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Chapter 11

The Spy Race: First Developments on US Spy Satellites during the Cold War*

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Abstract

On October 8, 1957, a few days after the successful launch of the Soviet satellite Sputnik, US President Dwight D. Eisenhower, gave a speech and a press conference to address this new space situation. One journalist asked President Eisenhower: "Do you not think that it has immense significance, the satellite, in surveillance of other countries?" Indeed, that question proves to be one of the most significant uses satellites would have in the following years. After Sputnik, and far away from public opinion and the most well-known space race, another more calculated, secret, and strategic race was in place. The use of satellites for reconnaissance and intelligence missions was a possibility long studied in the United States since the 1940s. And as soon as the space race began, the development of military spy satellites took place. This chapter will examine and analyze the first programs and efforts in reconnaissance, electronic intelligence, and space science related to these spy satellites, that took place in United States during the first decades of the Space Age. It will analyze first US spy programs and success such as Corona, Samos, Gambit, Grab, or Poppy. Programs that were key

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elements for the intelligence community and the military. And that despite being less famous than their manned contemporary civil ones, such as Mercury, Gemini, or Apollo, they had a tremendous impact in shaping the actual international framework for space activities and legislation (such as the notion of freedom of space). And in essence, they shaped the military uses of space and space systems nowadays.

Acronyms/Abbreviations

AEDS—Atomic Energy Detection System
AFB—Air Force Based
AFOAT-1—Air Force Office of Atomic Energy-1
ARPA—Advanced Research Projects Agency
CIA—Central Intelligence Agency
DoD—Department of Defense
DMSP—Defense Meteorological Satellite Program
ELINT—Electronic Intelligence
GRAB—Galactic Radiation and Background
ICBM—Intercontinental Ballistic Missile
KH—Key Hole
PARPRO—Peacetime Aerial Reconnaissance Program
RAF—Royal Air Force
MIT—Massachusetts Institute of Technology
NACA—National Advisory Committee on Aeronautics
NASA—National Aeronautics and Space Agency
NRO—National Reconnaissance Office
NRL—Naval Research Laboratory
SAC—Strategic Air Command
SALT—Strategic Arms Limitations Treaties
SAMOS—Satellite and Missile Observation System
SENSINT—Sensitive Intelligence Program
SIGINT—Signal Intelligence
SIOP—Single Integrated Operational Plan
US—United States of America
USAF—United States Air Force
USSR—Union of Soviet Socialist Republics
WWI—World War I
WWII—World War II
WS—Weapon System

I. Introduction

At the end of WWII, and the 1940s, it was clear that information and reconnaissance were key aspects to defeat an enemy. In 1941, the surprise attack on Pearl Harbor had shown the United States what an error on intel could lead to. The loss of the nuclear monopoly in 1949 against the Soviet Union, shocking the US estimates, was also putting in manifest the need for good, reliable, constant, and autonomous sources of information. The dawn of the Space Age and the new developing technologies such as the intercontinental ballistic missiles (ICBMs), increased the needs of more intelligence on these new assets. But more important, they opened the way to new ways of getting this information.

With the first successful steps into space, and behind the most well know new National Aeronautics and Space Agency (NASA), other programs and efforts were created. The National Reconnaissance Office (NRO) was established on September 6, 1961. Its main mission was to manage the rising importance, development, and implementation of spy satellites. Programs such as CORONA, GAMBIT, GRAB, and POPPY were the first outcomes of these early decades. Aimed at getting photoreconnaissance or signal intelligence, they were key to establish the real size and developments of Soviet military power. And later also, were key elements not only to plan the US military strategy but also to implement weapons reductions arms treaties. While the world was looking at the space race between the United States and the Soviet Union, these spy satellites were making developments in new technologies and to pursue its mission. Each time in a more successful and optimal way.

This chapter will take a look at the origin of these first spy programs, their description and how they were developed.

In an era where the space race was the main concern for the general public, the use and developments of spy satellites were indeed shaping more than anything the laws, uses, and importance of this new domain and technologies.

II. Fear of an Atomic Pearl Harbor and the Need for Reconnaissance and Surveillance

> "Japan's attack on American forces at Pearl Harbor on December 7, 1941, demonstrated the critical importance of reconnaissance to prevent surprise attack on the United States and its allies … Moscow tested its first atomic device in 1949, and in the 1950s moved steadily toward acquiring first heavy bombers, and then long-range missiles as strategic delivery systems. War with the Soviet Union was a growing possibility and America looked

to intelligence agencies for indications and warnings of surprise attack"—NRO, extracted from [1].

After WWII, the importance of intelligence and reconnaissance for military strategic and tactical decisions and operations was clear. The lack of good intelligence could lead to potentially disastrous outcomes, such as the surprise Japanese attack on Pearl Harbor. On the other hand, operations such as Overlord were a success for allied forces. Where successfully intelligence initiatives such as Ultra provided the essential piece of information on the enemy order of battle [2].

At the end of WWII, the United States was the only country with nuclear weapons. This nuclear monopoly was expected to last according to US intelligence reports until mid-1953 as "the most probable date" [3]. US officials, scientists, and militaries knew that monitoring and surveillance of possible nuclear weapons tests and activities should be also established worldwide. It was a quick way to detect any nuclear weapon and thus avoid an "atomic Pearl Harbor" out of the blue. In this respect, from all the traditional intelligence-gathering methods, aerial reconnaissance seemed more fitting for this mission.

Aerial reconnaissance can be dated back to 1749, where balloons were used for spying and providing intelligence information to the French at the battle of Fleurus [4]. But it was during the WWI and most notably WWII when aerial reconnaissance achieved its highest roles for both strategic and tactical objectives. The new strategic bombers, such as the B-29, were an excellent platform to conduct these reconnaissance and surveillance missions. And it was with all this, that the Army Chief of Staff Dwight D. Eisenhower, in 1947, assigned to the Army Air Forces the responsibility of establishing an Atomic Energy Detection System (AEDS) [3]. In 1948, the newly established US Air Force (USAF) created the Air Force Office of Atomic Energy-1 (AFOAT-1). The main responsibility of AFOAT-1 would be managing AEDS and the mission to discover foreign atomic tests and other nuclear-weapons related activities [5]. The USAF started a series of surveillance and monitoring flights all around the world. It was a WB-29 (W for "weather") aircraft that first picked up radioactive particles from the first Soviet nuclear test. This was on September 3, 1949. The aircraft, operated by the Air Force's weather service, was carrying special filters designed to pick up the radiological debris that an atmospheric nuclear test would inevitably create. And it was on a routine flight from Misawa AFB (Japan) to Eielson AFB (Alaska). After more flights to collect more air samples, the test was clear. Days later, President Truman made a statement to the nation on the First Soviet Nuclear Test:

> We have evidence that within recent weeks an atomic explosion occurred in the USSR—extracted from [6].

This evidence was obtained by air reconnaissance. With the loss of the nuclear monopoly, the United States and the Soviet Union started an arms race, where intelligence on the adversary nuclear weapons, delivering methods, and air defense was elementary to plan any nuclear strategy. Added to this there was a lack of information on the Soviet Union. Cities, communication roads and railways, military bases and industrial complexes were much time unknown or in wrong locations due to the fact that many maps in the hands of Western countries dated back to the pre-revolution era or the Nazi-Germany in the pre-invasion of the Soviet Union in WWII. All this lack of information raised the need for more and better surveillance and reconnaissance methods, programs, and missions. Especially needed were missions to map and know better the Soviet Union and its nuclear forces, but also to detect and prevent any kind of surprise attack. As President Dwight D. Eisenhower would explain on May 11, 1960, during a news conference following the U-2 incident:

> … first point is this: the need for intelligence-gathering activities.
>
> No one wants another Pearl Harbor. This means that we must have knowledge of military forces and preparations around the world, especially those capable of massive surprise attack.
>
> Secrecy in the Soviet Union makes this essential. In most of the world no large-scale attack could be prepared in secret. But in the Soviet Union there is a fetish of secrecy and concealment. This is a major cause of international tension and uneasiness today. Our deterrent must never be placed in jeopardy. The safety of the whole free world demands this.
>
> As the Secretary of State pointed out in his recent statement, ever since the beginning of my administration I have issued directives to gather, in every feasible way, the information required to protect the United States and the free world against surprise attack and to enable them to make effective preparations for defense.

Now, let's take a look at all these "directives to gather, in every feasible way, the information required" that President Eisenhower mentioned in his speech.

III. From PARPRO to SENSINT, Overflying the Soviet Union

As early as 1946, the United States had initiated a series of flights near the Soviet Union and satellite territories to gain military information. These flights were part of the Peacetime Airborne Reconnaissance Program (PARPRO). PARPRO conducted flights on the periphery of the Soviet Union, China, and other territories. And unlike the later overflights, they weren't supposed to go inside national airspace. Staying in the complete legacy [7]. PARPRO missions were to gather radar data on the air defense (SIGINT missions) and, if possible, take photographs of interest zones near the borders.

However, on April 8, 1950, a PARPRO US Navy plane flying over the Baltic Sea, was shot down. The US Navy PB4Y-2 Privateer was intercepted by Soviet Lavochkin LA-11 fighters. The ten crew members were reported missing in action by the United States [8].

Figure 11–1: US Navy consolidated PB4Y-2S Privateer. Credit US Navy National Museum of Naval Aviation.

This incident, linked to the need for more reconnaissance inside the Soviet Union, led President Truman to escalate PARPRO to a new program of overflights over the Soviet Union. But what do we mean by "overflights"? In the words of NRO historian Cargill Hall: "I mean [by overflight] a flight by a government aircraft that, expressly on the direction of the head of state, traverses the territory of another state in peacetime without that other state's permission" [7]. So, we can clearly see the escalation of the situation. And the dangers that these overflights might imply. But the need for information was so great that the United States was willing to assay these overflights. These overflights would be carried out in what was known as the SENSIT program (standing for sensitive intelligence).

SENSIT was carried out from early 1954 until late 1956 [9]. And flights of the program could be only authorized by the president of the United States. The first recorded USAF overflight dated back to 1949 over Kuril Island in the far east of the Soviet Union [7].

However, the Soviet Union was very sensitive to all these kinds of flights. Especially after WWII. Where previous to the Nazi-Germany invasion, nearly 500 overflights were done by the Luftwaffe, gathering the intel for the future invasion [7]. With this in mind, Soviet political and military leaders were putting great importance in defending their sovereign airspace. Giving as a result, an aggressive Soviet air defense. In constant modernization to meet the threat, to put in danger and in some cases shoot down these SENSIT aircraft overflights.

The USAF used new and different aircraft models to try to overcome the Soviet air defense. And in that way to have more chances to accomplish these intelligence missions in a safer and better way. The basic idea was to go “faster” or “higher” to be out of reach of the Soviet air defense. However, this proved to be challenging. Soviet air defense kept improving with a new surface-to-air missile (SAM) and aircraft. And it kept shooting down US aircraft on PARPRO missions. (No SENSIT aircraft were ever lost to Soviet anti-air.)

Around 170 US aircrew members lost their lives during all these PARPRO and SENSIT missions in the 1946–1960 period [10]. By the beginning of the 1950s, the USAF started searching for more radical ways of outpacing Soviet air defenses. And it seemed that getting high-altitude reconnaissance photos could be the way.

IV. Going Higher—Genetrix and the U-2

Project Genetrix (also known as WS-119L) [4] was developed in the 1950s. The idea was simple: cameras attached to high-altitude balloons were released in northern latitudes during winter months. There, with the westerlies, they would be blown across the Soviet Union until they reached the northwest Pacific Ocean. At that point, the camera which would have taken photos of the enemy territory, would be released and recovered by US forces.

However, this program proved to have a lot of practical problems. Since the balloon had no attitude control, the path was totally up to the wind. Thus, the areas photographed were also many times of no intelligence interest. Also, clouds or bad weather could completely render useless the pictures. Also, some balloons could be lost during the trip (due to technical problems or even drive far away from the estimated routes and being “lost”). And of course, sometimes the release of the camera happened before planned. Leaving it in Soviet territory or other hostile states. For this possibility, all the program was operating under the cover story of a worldwide effort to study weather patterns. Giving thus a scientific and civilian cover to program GENETRIX.

The first balloon of the program was launched December 27, 1955. But the launches were stopped on February 6, 1956, due to Soviet formal protest. In that time, over 516 balloons were released, from which only forty-six payloads were recovered by the United States, from which only thirty-four could be considered “successful” [11]. Leaving project GENETRIX with poor performance. But high-altitude balloons weren't the only method the USAF was studying to get high-altitude reconnaissance.

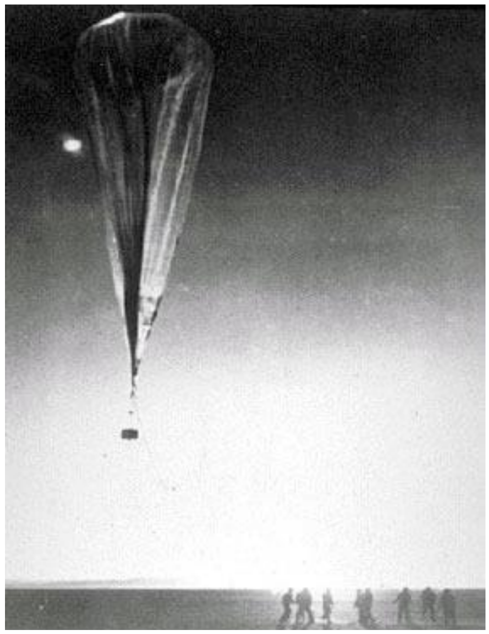


Figure 11–2: Project GENETRIX balloon during launch, January 1956. Credit USAF.

In July 1953, the USAF awarded different study contracts to different companies to develop a new high-altitude reconnaissance aircraft. And also, to examine the possibility of converting the exiting B-57 bomber (derived from the English Canberra) into a high-altitude reconnaissance aircraft.

These studies produced different proposals from different contractors. Mainly the M-195 from Fairchild Engine and Airplane Corporation of Hagerstown, the Model 67 (X-16) from Bell Aircraft and Model-294 (the converted B-57) [11]. All these models demonstrated the feasibility of high-altitude reconnaissance aircraft. One year later, Lockheed also presented the CL-282 (later know as U-2). Designed by Clarence Leonard (Kelly) Johnson, the aircraft was designed to operate at altitudes between 65,000–70,000 feet (around 20 km of altitude) and Mach 0.8. Making the aircraft "capable of avoiding virtually all Russian defenses until about 1960" [11]. The USAF started the development of the Martin B-57 and Bell X-16, leaving out the U-2. However, the Lockheed U-2 found another opportunity with the Central Intelligence Agency (CIA).

Also, in 1952, the Beacon Hill study group produced a report (Bacon Hill Report) on "Problems of Air Force Intelligence and Reconnaissance" [12]. This report expressed the importance of aerial reconnaissance and, moreover, the recommendation of high-altitude aircraft or rocket-like aircraft to pursue this mission. Giving a backup to all the U-2 project.

In the meantime, in the first half of 1953, the RAF employed a high-altitude Canberra to conduct an overflight of the Soviet Union. Photographing the missile test range at Kapustin Yar. But the flight was intercepted and nearly shot down by Soviet air defense fighters [11].

In the meantime, the USAF and CIA were negotiating the partnership for the U-2 program. With the initial interagency meeting held in December 1954, the two agencies had more or less the whole program settled in August 1955. The agreement titled "Organization and Delineation of Responsibilities—Project OILSTONE" gave the USAF responsibility for pilot selection and training, weather information, mission plotting, and operational support. The CIA was taking care of the cameras, security, contracting, film processing and arrangements for foreign bases. Finally, all the construction and testing of the aircraft remained responsibilities of Lockheed [11]. Also, as it has happened with the program GENETRIX, a good cover story for the U-2 was prepared. In 1956, CIA approved the final version of the overall cover story: The U-2 was on a mission of high-altitude weather research by the National Advisory Committee for Aeronautics (NACA), predecessor of NASA. By June 20, 1956, the first U-2 overflight took place. A U-2 equipped with an A-2 camera flew over Poland and East Germany, obtaining good-quality pictures. Later, on July 4, 1956, the first overflight of the Soviet Union took place [11]. More overflights followed. Moscow started a protest on July 10. It was clear that the U-2s could not overfly undetected. However, the U-2 photos proved to be extremely useful. Ending the discussion of the "Bomber Gap" that had raised in the first years of the 1950s over the Myasishcev-4 "Bison" heavy bombers. This encouraged use of the U-2 in more places and for more aerial reconnaissance. In 1957, the U-2 program even photographed the Tyuratam complex where the first Soviet ICBM and artificial satellite were launched.

In 1960, operation GRAND SLAM mission 4154 began its deep penetration overflight of the Soviet Union on Sunday, May 1, 1960. The pilot was Francis Gary Powers, one of the most veteran U-2 pilots. The fact that the flight was during the major Soviet holiday, with less Soviet military air traffic than usual, made easier for Soviet air defense to track the whole flight, even before penetrating deep inside the Soviet Union. Four-and-a-half hours into the mission, and after some unsuccessful attempts to intercept the U-2, a SA-2 SAM shot down Gary Powers. Gary Powers survived and was captured by Soviet forces. The Soviets were also able to recover wreckage of the U-2 that was on display for international press along with the whole trial to Gary Powers. The Soviets used all this incident to press the United States to end the overflights.

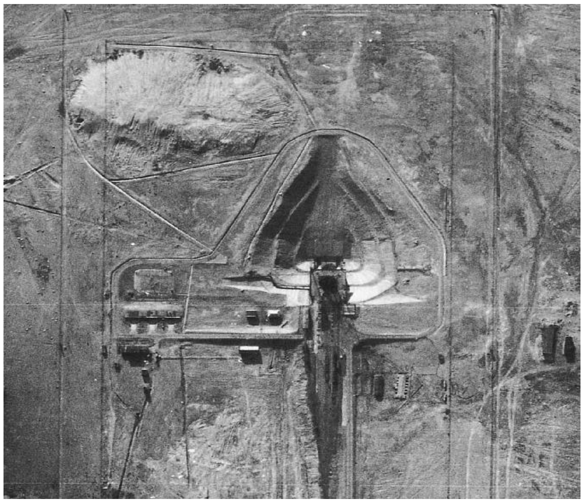


Figure 11–3: U-2 photography of Tyuratam Missile Testing Range. Credit CIA.

Figure 11–4: Rest of Gary Powers's U-2 at the central armed forces museum in Moscow. Credit by the author.

President Eisenhower ended the overflights of the Soviet Union, ending the most reliable high-altitude reconnaissance method the United States had at that time. However, the international and political consequences, along with the danger for the U-2, deemed further overflights too risky. The United States needed another way of getting these pictures. And maybe space was the answer.

V. The Need for Space—Freedom of Space

In 1946, interest in artificial space satellites had been already expressed by the US Navy. In this context, Major General Curtis E. LeMay, then deputy chief of the Air Staff for Research and Development, tasked project RAND to undertake a feasibility study on this matter [13]. This study outcome was a report made by the Douglas Aircraft Company, where it was already stated that: "It should also be remarked that the satellite offers an observation aircraft which cannot be brought down by an enemy who has not mastered similar techniques"—extracted from [14].

So, it was clear from the beginning the advantages of using a satellite to gather intelligence and data. Especially when aerial reconnaissance was proven to be so risky. However, technical difficulties and incertitude along with budget shortages, kept these developments on a slow path.

Also, the US administration was wondering if the overflight in space by a reconnaissance satellite would be considered as an overflight by an airplane. In this aspect, this view was even reinforced after the refusal of the Soviet Union to accept the "Open Skies" initiative in 1955. This initiative was to open the national skies to reconnaissance aircraft from other nations. And its refusal was the last thing President Dwight D. Eisenhower needed to authorize the risky U-2 overflights.

But related to space, it was believed that if an international framework could be established, to consider space as a commonplace for international and science cooperation, then no country could oppose to the pass of satellites over its territory. In some cases, during discussion on this matter, it was even considered that it was the earth that was moving and not the spacecraft:

> There would be a legal point involved in its [a satellite's] use for reconnaissance purposes. Would not this violate sovereignty?
>
> There is no legal responsibility. All we do is to send it up at one point, the earth does the rest by revolving under it. The other country would simply get under the satellite.
>
> —Discussion during January 1949 RAND conference about implications of reconnaissance satellites [15].

However, all these political and technical concerns were radically changed by the first artificial satellite. In the framework of the International Geophysical Year, the United States and the Soviet Union had announced their intention of orbiting an artificial satellite. The US administration had in mind to use this international framework to help establish the concept of "freedom of space." Or in other words, that there is no national sovereignty in space, and thus overflights of other countries are perfectly legal since space is a common area. In this aspect, the flight of Sputnik in 1957 by the Soviet Union helped clearly to establish this concept. Sputnik had a great impact on public opinion and views on space. But also helped a lot to settle the political concerns and difficulties the United States was having to implement and create a reconnaissance satellite. Since the satellite had been launched and overflew all the Earth without the minor notification of the Soviet Union, the United States rapidly saw this as an example of their long searched for "freedom of space." If the United States could also achieve another "science and exploration" satellite launch, it would be clear that "freedom of space" was a fact. And it would open the way to reconnaissance satellites. Also, Sputnik showed the viability of satellites. Something that linked with the impact on public opinion helped to put more money and effort into the US satellite programs.

All these paved the way to the long-discussed reconnaissance satellite. And one year after the Sputnik flight, the United States would be launching its first "spy satellite."

VI. The WS-117L (SENTRY) Program

In 1956, the USAF started the development of a strategic reconnaissance weapons system, employing the use of satellites. The program designation was Weapon System (WS)-117L [16]. This program was soon to be named SENTRY by the main contractors, mostly Lockheed [4]. The program progressed slowly and with too many capabilities in mind. Especially after the Sputnik launch, where to the already visual and electronic reconnaissance capabilities, there were added the infrared reconnaissance for early warning of ICBM launches, and weather reconnaissance along with possible communications capabilities.

The SENTRY program continued to evolve with the idea of a sequential achievement of the tasks it would perform. Visual reconnaissance began in 1958 with satellites that would employ Thor rockets that later would be replaced by the more powerful Atlas rocket in 1959. Later, by 1961, advanced visual reconnaissance systems would follow. And in 1962, the incorporation of infrared and SIGINT systems would donate early warning capabilities along with the possibility of Soviet air defense mapping and characterization [4]. All these objectives gave SENTRY a vast range of capabilities and missions to be achieved in a relatively short time.

However, after Sputnik, President Dwight D. Eisenhower implemented a lot of organizational changes at military and political levels. One of these changes was the creation of the Advanced Research Projects Agency (ARPA). This agency, created February 7, 1958, opposed the whole schedule and idea of SENTRY. Its director, Roy W. Johnson, issued a directive authorizing the Air Force to use the Thor rocket and Agena second stage to start a series of launches for photographic reconnaissance, biological experiments, and technical validation of satellite components. These launches would start the CORONA program, to be known by the public as the Discoverer program. With this, the Discoverer program was authorized by ARPA to have twenty-nine flights manifested by July 1958. At the same time, ARPA started to examine the SENTRY program and proposed a reorientation of its functions. The program would be divided into different sub-programs and some of its elements added to other existing ones. So, the capabilities studied for the WS-117L evolved into:

- Discoverer/CORONA—a new program for visual reconnaissance.
- SAMOS—The mapping and charting reconnaissance capabilities would be moved to this program.
- Missile Defense Alarm Satellites (MIDAS)—would take the infrared reconnaissance and the early warning capability.
- For the SIGINT/ELINT capabilities—the Galactic Radiation and Background (GRAB) program was proposed by the Naval Research Laboratory (NRL).

To see a diagram of the programs that emerged from the WS-117L/SENTRY, go to Appendix A.

VII. CORONA/DISCOVERER

CORONA was the first operational photo reconnaissance program in the United States. It was approved by Dwight D. Eisenhower as a project in February 1958 [4], following an ARPA recommendation. As happened before with the U-2 overflights, the US administration worked out a cover story for this program. That’s how CORONA was known by the public as the Discoverer program. By mid-1958, ten flights had been approved.

All the technical decisions were largely determined for the program by October 1958 [17]. The reconnaissance payload would be integrated with the Agena upper stage. It would be launched with the USAF Thor. And it would eject a reentry vehicle with the reconnaissance film/data to be recovered. For the recovery method, the air catch was chosen. With the backup of water recovery if the catch failed. Taking advantage of the recovery method that had been already implemented for the GENETRIX program. The CORONA vehicle was launched by a Thor booster and used the AGENA spacecraft upper stage as the main structure. In orbit, CORONA took photographs with a camera system that loaded the exposed film into recovery vehicles [18].

Flights Programmed in 1958	**DISCOVERER Mission**	**CORONA Mission**
Flights 1 and 2	Engineering development	Engineering development
Flights 3, 4, 6, 8, and 10	Biological flights	Some of them would carry reconnaissance cameras.
Flights 5, 7, and 9	Advanced engineering activities	All of them would carry reconnaissance cameras.

Table 11–1: First ten Discoverer and Corona flights programmed in 1958. Elaborated by the author from info from [4].

The first CORONA launch was on February 28, 1959 [19]. But the spacecraft went dead in orbit. The program had technical problems with the launcher and spacecraft at the beginning, along with the recovery of the film capsule. But finally, on August 18, 1960, the first successful images of CORONA were taken. CORONA continued operating through the Key Hole (KH) series with different versions from 1960 until 1972.

To see more details about the architecture, launch, and recovery methods for CORONA, along with the different series versions of the CORONA-KH series, see Appendix B.

Also, it is important to mention that it was due to the need for weather forecasting for CORONA, that in 1961 the National Reconnaissance Office (NRO) authorized the construction and launch of a small meteorological satellite. The NRO had been created in 1961 and was put in charge of all the intelligence satellite programs in the United States. The meteorological satellite proposed by the NRO would be launched on NASA Scout boosters [20]. This first program would pave the way to the Defense Meteorological Satellite Program (DMSP).

The last CORONA flight was on May 25, 1972. Making the program last almost fourteen years.

VIII. GRAB and POPPY

While CORONA was the first photoreconnaissance program of the United States, it wasn't the first reconnaissance program to successfully complete a mission in orbit. The first would be for GRAB, an ELINT/SIGINT satellite launched on June 22, 1960, by a Thor Able-Star rocket. This launch had been approved August 24, 1959, by President Eisenhower [21]. And its name was the acronym for the Galactic Radiation and Background (GRAB). A name in line with the scientific cover history for these ELINT/SIGINT missions, the study of space radiation background.

The GRAB concept dated back to 1958 and the NRL. The NRL was studying who to conduct SIGINT and ELINT operations in order to analyze and intercept radar signals from Soviet air defense. Something critical for the Strategic Air Command (SAC) attack routes and flights. The idea was presented to the DoD, which considered it feasible and allowed the development of the GRAB spacecraft in coordination with the US space and ELINT programs. Between 1960 and 1962, the NRL would attempt five GRAB missions, from which two were successful [21]. The GRAB satellites were launched as piggyback payloads on other launches.

The GRAB satellite was equipped with ELINT antennas for intercepting radar signals. When terrestrial radars emitted their pulse-radar signals above the horizon, GRAB collected each pulse of the signal, and a transponder sent a corresponding signal to the United States. These data were recorded when received and later distributed to the National Security Agency (NSA) and SAC to be exploited by them.

Figure 11–5: GRAB satellite. The solar panels for energy and the antennas along its spherical shape were really characteristic of GRAB. Source NRO.

In 1962, the NRO assimilated the GRAB program. With the associated multiagency collaborations and infrastructure, it became NRO’s Program C. The NRO continued the efforts of GRAB by developing POPPY, its successor.

POPPY would be launched by a combination of USAF Thor Agena-D, Thrust-Augmented-Thor Agena-D, and Thorad-Agena-D launchers. POPPY spacecraft were completed spherical with a twelve-sides, multifaced design. POPPY not only improved the spacecraft but also its ground installations, improving the ELINT capacity and efficiency.

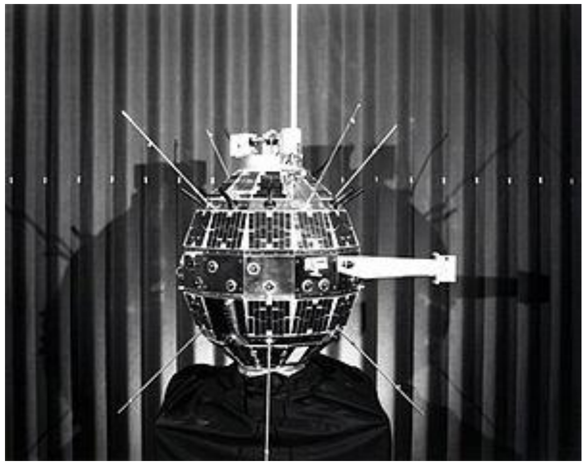


Figure 11–6: POPPY satellite. And improvement of the former GRAB. Source NRO.

Thanks to these early ELINT/SIGINT programs, the United States was able to improve considerably its knowledge of the Soviet air defense. It helped to characterize routes and objectives and helped also to improve the US SIOP in the 1960s.

IX. SAMOS

The Satellite and Missile Observation System (SAMOS) was a program to implement a reconnaissance satellite that would transmit the images back to Earth. The idea would be that once the film was exposed in the camera, it would be scanned and transformed into an electrical signal whose strength varied with the density of the emulsion layer of the film. The electrical signal was then radioed back to Earth as frequency-modulated analog signals [22].

The SAMOS imaging system had been conceived in the mid-1950s. The Eastman Kodak Company built the E-1 and E-2 payloads for SAMOS. Where the first one was a preliminary payload and the second one an advanced payload.

When SAMOS E-1 was launched in 1960 and 1961, it encountered problems. These problems were related to a film-limited life in orbit, along with the limited transmission of the images back to Earth. Since the signal was not encoded, it could only transmit back to US territory stations. Reducing the time these signals could be transmitted back to Earth. Also, this problem was added to the velocity of the transmission of these readouts. In view of these technical limitations, NRO terminated SAMOS in September 1961 in favor of CORONA [22].

However, taking into account the advances that SAMOS had incorporated, the NRO officials agreed to consign the SAMOS imaging system to NASA and its deep space exploration program. That's how SAMOS helped NASA with its lunar orbiters, which were obtaining detailed photographs for the Apollo program. NASA launched the successful spacecraft between August 1966 and August 1967 [22]. Obtaining unique data and images of the surface of the Moon.

Spacecraft	**Launch Date**	**Imaged Moon Date**	**Mission**
Lunar Orbiter 1	August 10, 1966	August 18–29, 1966	Apollo landing site survey
Lunar Orbiter 2	November 6, 1966	November 18–25, 1966	
Lunar Orbiter 3	February 5, 1967	February 15–23, 1967	
Lunar Orbiter 4	May 4, 1967	May 11–26, 1967	Lunar Mapping
Lunar Orbiter 5	August 1, 1967	August 6–18, 1967	Lunar Mapping and hi-res survey.

Table 11–2: Lunar orbiter mission that employed the SAMOS imaging payload. Elaborated by the author from [23].

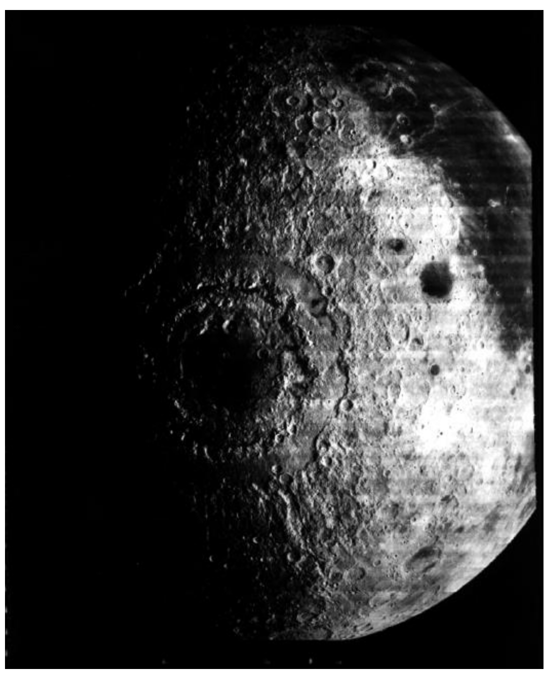


Figure 11–7: Image from the mapping of the Moon from the Lunar Orbiter 4. Source NASA.

X. GAMBIT

While CORONA was a good program for area reconnaissance, it lacked the detail and resolution for concrete assessment and characterization of targets or military forces by the intelligence community. That's why GAMBIT was developed. The idea would be that CORONA would be used for wide-area search and locate, while GAMBIT would focus in close areas of interest.

GAMBIT, also known as the KH-7 series, was developed with a different approach than CORONA. For getting high-resolution images, a combination of mirrors and optical lenses, as in a telescope, were used. This allowed GAMBIT to give a ground resolution at the nadir of 60 cm, around three times that of CORONA [4]. The first GAMBIT-1 mission was launched on July 12, 1963. It used an Atlas D booster with an Agena D upper stage. As it happened with CORONA, the GAMBIT payload was incorporated into the Agena upper stage. The NRO launched thirty-eight GAMBIT-1 missions from 1963 until 1967, of which twenty-eight were successes [24]. GAMBIT-1 had three times the focal length of CORONA and provided an average of a thousand high-resolution photographs per mission [25].

KH-7 Image of U.S. Capitol in Washington, DC, 19 February 1966

Figure 11–8: Image of the US Capitol obtained by GAMBIT. Source NRO.

Following the good results of GAMBIT-1, GAMBIT-3 (KH-8) was an improvement of the program. The payload now had the capability to rotate while the Agena booster remained stable, allowing for better area coverage and target acquisition. Also, the film used was thinner, allowing for more capability and extended mission time. And the focal length was improved from three to seven times that of CORONA [25].

The NRO launched fifty-four Gambit-3 satellites from July 1966 until April 1984. Also using the new Titan booster for it.

GAMBIT missions helped not only to image assets of Soviet or Chinese armed and nuclear forces, but also was a key component of arms reduction treaties such as SALT-1. These treaties were always relying on national means to check the other nations' compliance with the treaties. And it was thanks to GAMBIT that this assessment could be made. Its high-resolution pictures allowed the identification and characterization of weapon systems, armed forces, and infrastructures. Also, GAMBIT even monitored Soviet efforts on their lunar program. And assessed their progress vs the Apollo program. For more information on the GAMBIT architecture and profile mission, go to Appendix C.

KH-8 Image of Space Booster at the Tyuratam Missile Test Center in the Former Soviet Union, 19 September 1968

Figure 11–9: Image of the N1-L3 Moon rocket at Baikonur tacked by a GAMBIT-3 (KH-8). Source NRO.

XI. Conclusions

After WWII and with the introduction of nuclear weapons, intelligence became a key element of strategic decisions in United States. When a surprise nuclear attack could mean a new “nuclear Pearl Harbor,” the capacity of assessment of enemy forces was a high priority. In this aspect, aerial reconnaissance rapidly evolved into space.

Aerial reconnaissance was too risky, as shown by the U-2 incident and the losses of the PARPRO and SENSIT programs. In that way, space presented a new legal environment from which reconnaissance could be conducted with lower risk. Of course, in the beginning, the technical challenges posed by space systems were a great problem to solve. However, despite the failures, as soon as GRAB or CORONA started to generate intel on the Soviet Union and other targeted nations, it was clear that space reconnaissance and surveillance were worth the investment.

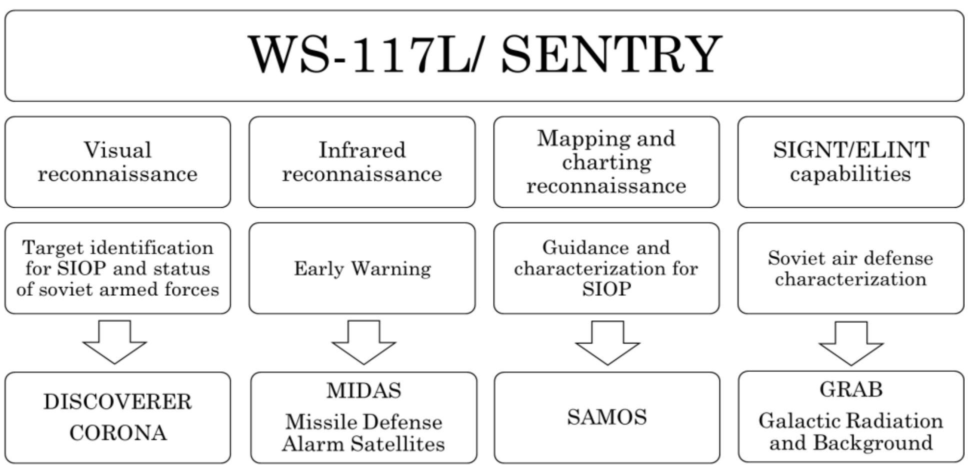
These US spy satellite programs were conducted with public covers, which used science and exploration as the main justification for their existence. It is thanks to the US intelligence community, that these activities were kept from public knowledge despite their open conduction, until their declassification in the 1990s. In some cases, as SAMOS demonstrates, even the investment in these spy satellites was transferred directly to civil programs, such as the Lunar Orbiters of NASA. And it is clear that the cover stories of conducting these launches for science and exploration, helped to establish the concept of “freedom of space.” Where space was seen as a common ground to conduct exploration and science activities by the different nations.

Also, these reconnaissance programs helped to implement weapons reduction treaties, such as SALT-1. And it is clear that apart from the weapons and military forces assessment, programs such as GAMBIT helped the United States to make better estimations of Soviet armed and space capabilities. Helping to dissolve the concerns over “the bomber gap” and “the missile gap.” And also helped to establish Soviet status and development during the “space race.” Avoiding more “public” shocks such as Sputnik.

These programs, were in service for many years, demonstrating that the technology remained capable even with the incredible technological advances that were made in the second half of the twentieth century. Demonstrating that a strong investment, along with efficient, rational, and centralized (through ARPA or NRO) controls over these programs, produced the best outcomes. They also fostered technological advancements into space launch architectures (such as the Agena upper stage).

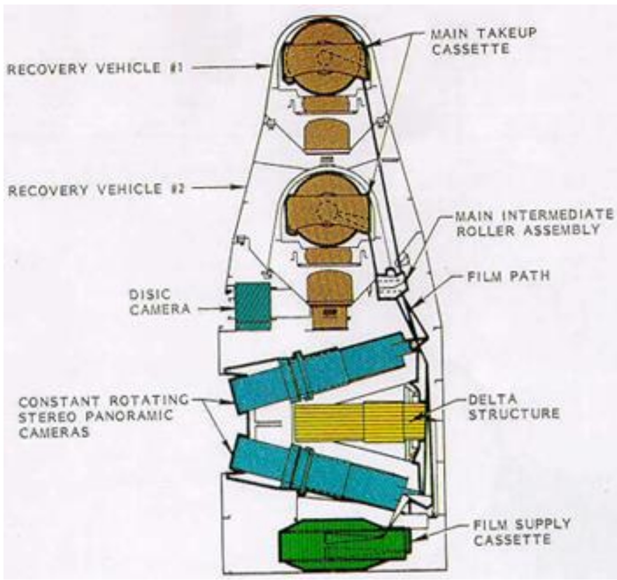
In conclusion, early US spy satellite programs, such as CORONA, SAMOS, GAMBIT, GRAB, or POPPY extended way beyond their military applications. These programs not only helped the intelligence and military community to assess better enemy capabilities and developments. Helping to stabilize the unstable Cold War, they also helped to establish the separation between civil and military missions in space. And proved that the militarization of space for intelligence gathering was more interesting than aggressive activity and weapon systems in space. They showed that space is a great place to gather knowledge, not only for science but also from our neighborhoods back on Earth. And in doing this they opened the way to all the remote sensing missions we have today.

Appendix A
Evolution of the WS-117L/SENTRY Program into the First US Reconnaissance Programs



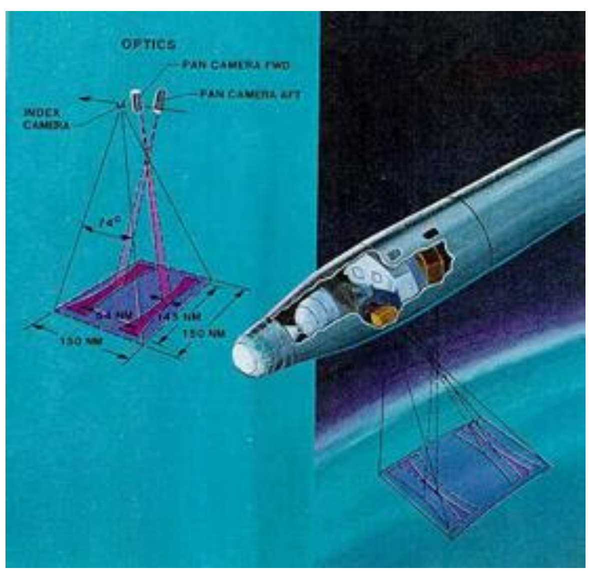
Appendix B
CORONA Basic Architecture and Mission Profile

All images are from NRO, coming from source [18].

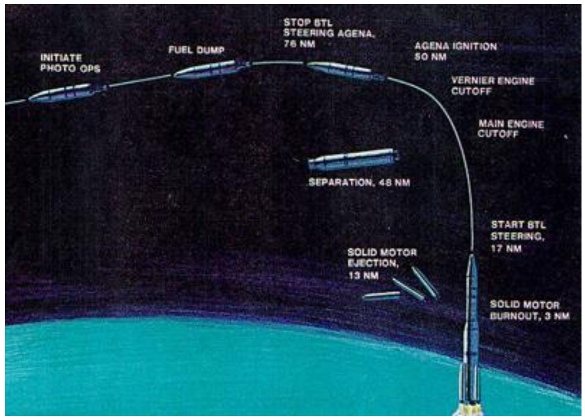


Direction of the movement of the film. Going out from the Cassette, passing through the cameras and being later stored in the Recovery Vehicles. Spacecraft would be 3-axis stabilized and flight horizontal respect to the surface of the Earth.

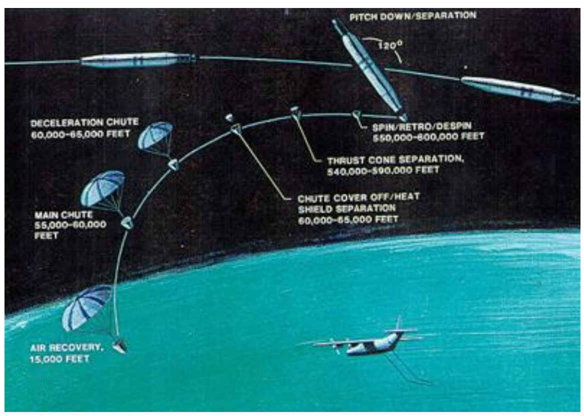
Basic schematic of the CORONA KH-4 A, J-1 payload. The CORONA payload evolved, where the initial flight would carry a camera/single recover vehicle. Then, evolved versions would carry a dual stereo camera/single recover vehicle or (as seen in the schematic here), a dual stereo camera/dual recovery vehicle.



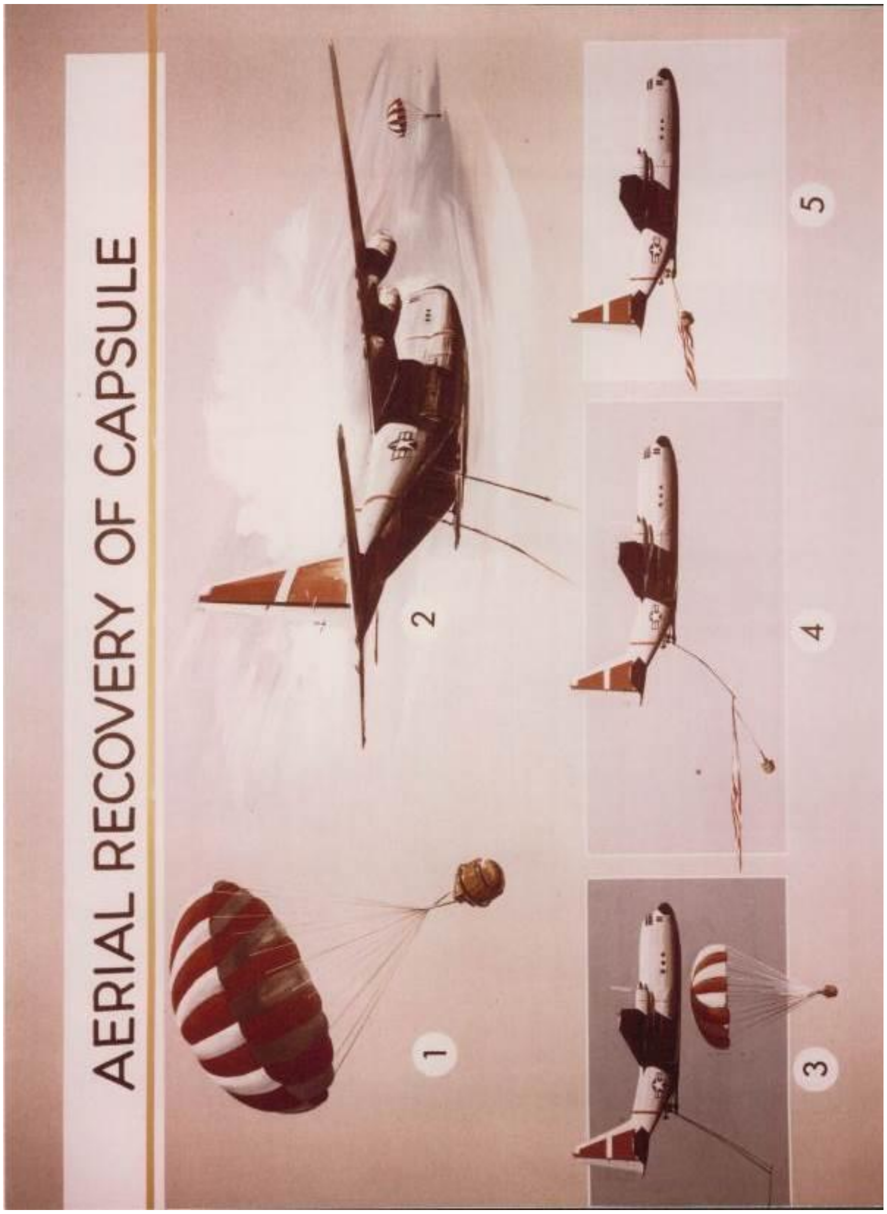
Basic schematic of the CORONA dual stereo camera use and operations.



CORONA launched sequence. CORONA used a THOR launcher with an AGENA upper stage that had integrated the CORONA payload.



CORONA recovery vehicle ejection and air recovery sequence. If the air recovery failed, a water recovery was the backup plan.



Schematics of an air recovery operation of a CORONA reentry vehicle by the USAF. This method was firstly developed for GENETRIX recovery vehicles.

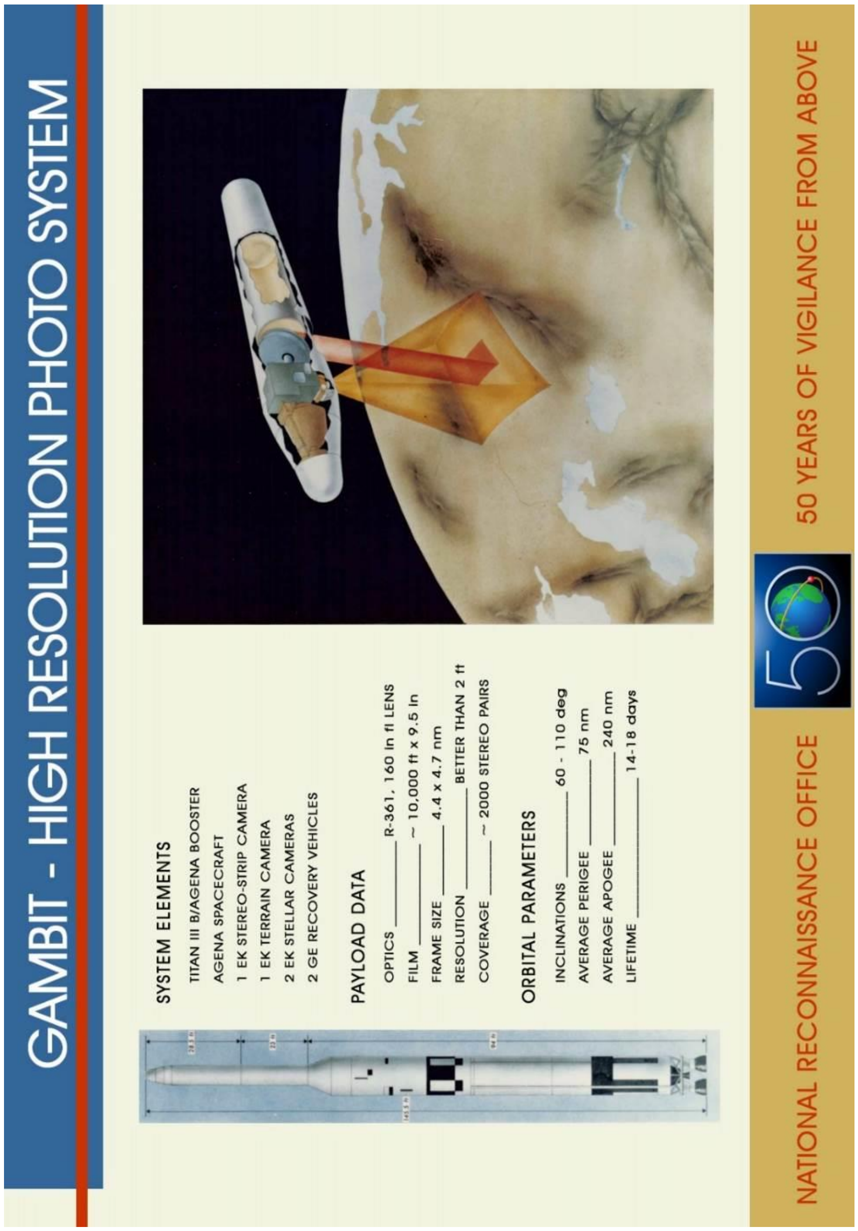
KH series	Active Period	Camara Name	Camara Type	Number of Recovery Vehicles	Number of systems launched/recoveries	Main mission/objective	Launcher Architecture
KH1, CORONA	1959-1962	C	70° pan vertical reciprocating	1	26/10	Aerial photographs	Thor-Agena A
KH2, CORONA		C'		1			Thor-Agena B
KH3, CORONA		C''		1			
KH-4, MURAL	1961-1963	M	70° pan, 30° stereo, reciprocating (2)	1	26/20	Aerial photographs with stereo capability	Thor-Agena B Thor-Agena D
KH-4 A, J-1	1963-1969	J-1	70° pan, 30° stereo, reciprocating (2)	2	52*/92 *(2 recoveries per system)	Aerial photographs with stereo capability and with index and "zombie" mode	
KH-4 B, J-2	1967-1972	J-2/CR	70° pan, 30° stereo, rotating (2)	2	17*/32 *(2 recoveries per system)		
KH-5, ARGON	1961-1964	A	Frame	1	12/6	Mapping	
KH-6, LANYARD	1963	L	90° Pan, 30° stereo, roll joint.	1	3/2	Aerial photographs with stereo capability and with index	Thor-Agena D

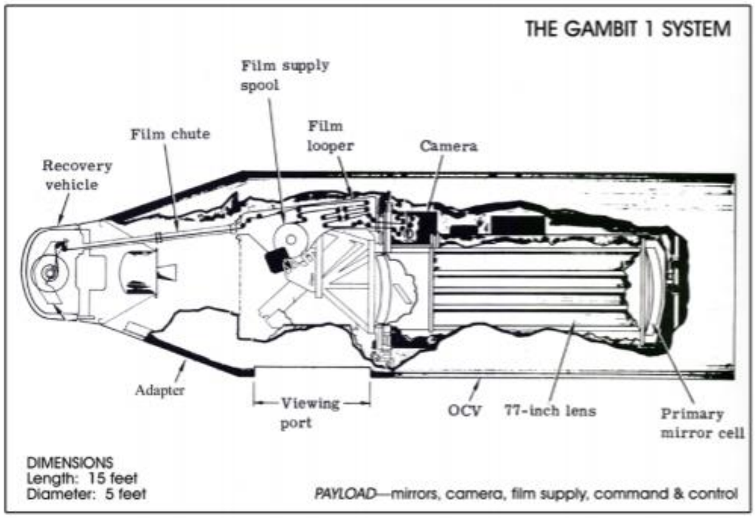
Table with the differences in the CORONA KH series mostly related to the cameras and the number of recovery vehicles. Elaborated b the author with information from the source [4]

Appendix C
GAMBIT Basic Architecture and Mission Profile

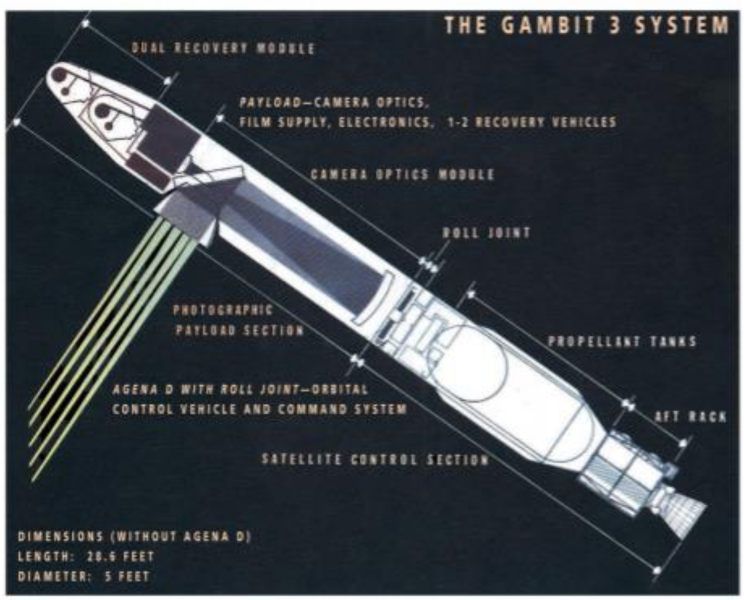
All images are from the NRO, coming from sources [24], [26], and [27].

GAMBIT Overall Schematics of the System

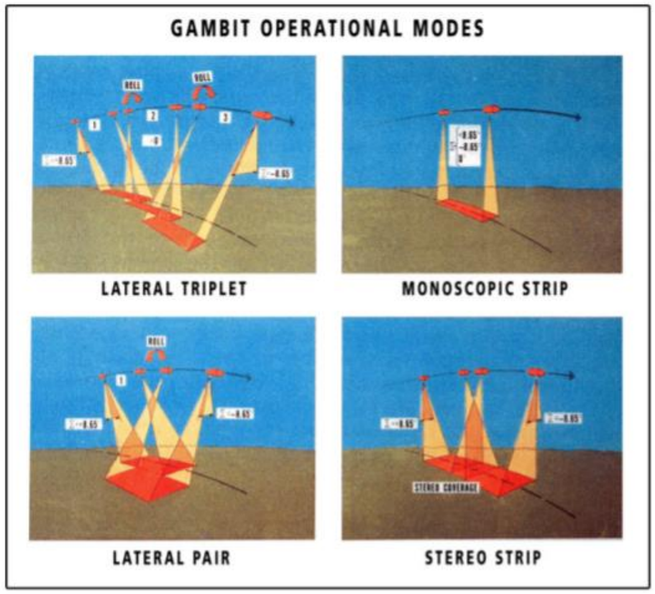




GAMBIT-1 schematics of the Payload



GAMBIT-3 schematics of the Payload and Agena upper stage.



GAMBIT-3 schematics of the Payload and Agena upper stage.

KH-8 Image of Ammunition Loading and Explosives Plant Raketa 392 at Kemerovo in the Former Soviet Union, 3 August 1966

GAMBIT-3 schematics of the Payload and Agena upper stage.

References

[1] NRO, "The NRO: America's Eyes and Ears in Space," October 2015, https://www.youtube.com/watch?v=x1kg-bBozQI (accessed 3.10.2019).

[2] S.E. Ambrose, "Eisenhower, the Intelligence Community, and the D-Day Invasion," *The Wisconsin Magazine of History,* vol. 64 no. 4 (1981) 261–277.

[3] William Burr, Jeffrey Richelson, and Michael Goodman, "U.S. Intelligence and the Detection of the First Soviet Nuclear Test, September 1949," September 22, 2009, https://nsarchive2.gwu.edu/nukevault/ebb286/index.htm.

[4] David Baker, *US Spy Satellites 1959 onward (all mission, all models),* ed., Haynes, Somerset, 2016.

[5] William Burr, "Documents on the U.S. Atomic Energy Detection System [AEDS], 2009," https://nsarchive2.gwu.edu/NSAEBB/NSAEBB7/nsaebb7.htm.

[6] "Statement by President Truman in Response to First Soviet Nuclear Test," September 23, 1949, History and Public Policy Program Digital Archive, *Department of State Bulletin,* Vol. XXI, No. 533, October 3, 1949. http://digitalarchive.wilsoncenter.org/document/134436.

[7] Walter J. Boyne, "The Early Overflights," *Air Force Magazine*, June 2001 Vol. 84, No. 06, 60–65.

[8] LTC Jim Caswell, "Remembering Crew Members of U.S. Navy PB4Y-2 Shoot Down, April 8, 1950 — And Shocking Cold War Case Study," https://stationhypo.com/2018/04/08/remembering-the-crew-members-of-u-s-navy-pb4y-2-shootdown-by-the-soviets-april-8-1950/.

[9] David Haight, "Ike and his Spies in the Sky," December 2009, *Prologue* (Washington, DC) 41 (4), 14–22.

[10] NRO, "The Forgotten Sacrifice," May 10, 2017, https://www.youtube.com/watch?v=VAGPY5MYsgA.

[11] Gregory W. Pedlow and Donald E. Welzenbach, *The CIA and the U-2 Program, 1954-1974,* History Staff Center for the Study of Intelligence, Central Intelligence Agency, 1998.

[12] MIT, "Beacon Hill Report, Problems of Air Force Intelligence and Reconnaissance, Project Lincoln," MIT, June 15, 1952.

[13] RAND Corporation, Published Research, *Special Memoranda, Preliminary Design of an Experimental World-Circling Spaceship,* 2019, https://www.rand.org/pubs/special_memoranda/SM11827.html#download.

[14] Douglas Aircraft Company, Inc.—Santa Monica Plant Engineering Division, *Preliminary Design of an experimental World-Circling Spaceship,* Report no. SM-11827 Contract W33-038 ac-14104, May 2, 1946. p. 11.

[15] Mark A. Erickson, "The Evolution of the NASA-DOD Relationship from Sputnik to the Lunar Landing," PhD Diss., George Washington University, Department of the Air Force, 1997.

[16] Kevin C. Ruffiner and CIA History Staff, "CORONA: America's First Satellite Program," *Center for the Study of Intelligence,* Washington, DC, 1995.

[17] Robert Perry, "A history of satellite reconnaissance, Volume I—CORONA"; NRO, October 1973.

[18] NRO, “CORONA System information,” https://www.nro.gov/History-and-Studies/Center-for-the-Study-of-National-Reconnaissance/The-CORONA-Program/System-Information/.

[19] NRO, “CORONA Fact Sheet,” https://www.nro.gov/History-and-Studies/Center-for-the-Study-of-National-Reconnaissance/The-CORONA-Program/Fact-Sheet/.

[20] R. Cargill Hall, “A history of the military polar-orbiting meteorological satellite program,” NRO, office of the historian national reconnaissance office, September 2001.

[21] Robert A. McDonald and Sharon K. Moreno, “Grab and Poppy: America’s First Early ELINT Satellites,” *Centre for the Study of National Reconnaissance,* September 2005.

[22] R. Cargill Hall, “Samos to the MOON: The Clandestine Transfer of Reconnaissance Technology between Federal Agencies,” NRO, October 2001.

[23] NASA, Lunar Orbiter (1966-1967), November 2018, https://nssdc.gsfc.nasa.gov/planetary/lunar/lunarorb.html.

[24] NRO, “Gambit 1 Fact Sheet,” https://www.nro.gov/Portals/65/documents/history/csnr/gambhex/Docs/GAM_1_Fact_sheet.pdf.

[25] NRO, “Gambit Hexagon Declassification Overview,” https://www.youtube.com/watch?v=titUlLZvTi4&feature=youtu.be.

[26] NRO, “Gambit 3 Fact Sheet,” https://www.nro.gov/Portals/65/documents/history/csnr/gambhex/Docs/GAM_3_Fact_sheet.pdf.

[27] NRO, “The Gambit and Hexagon Programs,” https://www.nro.gov/History-and-Studies/Center-for-the-Study-of-National-Reconnaissance/The-GAMBIT-and-HEXAGON-Programs/.