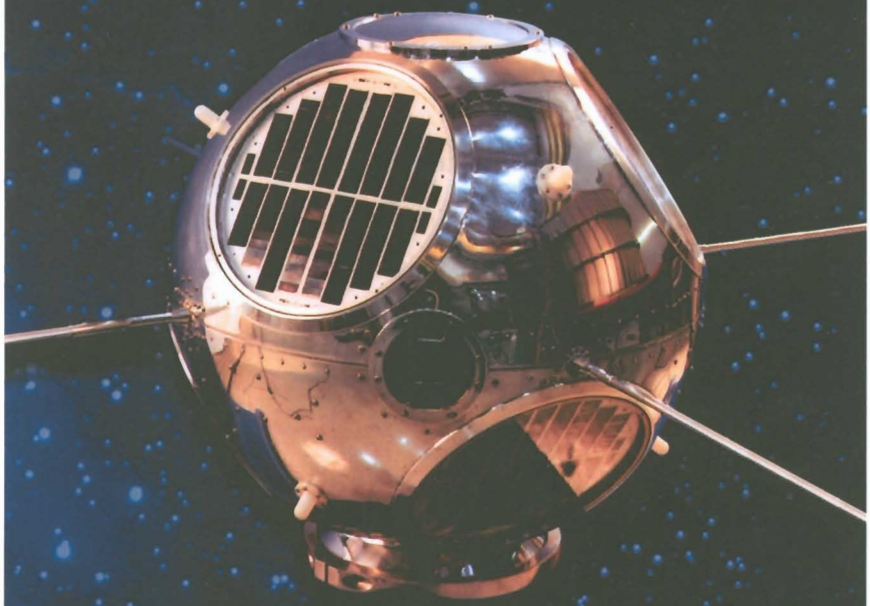
RAISING THE PERISCOPE...



GRAB AND POPPY:
AMERICA'S EARLY ELINT SATELLITES

NATIONAL RECONNAISSANCE OFFICE

50 YEARS OF VIGILANCE FROM ABOVE

Raising the Periscope…

Grab and Poppy: America's Early ELINT Satellites

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Foreword: Declassification of the *Grab* and *Poppy* Systems

With public acknowledgement of the "fact of" signals intelligence (SIGINT) from space in the 1990s, it became imperative to examine historical electronic intelligence (ELINT) reconnaissance satellite programs for potential declassification.

In 1997 the Director, National Security Agency (DIRNSA), and the Director, National Reconnaissance Office (DNRO), established a team of experts from the NRO, the NSA, the Central Intelligence Agency (CIA), and the Department of the Navy with co-leads from NRO and NSA to accomplish this goal. I had the privilege to serve as the NRO lead of that integrated process team (IPT).

The IPT limited its assessment to two of the earliest ELINT satellite systems that the Naval Research Laboratory (NRL) developed and fielded: *Grab* and *Poppy*. In order not to jeopardize national security but to tell the history of the *Grab* and *Poppy* programs, the IPT rigorously examined the security risk of each element to be declassified. Only then did the IPT prepare its declassification recommendations for the Director of Central Intelligence (DCI).

As a result of the IPT's recommendations, the DCI authorized declassification of limited information about *Grab* in 1998—in time for the 75th anniversary of the NRL. *Grab*, "Galactic Radiation and Background," operated from 1960 to 1962.

The second program, *Poppy*, operated from 1962 to 1977. In 2004 the DCI authorized the DNRO to declassify the "fact of" the *Poppy* program along with limited information about it. The objectives of this declassification were to let the public know about these programs and their major accomplishments and, especially, to recognize those key contributors and intelli-

gence community participants who performed the *Grab*- and *Poppy*-related research, development, and operations. We recognized *Grab* alumni during NRL's 75th anniversary celebration. Now we can recognize the *Poppy* alumni for their significant contributions to the national security during the Cold War.

Despite the many security obstacles to declassification of these early satellite ELINT programs, we were successful and now have an opportunity to both recognize the people and share artifacts of the programs with the public. The National Air and Space Museum and the National Cryptologic Museum both have public displays of the *Grab* satellite. We plan similar displays of *Poppy* artifacts at the National Cryptologic Museum and the NRO.

For the *Grab* and *Poppy* declassification efforts, the Intelligence Community cooperated to lift the veil of secrecy that necessarily surrounds the nation's satellite reconnaissance programs. This history pamphlet from the Center for the Study of National Reconnaissance (CSNR) is the first step in sharing the *Grab* and *Poppy* stories veiled for so long. In this way we are able to recognize in a more public way two important historical Intelligence Community activities.

It is our hope that the IPT's declassification efforts and this history pamphlet will provide Americans with an appreciation of the importance of satellite reconnaissance programs and the value of those who have dedicated their professional lives to ensuring that the very best possible intelligence is continuously available to keep the nation strong and safe from potential adversaries.

W. J. Breedlove, Jr., Ph.D.
Chair, Poppy Declassification
Integrated Process Team (IPT)

Preface

We offer in this publication a brief history of *Grab* and *Poppy*—two of the earliest U.S. satellite-based electronic intelligence (ELINT) programs. Our brief history represents the scope of programmatic details that former Director of Central Intelligence George Tenet authorized the Director of National Reconnaissance to declassify.[1] Our goal was to produce a consolidated summary of these programs on the occasion of DNRO Donald Kerr's recognition of key contributors to the *Poppy* program.[2] Although security constraints limit how much we can say about these programs, we present an overview and summary of *Poppy*'s early contributions to national security. Such information can provide current NRO program managers with an unclassified historical context for programmatic and policy decisions.

Grab and *Poppy* were pioneering space reconnaissance activities during the 1960s. The intelligence these programs collected played a vital role in U.S. national security at the

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[1] On 11 May 2004, DCI Tenet approved an Intelligence Community recommendation to declassify the "fact of" the *Poppy* ELINT satellite program along with limited information about the program. This *Poppy* information now supplements earlier *Grab* ELINT satellite program information that the DCI authorized for release in conjunction with the Naval Research Laboratory's 75th anniversary celebrations in June of 1998.

[2] On 12 September 2005, DNRO Kerr hosted a closed Intelligence Community recognition event at NRO headquarters for the key contributors to the *Poppy* program as well as other distinguished alumni who participated in Poppy development and operation. The key contributors are those whose names are so documented in classified NRL and NRO historical records. Whereas hundreds of individuals were involved with the *Poppy* system over the life of the program, the September 2005 event highlighted the work of those whom the CSNR was able to identify and locate nearly 30 years after the program ended.

height of the Cold War. The programs succeeded only because of the creativity and perseverance of key contributors and others who participated in *Grab* and *Poppy* development and operation. It is most appropriate that the Center for the Study of National Reconnaissance (CSNR) publish this brief story of the *Grab* and *Poppy* programs on the occasion of DNRO Donald Kerr announcing declassification of the *Poppy* program and recognizing the role of *Poppy* alumni who contributed to its success.

We prepared this history based in large part on early draft manuscripts researched by former NSA historian Dr. Tom Johnson, NRL history consultant Dr. Ron Potts, former NRO historian R. Cargill Hall, former NSA historian Dr. David Hatch, and the late NRL historian Dr. David van Keuren. We are grateful to them for their work. We supplemented the work of these earlier researchers with additional information from the reference collection at the Center for the Study of National Reconnaissance. We also received research support from the NRO curator, James Rosolanka. Frances Lawson was our production editor.

We especially are indebted to Dr. Ron Potts, whose personal knowledge and extensive historical research of the *Grab* and *Poppy* programs have proved invaluable in documenting the programs. He also reviewed our draft manuscript and offered suggestions to improve its accuracy.

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Director, Center for the Study of National Reconnaissance

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The United States was the first nation in space with a reconnaissance satellite—and that satellite, designed to intercept Soviet radar signals, was a 20-inch-diameter metal ball packed with electronic equipment. The Naval Research Laboratory (NRL) developed this electronic intelligence (ELINT) satellite in early1958 under the code name *Tattletale*. *Tattletale* is better known as *Grab*, for Galactic Radiation and Background Satellite (*Tattletale's* cover mission).[3] In 1962, NRL launched *Grab*'s successor, *Poppy*—also designed to collect Soviet radar signals. *(See Figure 1, Aerial view of NRL)*

Both *Grab* and *Poppy* served as valuable national reconnaissance ELINT collectors and made significant contributions

[3] Multiple nomenclatures are associated with *Grab* and its follow-on *Poppy*. The project name *Grab* in this pamphlet refers to the then-classified ELINT project, initially called *Tattletale* in classified channels and later known as *Canes*. (*Canes* also refers to the project's security control system.) The Navy used the name *Dyno* for a proposed *Grab* upgrade (superseded by *Poppy*). At the same time, *Grab*'s cover mission initially was referred to as Galactic Energy Balance-Experiment (*Greb-E*) and later became known as SolRad (for solar radiation). The *Greb/SolRad* cover mission was a real scientific experiment whose purpose was to measure solar radiation (Lyman-alpha and X-ray).That mission focused on the effect of solar radiation on high frequency (HF) communication propagated via ionospheric reflection. Navy scientists discovered that solar flares produced ionospheric disturbances, such as sudden short wave fading and cosmic noise absorption. In addition to its value for pure research into the sun's nature, data would be used to predict propagation conditions for HF communications. The NRL eventually built Navy and NASA satellites dedicated to solar radiation measurement and related experiments, and they applied the nickname *SolRad* retroactively to the progenitor, *Greb*.

to America's national security. The NRL had completed its development of the *Grab* satellite system by the time the Soviet Union shot down Francis Gary Powers' high-altitude U-2 reconnaissance aircraft on 1 May 1960. After the U-2 shoot-down, President Eisenhower cancelled all further U-2 over-flights of the Soviet Union. Now, in order to access the heart-land of the Soviet Union, the U.S. had to turn to space. *Grab* and *Poppy*, along with their imagery cousin, *Corona*, were available to fulfill this need in the 1960s and 1970s.[4]

Photo courtesy NRL

Figure 1. **Naval Research Laboratory, June 1960**

Why National Reconnaissance?

When World War II ended in 1945, the United States held a position of military dominance derived in large part from its possession of the atomic bomb. However, by 1949, the Soviet

[4] *Corona*, a joint CIA and USAF project with its first successful mission on 18 August 1960, was the world's first imagery satellite reconnaissance system.

Union had its own A-bomb. As the Soviet threat appeared to be growing, it had become more difficult to gain access to Soviet territory. Winston Churchill foresaw this as early as 5 March 1946, when he observed:

> "From the Stettin in the Baltic to Trieste in the Adriatic, an iron curtain has descended across the Continent. Behind that line lie all the capitals of the ancient states of Central and Eastern Europe. . . . The Communist parties, which were very small in all these Eastern States of Europe, have been raised to preeminence and power far beyond their numbers and are seeking everywhere to obtain totalitarian control."

As the Soviet Union and its Eastern Bloc allies became denied areas, classical espionage became more difficult. Increasingly our U.S. Intelligence Community needed to explore technical means of collection.

Emerging Technical Means—
Origins of National Reconnaissance

In 1946 RAND Corporation[5] published a research study that called for a multistage "experimental world-circling spaceship." During the same period, the U.S. Navy proposed construction of a single-stage earth satellite vehicle; it continued to fund a modest satellite research effort until 1948. The War Department did not have funds to design and launch satellites and in any case showed scant interest in the concept. However, it had proposed using satellites as observation platforms and

[5] RAND Corporation is a nonprofit research organization with historical ties to the Air Force. RAND's founders initially set it up as Project RAND under special contract to the Douglas Aircraft Company with Project RAND reporting to the Deputy Chief of Air Staff for Research and Development. RAND's 1946 report, *Preliminary Design of an Experimental World-Circling Spaceship,* analyzed the potential to design and engineer an earth-orbiting satellite vehicle. (In 1948 the Air Force Chief of Staff approved evolution of RAND into a nonprofit corporation.)

weather reconnaissance vehicles, though this never proceeded beyond the concept stage, because rocket development/production lagged.

The Soviet Union's 1957 launch of Sputnik, the world's first orbiting artificial satellite, impelled President Eisenhower's Administration to look more closely at the concept of space-based reconnaissance. After the 1960 U-2 shootdown, satellite reconnaissance became more compelling.

Navy Builds First Reconnaissance Satellite—*Grab*

President Eisenhower approved full development of *Grab* on 24 August 1959; four days after the U-2 shootdown, he approved the first *Grab* launch. On 22 June 1960, a Thor Able-Star rocket roared off the launch pad at Cape Canaveral, Florida, carrying *Grab 1* into orbit. The U.S. now had a space reconnaissance program.

The *Grab* concept originated in 1958 with an NRL research engineer, Reid D. Mayo, who investigated the problem of intercepting and analyzing radar signals from Soviet air defenses. While stranded in a Pennsylvania restaurant during a March blizzard, he pondered the application to space reconnaissance of crystal video technologies he had developed for submarines. Specifically, he wondered if the submarine periscope system could be modified so that a solid-state version of this intercept system could be mounted in a 20-inch solar-powered Vanguard satellite. He penciled range calculations on a paper placemat and determined that such a system could in fact intercept Soviet radar signals up to an altitude of 600 miles.

When Mayo returned to Washington, he presented his idea for ELINT collection to Howard Lorenzen, chief of NRL's countermeasures branch and in the front rank of the nation's electronic warfare program. Lorenzen agreed it could work and championed the idea within the Department of Defense and the Intelligence Community. The NRL continued research and

development in coordination with elements of the U.S. space and ELINT programs. The NRL attempted five *Grab* missions between 1960 and 1962; two were successful.

(Photo courtesy NRL)

Figure 2. **Thor Able Star launch vehicle at Cape Canaveral with Grab 2**

The U.S. Air Force launched *Grab 1* from Cape Canaveral, Florida using a Thor-Able-Star booster.[6] *(See Figure 2, Thor Able Star.)* It launched in "piggyback" fashion with a second

[6] The Thor-Able-Star booster, an early US launch vehicle, was succeeded in the early 1960s by the Thor Agena series of launch vehicles.

satellite, Transit 1B.[9] *(See Figure 3, Piggybacked Grab.)* This first *Grab* satellite operated for three months. Its initial collection of data on 5 July 1960 far exceeded Mayo's expectations. *Grab*'s yield provided intelligence analysts at the National Security Agency (NSA) with ELINT data that kept them busy until the next mission.

On 29 June 1961, a little over one year after the first successful *Grab* mission, the NRL launched the second successful *Grab* satellite. It began collecting signals on 15 July and operated for 14 months. Like *Grab 1*, it produced a large volume of radar intercept data. By October 1961, NSA had developed an automatic system to improve the

Photo courtesy NRL

Figure 3. **Piggybacked *Grab 2 (top)* mated with *Injun*[7] *(middle)* and *Transit 4A*[8] *(bottom)*, atop an Able Star.**

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[7] The University of Iowa designed and built Injun to study natural and artificial trapped radiation belts, auroras and airglow, and other geophysical phenomena.

[8] Transit 4A was the first satellite to carry a nuclear power plant, known as SNAP-3, for Systems for Nuclear Auxiliary Power-3.

[9] The *Transit 1B* navigation satellite is part of the heritage of the global positioning system (GPS). This first U.S. Navy navigation satellite, *Transit 1B*, was designed to meet the Navy's need for accurately locating ballistic missile submarines and other ships by updating shipboard inertial navigation systems. Transit receivers used known characteristics of the satellite orbit, and measured the Doppler shift of the satellite's radio signal to calculate the receiver's position on earth.

time-consuming processing of ELINT data it received from the *Grab* satellites.

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. *(See Figure 4, Grab with antennas.)*

Photo courtesy NRL

Figure 4. **Grab 2 with turnstile antennas**

When terrestrial radar emitted its pulsed-radar signals above the horizon, *Grab* satellites collected each pulse of a radar signal in a specified bandwidth and transponded a corresponding signal to NRL radio receiving and control huts at ground sites within *Grab*'s field of view. The huts' 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). *(See Figure 5, antennas on Grab hut; and Figure 6, interior of Grab hut.)*

Personnel at *Grab* receiving and control huts recorded data from the satellites and then dispatched tapes with these data, initially to NRL, and then to the National Security Agency (NSA) and the Air Force Strategic Air Command (SAC). The NSA and SAC exploited the data to develop technical intelligence about Soviet radar. The success of the two *Grab* mis-

sions was encouraging, and the NRL made two unsuccessful attempts at a third *Grab* mission.

Poppy—Successor To *Grab*

In 1962, shortly after NRL's second unsuccessful attempt at a third *Grab* mission, the newly formed National Reconnaissance Office (NRO) assimilated NRL's ELINT satellite activities and associated multi-agency infrastructure into what became NRO's Program C.[10, 11] Program C continued NRL's satellite ELINT collection by developing *Poppy*, *Grab*'s successor.

Following the conclusion of *Grab 2*'s useful lifespan in August 1962, the Air Force used a Thor Agena-D launch vehicle on 13 December 1962 to carry *Poppy 1* into orbit from Vandenberg Air Force Base (VAFB), California. *(See Figure 7, Thor Agena.)*

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[10] Secretary of Defense Robert S. McNamara formally established the NRO under its current name on 6 September 1961. Its mission was to manage the newly created National Reconnaissance Program (NRP). The NRP would consist of all satellite and overflight reconnaissance projects; thus, Navy ELINT satellite projects at NRL, and the Air Force and CIA *Corona* imagery program, became part of the NRP budget under NRO control.

[11] DNRO Joseph V. Charyk organized NRO functions into four alpha-designated programs areas in July 1962: Program A for Air Force; Program B for CIA; and Program C for Navy. Under Program C, the Navy was responsible for the design, development, and operation of its reconnaissance satellites, and the Air Force was responsible for launching those satellites. Program C included the U.S. Navy element of the NRP in association with the Technical Operation Group, which was made up of representatives from the Office of Naval Intelligence, National Security Agency, NRO, Naval Security Group, Army Security Agency, and Air Force Security Service.

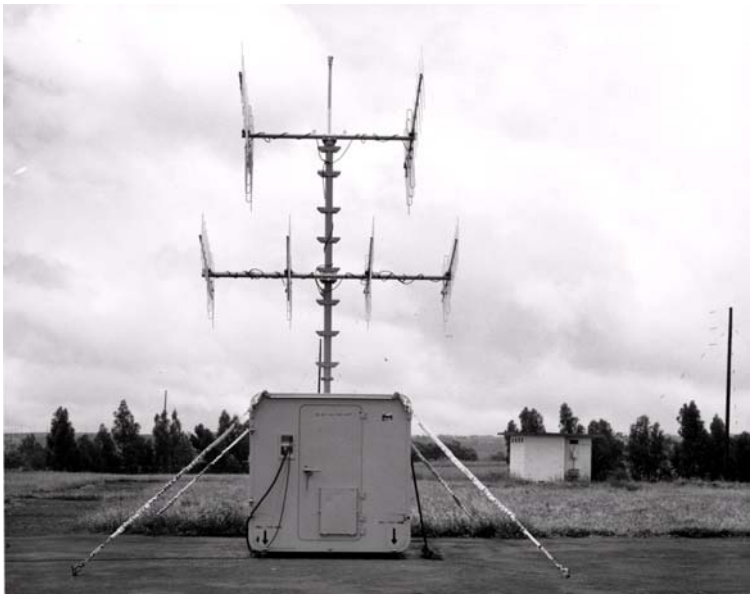

Photo courtesy NRL

Figure 5. **Grab radio receiving and control hut in Hawaii with yagi antennas**

Photo courtesy NRL

Figure 6. **Interior of Grab hut**

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*.

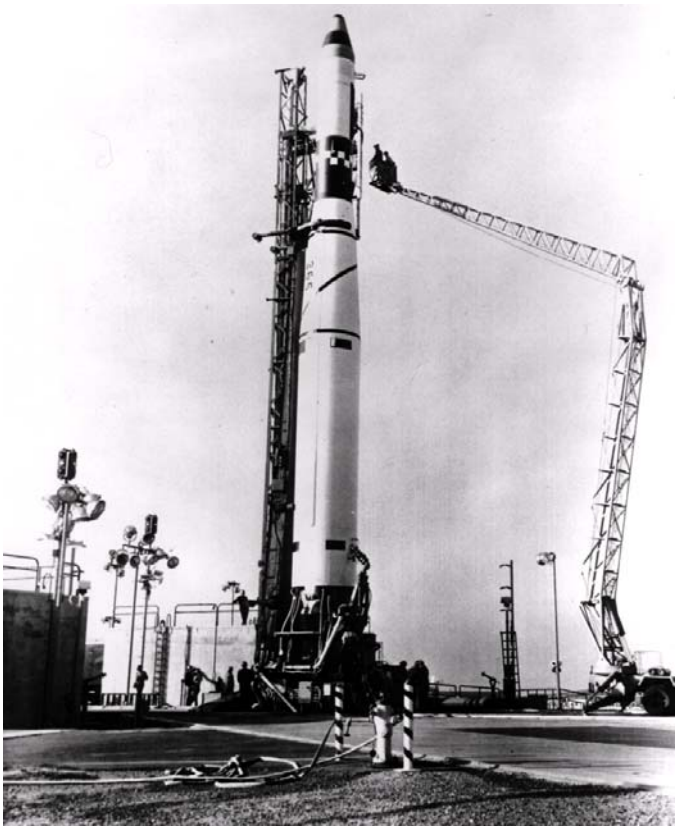

Photo courtesy NRL

***Figure 7*. Thor Agena with Poppy 1 at Vandenberg AFB on 12 December 1962.**

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). *(See Figure 8, two Poppy designs.)*

Photos courtesy NRL

Figure 8. **Two Poppy designs—stretched sphere *(left)*; multiface *(right)***

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. By the 1970s, the *Poppy* program used prefabricated buildings in the field for its Siss Zulu operations.[12] *(See Figure 9, Poppy operations building.)*

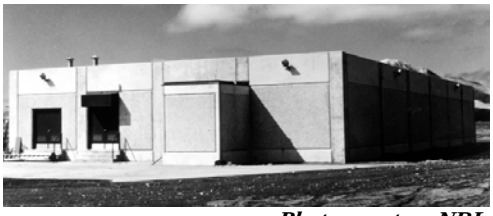

Photo courtesy NRL

Figure 9. **Poppy Operations Building, 1970s**

At the field sites, a pair of receiving consoles collected ELINT data downlinked from *Poppy* satellites. One operator

[12] By this time, the Navy referred to the *Poppy* program with the unclassified term "Siss Zulu."

tracked the pass in azimuth/elevation and selected polarization for recording. A second operator logged signals of interest. *(See Figure 10, Poppy Receiving Console.)* An analog analysis operator performed post-pass measurements for signals that the collection operators detected, incorporating signals of interest into daily logs. *(See Figure 11, Analog Position.)* The analysts reported information on signals of interest to NSA and others, using the nation's critical communications channels.

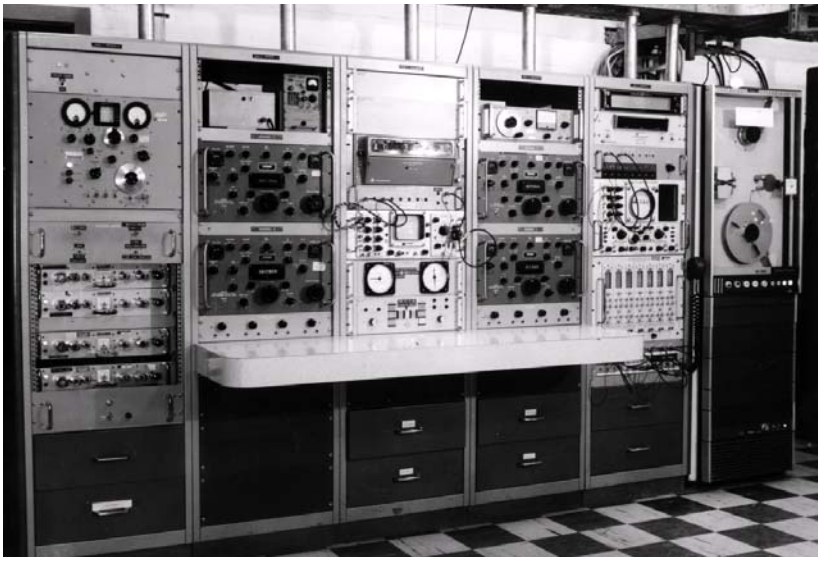

Photo courtesy NRL

Figure 10. **Poppy receiving console**

One-operator transmitter consoles used over the life of the program included three receiver groups for telemetry readout and two transmitter groups for payload commands. The operator would tune the receiver groups to radio frequencies for scheduled satellites, and the groups would operate as the satellites rose above the field site's radio horizon. *(See Figure 12, One-operator Transmitter Console.)*

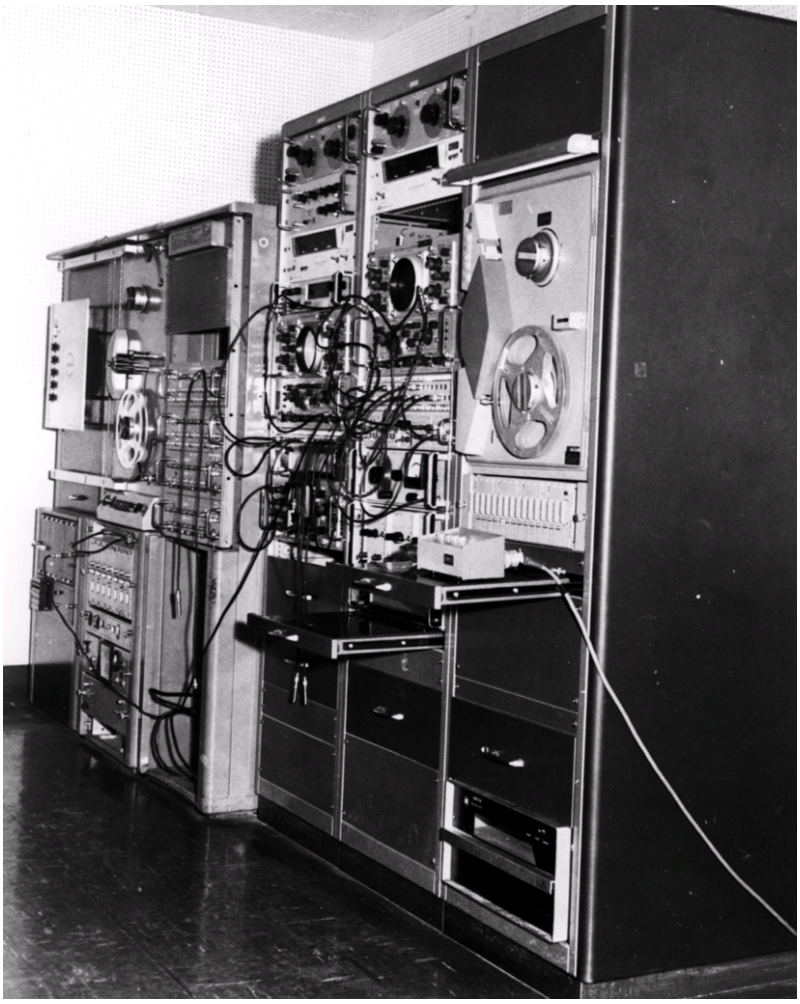

Photo courtesy NRL

Figure 11. **Poppy analog analysis position**

The Naval Security Group (NSG), Air Force Security Service (AFSS), and Army Security Agency (ASA) staffed the *Poppy* field sites. Their cryptologic technicians operated and maintained *Poppy* equipment. A *Poppy* Technical Operations Group, composed of representatives from participating organi-

zations, held monthly meetings. The NSG coordinated all field operations for the *Poppy* program. The field sites collected radar data and forwarded intercepted signals to the National Security Agency (NSA). The NSA analyzed the signals and produced reports for the Intelligence Community.

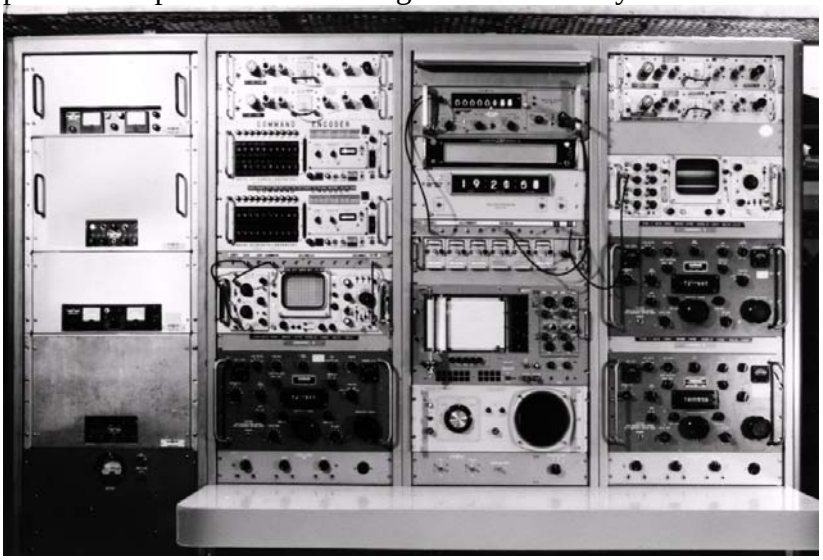

Photo courtesy NRL

Figure 12. **One-operator transmitter console**

Grab and Poppy Contributions

Early NRO ELINT satellite reconnaissance programs constituted a critical component of our U.S. technical reconnaissance operations during the 1960s and into the 1970s. Before development of these satellite systems, technical intelligence about Soviet air defense radars was limited to that which could be collected by airborne and ground-based collection platforms, often limiting collection to radar sites less than 200 miles inside the Soviet Union. *Grab* and *Poppy* dramatically increased the capability of U.S. intelligence to acquire ELINT data deep within the Soviet Union.

Intelligence derived from data that *Grab* and *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.

[13] The SIOP was the U.S. war plan that governed targeting of U.S. strategic weapons employed by the Air Force, Army, and Navy, including the triad of SAC's strategic bombers, land-based ballistic missiles, and Polaris submarines.

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Appendix: Grab, Poppy Launches

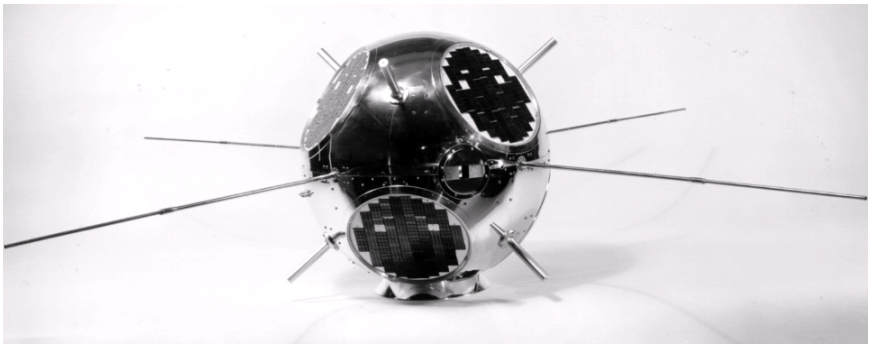
Date	Vehicle	Site[14]	Mission	Remarks
GRAB				
22 Jun 1960	Thor Able Star	CC	*GRAB 1*	
30 Nov 1960	Thor Able Star	CC		Failure
29 Jun 1961	Thor Able Star	CC	*GRAB 2*	
24 Jan 1962	Thor Able Star	CC		Failure
26 Apr 1962	Scout	NMFPA		Failure
POPPY				
13 Dec 1962	Thor Agena D	VAFB	*POPPY 1*	
15 Jun 1963	Thor Agena D	VAFB	*POPPY 2*	
11 Jan 1964	TAT Agena D	VAFB	*POPPY 3*	
9 Mar 1965	Thor Agena D	VAFB	*POPPY 4*	
31 May 1967	Thor Agena D	VAFB	*POPPY 5*	
30 Sep 1969	Thorad Agena D	VAFB	*POPPY 6*	
14 Dec 1971	Thorad Agena D	VAFB	*POPPY 7*	

Grab – 22 June 1960

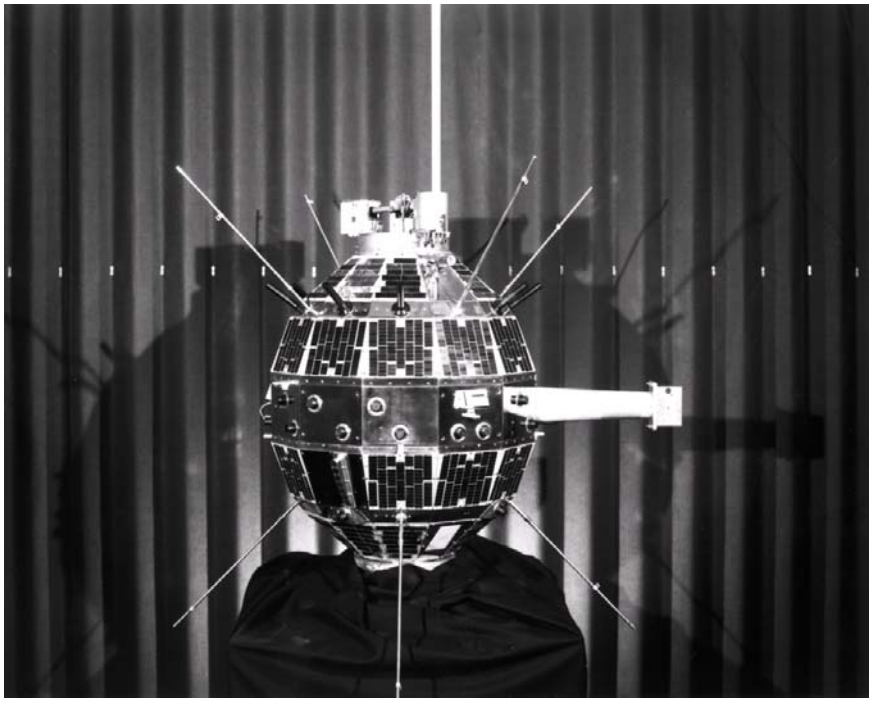
Poppy – 14 December 1971

U.S. Air Force photos

[14] Launch Sites: CC = Cape Canaveral, Florida; NMFPA = Naval Missile Facility, Point Arguello, California; VAFB = Vandenberg Air Force Base, California.



Grab (Photo courtesy NRL)



Poppy (Photo courtesy NRL)