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27 June 1969

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S I G I N T   C O M M I T T E E

SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

MEMORANDUM FOR MEMBERS OF THE SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

SUBJECT: Description of SIGINT Mission 7106 - POPPY

1. The Mission Description for POPPY, SIGINT Mission 7106, has been provided by the NRO and is forwarded herewith for your information.

2. The NRO Member, SORS, at the 25 June 1969 SORS Meeting, suggested that the Subcommittee Members consider well the [redacted] capabilities of POPPY Mission 7106 in developing the initial guidance for this mission. (b)(1) (b)(3)

[redacted] (b)(1) (b)(3)

EXECUTIVE SECRETARY
SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

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GROUP 1
Excluded from automatic downgrading and declassification

(S) NATIONAL RECONNAISSANCE OFFICE

WASHINGTON, D.C.

27 June 1969

THE NRO STAFF

COPY 16
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MEMORANDUM FOR CHAIRMAN, SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

SUBJECT: Mission Description of SIGINT Mission 7106 (POPPY)

The mission description for Mission 7106 is forwarded as an attachment to this correspondence. This SIGINT reconnaissance system is designed to meet the requirements of USIB S-10.9/11 and USIB S-10.9/13.

Mission 7106 will detect and transpond on a real-time basis to collection sites on the periphery of the Chinese-Soviet land mass pulsed emissions in the 154 to 10,000 MHz and 14.6 to 15.1 GHz frequency range with sufficient bandwidth to permit identification of frequency, pulse repetition frequency, scan rate, power and geoposition of the emitter.

Four satellites, comprising Mission 7106, will be launched from the Western Test Range into a nominal 500 nautical mile circular orbit in mid-September 1969. Mission 7313 (WESTON) will be the companion payload for this launch.

Mission capabilities, over that of previous POPPY collection systems, have been enhanced by the installation of field digitizing equipment at the [redacted] collection sites. This capability, which will also be installed at the [redacted] station in 1970, increases processing accuracy of collected data and facilitates exploitation of data from all four satellites simultaneously vice only two satellites, as currently exists at the analog recording sites at [redacted] (b)(1) (b)(3)

On-orbit spacing between satellites in a [redacted] to ensure accurate pulse time-of-arrival processing and (b)(1) (b)(3)

EARPOP

permit illumination of all four satellites by a single emitter. A mission lifetime of one year minimum is expected.

George H. Smith Jr.
for EDWIN F. SWEENEY
Colonel, USAF
Deputy Director for
Satellite Operations

Attachment
Mission Description

Mission Description, Mission 7106 (POPPY)

1.1 GENERAL OPERATIONAL DESCRIPTION

1.1.1 <u>Basic Command and Control Systems</u>:

The basic command and control systems used in the four spacecraft for Mission 7106 are similar to those used in the Mission 7105, with the important operational differences listed below:

(1) The number of individual commands that can be sent to each spacecraft has been increased from forty to eighty.

(2) A different "RESET" tone pair is used for each spacecraft, as opposed to the previous POPPY missions which had a common RESET and all spacecraft within range of the command signal would reset even though the reset was desired on only a single spacecraft.

(3) Commands may now be sent in any sequence after the command system is "enabled."

(4) The on-board timer is programmable so that all ELINT collection commands may be executed in a delayed mode of up to 140 minutes in 10-minute increments following the command being sent to the spacecraft.

(5) The timed cycle for operation of the ELINT collection systems is either the normal 50-minute period or a new period of 20 minutes, which is designed for use in the engineering evaluation effort at the domestic R&D site at [redacted] (b)(1) (b)(3)

(6) All spacecraft have a separate command, referred to as the "unique mode reset" which permits the ELINT systems to be operational and still allow the spacecraft to accept housekeeping and engineering commands followed by the required normal reset command.

(7) The timer system, in case of failure, may be bypassed, thus allowing any combination of ELINT bands to be turned on, but without the timed reset feature. In this mode, the only reset available is a command transmitted from one of the POPPY command stations.

1.1.2 Telemetry System:

The housekeeping telemetry on all four spacecraft is a [redacted] as opposed to the analog system used in the past. The analog system is retained as a secondary or backup system and will be used for readout of the spacecraft engineering status by those stations which are not yet equipped with the necessary [redacted] documentation equipment. This [redacted] Typical of the analog inputs are the spacecraft temperatures at various critical locations, the battery-bus voltage levels, pressure sensor values, etc. Typical of the digital inputs are the relay position indicators (RPI) for the command system which describe the state of command with regard to the ELINT systems. Almost all of the digital data are available in the analog system so they act as backup for each other. The most significant improvement which results from use of the [redacted] is the relative speed and reliability with which the ground station operator can properly and safely command the spacecraft and verify the entire command system status.

(b)(1)
(b)(3)

1.1.3 Spacecraft Physical Characteristics:

A. Size and shape: All four spacecraft utilize the same general structure as that employed for 7105B, 7105C and 7105D which can be described as a 12-sided multiface. The major difference has been a three-inch increase in vertical height of the structure to accommodate the larger volume of electronics for the addtional number of ELINT collection systems for Mission 7106. The collection antennas are located symetrically around the polar axis at various latitudes of the spacecraft. In addition to these receiving antennas, there will be a turnstile array which deploys in orbit nearly straight down toward the earth at the end of a four-foot boom. This turnstile antenna system serves the two data link transmitters and provides a considerable improvement in the uniformity of antenna pattern radiated by the 7106 spacecraft as compared to the transmitter antenna patterns of Mission 7105.

B. All surfaces of the spacecraft not covered with the solar cells are covered with a vapor-deposited aluminum and then coated with a layer of vapor-deposited silicon monoxide to provide what is referred to as a "second surface mirror" or "cold mirror." This passive-thermal design will keep the spacecraft electronics at a temperature between -10°C and 60°C for the sunlight condition of the normal POPPY orbit.

C. The solar cell recharging system is capable of supplying sufficient power to operate the ELINT data collection system for 12 hours out of every 24 hours.

1.1.4 Gravity Gradient Stabilization Systems:

All four spacecraft will be equipped with 3 axis Gravity Gradient Stabilization (GGS) systems. There is a twofold purpose to this stabilization system: (1) to maintain the directional antennas of the ELINT collection systems aimed at the horizon and (2) to maintain the solar cell panels toward the sun for optimum electrical recharging capability. To accomplish this, it is only necessary to establish and maintain a two-axis stability (pitch and roll axis). However, the second purpose of the GGS system is to orient an on-board microthruster system along the flight line so that optimum spacecraft separation can be maintained. This requires that the third axis (yaw) also be stabilized and maintained in a known attitude relative to the flight line.

1.1.5 Microthruster Systems:

C 50 A 100 D 50 B

All four spacecraft have the ammonia vapor microthruster which is similar to the system on the 7105B spacecraft. This system coupled with the 3 axis GGS system will permit maintaining optimum spacing between all four spacecraft for the entire useful life of the mission. The spacecraft will approach a ground site, all on the same orbital path, in the following order: 7106C, 7106A, 7106D and 7106B. [redacted] (b)(1) (b)(3)

1.2 COLLECTION SYSTEMS TECHNIQUES AND OPTIONS

1.2.1 ELINT Data:

Each of the four spacecraft of Mission 7106 are equipped with crystal-video type receiving systems. As these systems intercept signals from a radar which illuminates the spacecraft with sufficient signal strength to exceed the on-board threshold level, the rf pulse from the radar is detected and stretched in time duration to either 80, 120, 160 or 200 microseconds in duration depending upon the particular pulse width coding assigned to the ELINT collection band where the radar pulse was intercepted. Henceforth, these data pulse durations will be referred to as pulse widths "W", "X", "Y", or "Z" respectively. The stretched pulses are then retransmitted on a pulse for pulse basis, using one of the two data link transponding systems contained in each of the spacecraft. Thus, the Pulse Repetition Frequency (PRF) of the intercepted radar signal is preserved. As the radar antenna scans and cyclically illuminates the spacecraft, the radar antenna scan characteristics are also preserved very accurately in the POPPY data. Performance characteristics of the collection bands for each of the spacecraft of Mission 7106 are provided in Tables 1 and 2. Unless otherwise noted, identical design goals are maintained for the collection systems which are duplicated in either two or all four of the spacecraft for the purposes of providing location analysis type data.

1.2.2 Parametric Measurements:

In order that the data derived from POPPY may be of sufficient versatility to support the technical assessment necessary to disclose: (1) the performance functions, (2) the limitations and (3) capabilities of the "new and unusual" emitter at the earliest possible time after their discovery, POPPY systems have provided certain parametric measurement options in the past. Mission 7106 has the capability for [redacted] (b)(1) in all four spacecraft available by command in every band. (b)(3) In addition, all collection bands above 3600 MHz will have the choice of either 360^{o} azimuthal collection coverage or either of two, "opposite-quadrant" type collection antenna coverage patterns. [redacted] provide the capability for sorting data which by PRF (b)(1) and antenna scan characteristics appears to be emanating from the same emitter. (b)(3) The spacecraft instrumentation has been carefully calibrated for variations in spacecraft temperatures and voltages to permit absolute power measurements and emitter antenna beam width measurements. These calibrated collection bands are indicated on the ELINT coverage characteristics presented in Tables 1 and 2. In order that a signal level measurement option may have a greater degree of dynamic range in certain of the collection bands, rf preamplifiers have been added to provide a high sensitivity mode of operation. This will allow [redacted] option to view deeper into a (b)(1) radar antenna radiation pattern and distinguish the minor lobe structure in addition (b)(3) to providing greater range of definition of the main beam structure. Rf preamplifiers will also provide the opportunity to intercept signals which would otherwise be too weak to trigger the POPPY system. The band which these command options are available on are indicated in Tables 1 and 2.

1.2.3 Location Analysis Capability:

Very accurate emitter location analysis may be made by carefully observing the difference in the [redacted] of a single pulse through two or (b)(1)
(b)(3)

more satellite data paths and integrating these observations over a period of up to several minutes. Every collection band in Mission 7106 will be able to provide, when tasked appropriately, data from which [redacted] type location-analysis may be performed. Thus, each part of the spectrum from 154 MHz to 10,000 MHz and from 14.8 to 14.9 GHz can be utilized for emitter location analysis providing about 10 nautical miles diameter CEP on an emitter. (b)(1) (b)(3)

1.2.4 Ground Based Data Collection System:

The pulses which are transponded from Mission 7106 via the two data link channels from each spacecraft will be intercepted by a chain of six dedicated POPPY collection sites situated around the Sino Soviet Bloc land mass. These data collection sites are equipped with two identical analog receiving complexes called the "Red" and "Green" complexes. Three of the sites [redacted] are equipped with the transmitter (Blue) complex for interrogating and commanding the spacecraft for operational tasking. A field digitizing system has been installed at the first 2 of these 3 stations. [redacted] digital system is under procurement at this time and will be operational in 1970. In addition to the receive, the record, the command and the digital systems, each of the sites has extensive analysis or Quality Control (QC) systems to assist in the real time appraisal of the data. This provides for a quick reaction alert capability within minutes after a new or unusual Signal of Interest (SOI) is detected. The field digitizer system will, in addition to improving the overall data timing accuracy, enable the full utilization of all four of the Mission 7106 spacecraft simultaneously. (b)(1) (b)(3)

2.1 ORBITAL CHARACTERISTICS FOR MISSION 7106:

The four spacecraft of Mission 7106 are to be placed in a circular orbit of 500 nautical miles altitude, and inclined 70^{o} to the earth's equatorial plane. The in-flight spacing has already been described under the section on Microthruster systems, but for clarity will be repeated here.. [redacted] (b)(1) (b)(3)

3.1 SPACECRAFT ELINT COLLECTION SYSTEMS:

A. Basic Description:

The POPPY systems employ receiver techniques which provide complete coverage over the frequency spectrum from 154 MHz to 10,000 MHz. Using omni-directional ELINT antenna arrays the POPPY spacecrafts are capable of intercepting any pulsed signal within the optical horizon of the spacecraft (a 1750 nautical mile radius). In the frequency band from 14.6 to 15.1 GHz, the collection antenna system provides two forward looking 60° wide lobes centered 60° to the right and 60° to the left of the flight line of the 7106C and 7106D spacecrafts.

B. Frequency Spectrum:

(1) The individual collection sub-system or band is designed so that a set of matched band-pass filters with built in detectors is connected between each receiving antenna element and the video amplifier (Diagrams 3 and 4). The amplifier normally has a combining circuit in its input stage so that the detected video signal plus noise from each antenna of that band goes into a single video amplifier. An adjustable thresholding circuit is at the output of the video amplifier. The threshold level is adjusted to operate at a predetermined level of input signal. The radio frequency definition is determined by the selectivity characteristics of the matched filters.

(2) In the collection system adjacent to the frequency where the spacecraft data link transmitters radiate, there is a difficult technical requirement to avoid unintended intercept of the spacecraft's own data link signals and cause regeneration or oscillation. To avoid this potential problem area, these particular band-pass filters (band 1) have at least 21 sections of filtering with extremely well defined and matched response characteristics. The frequencies tabulated for all the collection systems of the four spacecraft of Mission 7106 are given in Tables 1 and 2 to provide the frequency response points 3 db down at the upper and lower ends of the pass-band.

3.1.2 Receiving Antenna Systems:

A. Two general types of receiving antenna patterns are utilized in the POPPY mission for the ELINT collection systems aboard the spacecraft. The first is exemplified by the dipole above a ground plane which provides an outward looking pattern away from the surface of the spacecraft. The second, exemplified by a monopole which provides a pattern that is tangent to the surface of the spacecraft with a null in the direction of the element axis. In general, the frequencies below 1800 MHz are all equipped with the monopole type antenna system using quarter wavelength monopoles arranged symetrically around the "equatorial" axis of the spacecraft at various "latitudes." Combination of the detected video signals results in an omnidirectional and omnipolarization capability for these receiving antenna systems.

B. In the frequency bands between 3600 and 10,000 MHz, the standard antenna element is a half-wave dipole symetrically spaced in quadrature around the equatorial section of the spacecraft. For optimum elevation coverage, these antennas are mounted on 20° inclined wedges so that the pattern is canted downward. Each dipole element is oriented to optimize the pattern for both horizontally and vertically polarized signals. The two antennas which are on opposite sides of the spacecraft are combined through hybrids (for isolation) to form two orthagonal receiving channels. Thus, these two orthagonal channels can be used together to give complete 360° azimuthal coverage or used separately by the "opposite-quadrant" command option. Several reasons for using them separately are: (1) to de-populate the data in areas where excessive data density is apt to be encountered, (2) as a means of eliminating interfering signals if they come from one offending quadrant, (3) as a diagnostic tool to get rough arrival direction information on signals of interest, (4) as a back-up feature which could be employed if one channel were to fail.

C. The two collection bands in 7106C and 7106D which cover the frequency range from 14.6 to 15.1 GHz are the only bands in Mission 7106 which do not provide complete 360° coverage. To attain a usable sensitivity in this band, 16 db of receiving antenna gain is required. Thus, it has been necessary to provide only two forward looking receiving antenna lobes, on to the right and off the flight line by about 60° and the other to the left also off the flight line about 60°. Two horn antennas are used to form each beam. One set of receiving electronics is connected to the two horns nearest the flight line (one on either side of the spacecraft), and the other electronic receiving system is connected to the two horn antennas further back on either side of the spacecraft. Thus, there is a versatile command option for in-flight tasking of either or both of these electronic receiving systems. The most forward looking antenna and associated receiving system when used by itself will provide an antenna pattern with two 30° wide lobes centered about 45° either side of the flight line. Conversely, the other system of antennas and electronics will provide, when tasked separately, a collection antenna pattern with two 30° wide lobes centered 75° away from, and on both sides of the flight line.

4.1 PARAMETRIC MEASUREMENT CAPABILITIES:

[redacted] (b)(1) (b)(3)

(b)(1)
(b)(3)

[redacted]

4.1.3 System Sensitivity:

Several of the ELINT Collection bands of 7106C and 7106D are annotated in Table 2 as possessing both high and standard sensitivity command options. This option has particular value which when coupled with the measurement which describes the signal amplitude, a wider range of definition can be obtained in the description of the emitter antenna pattern and its side-lobe structure. The additional sensitivity available through this command option may be used to intercept signals which under standard conditions would not be available. The 350 to 450 MHz band of 7106D has, in addition to the standard -50 dbm sensitivity, two other options available. A high sensitivity option with an additional 15 db of sensitivity can be exercised with the data coming out of the spacecraft on the other data link transmitter as "Z-width" pulse coded data. In this special case, [redacted] For this reason, this band incorporates [redacted] (b)(1) (b)(3)

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[redacted]

(b)(1)
(b)(3)

7106A and B

Band Number	Bandpass (MHz)		Sensitivity (dbm)	Antenna Modes **
1	154-165		-40	153.5 MH at -10 db
2 ►	165-200		-47	
3	200-240		-50	
4 ►	350-450		-50	
5	450-550		-50	
6	550-650		-50	
7	650-820		-50	
8 ►	820-920		-50	
9 ►	920-1080		-50	
10 ►	1800-2100		-50	Selectable Polarization
11	2100-2580		-50	
12	2580-2680		-50	
13	2680-2930		-50	
14	2930-3120		-50	
15	3120-3300		-50	
16	5250-5850		-76	Selectable Opposite-Quadrant
17 ►	5850-6720		-76	
18	8600-9340		-76	
19	9340-9500		-76	
20	9500-10,000		-76	

(b)(1)
(b)(3)

* W=80 Sec., X=120 Sec., Y=160 Sec., Z=200 Sec.
** All bands have Omni-directional Azimuth Coverage
► Absolute Temperature & Voltage Calibration of

(b)(1)
(b)(3)

Table 1

7106C and D

Band Number	Bandpass (MHz)	[redacted]	Sensitivity (dbm)	Antenna Modes**	Notes	
1	154-165		-40	****		(b)(1) (b)(3)
2 ►	165-200		-47			
3	240-350		-50			
4	350-450		-50 -65		High Sens Opt in 7106D only	
4 ►	350-450		-65			
5						
6	550-650		-50 -65		High Sens Opt in 7106D only	
7 ►	835-970		-50 -65			
8	1080-1205		-65			
9	1205-1800		-50			
10	1800-2100		-50 -65		High Sens Opt in 7106D only	
11 ►	2100-2580		-50 -65			
12						
13	2680-2930		-50			
14	2930-3120		-50			
15	3120-3300		-50			
16	3300-3600		-50			
17	3600-4050		-70		Selectable Opposite-Quadrants	
18	4050-4850		-70			
19	4850-5250		-65 -75		High Sens Option	
20 ►	6700-7300		-76			
21 ►	7300-7900		-76			
22	7900-8600		-76			
23 7106D	14.8-15.1 GHz		-102		60^o Beams @ 60^o to right & left of flight li	
23 7106C	14.6-14.9 GHz		-102			

* W=80 msec., X=120 msec., Y=160 msec., Z=200 msec.
** All bands have Omni-Directional Azimuth Coverage
*** [redacted]
**** 153.5-165 MHz at 10 db
► Absolute Temperature & Voltage Calibration [redacted] (b)(1) (b)(3)

Table 2

CHANNEL

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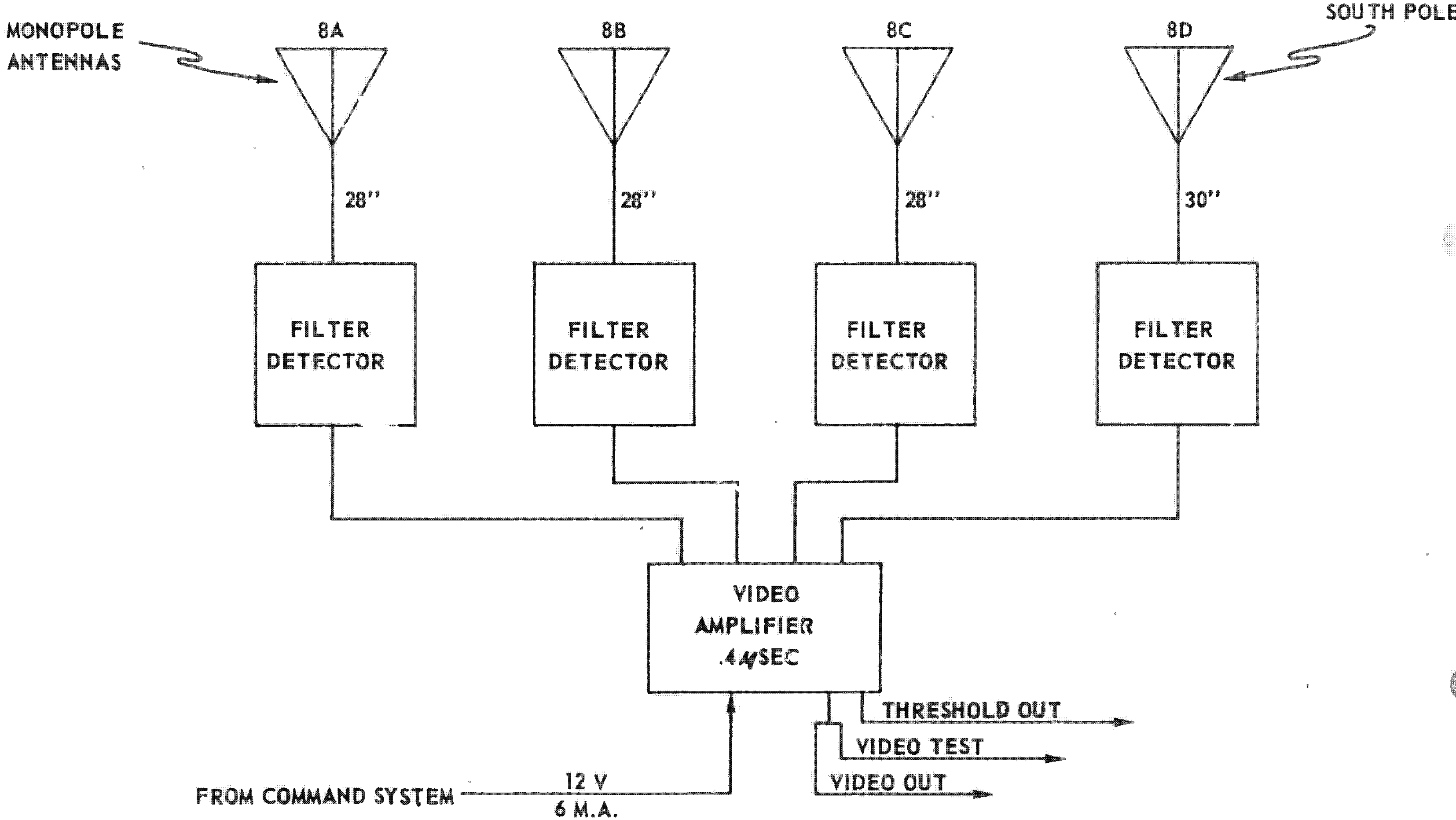
EQUATORIAL BAND



BAND 8
7106 C
7106 D

SIMPLIFIED BLOCK DIAGRAM (.15 – 1.8 GHz)

EARPOP
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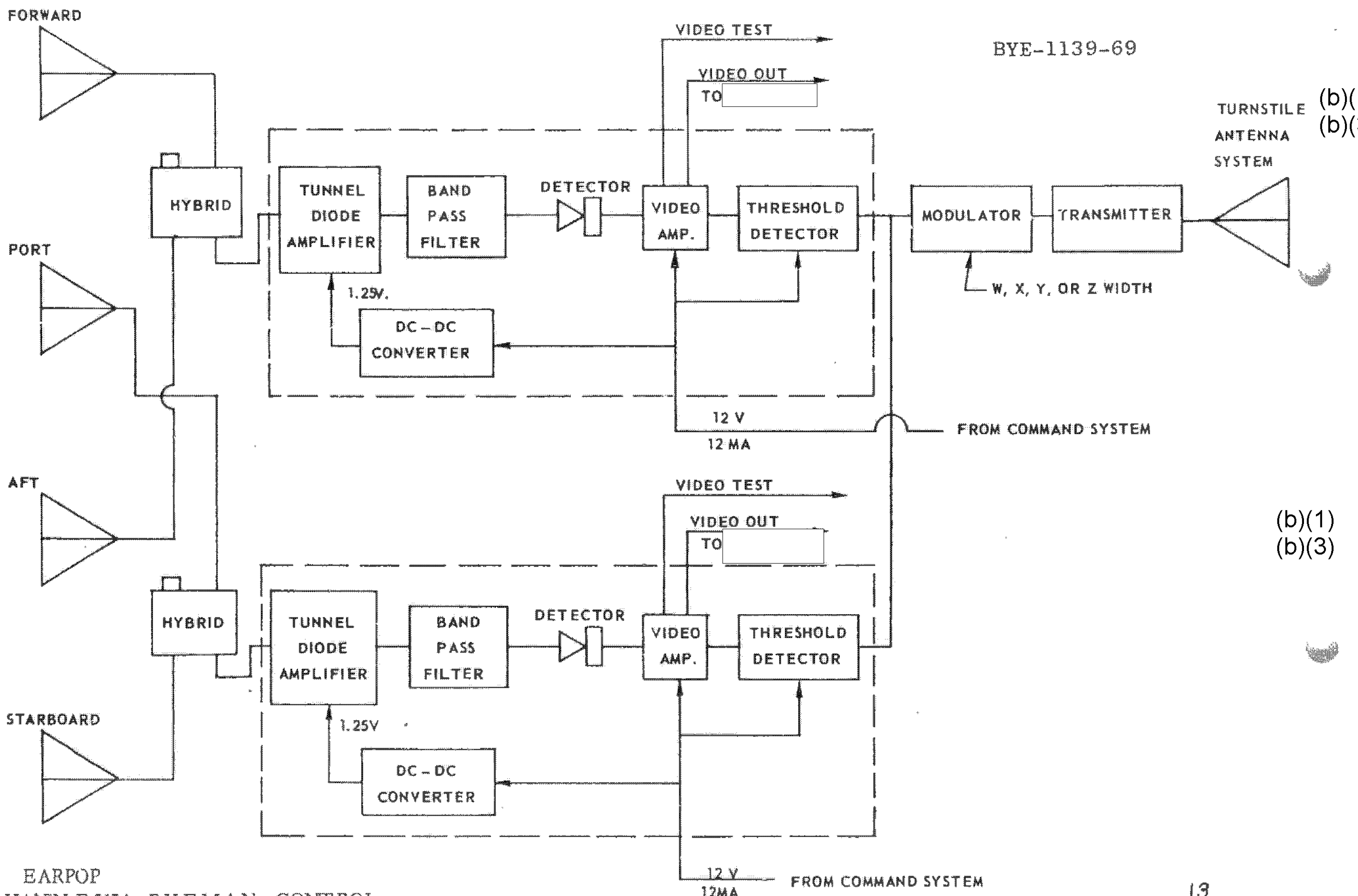
(b)(1)
(b)(3)



(b)(1)
(b)(3)

SIMPLIFIED BLOCK DIAGRAM (4 – 10 GHz)