DESCRIPTION OF THE 406-MHz PAYLOADS USED IN THE COSPAS-SARSAT LEOSAR SYSTEM

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Annex B: Cospas-Sarsat LEOSAR Frequencies

1. INTRODUCTION

The Cospas-Sarsat space segment consists of the Cospas and Sarsat satellites and their respective search and rescue (SAR) payloads. The SAR payload consists of the SAR repeaters (SARR), SAR processors (SARP) and SAR antennas. The Cospas satellites and SAR payloads are provided by Russia. The Sarsat satellites and SAR antennas are provided by USA and Europe. The Sarsat SARR and SARP are provided by Canada and France respectively.

Figure 1.1 illustrates the Cospas and Sarsat satellites in orbit.

1.1 Purpose

The purpose of this document is to describe the performance parameters of each generation of the Cospas and Sarsat payloads and of the downlink signals for nominal operational satellites. This document is intended to be used to ensure the interoperability of the Cospas and Sarsat satellites and to sufficiently define the downlink to ensure compatible design of LUTs. This document is not intended to be used as a specification for the procurement of hardware for the space segment.

1.2 Scope

This document presents the technical definition and parameters of the Cospas-Sarsat space segment. It is divided into the following sections, where part 1 of each section covers Cospas payloads and part 2 covers Sarsat payloads:

a. section 2 describes the Cospas and Sarsat payloads and the interoperability parameters;

b. section 3 gives the technical parameters of all repeaters;

c. section 4 gives the technical parameters of all processors; and

d. section 5 gives the technical parameters of all antennas.

1.3 Reference Documents

a. C/S G.003 : Introduction to the Cospas-Sarsat System;

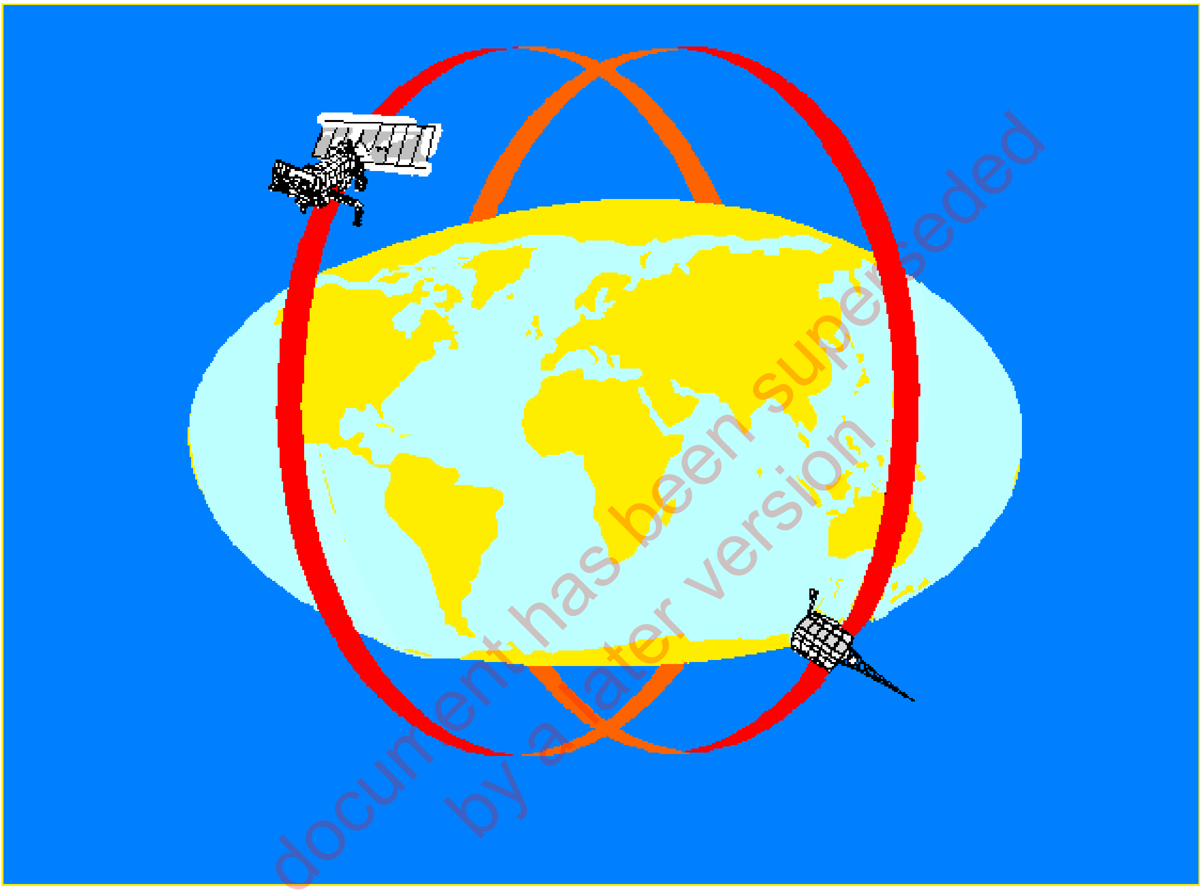
b. C/S G.004 : Cospas-Sarsat Glossary;

c. C/S T.001 : Specification for Cospas-Sarsat 406 MHz Distress Beacons;

d. C/S T.002 : Cospas-Sarsat LEOLUT Performance Specification and Design Guidelines; and

e. C/S T.006 : Cospas-Sarsat Orbitography Network Specification.

Figure 1.1: Illustration of Cospas and Sarsat LEOSAR Satellites*



* Note: Under normal operating conditions, the Cospas-Sarsat LEOSAR Space Segment consists of four satellites, two Cospas and two Sarsat, in near-polar orbit.

- END OF SECTION 1 -

2. COSPAS-SARSAT PARAMETERS

The payloads and interoperability parameters for the Cospas-Sarsat space segment are summarised in this section.

2.1 Cospas Payload

2.1.1 Cospas Payload Summary

The Cospas payload is composed of:

a. a SAR repeater (SARR);

b. a SAR processor (SARP); and

c. uplink and downlink antennas.

The SARR provides local mode coverage for the 406 MHz band.

The SARP provides both local mode and global mode coverage for the 406 MHz band. Cospas satellites have an improved SARP with memory (SARP-2). Processed data is transmitted to the ground stations via the downlink transmitter.

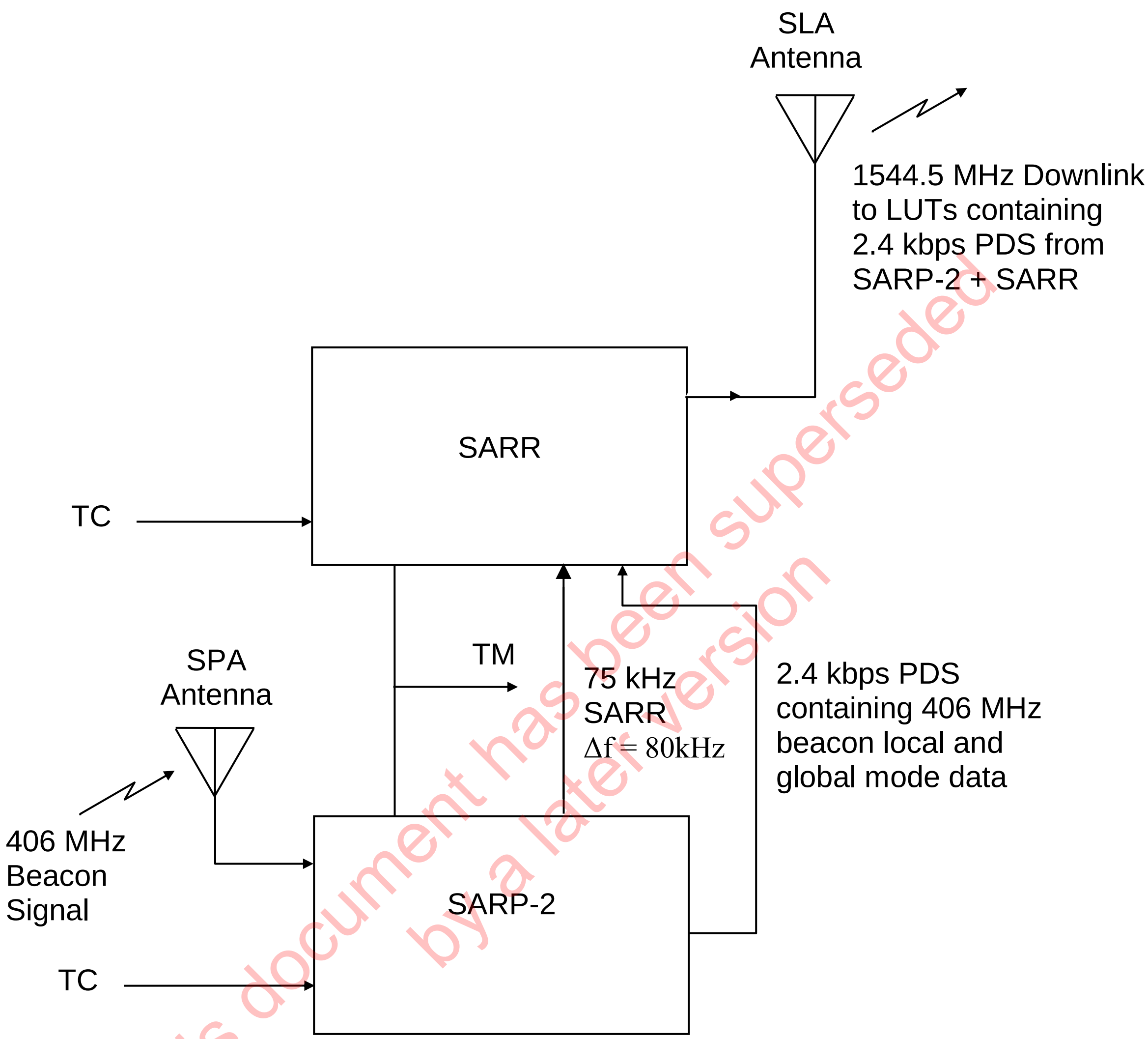
Cospas SARR and SARP are described in sections 3.1 and 4.1 respectively. Processed data is transmitted to the ground stations via the downlink transmitter.

Antenna parameters are given in sub-section 5.1.

2.1.2 Cospas Payload System Functional Diagram

The Cospas payload system functional diagram is shown in Figure 2.1. The downlink signal from the SAR L-Band transmit Antenna (SLA) can be detected by any Cospas-Sarsat Local User Terminal in the LEOSAR satellite system (LEOLUT).

Figure 2.1: Cospas Payload System Functional Diagram



Legend

SLA - SARR L-band transmit antenna
SPA - SARP and SARR receive antenna
TC - Telecommand from spacecraft
TM - Telemetry to spacecraft

2.2 Sarsat Payload

SARSAT payload descriptions in this document cover payloads on-board TIROS, METOP and the future SIDAR satellites.

The first generation of SAR Repeaters (SARR-1) is currently in service on TIROS and METOP satellites. The second generation of SAR Repeaters (SARR-2) will be on-board the SIDAR satellites (Sarsat-14) and has been designed with the PDS channel exclusively.

The second generation of SAR Processors (SARP-2) is in service on TIROS satellites (Sarsat-7 to Sarsat-10). The third generation of SAR Processors (SARP-3) is in service on METOP-A (Sarsat-11) and will be also on-board the last TIROS satellite (Sarsat-12), METOP-B (Sarsat-13) and the future SIDAR satellites.

2.2.1 Sarsat Payload Summary

The Sarsat payload is composed of:

a. a SAR repeater (SARR);

b. a SAR processor (SARP); and

c. uplink and downlink antennas.

The SARR provides local mode coverage for the 406 MHz band and its parameters are given in sub-section 3.2 for SARR-1 and PDS only coverage as given in sub-section 3.3 for SARR-2.

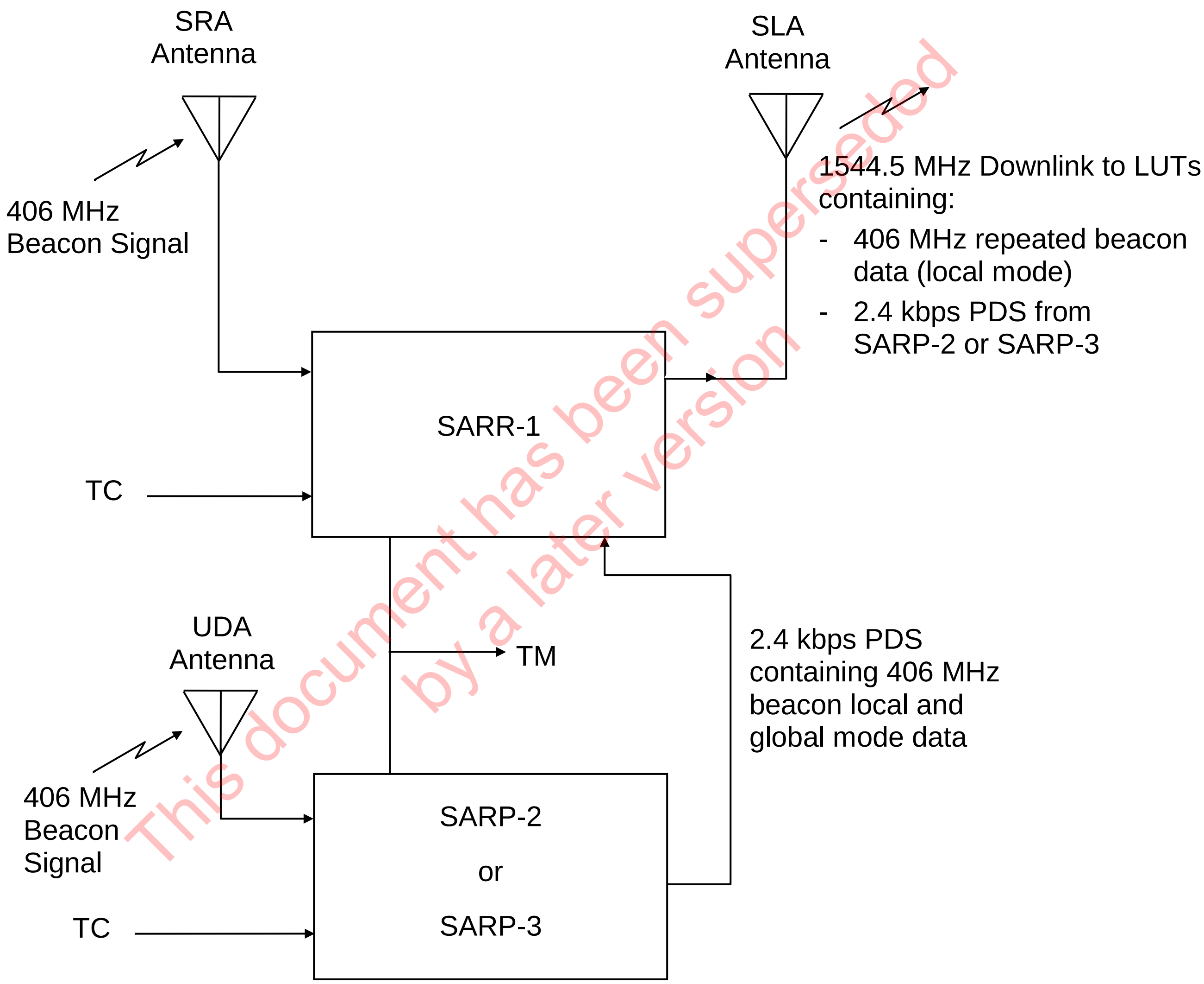
The SARP provides both local mode and global mode coverage for the 406 MHz band. Sarsat satellites may have one of two possible SARP configurations installed: SARP-2 or SARP-3. These processors are described in sub-sections 4.2.1 and 4.2.2 respectively. Processed data is transmitted to the ground stations by the repeater downlink transmitter.

Antenna parameters for the payload are given in sections 5.2, 5.3 and 5.4 for the TIROS, METOP and SIDAR satellites respectively.

2.2.2 Sarsat Payload System Functional Diagram

As shown on the Sarsat payload functional diagram in Figures 2.2a, 2.2b and 2.2c, the 2.4 kbps digital data is routed directly to the SARR.

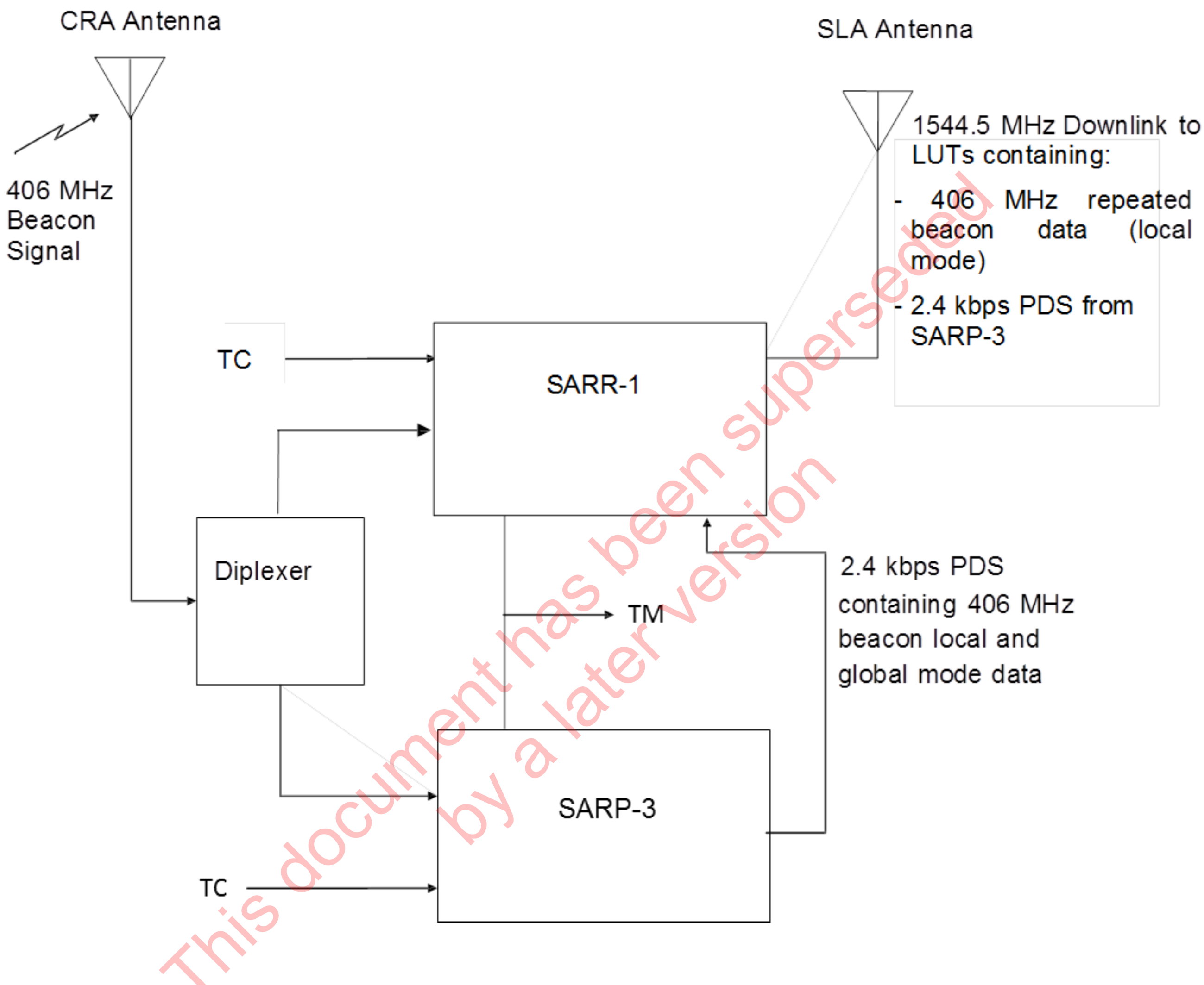
Figure 2.2a: Sarsat-TIROS Payload and Spacecraft Interface Functional Diagram with SARR-1 and SARP-2 or SARP-3



Legend

SLA - SARR L-band transmit antenna
SRA - SARR receive antenna
TC - Telecommand from spacecraft
TM - Telemetry to spacecraft
UDA - UHF data collection system antenna

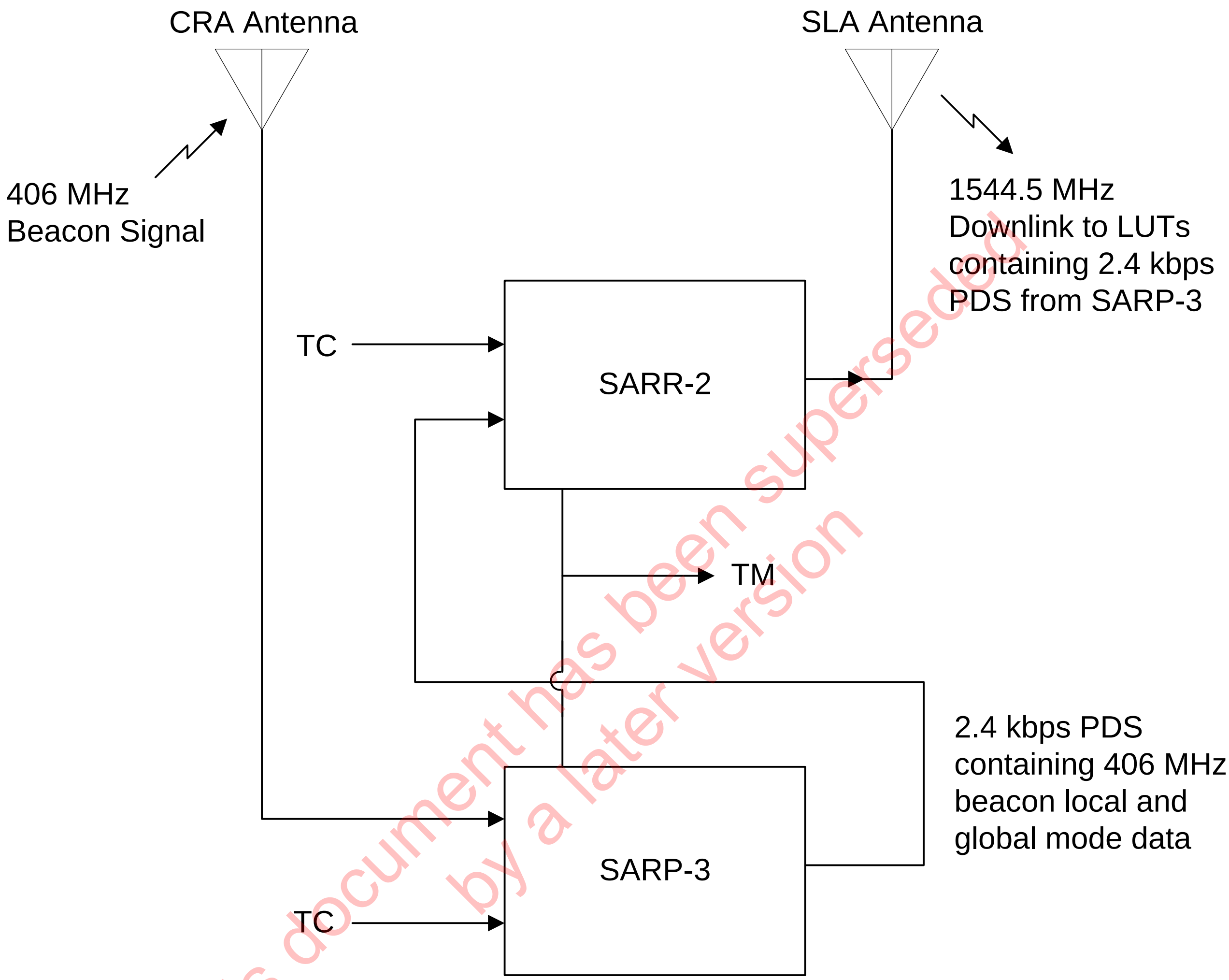
Figure: 2.2b Sarsat-METOP Payload and Spacecraft Interface Functional Diagram with SARR-1 and SARP-3



Legend

SLA - SARR L-Band transmit antenna
CRA - Combined receive antenna
TC - Telecommand from spacecraft
TM - Telemetry to spacecraft

Figure 2.2c Sarsat-SIDAR Payload and Spacecraft InterfaceFunctional Diagram with SARR-2 and SARP-3



Legend

SLA	-	SARR L-Band transmit antenna
CRA	-	Combined receive antenna
TC	-	Telecommand from spacecraft
TM	-	Telemetry to spacecraft

2.3 Interoperability Parameters

2.3.1 Orbit Parameters

Basic orbital parameters for Cospas and Sarsat satellites are listed in Table 2.1. Each satellite is in a different orbital plane.

Table 2.1: Cospas and Sarsat Satellites Orbital Parameters

Parameters	Unit	Cospas on Meteor-M	Sarsat on TIROS	Sarsat on METOP	Sarsat on SIDAR
Orbit Type	N/A	Circular, Sun-Synchronous, Near-Polar	Circular, Sun-Synchronous	Circular, Sun-Synchronous	Circular, Sun-Synchronous
Altitude	km	832 (mean value)	833 to 870	800 to 850	816 to 850 TBC by USA
Inclination	Deg	98.85	98.7 to 98.86	98.7	98.65 to 98.75 TBC by USA
Period	min	101.41	101.35 to 102.12	100 to 101.7	101 to 101.7 TBD by USA
Eccentricity	N/A	0.00124	<0.001	0.001165	<0.001 TBD by USA

2.3.2 Input Parameters

Table 2.2 lists the functions that are provided by each type of satellite and identifies where they are described within this document.

Table 2.2: Functions Provided by Cospas and Sarsat Satellites

Functions	Cospas	Sarsat
406 MHz Repeater	Section 3.1	Section 3.2 (SARR-1) Section 3.3 (SARR-2)
406 MHz Processor	Section 4.1	Section 4.2

Table 2.3 lists input parameters for individual functions provided by the satellites.

Table 2.3: Cospas and Sarsat Input Parameters

Parameters	**Unit**	**Cospas**	**Sarsat**
406 MHz Repeater:			
Centre Frequency	MHz	406.05	406.05 (4)
1 dB Bandwidth	kHz	80.0	80.0 (4)
Receiver Noise Temperature	K	600	350 (4)
S/C Antenna Polarisation	N/A	RHCP	RHCP (4)
Nominal Background Noise	K	N/A	1000 (4)
406 MHz SARP Processor:			
Centre Frequency	MHz	See Note 1	See Notes 2 and 3
1 dB Bandwidth	kHz	See Note 1	See Notes 2 and 3
Receiver Noise Temperature	K	600	300
Input Signal from Beacon			
a. Power Flux Density:	dBW/m^2		
(Nominal orbit) Maximum:		-121.4	-120.0
Nominal:		-142.4	-141.0
b. Polarisation:	N/A	Linear/RHCP	Linear/RHCP
S/C Antenna Polarisation	N/A	RHCP	
Nominal Background Noise	K	1000	

Note 1: SARP-2 allows selection of three different centre frequencies and bandwidths, as listed in Table 4.1.

Note 2: SARP-2 allows selection of three different centre frequencies and bandwidths, as listed in Tables 4.2 and 4.3.

Note 3: SARP-3 has a fixed bandwidth of 80 kHz centered at 406.050 MHz.

Note 4: SARR-1 only.

2.3.3 Output Parameters

Table 2.4 provides downlink signal parameters for each type of satellite. The modulation index given in the table for each channel is the Root-Mean-Square (RMS) value of the carrier phase deviation due to that channel. The composite modulation index (RMS) is equal to the square root of the sum of the squares of the individual channel modulation indices. The RMS values are related to other common methods of measurement as follows.

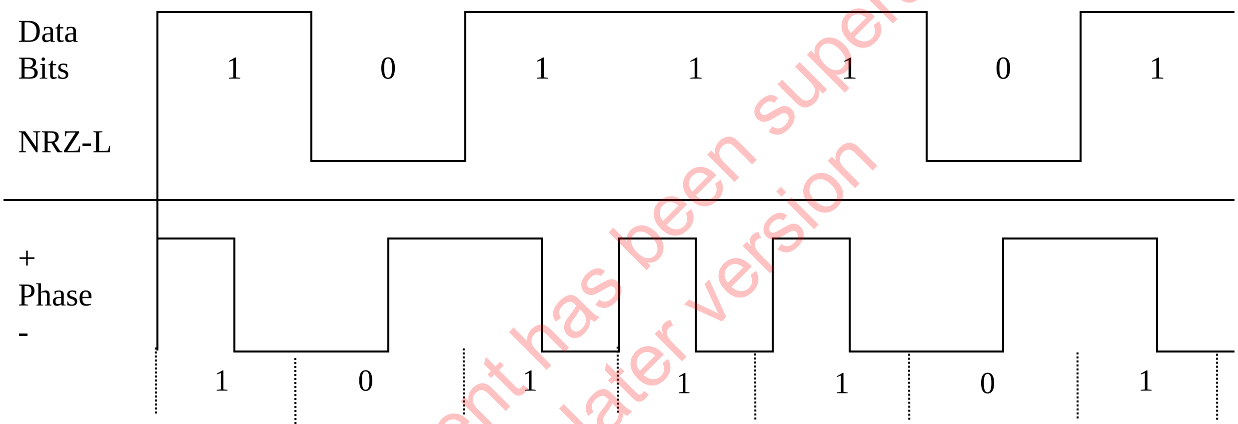
a. For the Processed Data Stream (PDS) digital channel, the full excursion of the phase deviation, also called the peak-to-peak value, is two times the RMS value. The peak value equals the RMS value (i.e. signal is basically a square wave).

b. For an analogue channel, when a single unmodulated carrier is present at a level sufficient to suppress the noise, the peak value of the deviation is approximately 1.414 times the RMS value (i.e. signal is basically a sine wave).

2.3.4 Biphase-L Data Encoding

A biphase-L data encoding scheme is used in the downlink for the processed 406 MHz data from processors. It is shown in Figure 2.3.

Figure 2.3: Processed Data Encoding Scheme



Notes:

Biphase-L is defined as a transition occurring at the centre of every bit period.

Symbol "1" is transmitted as:
"+ phase": the first part of the bit
"- phase": the second part of the bit; and

Symbol "0" is transmitted as:
"- phase": the first part of the bit
"+ phase": the second part of the bit

Table 2.4: Cospas and Sarsat Output Parameters

Parameter	Unit	Cospas	Sarsat SARR-1	Sarsat SARR-2
Transmitted Signal				
Centre Frequency	MHz	1544.5		
Nominal Power Output of Transmitter	W	4.0	7.2	4.0 EOL min
Phase Jitter (in 50 Hz Bandwidth)	° (RMS)	≤ 10		
Occupied Bandwidth [1] (including Doppler)	kHz	≤ 800		
Modulation Type		Linear Phase Modulation		
Nominal Composite Mod. Index	rad (RMS)	0.69 to 0.87	0.70 ± 10%	0.347 to 0.476
406.05 MHz Repeater Channel Baseband				
Centre Frequency	kHz	75.0	170.0	N/A
Frequency Translation	N/A	Uninverted	Uninverted	N/A
Nominal Modulation Index	rad (RMS)	0.63 to 0.75	0.58 ± 10 %	N/A
1 dB Bandwidth	kHz	80	80	N/A
PDS Channel				
Bit Rate	bps	2400 ± 0.1%	2400±0.5%	
Nominal Modulation Index	rad (RMS)	0.28 to 0.44	0.39 ± 10%	0.347 to 0.476
Data Encoding (see Figure 2.3)	N/A	Biphase-L		
Doppler Measurement Accuracy [2]	Hz (RMS)	≤ 0.35		
Time Tagging Accuracy [3]	ms	< 10		
Frequency Measurement Period	ms	200	120	
Prob. of Good Signal Processing	N/A	> 0.99		

Note 1: The occupied bandwidth, defined by ITU Radio Regulation no. S1.153, remains within the 1,000 kHz allocated by the ITU in normal operating conditions.

Note 2: Both payloads are accurate and stable such that the value of the received frequency at the spacecraft can be determined to the indicated accuracy from the data received by the LUT and from equations provided in section 4.

Note 3: The Cospas satellites have an on-board clock providing absolute time which is maintained to the required accuracy. The SARP-2 and SARP-3 instruments on Sarsat satellites do not use an onboard absolute time clock. The absolute time tagging may be calculated by the ground stations using the on-board relative time scale and the time calibration (TCAL) routinely provided by the FMCC.

- END OF SECTION 2 -

3. COSPAS-SARSAT REPEATERS

3.1 Cospas Repeater

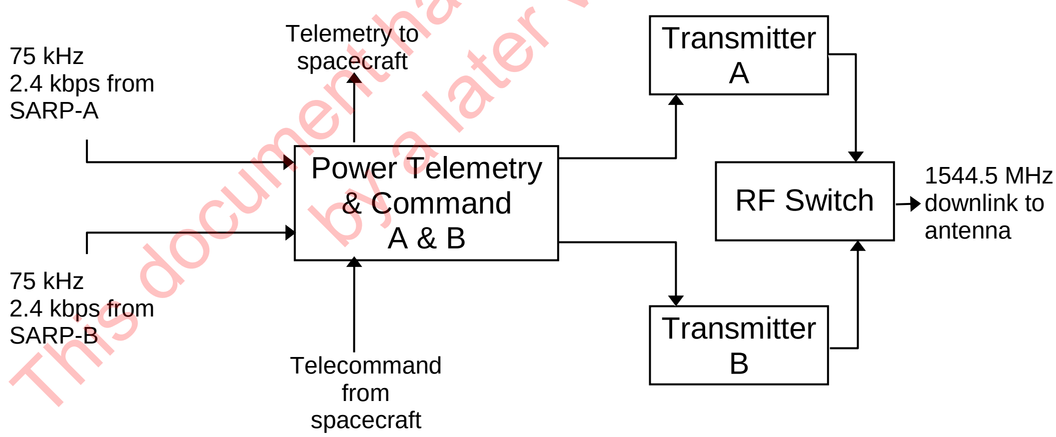
As shown in Figure 3.1, the Cospas SARR is redundantly configured and consists of the following units:

a. two 4.0 W phase modulated L-band transmitters; and

b. two Power, Telemetry and Command (PTC) units.

Redundant units (A side and B side) are selected by commands from the ground which are processed by the PTC. The PTC also generates necessary voltages for the repeater system and contains interfaces to the spacecraft for all repeater telemetry and command channels.

Figure 3.1: Cospas Repeater Functional Diagram



A functional diagram of the Cospas transmitter is given in Figure 3.2. It employs a temperature controlled crystal oscillator. The linear modulator operates at a frequency of 386.125 MHz. After modulation, the output frequency is multiplied by 4 and the final amplification takes place on the 1544.5 MHz frequency.

Before entering the linear phase modulator, modulation signals are amplified by a wideband linear amplifier. There is a two-level limiter in this amplifier, which prevents the instantaneous value of the summed modulating signal to exceed a certain level.

The modulation index adjustment is achieved by means of change of signal modulating voltage, which is subsequently passed to the input of the wideband linear amplifier.

The Cospas 1544.5 MHz transmitter parameters given in Table 3.1 are in addition to those given in section 2. The downlink signal observed on the ground is illustrated in Figure 3.3.

Table 3.1: Cospas 1544.5 MHz Transmitter Parameters

Parameters	**Unit**	**Values**
Downlink Baseband Spectrum	N/A	Figure 3.3
Incidental AM	%	≤ 5
Spurious Output Level	dBW	≤ -60
Frequency Stability Long term (5 yr.): Medium term (15 min.): Short term (0.1 sec.):	 kHz N/A N/A	 ± 1.5 5×10^{-8} 5×10^{-10}
Maximum Modulation Index Level: PDS: Composite:	 rad. (peak) rad. (peak)	 0.92 (max. setting) 2.80 (hard limiter)
Amplitude Ripple	dB	≤ 2.5

Figure 3.2: Cospas 1544.5 MHz Transmitter Functional Diagram

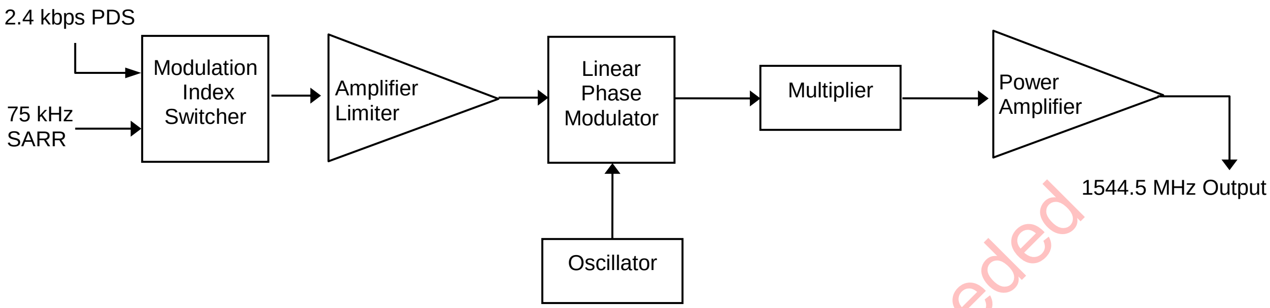
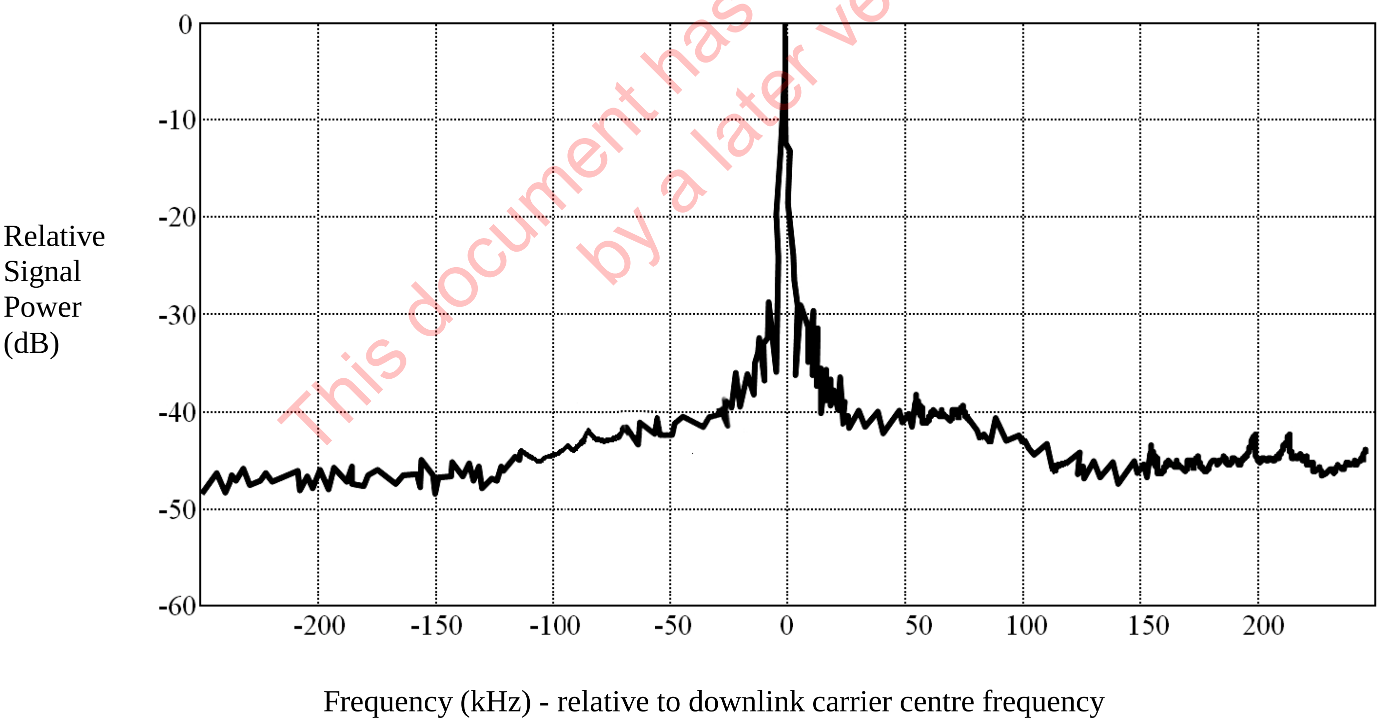


Figure 3.3: Typical Cospas 1544.5 MHz Observed Downlink Signal



3.2 Sarsat Repeater SARR-1 (Sarsat-13 and earlier)

As shown in Figure 3.4, the Sarsat SARR is redundantly configured and consists of the following units:

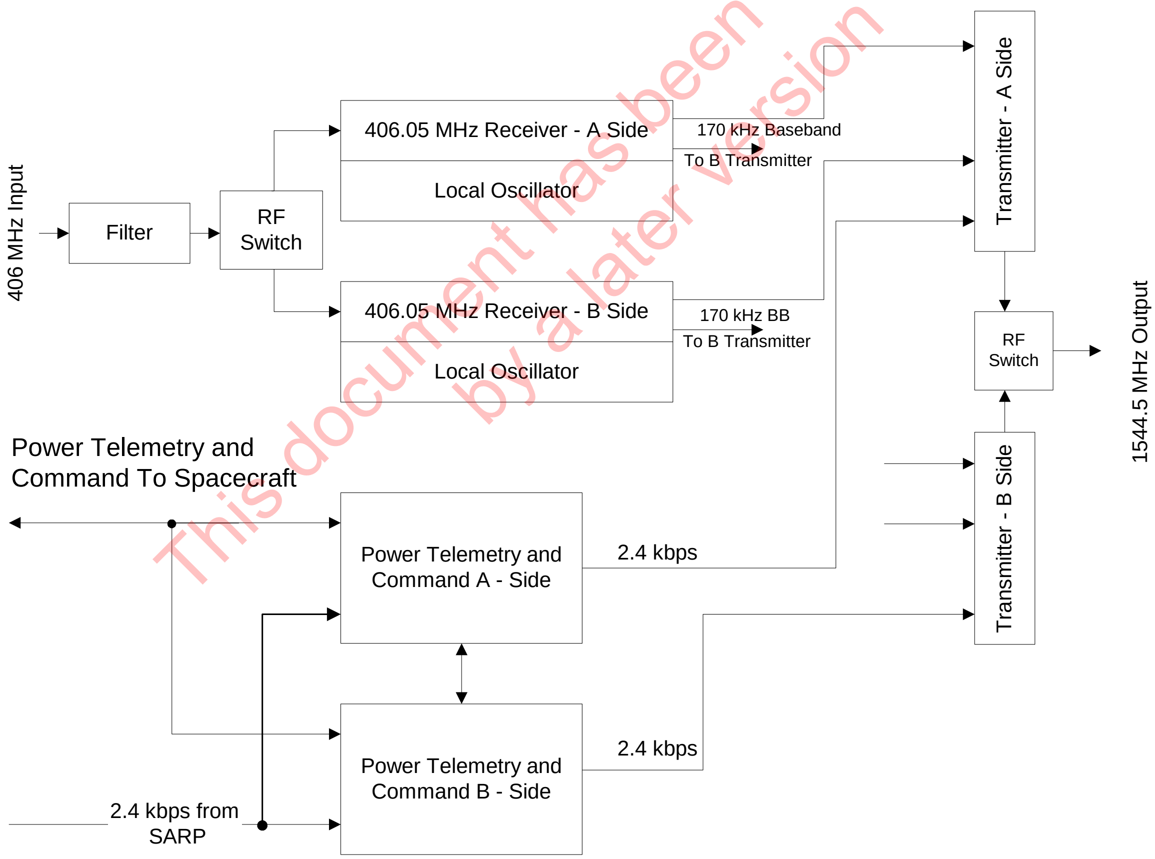
a. two dual-conversion 406.05 MHz receivers (Sarsat-1,-2,-3 and -4 have only one 406.05 MHz receiver mounted on the A side);

b. two 7.2 W phase modulated L-band transmitters; and

c. two Power, Telemetry and Command units.

Redundant units (A side and B side) are selected by commands from the ground which are processed by the PTC. The PTC also generates necessary voltages for the repeater system and contains interfaces to the spacecraft for all repeater telemetry and command channels.

Figure 3.4: Sarsat SARR-1 Functional Diagram



3.2.1 Sarsat SARR-1 Receivers

As shown in Figure 3.5, the 406 MHz receiver contains AGC and provides two outputs to drive the two transmitters. The Sarsat SARR receiver parameters given in Table 3.2 are in addition to those given in section 2.

Table 3.2: Sarsat SARR Receiver Parameters

Parameters	Unit	Values for 406.05 MHz Receiver
Nominal Input Level[1]	dBW	-143
Maximum Input Level	dBW	-50
Dynamic Range	dBW	-164.3 to -137.2
Linearity	N/A	Note 2
Group Delay Slope	µs/kHz	13
Image Rejection	dB	120
AGC Time Constant	ms	10 - 85
AGC Dynamic Range[3]	dB	> 50
Transient Recovery Time	ms	< 2
Frequency Stability Long term (2 yr.): Medium term (15 min.): Short term (1 sec.):	 N/A N/A N/A	 1×10^{-6} 1×10^{-10} 1×10^{-10}

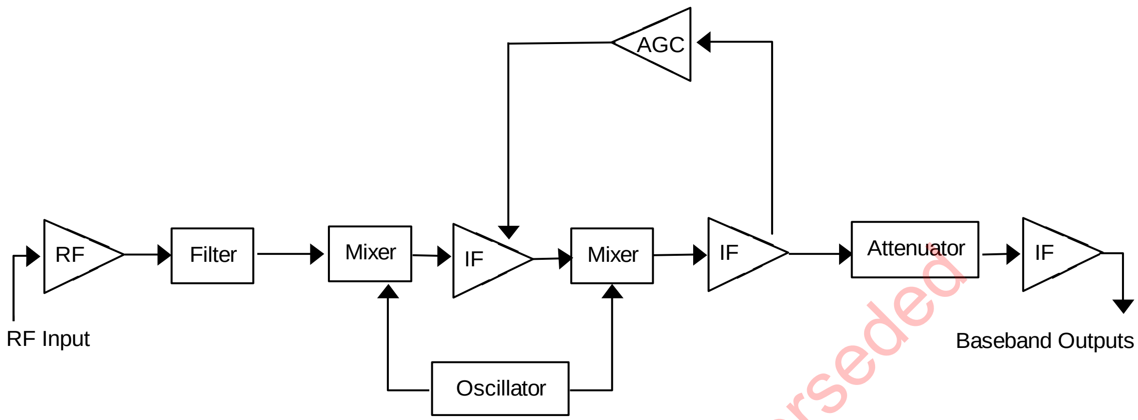
Note 1: Nominal input level for 406 MHz is defined as the nominal noise of 1000 K plus ten simultaneous signals, each of -147.6 dBW.

Note 2: With receivers in AGC mode and with nominal level settings, two out-of-band (for bandwidths in Figure 3.8) signals of -92 dBW at the receiver input, or two inband signals of -110 dBW, do not produce intermodulation products within the same baseband exceeding an output level of -170 dBW with respect to the receiver input.

Note 3: The peak modulation index limit of each repeater band is set such that any single inband signal of up to -110 dBW will not cause the composite modulation index limit to be reached before the AGC reduces the receiver output level back to nominal.

.

Figure 3.5: Sarsat SARR Receiver Functional Diagram



Medium term frequency stability (over a 15 minute period) for the receiver is given as:

Nominal Temperature:

Mean Slope: $\leq 1 \times 10^{-10}$/minute

Residual Noise: $\leq 3 \times 10^{-10}$

Full Temperature Range:

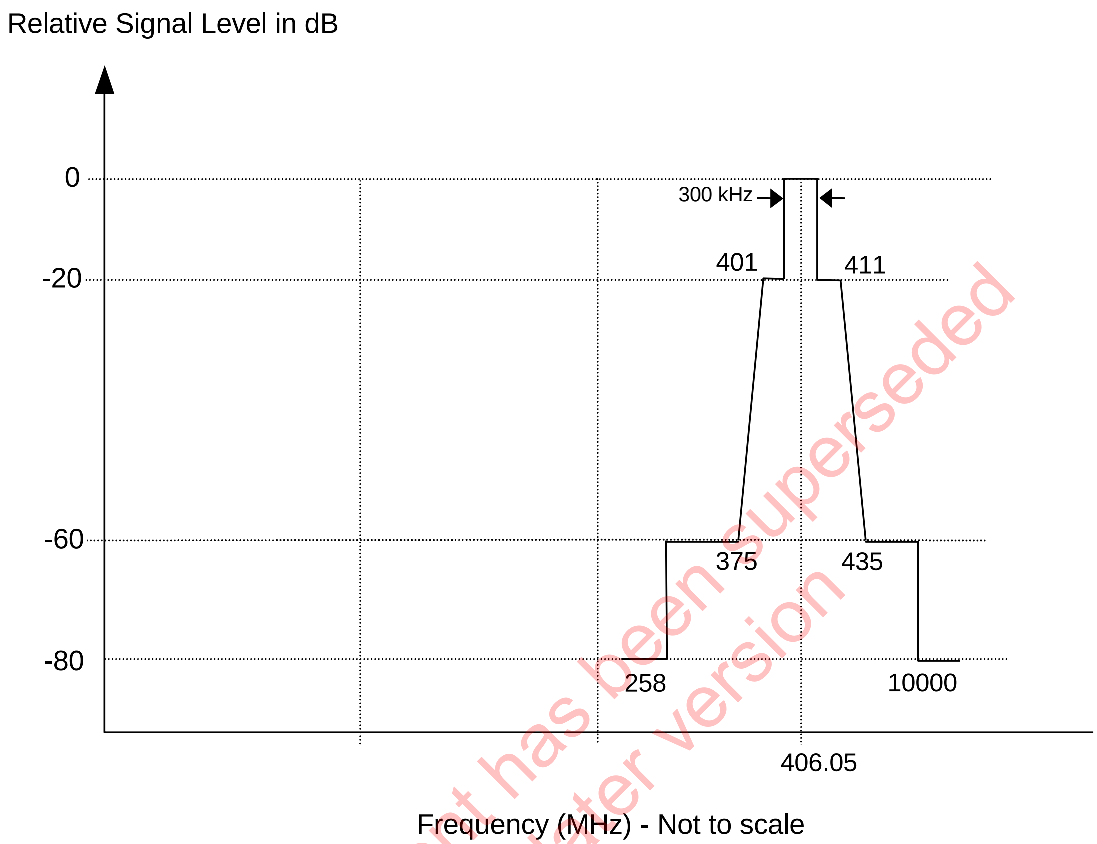
Mean Slope: $\leq 1 \times 10^{-9}$/minute

Residual Noise: $\leq 3 \times 10^{-9}$

The baseband filtering characteristic for the 406 MHz channel is given in Figure 3.6. Signals at frequencies indicated are attenuated by the corresponding amount with respect to the 0 dB level. Within this band, the receiver provides gain for those frequencies which fall within the band as specified in Table 2.4.

Inband interfering signals in the band do not induce unwanted signals in the band exceeding -175 dBW referred to the input and do not cause the modulation index to exceed the maximum level.

Figure 3.6: Sarsat SARR Receiver Bandpass Characteristics



3.2.2 Sarsat SARR-1 1544.5 MHz Transmitter

As shown in Figure 3.7, each one of the transmitters has four inputs; one for each of the two 406 MHz receivers, one for the PDS channel and one spare.

Sarsat transmitter parameters given in Table 3.3 below are in addition to parameters given in section 2. The downlink baseband frequency spectrum and an example of the signal observed on the ground are given in Figures 3.8 and 3.9.

When the receiver input is illuminated by a sinusoidal signal at the maximum frequency and level, and by the processed data stream, no single discrete sideband is produced which exceed the limits shown in Figure 3.10. Noise-like emissions do not exceed the levels specified in Figure 3.10.

With a receiver in AGC mode and nominal level setting, spurious output in the demodulated downlink spectrum do not exceed -175 dB with respect to a receiver input.

Table 3.3: Sarsat SARR-1 1544.5 MHz Transmitter Parameters

Parameters	Unit	Values
Downlink Baseband Spectrum	N/A	Figures 3.8 and 3.9
Incidental AM	%	≤5
Spurious Output Level	dBW	Figure 3.10
Frequency Stability Long term (2 yr.): Medium term (15 min.): Short term (1 sec.):	 kHz N/A N/A	 ± 3.2 $\leq 1 \times 10^{-10}$ $\leq 1 \times 10^{-10}$
Maximum Modulation Index Level: 406.05: PDS: Composite:	 rad. (peak) rad. (peak) rad. (peak)	 1.30 (hard limiter) 0.39 (max. setting) 2.10 (hard limiter)
Amplitude Ripple	dB	≤ 2.5

Figure 3.7: Sarsat SARR-1 1544.5 MHz Transmitter Functional Diagram

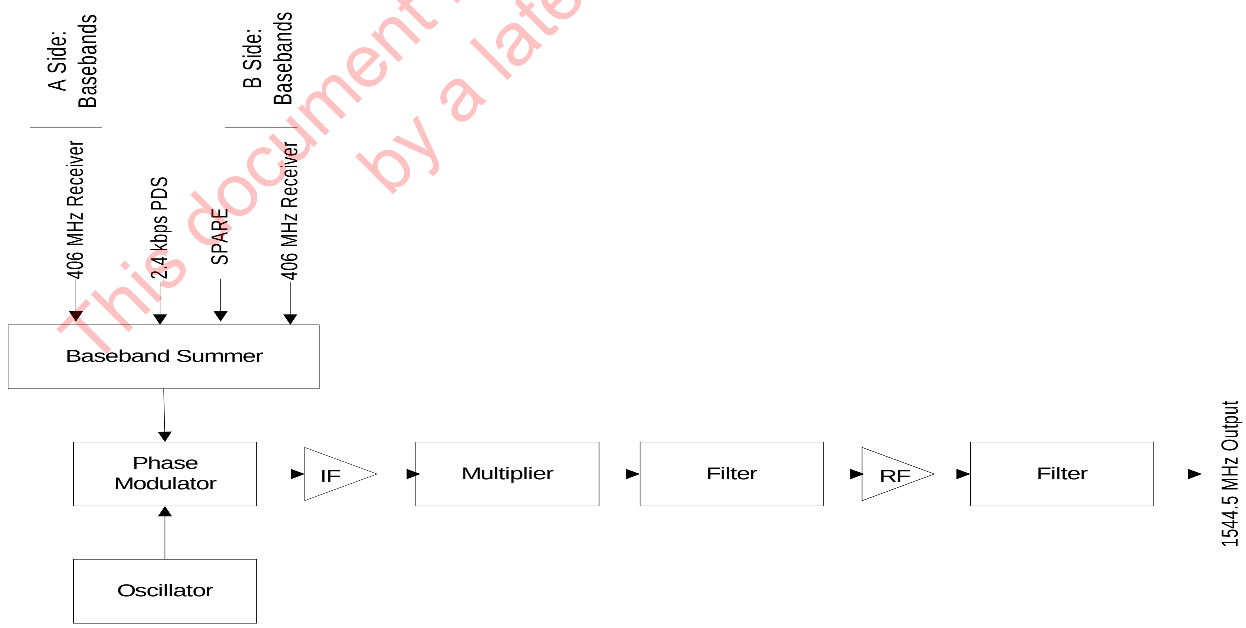
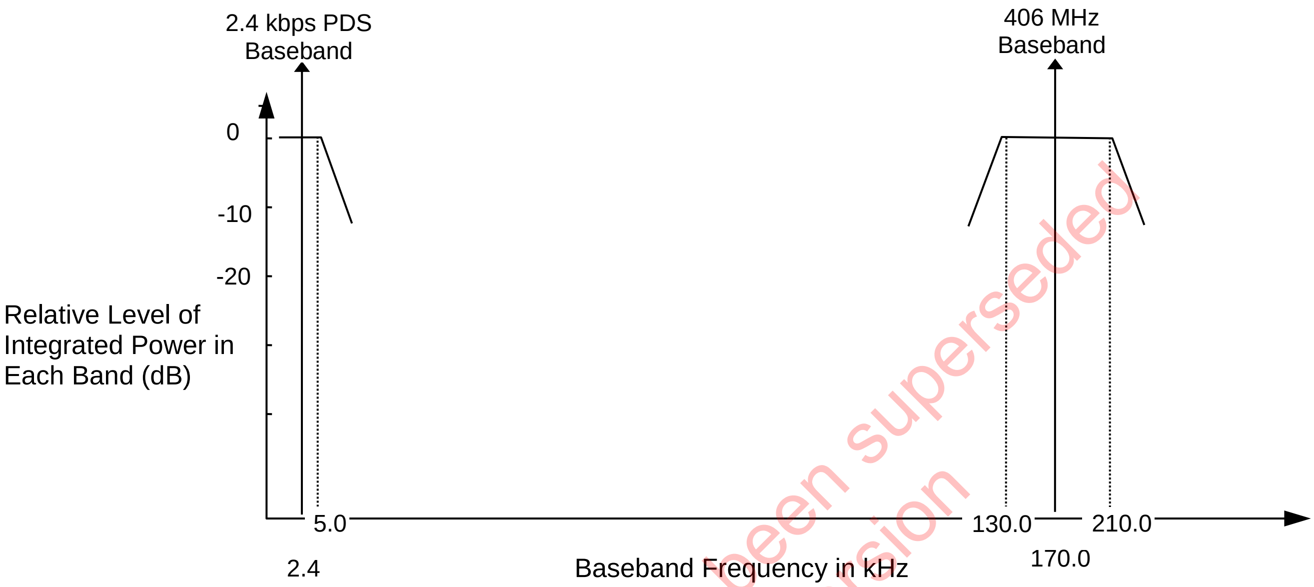


Figure 3.8: Sarsat SARR-1 Baseband Frequency Spectrum



Note: Drawing not to scale and bandwidths given are 1 dB bandwidths

Figure 3.9: Typical Sarsat SARR-1 1544.5 MHz Observed Downlink Signal

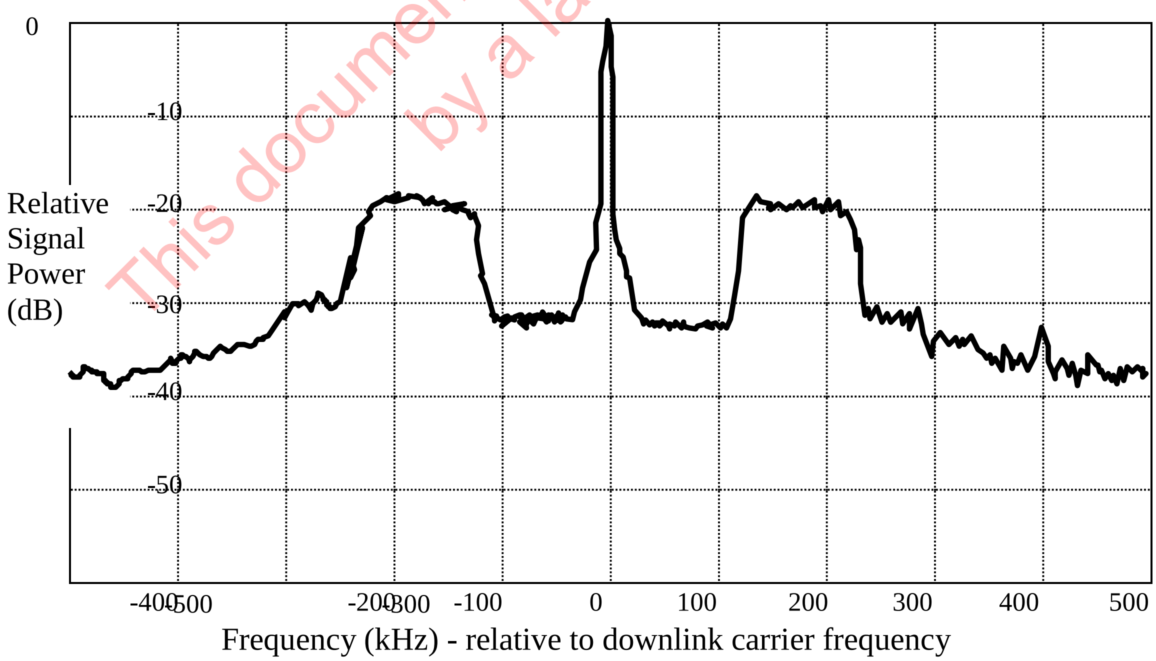
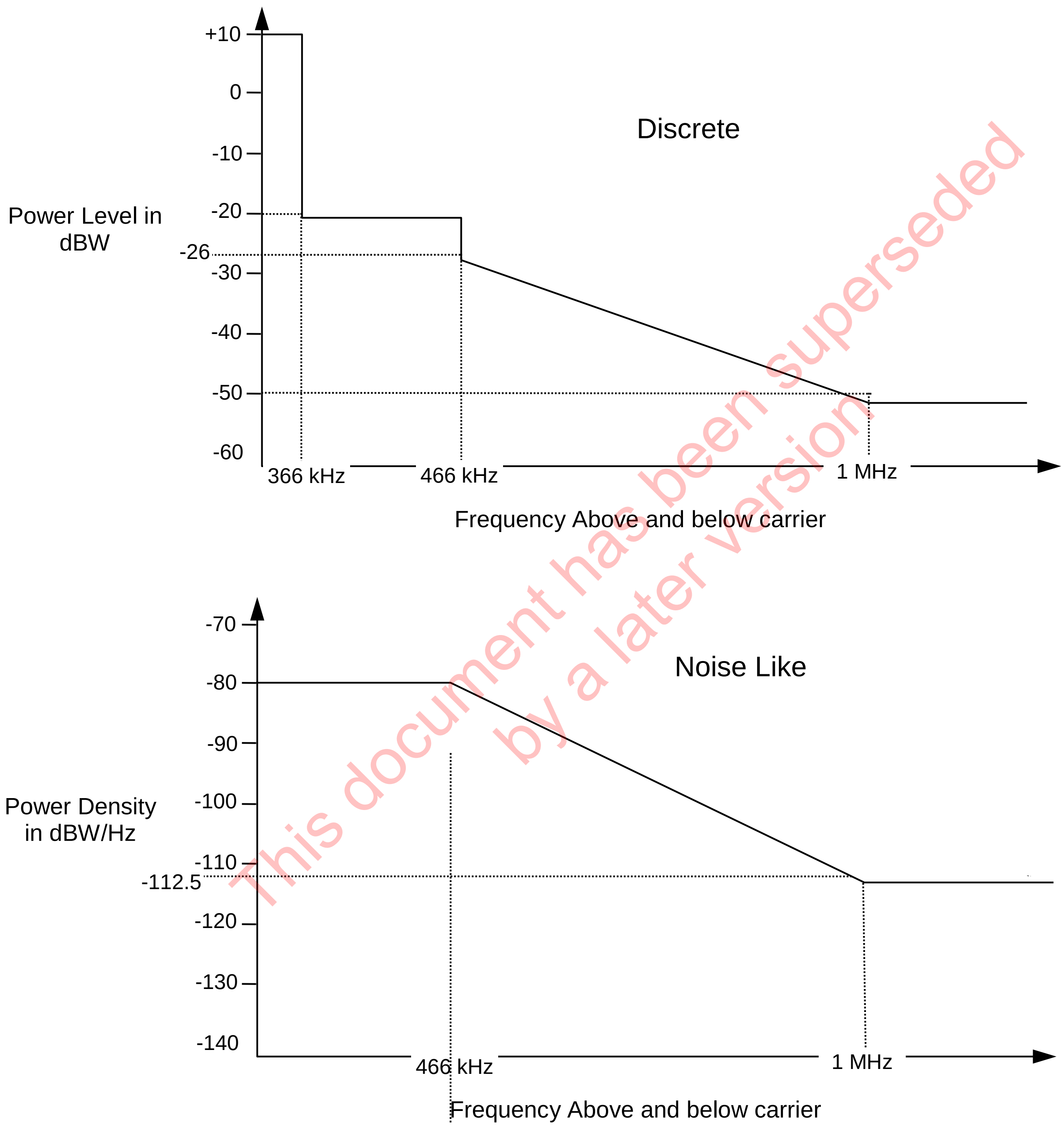


Figure 3.10: Sarsat SARR Transmitter Spurious Emission Limits



3.3 Sarsat Repeater SARR-2 (Sarsat-14 and after)

As shown in Figure 3.11, the Sarsat SARR-2 consists of the following modules:

a. one Power, Telemetry and Command (PT&C) module;

b. one Frequency Generator module;

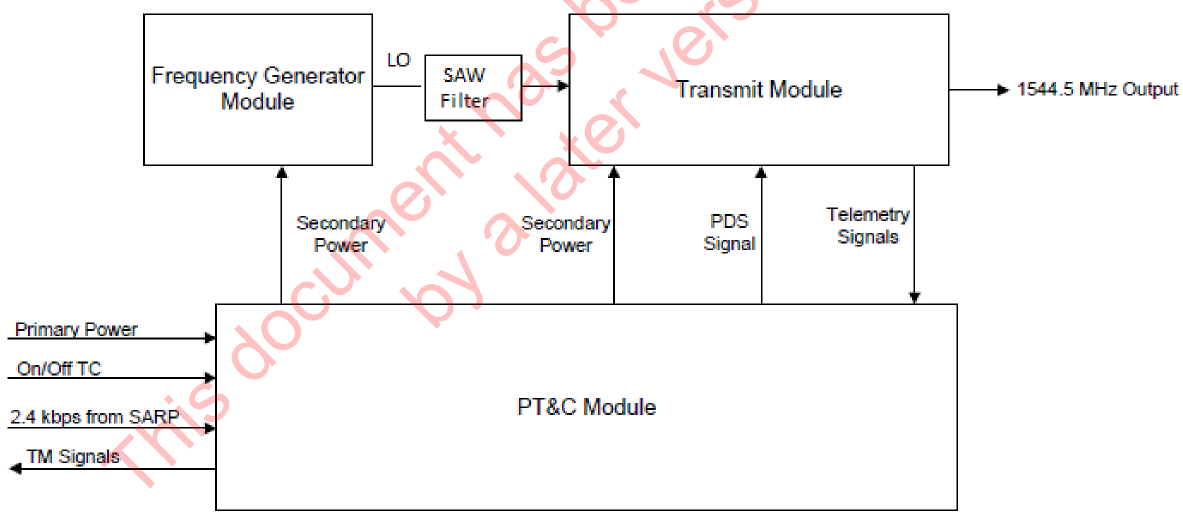
c. one SAW filter; and

d. one phase modulated L-band transmitter module.

3.3.1 SARR-2 Power, Telemetry and Command

The PT&C generates necessary voltages for the repeater system and contains the interfaces to the spacecraft for the repeater telemetry and command channels.

Figure 3.11: Sarsat SARR-2 Functional Diagram



3.3.2 SARR-2 Frequency Generator

In SARR-2, a portion of the transmitter has been separated into a module of its own. The module consists of a stable 10MHz reference and synthesizer to generate the L-Band (1544.5 MHz) carrier. This L-Band LO is then supplied to the phase modulator in the Transmit module where the baseband signal is modulated onto the carrier. The Sarsat

SARR-2 transmitter functional diagram is presented in Figure 3.12 and includes the functionality in the frequency generator module.

3.3.3 SARR-2 SAW FILTER

The SAW filter is placed between the frequency generator and the transmitter modules on the LO/Carrier signal path. The SAW filter is a band-pass filter used to reduce the out of band spurious and noise emission levels from the frequency generator module.

3.3.4 Sarsat SARR-2 1544.5 MHz Transmitter

The Sarsat SARR-2 transmitter Functional Diagram is presented in Figure 3.12. The transmitter module has two inputs; one for the PDS channel and one for the L-Band LO input from the SAW filter.

Sarsat SARR-2 transmitter parameters given in Table 3.4 below are in addition to parameters given in section 2. The downlink baseband frequency spectrum and an example of the signal observed on the ground are given in Figures 3.13 and 3.14.

When the processed data stream is present, no single discrete sideband is produced which exceeds the limits shown in Figure 3.10. Noise-like emissions do not exceed the levels specified in Figure 3.10, excluding the near/in-band frequency range of 1544.5 ± 10 kHz, and the range Fc ± 10 kHz to Fc ± 100 kHz. Noise-like emissions do not exceed -60dBW/Hz for the range Fc ± 10k Hz to Fc ± 100 kHz.

Table 3.4: Sarsat SARR-2 1544.5 MHz Transmitter Parameters

Parameters	Unit	Values
Downlink Baseband Spectrum	N/A	Figures 3.13 and 3.14
Incidental AM	%	≤5
Spurious Output Level	dBW	Figure 3.10 with exceptions for noise- like emissions stated above
Frequency Stability Long term (7 yr.): Medium term (15 min.): Short term (1 sec.):	 kHz N/A N/A	 ± 3.2 $\leq 1 \times 10^{-10}$ $\leq 1 \times 10^{-10}$
Maximum Modulation Index Level:	rad. (peak)	0.7 (hard limiter)
Amplitude Ripple	dB (peak to peak)	≤ 2.5

Figure 3.12: Sarsat SARR-2 1544.5 MHz Transmitter Functional Diagram

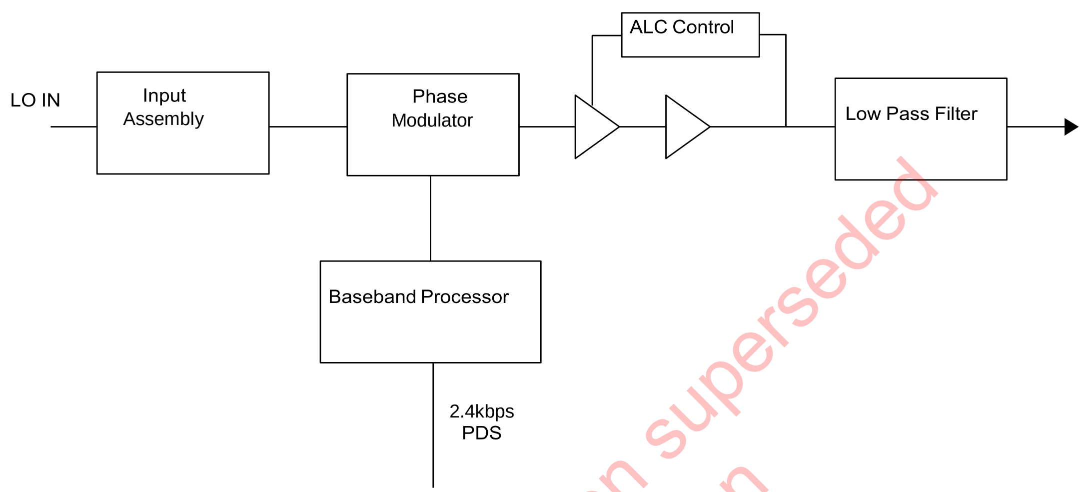
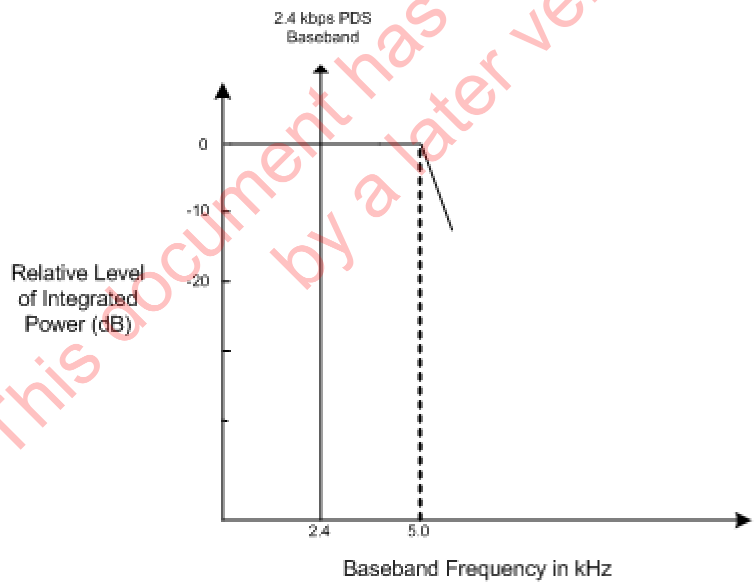
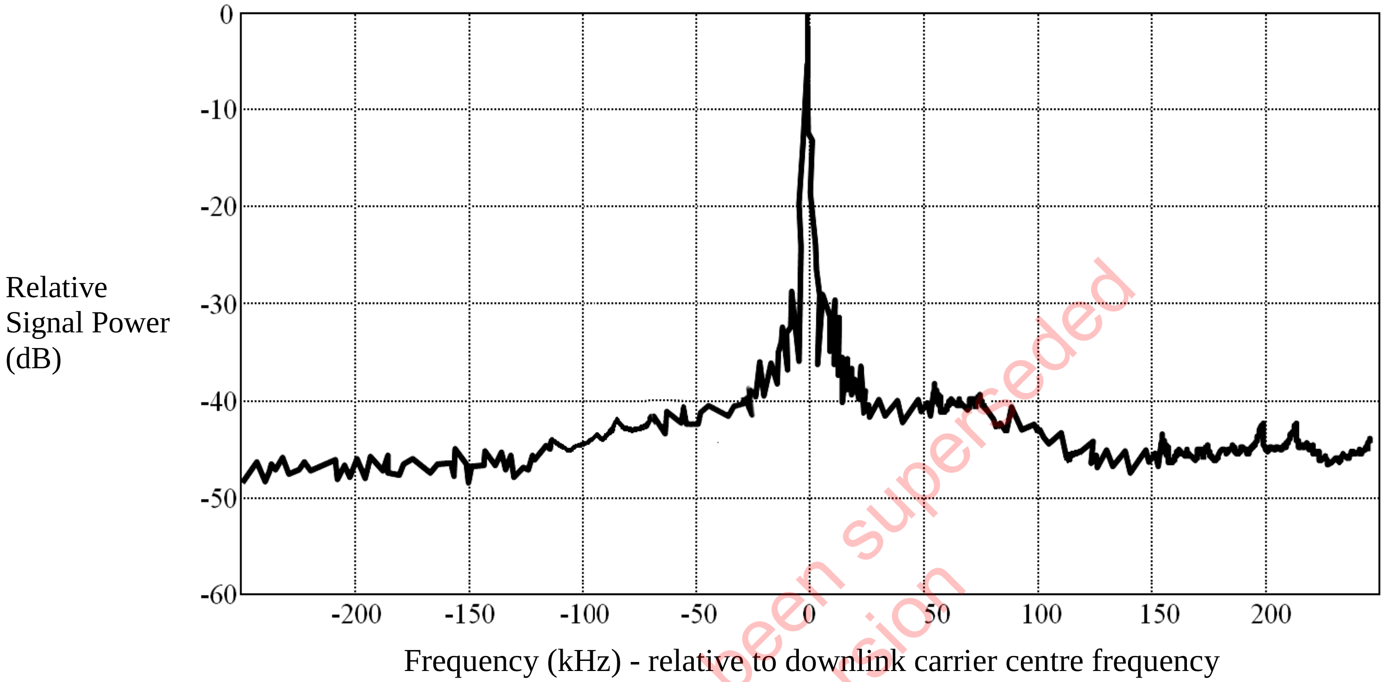


Figure: 3.13: Sarsat SARR-2 Baseband Frequency Spectrum



Note: Drawing not to scale and bandwidths given are 1 dB bandwidths

Figure 3.14: Typical Sarsat SARR-2 1544.5 MHz Observed Downlink Signal



- END OF SECTION 3 -

4. COSPAS-SARSAT SARPs

4.1 Cospas SARP

The Cospas SARP is composed of a Receiver Processor, a Frame Formatter (FF) and a memory unit. Each Cospas SARP is redundantly configured.

The following satellites contain the indicated SARPs which are described in this document:

Cospas-13: SARP-2 Cospas-14: SARP-2

Cospas satellites C-1 to C-10 have been decommissioned from service. Cospas satellites C-11 and C-12 were not commissioned due to technical problems.

The SARP-2 has improved performance in system capacity, bandwidth and protection against interferers. Both long and short messages are supported by this processor.

Cospas SARP-2 parameters given in Table 4.1 are in addition to those given in section 2.

4.1.1 Cospas SARP-2 Receiver Processor

A functional diagram of the Receiver Processor is shown in Figure 4.1.

The Receiver Processor unit is composed of the following:

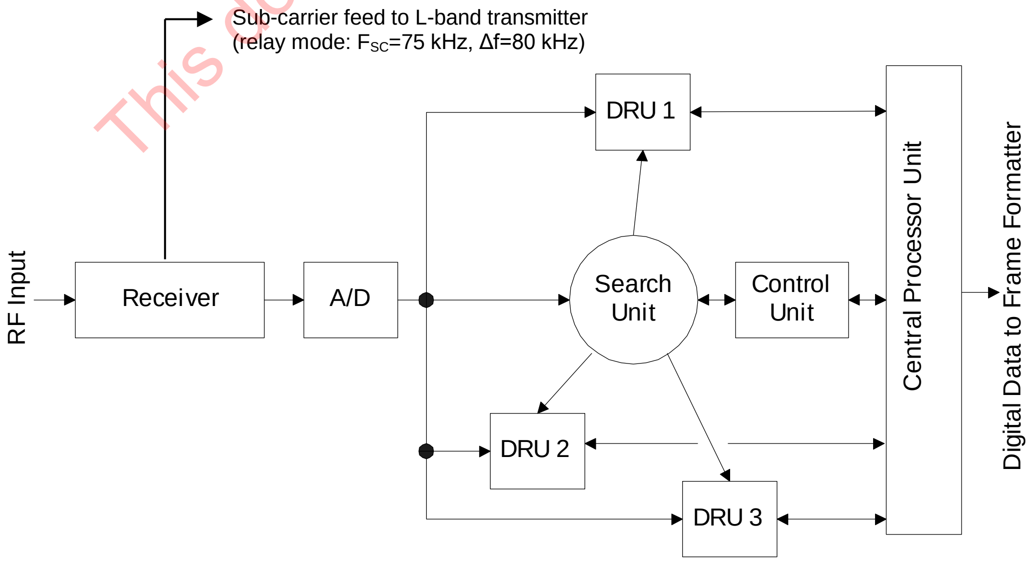
a. one dual-conversion receiver;
b. one Analog to Digital (A/D) converter;
c. one Search Unit;
d. three Data Recovery Units (DRUs);
e. one Control Unit;
f. one Central Processor Unit; and
g. Power, Telemetry and Command circuits.

Table 4.1: Cospas SARP-2 Parameters

Parameters		Unit	Values
Receiver Centre Frequency - (selectable)	Mode 1 Mode 2 Mode 3	MHz	406.0235 406.0300 406.0500
Receiver Bandwidth (1 dB) - (selectable)	Mode 1 Mode 2 Mode 3	kHz	27 40 80
Receiver Dynamic Range		dBW	-161 to -138
Frequency Stability Long-term (5 yr.): Short-term (0.1 sec.):		 kHz N/A	 ± 1.5 1×10^{-10}
Frequency of sub-carrier (406 MHz signals relay mode)		kHz	75.0
Bit Error Rate[1]		N/A	$< 1 \times 10^{-5}$
Output Data Rate		bps	2,400
Time Measurement Increment		ms	16
Ambiguity of Time Tagging		Hrs	24
Number of DRUs		N/A	3
Memory Capacity		messages bits	2,000 460,800
Message Types Supported		N/A	Short and long

Note 1: BER applies for signal level of -161 dBW and Receiver Noise Temperature of 600 K.

Figure 4.1: Cospas SARP-2 Receiver Processor Functional Diagram



The analog output of the receiver is converted into a digital form by the analog to digital converter. The search unit performs spectrum analysis to determine frequency and amplitude. The spectrum analyser on commands from the ground, can analyze one of the three bands.

When a signal is detected, the central processor assigns that signal to a DRU. On commands from the central processor, the DRU performs signal acquisition and demodulation, and determines the Doppler frequency of the received signal.

In addition to controlling the functioning of the DRUs, the central processor also:

- assigns DRUs to beacon signals;
- checks the performance of the DRUs;
- performs self-testing; and
- sets the DRUs, on external command, to a special interference monitoring (pseudo-message) mode.

This SARP-2 uses a new algorithm to protect the instrument against interferers. It is designed to avoid a continuous assignment of DRUs to interferer signals, thus making them available to process beacon signals.

To locate an interferer which has a stable frequency, the Control Unit can enable, on command from the ground, all 3 DRUs to generate "pseudo-messages" (i.e. messages which do not have valid identification data, but do have valid time / frequency points), which can be specially processed by LUTs to locate interferers. Because all 3 DRUs are in this special mode at the same time, the reception of beacon signals is not guaranteed during this period."

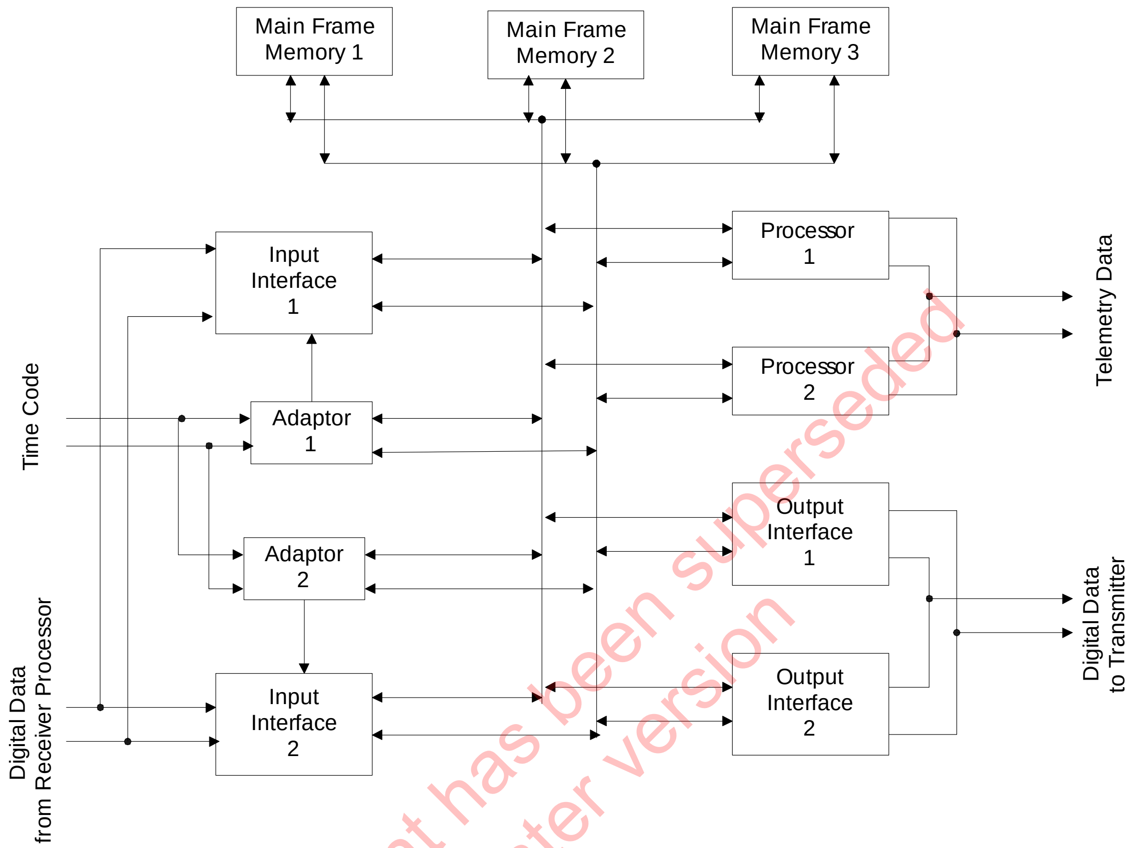
The control unit performs the following functions:

- performance monitoring of the analogue receiver;
- check out of the analogue receiver performance as well as that of the spectrum analyser; and
- self checking.

4.1.2 Cospas SARP-2 Frame Formatter

A functional diagram of the Frame Formatter (FF) is shown in Figure 4.2. The FF accepts all messages received from the DRUs and recorded messages are passed continuously to the modulator of the transmitter.

Figure 4.2: Cospas SARP-2 Frame Formatter Functional Diagram



4.1.3 Cospas SARP-2 Output Format

Beacon messages from the Cospas SARP-2 are transmitted in blocks of 25 words, as shown in the example of Figure 4.3.

Prime format rules are:

a. Zero words '000001'(Hex) are inserted at the end of each short message as necessary;

b. Word # 00 = always frame sync '42BB1F'(Hex);

c. DRU words are sequential and not interleaved; and

d. Long and short beacon messages can be mixed.

Bit formats for each type of message are shown in Figures 4.4 and 4.5. Words contain the following information:

Word 0: Sync word 'D60' (Hex) followed by 6 bits as described in the figures and then 6 bits of level and parity. The 5 bit received level is given by:

$$\text{Level (dBW)} = -161+L$$

where L is the 5-bit level in decimal form.

Word 1: The Doppler count is followed by its parity bit. The Doppler frequency is given by:

$$F_d\,(\text{Hz}) = 62{,}500\frac{N}{2^{22}} - 35{,}000$$

where N is the Doppler count in decimal form.

The frequency at the input of the satellite receiver, Fin, is given by:

$$\text{Fin (Hz)} = \text{Fd} + 406{,}010{,}000$$

Word 2: The time code followed by its parity bit. It is quantized in steps of 16 ms, synchronised with the beginning of the Doppler count and given as:

Hours (5 bits): Minutes (6 bits) : seconds(6 bits): 16 ms (6 bits)
The time given is 2hr 59min and 59 sec ahead of UTC
(i.e. UTC = Cospas time - 2:59:59)

Words 3 to 5: 72 bits of the beacon message.

Word 6a: Last 16 bits of beacon short message followed by 8 zeros.
Word 6b: 24 bits of beacon long message.

Word 7a: Zero word '000001' (Hex) for short message.
Word 7b: Last 24 bits of beacon long message.

Figure 4.3: Example of a Cospas SARP-2 Output Message

Word	Word Content (Hex)	
00	42BB1F	
01	D60…	Short Message
02	……	
03	……	
04	……	
05	……	
06	……	
07	……	
08	000001	
09	D60…	Long Message
10	……	
11	……	
12	……	
13	……	
14	……	
15	……	
16	……	
17	D60…	Long Message
18	……	
19	……	
20	……	
21	……	
22	……	
23	……	
24	……	
00	42BB1F	

Figure 4.4: Cospas SARP-2 Short Message Bit Format

Word #	MSB Word Content(24 bits) LSB
0	Sync word (12 bits); pseudo (1b) Notes: (1); DRU (2b) (2); latest (1b) (3); RT/PB (1b) (4); Parity (1b) (5); level (5b); Parity (1b) (5)
1	Doppler count (23 bits); Parity (1 bit) (note 7)
2	Time code (23 bits): hours (5 bits) : minutes (6 bits) : seconds (6 bits) : 16 ms (6 bits); Parity (1 bit) (note 7)
3	Format flag (1 bit)(note 6); Beacon data (23 bits)
4	Beacon data (24 bits)
5	Beacon data (24 bits)
6a	Beacon data (16 bits); 8 0's
7a	'zero word' (24 bits) = 000001 (hex)

Figure 4.5: Cospas SARP-2 Long Message Bit Format

Word #	MSB Word Content(24 bits) LSB
0	Sync word (12 bits) Notes: · pseudo (1b) (1) · DRU (2b) (2) · latest (1b) (3) · RT/PB (1b) (4) · Parity (1b) (5) · level (5b) · Parity (1b) (5)
1	Doppler count (23 bits) · Parity (1 bit) (note 7)
2	Time code (23 bits): hours (5 bits) : minutes (6 bits) : seconds (6 bits) : 16 ms (6 bits) · Parity (1 bit) (note 7)
3	Format flag (1 bit)(note 6) · Beacon data (23 bits)
4	Beacon data (24 bits)
5	Beacon data (24 bits)
6b	Beacon data (24 bits)
7b	Beacon data (24 bits)

Notes:
(1) "0" = beacon message.
(2) "01" = DRU1; "10" = DRU2; "11" = DRU3.
(3) "1" = most recent message(playback); "0" = others.
(4) "1" = real time message; "0" = playback message.
(5) Parity bit on previous five bits: "1" = odd number of "1".
(6) Format flag: "1" = long message; "0" = short message.
(7) Parity bit in words 1 and 2:'1' with odd number of '1s' in the 23 bits of the Doppler count or the Time code.

4.2 Sarsat SARP

The following satellites contain the indicated SARPs which are described in this document:

Sarsat-7: SARP-2
Sarsat-8: SARP-2
Sarsat-9: SARP-2
Sarsat-10: SARP-2
Sarsat-11: SARP-3
Sarsat-12: SARP-3
Sarsat-13: SARP-3
Sarsat-14: SARP-3
Sarsat-15: SARP-3

The SARP instruments on Sarsat satellites Sarsat-1 to Sarsat-6 have been decommissioned from service.

4.2.1 Sarsat SARP-2

The functional diagram of the SARP-2 Processor is shown in Figure 4.6.

SARP-2 parameters given in Table 4.2 are in addition to those given in section 2.

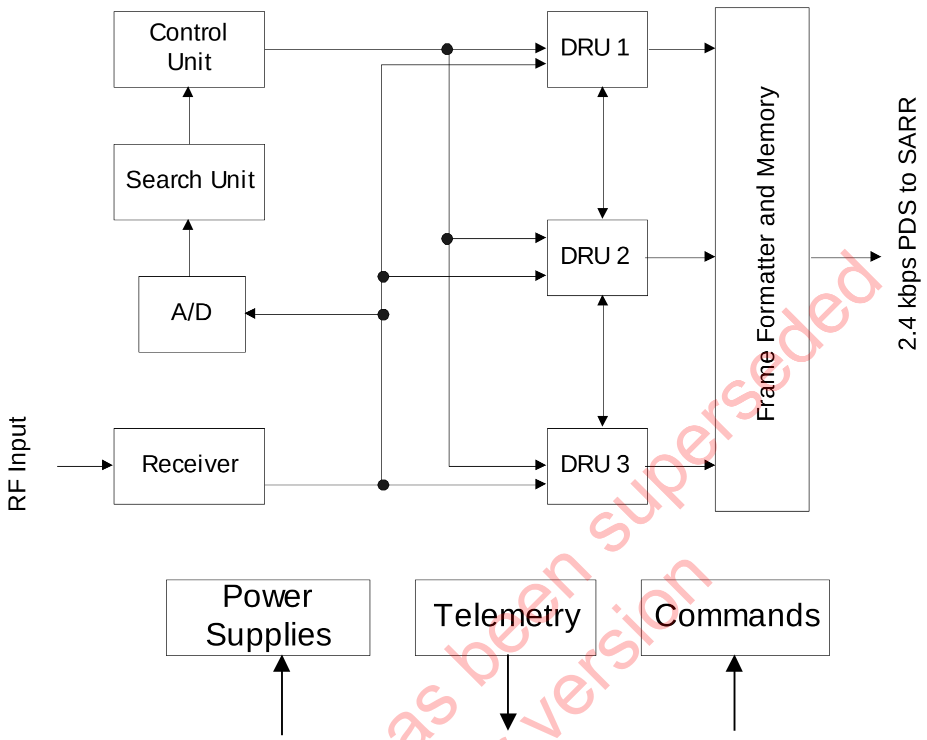
Table 4.2: Sarsat SARP-2 Parameters

Parameters		Unit	Values
Receiver Centre Frequency - (selectable)	Mode 1 Mode 2 Mode 3	MHz	406.0235 406.0300 406.0500
Receiver Bandwidth (1 dB) - (selectable)	Mode 1 Mode 2 Mode 3	kHz	27 40 80
Receiver Dynamic Range		dBW	-161 to -138
Bit Error Rate[1]		N/A	$< 1 \times 10^{-5}$
Output Data Rate		bps	2409
Time Measurement Increment		ms	19.1 approx.
Ambiguity of Time Tagging		Hrs	44.5 approx.
Signal Level Measurement Accuracy[2]		dBm	+/- 2.0
Signal Level Measurement Quantization		dBm	0.5
Number of DRUs		N/A	3
Memory Capacity (short or long messages)		messages bits	2048 400k approx.
Message Types Supported		N/A	Short and long

Note 1: BER applies for signal level of -161 dBW and Receiver Noise Temperature of 300 K.

Note 2: 1 to 2% of all signal level measurements provide erroneous information (i.e. the minimum allowable value is provided rather than the actual value).

Figure 4.6: Sarsat SARP-2 Functional Diagram



4.2.1.1 Sarsat SARP-2 Receiver Processor

The SARP-2 instrument has improved performance in system capacity, bandwidth and protection against interferers.

Logic circuits using the Fast Fourier Transform algorithm perform signal searching by making a spectrum analysis of the receiver output (determination of frequency and level).

The receiver is a temperature-compensated, constant-gain receiver.

This processor uses a new algorithm to protect the instrument against interferers. It is designed to avoid a continuous assignment of DRUs to interferer signals, thus making them available to process beacon signals. To locate an interferer which has a stable frequency, the Control Unit can enable, on command from the ground, any one of the DRUs (but only at a time) to generate "pseudo-messages", (i.e. messages which do not have valid identification data, but do have valid time/frequency points), which can be specially processed by LUTs to locate interferers. The average time between pseudo-messages generated is at least 10 seconds. While the one DRU is in this special mode, the other two DRUs continue to process beacon signals as normal.

It has three DRUs to improve reliability and capacity of the system. Each DRU comprises a phaselock loop with new circuits that are mostly digital, a bit synchroniser using a new digital design and a formatter. The capacity of the memory has been increased to approximately 400 kbits allowing the storage of up to 2048 messages (long or short or pseudo-messages) for global area coverage.

This instrument's mass memory operates similarly to the SARP-1 memory. The same five commands have the same effects.

The capacity of the memory has been increased to approximately 400 kbits to take into account the storage of pseudo-messages when the instrument is used to locate interferers. To simplify the hardware associated with the reading of the messages, all messages, short or long, are stored in the same number of addresses. A short message is followed by a zero word to occupy the same memory space as a long message.

4.2.1.2 Sarsat SARP-2 Output Format

Beacon messages from the Sarsat SARP-2 are transmitted in blocks of 25 words as shown in the example of Figure 4.7.

Prime format rules are:

a. Zero words '000001'(Hex) are inserted at the end of each short message as necessary;

b. Word # 00 = always frame sync '42BB1F'(Hex); and

c. If read continuous mode is active and if the oldest playback message has just been transmitted, a block of eight zero words will precede resumption of playback which will start with the first word of the most recently stored message.

The bit format for both length of message formats are shown in Figures 4.8 and 4.9, where the Most Significant Bit (MSB) of Word 0 is transmitted first. All words contain the following information:

Word 0: Sync word 'D60' (Hex) followed by 6 bits described in the figure and then the signal level. The received level is given by

$$\text{Level (dBm)} = 0.564L - 140$$

where L is the 6-bit level converted to decimal form

Word 1: The time code is quantized in steps of 's' ms and synchronised with the beginning of the Doppler count. The last bit is a parity bit. The quantization is given by:

$$s = \frac{99\,360}{F_r} = \frac{99\,360}{5\,203\,205\ \text{Hz}} \approx 19.096\ \text{ms}$$

where F_r is frequency of oscillator (approx 5 203 205 Hz)

The UTC time T is given by: $T = T_o + 2^{23}ks + s(M_d + 1)$

where $s \approx 19.096$ ms (the resolution time of the counter);

M_d = decimal value of the 23-bit on-board time code;

T_o = UTC of an arbitrarily chosen reset to zero of the counter; and

k = Number of resets to zero of the counter between time T_o and time T. The value of k is computed in ground processing, for each message, with a coarse estimate T_e of T as the integer part of:

$$\frac{(T_e - T_o)}{2^{23}s} \pm 1$$

The coarse estimate T_e can be obtained either by processing a time calibration beacon message from stored data or from the real time when processing local mode data. The time calibration beacon is described in C/S T.006.

Words 2 to 4: 72 bits of the beacon message.

Word 5a: Last 15 bits of beacon short message data followed by 9 zeros.

Word 5b: 24 bits of beacon long message data.

Word 6a and 7b: 23-bit Doppler word with parity. The frequency at the input of the satellite receiver, F_{in}, is given by:

$$F_{in} = F_r ((aN) + b) \text{ Hz}$$

where $a = \frac{1}{2^{19} \times 624} \approx 3.05664845002 \times 10^{-9}$;

$b = 78 + \frac{1}{2^{26}} + \frac{16}{624} + \frac{15.5}{2^{24} \text{ x } 624} \approx 78.02564104137$;

$F_r \approx 5\,203\,205$ Hz; and

N = Doppler count in decimal form.

Word 6b: Last 23 bits of beacon long message data followed by one zero.

Word 7a: Zero word "000001 (Hex)".

For pseudo-messages, the 13th bit of Word 0 is set. Pseudo-messages are short messages, having the bit format shown in Figure 4.8, but the beacon data is replaced by:

Words 2, 3 and 4: 0000 1111 0000 1111 0000 1111

Word 5: 0000 1111 0000 1110 0000 0000

Note: F_r is the frequency of the SARP Ultra Stable Oscillator. LEOLUTs should use a recent estimate of the USO frequency, as provided in a recent SARP calibration message (SIT 415) or as calculated by the LEOLUT, for determining the time and frequency of the beacon burst.

T_o is the UTC of an arbitrarily chosen time of reset to zero of the SARP time counter. For calculating the time of a beacon burst, LEOLUTs should use a recent To value as provided in a recent SIT 415 message or as calculated by the LEOLUT.

Figure 4.7: Example of a Sarsat SARP-2 Output Message

Word	Word Content (Hex)	
00	42BB1F	
01	D60…	
02	……	
03	……	Long
04	……	Message
05	……	
06	……	
07	……	
08	……	
09	D60…	
10	……	
11	……	
12	……	
13	……	Short
14	……	Message
15	……	
16	000001	
17	D60…	
18	……	
19	……	
20	……	
21	……	Long
22	……	Message
23	……	
24	……	
00	42BB1F	
01	D60…	
02	……	

Figure 4.8: Sarsat SARP-2 Short Message Bit Format

Word #	MSB		Word Content(24 bits)				LSB
0	Sync word (12 bits) Notes:	pseudo (1b) (1)	DRU (2b) (2)	Format (1b) (3)	latest (1b) (4)	RT/PB (1b) (5)	level (6b)
1	Time code (23 bits)			Parity (1 bit) (note 6)			
2	Beacon data (24 bits)						
3	Beacon data (24 bits)						
4	Beacon data (24 bits)						
5a	Beacon data (15 bits)			9 0's			
6a	Doppler word (23 bits)			Parity (1 bit) (note 6)			
7a	"zero word" (24 bits) = 000001 (hex)						

Figure 4.9: Sarsat SARP-2 Long Message Bit Format

Word #	MSB		Word Content(24 bits)				LSB
0	Sync word (12 bits) Notes:	pseudo (1b) (1)	DRU (2b) (2)	Format (1b) (3)	latest (1b) (4)	RT/PB (1b) (5)	level (6b)
1	Time code (23 bits)			Parity (1 bit) (note 6)			
2	Beacon data (24 bits)						
3	Beacon data (24 bits)						
4	Beacon data (24 bits)						
5b	Beacon data (24 bits)						
6b	Beacon data (23 bits)			zero bit (1 bit)			
7b	Doppler word (23 bits)			Parity (1 bit) (note 6)			

Notes :

(1) "1" = pseudo-message; "0" = beacon message.

(2) "01" = DRU1; "10" = DRU2; "11" = DRU3.

(3) "1" = long message; "0" = short message.

(4) "1" = most recent message(playback); "0" = others.

(5) "1" = real time message; "0" = playback message.

(6) Parity: "1" = odd number of "1s" in the 23-bit time code or the 23-bit Doppler code.

4.2.2 Sarsat SARP-3

The functional diagram of the SARP 3 Processor is shown in Figure 4.10.

SARP-3 parameters given in Table 4.3 are in addition to those given in section 2.

Table 4.3: Sarsat SARP-3 Parameters

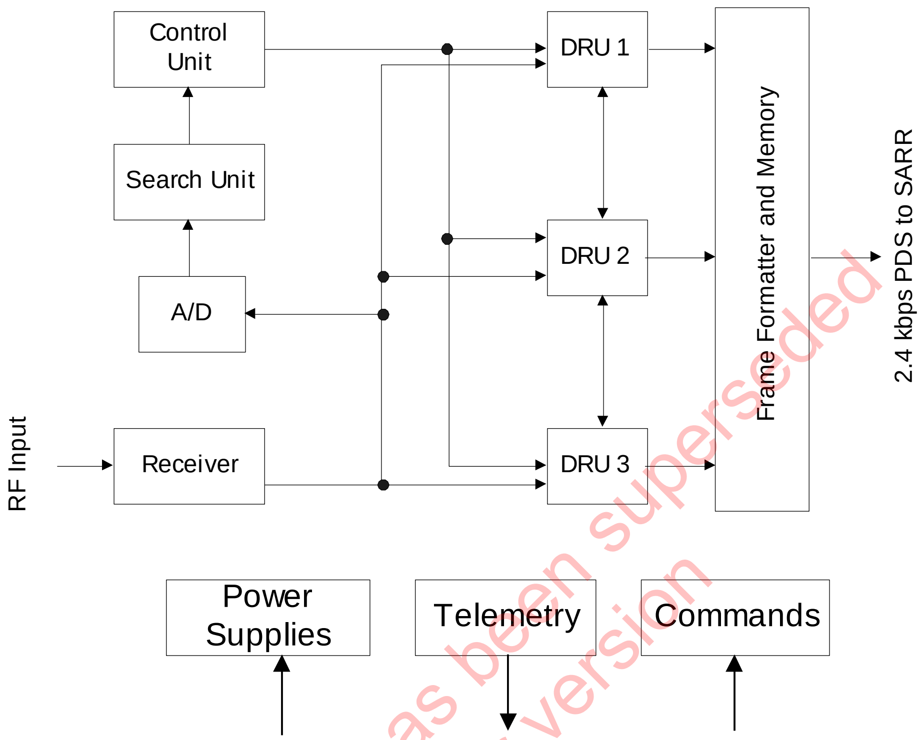
Parameters	Unit	Values
Receiver Centre Frequency	MHz	406.0500
Receiver Bandwidth (1 dB)	kHz	80
Receiver Dynamic Range	dBW	-164 to -138
Bit Error Rate (See Note 1)	N/A	$< 1 \times 10^{-5}$
Output Data Rate	bps	2399.8
Time Measurement Increment	ms	20 approx.
Ambiguity of Time Tagging	Hrs	44.5 approx.
Signal Level Measurement Accuracy	dBm	TBD
Signal Level Measurement Quantization	dBm	TBD
Number of DRUs	N/A	3
Memory Capacity (short or long messages)	messages bits	2048 (See Note 2) 400k approx.
Message Types Supported	N/A	Short and long

Notes: 1. BER applies for signal level of -164 dBW and Receiver Noise Temperature of 300 K.

2. The SARP-3 has a mode which increases the memory to 2,560 messages. This mode can only be activated on command by the payload provider.

SARP-3 processors will include a capability to process a new type of Cospas-Sarsat distress beacon that would enhance performance by providing a better link budget. Such beacons are not yet available for operational use, however, technical details on their modulation characteristics may be obtained from the Cospas-Sarsat Secretariat.

Figure 4.10: Sarsat SARP-3 Functional Diagram



4.2.2.1 Sarsat SARP-3 Receiver Processor

The SARP-3 instrument has similar performance to the SARP-2 instrument. The basic structure of the format of the data it provides mimics the format provided by the SARP-2, however, there are a few minor changes in the position of some of the bits.

The digital processing employed by the SARP-3 enable it to provide the S/No of beacon messages that it processes. Also, on command from the satellite operator, the instrument can be commanded to transmit House-Keeping (HK) messages in the 2.4 kbps PDS data stream. These messages are transmitted for reception by the French ground segment and should be ignored by all other LEOLUTs. HK messages are identified by the following:

a. Word 2 = 110 011 100 011 111 000 000 000; and

b. the BCH code provided in words 4 and 5 is consistent with the data in words 2, 3,4 and 5 that it protects.

The Sarsat SARP-3 HK message structure is provided at Figure 4.14.

4.2.2.2 Sarsat SARP-3 Output Format

Beacon messages from the Sarsat SARP-3 are transmitted in blocks of 25 words as shown in the example of Figure 4.11.

Prime format rules are:

a. Zero words 'H000001'(Hex) are inserted at the end of each short message as necessary;

b. Word # 00 = always frame sync '42BB1F'(Hex);

c. If read continuous mode is active and if the oldest playback message has just been transmitted, a block of eight zero words will precede resumption of playback which will start with the first word of the most recently stored message; and

d. If no message must be transmitted (at the beginning when no message has been received or when the read continuous mode is inactive), blocks of eight zero words H000001 are transmitted.

Real time messages are transmitted approximately 15 seconds after their reception by the SARP.

The bit format for both length of message formats are shown in Figures 4.12 and 4.18, where the Most Significant Bit (MSB) of Word 0 is transmitted first. All words contains the following information:

Word 0: Sync word 'HD60' (Hex) followed by 6 bits described in the figure and then the signal level. The received level, Pe, is given by

$$Pe\ (dBm) = -140 + LEVEL * 0.55$$

where LEVEL is a value between 0 and 63 defined by final six bits in Word 0.

Word 1: The time code is quantized in steps of 's' ms and synchronised with the beginning of the Doppler count. The last bit is a parity bit. The quantization, which is assigned the variable value s in the equations below, is defined by:

$$s = \frac{200{,}000}{F_r} = \frac{200{,}000}{10^7\ Hz} \approx 20\ ms$$

where F_r is the exact frequency of oscillator (the nominal frequency of the oscillator is approx 10 MHz)

The UTC time T is given by: $T = T_o + 2^{23}ks + s(M_d + 1)$

Where M_d = decimal value of the 23-bit on-board time code;

T_o = UTC of an arbitrarily chosen reset to zero of the counter; and

k = Number of resets to zero of the counter between time T_o and time T. The value of k is computed in ground processing, for each message, with a coarse estimate T_e of T as the integer part of:

$$\frac{(T_e - T_o)}{2^{23} s} \pm 1$$

The coarse estimate T_e can be obtained either by processing a time calibration beacon message from stored data or from the real time when processing local mode data. The time calibration beacon is described in C/S T.006.

Words 2 to 4: Message format followed by 71 bits of the beacon message.

Word 5a: Last 16 bits of beacon short message data followed by 8 zeros.

Word 5b: 24 bits of beacon long message data.

Words 6a and 7b: 23-bit Doppler word with parity. The frequency at the input of the satellite receiver, F_{in}, is given by:

$$Fin = \left(\frac{8121}{200} * Fo + Doppler * 0.015\right) * \frac{Fr}{Fo} \text{ Hz}$$

where the nominal USO frequency, Fo = 10^7 Hz

Fr = exact frequency of the USO (if available)

Doppler = signed integer value between -2^{22} and $+2^{22}$-1 defined by 23 bits with two's complement.

Word 6b: Last 24 bits of beacon long message data.

Word 7a: Zero word "H000001 (Hex)".

Note: F_r is the frequency of the SARP Ultra Stable Oscillator. LEOLUTs should use a recent estimate of the USO frequency, as provided in a recent SARP calibration message (SIT 415) or as calculated by the LEOLUT, for determining the time and frequency of the beacon burst.

T_o is the UTC of an arbitrarily chosen time of reset to zero of the SARP time counter. For calculating the time of a beacon burst, LEOLUTs should use a recent To value as provided in a recent SIT 415 message or as calculated by the LEOLUT.

Figure 4.11: Example of a Sarsat SARP-3 Output Message

Word	Word Content (Hex)	
00	42BB1F	
01	HD60…	Long Message
02	……	
03	……	
04	……	
05	……	
06	……	
07	……	
08	……	
09	HD60…	Short Message
10	……	
11	……	
12	……	
13	……	
14	……	
15	……	
16	H000001	
17	HD60…	Long Message
18	……	
19	……	
20	……	
21	……	
22	……	
23	……	
24	……	
00	H42BB1F	
01	HD60…	
02	……	
	.	
	.	
	.	

Figure 4.12: Sarsat SARP-3 Short Message Bit Format

Word #	MSB Word Content(24 bits) LSB					
0	Sync word (12 bits) Notes:	S/No (3b) (1)	Type (1b) (2)	latest (1b) (3)	RT/PB (1b) (4)	level (6b)
1	Time code (23 bits)				Parity (1 bit) (note 5)	
2	Format (1b) (note 6)				Beacon data (23 bits)	
3	Beacon data (24 bits)					
4	Beacon data (24 bits)					
5a	Beacon data (16 bits)				8 0's	
6a	Doppler word (23 bits)				Parity (1 bit) (note 5)	
7a	"zero word" (24 bits) = H000001 (hex)					

Figure 4.13: Sarsat SARP-3 Long Message Bit Format

Word #	MSB Word Content(24 bits) LSB					
0	Sync word (12 bits) Notes:	S/No (3b) (1)	Type (1b) (2)	latest (1b) (3)	RT/PB (1b) (4)	level (6b)
1	Time code (23 bits)				Parity (1 bit) (note 5)	
2	Format (1b) (note 6)				Beacon data (23 bits)	
3	Beacon data (24 bits)					
4	Beacon data (24 bits)					
5b	Beacon data (24 bits)					
6b	Beacon data (24 bits)					
7b	Doppler word (23 bits)				Parity (1 bit) (note 5)	

Notes :

(1) S/No in 8 steps as defined in the following table:

code	S/No	code	S/No
000	32.3 (31 ≤ S/No < 33.7)	100	45.2 (43.0 ≤ S/No < 47.4)
001	34.8 (33.7 ≤ S/No < 35.9)	101	50.1 (47.4 ≤ S/No < 52.8)
010	37.5 (35.9 ≤ S/No < 39.2)	110	55.5 (52.8 ≤ S/No < 58.3)
011	41.1 (39.2 ≤ S/No < 43.0)	111	62.1 (58.3 ≤ S/No < 66)

(2) "1" = Cospas-Sarsat Beacon (document C/S T.001); "0" = new type beacon.
(3) "1" = most recent message(playback); "0" = others.
(4) "1" = real time message; "0" = playback message.
(5) Parity: "1" = odd number of "1s" in the 23-bit time code or the 23-bit Doppler word.
(6) "1" = long message; "0" = short message.

Figure 4.14: Sarsat SARP-3 House-Keeping (HK) Message Bit Format

Word #	MSB Word Content(24 bits) LSB	
0	HK data (24 bits)	
1	HK data (24 bits)	
2	110 011 100 011 111 000 000 000	
3	HK data (24 bits)	
4	HK data (13 bits)	First ll bits of BCH
5	Last 10 bits of BCH	HK data (14 bits)
6	HK data (24 bits)	
7	HK data (24 bits)	

- END OF SECTION 4 -

5. COSPAS-SARSAT ANTENNAS

5.1 Cospas Antennas

As shown in Figure 5.1, two antennas (one receive and one transmit) have been provided on the spacecraft in support of the Cospas payload.

5.1.1 Cospas Receive Antennas

Cospas receive antennas (SPA for 406 MHz) have the following characteristics:

Polarisation:	LHCP for 406 MHz
Gain:	As shown in Figures 5.2 Maximum and minimum contours of antenna gain referred to the receiver input when illuminated with a rotating linear source
Axial ratio:	As derived by the maximum and minimum contours on gain Figures
Frequency:	406.05 MHz ±50 kHz

5.1.2 Cospas Transmit Antenna

Cospas transmit antenna (SLA) has the following characteristics:

Polarisation:	LHCP
Gain (referred to the transmitter output port):	As shown in Figures 5.3 Minimum antenna gain on LHCP with an axial ratio ≤6 dB over 90% of region defined by 0º ≤ azimuth ≤ 360º and by 0º ≤ nadir ≤ 60º
Axial ratio:	As stated in gain Figure
Frequency:	1544.5 MHz ±500 kHz

Figure 5.1: Cospas Antenna System Functional Diagram

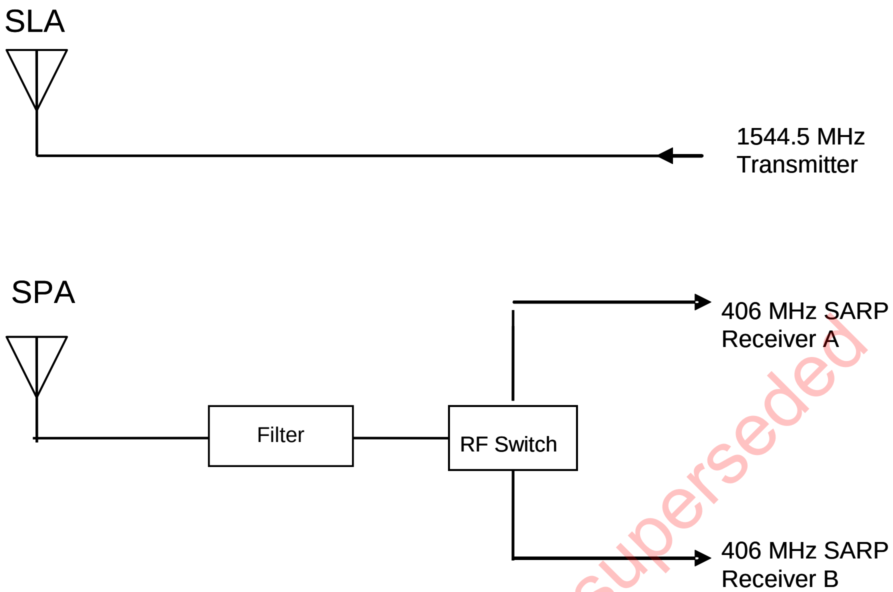


Figure 5.2: Cospas (SARP-2) 406 MHz Receive Antenna (SPA) Gain Pattern

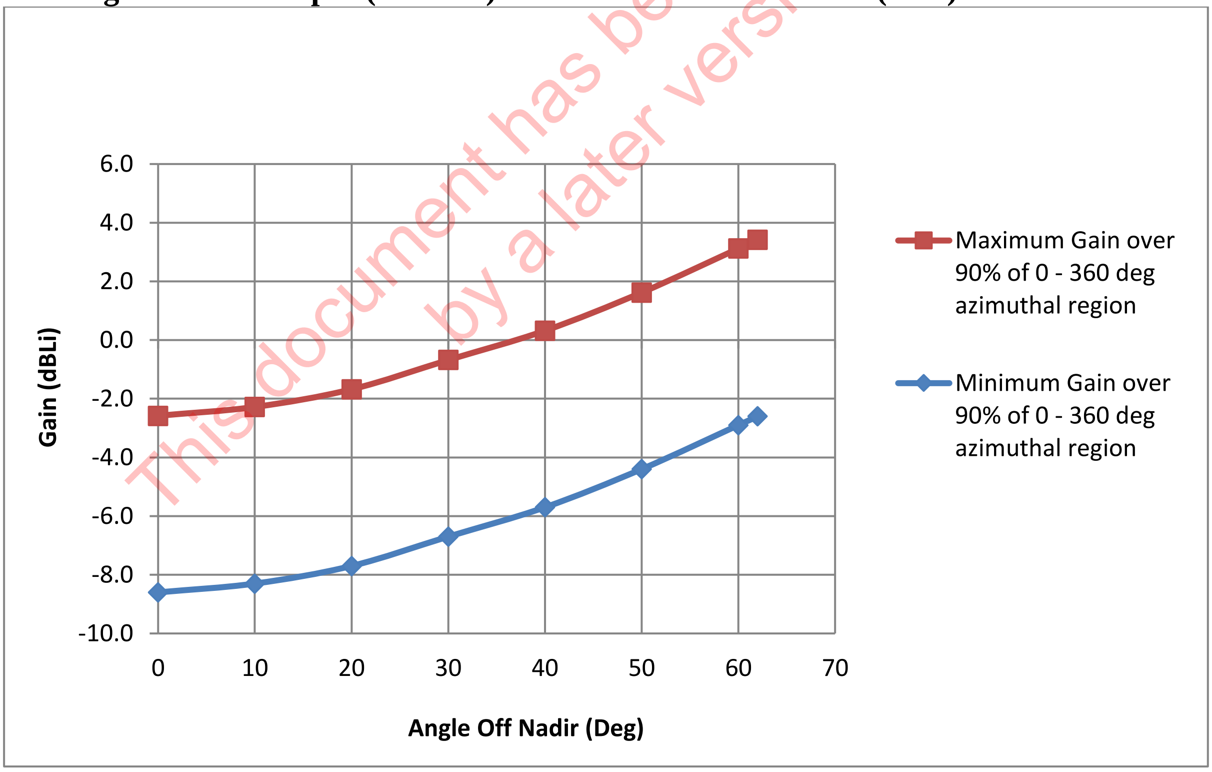
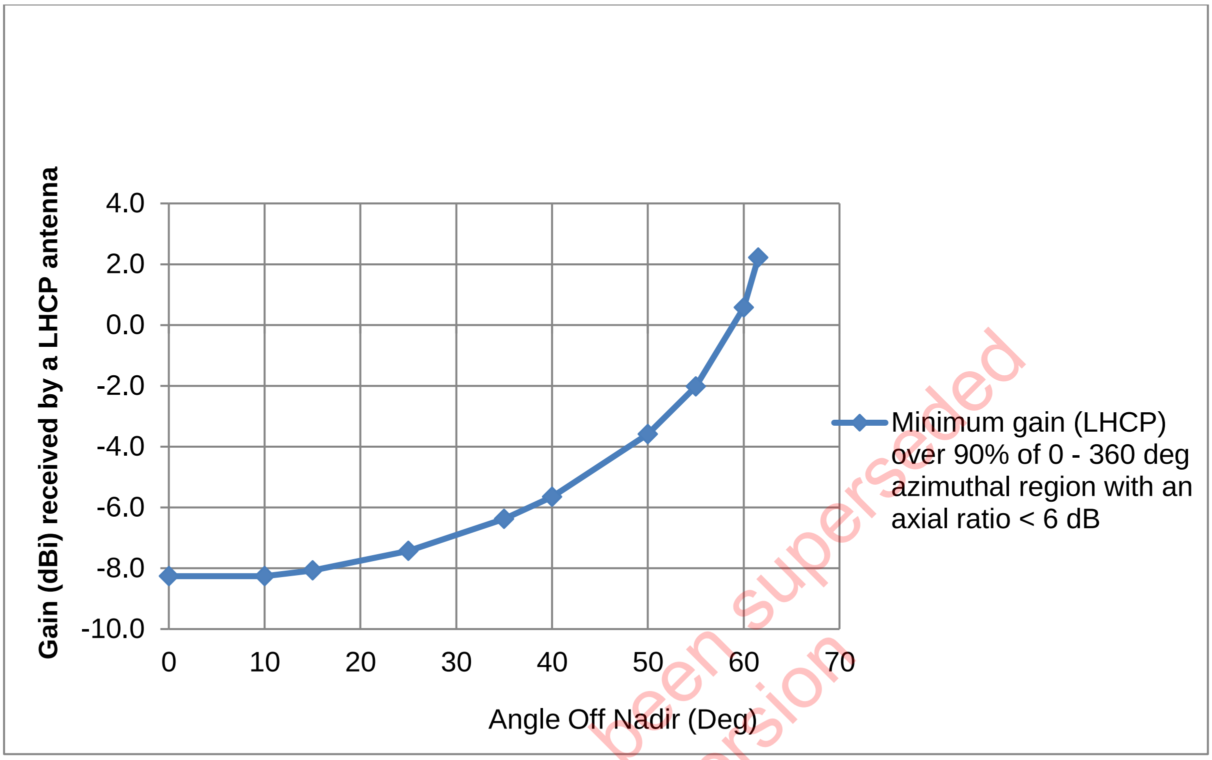


Figure 5.3: Cospas (SARP-2) 1544.5 MHz Transmit Antenna (SLA) Gain Pattern



5.2 Sarsat-TIROS Antennas

As shown in Figure 5.5, three antennas (two receive and one transmit) have been installed on the spacecraft with necessary diplexers and filters in support of the Sarsat payload.

5.2.1 Sarsat-TIROS Receive Antennas

The SARR Receive Antenna (SRA) is a coaxial quadrifilar antenna.

The SARP receive antenna signal comes from the quadrifilar UHF Data collection system Antenna (UDA).

Sarsat receive antennas have the following characteristics:

Angle of Nadir (deg.)

Polarisation: Minimum Gain (LHCP) over 90%

Gain: As shown in Figures 5.5 to 5.6

Axial ratio: As derived by the maximum and minimum contours on gain Figures

Frequency: SARR: 406.05 MHz ±50 kHz
SARP: 406.05 MHz ±50 kHz

5.2.2 Sarsat-TIROS Transmit Antenna

The SARR L-band transmit Antenna (SLA) is a quadrifilar antenna that has been optimised to produce a hemispherical pattern.

Sarsat transmit antenna has the following characteristics:

Polarisation:	LHCP
Gain (referred to the transmitter output port):	As shown in Figures 5.7
Axial ratio:	As stated in gain Figure
Frequency:	1544.5 MHz ±500 kHz

Figure 5.4: Sarsat-TIROS Antenna System Functional Diagram

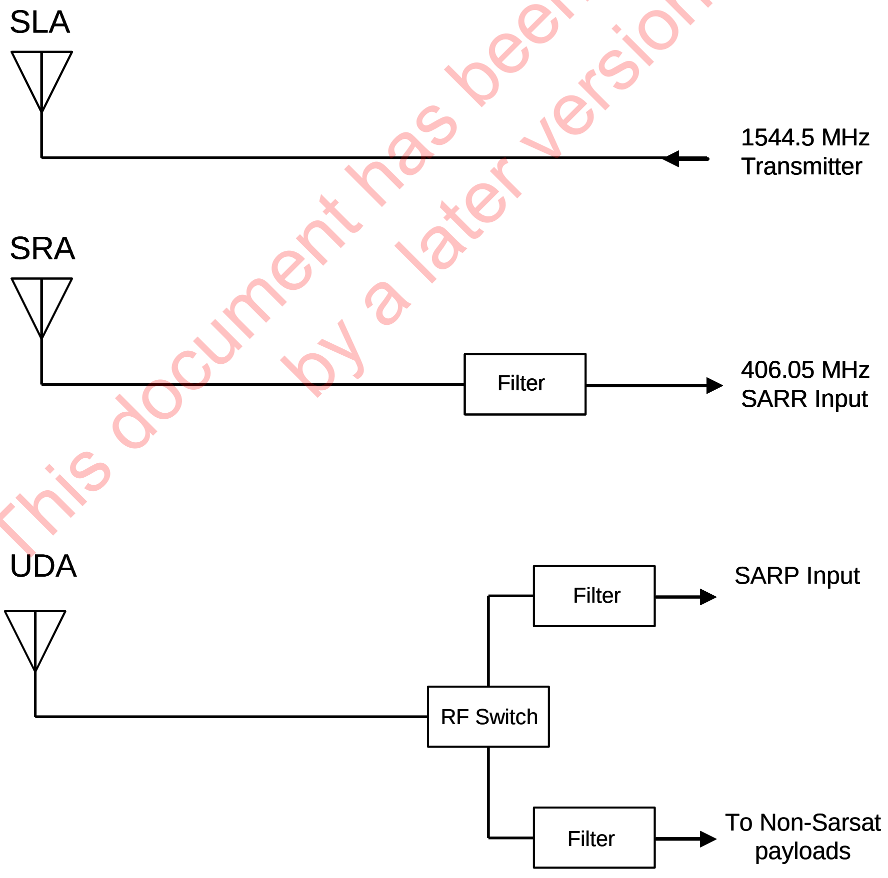
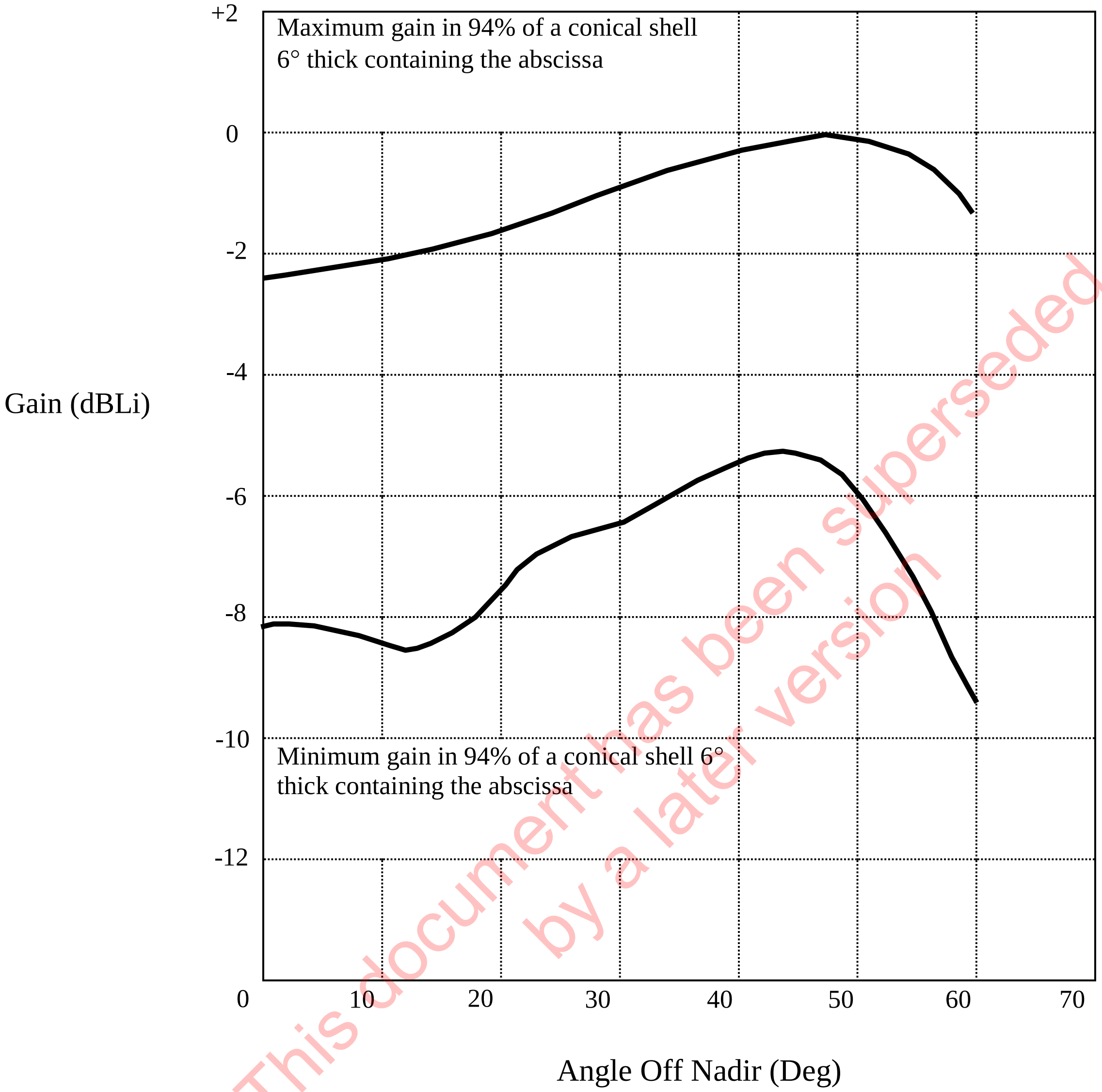
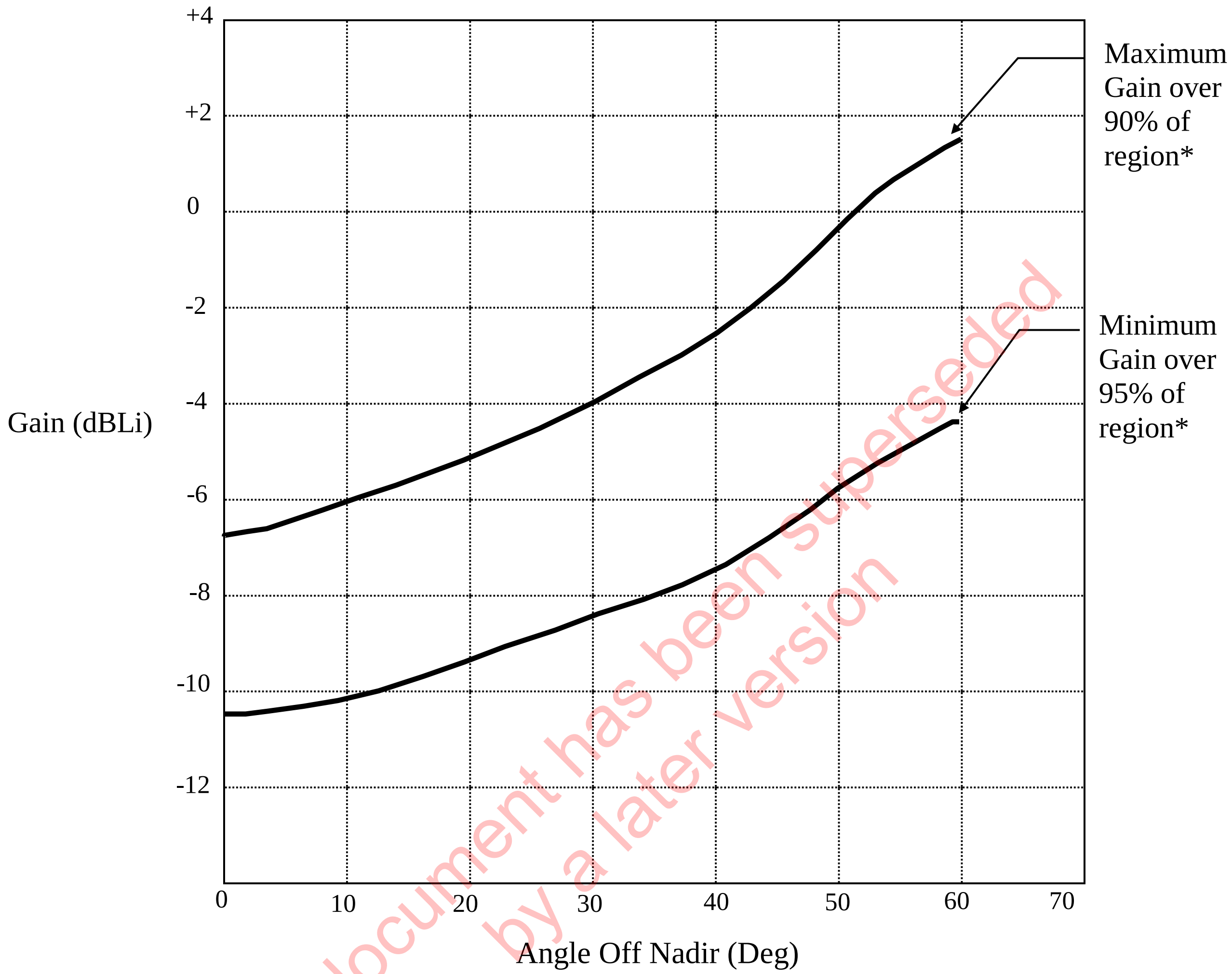


Figure 5.5: Sarsat-TIROS 406.05 MHz Receive Antenna (SRA) Gain Pattern (at receiver input)



Antenna gain referenced to the receiver input, when illuminated with a rotating linear source.

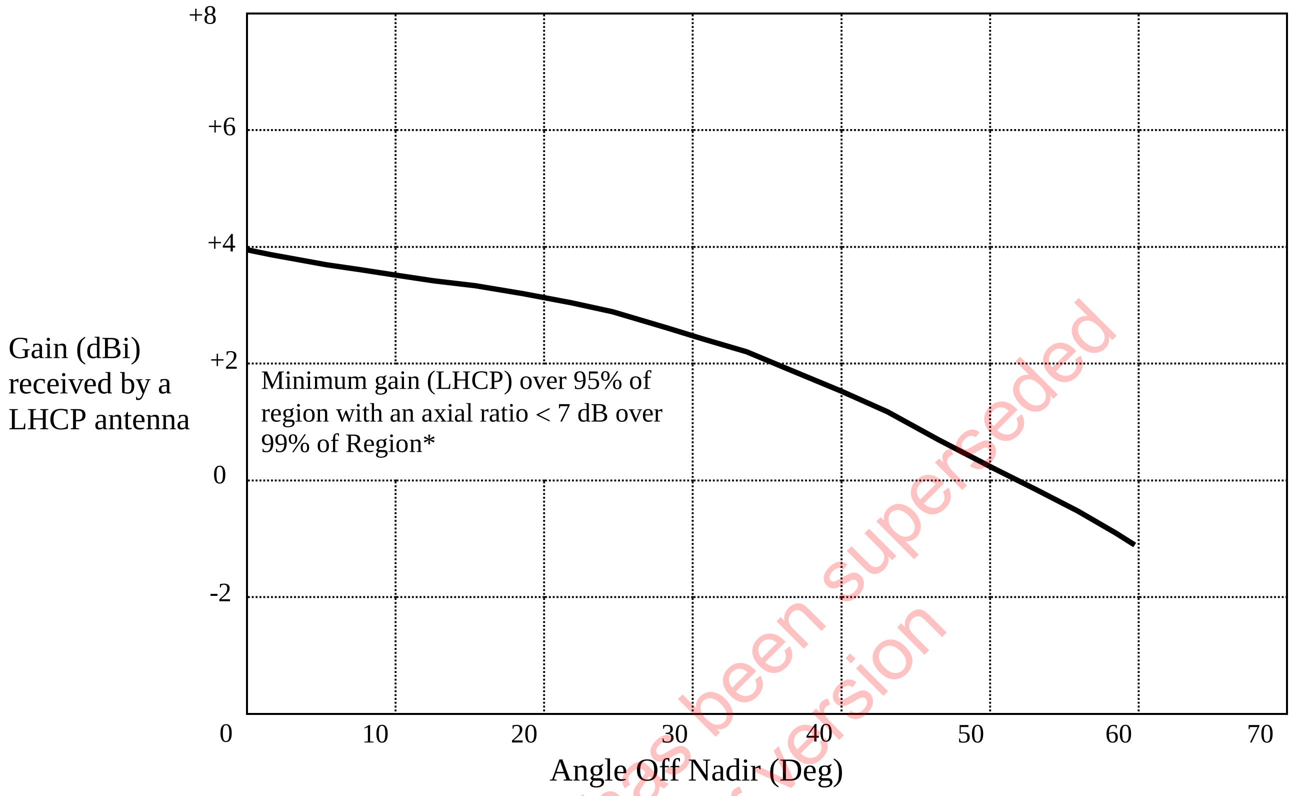
Figure 5.6: Sarsat-TIROS SARP Receive Antenna (UDA) Gain Pattern (at receiver input)



Antenna gain referenced to the receiver input, when illuminated with a rotating linear source.

* Region defined by 0° ≤ azimuth ≤ 360° and 0° ≤ nadir ≤ 60°

Figure 5.7: Sarsat-TIROS 1544.5 MHz Transmit Antenna (SLA) Gain Pattern



* Region defined by 0° ≤ azimuth ≤ 360° and 0° ≤ nadir ≤ 60°

5.3 Sarsat-METOP Antennas

As shown in Figure 5.8, two antennas (one receive and one transmit) have been installed on the spacecraft with necessary diplexers and filters in support of the Sarsat-METOP payload.

5.3.1 Sarsat-METOP Receive Antennas

The Combined Receive Antenna (CRA) combines the receive antenna for SARP and SARR into one helical antenna. It is operating at 406 MHz and is connected to both SARR and SARP instruments.

The CRA Antenna is deployable.

Sarsat-METOP receive antenna (CRA) has the following characteristics:

Polarisation:	RHCP
Gain:	As shown in Figures 5.9
Axial ratio:	As derived by the maximum and minimum contours on gain Figures
Frequency:	SARP/SARR: 406.05 MHz ±50 kHz

5.3.2 Sarsat-METOP Transmit Antenna

The SARR L-band transmit Antenna (SLA) is a conventional quadrifilar helix that has been optimised to produce a hemispherical pattern.

Sarsat-METOP transmit antenna has the following characteristics:

Polarisation:	LHCP
Gain (referred to the transmitter output port):	As shown in Figures 5.10
Axial ratio:	As stated in gain Figure
Frequency:	1544.5 MHz ±500 kHz

Figure 5.8: Sarsat-METOP Antenna System Functional Diagram

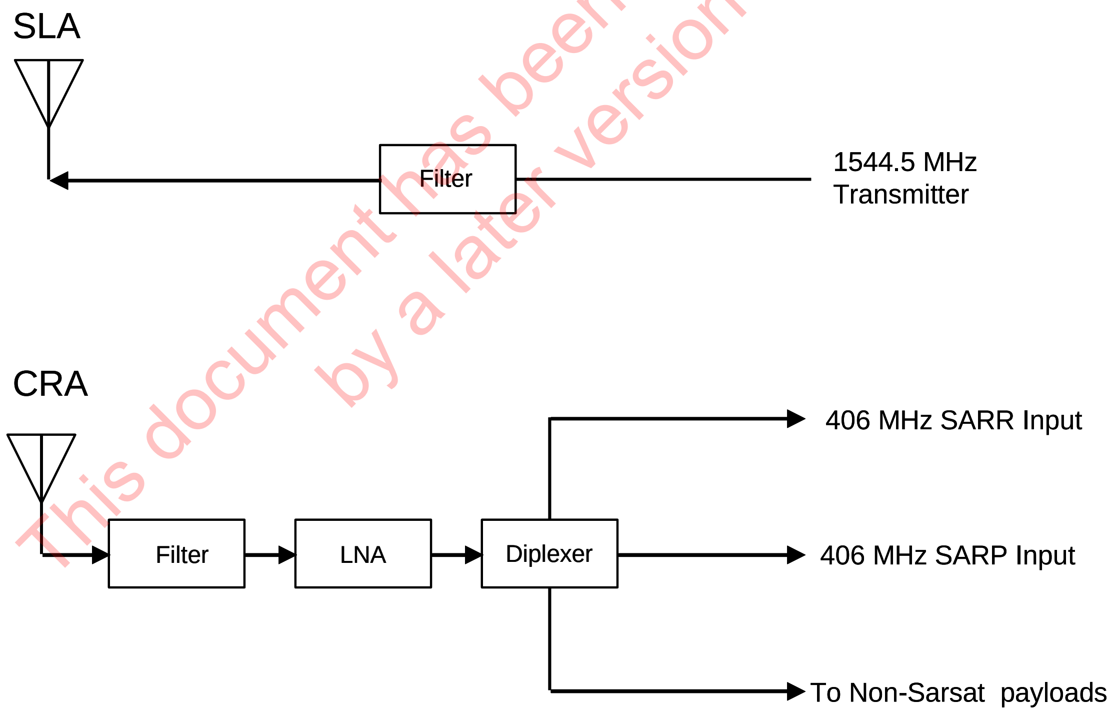


Figure 5.9: Sarsat-METOP 406 MHz SARR and SARP Receive Antenna (CRA) Gain Pattern (at receiver input)

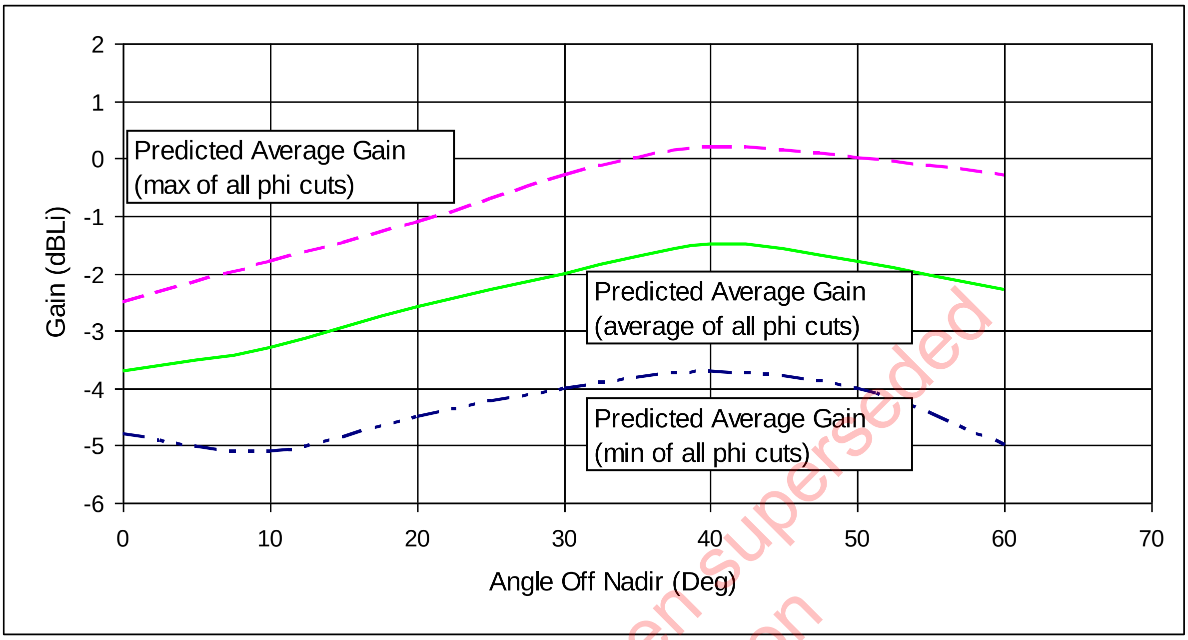
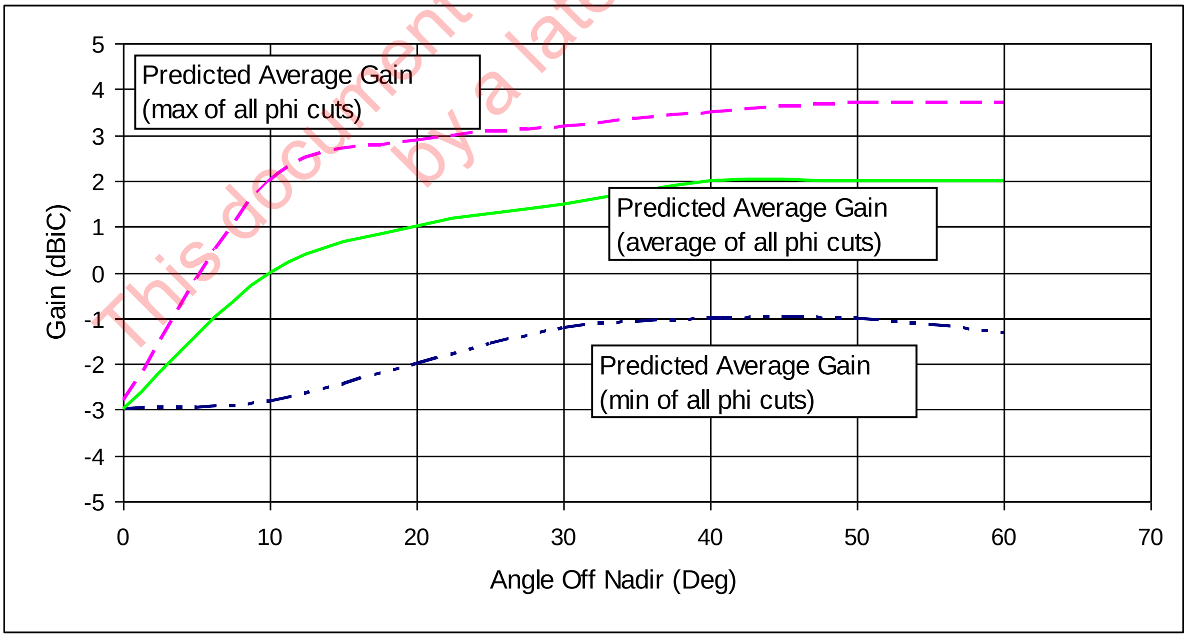


Figure 5.10: Sarsat-METOP 1544.5 MHz Transmit Antenna (SLA) Gain Pattern



5.4 Sarsat-NPOESS Antennas

As shown in Figure 5.11, two antennas (one receive and one transmit) have been installed on the spacecraft with necessary accommodation hardware in support of the Sarsat-NPOESS payload.

5.4.1 Sarsat-NPOESS Receive Antenna

(description TBD by USA)

Sarsat-NPOESS receive antenna has the following characteristics:

Polarisation:	RHCP
Gain:	As shown in Figure 5.12 for 95% of the azimuth angles and any nadir angle
Center Frequency:	403 MHz ± 30 MHz (TBC by USA)

5.4.2 Sarsat-NPOESS Transmit Antenna

(description TBD by USA)

Sarsat-NPOESS transmit antenna has the following characteristics:

Polarisation:	LHCP
Gain:	As shown in Figure 5.13 for 95% of the azimuth angles and any nadir angle
Axial ratio:	For 99% of the azimuth angle and any nadir angle between 0 and 61.97 deg.
Frequency:	1544.5 MHz ±500 kHz

Figure 5.11 : Sarsat-NPOESS Antenna System Functional Diagram

(TBD by USA)

Figure 5.12: Sarsat-NPOESS Receive Antenna Gain Pattern

(TBC by USA)

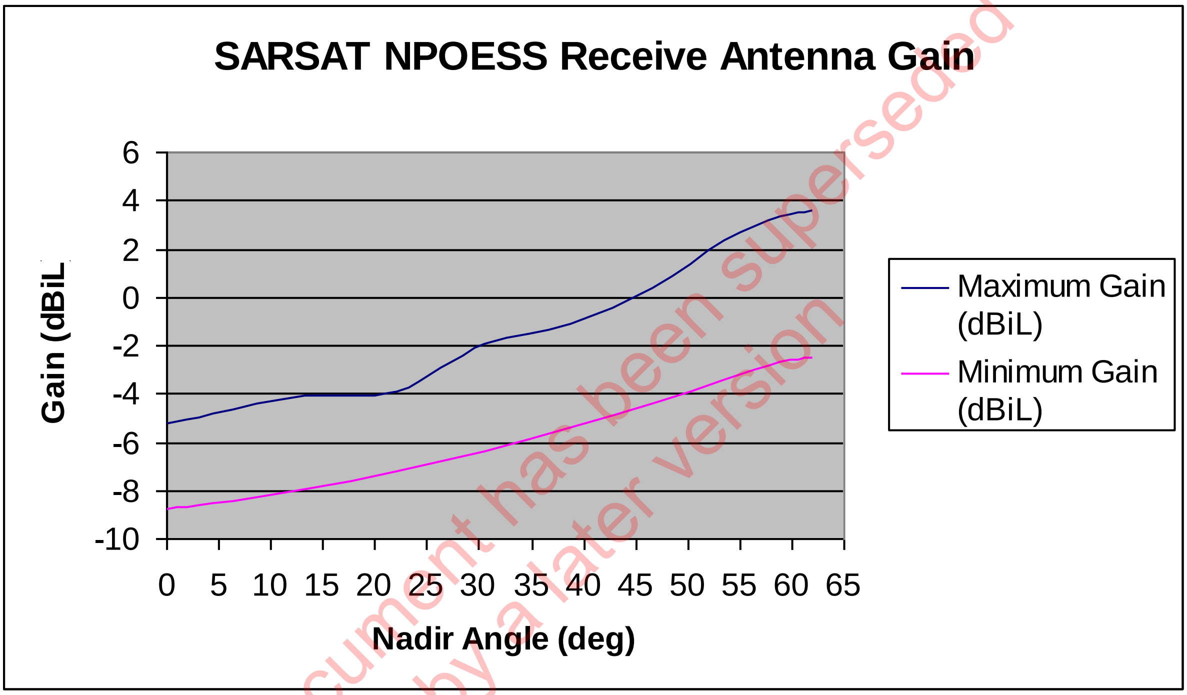
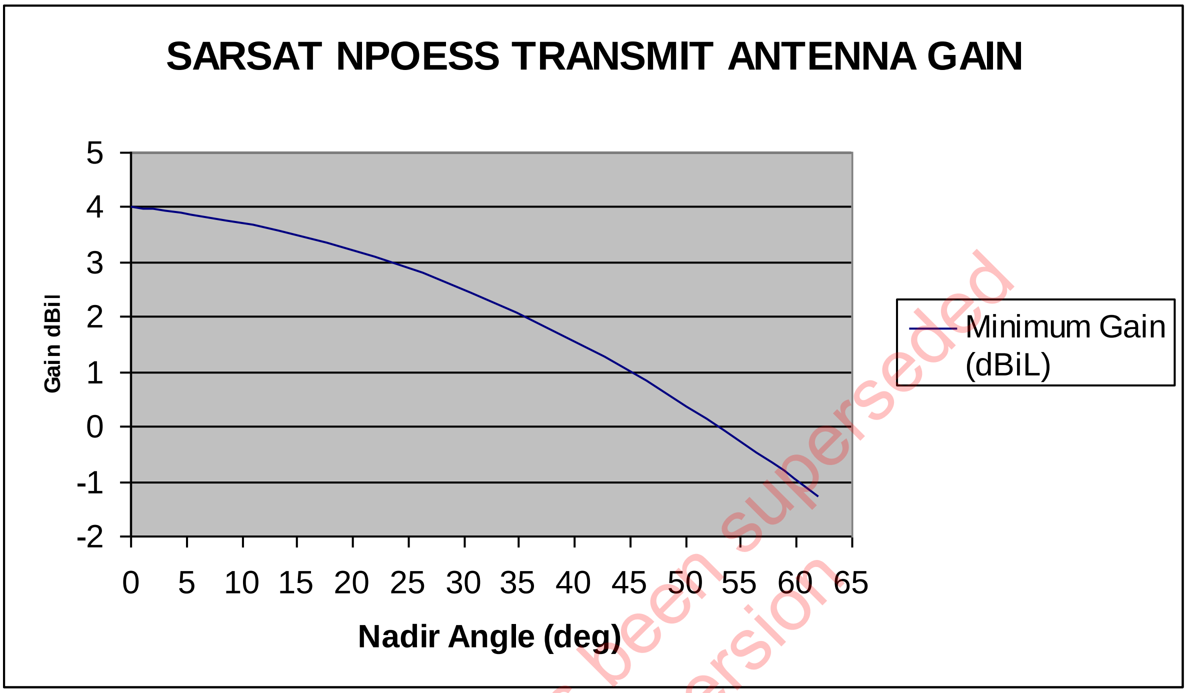


Figure 5.13: Sarsat-NPOESS Transmit Antenna Gain Pattern

(TBC by USA)



- END OF SECTION 5 -

ANNEXES TO DESCRIPTION OF THE PAYLOADS USED IN THE COSPAS-SARSAT LEOSAR SYSTEM

ANNEX A

LIST OF ABBREVIATIONS AND ACRONYMS

AGC	Automatic Gain Control
BTA	Beacon Transmit Antenna (NOAA satellite)
COSPAS	COsmicheskaya Sistema Poiska Avarinykh Sudov (Russian equivalent to SARSAT)
C/S	Cospas-Sarsat
dB	decibel
dBLi	gain in decibels relative to a linear isotropic antenna
dBm	power in decibels relative to 1 milliwatt
dBW	power in decibels relative to 1 Watt
DRU	Data Recovery Unit
EIRP	Equivalent Isotropically Radiated Power
FF	Frame Formatter
hex	hexadecimal
IF	Intermediate Frequency
K	Kelvin (degrees)
kbps	kilo bits per second
LHCP	Left Hand Circular Polarisation
LSB	Least Significant Bit
LUT	Local User Terminal
METOP	European **Met**eorological **Op**erational satellite programme
MIRP	Manipulated Information Rate Processor (on NOAA satellite)
MSB	Most Significant Bit
N/A	not applicable
NOAA	National Oceanic and Atmospheric Administration (USA)
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRZ-L	Non Return to Zero biphase-L data encoding
PB	Playback
PDS	Processed Data Stream
PM	Phase Modulation
PTC	Power, Telemetry and Command

LIST OF ABBREVIATIONS AND ACRONYMS
(Continued)

rad	radian(s)
RF	Radio Frequency
RHCP	Right Hand Circular Polarisation
RMS	Root Mean Square
RT	Real Time
SAR	Search And Rescue
SARP	Search And Rescue Processor
SARP-1	SARP with memory
SARP-2	Second generation SARP with memory
SARP-3	Third generation SARP with memory
SARR	Search And Rescue Repeater
SARR-1	First generation of SARR
SARR-2	Second generation of SARR (PDS channel only)
SARSAT	Search And Rescue Satellite Aided Tracking
SBA	NOAA S-band transmit antenna
SIDAR	Solar Irradiance, Data and Rescue program
SLA	SARR L-band transmit antenna SPA SARP receive antenna
SRA	SARR receive antenna
TC	Telemetry command from spacecraft interface to SAR payload
TIP	TIROS Information Processor (NOAA satellite) TIROS Television Infrared Observation Satellites
TM	Telemetry information from SAR payload to spacecraft interface
UDA	UHF data collection system antenna (NOAA satellite) UTC Universal Time Co-ordinated
VCO	Voltage Controlled Oscillator

- END OF ANNEX A -

ANNEX B

COSPAS-SARSAT LEOSAR FREQUENCIES

1. Introduction

The 1992 ITU World Administrative Radio Conference (WARC-92) addressed the worldwide use and allocation of the radio spectrum, including mobile satellite services.

Cospas-Sarsat, an international satellite system for search and rescue, provides a distress alerting and locating service using distress beacons operating on 406 MHz, a constellation of satellites, a number of ground receiving stations (called Local User Terminals, LUTs) and a network of Mission Control Centres which distribute the alert and location data to search and rescue authorities.

The 406 MHz Cospas-Sarsat System has been adopted by the International Maritime Organization as part of the Global Maritime Distress and Safety System (GMDSS).

2. Frequency Matters

2.1 Frequency Requirements

The Cospas-Sarsat Council considers it essential that the existing frequency allocations for Cospas-Sarsat remain in effect, because Cospas-Sarsat satellite payloads are already being built for use into the foreseeable future, with more than 30 ground receiving stations installed world-wide, any changes to operating frequencies would be very difficult to implement.

The frequencies used by the Cospas-Sarsat LEOSAR System are identified in the radio regulations (Table B.1 refers), and the Cospas-Sarsat instruments using these frequency bands have been registered with the ITU.

2.2 Interference

The international community has recognised the negative impact that interference could have on Cospas-Sarsat operations. To mitigate the risk, the ITU has approved a recommendation (ITU-R M.1478) which identifies the maximum interference levels which could be tolerated by Cospas and Sarsat SARP instruments.

Table B.1: Cospas-Sarsat LEOSAR Frequencies

Frequencies					
Earth-to-space			Space-to-earth		
Centre frequency	Bandwidth	ITU Radio Regulation Footnote	Centre Frequency	Bandwidth	ITU Radio Regulation Footnote
406.05 MHz	100 kHz	S5.266 & S5.267	1544.5 MHz	1000 kHz	S5.354 & S5.356

-END OF ANNEX B-

- END OF DOCUMENT -

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