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Tech. Dec of Mis 7106

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PRELIMINARY TECHNICAL DESCRIPTION OF MISSION 7106

up dated 3 June 1969

I. INTRODUCTION AND PURPOSE

Since the launch of Mission 7105 on 31 May 1967 the Naval Research Laboratory has been engaged in the development cycle for Mission 7106 which is now scheduled for launch in September 1969. A "Preliminary Technical Description of Mission 7106" was promulgated by NRL letter BYE-51910-68. The present paper provides a revision and up-date of the earlier letter. It must be clearly understood that the facts presented here are not final and will be obsolete upon distribution of the final technical description which is scheduled for release during the month prior to the launch of Mission 7106. The purpose of this up-date is to bring into sharper focus certain of the system capabilities of Mission 7106 so that the Tasking Community can prepare for the operational utilization of the Mission.

The "design goals" for this Mission 7106 will continue to be used instead of the final observed system characteristics which are incomplete at this time.

To make this up-dated document complete those sections of the original description which are not changed will be included along with those sections changed to reflect modification brought about by operational requirements or engineering innovation

II. DESCRIPTION OF THE BASIC FUNCTIONS

The 4 satellite spacecraft are under development by the Naval Research Laboratory and are being readied for launch from the Pacific Test Range in early September 1969. These satellites are for use in the Program-C (POPPY) SIGINT data collection effort of Mission 7106, and will be known by their respective nomenclature identifications as 7106A (ALPHA), 7106B (BRAVO), 7106C (CHARLIE), and 7106D (DELTA).

The four satellites with their 82 primary collection systems are designed to fulfill two basic requirements in the collection of ELINT data of sufficient quality and quantity to disclose (?) the early identification and location of existing and future major

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weapon systems within the denied Soviet and CHICOM areas and (2) the advancements in radar technology which may be applied to future weapon and space systems in any part of the world where crisis situations may develop.

In conformance with the capabilities demonstrated in earlier POPPY missions, Mission 7106 will provide data to support the following intelligence priorities:

(1) Timely discovery of the existance of previously unknown emitter subsystems.

(2) Technical assessment of these new subsystems to ascertain the performance function, capabilities and limitations as they are deployed into a major overall weapon system.

(3) Electronic Order of Battle (EOB) surveillance capability for timely periodic determination of location of known emitter subsystems with sampling by geographic area sufficient to disclose a measure of the activity level as well as the interrelationships and usage patterns of these subsystems relative to the overall weapon systems.

III. OVERALL OPERATIONAL DESCRIPTION

Basic Command and control systems:

a. 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 improtant operational differences listed below:

(1) Eighty individual commands are available in each spacecraft.

(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 be sent in any sequence after the command system is "enabled".

(4) The on-board timer is programable so that all ELINT collection commands may be executed in a delayed mode of up to 140 minutes in ten 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 ~~of~~ 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]

(6) All spacecraft have a separate command, referred to as the "unique mode reset" which allows 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) As a back up for the timer system in case of failure, it may be by passed, 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.

Telemetry system:

[redacted] a. The primary telemetry on all four spacecraft is the [redacted] The analog system is retained as a secondary or back up system and will be used for read out of the spacecraft engineering status by those stations which are not yet equipped with the necessary [redacted] equipment. [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 same digital data is available in the analog system so they act as back up for each other.

b. The most significant improvement which results from use of the [redacted] telemetry system 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.

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TABLE 1

Addition Mission 7106 spacecraft characteristics

(1)	Size	34" high
(2)	Shape	27" dia multiface
(3)	Weight	240 lbs

[redacted]

which can be described as a 12-sided multiface. The major difference has been a three inches increase in vertical height of the structure to accommodate the larger volume of electronics for the additional number of ELINT collection systems which for mission 7106 will ~~have in each spacecraft~~. There will be approximately 80 antenna elements located on the skin of each of the spacecraft to serve the ELINT collection systems. 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 for instance.

b. All surfaces of the spacecraft not covered with the solar cells (used for recharging the battery system) are covered with a vapor deposited aluminum and then covered again 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 $0^{\circ}C$ and $60^{\circ}C$ for the sunlight condition of the normal POPPY orbit.

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

Gravity gradient stabilization systems:

a. All four spacecraft will be equipped with 3-axis Gravity Gradient stabilization (GGS) systems. There is a two fold 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). [redacted]

ELINT collection systems techniques and options:

a. Spacecraft ELINT data collection systems; each of the four spacecraft of Mission 7106 will be equipped with at least twenty ELINT data collection systems and ~~as mentioned earlier~~ they will all be crystal-video type receiving sytems. As these systems intercept signals from a radar which illuminates the spacecraft with sufficient signal strength ~~th~~ to exceed the on board thresholder level, the rf ~~pulses~~ pulse from the radar ~~are~~ is detected, [redacted]

Parametric measurement options:

a. In order that the data derived from POPPY ~~May~~ 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 available throughout all four spacecraft and in each portion of the spectrum, [redacted] measurement and [redacted] options available by command. In addition all collection systems above [redacted] will have the choice of either 360^{o} azimuthal collection coverage or either of two, "opposite -quadrant" type collection antenna coverage patterns. The signal amplitude

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[redacted]

Ground based data collection systems:

a. The pulses which are transponded from Mission 7106 via the two data link chennels from each spacecraft will be intercepted by a chain [redacted] dedicated POPPY collection sites situated around [redacted] Soviet Bloc land-mass. These data collection sites are provided with two receiving complexes called the "Red" and "Green" complexes. [redacted] are provided with the transmitter (Blue) complex for interrogating and commanding the spacecraft for operational tasking. The first [redacted] stations have the field digitizing system; [redacted] has had this operational for 2 years (since June 1967), while the [redacted] site has hadit's system operational for about two months (April 1969). [redacted] digital system is under procurement at this time and will be operational within one year. The pace setting aspect for this schedule is the site modification necessary to accommodate a system of this size and complexity. In addition to the receive, the record, the command and the the digital systems, each of the sites have extensive analysis or quality control (QC) systems to assist in the real time appraisal of the data. [redacted] 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. In contrast the analog station will be able to only utilize one fourth of the total Mission operational capability. This is due to being able to monitor only two spacecraft simultaneously and

[redacted]

Orbital characteristics for Mission 7106:

a. The 4 spacecraft of Mission 7106 are to be placed in a circular orbit of 500 nautical miles altitude, and inclined of 70^{o} to the earths equatorial plane. The in flight spacing has already been described under the section on the Microthruster systems, but for clarity will be repeated here...7106C will arrive at a ground site first, followed 50 n.m. later by 7106A, then 100 n.m. later will be 7106D and bringing up the rear about 50 n.m. later will be 7106B. Thus the four spacecraft will be in a group, one behind the other with relatively tight spacing as compared to previous POPPY missions. Tight spacing will provide the opportunity to utilize the full collection capability all four spacecraft against signals of high priority.

4. SPACECRAFT ELINT COLLECTION SYSTEMS:

Basic description

a. The historic POPPY ELINT intercept system has utilized the high probability of intercept crystal-video or detector-video type receiver. Such receivers are reliable and utilize a minimum of power . From this system several inherent benefits are derived which have been apparent throughout the history of the POPPY program. There are no spurious image products generated in the receiving systems so thatthe data is free from self induced artifacts and has thus been of the highest confidence. The long lifetime aspects of the POPPY system have been attained through these simple systems wihich are unusually stable and maintain their calibration characteristics extremely well over wide flight temperature and voltage fluctuations. The receiving antennas associated with the POPPY system have had extensive documentation and have experienced a high degree of performance predictability during the long lifetime missions. Typical block diagrams and frequency response characteristics for Mission 7106 are provided in appendix 1 attached.

b. Since these POPPY systems are wide open in frequency by benefit of the detector-video type receivers employed and all around looking by virtue of the spacecraft ELINT collection antenna [redacted] singnal within the optical horizon of the spacecraft (a distance of 1750 nautical miles range in every direction) over the complete frequency spectrum from 154 MHz to 10,000 MHz. In the frequency band from 14.6 to 15.1 GHz the collection antenna system does not provide complete 360° coverage but instead provides two 60° wide lobes centered 60° to the right and 60° to the left of the flight line toward the front of the 7106C and 7106D spacecrafts.

Frequency spectrum consideration:

a. The individual collection sub-system or band is designed so that a set of matched band-pass filters with built in detector mounts is connected between each receiving antenna element and the video amplifier which normally has a combining circuit in its input stanges sothat several antennas worth of signal plus noise go into a single video amplifier. An adjustable thresholding circuit is at the output of the video amplifier and is set so that under no ordinary circumstance will the data link transmitter trigger on noise alone. The radio frequency definition is determined by the selectivity characteristics of the matched filters and in the final description of these systems the band pass frequencies will be defined at 3, 10 and 20 db points. Generally the band-pass characteristic is selected so that there is at least one known target emitter family or one magnetron-family within the frequency band of each collection system. This arrangement provides a continuous means of assurance that the spacecraft ELINT collection system performance remains relatively unchanged over the long operational lifetimes.

b. 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 wiht 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 table 2 and 3 to provide the frequency response points 3 db down at the upper and lower ends of the pass-band.

Receiving antenna system:

a. Two general type 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 thatis 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 lattertype 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 onmidirectional collection antenna pattern of reception for either vertical or horizontal polarized emissions.

b. In the requency range from 1800 to 3600 MHz the standard antenna for use in these ELINT Collection systems is the "open-ended" waveguide type arranged symetrically about the southern latitudes of the spacecraft. Again video combination provides omnidirectional and omnipolarization capability for these receiving antenna systems.

c. 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.

Usually these antennas are mounted on 20^{O} inclined wedges so that the pattern is canted downward toward theearth so that the territory more nearly under the spacecraft will also be capable of surveillance. Each dipole element is rotated slightly so as to optimize the collection for both horizontal and vertical polarized signals. The two antennas which are on opposite sides of the spacecraft are combined through hybrids (for isolation) to form two orthogenal channels which have separate RF amplifiers ahead of the video receiving syst4ms. Thus these two orthogonal channels can be used together to give complete 360^{O} 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 interst; (4) as a fall-back situation which could be employed if one channel were to fail, the other could be used to extend the operational lifetime of the collection system.

d. The two collection systems in 7106C and 7106D which cover the frequency range from 14.6 to 15.1 GHz are the only ELINT system in 7106 which does not provide complete 360^{O} 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 main receiving antenna lobes, one to the right and off the front flight-line by about 60^{O} and the other to the left also off the front flight-line about 60^{O}. Two horn antennas are used to form each beam. One set of receiving eletronics 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 furthest back from the front of the spacecraft (one on either side of the spacecraft). Thus there is a versatile command option possible to allow for in-flight tasking of one of these two electronic receiving systems or the other or both. 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 the outward from the front of the spacecraft. Conversely, the other system of antennas and elecrronics will provide when tasked separately, a collection antenna pattern with two 30° wide lobes centered 75° from the front and to the left and right sides of the spacecraft.

RF preamplifiers in ELINT receiving systems:

a. RF preamplification is utilized in all collection systems above 3600 MHz to achieve the required sensitivity. Low noise [redacted] the spectrum where there is a high priority emitter target which is too weak for normal or standard POPPY crystal video type systems to detect it has been necessary to add rf preamplification. An example of this design requirement is the 1200 MHz signal thought to be associated with the [redacted] emitter. In order to accommodate this operational demand it has been necessary to adjust the frequency coverage as well as the sensitivity to the values shown in the table 3. It will be possible by this adjustment to simultaneously intercept both the [redacted]

b. In the case of the rf preamplifiers used at frequencies below 3600 MHz the transistor technology has advanced sufficiently so that the ultra minature and highly reliable transistor type rf amplifiers are being used in 7106C and 7106D where "high sensitivity" options are indicated in the sensitivity tabulation of Table 3.

5. PARAMETRIC MEASUREMENT CAPABILITIES OF MISSION 7106

[redacted]

a. In each of the four spacecraft of Mission 7106 there will be a [redacted] option which can be commanded into use with any of the collection bands. NSA has promulgated the suggested [redacted] which are

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TABLE 2

7106 A and B

Band Number	Bandpass (MHz)	Transmitter	Sensitivity (dbm)	Antenna Modes**
		[redacted]		
1	154-165	[redacted]	-40	153.5MHz 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	SELECTABLE POLARIZATION
12	2580-2680		-50	
13	2680-2930		-50	
14	2930-3120		-50	
15	3120-3300		-50	
16	5250-5850		-7 [redacted]	
17 ▶	5850-6720		-7	
18	8600-9340		-7	
19	9340-9500		-7	
20	9500-10,000		-7	

* [redacted]

**ALL BANDS HAVE OMNI-DIRECTIONAL AZIMUTH COVERAGE

▶ ABSOLUTE TEMPERATURE & VOLTAGE CALIBRATION [redacted]

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TABLE 3

7106 C and D

Band Number	Bandpass (MHz)	Transmitter [redacted]	Sensitivity (DBM)	Antenna Modes**
1	154-165	[redacted]	-40	153.5 MHz at -DB
2 ▶	165-200		-47	
3	240-350		-50	
4 ▶	350-450		-50	
4	~~3-50-450~~	**	-65	7106D only
6	550-650		-50, -65	High Sens. Option in 7106 C Only
7 ▶	835-970		-50, -65	
8	1080-1205		-65	
9	1205-1800		-50	
10	1800-2100		-50	High Sens. Option in 7106 D 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	
18	4050-4850		-70	
19	4850-5250		-65, [redacted]	High Sens. Option
20 ▶	6700-7300		-76	
21 ▶	7300-7900		-76	
22	7900-8600		-76	
23 (7106D)	14.8-15.1 GHz	(7106D)	-102, 60°	Beams @ 60° to right & left of flight line
23 (7106C)	14.6-14.9 GHz	(7106C)	-102	

[redacted]

**ALL BANDS EXCEPT 23 HAVE OMNI-DIRECTIONAL AZIMUTH COVERAGE

[redacted] Detection and high sensitivity option in 7106D

▶ ABSOLUTE TEMPERATURE & VOLTAGE CALIBRATION [redacted]

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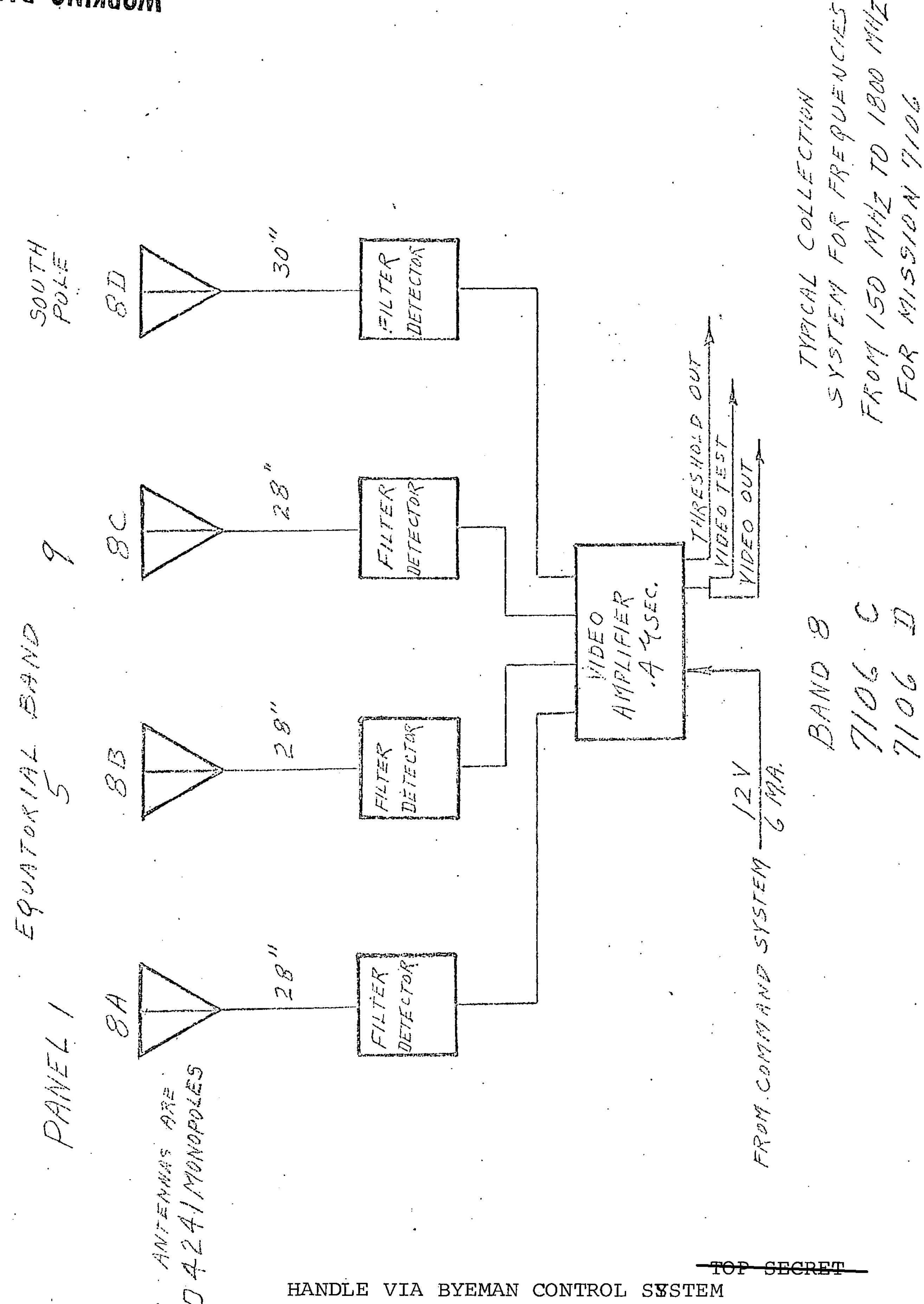

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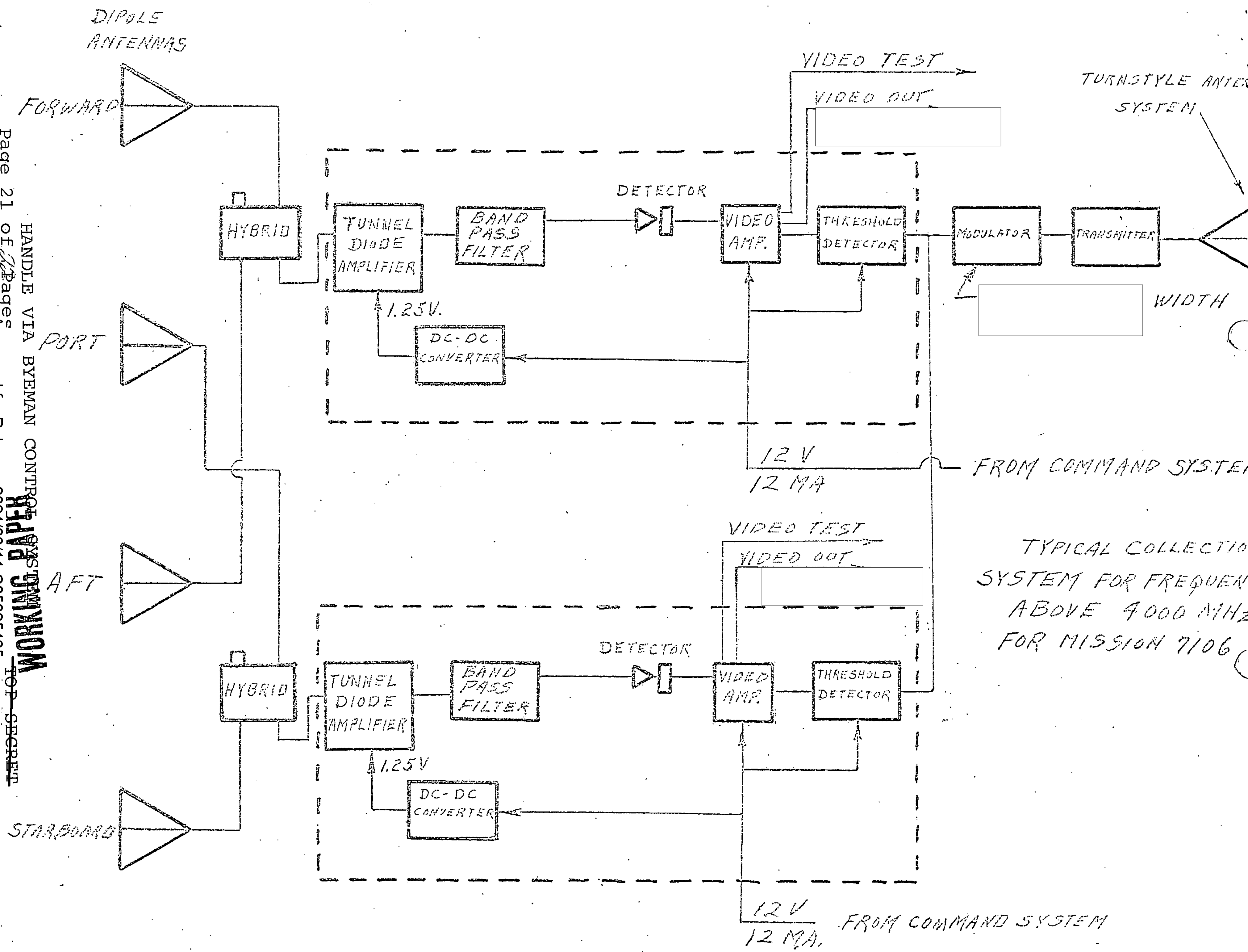

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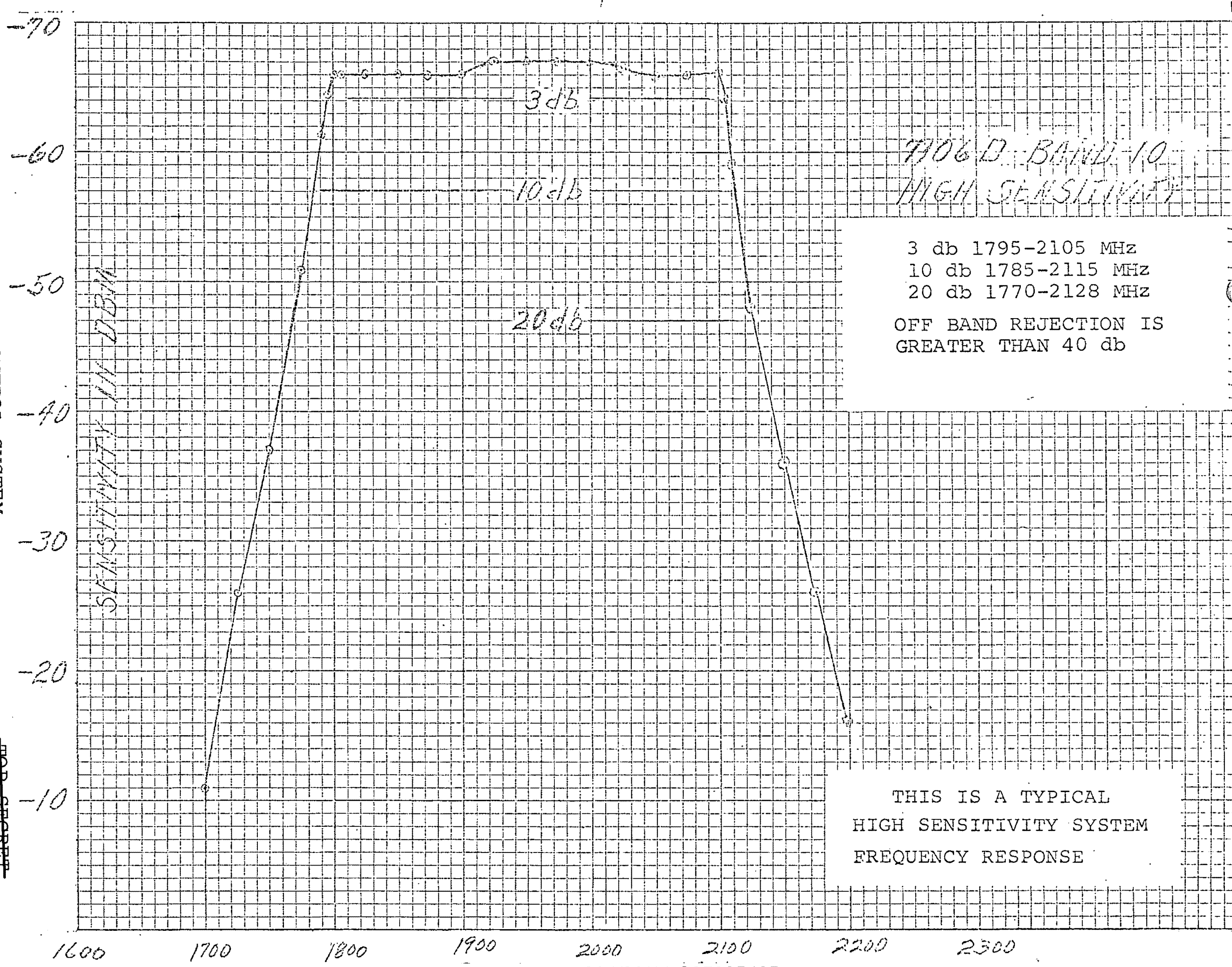

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