~~(C)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

NRO STAFF

26 July 1966

MEMORANDUM FOR THE CHAIRMAN, CSWG

SUBJECT: Mission Descriptions of SIGINT Mission 7314 (SAMPAN) and Mission 7315 (SOUSEA)

Attached are the mission descriptions for Missions 7314 and 7315.

A side-lobe cancellation technique used in Mission 7314 is being tried for the first time and is explained in detail in the mission descriptions.

Operational Concept

Mission 7314/15 is contained in a spin-stabilized P-11 sub-satellite which will be launched into a nominal 275-300 nautical mile circular orbit by an Atlas-Agena booster. It contains two separate reconnaissance systems: Sampan which is designed to intercept and record signals in the 2000 to 4000 mc band and Sousea which is designed to intercept and record signals in the 8000-1200 mc band.

Ground based direction finding technique will be used to determine the locations of intercepted signals. The planned launch date, predicated on the launch of the primary payload is 15 August 1966. Mission life is expected to be 6 months. The recorder capacity (12.5 min) is such that the payload will not be able to cover "border-to-border," however, coverage of China will be optimized by proper utilization of the standard command/delay system. A nominal 5 to 8 collection revs per day will be available and of the 4 daily revs that pass over China 3 to 4 will be tasked. The combination of spin and narrow antenna beams will enable the processor to determine emitter locations to varying accuracies, depending on the position of the emitters to nadir.

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2 Attachments
1 Sampan Mission 7314
2 Sousea Mission 7315

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SAMPAN MISSION 7314

A. OVERALL SYSTEM DESCRIPTION

The SAMPAN receiving system consists of an antenna system, three crystal video receivers with rf preamplification and a dual track tape recorder for storing received data. In general, it is similar to the Sousea system but it has the added capability of inhibiting any intercept made through the side-lobes of its directional antenna. The side-lobe cancellation technique used in this payload is being used in the P-11 program for the first time.

A total of five video channels are derived which provide the following measurements: radio frequency, peak received power, pulse sidth/pulse interval, prf, scan rate, and geoposition of emitters.

The radio frequency measurement is processed by sweeping YIG filters providing measurement accuracy of $\pm 0.5\%$. An operation mode decoder, is used to change the band that the two YIGs sweep to one of four ranges.

All receiver outputs are recorded on a 75 KC bandwidth, 2:1, dual track tape recorder with the same recording specifications as in the Sousea system.

The earth sensor output modulates a VCO. Once per minute the earth sensor data is interrupted and a frame of the payload status commutator is read out. The earth sensor data being recorded by the Sampan system is the same as the Sousea system records.

B. SPECIFIC PAYLOAD CHARACTERISTICS.

1. Antennas

The deployable antennas for the Sampan payload consist of an omnidirectional antenna system and a three foot parabolic reflector with a dual band conical spiral feed. The parabolic reflector is common to both Sousea and Sampan; however, the dual channel feed is optimized for the Sampan inhibit requirements. The omnidirectional antenna system consists of two conical spirals effectively positioned back-to-back on the P-11. The gains of the forward and aft looking antennas match the forward and rear side lobes of the directional antenna. This gain pattern is required in order to permit side lobe cancellation techniques to be utilized in the receiver without suffering a significant loss in detection sensitivity.

2. Receivers rf

The Sampan rf front end consists of three channels, each containing tunnel diode rf bandpass amplifiers. Each amplifier has four stages producing a nominal gain of 26 db. To satisfy the inhibit requirements the amplifiers are gain matched across the frequency band within 2 db. By a ground command the gain of the DF channel TDA may be increased by a 6 db. This high gain mode increases the detection sensitivity of the DF channel by 6 db.

3. Receiver, Omnidirectional Channels

The two conical spiral antennas which comprise the omnidirectional antenna system feed two identical rf receivers. Each of these receivers has a wideband video channel and a YIG filter video channel. After detection, the two wideband video channels are added together and comprise one combined omnidirectional wideband channel. Likewise, the two YIG video channels are added after detection and together comprise one combined omnidirectional YIG channel. Dual rf channels must be provided to each antenna with postdetection summing rather than predetection summing in order to avoid the pattern lobing effects (interferometer action) of two closely spaced antennas.

The wideband video channel is required (in addition to its inhibit function) to provide long-term intercepts necessary to measure ground emitter main beam scan rates, main beam shapes and sidelobe pattersn, and other target parameters of an operational nature. Since this channel covers all of S-Band including the extremely high-density portion between 2.6 GHz and 3.2 GHz and has omnidirectional coverage, and since it feeds a video recording channel of limited bandwidth, the sensitivity of the channel as far as recording data is concerned must be decreased from the maximum sensitivity used for inhibit function. The sensitivity chosen, based on the above considerations is -56 dbm tangential. This sensitivity will prevent the data rate from being excessive by insuring intercepts only from main beams and significant first-order sidelobes.

The omnidirectional YIG filter channel measures the frequency of those signals received in the omnidirectional antenna system. The dual YIG filters have a 3 db bandwidth of 30 MHz and sweep at a constant rate of 4.5 MHz/ms. This sweep rate insures the reception of 3 pulses of a 300 pps emitter within the 3 db points of the filter response. The dual YIG filters are swept in common.

The sweep range of the YIG channels (DF channel as well as omnidirectional channel) can be commanded to cover either the total 2 to 4 GHz band or any one of three narrower bands within the 2 to 4 GHz octave. The narrow frequency bands are 2.0-2.6 GHz, 2.6-3.2 GHz, and 3.2-4.0 GHz. These narrower ranges increase the probability of frequency measurement over the wideband case. Band-edge marker pulses are provided at the beginning and end of each sweep. The frequency of an intercept is determined by a linear time interpolation between the centroid of the intercept and the band-edge markers. The YIG channel video output frequency modulates a VCO.

This output is combined in an adder amplifier with the 15 kHz wideband video baseband and a 50 kHz reference oscillator which is amplitude modulated by a time word of an AN/GSQ-53A format (the same word used in Sousea). The output of the adder amplifier goes directly to track 1 of the 75 kHz 2:1 Leach tape recorder.

Upon playback from the tape recorder vehicle status data is added to this data track during tracking station acquisitions.

4. Receiver, Direction Finding Channels

A total of three video channels are provided by the DF receiver. The three channels consist of a wideband video channel, a sweeping YIG filter video channel, and a pulse width/pulse interval measurement circuit.

The wideband channel provides the necessary data to measure the prf of an emitter and the ground location of the emitter. Only intercepts from the mainbeam of the 3-foot parabola will be seen in this channel because of the inhibit action of the receiver. Frequency measurements of those signals appearing at the DF antenna terminals is made with a sweeping YIG filter. Although this YIG can be commanded to cover any of four ranges, the wideband channel constantly monitors the total 2 to 4 GHz range.

Pulse width and pulse interval measurements are performed on signals detected in the wideband channel. The range of measurement is from 0.2 microseconds to 10 microseconds. The output of this circuit is a pulse width modulated and pulse amplitude modulated waveform which has been designed for ready analysis on a scope display. The output of this circuit frequency modulates a VCO.

Bidirectional earth sensor pulses frequency modulate a VCO. Once per minute the sensor output is interrupted and one frame of the Sampan status commutator is read out.

5. Receiver, Inhibit Function

A unique feature of the Sampan receiver system is the manner in which signals intercepted in the sidelobes of the DF antenna are eliminated from the output. This is done by careful gain matching of the three rf front ends and by careful design of the antenna system. The design requirements for the antenna system were to provide a pencil beam pattern of maximum gain and minimum sidelobes and to provide an omnidirectional pattern which had higher gain than the pencil beam in all areas but the main beam.

With this gain characteristic in the antenna system and with front ends of equal sensitivity, it is possible to make a decision in the receiver, on the basis of amplitude, whether or not an intercept occurred in the DF antenna's main beam or in its sidelobes. The two omnidirectional wideband videos are summed together to generate the total omni wideband signal which is then subtracted from the DF channel wideband video. If the pulses in the omni channel were of greater amplitude than the pulses in the DF channel, then the output is negative. Conversely, if the pulses in the omni channel were of smaller amplitude, then the output would be positive. A baseline clipper eliminates all negative pulses from reaching the output. Therefore, only pulses whose DF amplitudes were greater than omni amplitudes will be recorded at the DF output.

If the omni receiver sensitivity exactly matches the DF receiver sensitivity, false alarms or poke-throughs will exist at any point that the omni antenna gain falls below that of the DF antenna gain (with the legitimate exception of the main beam). To protect against this, the normal operating mode of the Sampan System is to operate the DF receiver with 6 db less gain than the omnidirectional receiver. This provides a margin of protection against pattern poke-throughs. Preliminary results indicate that 100% sidelobe cancellation will be achieved in the Sampan system when operating in the normal gain mode. When operating in the high gain mode over 90 to 95% of the sidelobes will be cancelled.

6. C.W. Detection Capability

The Sampan receiver system has the capability of detecting high duty cycle emitters, such as C.W. radars, FM transmission links, etc. These type of emitters will be seen in the YIG filter video channel but not in any of the wideband video channels. The reason for this is that A. M. postdetection channels with dc response are required to pass either a C.W. signal or an FM signal unless that signal is effectively chopped at some rate which is above the low frequency cut off of the video channels. The sweeping YIG filter is a device that acts as a chopper to the C.W. signal, and in fact, when scanning through a C.W. signal, generates a pulse which is the shape of the YIG bandpass. Therefore, any such pulse detected on the YIG channel is an alarm that either a C.W. or FM emitter has been intercepted. Detection will be possible only in the DF YIG channel due to the sensitivity required to detect the usually low powered C.W. emitter.

C. TIME REFERENCE GENERATOR (TRG)

The TRG used in the Sousea-Sampan payloads generates a serial time word with a binary coded decimal (BCD) expression of time in hours, minutes, and seconds. The recycle time of the clock is 24 hours, resetting from 23:59:59 to 00:00:00. This time format is the standard AN/GSQ-53A format. The only exception to this format is the absence of four four-millisecond updating pulses at the end of the time word. These pulses are not part of the time of day expression and were therefore eliminated in order to compress the signal spectrum.

The output time word is recorded on the tape recorder as the amplitude modulated sidebands of a 50 KC reference oscillator. This is a separate oscillator from the TRG oscillator, therefore this is not a synchronous modulation system. The basic stability of the TRG oscillator is $\pm$.005% over the temperature range of -50 to +50°C.

The TRG also provides a pulse to both payloads once every minute. This pulse initiates the rf calibration sequence in both payloads. This sequence lasts for one second as timed by the TRG.

SOUSEA MISSION 7315

A. OVERALL SYSTEM DESCRIPTION

The SOUSEA receiving system consists of an antenna system, crystal-video receiver with r.f. preamplification and a dual-track tape recorder. The receiver contains two identical r.f. front ends which are designated as the omnidirectional and direction finding (DF) channels. Each channel covers the frequency range of 8.0-12.0 GHz. A total of six video channels are derived which provide the following measurements: Radio frequency, peak received power, pulse width/pulse interval, p.r.f., scan rate, and geoposition of emitters.

The radio frequency measurement is processed by a sweeping YIG filter providing a measurement accuracy of ±0.3%. An operation mode decoder, is used to change the band that the DF YIG sweeps to one of eight narrower frequency ranges within the 8 to 12 GHz range. The YIG filter in the omnidirectional channel is not switchable, and constantly sweeps the 8-12 GHz range.

All the receiver outputs are recorded on a 75 KC bandwidth, 2:1, dual track tape recorder. The readin time for the tape recorder is approximately 12:5 minutes with a readout time of approximately 6.25 minutes.

The earth sensor output modulates a VCO, the output of which is summed in the direction finding adder amplifier with three other data channels. The earth sensor output pulses are bidirectional for ease in determining which is the sky-earth transition and which is the earth-sky transition.

B. SPECIFIC PAYLOAD CHARACTERISTICS

1. Antennas

The deployable antenna system for the SOUSEA payload consists of an omnidirectional antenna and a three foot parabolic reflector with a dual band conical spiral feed. The omnidirectional antenna is a planar spiral and has a pattern approaching that of a circularly polarized dipole.

2. Receivers, r.f.

The SOUSEA system is comprised of two identical r.f. receivers producing a total of six video channels. Each receiver utilizes the combined gains of a tunnel diode amplifier and traveling wave tube producing a gain of approximately 58 db and a system noise figure of 7.5 db. The tunnel diode amplifier, directional coupler, and bandpass filter are mounted external to the payload, and as close as practical to the deployable antennas in order to minimize the receiver noise figure. A gain equalizer is used to minimize the amplitude variations vs frequency of the TWT. After r.f. amplification the signal is coupled to several video channels for further processing.

3. Receiver, Omnidirectional Channels

The individual channels associated with the omnidirectional receiver are a wideband video channel and a sweeping YIG filter video channel. The detected wideband video is processed through a log video amplifier, pulse stretcher, and 15 KC low pass filter. The purpose of this channel is to provide long-term intercepts required to measure ground emitter scan rates, main beam shapes and sidelobe characteristics, and other target parameters of an operational nature. The companion YIG filter channel measures the frequency of those signals received in the omnidirectional antenna. The YIG filter has a 3 db bandwidth of approximately 60 MHz, and sweeps across the 4 GHz band at 20 MHz/ms. This sweep rate insures the reception of 3 pulses of a 660 pps emitter within the 3 db points of the filter response.

Frequency measurement is made in an identical manner as is done in Sousea. The YIG channel video output frequency-modulates a VCO.

This output is combined in an adder amplifier with the 15 KHz wideband video baseband, a 50 KHz reference oscillator which is amplitude modulated by a time word of AN/GSQ-53A format, and a VCO which is modulated by a 30 point Rzcommutator. This commutator contains intercept PW/PI data from the DF receiver and general system status data. The output of the adder amplifier goes directly to track 1 of the 75 KHz, 2:1 Leach tape recorder.

4. Receiver, Direction Finding Channels

A total of four video channels are provided by the DF receiver. The four channels consist of two video channels, a sweeping YIG filter video channel, and a pulse width/pulse interval measurement channel.

The two DF video channels separate the 8 GHz range into a high density channel and a low density channel. The high density channel has a 3 db r.f. passband between 8.9 and 9.7 GHz. This channel contains most of the known US and foreign X-Band radars and will at times containtain very high data rates. The video bandwidth of this channel is 15 KHz and is recorded as the baseband of recorder track 2. The low density channel has a 3 db r.f. passband covering the balance of 8-12 GHz band I.E.; 8 thru 8.9 GHz and 9.7 thru 12 GHz with 40 db of rejection in the high density region. The two filters are complementary and when summed cover the entire 8 to 12 GHz band. The low density band is being handled as a separate channel in order to provide a high degree of detection probability to unknown radars which are not in the high density region. This low density channel will not contain excessive data rates and is therefore being recorded on a 40 kHz carrier with ±20% frequency deviation. Operating this VCO at a modulation index of 1 will provide a video bandwidth of approximately 8 kHz.

A frequency measurement of those signals appearing at the DF antenna terminals is made with a sweeping YIG filter. The filter is similar to that used in the omnidirectional channel, scanning at the identical rate of 20 MHz/ms. However, the DF YIG filter is commanded by ground command to sweep any of 8 narrower frequency bands within the 8 GHz to 12 GHz region. The narrow frequency bands are 8-8.6 GHz, 8-11 GHz, 8.5-9.3 GHz, 9.2-10.0 GHz, 9.9-10.7 GHz, 10-12 GHz, 10.6-11.4 GHz and 11.3-12.0 GHz. These narrower YIG sweep ranges are required in the DF channel owing to the limited amount of intercept time provided by the narrow pencil beam pattern.

Pulse width and pulse interval measurements are performed on signals detected in either the high density or low density video channel. The range of measurement is from 0.2-20 microseconds. Ten measurements of each parameter are made per frame of the 30 point RZ commutator.

5. C. W. Detection

The C.W. detection capability in SOUSEA is essentially identical to that in SAMPAN. All the statements in the SAMPAN paragraph of this subject are therefore applicable.