

MISSION OPERATIONS DIRECTORATE

NRO STAFF OFFICE MANAGEMENT

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NEW APPROACH TO THE OPERATION OF NRO SATELLITES

Prior to the 1992 reorganization, the CIA, Air Force, and Navy all operated their satellites independently. After the reorganization, satellite operations began to be consolidated to one of three NRO ground stations located in Virginia, Colorado, and New Mexico.

By the time Donald Kerr became Director of the NRO, satellite program managers were developing plans for implementing a more integrated enterprise construct, adopting the recommendations of working groups, "tiger teams," and internal and external transformation teams. Kerr had outlined goals and objectives in his April 2006 "Strategic Framework" document, which laid out his vision to build an integrated overhead architecture to support the intelligence needs of a growing user population analyzing increasingly complex and diverse intelligence problems. The genesis of the office that became the Mission Operations Directorate (MOD) began with Kerr's announcement, made shortly before he left the NRO to become the Principal Deputy Director for National Intelligence (PDDNI), of an "Enterprise Integration Initiative," which included among its actions the establishment of an "Integrated Operations Directorate" (IOD). The proposed IOD, along with a new "Enterprise Integration Directorate," encompassed operations, processes, and procedures of several entities, most notably systems operations offices in the Imagery Systems Acquisition (IMINT) and Signals Intelligence Systems Acquisition (SIGINT) directorates.

In combination with other organizational and managerial changes, Kerr believed the agency could "increase the intelligence value of NRO capabilities by improving content, access, and timeliness of information we provide to our mission partners and other users." Dave Shields was to direct IOD, but shortly after Scott Large's promotion from principal deputy director to become the new DNRO in October 2007, the "IOD" became "SOD" for Systems Operations Directorate, or sometimes more simply "SO" for systems operations.

MOD TODAY

The seating of a new Congress and the inauguration of a new President from a different political party in January 2009 brought the customary, gradual changes in leadership positions at IC agencies and elsewhere over the subsequent months. On 12 June 2009, the new administration announced that Mr. Bruce Carlson (General, USAF, Ret.) would become the 17th director of the National Reconnaissance Office. On 1 October 2009, Carlson established the "Mission Operations Directorate" and assigned SO to MOD.

Since that time, MOD has operated the NRO's constellation of satellites with innovation and sophistication. MOD's mission, vision, and tenets statements described the directorate's critical role in today's NRO.

MISSION: Lead innovative, adaptive, and dynamic operations to enhance NRO intelligence collection

VISION: Pioneering NRO Operations – the Vanguard of National Security

TENETS:

- Operate the NRO's overhead intelligence systems to fully meet our commitments
- Employ our systems to deliver capability, emphasizing innovation over longevity
- Continually identify opportunities to improve effectiveness and enhance capabilities
- Innovate how we deliver, employ, and integrate NRO systems to creatively solve our most challenging problems
- Continually improve how we deliver new capabilities into the mission baseline, championing changes to NRO systems that are necessary to stay ahead of threats and opportunities
- Lead multi-INT discovery activities with our mission partners to meet evolving critical needs
- Defend and Fight to satisfy U.S. and allied nations' intelligence needs in an increasingly contested mission environment
- Operate NRO assets through conflict to deliver overhead capability and provide unity of effect
- "Train like you fight" – incorporate training and readiness as an integrated part of normal operations

DIRECTORS OF MOD

Mr. David Shields
Sep 2007 - Jul 2008

Ms. Michele Brunngraber
Aug 2008 - Sep 2009

Brig Gen Cary Chun
Sep 2009 - Mar 2012

Mr. David Carey
Mar 2012 - Apr 2013

Dr. Raymond Cook
Apr 2013 - Sep 2015

Ms. Tonya Wilkerson
Sep 2015 - Apr 2019

Timothy (T. J.) Lincoln
Apr 2019 - Present

MANAGEMENT SERVICES & OPERATIONS

EARLY MANAGEMENT OF THE NRO

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MAJOR NRO REORGANIZATION

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ESTABLISHMENT OF MS&O

The NRO's Management Services and Operations directorate was established in January 1992, with the first director, Roger Marsh beginning his service on 15 January 1992. The creation of the MS&O consolidated support functions that had previously been carried out by the NRO headquarters staff, as well as the original Air Force, CIA, and Navy programs. MS&O was responsible for providing all support services including facilities development and operations, headquarters security, human and personnel resources, information management, program services, logistics, and employee assistance programs.

Upon its establishment, MS&O was charged with building a new headquarters for the newly consolidated NRO. Previously the major NRO programs support staff were housed in California for the Air Force program, in Northern Virginia for the CIA program, and in Washington, D.C. for the Navy program.

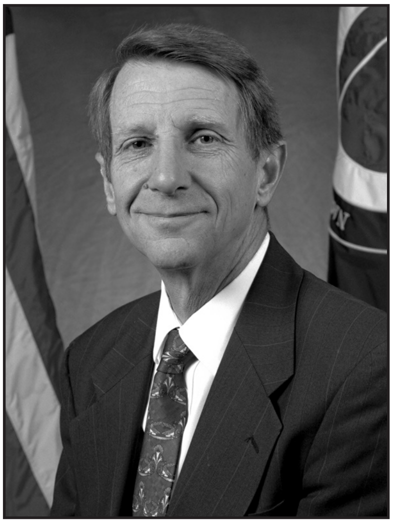
Although ahead of its time in design and construction, the NRO's Headquarters (Westfields) in Chantilly, Virginia encountered some early headwinds. Members of the U.S. Senate alleged the headquarters was constructed without Senate notification. NRO leadership and Marsh faced an early challenge in delicately handling this issue that found its origins in tensions between the Senate intelligence oversight committee leadership and the Director of Central Intelligence. MS&O leadership was able to defuse the controversy and successfully opened the building in 1996.

MS&O TODAY

MS&O today is responsible for many support activities for the NRO. In addition to managing the NRO Headquarters facilities, they also manage the NRO's ground station facilities in Virginia, Colorado, and New Mexico. MS&O also provides logistics, warehousing, and transportation support in support of NRO's global enterprise. Additionally, the NRO depends on MS&O for its employee assistance, medical, and fitness programs.

MS&O maintains an award winning media services program. Assuring that operations continue under adverse conditions, MS&O also maintains continuity of operations and emergency management support.

DIRECTORS OF MS&O



Roger Marsh
January 1992 - July 2001

Brian Malone
July 2001 - October 2013

John Guyant
October 2013 - October 2018

Elizabeth Taylor
October 2018 - present

SYSTEMS ENGINEERING DIRECTORATE

EARLY MANAGEMENT OF THE NRO

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ESTABLISHMENT OF SYSTEMS ENGINEERING DIRECTORATE

During the early existence of the NRO, systems engineering efforts and architecture requirements were generally decentralized functions disbursed throughout the individual directorates and programs, with no common NRO enterprise-level program or approach. Throughout the late 1990s and early 2000s, the struggles of the Future Imagery Architecture (FIA) program and the resulting Congressional scrutiny highlighted the need for a more robust NRO strategy for oversight of systems engineering processes. Beginning in 1998, several corporate level offices were formed or realigned to implement a strategic direction for NRO enterprise-level systems engineering. Finally, on 10 September 2001, those offices were merged into the office of the Deputy Director for Systems Engineering (DDSE).

On 17 October 2006, the DDSE was dissolved and replaced by the Office of Deputy Director for Systems Integration and Engineering (DDSIE) that was charged with consistent delivery of NRO acquisition commitments through the implementation of a new and more substantive enterprise-level systems engineering function. Just one year later, in November 2007, SIE was renamed simply Systems Engineering, and in October 2009, the group was officially declared the Systems Engineering Directorate (SED).

SED was initially a conglomerate of system engineering elements from the IMINT, SIGINT and COMM directorates charged with establishing a single enterprise architecture approach for the DNRO across all mission areas, with the goals of reducing duplicative efforts, costs, and risks, while promoting multi-INT approaches. After working through the initial growing pains with organization structure and governance, in 2012 SED emerged into the structure of today, with clearly defined roles and responsibilities that solidified their business practices.

SYSTEMS ENGINEERING DIRECTORATE TODAY

Today, SED continues to work toward improvements in efficiencies and adding optimum value to the NRO enterprise. SED describes their mission and goals as follows:

> The Systems Engineering Directorate defines, assesses, and delivers the Integrated Overhead Mission Enterprise that provides assured intelligence capabilities by providing enterprise engineering excellence ahead of the speed of change. To accomplish this, the SED:
>
> - proactively defines and delivers the future NRO mission architecture;
> - shapes NRO investment decisions;
> - enables and informs enterprise decisionmaking;
> - ensures enterprise capabilities are fully integrated into the NRO architecture;
> - attracts and develops a world-class workforce; and
> - improves the effectiveness and efficiency of NRO system engineering.

DIRECTORS OF SED

Michael Orr
Aug 2014 – Present

Tina Harrington
Jun 2012 – Dec 2013

RADM Liz Young
Oct 2009 – Jun 2012

DSI&E/SYSTEMS ENGINEERING DIRECTOR

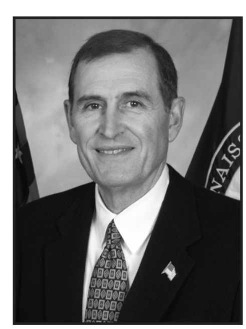
RADM Liz Young
Oct 2008 – Oct 2009

Vernon Grapes
Jan 2008 – Oct 2008

Brig Gen Edward Bolton
Oct 2006 – Jan 2008

DDSE DIRECTORS

Maj Gen Robert Latiff
Nov 2003 – Oct 2006



Dr. William A. "Art" Decker
Sep 2001 – Sep 2003

SIGINT DIRECTORATE

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ESTABLISHMENT OF SIGINT DIRECTORATE

During the first three decades, the Air Force, CIA, and Navy all developed signals collection satellites. The reorganization brought the three programs under the direction of a single entity, the Signals Intelligence Systems Acquisition and Operations Directorate (SIGINT). The first SIGINT Director was Brig Gen Donald R. Walker who previously led the NRO Staff as it was disestablished under the 1992 reorganization plan. The directorate was charged with responsibility for consolidating the development of new signals collection satellites into an integrated structure, completing satellites under acquisition, operating existing satellites, and managing ground stations supporting signals collection satellites. In the early years, the SIGINT Directorate devoted significant time and attention to developing a single overhead architecture that integrated the signals collection satellites—an effort requiring innovation and adoption of new approaches to the management of existing and future signals collection satellites.

SIGINT TODAY

Today, the SIGINT Directorate describes their organization as follows:

> The SIGINT Directorate acquires and deploys an integrated worldwide network of preeminent, adaptable, and innovative overhead SIGINT reconnaissance systems. Our systems, which include organizations, processes, and equipment, deliver responsive, actionable intelligence and world-wide situational awareness of new and evolving threats. Integrating processes and systems within the directorate, across the NRO enterprise, and throughout the Intelligence Community enables our Nation to meet the new and evolving threats of the 21st century. These challenges demand innovative and collaborative solutions to ensure that our vision becomes reality. Silence is their only refuge!

DIRECTORS OF SIGINT

Brig Gen Don Walker
December 1992 - July 1995

Brig Gen Thomas Scanlan
July 1995 - August 1996

Brig Gen Robert Larned
August 1996 - October 1996

Mr. Dennis Fitzgerald
November 1996 - June 2001

Maj Gen James Armor
June 2001 - April 2005

Brig Gen Larry James
July 2005 - May 2007

Brig Gen Kathy Roberts
May 2007 - November 2008

Dr. Troy Meink
November 2008 - December 2013

Ms. Tina Harrington
December 2013 - present

INNOVATORS

GOVERNMENT PARTNERS

NRO-JOINT ORGANIZATION

THE NEED FOR JOINT DUTY

The 11 September 2001 terrorist attacks forced dramatic changes in U.S. national security. Domestic reaction was widespread, and people on Capitol Hill and in the press wanted answers and demanded change. The 9-11 Commission investigated the disaster and made many recommendations. One of the recriminations levelled against the IC was that there was not enough interagency coordination. To better integrate the IC, the suggestion was made that all IC employees should complete at least one joint duty assignment (JDA) at another agency to become familiar with their processes and bring that knowledge back to their home agencies. In response, Congress passed the 2004 Intelligence Reform and Terrorism Prevention Act (IRTPA), which included the provision that a JDA was a condition for promotion to senior executive. This directive was similar to the 1986 Goldwater-Nichols Act that made a joint assignment for military officers a requirement for promotion to flag rank. What many people had forgotten was that the NRO had been doing exactly that for the past 40 years.

NRO WAS BUILT THAT WAY

In the late 1950s, all three military services and the CIA were involved in designing satellites. Although launching rockets was not in the CIA's repertoire, the agency was purposely brought into the Corona program by President Eisenhower because of previous success in jointly running the U-2 program with the Air Force. With the stakes becoming higher as reconnaissance moved into space, Eisenhower did not want the Air Force to take full control of all strategic reconnaissance efforts. By the time President Kennedy took office in 1961, it was clear that these disparate space program efforts would be more effective and efficient if they were managed by one organization to control budgets and facilitate coordination. To that end, on 6 September 1961, an agreement was signed by the CIA and DoD to form the jointly managed National Reconnaissance Office to run the National Reconnaissance Program. From "Day One" the NRO was designed to be a joint organization, not with simply a few managers and liaisons, but with jointly manned offices, placing CIA officers side-by-side with DoD civilians and service members.

Throughout NRO's early history, particularly in the 1960s when the organization was taking shape, there has been friction among DoD and IC elements as to which had more control over the NRO. Indeed, many books have explored this topic in depth. But while the balance of power in the upper echelons between the DoD and CIA has swayed from time to time, throughout all of that, the jointly manned offices of the NRO continued to accomplish amazing feats of technological ingenuity and perseverance. Without letting high-level turf wars deter them, CIA and DoD employees worked together in their joint offices to keep America more safe and secure.

WORKING TOGETHER

Today, just as in the early 1960s, uniformed military DoD members and civilian-clad CIA personnel sit at adjacent desks, attend the same meetings, take the same training classes, eat in the same cafeterias, and attend the same Family Day celebrations. They get to know each other, learn how their counterparts think and accomplish tasks, and become coworkers, compatriots, and often friends. As a result, they often stay in touch after they leave the NRO and return to their home agencies with the lessons they learned. After the IRTPA was passed in 2004, many IC partners worked hard to add liaisons and increase joint duty opportunities to fulfill the Congressional directive. By its very nature, the NRO has quite successfully integrated the IC through joint duty for the past 60 years.

CIA

The CIA has been a formal partner with the Department of Defense in the management, staffing, and funding of the NRO since the day the NRO was formed in 1961. At that time, Under Secretary of the Air Force, Dr. Joseph V. Charyk, and the CIA Deputy Director for Plans, Dr. Richard M. Bissell, Jr., served as Co-Directors. The two men worked well together, having previously launched the U-2 and Corona programs with astonishing speed, so the joint arrangement was mutually beneficial. However, in February 1962, Bissell resigned from the CIA under pressure after the failed Bay of Pigs operation, leaving the NRO with just a single director. Knowing that a single director was probably the wisest course of action, a second agreement was signed in May 1962 formalizing the NRO leadership with a single director. From that date until March 2005, the Director of the NRO was always a senior Air Force official (usually an Assistant or Under Secretary of the Air Force). In March 1963, a third agreement was signed between the DoD and the CIA formally creating the position of Deputy Director of the NRO, and that position was thereafter filled with a CIA official.

Even by 1961, the CIA had a history of utilizing technology to enhance intelligence collection. They had previously tunneled under Berlin to tap Soviet military communications and, of course, had already built the U-2. In August 1963, the Directorate of Science and Technology (DS&T) was formed, due in no small part to the former Development Projects Staff being too enmeshed with the Directorate of Plans and their involvement with the Bay of Pigs failure. DS&T's first director, Albert "Bud" Wheelon brought together all of the Agency's best scientists and engineers to create world-class technological solutions to intelligence problems. He formed the Office of Special Projects in 1965, and in April 1973, the Office of Development and Engineering was formed; these two offices supported the NRO throughout their histories. In addition to their breakthrough work with the U-2 and A-12 aircraft, these groups also invented the lithium-iodine battery, essential for use in pacemakers, and developed change-detection technology used by the medical community in mammography, among a multitude of other critical classified developments.

PROGRAM B

Shortly after being named as the sole DNRO in 1962, Dr. Charyk created the organizational structure that the NRO would follow for the next three decades when he set up Program A (Air Force), Program B (CIA), Program C (Navy), and later Program D (Aircraft). While the CIA utilized many Air Force personnel and resources for its satellite launches, the Agency was in charge of the direction and pace of satellite developments in Program B. Because of its previous success with the U-2, the CIA partnered with the Air Force in the development of the Corona program, before the NRO had even been formed, and that partnership continued after September 1961. Program B's most significant contributions were the development of the Hexagon wide area search photoreconnaissance satellite and the KH-11 Kennen system, the world's first near real-time electro-optical satellite and the precursor to today's NRO imagery constellation.

OSR

Today, the CIA continues to be a critical partner in the operation of the NRO, and a senior CIA official still serves as the Principal Deputy Director of the NRO. The Office of Space Reconnaissance, as part of the DS&T, was created in September 2014 to support the NRO in an effort to create a more stable and less transient workforce at the NRO. CIA personnel serve in all NRO directorates and in numbers proportional to their uniformed and cadre colleagues.

U.S. AIR FORCE

NROL-71 launch on 19 January 2019 from Vandenberg.

NROL-61 launch on 28 July 2016 from Cape Canaveral.

NRO FORMED

The Air Force is an integral part of the NRO and has been since the day the NRO was formed. In the late 1950s, each military service was involved in trying to get satellites into orbit, each for their own particular mission. Most of the Army's satellite and launcher effort, located in Huntsville, Alabama, was transferred to the National Aeronautics and Space Administration when it was created in 1958. When the NRO was formed three years later, it subsumed the Air Force's satellite efforts into Program A and the Navy's efforts into Program C. However, the Air Force continued its own research into missile technology for its various missile programs, and thus, it continued to support the NRO even through its non-NRO components.

When the NRO was first set up into organizational programs in 1962 by Dr. Charyk, the first Director of the NRO, Air Force personnel formed the vast majority of Program A personnel. Although Program B was organized and funded as a Central Intelligence Agency program, Air Force personnel accounted for a significant portion of the manpower in that program as well. While the CIA managed Program B, made all the decisions, and dictated what satellites to investigate and develop, Air Force personnel were needed to provide the launch platforms, facilities, and other such activities related to launching the program's satellites into orbit because the CIA did not have those types of personnel in its employ.

WHERE THEY WERE

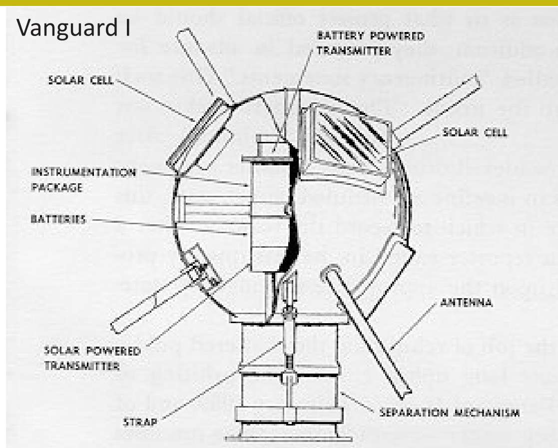
While Program A, B, and C's personnel were located outside the Washington, D.C. area, the NRO was managed by the DNRO and the NRO Staff in the Pentagon. When initially set up, the core of the NRO Staff was formed by the Air Force's Office of Missile and Satellite Systems, which consisted of 10 Air Force officers and one officer each from the Army and Navy.

Thirteen of the first 14 Directors of the NRO were senior Air Force officials (usually Assistant or Under Secretary of the Air Force). In 2005, Donald Kerr was appointed as the first independent civilian DNRO, and now, one of the two Deputy Directors of the NRO is always a uniformed Air Force general officer.

NRO launches are conducted from primarily Air Force bases in Florida (Cape Canaveral Air Force Station) and California (Vandenberg Air Force Base), and one of the NRO's ground stations is located on Buckley Air Force Base in Colorado. Today, the Air Force provides the largest percentage of NRO's manpower of any organization.

U.S. NAVY


Vanguard I Launch



Vanguard I


Vanguard I Model

When most people think of U.S. satellite reconnaissance, they invariably think of the NRO and, to a lesser extent, the Central Intelligence Agency and the Air Force. What few people outside of the Intelligence Community realize is that the U.S. Navy actually developed the world's first operational reconnaissance satellite.

REACHING SPACE

In the late 1950s, the Navy was involved in satellite research, just like the Air Force and Army. While the Army got the credit for the first successful launch of a U.S. satellite with Explorer-1 on 31 January 1958, the Navy launched the second U.S. satellite, the Vanguard-1, 45 days later on 17 March. The Vanguard satellite, developed by the Naval Research Laboratory, was the world's fourth orbiting satellite (after two Sputnik launches and the Explorer), and it was the first to utilize solar power. The Vanguard ceased transmissions after six years of operation, but it still has not de-orbited and so remains the oldest man-made object in space.

THE FIRST RECONNAISSANCE SATELLITE

When the National Aeronautics and Space Administration was formed in October 1958, most of the technicians at the NRL transferred to NASA and moved to what is today the Goddard Space Flight Center. However, the Navy retained some of their engineers to continue working on classified Navy programs. Right about the time of the Vanguard launch, NRL engineer and future NRO Pioneer Reid D. Mayo envisioned placing a solid-state version of a radar detector the Navy had been placing on submarine periscopes onto a Vanguard-like satellite. He and his idea remained with the NRL after the NASA takeover, and the Navy continued in the satellite business. Two years later on 22 June 1960, the GRAB satellite was launched and mapped Soviet radar installations for more than two months. The GRAB program lived for two years, although only one of the remaining four launches was successful, and it provided a wealth of intelligence data on Soviet radar locations.

PROGRAM C

When the NRO was formed in 1961, it absorbed most of the remaining NRL personnel, as well as the GRAB program, and placed them into Program C, based in southeast Washington, D.C. and Maryland. The following year, the Navy personnel in Program C developed a follow-on to GRAB and launched the first Poppy mission on 13 December 1962. The Poppy program produced seven successful launches and operated until 1977, providing a wealth of electronic intelligence intercepts on a variety of subjects. The intercepts were analyzed by National Security Agency personnel, who had been incorporated into Program C along with the Navy personnel, and the analysis was transmitted throughout the Intelligence Community. Since Programs A and B were concerned primarily with imagery systems, Program C soon became the de facto signals intelligence center for the NRO until the 1992 NRO reorganization and the creation of the Signals Intelligence Systems Acquisition and Operations Directorate.

NSA

STAND UP

The National Security Agency stood up in 1952 with Lt. General Ralph Canine as the first Director of NSA (DIRNSA), and its main charter was to deal with electronic intelligence that contained speech or text, or Comint. DIRNSA Canine decided that the most important challenge for NSA would be to focus on just Comint, and other electronics intelligence would be handled by the components already managing it. However, two presidential-level committees, the Mark Clark subcommittee of the Hoover Commission in 1954 and the William O. Baker Committee in 1957, recommended Elint be brought into NSA's domain.

Dr. Baker was a big proponent of U.S. Elint efforts being managed by the NSA and was strongly backed by President Eisenhower. In 1958, Baker's Committee issued the National Security Council Intelligence Directive (NSCID) No. 6, "Communication Intelligence and Electronics Intelligence." In early 1959, DoD Directive S-3115.2 focused on a DoD top management review with the Director of Defense Research & Engineering (DDR&E) having the NSA manage DoD Elint activities, with certain exceptions. The Directive was updated again in 1972 and retitled "Signals Intelligence (Sigint)," and it assigned NSA even more Elint duties. The DoD Directive gave NSA the responsibility for managing all Sigint within DoD including Comint, Elint and Telemetry Intelligence (Telint).

THE FIRST RECONNAISSANCE SATELLITE

In 1958, Reid Mayo, a Naval Research Laboratory engineer and future NRO Pioneer, was trying to find a better way to intercept and analyze signals from Soviet air defense radars, and he determined that it would be possible to place an improved version of a current signals detector into a satellite and collect returns from space. He presented his idea for Elint collection to Howard Lorenzen, Chief of NRL's countermeasures branch. Lorenzen agreed to the project and championed the idea within the Department of Defense and the Intelligence Community. On 24 August 1959, President Eisenhower approved the development of the GRAB satellite under Project Tattletale. The first GRAB satellite launched from Cape Canaveral on 22 June 1960, less than two months after Francis Gary Powers' U-2 reconnaissance plane was shot down over the Soviet Union and two months before the first successful Corona photoreconnaissance satellite mission.

NSA developed an automatic system to improve the time-consuming processing of Elint data that was received from GRAB satellites. The data was collected in NRL radio receiving and control huts at ground sites and then sent on to NSA and the Air Force Strategic Air Command for exploitation. The intelligence from GRAB and its follow-on, Poppy, provided the location and capabilities of Soviet radar sites and ocean surveillance information for analysis and distribution to U.S. military and intelligence organizations. In the early 1970s, a joint NRO and NSA field Elint processing center was opened. This added to NSA's expertise in signal processing, and its reporting responsibilities on NRO data provided many collection and processing advantages and improved timely reporting on NRO's collection activities.

After the NRO was formed in 1961, the NSA continued to work with the former Navy programs that now found themselves inside NRO's Program C, as well as a few Sigint projects developed by the other NRO Programs. NSA was essential in the development of the Poppy program, which had seven successful launches without a failure from 1962 to 1971.

CONTINUED COLLABORATION

Since those early years, NSA has continued to sponsor and collaborate with the DoD, NRO, and CIA in developing sophisticated signals collection equipment for an ever-expanding array of signals targets and changing technology. Since the GRAB, NSA has consulted with NRL and NRO engineers on the development of every major U.S. Sigint satellite ever produced. Today, the NSA is still the chief customer of Sigint data collected by the NRO, as well as the primary tasker of the NRO's Sigint collection platforms.

NIMA/NGA

REORGANIZATION

The National Geospatial-Intelligence Agency (NGA) was originally formed as the National Imagery and Mapping Agency (NIMA) in 1996 by the combination of two other NRO innovation partners, the National Photographic Interpretation Center and Defense Mapping Agency (DMA), as well as the smaller Defense Dissemination Program Office and Central Imagery Office. One of the "lessons learned" from the first Gulf War was that national intelligence needed to be more agile in its support of U.S. warfighters, so one of the responses was to combine all national imagery and mapping activities into one organization. NIMA was officially formed on 1 October 1996 when the National Defense Authorization Act for FY 1997 went into effect. NIMA changed its name to NGA in 2003 to more accurately portray the new vision of geospatial intelligence (Geoint), which had been developed over the preceding 10-15 years but was finally receiving acceptance across the community as a legitimate formal discipline.

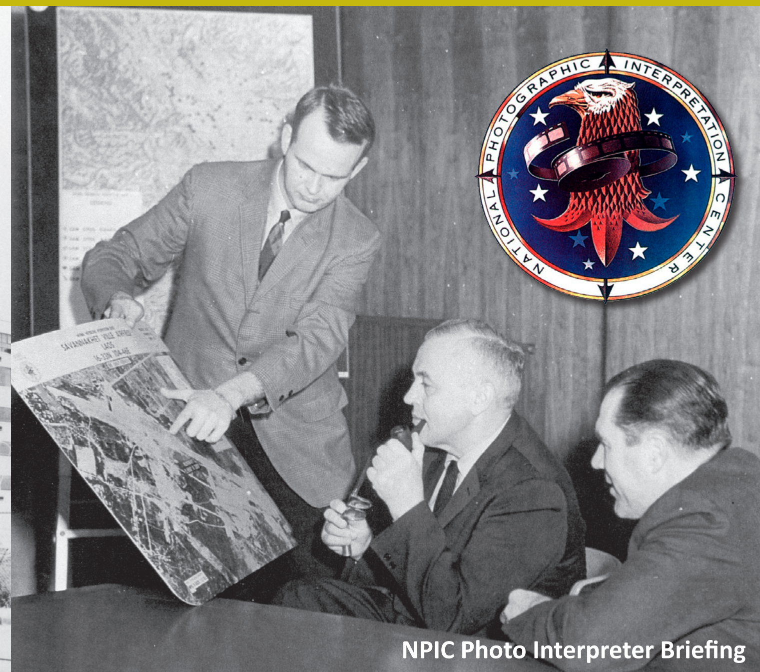
When NIMA was formed, it not only merged its component agencies, but also small pieces of other organizations related to imagery and mapping. Some members of the Central Intelligence Agency, the Defense Intelligence Agency, and the Defense Airborne Reconnaissance Office, as well as a few members of the NRO, suddenly became NIMA employees. But NIMA did not just absorb these personnel, it also subsumed the missions of those personnel. NIMA became the preeminent customer for NRO's imagery collection, even more so than NPIC, since it now had DMA's mapping requirements to fulfill. NIMA officially was renamed NGA with the 24 November 2003 signing of the 2004 Defense Authorization Bill, although no organizational changes accompanied the rebranding.

THE PATH FORWARD

Today, NGA and NRO continue to work on all aspects of space-based imagery collection, and roles continue to be refined. In 2017, for example, the acquisition of commercial imagery for U.S. Government use was passed from NGA to NRO, even though this imagery is not coming from U.S. Government systems. It was decided that while NGA had pioneered the acquisition process of commercial imagery, the role was still acquisition of satellite imagery and so should be under the NRO's purview. So while personnel and missions continue to develop, NGA and NRO continue to evolve their partnership, and will continue to do so as long as the NRO collects imagery.

NPIC

NPIC Building 213, Navy Yard 1960s



NPIC Photo Interpreter Briefing

BEGINNING THE TRADECRAFT

The National Photographic Interpretation Center was a part of the U.S. satellite Intelligence Community before the NRO was even created. Formed from satellite imagery components of the CIA and the military in one of President Eisenhower's last acts on 18 January 1961, NPIC was the primary customer for U.S. satellite imagery for 35 years. With Arthur C. Lundahl at the helm, NPIC earned its stripes, and possibly reached the peak of its reputation, almost as soon as it was formed by identifying Soviet missiles in Cuba in October 1962 and cementing its place as a vital component of the U.S. Intelligence Community during the subsequent crisis.

When the NRO was formed eight months later in September 1961, its two main customers, the NSA and NPIC, were already involved with exploiting satellite-provided intelligence data. From that very first day, the NRO worked hand-in-hand with both organizations. NPIC was the primary customer for all the product from NRO film-based satellites, including Corona, Gambit, and Hexagon, as well as aircraft-derived imagery (U-2, A-12/SR-71, etc.) supplied by Program D. NPIC personnel were consulted in the decisionmaking processes for new imagery satellites created by NRO Programs A and B and also for a short time after the NRO was declassified and reorganized into its current "INT-based" structure in 1992.

WORKING TOGETHER

NPIC personnel often forward deployed to NRO facilities around the world to get immediate feedback on data returns and to provide immediate analysis on priority targets. NPIC personnel deployed to Eastman Kodak facilities in Rochester, NY to analyze returns from all NRO film-based systems. When the NRO created electro-optical imagery systems in the 1970s, NPIC was not only the primary customer, but NPIC personnel were stationed at NRO facilities to provide immediate analysis and feedback.

When the NRO and Air Force were preparing astronauts to launch into space as part of the Manned Orbiting Laboratory program in the late 1960s, NPIC was also involved. MOL astronauts visited Building 213 in southeast Washington, D.C. where NPIC personnel trained them on how to analyze ground targets to allow them to utilize MOL's reconnaissance instruments more efficiently.

NPIC continued to be the primary customer for NRO imagery systems right up until 1 October 1996, when it was merged with the Defense Mapping Agency and several smaller entities to form the National Imagery and Mapping Agency. On that day, it ceased to be a component of the CIA and became a combat support agency of the Department of Defense.

DEFENSE MAPPING AGENCY

Hexagon (KH-9) Mapping Camera image of Moscow, Russia, 6 April 1979

Hexagon (KH-9) Mapping Camera image of Kubinka Airfield Soviet Union, 6 April 1979

DMA FORMED

The Defense Mapping Agency was created on 1 January 1972 in order to bring together all of the mapping, charting, and geodesy operations of the three main military services, the Air Force's Aeronautical Chart and Information Center, the oceanographic and charting services of the Naval Hydrographic Office, and the Army Map Service. From the start, DMA was a voracious customer of NRO imagery, since satellite imagery was a boon to the mapping services, allowing for much greater production, as well as accuracy.

EXPLOITING THE MCS

In March 1973, the NRO launched its fifth Hexagon satellite, which was the first Hexagon to have the new Mapping Camera System onboard. The MCS was both revolutionary and evolutionary. It provided better than a four-fold improvement in accuracy, and more than a ten-fold improvement in resolution, over the previous best KH-5 mapping camera. This data provided far better geographic positioning and elevation information for the nation's mapping community, allowing them to produce more and better maps and targeting data for tactical and strategic weapon systems. Over the course of 12 missions, the MCS provided imagery of over 100 million square miles of denied areas for use by DMA cartographers and analysts. By the time Hexagon had become a mature system, DMA had begun to rely almost exclusively on satellite imagery as the source for its mapping needs.

As near real-time imagery emerged and NRO's film-return systems retired, DMA also adapted to using new imagery for their needs. However, they continued to utilize older Hexagon KH-9 imagery whenever possible, due to the large formatting of the film and the ability to acquire much greater land area on a single piece of film, making the mapmakers' jobs much easier.

CLOSING DOWN

DMA continued to be the primary customer for NRO mapping imagery throughout the 1980s and early 1990s. But as with many other imagery users, DMA ceased being a customer on 1 October 1996, after it was absorbed into the new National Imagery and Mapping Agency.

INNOVATORS

INDUSTRY PARTNERS

AEROSPACE CORPORATION


SCHRIEVER


DynaSoar


DELTA IV HEAVY

The Aerospace Corporation was founded in June 1960 as a non-profit federally funded research and development center (FFRDC). Aerospace provides technical advice and guidance on acquisition, launch, and engineering related to space missions for the U.S. military and civilian agencies, as well as a variety of commercial customers. Aerospace Corporation has worked with the National Reconnaissance Office since its inception in 1961 when it supported the Air Force's satellite programs brought into the NRO.

ESTABLISHMENT AND EARLY HISTORY

On 1 July 1954, the U.S. Air Force established the Western Development Division, under the command of Brigadier General Bernard A. Schriever with the primary responsibility to study and develop an intercontinental ballistic missile. The newly formed Ramo-Wooldridge Corporation (a forerunner of TRW), utilizing their Space Technology Laboratories division, was selected as the industry partner responsible for missile systems engineering.

Simon Ramo and Dean Wooldridge, founders of the Ramo-Wooldridge Corporation, were also full members of the Teapot Committee (codename for the Strategic Missile Evaluation Committee). The Assistant Secretary of the Air Force for Research and Development established the committee in October 1953 to study the development of ballistic missiles, including ICBMs, after the Soviet Union test detonated their first hydrogen bomb in August 1953.

Concerns were raised from both government and industry that Ramo-Wooldridge had conflicts of interest and an unfair competitive advantage on ICBM development due to Simon Ramo's and Dean Wooldridge's participation on the committee, as it was perceived they had privileged access to Air Force missile information and technology. When Ramo Wooldridge Corporation merged with Thompson Products in 1958 to form Thompson Ramo Wooldridge, Inc. (TRW), the Space Technology Laboratory became an independent subsidiary; however, concerns persisted. To address the concerns, in September 1959 Congress issued House Report 1121 that recommended the Space Technology Lab be converted to a non-profit entity.

On 3 June 1960, Aerospace Corporation was established under the laws of the State of California as a nonprofit corporation. On 25 June 1960, at a press conference held at the Air Force Ballistic Missile Division headquarters in El Segundo, California, Lieutenant General Schriever announced the "formation of a new nonprofit organization, The Aerospace Corporation, to serve the Air Force in the scientific and technical planning and management of missile-space programs."

AEROSPACE CORPORATION AND THE NRO

Aerospace Corporation had a strong relationship with the Air Force by the time the NRO was established in 1961. Aerospace supported some of the most innovative national security and civilian space programs in the 1960s, including the DynaSoar orbital space plane, the Mercury program, development of the Atlas and Titan II launch vehicles, development of the Advanced Ballistic Re-Entry System and Defense Satellite Communications System, as well as early warning satellite programs.

Through its relationship with the Air Force, Aerospace Corporation began providing support to the NRO's Program A, which housed the Air Force's reconnaissance satellite programs. Aerospace assisted the NRO in developing launch requirements for its unique satellites. Aerospace also provided expertise in risk assessment, systems engineering, and systems integration.

In 1963, Program A launched the first imagery satellite developed under the NRO, known as Gambit. The Gambit satellite provided capability that the earlier launched Corona imagery satellite could not, and that was high-resolution imagery. Aerospace assisted in the development of the Gambit satellite, providing the key expertise it developed in supporting other Air Force programs. With Aerospace's assistance, the Gambit program would eventually develop a second generation satellite that could obtain images from space of objects smaller than one foot.

In the 1960s, the Air Force initiated the Manned Orbiting Laboratory program. MOL was a human spaceflight program developed to place manned space stations in orbit with reconnaissance capabilities. Known as Dorian and developed by Program A, MOL would carry an imaging system using Gambit components to obtain high-resolution imagery. Since the station was to be manned by Air Force astronauts, they could better select targets for imaging and provide early readout of those images. Aerospace again provided key expertise in this program. Although the program was cancelled due to growing costs and in favor of more sophisticated reconnaissance satellites, major components of the program would benefit NASA's manned space flight program and future NRO satellite programs.

Aerospace would continue to provide expertise in most of the U.S.'s innovative space programs, including the Space Shuttle, Defense Meteorological Satellite Program, Global Positioning System, Strategic Defense Initiative, and many other military satellite programs. Aerospace also provided essential expertise in the development of new generations of launch vehicles, including those in the Atlas, Titan, and Delta vehicle families. When the nation undertook the effort to develop Evolved Expendable Launch Vehicles, Aerospace again provided key assistance. The NRO was a direct beneficiary of these launch program evolutions.

As the NRO evolved and developed more and more sophisticated imagery and signals collection satellites, Aerospace remained a key partner for assuring the success of those programs. This partnership endures today between the NRO and Aerospace Corporation, helping the NRO continue to develop innovative national reconnaissance satellites.

BOEING

FORMATION OF TODAY'S BOEING

When the United States emerged from World War II, airplane manufacturers looked for new opportunities in commercial aviation, as military aviation demand decreased with the conclusion of the war. Over time, many of those manufacturers would merge with the Boeing Company, forming the U.S.'s largest aviation company. At the same time, Boeing and other airplane companies seized opportunities to support the U.S.'s civilian and national security space programs. Boeing and the many companies that merged with Boeing were essential partners with the NRO in developing highly innovative space programs. The partnership continues today, although little can be shared publicly of the current NRO and Boeing classified programs.

William Boeing founded Pacific Aero Products in Seattle, Washington on 15 July 1916, renaming the company the Boeing Airplane Company in April 1917. With early success in manufacturing aircraft, Boeing sought opportunities to combine with other companies in pursuit of aviation innovation. By 1929, the Boeing Airplane Company merged with other aviation companies, such as Pratt and Whitney Airplane Company, Sikorsky Aviation, Stearman Aircraft, and Chance Vought to form the United Aircraft and Transport Corporation (UATC). In the early days of aviation, airplane manufacturers established their own airlines. In 1931, UATC merged its four smaller airlines into United Airlines. By 1934, the U.S. Government ordered the breakup of UATC into three companies—the Boeing Airplane Company, United Airlines, and the United Aircraft Company, which would later become United Technologies.

By the end of the 20th century, Boeing again would seek opportunities to spur on innovation by merging or acquiring other companies. In 1996, Boeing acquired North American Rockwell's space divisions, which were formed through mergers of North American Aviation and Rocketdyne. In 1997, Boeing and McDonnell Douglas announced a merger of the two companies. McDonnell Douglas had been created in 1967 as a result of a merger of the McDonnell Aircraft Corporation and the Douglas Aircraft Corporation. In 2000, Boeing acquired the communications satellite business of Hughes Electronics. These many merged companies that form today's Boeing brought with them a rich heritage of developing space systems for the NRO.

SAMPLER OF INNOVATIVE PROGRAMS

The idea for the establishment of the NRO was the culmination of an early effort that grew out of the Douglas Aircraft Corporation in 1946. After the end of World War II, U.S. military leaders turned to American industry for recommendations on how to prepare for future defense of the nation. In 1946, the Army Air Forces turned to Douglas Aircraft for such an undertaking, requesting advice on what the future held. Douglas Aircraft formed a group to assess future opportunities. The group would quickly be spun off into the RAND Corporation. Its first report explained that future defense of the United States depended on developing man-made satellites for obtaining intelligence. For nearly a decade, RAND would continue this effort, with their final report outlining a national reconnaissance program that the U.S. would undertake, forming the foundation for the NRO.

As the U.S. developed reconnaissance satellites, launching them into space was a critical requirement. The companies that make up today's Boeing offered innovative solutions to this requirement. Douglas Aircraft developed the Thor rocket, which carried the U.S.'s first imagery satellite, Corona, into space in 1960. Douglas also developed the Delta series of launchers, which eventually carried NRO satellites into space. Rocketdyne manufactured the rocket engines used for the Thor, Atlas, and Delta launch vehicles—generations of which carried NRO satellites to space. North American Rockwell served as one of the prime contractors for NASA's Space Shuttle, used to carry some NRO satellites into space. Boeing also provided a modified 747 aircraft to transport the shuttle, as well as a booster vehicle to carry satellites off the shuttle and deeper into space.

The companies that now make up today's Boeing played essential roles in building spacecraft. NASA awarded Boeing a contract to build the Lunar Orbiter to image the Moon. NASA needed detailed imagery of the Moon's surface to find safe landing locations for the Apollo program astronauts. Boeing utilized image processing hardware from an earlier reconnaissance satellite program, Samos, to obtain the necessary imagery to help make the Apollo program successful. McDonnell built the Gemini capsule that would have carried astronauts to and from space to operate the NRO's Dorian camera system from the Air Force's Manned Orbiting Laboratory. Although the U.S. cancelled MOL, hardware from the program helped NASA advance its manned spaceflight programs and provided launch facilities still used by the NRO today.

BOEING TODAY

An essential innovative industrial partner of the NRO, Boeing Defense, Space, and Security is responsible for defense and aerospace products. Current classified NRO programs benefit from the rich heritage of companies that form today's Boeing and have innovated for the NRO since its founding in 1961.

Additionally, Boeing is one of two major partners in the United Launch Alliance (ULA), successfully carrying NRO satellites into space for more than a decade. In December 2006, Lockheed Martin Space and Boeing Defense, Space, and Security formed ULA as a joint venture. ULA provided launch services using the Delta IV Heavy, Atlas V, and until 2018, the medium-lift Delta II. In addition to NRO payloads, other payloads included weather, telecommunications, other national security satellites, scientific probes and orbiters, and commercial satellites. Continuing a tradition of innovation, ULA is developing the Vulcan Centaur, a follow-on to the Atlas V that also includes Delta IV technology.

ITEK CORPORATION


RICHARD LEGHORN

ITEK CORPORATION FACILITY - 1960s

In 1960, the U.S. launched Corona, a photoreconnaissance satellite that successfully returned imagery from space and fundamentally changed viewpoints on the possibilities for technical intelligence collection. Itek Corporation was key to the 12-year success of the Corona program for the innovative satellite camera systems they developed.

FOUNDING OF ITEK

Itek traces its roots back to World War II and the efforts of James G. Baker, a member of Harvard University's Observatory staff. Baker held a PhD in astronomy and focused on developing better instruments for astronomical observation. Beginning in 1941, Baker turned his talents and attention to developing aerial reconnaissance lenses. Baker's research laboratory at Harvard developed unparalleled cameras by the end of the war. The Army Air Force found Baker's research so promising, they funded continued research after the war.

In 1946, the laboratory transferred to Boston University under the direction of Duncan E. McDonald, becoming the Boston University Physics Research Lab. Baker remained with the laboratory continuing cutting edge work on lenses. Over the next several years, the lab would produce camera systems for military applications and push forward the state of the art for cameras that could obtain imagery from very high altitudes.

Richard Leghorn, a retired Air Force officer who had extensive experience in airborne reconnaissance, established Itek in October 1957 to improve document retrieval systems. Not long after the establishment of Itek, Boston University sought out opportunities to divest the Physics Research Lab after the departure of Duncan McDonald. Leghorn recognized the potential for the Lab and purchased it, folding it into Itek. With the purchase, the focus of Itek changed to development of imagery optics and cameras, becoming one of the best sources for such components by the end of that decade.

CORONA CAMERAS

The United States faced a pressing problem in waging the Cold War against the Soviet Union following World War II—namely, how to assess growing Soviet military capabilities with very limited access to travel in the USSR. Immediately following World War II, technologists charged with responsibility for assessing how the U.S. could best defend itself leveraging advanced technology recommended the nation develop satellite reconnaissance systems.

About a year prior to the successful launch of the Soviets' 1957 launch of the Sputnik satellite, the U.S. Air Force initiated a reconnaissance satellite program. After the Sputnik launch, the program took on new urgency. Recognizing that the U.S. needed an accelerated photoreconnaissance satellite program, President Eisenhower authorized the Corona program to that end.

The CIA, in partnership with the U.S. Air Force, engaged in developing the Corona photoreconnaissance satellite. They turned to two companies with proven success in developing airborne reconnaissance cameras, the Fairchild Instrument and Camera Corporation and the Itek Corporation. Fairchild offered a design drawing upon its airborne cameras. Itek offered a more complicated but potentially more promising design. In the end, CIA opted for using both companies. Because of the urgency to orbit Corona, the CIA first used Fairchild cameras identified as the C, or KH-1, camera and a later version identified as the C′ (C prime), or KH- 2 camera. The Fairchild cameras used Itek lenses. The CIA used each for 10 missions. The C camera could produce imagery for identifying objects 40 feet in size. The C′ camera improved on this, producing imagery that could be used to identify objects 25 feet in size. The Fairchild cameras were used for test and early operational flights of Corona from 1959 to 1961.

By 1961, Itek developed its more advanced C‴ (C triple prime), or KH-3 camera. The CIA did not use the proposed C″ camera, favoring instead moving immediately to the more advanced C‴ camera. Itek's C‴ camera was much more complicated than the previous Corona cameras. It had faster optics but slower film speed. Additionally the camera incorporated improved image-motion compensation. These advancements improved imagery resolution, allowing analysts to identify objects as small as 12 feet in size. By this time, the Kennedy administration established the NRO, which used the C‴ cameras on six missions in 1961 and 1962.

At the same time Corona was going through its early development, program officers started weighing approaches for eventually obtaining stereo imagery from space. The early concept involved integrating two cameras into the optical system for stereo imaging capability. The early Fairchild and Itek cameras only provided monoscopic imagery. Itek's advancements moved the program closer to stereoscopic imagery capability.

By April of 1961, the Corona program received permission to develop a stereo version of the C‴ camera using Itek. The system included two cameras tilted 15 degrees fore and aft. They imaged the same areas separated by 12 frames allowing the processing of the film into stereo imagery. This improved capability allowed analysts to detect details of imaged targets that could not be identified using the earlier camera. Although the program officers originally only planned to develop a half dozen engineering systems, the camera eventually became the Mural, or KH-4 system. It flew on 26 Corona missions in 1962 and 1963, providing resolution of objects as small as 10 feet in size.

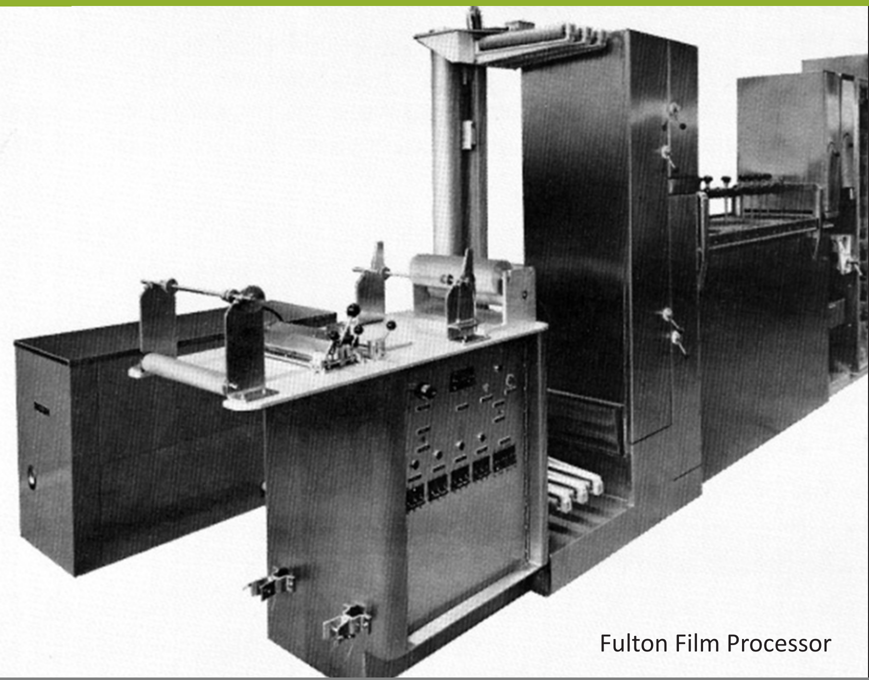
Not wanting to rest on laurels, Itek improved the Mural camera with a new design known as the J-1. The J-1 had no oscillating parts. The camera also included a completely new design of the control systems. It flew on 52 missions from 1964 to 1969 and provided a best resolution of 9 feet. Itek's final improvement was the J-3 camera. The camera system included four selectable exposures and two selectable filters for use in varying imaging conditions. The J-3 was used on the final 17 Corona missions until the program ended in 1972. The J-3 provided Corona's best resolution with imagery that could be used to identify objects as small as six feet in size. The J cameras also handled a much larger film load due to a Corona design change that allowed the system to return two film return vehicles to Earth. Additionally, program officers included new design elements that allowed Corona vehicles to orbit at lower altitudes, helping improve imagery capability.

ITEK AFTER CORONA

Richard Leghorn left Itek in 1962, a time during which the company had attempted to diversify. Under new leadership, Itek returned to a focus on satellite reconnaissance optical systems that were highly innovative.

In the mid-1960s, the CIA began working on a replacement for Corona. Eventually the CIA would transfer the program to its element at the NRO under the Hexagon program. Itek initially worked on an optical system for Hexagon, but eventually withdrew from the competition. With the decision to discontinue work on the follow-on to Corona and the closure of the Corona program, Itek again turned to other sectors for company growth. They turned to developing cameras for the high altitude reconnaissance aircraft and provided optical systems for the Apollo program. By the early 1980s, Itek was acquired by Litton Industries, who wanted to expand into military support efforts. Eventually, the elements of Itek were purchased by Hughes Electronics in support of optical systems development. Hughes had already purchased Perkin-Elmer's optical systems division, the same company that had secured the Hexagon optical system development. After Hughes the original assets of both companies remained merged and today are Danbury Mission Technologies.

KODAK



Fulton Film Processor

Oneida Continuous Printer

The Eastman Kodak Company was a partner with the U.S. Government in aerial reconnaissance long before the NRO was even created. Approached by the Central Intelligence Agency in 1954 to provide support for the U-2 program, Kodak quickly agreed to help, and by 1956, the company was deeply involved in providing film for the U-2's cameras, processing the film, and making duplicate copies to be used by the various photo interpreters across the U.S. Government.

WS-117L

Meanwhile, Kodak was also working in a separate program with the Air Force (WS-117L) to design the Samos satellite imaging system. Kodak began working on both a film-return system, as well as an electrical system to scan images and transmit them to Earth. In February 1958, President Eisenhower authorized recommendations to split the WS-117L program into two parts, to allow a crash-course effort to pursue the film-return system, which promised earlier success. This effort resulted in the launch of the world's first imaging reconnaissance system–Corona–two years later. Kodak continued working on the electronic imaging system and produced the analog near real-time E-1 camera which, while functional, was of limited use for a reconnaissance payload in low earth orbit due to technological limits of the time.

REACHING FOR THE MOON

Shortly after the NRO was formed, DNRO Charyk cancelled the electronic imaging portion of Samos and decided to direct NRO efforts to improving the nascent film return satellite programs. But in 1963, NASA asked for proposals to build a camera for their Lunar Orbiter project, which was being planned to map the Moon's surface for suitable landing sites for the Apollo program. With NRO approval, Kodak proposed a system based on the E-1 camera; while it was the most expensive of the five bids NASA received, Kodak's was accepted since it was the only one with proven technology. In 1966-67, NASA launched five "Samos Lunar Orbiters" that mapped 90% of the Moon's surface, allowing NASA to pick appropriate landing sites for Apollo missions. Without that Kodak-NRO connection, the Lunar Orbiter missions would have been delayed, which would have delayed the Apollo program and prevented NASA from fulfilling President Kennedy's challenge to reach the Moon by the end of the decade.

FILM-RETURN SATELLITES

Because of their expertise in the film business and their experience with the U-2, Kodak was naturally the "go-to" company for the CIA when they began the development of the Corona program in 1958. But moving from aerial photography to space-based satellite reconnaissance is easier said than done. Photography is vastly different between an aircraft in the upper atmosphere and a satellite in the vacuum of space. But Kodak was up to the task, developing completely new types of films and processing procedures to enable the world's first photoreconnaissance satellite.

After the NRO was formed in 1961 and the new Gambit and Hexagon systems were being developed, Kodak was there, combining its expertise with that of the satellite and camera designers. When the CIA and NRO turned over all their U-2s to the Air Force in 1974 after the cancellation of Program D, Kodak continued to partner with the Air Force and supported that program for as long as the U-2s collected film. Kodak was the major supplier of film and processing throughout the life of the Corona, Gambit, and Hexagon programs, ceasing in 1986 after the last Hexagon launch.

OTHER ENDEAVORS

During the tenure of Kodak's relationship with the NRO, the company produced groundbreaking new technologies involving film and film-based products, processing machines and procedures, and production machines and processes. Kodak developed the first color aerial film in 1964 and the first satellite color film in 1968. In 1969, they developed the first high-resolution color film, and in 1973, they developed the first aerial infrared film. Since they developed all of the film and processes, all of the machines they used for processing, developing, and duplicating film were built from scratch by their engineers. They even developed an environmental process—called the "Bug Farm"—that used active biological colonies that fed on the photographic waste from color film and converted it into harmless, non-toxic sludge (that could be safely incinerated) and water. This process kept decades of toxic waste chemicals from being released into the environment.

Kodak set up and supported the Westover Air Force Base Special Projects Processing Facility (SPPF), which was the official photographic support center for all of the government's reconnaissance programs. The SPPF was created, not only to be a backup for Kodak's operations, but also to be the official photo center for the government, to keep Kodak's confidential relationship with the government a secret until the Corona program was declassified in 1995.

In 1962, Kodak hosted NRO Director Joseph V. Charyk at the start of the Cuban Missile Crisis to discuss ways Kodak could step up to support the increased need for aerial reconnaissance. At a moment's notice, Kodak redirected thousands of pounds of film products and tons of machinery that was on the way to other customers to support the emergency needs of the government and military. In 1976, the Director of the CIA and future President George H. W. Bush covertly visited Kodak's Rochester, NY facility to discuss Kodak's support program, without the public or press ever learning of the visit.

THE END OF AN ERA

In the end, however, the invention that was perhaps the greatest-ever enabling technology for the NRO was also the death knell for the NRO's relationship with Kodak— digital imagery. When the NRO launched the KH-11 Kennen near real-time electro-optical imagery system in 1976, it leapt into the digital age and made film-return satellites obsolete. Kodak continued for some years to provide services, but that need disappeared after the government discontinued film-return reconnaissance systems in the 1980s. In 2001, Kodak sold its government operations to ITT Space Systems, ending an almost 60-year relationship with government reconnaissance efforts.

For further information, see CSNR's *Bridgehead: Eastman Kodak Company's Covert Photoreconnaissance Film Processing Program*.

LOCKHEED MARTIN

LOCKHEED FACILITY 1971-1991

In 1926, Allan Lockheed, John Northrop, Kenneth Kay, and Fred Keeler founded the Lockheed Aircraft Corporation as an American aerospace company. It later merged in 1995 with Martin Marietta to form Lockheed Martin. Lockheed has had a long partnership with the United States Air Force and the National Reconnaissance Office from as far back as the development of the Weapon System 117L to the Titan booster and beyond.

AIRCRAFT

On 26 July 1954, President Eisenhower appointed a "Technological Capabilities Panel" that was chaired by MIT President James Killian to study options to deal with the Soviet threat. The TCP was organized into committees, each with its own separate issue or area of study. One of those committees, the Intelligence Projects Committee headed by Edwin "Din" Land, the president of Polaroid, recommended that the government proceed with the Lockheed Corporation plan to build a reconnaissance aircraft that could fly above Soviet air defenses. That recommendation eventually spawned the development of the U-2 reconnaissance aircraft.

Lockheed developed the U-2 in its Advanced Development Projects (ADP) division, also known as the "Skunk Works." The name was taken from the moonshine factory of the Li'l Abner comic strip. Clarence "Kelly" Johnson, Lockheed's genius aircraft designer and the vice president of ADP and director of the Skunk Works, designed the U-2, as well as many other successful Lockheed aircraft. President Eisenhower approved the U-2 project in November of 1954, as part of a joint Air Force, CIA, and Lockheed program under the name Project Aquatone.

As a follow-on to the U-2, Kelly Johnson proposed several concepts he called Archangel, which was a play on Lockheed's original name for the U-2, "Angel." After the twelfth concept was adopted, the aircraft was named the A-12 and was developed under the CIA project name Oxcart, which also became synonymous with the aircraft. Later, Kelly Johnson and the Air Force developed an Air Force version of the A-12, which became the SR-71.

LAUNCH SYSTEMS

In 1946, the Air Force-funded Project RAND studied the technical feasibility of orbiting artificial satellites, which became the origins of the Advanced Reconnaissance System or WS-117L. On 29 October 1956, Lockheed Aircraft Corporation (which had teamed with Eastman-Kodak) was awarded the prime contract for the liquid-propellant Agena booster-satellite developed for the WS-117L. Lockheed developed the Agena vehicle that was used for Corona satellite launches. The Glenn L. Martin Company (and later, Martin Marietta and then Lockheed Martin) developed the Titan rocket family that was primarily used by the Air Force and the National Aeronautics and Space Administration. The Titans played a crucial role, along with the Thor and Atlas booster rockets, in launching many NRO satellites into space. The Titan IV was produced primarily for the NRO in order to launch satellites, but as satellites remained in orbit longer, the need for the Titan IV declined. The Titan IVB was the last Titan rocket to remain in service, making its final launch from Vandenberg Air Force Base on 19 October 2005 carrying a satellite for the NRO.

In December 2006, the United Launch Alliance, a joint venture between Lockheed Martin Space and Boeing Defense Space & Security, was formed. ULA provided launch services with the Delta IV Heavy, Atlas V, and until 2018, the medium-lift Delta II. Recently, the company unveiled the Vulcan Centaur, a heavy-left launcher utilizing Atlas V and Delta IV technology.

SATELLITES

Lockheed was also involved in some lesser-known NRO satellite programs such as Quill, a synthetic aperture radar technology demonstrator. Lockheed, along with Goodyear Aerospace, launched the first and only Quill satellite on 21 December 1964 to demonstrate the utility of SAR in a reconnaissance satellite. The Quill satellite worked so well that a second planned launch was cancelled because all of the test objectives were met with the first launch. While the Quill proved the effectiveness of the technology, the resolution was so poor that it did not meet the utility threshold it needed to meet intelligence requirements, and the concept was shelved for decades. Quill was declassified by the DNI in 2009.

In the late 1960s, Lockheed Corporation, along with 20 other contractors, was involved in developing the Manned Orbiting Laboratory program, a joint NRO-Air Force project to build a manned satellite to increase the effectiveness of NRO's imaging systems. The project was designed to house astronauts in a pressurized lab for up to 30 days to manually operate and repair NRO's KH-10 Dorian camera system to acquire exceptional reconnaissance imagery. The MOL project was cancelled during President Nixon's administration in favor of unmanned satellites that were advancing much faster than anticipated. Afterwards, some of the MOL astronauts went to work for NASA and flew in the Space Shuttle.

In addition to the key role Lockheed played in the success of the Corona, it also provided the Agena D to serve as a control vehicle after the launch of KH-8 Gambit satellites into polar orbit from Vandenberg Air Force Base in California. The KH-8 or Gambit 3 satellite, was designed to replace the earlier Gambit 1 satellite which provided very high-resolution imagery of areas of interest identified by the Corona search satellites. In addition to the Agena, Lockheed also developed a highly unique roll-joint that enabled the entire camera section to rotate in carrying out its imaging functions.

When it came time to replace the Corona system, the NRO once again turned to Lockheed to help build a new generation of search satellites known as Hexagon. The Hexagon vehicle was the size of a train locomotive. It had three sections—the rear section propelled the satellite, the middle section carried a film load with 60 miles of film feeding the camera and optical system, and the forward system carried four large film return vehicles as well as experimental subsatellites. The NRO contracted with Lockheed to build all three satellite structures and integrate components from other contractors. The first launch of Hexagon in 1971, brought a dramatic increase in the amount of satellite imagery for exploitation by U.S. intelligence analysts.

Lockheed remains a key partner in the success of NRO satellite systems.

PERKIN-ELMER

PERKIN-ELMER DANBURY FACILITY


CHARLES ELMER & RICHARD PERKIN

Perkin Elmer Corporation provided the optical system for the Hexagon film return photoreconnaissance satellite. The optical system included highly innovative features that permitted imaging of very broad areas with high-quality resolution.

FOUNDATIONS

Perkin Elmer's founders had unexpected backgrounds for entering into the development and fabrication of optical systems. Richard Perkin was a young Wall Street investment banker. Charles Elmer owned a firm that provided court reporters to courts in New York. The two founders, although differing in professional backgrounds, shared a common interest in astronomy. Elmer attended a lecture on that subject given by Perkin. After meeting at the lecture, the two established a friendship. Recognizing opportunities in developing and marketing precision optics, they formed the Perkin-Elmer partnership in 1937. Perkin raised capital for the enterprise and Elmer made a sizable investment in the company. Within a year, they moved from their start-up location in Manhattan and would eventually establish facilities in Connecticut and Massachusetts.

Perkin-Elmer's high precision optics were designed for telescopes—eventually used on NASA's Hubble Telescope. During World War II, they assisted the U.S.'s war effort by providing optics for bombsights, airborne reconnaissance systems, and other military applications. In an effort to diversify, Perkin-Elmer entered into other business sectors, including electronic component manufacturing and a computer division. By the 1960s, the corporation was a leader in optical systems for scientific and medical instruments, as well as the other sectors Perkin-Elmer pursued.

FOLLOW-ON TO CORONA AND GAMBIT

In 1960, the United States began collection of imagery from space using the Corona photoreconnaissance satellite. In 1963, the National Reconnaissance Office—with responsibility for building and operating the U.S.'s reconnaissance satellites—launched the Gambit photoreconnaissance satellite to gather high-resolution imagery of targets identified from Corona's broad area coverage capabilities.

Looking forward, CIA officers working on space systems conceptualized a photoreconnaissance satellite that could image broad areas like Corona, but at high enough resolution that same imagery could be magnified to identify features of targets like Gambit accomplished. Those working on this new system hoped it would replace both Corona and Gambit. CIA officers assigned to support the NRO carried the project forward from conceptualization to operation.

THE HEXAGON CAMERA

Program officers running the project for building the new satellite selected Hexagon for the program's name. Key to the success of the program, those officers needed a highly innovative camera design that provided both broad-area and high-resolution capabilities. Those officers turned to one of the leaders in optics design in the United States, Perkin-Elmer, to design and build the optical camera system. Perkin-Elmer embraced the highly secret project, constructing a facility in Danbury, Connecticut to design and build the new camera system for Hexagon. The optical system contained two cameras—one that looked forward and one that looked behind the satellite vehicle. The optical system contained a 60-inch focal length with a 20-inch aperture. Images were reflected in a 24-inch mirror with optical bars rotating 360 degrees to scan for images. Images were captured on film that were fixed using the optical bars. A complex system including twisting, fed the film from the supply reels to one of four film-return vehicles. The optical system captured stereo and monoscopic images. The satellite was designed to carry 300,000 linear feet of film, capturing images up to 370 nautical miles in length out to 120 degrees from the satellite vehicle.

The NRO launched the first satellite vehicle in 1971, with the last launch in 1986. Perkin-Elmer's 20 Hexagon satellites imaged the entirety of areas of interest of the Soviet Union, as well as denied areas of the globe controlled by U.S. adversaries. Although the system did not achieve the best resolution of Gambit, the Hexagon satellite was able to allow identification of objects of approximately 18 inches in size. This was a remarkable accomplishment for the Perkin-Elmer design, especially given the very broad areas captured by the optical system.

PERKIN-ELMER AFTER HEXAGON

Although highly profitable for many years, by the 50th anniversary of Perkin-Elmer's founding, the company encountered strong financial headwinds. It eventually divested several divisions, including the division responsible for Hexagon, retaining business lines for developing scientific and medical instruments, as well as a focus on material sciences. Today Perkin-Elmer continues to flourish, even though its remarkable and innovative contributions to the National Reconnaissance Office and the United States have faded into history.

RAND CORPORATION

WORLD WAR II LEGACY

General Henry "Hap" Arnold made a key decision amid the immediate aftermath of World War II that helped lay the foundation for the National Reconnaissance Office. General Arnold wrote to the Secretary of War Henry Stimson in November 1945:

> During this war, the Army, Army Air Forces, and the Navy have made unprecedented use of scientific and industrial resources. The conclusion is inescapable that we have not yet established the balance necessary to insure the continuance of teamwork among the military, other government agencies, industry, and the universities. Scientific planning must be years in advance of the actual research and development work.

In the weeks preceding this report, Arnold had worked with Don Douglas of Douglas Aircraft Company to establish a think tank that would provide the U.S. Army Air Forces this kind of ongoing civilian scientific and technical advice that proved essential in winning World War II. Douglas created Project RAND—an abbreviation for research and development—for this purpose. Project RAND was located in Douglas Aircraft facilities and employed scientists, engineers, and other technical experts.

RAND'S ADVOCATES FOR SATELLITES

Project RAND wasted little time in providing research to the Army Air Force. Rand's first report, entitled Preliminary Design of an Experimental World-Circling Spaceship—called for the development of U.S. satellites for national security purposes. Prior to the drafting to the report, Arnold and other senior leaders recognized the necessity for an advanced national security system as they learned more of the vanquished Germany's advanced technology development. Of special interest, they requested insight into how rocket technology could be used to defend the interests of the United States.

During the next year, Rand produced another twelve reports on technologies related to satellite development, including the mechanics and dynamics of rockets necessary to carry a satellite, the means for a satellite to communicate back to the Earth, costs of satellites, and specifications for satellite development.

By late 1947, Don Douglas grew concerned that Project RAND would raise conflicts of interest, since his company was both making acquisition recommendations and competing for those acquisition opportunities. The recently formed U.S. Air Force agreed, and Project RAND became the independent RAND Corporation on 14 May 1948.

PROJECT FEEDBACK

Charged with the responsibility from the Air Force to spearhead studies and technology development for a successful Air Force space program, during the next six years, RAND Corporation published another 16 studies on space technology development. RAND's efforts culminated in the 1954 Project Feed Back report. The report's authors concluded that in order for successful space program development to occur, the U.S. Air Force must invest in a full scale development program. RAND recommended the development of satellites that would capture images from space.

In their Project Feed Back report, RAND recommended the development of a photoreconnaissance satellite with a television on-board camera. They proposed building a mechanism that would scan the television images on orbit for transmission back to Earth. RAND suggested in the report that the technology to both build the satellite and launch it existed at the time the report was published. RAND concluded the proposed satellite, if launched on their recommended Atlas rocket, could obtain military, mapping, and weather intelligence. In the eight years since their first report on development of reconnaissance satellites, RAND observed that the many earlier technical limitations had been overcome. With a reconnaissance satellite now possible, RAND concluded the time to study the matter was over, and the United States should engage in building the satellite system they discussed in the Feed Back report.

FOUNDATION FOR 60 YEARS OF INNOVATION

By 1956, the U.S. Air Force received funding for developing a reconnaissance satellite along the lines suggested by RAND. After the successful launch of the Soviet Union's Sputnik satellite in 1957, the U.S. rapidly increased funding for the Air Force's satellite reconnaissance program. The program was renamed the Samos satellite program. By the end of the decade, the Samos program grew to include plans for photoreconnaissance satellites that not only scanned video images, but also satellites that obtained images on film to be returned to Earth for development and intelligence exploitation. Additionally, the Samos program called for the development of signals collection satellites. From its origin in the RAND research effort, the Samos satellite program established the foundation for the development of the first successful U.S. photoreconnaissance satellite, Corona, as well as early signals collection satellites. This foundation would also serve the many additional reconnaissance satellites, both imagery and signals collection, that the NRO would build over the next 60 years.

TRW

RAMO-WOOLDRIDGE FACILITY - INGLEWOOD

HISTORY OF TRW

TRW can trace its origins to 1901 when David Kurtz and four other Cleveland, Ohio residents founded the Cleveland Cap Screw Company, a manufacturing company focused on hexagon and square-head cap screws, specialty fillister screws, and coupling bolts and studs. Among their initial products were bolts with the bolt head electrically welded to the shaft.

Three years later, in 1904, Charles E. Thompson, a welder at Cleveland Cap Screw Company, adapted the cap-screw manufacturing process with the production of automobile engine valve stems. Alexander Winton, a pioneer automaker, was so impressed with Thompson's idea that he purchased Cleveland Cap Screw Company and named Thompson as the general manager. In 1908, the firm changed its name to Electric Welding Products. In 1915, Thompson took over the company, and it was incorporated as Steel Products Company. It was, at that time, the leading American manufacturer of automobile engine valves. The manufacturing line also included the aircraft engine valves used in Allied fighter planes during World War I.

In 1917, the company produced the first one-piece valve, and in 1921 it produced a new and exceptionally durable silicon and chrome steel valve. Known as the Silicrome Valve, it allowed aircraft engines to run continuously for long periods of time - thus permitting long distance flights and aviation. In 1926, the company was re-named Thompson Products, Inc. and in 1927, Thompson's experimental hollow sodium-cooled valves were used in the *Spirit of St. Louis*, the aircraft used by Charles Lindberg in his 33.5 hour solo flight across the Atlantic Ocean from New York to Paris. Throughout the next decade, Thompson Products continued to develop its aircraft technology, and by the early 1940s, their engine valves and fuel booster pumps enabled the first high-altitude flights. Later, as aircraft piston engines were replaced by jet engines, Thompson Products became a major manufacturer of jet engine turbine blades.

Separately, in the early 1950s, Simon Ramo and Dean Wooldridge were working for Hughes Aircraft and leading the development of the Falcon radar-guided missile system. The Falcon was the first operational guided air-to-air missile of the U.S. Air Force. Ramo and Wooldridge decided to break away from Hughes, and with the financial backing of Thompson Products, formed the Ramo-Wooldridge Corporation in September 1953. In October 1953, shortly after the Soviets detonated their first hydrogen bomb in August, the Assistant Secretary of the Air Force for Research and Development established the Teapot Committee, the code name for the Strategic Missile Evaluation Committee (SMEC), to study the development of ballistic missiles, including ICBMs, for the Air Force. The Ramo-Wooldridge Corporation was initially hired to administer the SMEC's work, and Simon Ramo and Dean Wooldridge were also full committee members. The Ramo-Wooldridge Corporation later became the lead contractor of the ICBM development effort.

Throughout the 1950s, Ramo-Wooldridge continued to diversify their product lines with computers and electronic components, and their Space Technology Laboratories Division went on to build scientific spacecraft, including the Pioneer 1, launched from Cape Canaveral on 11 October 1958, which was the first American space probe under the auspices of NASA.

In October 1958, Thompson Products and Ramo-Wooldridge merged to form Thompson Ramo Wooldridge, Inc., known unofficially as TRW until July 1965 when TRW became the corporation's official name. Over the years that followed, there were several mergers and acquisitions that allowed TRW to focus on the automotive, information systems, and space and defense industries. TRW remained one of the leading aerospace companies in the United States, employing hundreds of thousands of people over the years, operating in 25 countries, and was ranked as a Fortune 500 company.

Ultimately, TRW was acquired by Northrop Grumman in December 2002, and the TRW automotive group was sold to the Blackstone Group.

ACHIEVEMENTS IN AEROSPACE

TRW was a primary contributor and longtime partner of the National Reconnaissance Office and its mission. TRW was considered a national asset in spacecraft used for science and defense purposes. Many of TRW's contributions to national security remain classified to this day. Outside of its classified work, TRW carried out a number of unclassified space projects including:

- First private Company to build a spacecraft (Pioneer 1, launched in 1958), which set a distance record from Earth and collected and returned data on the Earth's radiation belts. Also built Pioneer 2, 10, and 11.

- Designed and built the lunar module descent engine (LMDE) for the Apollo lunar lander. This was also the engine used on Apollo 13 to achieve the free return trajectory and to make a course correction and safely return the crew to Earth after the service module was damaged, endangering the crew and nearly ending the mission in disaster.

- Built the High Energy Astronomy Observatory (HEAO) 1, 2, and 3 space observatories. HEAO was a multi-satellite telescope program launched in 1977 that surveyed the sky in the various ranges of the electromagnetic spectrum, including x-rays, cosmic rays, and gamma rays.

- Built two of the four satellites for the NASA Great Observatories program—a series of four powerful space-based astronomical telescopes launched between 1990 and 2003 to collect information and examine specific wavelength/energy regions along the electromagnetic spectrum: gamma rays, x-rays, visible and ultraviolet light, and infrared light.

- Built the Compton Gamma Ray Observatory, designed to identify the sources of celestial gamma rays, that operated from 1991 to 1999. Launched from the Space Shuttle *Atlantis* in April 1991. (2nd in the series)

- Built the Chandra X-Ray Observatory, designed to identify and detect x-ray emissions from astronomical objects such as black holes and neutron stars. Launched from the Space Shuttle *Columbia*, July 1999. As of 2020, Chandra is still operating. (3rd in the series)

- Designed and manufactured the Vela series of nuclear detection satellites to monitor the 1963 nuclear Partial Test Ban Treaty.

- Built all 23 reconnaissance satellites in the Defense Support Program (DSP), which are the primary components of the Satellite Early Warning System used by the U.S. First launched in 1970, they are still used today, and during Operation Desert Storm, the DSP satellites detected launches of Iraqi SCUD missiles to provide warnings to civilians and military forces in Saudi Arabia and Israel.

- Built the first seven Tracking and Data Relay Satellites (TDRS) to improve communications for the Space Shuttle, International Space Station, and U.S. military satellites.

INNOVATORS

GROUND LOCATIONS

GROUND STATIONS

ADF-E GROUND STATION

GRAB HUT

GRAB HUT INTERIOR

NRO GROUND STATIONS

The NRO satellite constellation is supported by a network of ground stations. This network includes the Aerospace Data Facility-East at Ft. Belvoir in Virginia; the Aerospace Data Facility-Southwest at White Sands Missile Test Range in New Mexico; and the Aerospace Data Facility-Colorado at Buckley Air Force Base in Colorado. Each is a multi-mission facility that supports worldwide defense operations, satellite command and control, and the collection, analysis, reporting, and dissemination of intelligence information for multiple agencies.

A member of both the IC and the DoD, the NRO builds and operates intelligence, surveillance, reconnaissance space and ground systems that collect and process signals, imagery, and data to discover and follow activities for a wide range of intelligence, defense, and civil applications. Ground stations must respond to a wide range of intelligence issues including: maintaining global situational awareness in great power competition; monitoring the proliferation of weapons of mass destruction; tracking international terrorists, drug traffickers, and criminal organizations; developing highly accurate military targeting data and battle damage assessments; and supporting international peacekeeping, humanitarian relief operations, as well as natural disaster response and mitigation.

GROUND STATION PURPOSE

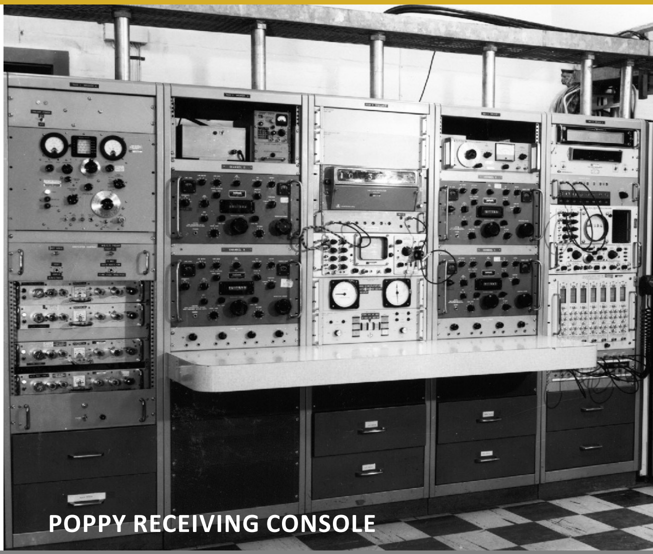
Satellites orbit the earth for a number of reasons including commercial and civil applications such as communication, broadcast, and weather forecasting. NRO satellites provide imagery and signals collection, as well as provide relays between satellites and the earth. All satellites have one thing in common and that is the need to communicate back to the Earth. Ground stations play that critical role, receiving and sending signals and data between satellite operators on earth and the satellite vehicle. Ground stations also process data obtained from satellites to meet the requirements for which the satellites were designed.

EARLY ELINT GROUND STATIONS

The U.S.'s first successful reconnaissance satellite was launched in June 1960. Built by the Navy, they named the satellite the Galactic Radiation and Background satellite or GRAB. When GRAB satellites launched from Cape Canaveral, Florida, they provided electronic signals intelligence data to National Security Agency analysts and other intelligence analysts.

In order to receive the signals from the satellites, the GRAB program officers had to solve a particularly difficult problem. Because GRAB circled the globe in a low earth orbit, a single ground station would only be in a satellite's field of view for relatively short periods. Additionally, communications technology available at the time only allowed very limited amounts of information for transfer between the ground

POPPY PREFAB OPERATIONS BUILDING



POPPY RECEIVING CONSOLE

and the satellite. To solve this problem, GRAB's program officers built several portable control huts they could locate at multiple sites. This innovative approach allowed the GRAB satellite to provide and receive more consistent and greater data communication.

The first GRAB hut was in Hawaii, with a yagi antenna receiving telemetry and sending commands to the satellite. The personnel in the control huts recorded data from the satellites and transmitted the data to NRL and then to NSA and Air Force Strategic Air Command.

From 1965 to 1967, the Navy's satellite program at the NRO—known as Program C—phased out the early receiving and control huts that were used for GRAB in support of operation of their follow-on satellite, Poppy. They upgraded the data quality by installing equipment in buildings provided by host installations for analysis in the field. By the 1970s, the Poppy program used prefabricated buildings in the field. At the field sites, a pair of receiving consoles collected Elint data from Poppy. The analysts would then report the signals of interest to NSA and others. Many of the Poppy field sites were staffed with Naval Security Group, Air Force Security Service, and Army Security Agency personnel. The NSA analyzed the signals and produced reports for the Intelligence Community.

GROUND STATIONS TODAY

As NRO satellites grew in sophistication and number, NRO ground stations grew in size and capability. The ground stations developed and operated innovative systems for satellite communications. Additionally, NRO ground stations developed very sophisticated systems for processing large amounts of imagery and signals collection data. The NRO's three ground stations support multiple satellites and fuse the intelligence data from those satellites to provide more complex intelligence to navigate the more complex challenges of today's world. Those stations are the essential ground infrastructure for enabling the powerful collection capabilities of NRO satellites against U.S. adversaries.

ADF-C

EARLY HISTORY

In 1938, the city of Denver, Colorado donated land to the War Department to set up an auxiliary airfield east of the city. When World War II started, the installation was turned into an active military garrison and named Buckley Field, in honor of Lt John H. Buckley, a WWI pilot from Longmont, CO who was killed in action in 1918. After the war, the airfield was turned over to the Colorado Air National Guard for a short time before being turned over to the Navy in 1947 and being renamed Naval Air Station – Denver. In 1960, the Navy closed NAS-Denver and returned it to the Air Force to become the Buckley Air National Guard Base.

In 1969, the Air Force began construction on the support infrastructure for the first Defense Support Program satellite, which launched in late 1970. The DSP satellites were early warning missile launch detectors used to monitor foreign missile launches, and the program ran through 2007. In 2000, the base was renamed Buckley Air Force Base, and in 2021, it was renamed the Buckley Space Force Base, after the creation of the U.S. Space Force.

NRO AT COLORADO

In 2008, the NRO declassified the fact that one of its three ground stations was located on Buckley Air Force Base in Colorado. The Aerospace Data Facility-Colorado (ADF-C) is a multi-mission ground station responsible for supporting worldwide defense operations and multi-agency collection, analysis, reporting, and dissemination of intelligence information. It provides data to defense, intelligence, and civil agencies supporting the U.S. Government and its Allies. The other two NRO ground stations are in New Mexico and Virginia.

ADF-E

EARLY HISTORY

Fort Belvoir, in northern Virginia, was constructed during World War I to help train Army recruits. The base was initially named Camp Humphreys after Major General Andrew A. Humphreys, an important Civil War-era general and later the Chief of Engineers for the Army. In 1935, President Franklin D. Roosevelt was persuaded to change the name to Fort Belvoir by Virginia congressman Howard W. Smith, an avowed white supremacist, who chafed at a Virginia military base being named after a Union general. Belvoir was the name of the Colonial home (Belvoir Manor) of Colonel William Fairfax (who Fairfax County was named after), and it was argued that the base should honor its Colonial roots, since a small portion of the fort's land was once owned by George Washington. Ironically, Belvoir Manor was a slave plantation, and William Fairfax was a British loyalist. So today, Fort Belvoir is one of the many DoD properties being considered by a national commission to have its name changed because of associations with offensive historical personages and beliefs.

Today, Fort Belvoir is designated as a Strategic Sustaining Base for the DoD in the National Capital Region and houses dozens of units, commands, agencies, and offices from every military branch. It is the largest employer in Fairfax County, with nearly twice as many workers as the Pentagon, working on the 8,600-acre post.

NRO AT ADF-E

In 2008, the NRO declassified the fact that one of its three ground stations was located on Fort Belvoir. The Aerospace Data Facility-East (ADF-E) is a multi-mission ground station responsible for supporting worldwide defense operations and multi-agency collection, analysis, reporting, and dissemination of intelligence information. It provides data to defense, intelligence, and civil agencies supporting the U.S. Government and its Allies. The other two NRO ground stations are in New Mexico and Colorado.

ADF-SW

EARLY HISTORY

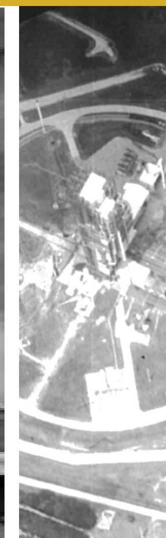
The U.S. military established a permanent presence during World War II in New Mexico's Tularosa Basin near Las Cruces in southern New Mexico. The Army created the White Sands Proving Grounds (now White Sands Missile Range-WSMR), and the Army Air Force built the Alamogordo Bombing and Gunnery Range, known today as Holloman Air Force Base. In 1945, WSMR's Trinity site was the testing location of the first atomic bomb developed by the Manhattan Project. Following the end of WWII, Wernher Von Braun, leader of Germany's rocket program and proponent of space exploration, started working for the U.S. Army testing captured V-2 rockets at WSMR. The V-2s enabled the development of ballistic missiles and eventually space launch vehicles. The National Aeronautics and Space Administration began its tenancy at WSMR in 1963 to test propulsion systems for the Apollo program. Managed by the Army, WSMR has supported and continues to support essential defense and space exploration programs for all branches of the military services and NASA, as well as other forms of scientific research.

NRO AT SW

NRO selected WSMR to house its Aerospace Data Facility-Southwest (ADF-SW) ground station to leverage NASA's established space technology at the site. ADF-SW supports worldwide defense operations and multi-agency collection, analysis, reporting, and dissemination of intelligence information. ADF-SW's multi-mission ground station provides data to defense, intelligence, and civil agencies supporting the United States Government and its Allies. Key to ADF-SW's mission are its intergovernmental collaborations inside and outside the Intelligence Community, which include all military services and the Coast Guard, Defense Intelligence Agency, National Geospatial-Intelligence Agency, National Security Agency, and NASA. Additionally, ADF-SW provides products and services to agencies involved in the drug war, combating terrorism, law enforcement, border surveillance, and disaster relief.

ADF-SW's early operational capabilities were limited processing and forwarding of intelligence data. Today ADF-SW's mission has expanded to exploiting the intelligence data it receives, as well as other multi-platform data. ADF-SW has initiated a wide range of innovative real-time automated information services and products; increased the value of its collected data through fusion at the source; initiated a more efficient use of on-orbit and airborne collections through innovation; and capitalized on cross-program commonalities and synergies through its management of the mission and processing of information. ADF-SW is a critical piece of NRO's ground enterprise.

NRO CAPE



BACKGROUND

The Cape Canaveral Air Force Station (CCAFS), often referred to as NRO Cape, is an element of NRO's Office of Space Launch (OSL). CCAFS was established in 1949 by President Harry Truman to test missiles and was first dubbed the Joint Long Range Proving Grounds at CCAFS. Located on the eastern coast of Florida, the site was perfect for missile testing since the rockets could be directed toward the Atlantic Ocean, and the site's close proximity to the equator gave the rockets an added boost from the Earth's rotation.

CHANGING NAMES

CCAFS is operated by the U.S. Space Force's 45th Space Wing. The site has been known by many names over the years, including the Air Force Space Center (1951) and the Kennedy Space Center (KSC) renamed by President Lyndon Johnson in Executive Order 11129 in 1963. To make the distinction between themselves and NASA, the Air Force renamed their operational elements the Cape Kennedy Air Force Station around the same time. More recently, the site was renamed Patrick Air Force Base (AFB) to commemorate Maj Gen Mason Matthews Patrick, a World War I war hero who proposed that Congress make the Air Force an independent department in 1926. NRO Cape, managed by OSL, provides communications, operations, and integration support to launch defense reconnaissance systems from Patrick AFB and has been a central element at the site since the late 1950.

INTERAGENCY OPERATIONS AND LAUNCH PAD EXPANSION

In 1951, the Air Force established the Air Force Missile Test Center at Banana River Naval Air Station, and the first American sub-orbital rockets were launched from CCAFS in 1957. After NASA's founding in 1958, the site expanded and new launch pads were built for increasingly complex defense and exploratory civil space launches, including the Thor, Atlas, Titan, Apollo, and Space Shuttle, to highlight just a few. The row of Titan and Atlas launch pads along Florida's coast later became known as Missile Row. The location has expanded to 144,000 acres of land with 700 Air Force, NASA, and NRO launch installations scattered between Miami and Jacksonville and east of Orlando, Florida. Because much of the installation is a restricted area and only nine percent of the land is developed, the site serves as an important wildlife sanctuary. NRO Cape is the preferred site for equatorial and geosynchronous launches and has been used for all U.S. manned spaceflights, geostationary transfer orbit launches, and nearly all planetary science missions.

Images from Left: Cape Canaveral Control Center 10 January 1962, Bumper 2 first launch from the Cape, Satellite image of launchpad 41.

GOING COMMERCIAL

In 1984, CCAFS underwent many changes with implementation of the Commercial Space Launch Act, which mandated that NASA only coordinate and launch its own and National Oceanic and Atmospheric Administration Expendable Launch Vehicles. This meant that commercial companies were allowed to operate and launch their own vehicles utilizing NASA's facilities. Moreover, payload processing for commercial vendors was beginning to take place outside of then Kennedy Space Center installations. President Reagan's 1988 space policy furthered the advancement of commercial space companies, and the same year many launch complexes on CCAFS started transferring from NASA to Air Force management.

SHARED HISTORY AND LASTING CONTRIBUTIONS

NRO, NASA, and the Air Force have a long and storied, and at times, tumultuous history. While much of that history remains classified, some missions have been made public. For example, the NRO's Defense Meteorological Satellite Program, in collaboration with the Air Force, created the first TIROS meteorological weather satellite, which delivered surveillance over denied areas in Eurasia while identifying atmospheric triggers that provided advanced warning about severe weather conditions. While NRO's work with NASA on the Space Shuttle was rockier, it was more at the senior level than the working level. Overall, that collaboration was a success story because they avoided duplication of effort, made vast improvements in space technology, and in the end, resolved their differences to achieve mission goals.

NRO's association with CCAFS spans over six decades, and while the relationships between NASA, the Air Force, and the NRO have not always been perfect, together they have accomplished extraordinary feats of engineering innovation—like TIROS, as one example. From the enormous success of Apollo's first landing on the Moon in 1969—to the devastating loss of the *Challenger* in 1986—and everything in between, what was only dreamed of when that strip of land was first discovered on Florida's coast, should serve as motivation to keep working together despite differences and serve as inspiration for those who wish to follow in their footsteps.

NRO VANDENBERG

NROL-82 at Vandenberg - Launch 26 April 2021

NRO Vandenberg (NROV) is an element of NRO's Office of Space Launch. It is located at Vandenberg Space Force Base (VSFB) on the California central coast, north of Los Angeles. Vandenberg has hosted military space projects for over 50 years. In addition to launching intercontinental ballistic missiles, it is the only military base in the U.S. that launches unmanned government and commercial satellites into polar orbit. Its location is well suited for missile and space launches. Launching in a southern direction from Vandenberg avoids flying over heavily populated areas and also provides the right inclination for polar orbits.

CHANGING NAMES

Space Launch Delta 30, formerly the 30th Space Wing, operates the Vandenberg Space Force Base. The base's history began when Camp Cooke was established in 1941. During World War II, it was a training site for Army tank, artillery, and infantry training, and a prisoner of war camp. Its size, remote location, and moderate climate led to its selection in the late 1950s as an Air Force training and missile base. In 1958, Cooke Air Force Base was redesignated as Vandenberg Air Force Base (VAFB) to honor General Hoyt S. Vandenberg, who was the second Chief of Staff of the Air Force and the second Director of Central Intelligence. Its most recent name change came in 2021 when it became Vandenberg Space Force Base as part of the standup of the U.S. Space Force.

INTERAGENCY OPERATIONS, EXPANSION, AND MANY FIRSTS

Vandenberg's affiliation with national reconnaissance predates the official 1961 establishment of the NRO. At the dawn of the Space Age, the U.S. needed a space launch facility on the West Coast. Geography and safety dictate launch locations, and both factors made this location well suited for satellite launches. In 1963, the Navy transferred its Point Arguello facilities to the base. This area became known as South Vandenberg. Land was added to the base in 1966 to provide additional space flight corridors and a new space launch complex for the planned Manned Orbiting Laboratory program with NASA. At that point, Vandenberg reached its current size of approximately 99,000 acres. Vandenberg's varied terrain is home to dozens of species of wildlife.

Vandenberg was the first and foremost launch site for U.S. photoreconnaissance satellites. The Air Force and the CIA selected then-named Camp Cooke in 1958 as the site for launching Corona satellites. The launch trajectory southward over the Santa Barbara Channel and the Pacific Ocean was ideal for the necessary near-polar orbit. The base already had Thor launching pads suitable for Corona's Thor-Agena launch vehicle configuration. The first Corona launch took place on 28 February 1959, and the first successful operational launch occurred on 18 August 1960. Launching from Vandenberg made it possible for the Corona satellites to eject their film return capsules while passing over the Alaska tracking station, so the capsules subsequently could be recovered in the Hawaii area. Vandenberg administered the launch of 121 Corona satellites, 95 of which were successful, through the end of the Corona program in 1972.

Vandenberg launched the first Argon (KH-5) mapping camera system on 17 February 1962. Continuing through 1964 were 11 more Argon launches from VAFB, some of which were launched in piggyback fashion with Corona missions. VAFB launched 11 Samos reconnaissance satellites between 1960 and 1962 and all three of the Lanyard (KH-6) panoramic camera systems in 1963.

Vandenberg successfully launched seven of the Poppy Elint satellites (1962-1971). VAFB was the launch site and also a satellite tracking station for Quill, the first space-based system to use synthetic aperture radar. After the launch team resolved a situation with an approaching train that could have halted the launch countdown, Quill launched on a thrust-augmented Thor booster and an Agena upper-stage from Vandenberg on 21 December 1964.

Gambit (KH-7) was the first operational U.S. satellite system that returned high-resolution photography consistently. VAFB launched the first Gambit flight vehicle on 12 July 1963. Ninety-one additional Gambit launches at VAFB continued through the end of the Gambit program in 1984. VAFB launched the first Hexagon (KH-9) search and mapping satellite atop a Titan IIID vehicle on 15 June 1971. Continuing through 1986, Vandenberg oversaw the launch of the 20 Hexagon satellites. All but the last of these Hexagon launches were successful. The State of California restricted the pre-launch transportation of the Hexagon, sometimes called "Big Bird" for its very large size, to daytime weekdays outside of rush hours. The first Kennen (KH-11) imagery mission launched from Vandenberg on 19 December 1976.

SHARED HISTORY AND LASTING CONTRIBUTIONS

In the early 1970s, NASA proposed making Vandenberg the site for shuttle launches for classified payloads; its location was very suitable to facilitate high-inclination orbits. There were potential impediments, including the expense and effort necessary to build a new launch pad at Vandenberg. In 1979, work began to construct the new shuttle facility at VAFB's Space Launch Complex 6 that previously was occupied by the Air Force DynaSoar winged space glider (1959-1963) and the Air Force-NRO MOL (1965-1969) programs. There were delays due to politics, inter-agency frictions, and cost overruns. Several disasters in the mid-1980s led to the cancellation of Vandenberg as the shuttle launch site, but VAFB continued to work with NASA on space launches for other NASA endeavors.

In March 1997, the NRO declassified the fact that Vandenberg's space detachment, Operating Location Vandenberg, was part of the NRO. Its name then changed to NRO-Vandenberg, and its past presence at VAFB could be acknowledged. In addition to its classified space launch missions, Vandenberg Space Force Base performs space and missile testing, as well as space launches from the Western Range for NASA and other civil agencies, as well as commercial space entities such as SpaceX. While much of the information regarding NROV remains classified, aspects of its space reconnaissance history can be recognized. For six decades, the dedicated staff at the site known today as NROV has transported, processed, fueled, and launched scores of reconnaissance satellites.

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CENTER FOR THE STUDY OF
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MAY 2023