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

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

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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. 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;

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;

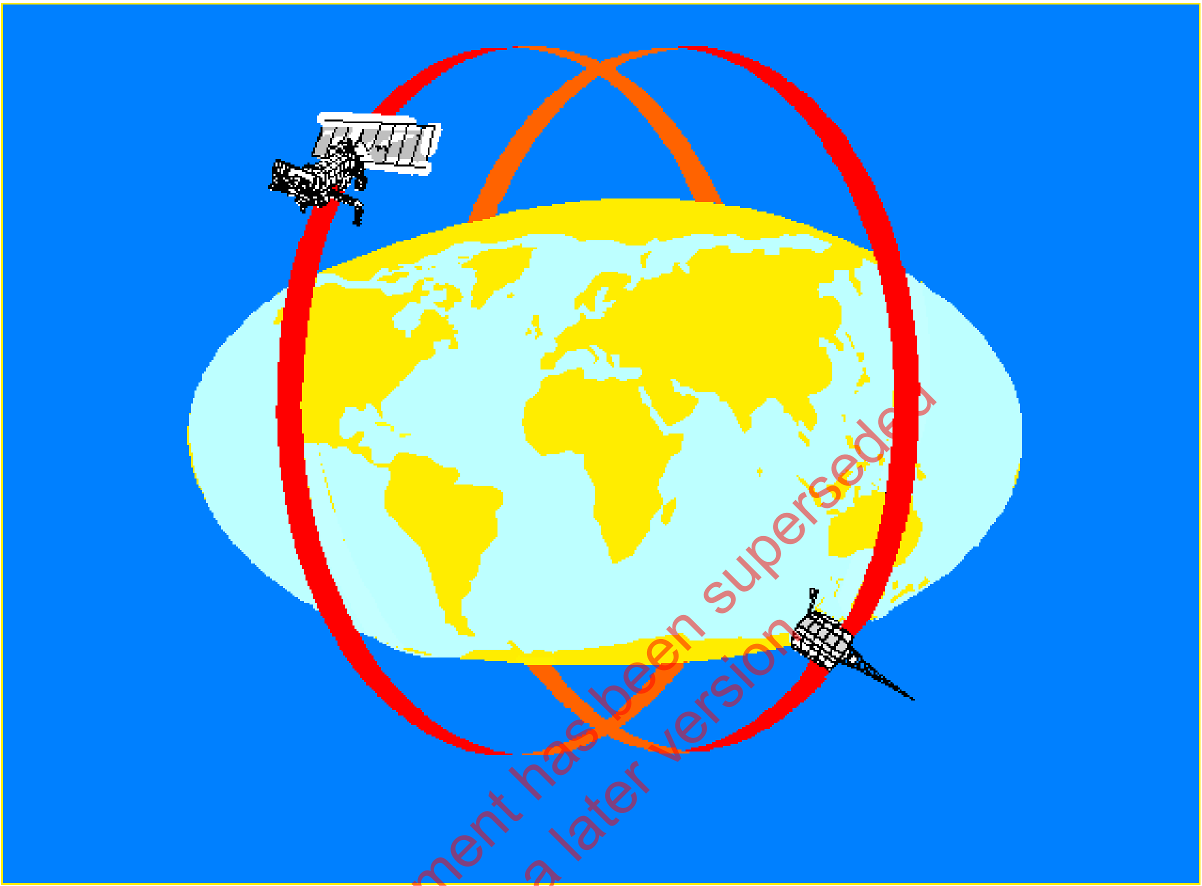
b. C/S G.004 : Cospas-Sarsat Glossary;

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 121.5 MHz band and its parameters are given in sub-section 3.1.

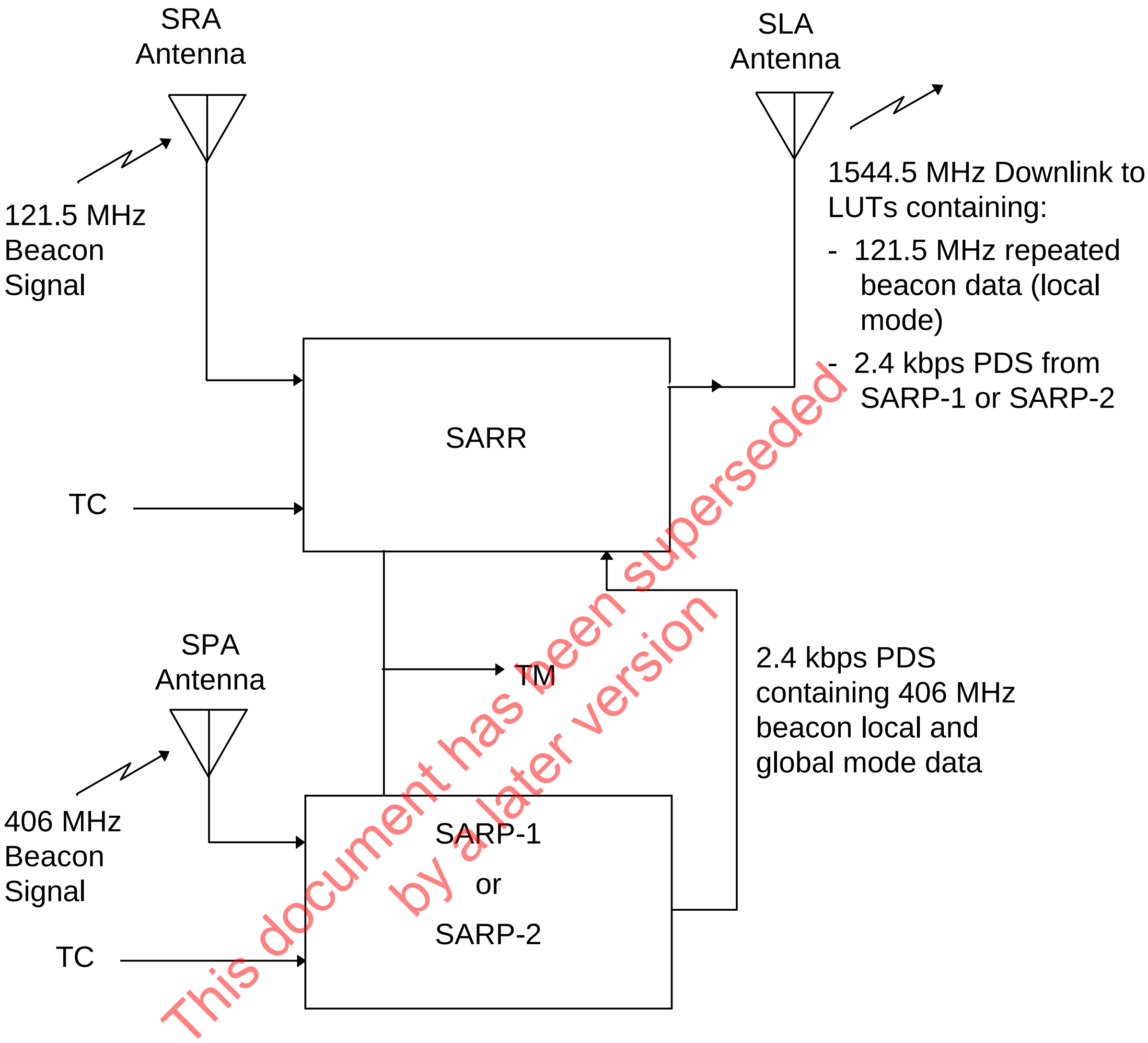
The SARP provides both local mode and global mode coverage for the 406 MHz band. Cospas satellites may have one of two possible SARP configurations installed: SARP with memory (SARP-1) or an improved SARP with memory (SARP-2). These processors are described in sub-sections 4.1.1 and 4.1.2 respectively. 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 SLA can be detected by any Cospas-Sarsat Local User Terminal (LUT).

Figure 2.1: Cospas Payload System Functional Diagram



Legend

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

2.2 Sarsat Payload

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 121.5 MHz, 243 MHz and 406 MHz bands and its parameters are given in sub-section 3.2.

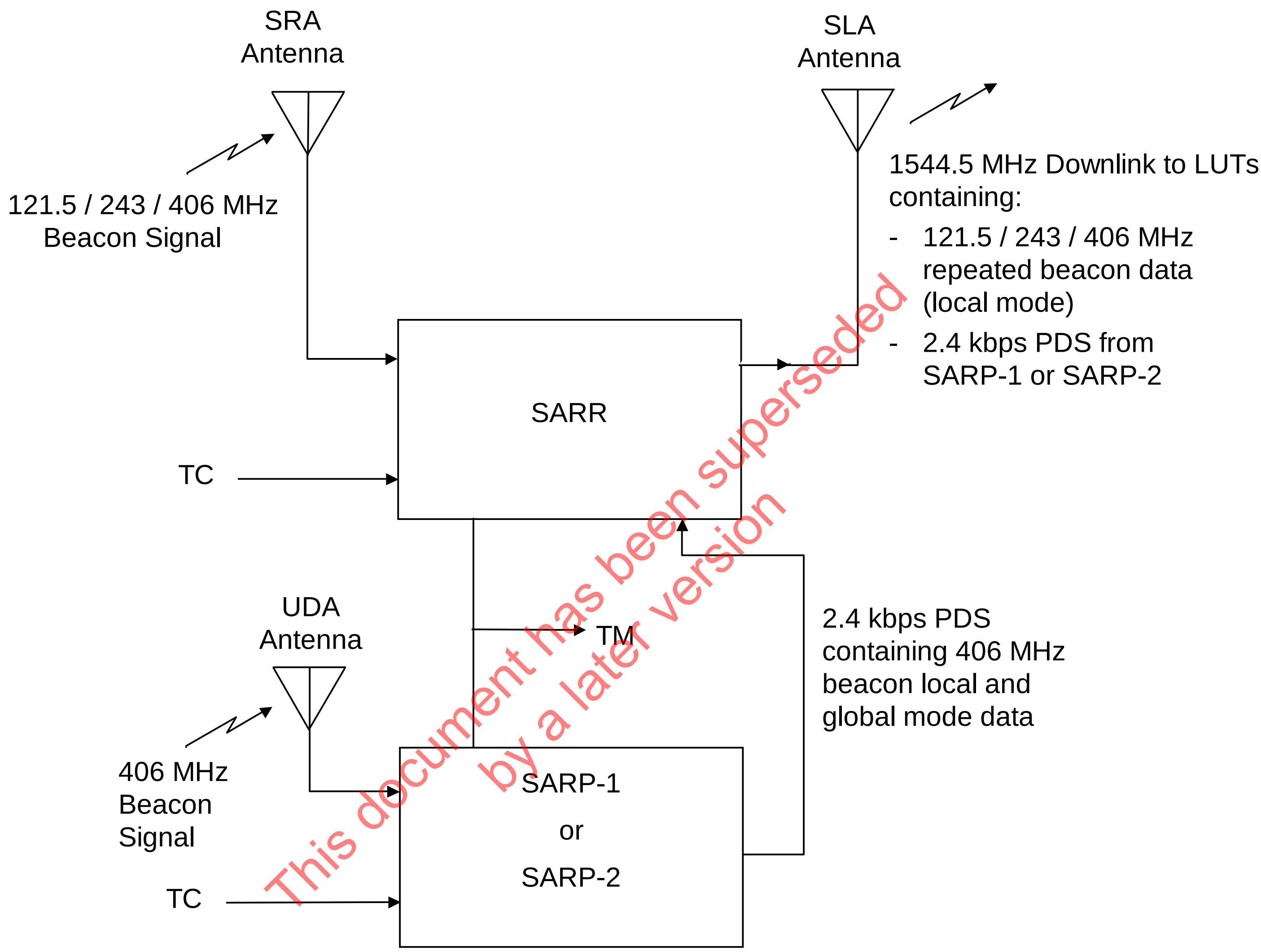
The SARP provides both local mode and global mode coverage for the 406 MHz band. Sarsat satellites may have one of three possible SARP configurations installed: SARP-1, SARP-2 or SARP-3. These processors are described in sub-sections 4.2.1, 4.2.2, and 4.2.3 respectively. Processed data is transmitted to the ground stations by the repeater downlink transmitter.

Antenna parameters for the payload are given in section 5.2.

2.2.2 Sarsat Payload System Functional Diagram

As shown on the Sarsat payload functional diagram in Figure 2.2, the 2.4 kbps digital data is routed directly to the SARR.

Figure 2.2: Sarsat Payload and Spacecraft Interface Functional Diagram with SARP-1 and SARP-2



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

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	Sarsat
Orbit Type	N/A	Circular, Near-Polar	Circular, Sun-Synchronous
Altitude	km	987 to 1022	833 to 870
Inclination	Deg	82.88 to 83.02	98.7 to 98.86
Period	min	104.6 to 105.2	101.35 to 102.12
Eccentricity	N/A	< 0.02	< 0.001

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
121.5 MHz Repeater	Section 3.1	Section 3.2
243 MHz Repeater	N/A	Section 3.2
406 MHz Repeater	N/A	Section 3.2
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
121.5 MHz Repeater:			
Centre Frequency	MHz	121.5	
1 dB Bandwidth	kHz	25	
Receiver Noise Temperature	K	600	
S/C Antenna Polarisation	N/A	LHCP	RHCP
Input Signal from Beacon a. Power Flux Density: (Nominal orbit) Maximum: Nominal: b. Polarisation:	 dBW/m^2 N/A	 -139.4 -153.4 Linear	 -138.0 -152.0 Linear
Background Noise: a. Unwanted Intermittent Voice Emitters (Max Transmitter Power): b. Broadband: Maximum: Nominal: Minimum:	 W K K K	 25 10,000 6,000 2,500	
243 MHz Repeater:			
Centre Frequency	MHz	N/A	243.0
1 dB Bandwidth	kHz	N/A	46.0
Receiver Noise Temperature	K	N/A	350
S/C Antenna Polarisation	N/A	N/A	RHCP
Nominal Background Noise	K	N/A	3000
406 MHz Repeater:			
Centre Frequency	MHz	N/A	406.05
1 dB Bandwidth	kHz	N/A	80.0
Receiver Noise Temperature	K	N/A	350[1]
S/C Antenna Polarisation	N/A	N/A	RHCP
Nominal Background Noise	K	N/A	1000
406 MHz SARP-1 Processor:			
Centre Frequency[2]	MHz	406.025	
1 dB Bandwidth[2]	kHz	24	
Receiver Noise Temperature	K	600	300
Input Signal from Beacon a. Power Flux Density: (Nominal orbit) Maximum: Nominal: b. Polarisation:	 dBW/m^2 N/A	 -121.4 -142.4 Linear/RHCP	 -120.0 -141.0 Linear/RHCP
S/C Antenna Polarisation	N/A	RHCP	
Nominal Background Noise	K	1000	

Note 1: Prior to Sarsat-6 noise temperature is 600 K

Note 2: SARP-2 allows selection of three different centre frequencies and bandwidths, as listed in Tables 4.2 and 4.4.

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.

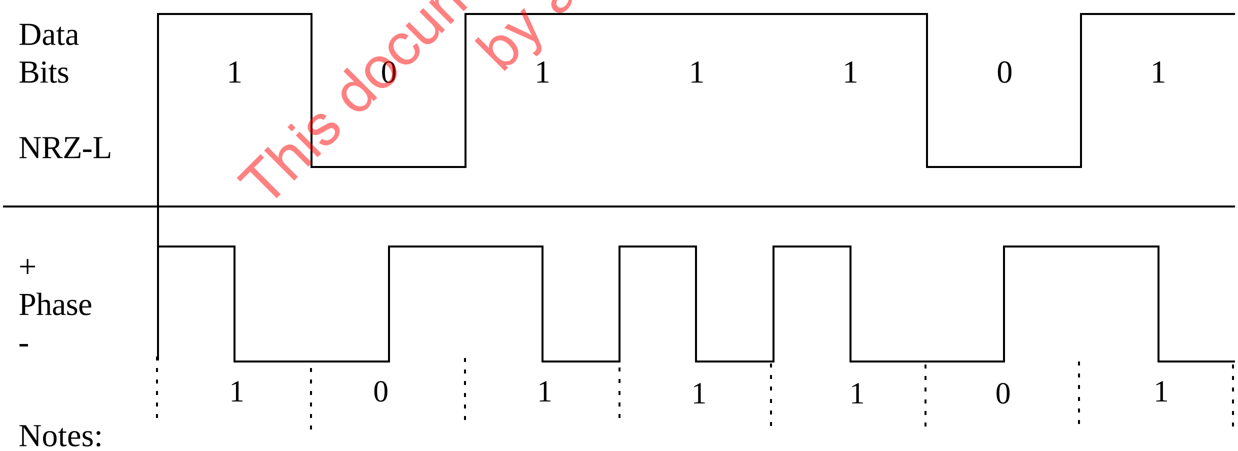
a. For the Processed Data Stream (PDS) digital channel, the full excursion of the phase deviation, also called the peak-to-peak value, is two times the RMS value. The peak value equals the RMS value (i.e. signal is basically a square wave).

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
Transmitted Signal:			
Centre Frequency	MHz	1544.5	
Nominal Power Output of Transmitter	W	4.0	7.2
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)	0.60± 10%	0.70±10%
121.5 MHz Repeater Channel Baseband:			
Centre Frequency	kHz	46.875	47.000
Frequency Translation	N/A	Uninverted	
Nominal Modulation Index	rad (RMS)	0.54± 10%	0.44±10 %
1 dB Bandwidth	kHz	25	
243.0 MHz Repeater Channel Baseband:			
Centre Frequency	kHz	N/A	94.0
Frequency Translation	N/A	N/A	Uninverted
Nominal Modulation Index	rad (RMS)	N/A	0.44±10 %
1 dB Bandwidth	kHz	N/A	46
406.05 MHz Repeater Channel Baseband:			
Centre Frequency	kHz	N/A	170.0
Frequency Translation	N/A	N/A	Uninverted
Nominal Modulation Index	rad (RMS)	N/A	0.22±10 %
1 dB Bandwidth	kHz	N/A	80

Table continued on next page

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.

Table 2.4: Cospas and Sarsat Output Parameters (continued)

Parameter	Unit	Cospas	Sarsat
PDS Channel:			
Bit Rate	bps	2400±0.1%	2400±0.5%
Nominal Modulation Index	rad (RMS)	0.27 ±10%	0.22 ± 10%
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 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-1 and SARP-2 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 -

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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 triple-conversion 121.5 MHz receivers;

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

c. 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.

3.1.1 Cospas SARR 121.5 MHz Receiver

A functional diagram of the triple conversion receiver is shown in Figure 3.2. AGC is used to maintain the output signal (signal plus noise) at a constant output level with ±10% tolerance.

The Cospas 121.5 MHz receiver parameters given in Table 3.1 are in addition to those given in section 2.

Figure 3.1: Cospas Repeater Functional Diagram

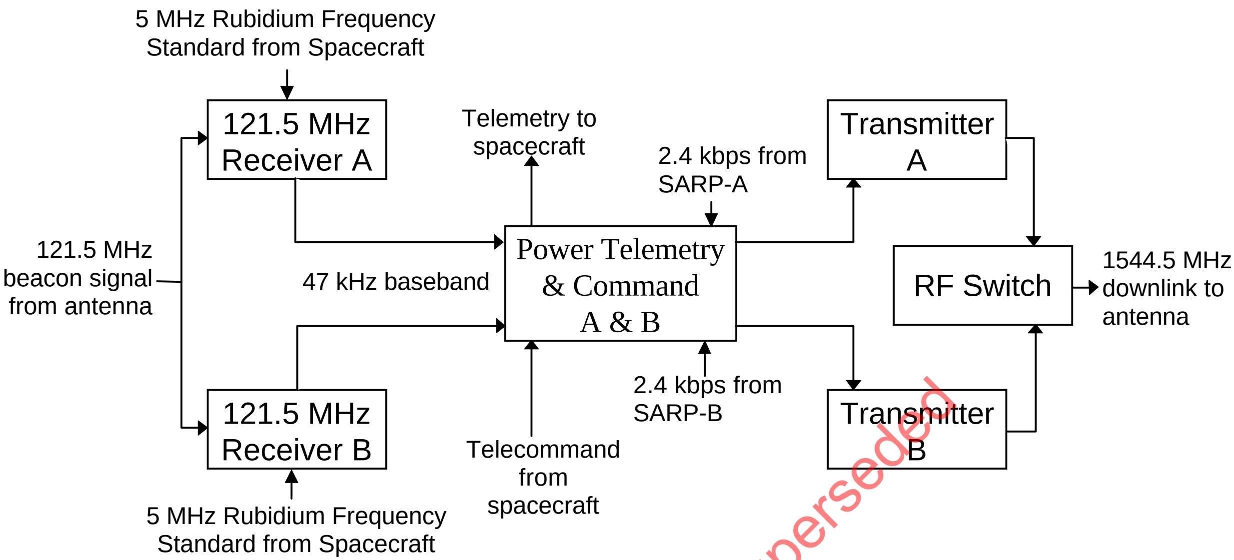


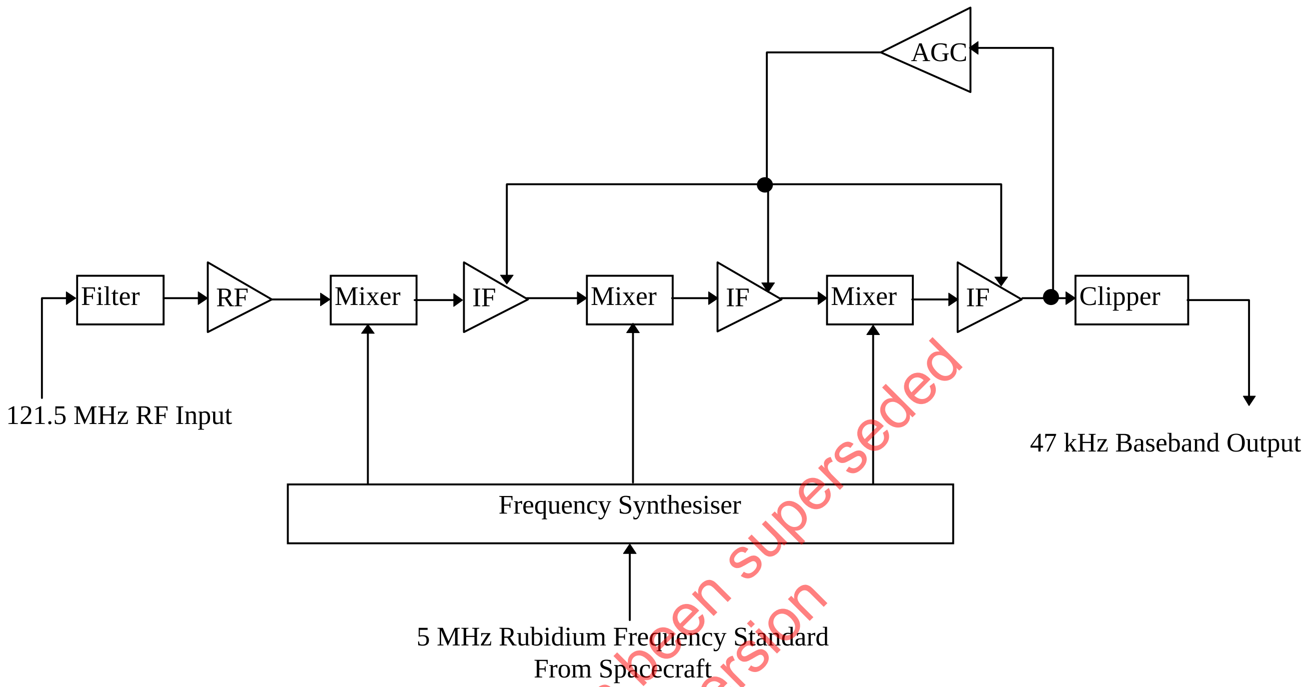
Table 3.1: Cospas 121.5 MHz Receiver Parameters

Parameters	Unit	Values
Nominal Input Level [1]	dBW	-144
Maximum Input Level	dBW	-50
Dynamic Range	dBW	-170 to -110
Linearity	N/A	see Note 2
Group Delay Slope	µs/kHz	≤ 50
Image Rejection	dB	120
AGC Time Constant	ms	25 to 100
AGC Dynamic Range	dB	> 50
Transient Recovery Time	ms	< 2
Frequency Stability: Long term (2 yr.) Medium term (15 min.) Short term (1 sec.)	N/A	 $\leq 1 \times 10^{-10}$ $\leq 1 \times 10^{-10}$ $\leq 3 \times 10^{-10}$

Note 1: Nominal input level is defined as nominal noise (6000 K) plus ten simultaneous nominal signals, each of -157.3 dBW.

Note 2: Neither two inband signals, at levels of -110 dBW at the receiver input, nor two out-of-band signals (i.e. beyond 121.5 MHz ± 50 kHz) at levels of -92 dBW, will produce output signals (i.e. products) exceeding the output level produced by an inband signal of -176 dBW referred to the receiver input.

Figure 3.2: Cospas 121.5 MHz Receiver Functional Diagram



3.1.2 Cospas 1544.5 MHz Transmitter

A functional diagram of the Cospas transmitter is given in Figure 3.3. 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 3.2 are in addition to those given in section 2. The downlink baseband frequency spectrum and an example of the signal observed on the ground are given in Figures 3.4 and 3.5.

Table 3.2: Cospas 1544.5 MHz Transmitter Parameters

Parameters	Unit	Values
Downlink Baseband Spectrum	N/A	Figures 3.4 and 3.5
Incidental AM	%	≤ 5
Spurious Output Level	dBW	≤ -60
Frequency Stability Long term (2 yr.): Medium term (15 min.): Short term (1 sec.):	 kHz N/A N/A	 ± 1.5 5×10^{-10} 5×10^{-11}
Maximum Modulation Index Level: 121.5: PDS: Composite:	 rad. (peak) rad. (peak) rad. (peak)	 2.10 (hard limiter) 0.92 (max. setting) 2.80 (hard limiter)
Amplitude Ripple	dB	≤ 2.5

Figure 3.3: Cospas 1544.5 MHz Transmitter Functional Diagram

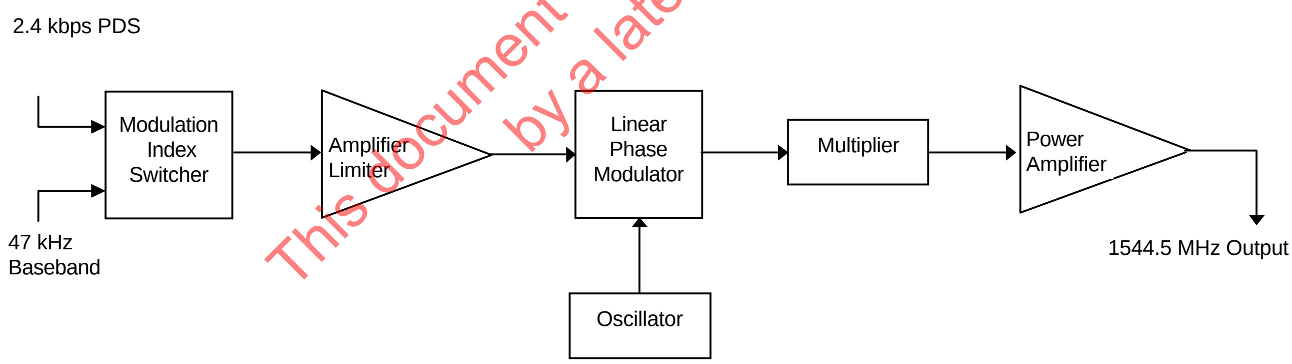


Figure 3.4: Cospas Baseband Frequency Spectrum

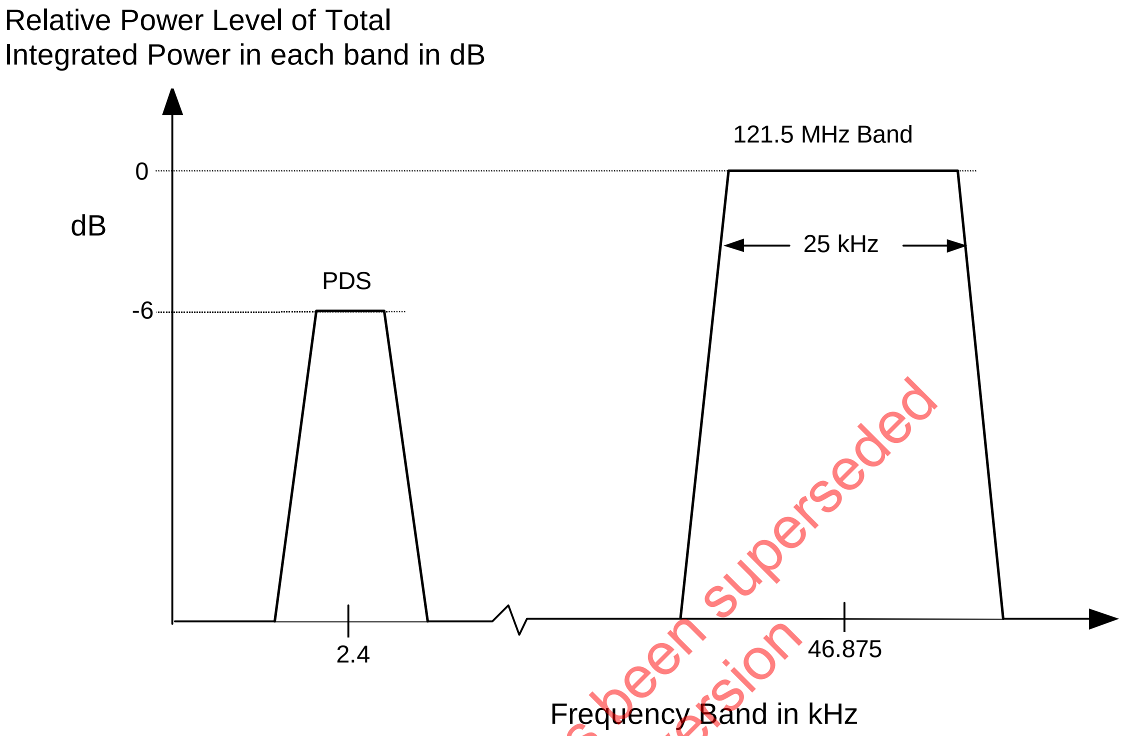
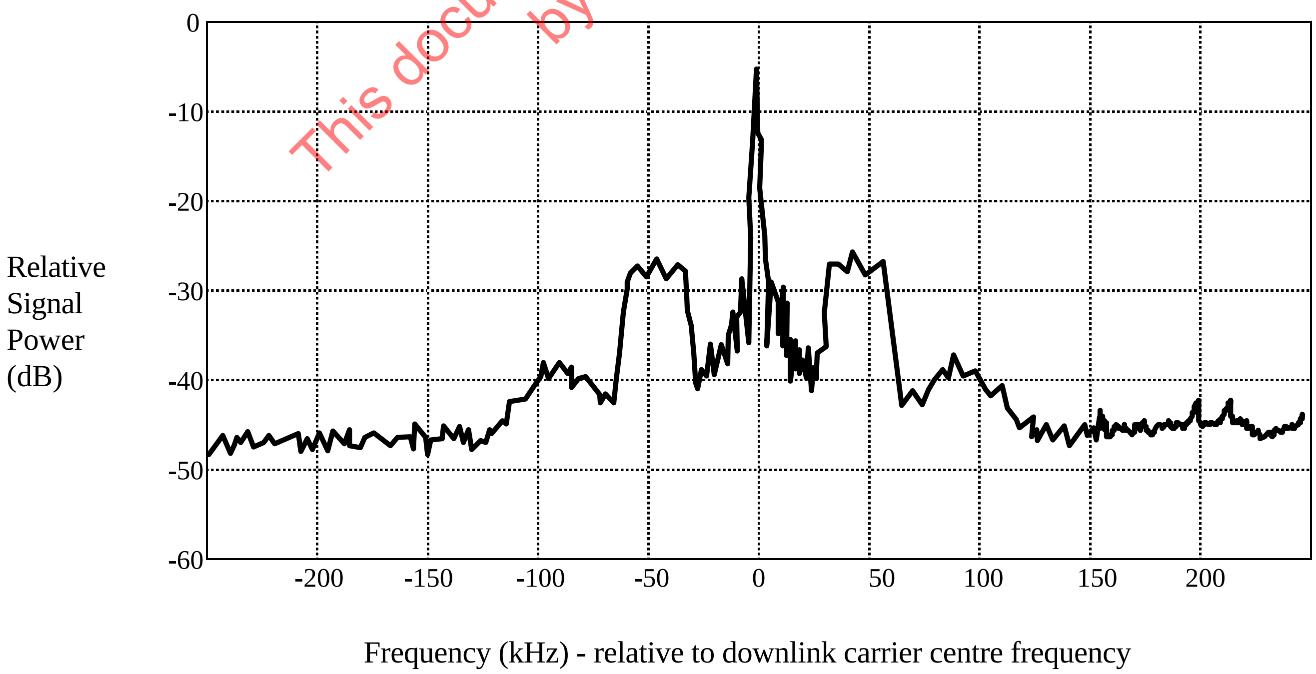


Figure 3.5: Typical Cospas 1544.5 MHz Observed Downlink Signal



3.2 Sarsat Repeater

As shown in Figure 3.6, the Sarsat SARR is redundantly configured and consists of the following units:

a. two dual-conversion 121.5 MHz receivers;

b. two dual-conversion 243 MHz receivers;

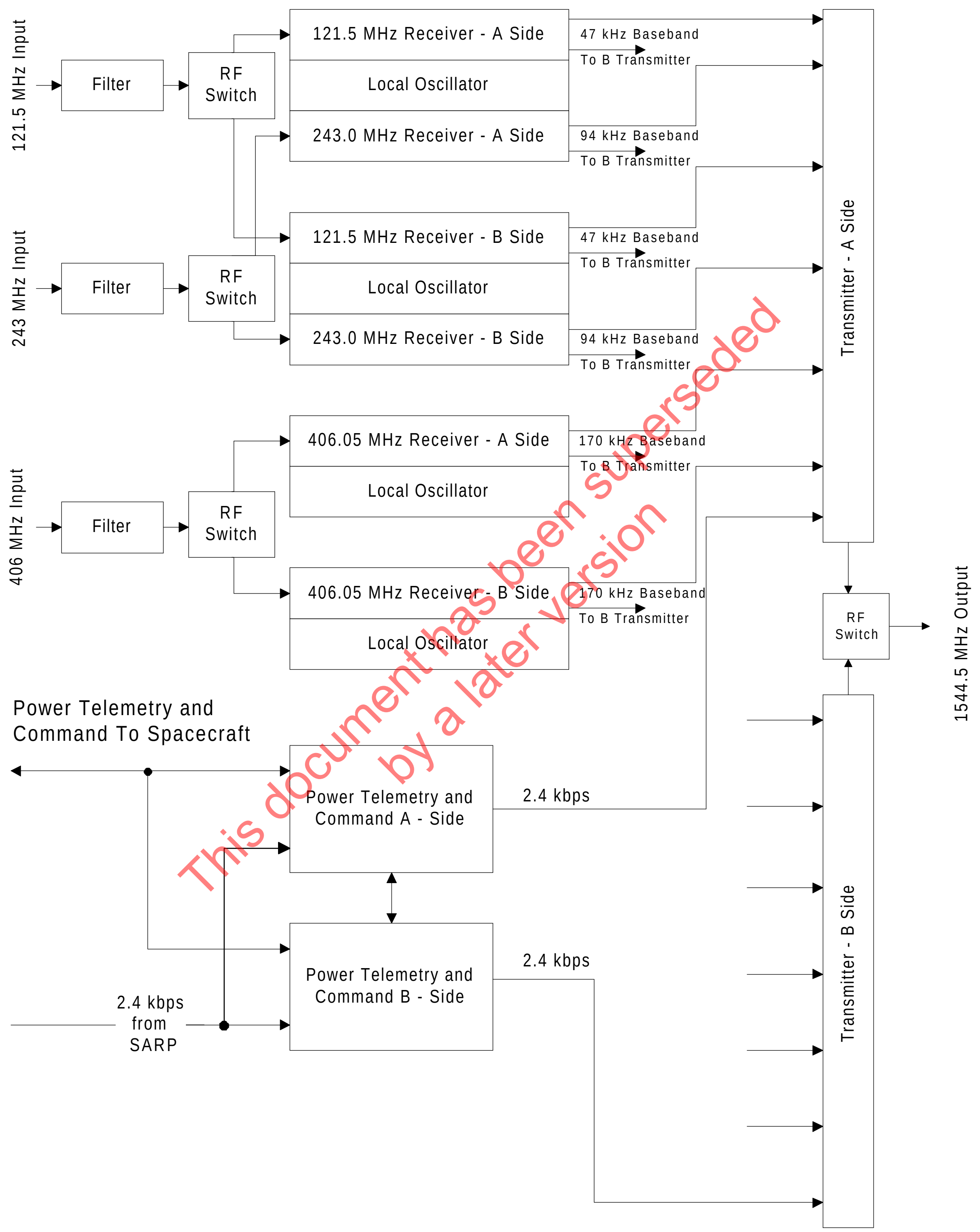
c. two dual-conversion 406.05 MHz receivers (Sarsat-1,-2,-3 and -4 have only one 406.05 MHz receiver mounted on the A side);

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

e. 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 3.6: Sarsat SARR Functional Diagram



3.2.1 Sarsat SARR Receivers

As shown in Figure 3.7, all three receivers contain AGC and provide two outputs to drive the two transmitters. The 121.5 and 243 MHz receivers share the same oscillator and are coherent in a ratio of 1:2. The Sarsat receiver parameters given in Table 3.3 are in addition to those given in section 2.

Table 3.3: Sarsat SARR Receiver Parameters

Parameters	Unit	Values For 121.5 MHz Receiver	Values For 243.0 MHz Receiver	Values For 406.05 MHz Receiver
Nominal Input Level[1]	dBW	-144	-146	-143
Maximum Input Level	dBW	-50		
Dynamic Range	dBW	-178.9 to -137.9	-181.8 to -149.9	-164.3 to -137.2
Linearity	N/A	Note 2		
Group Delay Slope	µs/kHz	50	25	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.):	N/A	1×10^{-6}		
Medium term (15 min.):	N/A	1×10^{-10}		
Short term (1 sec.):	N/A	1×10^{-10}		

Note 1: Nominal input levels are defined as follows:

121.5 MHz: nominal noise of 6000 K plus ten simultaneous signals, each of -157.3 dBW;

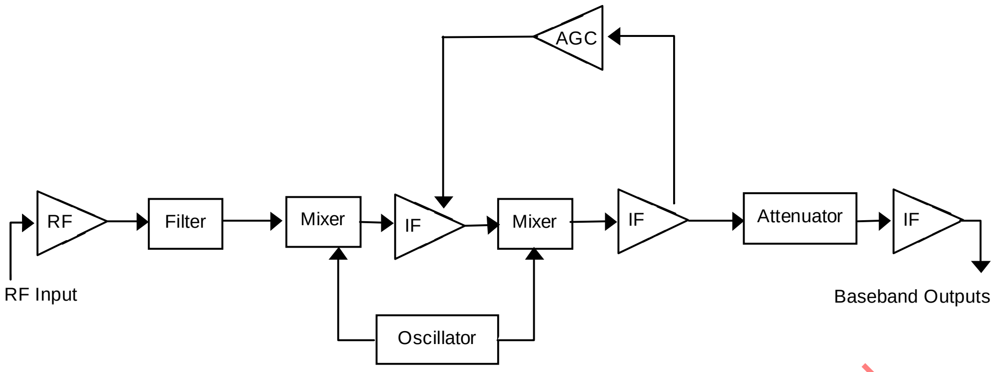
243 MHz: nominal noise of 3000 K plus ten simultaneous signals, each of -163.8 dBW;

406 MHz: 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 3.10) 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 3.7: Sarsat SARR Receiver Functional Diagram



Medium term frequency stability (over a 15 minute period) for all three receivers is given as:

<u>Nominal Temperature:</u>

Mean Slope:	$\leq 1 \times 10^{-10}$/minute *
Residual Noise:	$\leq 3 \times 10^{-10}$

<u>Full Temperature Range:</u>

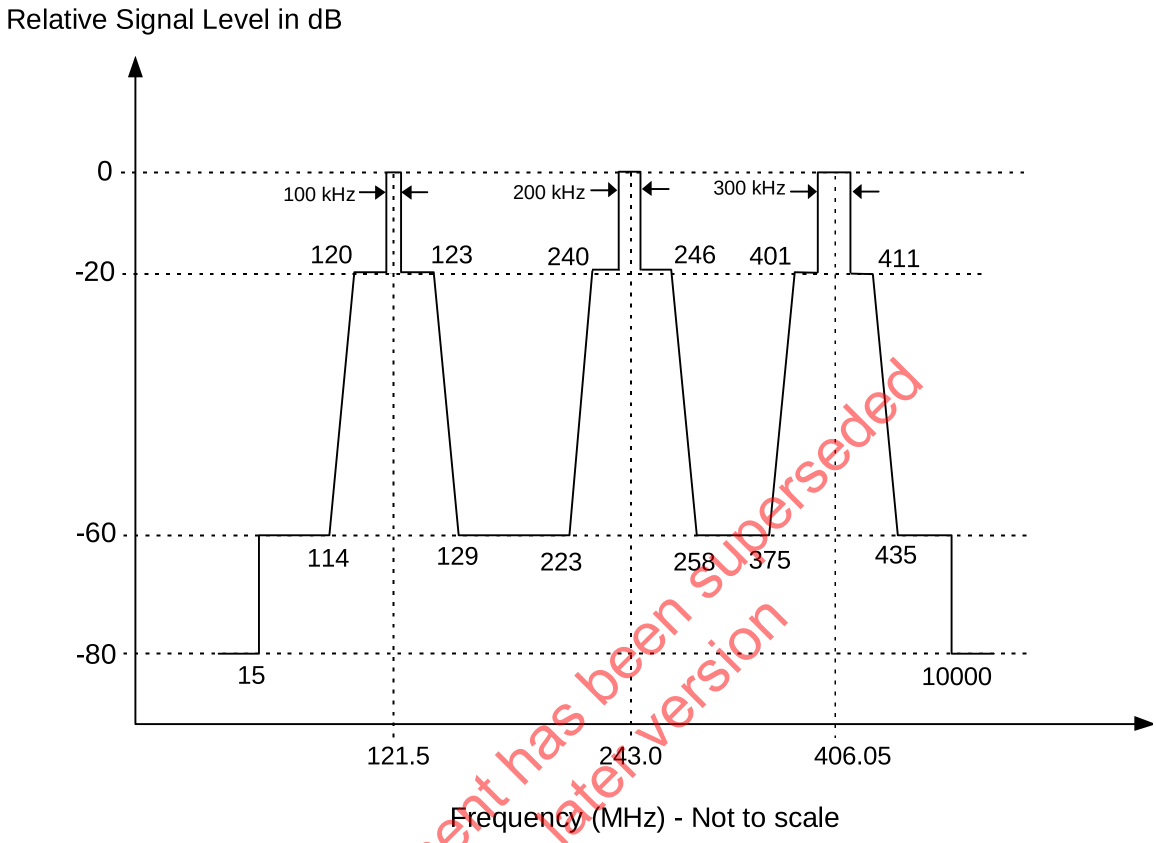
Mean Slope:	$\leq 1 \times 10^{-9}$/minute *
Residual Noise:	$\leq 3 \times 10^{-9}$

*Note: Prior to Sarsat-7, the value is $\leq 1 \times 10^{-8}$/minute

The baseband filtering characteristic for all three channels is given in Figure 3.8. Signals at frequencies indicated are attenuated by the corresponding amount with respect to the 0 dB level. Within each band, a receiver provides gain for those frequencies which fall within the band as specified in Table 2.4.

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

Figure 3.8: Sarsat SARR Receiver Bandpass Characteristics



3.2.2 Sarsat 1544.5 MHz Transmitter

As shown in Figure 3.9, each one of the transmitters has eight inputs; one for each of the six receivers, one for the PDS channel and one spare.

Sarsat 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 3.10 and 3.11.

When all receiver inputs are simultaneously illuminated by sinusoidal signals at the maximum frequency and levels, and by the processed data stream, no single discrete sideband is produced which exceed the limits shown in Figure 3.12. Noise-like emissions do not exceed the levels specified in Figure 3.12.

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 3.4: Sarsat 1544.5 MHz Transmitter Parameters

Parameters	Unit	Values
Downlink Baseband Spectrum	N/A	Figures 3.10 and 3.11
Incidental AM	%	≤5
Spurious Output Level	dBW	Figure 3.12
Frequency Stability Long term (2 yr.): Medium term (15 min.): Short term (1 sec.):	 kHz N/A N/A	 ± 3.2 ≤ 1 x 10^{-10} ≤ 1 x 10^{-10}
Maximum Modulation Index Level: 121.5: 243: 406.05: PDS: Composite:	 rad. (peak) rad. (peak) rad. (peak) rad. (peak) rad. (peak)	 1.30 (hard limiter) 1.30 (hard limiter) 1.30 (hard limiter) 0.39 (max. setting) 2.10 (hard limiter)
Amplitude Ripple	dB	≤ 2.5

Figure 3.9: Sarsat 1544.5 MHz Transmitter Functional Diagram

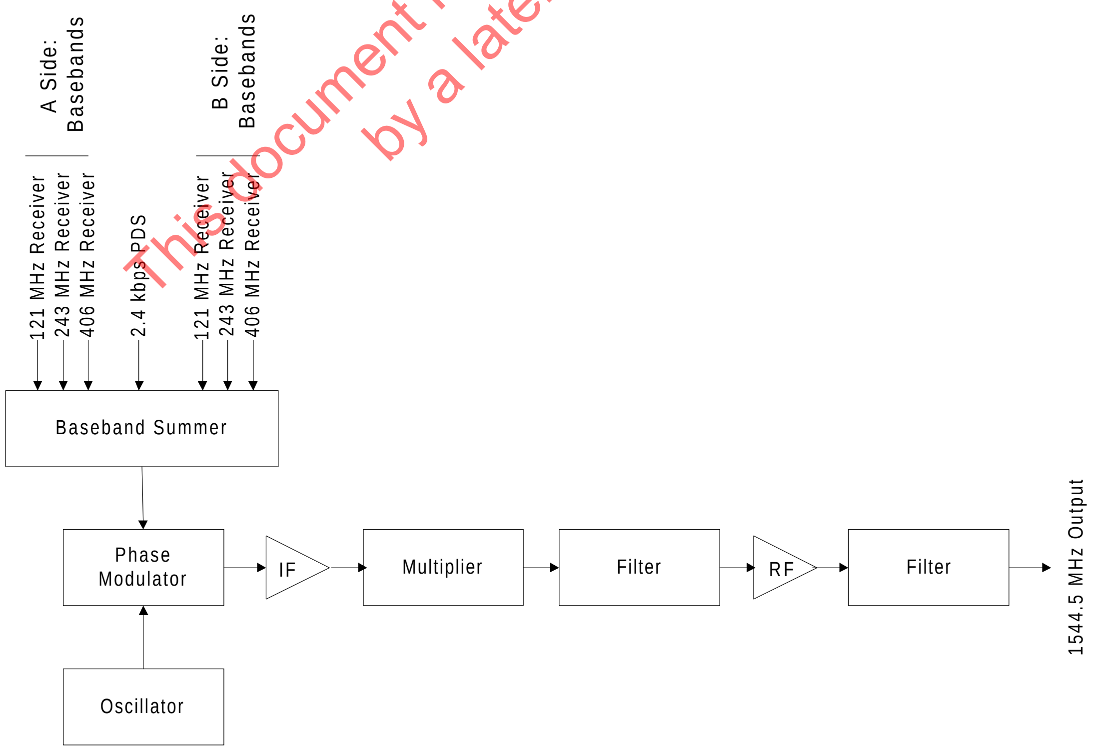


Figure 3.10: Sarsat SARR Baseband Frequency Spectrum

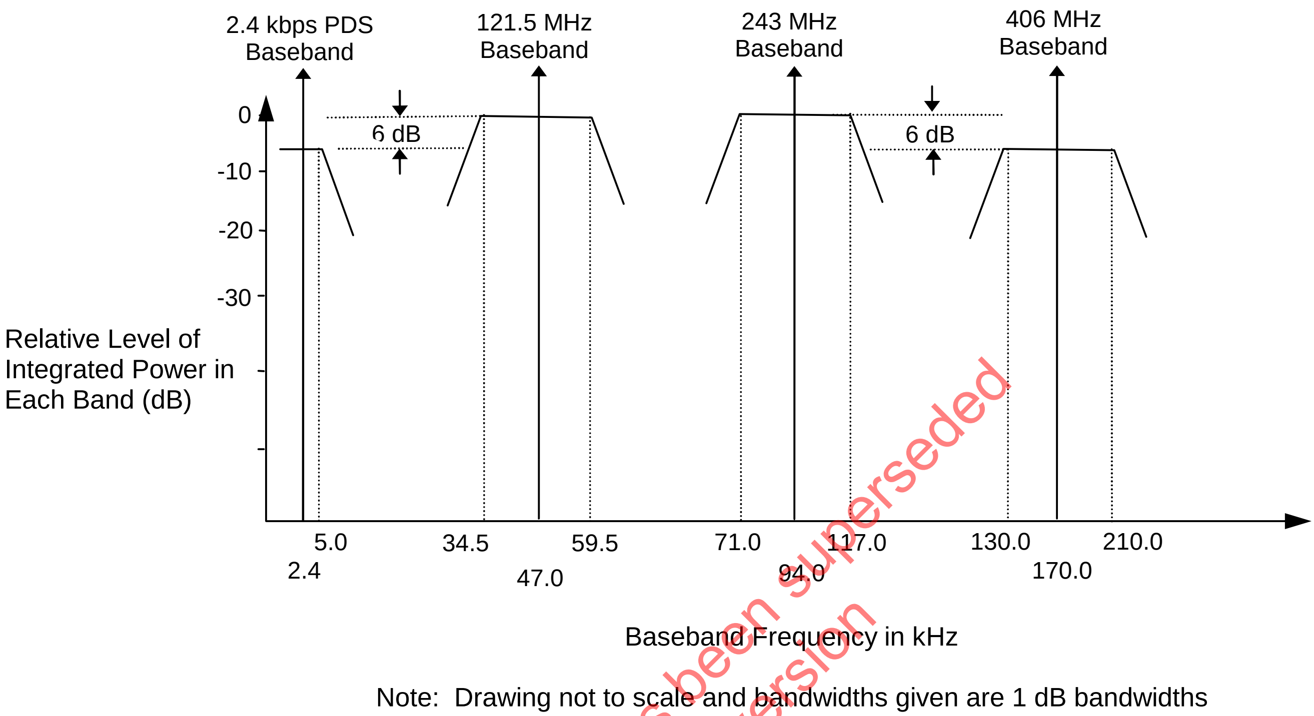


Figure 3.10a: Sarsat SARR Baseband Frequency Spectrum (after termination of 121.5 and 243 MHz satellite processing in February 2009)

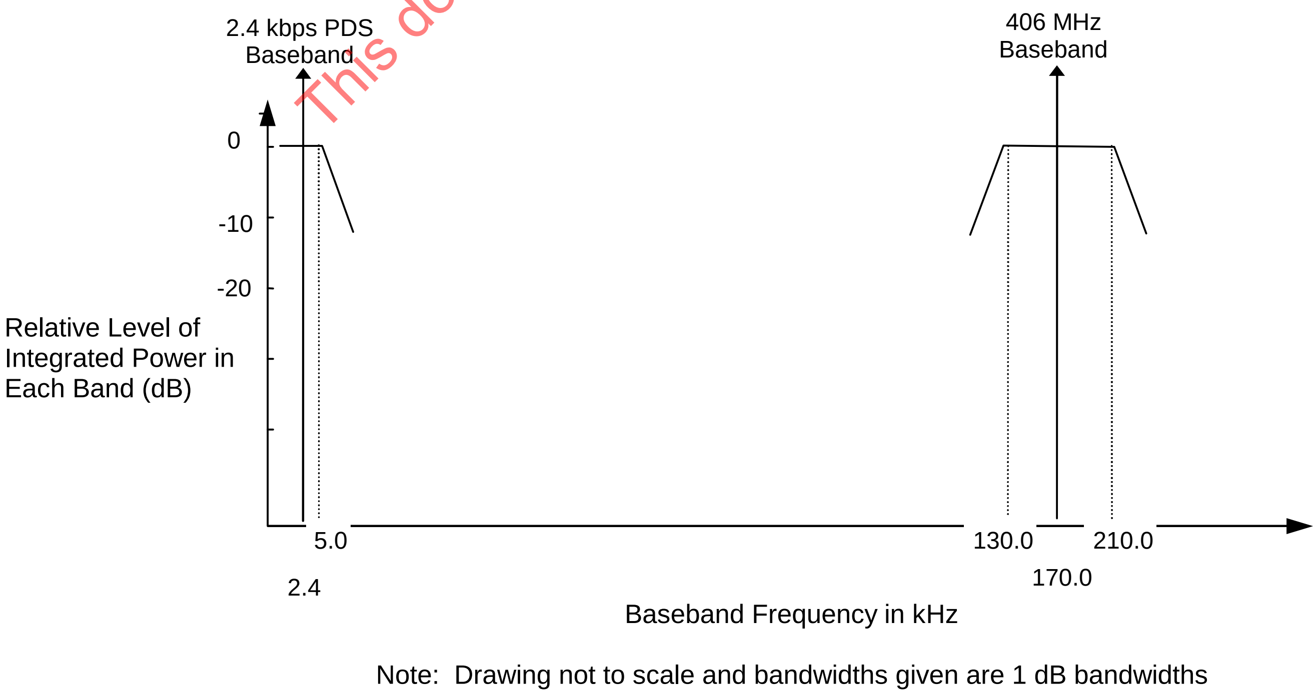


Figure 3.11: Typical Sarsat 1544.5 MHz Observed Downlink Signal

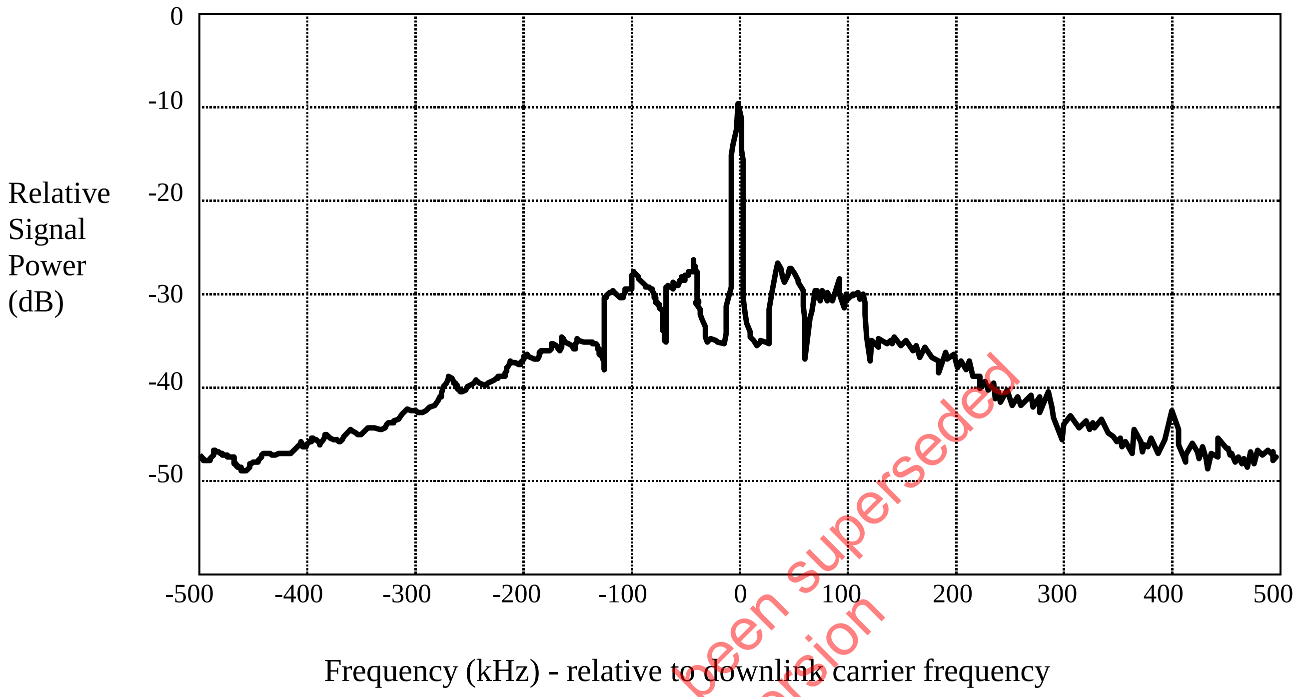


Figure 3.11a: Typical Sarsat 1544.5 MHz Observed Downlink Signal (after termination of 121.5 and 243 MHz satellite processing in February 2009)

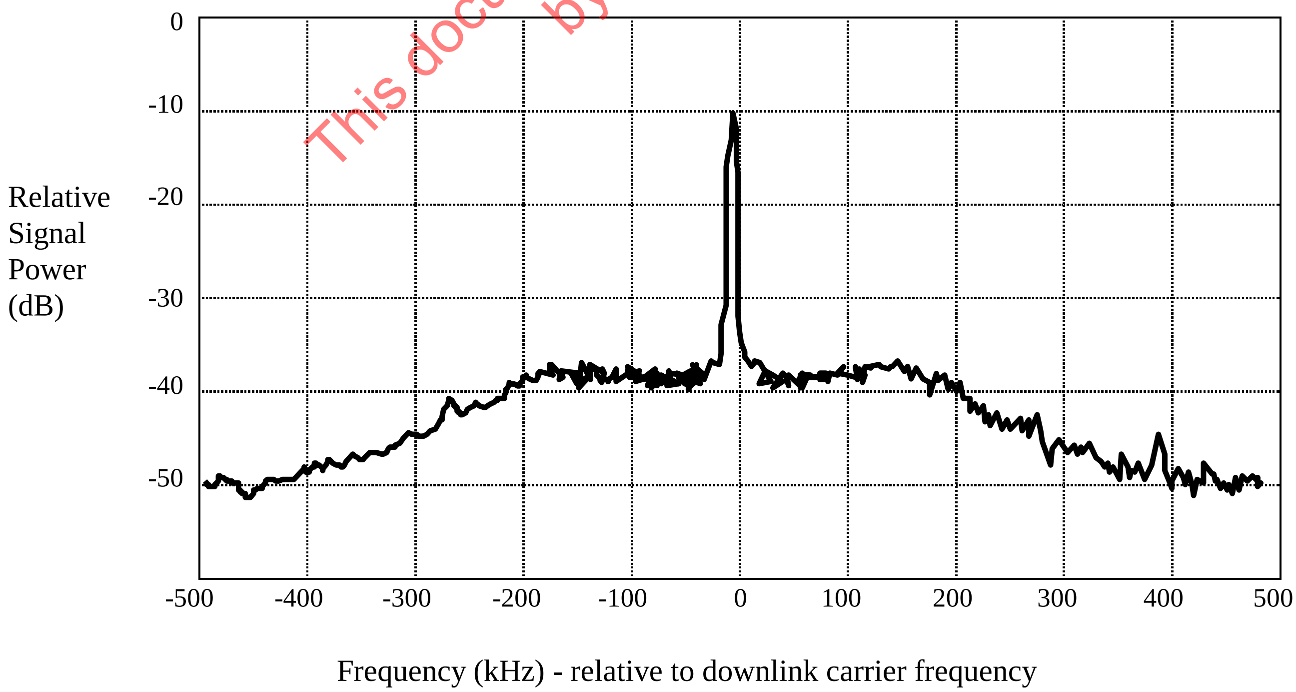
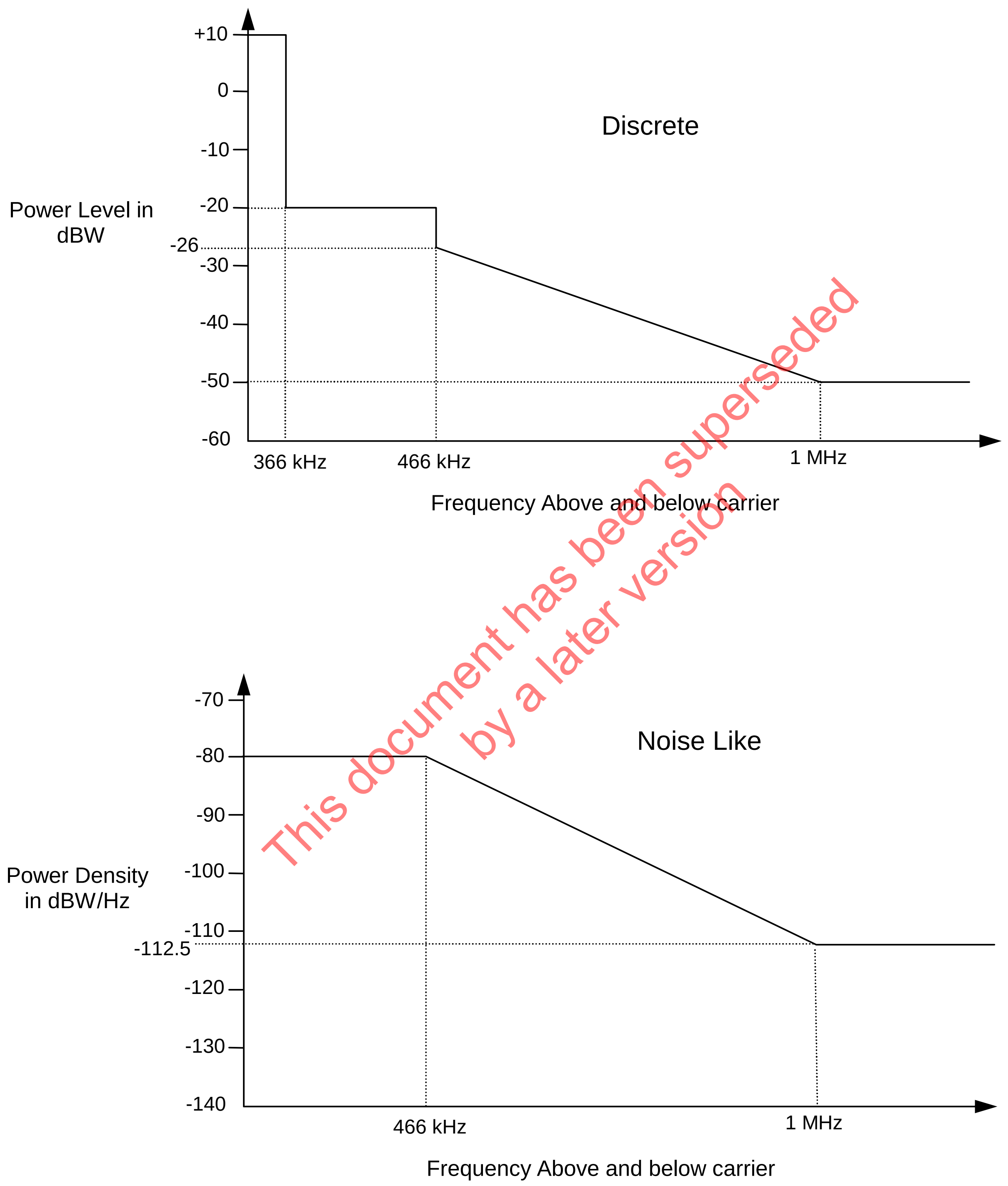


Figure 3.12: Sarsat SARR Transmitter Spurious Emission Limits



- 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-4: SARP-1
Cospas-6: SARP-1
Cospas-8: SARP-1
Cospas-9: SARP-1
Cospas-10: SARP-2
Cospas-11: SARP-2
Cospas-12: SARP-2

Cospas satellites C-1, C-2, C-3, C-5 and C-7 have been decommissioned from service.

4.1.1 Cospas SARP-1

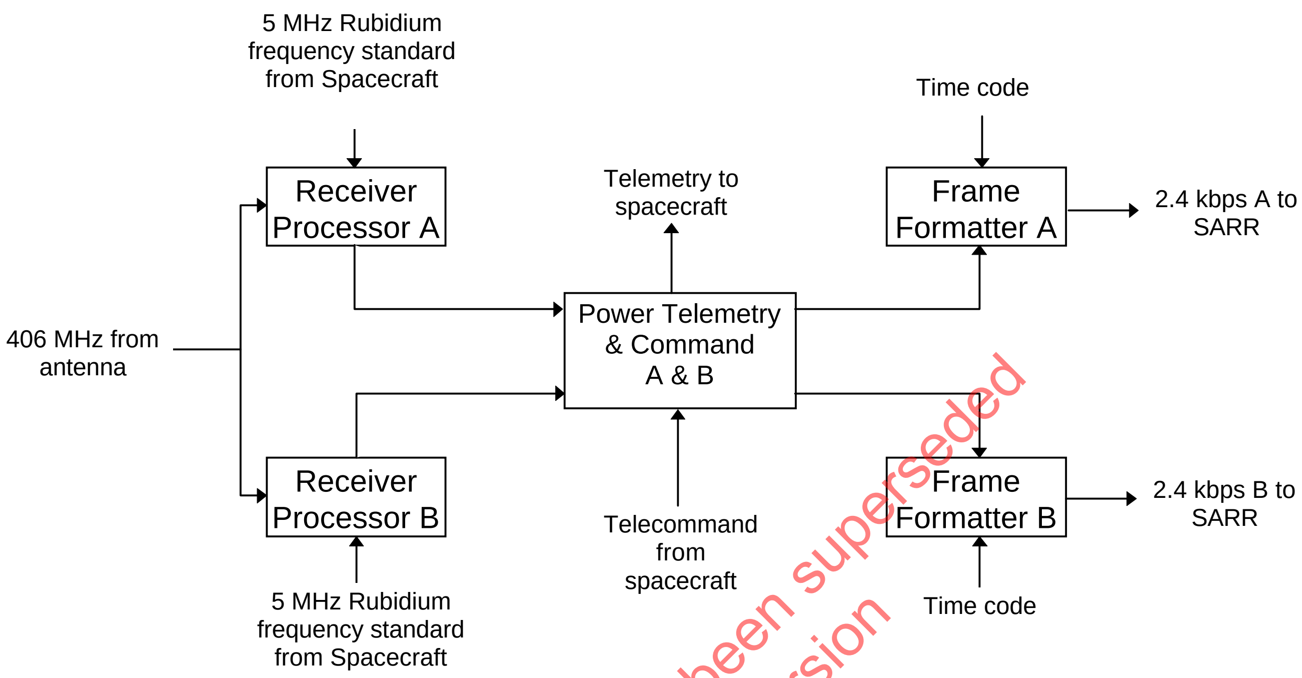
The Cospas SARP-1 functional diagram is given as Figure 4.1 and the SARP-1 parameters given in Table 4.1 are in addition to those given in section 2.

Table 4.1: Cospas SARP-1 Parameters

Parameters	Unit	Values
Receiver Dynamic Range	dBW	-160 to -140
Bit Error Rate[1]	N/A	$< 1 \times 10^{-5}$
Output Data Rate	bps	2400
Time Measurement Increment	ms	20
Ambiguity of Time Tagging	Hrs	24
Number of DRUs	N/A	2
Memory Capacity	messages bits	2048 327680
Message Type Supported	N/A	Short

Note 1: BER applies for signal level of -160 dBW and Receiver Noise Temperature of 600 K.

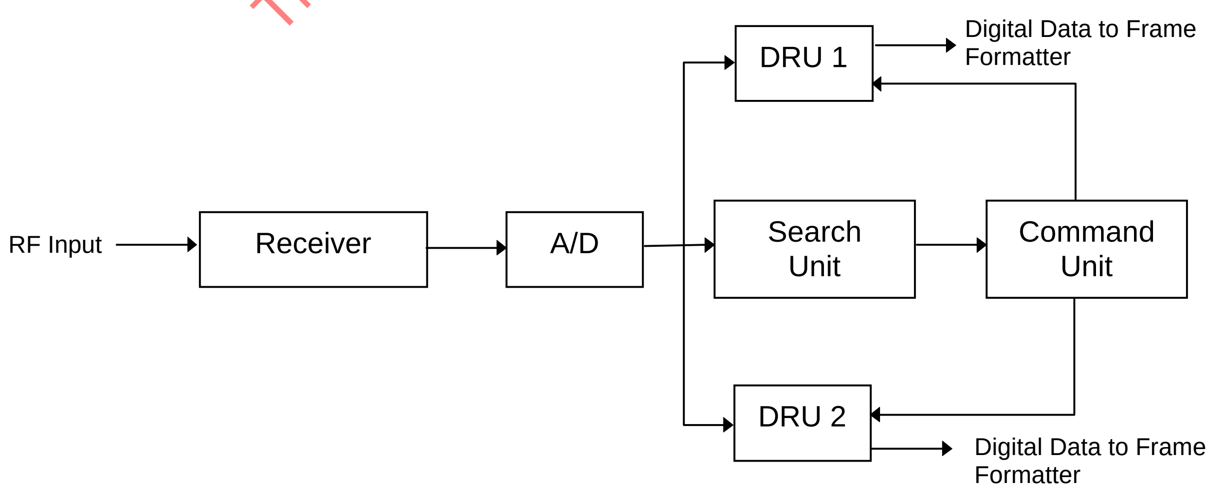
Figure 4.1: Cospas SARP-1 Functional Diagram



4.1.1.1 Cospas SARP-1 Receiver Processor

A functional diagram of the Receiver Processor is shown in Figure 4.2.

Figure 4.2: Cospas SARP-1 Receiver Processor Functional Diagram



Each Receiver Processor contains the following units:

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

After signal conversion to the digital form by the analog-to-digital converter, the spectrum of the signal is analysed by the search unit. The control unit forms commands and provides their distribution to the DRUs.

The two DRUs and the control unit are capable of simultaneously processing two input signals. Frequency reference is provided by a highly-stable oscillator.

4.1.1.2 Cospas SARP-1 Frame Formatter

A functional diagram of the Frame Formatter is shown in Figure 4.3 and consists of a Frame Processor and a Memory. The FF performs the following functions:

a. time-tagging the beginning of the Doppler frequency measurement with the onboard time;

b. formatting the digital information which includes:
   (i) a Doppler frequency measurement,
   (ii) the time at which the Doppler frequency was measured,
   (iii) the beacon digital message,
   (iv) the DRU number;

c. storing the digital information in memory for subsequent playback; and

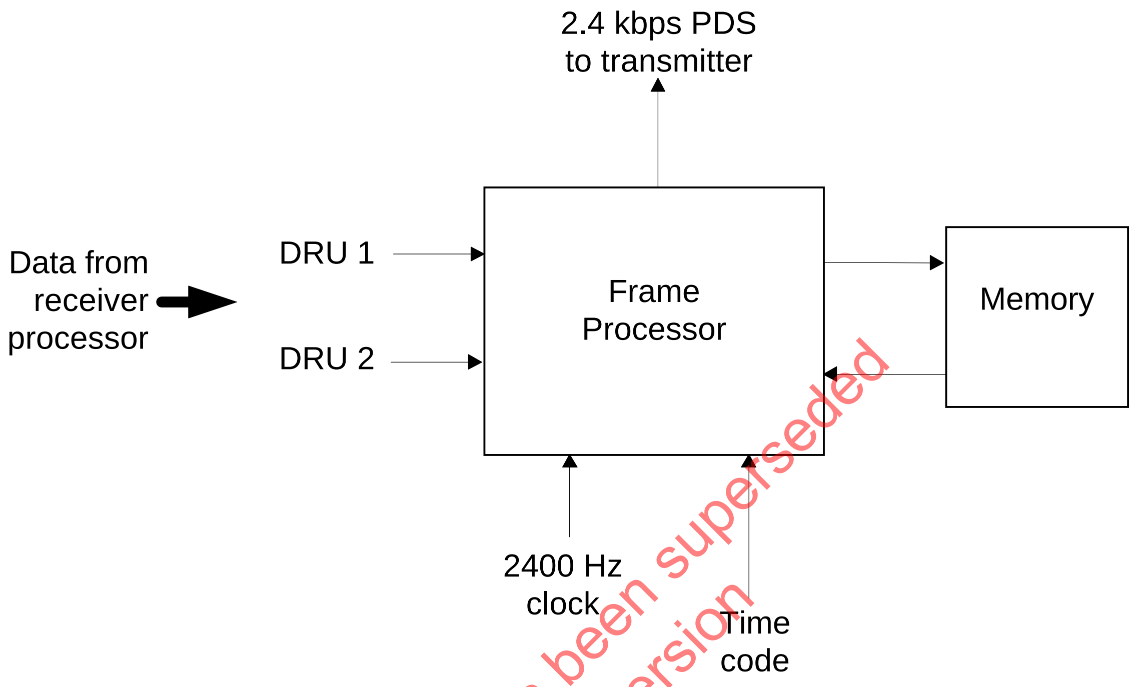
d. passing the Manchester encoded data to the modulator at 2.4 kbps.

The Doppler frequency measurement interval has a duration of 200 ms and begins no more than 20 ms after the start of the 24^{th} bit of the beacon message.

The FF is capable of receiving the information from either of the two DRUs or from both DRUs simultaneously, and the data from each is transmitted sequentially.

When a beacon signal is received during memory playback, the playback is interrupted at the end of its current message. The incoming beacon information is processed, stored in memory, forwarded to the transmitter and then the memory playback resumes. The data is played back from the memory in reverse order, such that the last recorded message is played back first.

Figure 4.3: Cospas SARP-1 Frame Formatter Functional Diagram



4.1.1.3 Cospas SARP-1 Output Format

Beacon messages from the Cospas SARP-1 are transmitted in blocks of 50 words, as shown in the example of Figure 4.4. (see the Note below Figure 4.4)

Prime format rules are:

a. Word # 49 = always '000001'(Hex);
b. Word # 00 = always frame sync '42BB1F'(Hex); and
c. DRU words are sequential and not interleaved.

The bit format for short message format (long not supported) is shown in Figure 4.5, where the Most Significant Bit (MSB) of Word 0 is transmitted first.

In addition to the 4 bit flag, all words contain the following information:

Word 0: Sync word 'D60'(hex) followed by 5 zero bits and the first 3 bits of the hour time code.

Word 1: The time, quantized in steps of 20 ms and synchronised with the beginning of the Doppler count, given as:

Hours	:	minutes	:	seconds	:	20 milliseconds
(remaining 2 bits of the hour code)		(6 bits)		(6 bits)		(6 bits)

The time given is 2hr 59min and 59 sec ahead of UTC (i.e. UTC = Cospas time - 2:59:59)

Words 2 to 5: The beacon format flag bit followed by 79 bits of the beacon message.

Word 6: Last 8 bits of beacon message followed by the DRU# bit and then 11 zeros.

Word 7: The Doppler count is followed by its parity bit. The Doppler frequency is given in Hz to 0.4 Hz by:

$$F_d\,(\mathrm{Hz}) = \frac{N}{12.388224} - 19{,}047.6$$

where N is the Doppler count in decimal form.

The frequency at the input of the satellite receiver, (F_{in}), is given by:

$$F_{in}\,(\mathrm{Hz}) = F_d + 406{,}025{,}000$$

Figure 4.4: Example of a Cospas SARP-1 Output Message

Word	Word Content (Hex)	
41	.D60..	
42	……..	
43	……..	
44	……..	Short
45	……..	Message
46	……..	
47	……..	
48	……..	
49	000001	
00	42BB1F	
01	.D60..	
02	……..	
03	……..	
04	……..	Short
05	……..	Message
06	……..	
07	……..	
08	……..	
09	.D60..	
10	……..	
11	……..	
12	……..	Short
13	……..	Message
14	……..	
15	……..	
16	……..	

Note: Every 24 hours, the Cospas SARP generates a special "zero message" to indicate a change of day in the memory data, as follows:

- a single message having all zeros (i.e. in the time field, the beacon data field and the Doppler data field) is automatically transmitted in the PDS and also inserted into the SARP memory of each Cospas satellite; and
- this "zero message" is generated each day when the on-board clock resets to zero at exactly 00h :00min :00sec Cospas time.

Figure 4.5: Cospas SARP-1 Message Bit Format

Word #	MSB	Word Content (24 bits)		LSB
0	FLAGS (4 bits)	Sync word (12 bits)	5 x 0s (5 bits)	Time Hours (3 bits)
1	FLAGS (4 bits)	Time code (20 bits)		
	Hours (remaining 2 bits)	Minutes (6 bits)	Seconds (6 bits)	20 ms (6 bits)
2	FLAGS (4 bits)	Format flag (1 bit)	Beacon data (19 bits)	
3	FLAGS (4 bits)	Beacon data (20 bits)		
4	FLAGS (4 bits)	Beacon data (20 bits)		
5	FLAGS (4 bits)	Beacon data (20 bits)		
6	FLAGS (4 bits)	Beacon data(8 bits)	DRU# (1 bit)	11 0's
7	FLAGS (4 bits)	Doppler count (19 bits)		Parity (1 bit)

FLAGS :

First bit: Always "0"
Second bit: "0" for primary memory or "1" for secondary memory
Third bit: normally "0", "1" when first message of playback
Fourth bit: "0" for dump from memory or "1" for real time

Sync word: D60

DRU# : "0" for DRU1 or "1" for DRU2

Parity bit in word 7: '1' with odd number of '1s' in the 19 bits of the Doppler count

4.1.2 Cospas SARP-2

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 4.2 are in addition to those given in section 2.

4.1.2.1 Cospas SARP-2 Receiver Processor

A functional diagram of the Receiver Processor is shown in Figure 4.6.

The Receiver Processor unit is composed of the following:

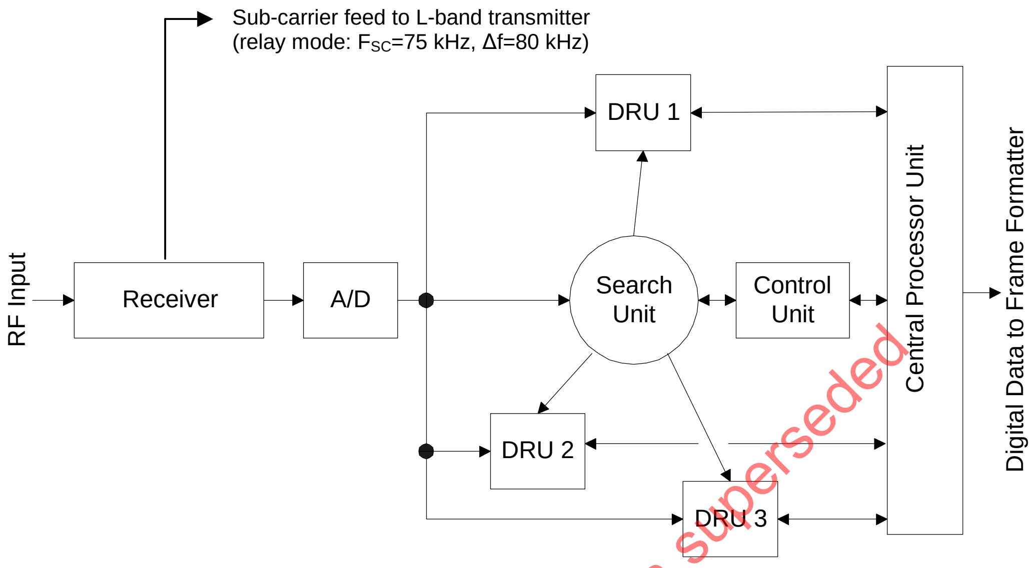
a. one dual-conversion receiver;
b. one Analog to Digital (A/D) converter;
c. one Search Unit;
d. three Data Recovery Units (DRUs);
e. one Control Unit;
f. one Central Processor Unit; and
g. Power, Telemetry and Command circuits.

Table 4.2: 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 (2 yr.): Short term (1 sec.):		 N/A N/A	 1×10^{-6} 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	2,400 460,800
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 4.6: 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."

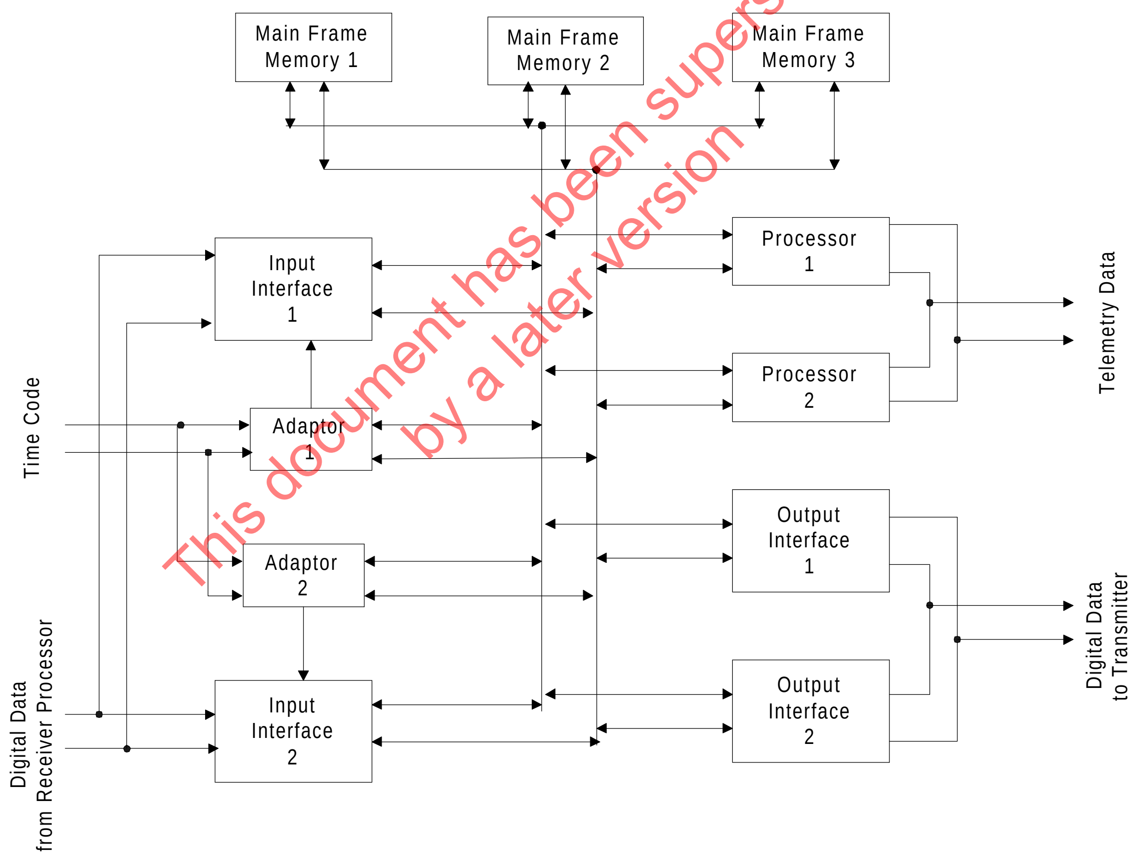
The control unit performs the following functions:

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

4.1.2.2 Cospas SARP-2 Frame Formatter

A functional diagram of the Frame Formatter (FF) is shown in Figure 4.7. The FF accepts all messages received from the DRUs and recorded messages are passed continuously to the modulator of the transmitter.

Figure 4.7: Cospas SARP-2 Frame Formatter Functional Diagram



4.1.2.3 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 4.8 (see the Note below Figure 4.8).

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 4.9 and 4.10. 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:

$$\text{Level (dBW)} = -(130 + L)$$

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, F_{in}, is given by:

$$F_{in}\,(\text{Hz}) = F_d + 406{,}010{,}000$$

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 4.8: 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	

Note: Every 24 hours, the Cospas SARP generates a special "zero message" to indicate a change of day in the memory data, as follows:

- a single message having all zeros (i.e. in the time field, the beacon data field and the Doppler data field) is automatically transmitted in the PDS and also inserted into the SARP memory of each Cospas satellite; and
- this "zero message" is generated each day when the on-board clock resets to zero at exactly 00h : 00min : 00sec Cospas time.

Figure 4.9: Cospas 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)	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 : minutes : seconds : 16 ms (5 bits) (6 bits) (6 bits) (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 4.10: 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 : minutes : seconds : 16 ms (5 bits) (6 bits) (6 bits) (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-4: SARP-1 Sarsat-6: SARP-1
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

The SARP instruments on Sarsat satellites S-1, S-2, S-3, and S-5 have been decommissioned from service.

4.2.1 Sarsat SARP-1

A functional diagram of the SARP-1 is shown in Figure 4.11. SARP-1 parameters given in Table 4.3 below are in addition to those given in section 2.

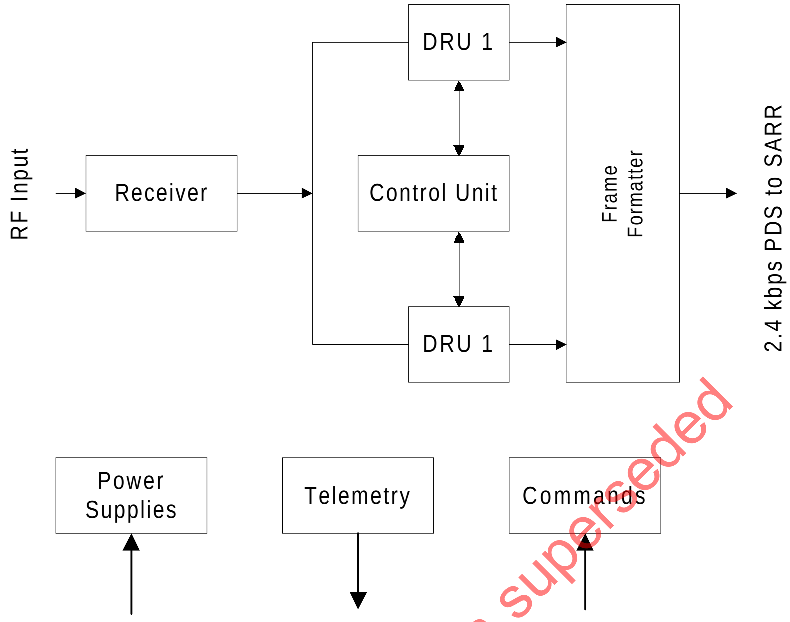
Table 4.3: Sarsat SARP-1 Parameters

Parameters	Unit	Values
Receiver Centre Frequency	MHz	406.025
Receiver Bandwidth (1 dB)	kHz	24
Receiver Dynamic Range	dBW	-161 to -138
Bit Error Rate[1]	N/A	< 1 x 10^{-5}
Output Data Rate	bps	2402
Time Measurement Increment	ms	19.6 (approx.)
Ambiguity of Time Tagging	Hrs	45.7 (approx.)
Number of DRUs	N/A	2
Memory Capacity Short messages: Long messages:	bits messages messages	330k (approx.)[2] 2048 1820
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: Not all the message bits are stored in memory. Bits that are not stored are generated on transmission.

Figure 4.11: Sarsat SARP-1 Functional Diagram



4.2.1.1 Sarsat SARP-1 Receiver Processor

The SARP-1 processes, formats and stores all data coming from the DRUs and outputs them for retransmission via the SARR downlink in either real-time (working if memory is either ON or OFF) or playback (working only if memory is ON).

Five commands control the memory operation as follows:

1. Memory OFF:

   Removes power from memory and resets status of all read modes to OFF. In this case, data are transmitted in real time mode only as shown in Figure 4.12.

2. Memory ON:

   Activates the writing but not the reading. When a message is received it is simultaneously transmitted in real time and stored in the memory. If the memory is already filled, the new message overwrites the oldest message. This command resets the status of all read modes to OFF.

3. Read memory continuously (operational mode):

   If memory is ON, this command causes stored messages to be read and transmitted on a "LAST IN FIRST OUT" basis, starting with the latest (most recent) message and ending with the oldest, and to repeat this process continuously until another memory command is received.

   Transmission of playback (stored) messages is interrupted (at the end of a message) when a new message is received, and resumes when the new message has been transmitted. If the memory is filled and new messages are received during the playback, the last message received will be stored as the latest message in memory. Memory content is not affected by reading in this mode. This command also resets the status of the other read modes to OFF.

During the orbital life, this mode will be the nominal one.

4. Read memory single shot (test mode):

   Exactly the same as read memory continuously, except that playback is terminated at the end of one cycle.

5. Read/Erase memory single shot:

   Exactly the same as read memory single shot, except that the content of the memory is erased (replaced by "zero" words) by the reading.

If any one of the read commands is received during the transmission of a message, transmission of that message is completed, and then the mode indicated by the read command is implemented with playback starting with the most recent message stored in the memory.

If the command "Memory ON" is received while the memory is already working in any one of the three read modes, the reading is stopped and the status of the read modes are reset to OFF.

Figure 4.12: Example of a Sarsat SARP-1 Real Time Message

Word #	Word Content (Hex)
48	word 6b
49	word 7b
00	42BB1F
01	word 8
02	000001
03	000001
04	word 0
05	word 1
.	
.	
.	
47	word 7a
48	000001
49	000001
00	42BB1F
01	000001
02	000001
03	word 0
04	word 1
05	word 2

4.2.1.2 Sarsat SARP-1 Output Format

Beacon messages from the Sarsat SARP-1 are transmitted in blocks of 50 words as shown in the example of Figure 4.13.

Whenever the memory is ON, incoming messages received into the memory unit are simultaneously transmitted directly (real time messages) and stored in the memory for the subsequent transmission on a Last In First Out (LIFO) basis. When any one of the playback (read memory) modes is active, there will be continuous transmission of stored messages (LIFO), one immediately following another.

Playback message transmission will be interrupted if a new message becomes available for real time transmission, but only upon completion of transmission (and storage) of the new message. Playback transmission will resume where it stopped.

If none of the playback modes is active and no messages are available for real time transmission, filler or "zero" words are transmitted.

Prime format rules are:

a. Zero words '000001'(Hex) are inserted between messages 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 zero word will precede resumption of playback which will start by the first word of the most recent stored message (see Figure 4.12).

Figure 4.13: Example of a Sarsat SARP-1 Output Message

Word #	Word Content Hex		
37	.D60..		
38	……		
39	……		
40	……	Long	Playback
41	……	Message	
42	……		
43	……		
44	……		
45	……		
46	.D60..		
47	……		
48	……		
49	……	Short	Real
00	42BB1F	Message	Time (RT)*
01	……		
02	……		
03	……		
04	……		
05	.D60..		
06	……		
07	……		Playback
08	……	Short	oldest
09	……	Message	message
10	……		in memory
11	……		
12	……		
13	000001		
14	.D60..		
15	……		Playback
16	……		of most
17	……	Short	recently
18	……	Message	stored
19	……		message
20	……		(RT* above)
21	……		

The bit format for both the short and long messages are shown in Figures 4.14 and 4.15, where the Most Significant Bit (MSB) of Word 0 is transmitted first. In addition to the DRU#, all words contains the following information:

Word 0: Sync word 'D60' (Hex) followed by an 5 bit received signal level and then the first 3 most significant bits of time code. The level is given by:

$$\text{Level (dBm)} = 1.02L - 137$$

where L = the 5-bit level converted to decimal form

Word 1: The next 20 bits of time synchronised with the start of the Doppler count. The time is given by:

$$T = T_o + 2^{23}ks + s(M_d + 1)$$

where $s = \dfrac{94208}{F_r} \approx 19.608\text{ms}$ (the resolution time of the counter);

$F_r \approx 4\ 804\ 434$ Hz;

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 reset 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 5: The flag bit followed by the first 79 bits of the beacon message.

Word 6a: Last 8 bits of beacon short message followed by 12 zeros.

Word 6b: 20 bits of beacon long message.

Word 7a
and 8: The Doppler count in two parts ('N' and 'n'). The frequency at the input of the satellite receiver, F_{in}, is given by:

$$F_{in} = \frac{F_r}{2}\left(169 + \frac{K + N_d}{P + n_d}\right) \text{Hz}$$

where K = 4096; P = 282560; $F_r \approx$ 4 804 434 Hz; and N_d is 'N' and n_d is 'n' in decimal

Word 7b: Last 20 bits of beacon long message.

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 4.14: Sarsat SARP-1 Short Message Bit Format

Word #	MSB Word		Content(24 bits)	LSB
0	DRU# (4 bits)	Sync word (12 bits)	Received level (5 bits)	Time code (3 bits)
1	DRU# (4 bits)		Time code (20 bits)	
2	DRU# (4 bits)		Format flag (1 bit)	Beacon data (19 bits)
3	DRU# (4 bits)		Beacon data (20 bits)	
4	DRU# (4 bits)		Beacon data (20 bits)	
5a	DRU# (4 bits)		Beacon data (20 bits)	
6a	DRU# (4 bits)		Beacon data (8 bits)	12 0's
7a	DRU# (4 bits)	Doppler count N (12 bits)	Doppler count n (7 bits)	Parity (1 bit)

Figure 4.15: Sarsat SARP-1 Long Message Bit Format

Word #	MSB		Word Content(24 bits)	LSB
0	DRU# (4 bits)	Sync word (12 bits)	Received level (5 bits)	Time code (3 bits)
1	DRU# (4 bits)		Time code (20 bits)	
2	DRU# (4 bits)		Format flag (1 bit)	Beacon data (19 bits)
3	DRU# (4 bits)		Beacon data (20 bits)	
4	DRU# (4 bits)		Beacon data (20 bits)	
5b	DRU# (4 bits)		Beacon data (20 bits)	
6b	DRU# (4 bits)		Beacon data (20 bits)	
7b	DRU# (4 bits)		Beacon data (20 bits)	
8	DRU# (4 bits)	Doppler count N (12 bits)	Doppler count n (7 bits)	Parity (1 bit)

Notes:
Format flag in word 2 : '0' for short message and '1' for long message.

DRU#: First bit: "0" for DRU 1 or "1" for DRU2.
Second bit: Always "0".
Third bit: Real Time = "0".
Playback = "1" most recent or "0" for all other.
Fourth bit: "0" for playback message or "1" for real time.

Parity bit in words 7a and 8: '1' with odd number of '1s' in the 19 bits of the Doppler count.

4.2.2 Sarsat SARP-2

Except for using three DRUs, the functional diagram of the SARP-2 Processor is similar to that of the SARP-1, as shown in Figure 4.16.

SARP-2 parameters given in Table 4.4 are in addition to those given in section 2.

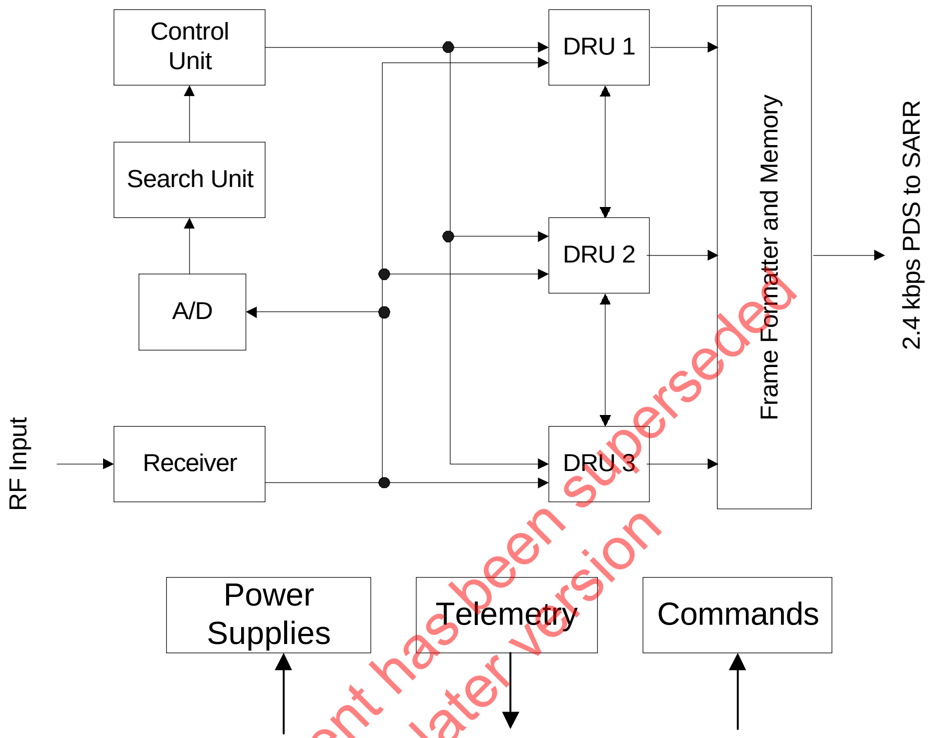
Table 4.4: Sarsat SARP-2 Parameters

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 4.16: Sarsat SARP-2 Functional Diagram



4.2.2.1 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.

4.2.2.2 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 4.17.

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 4.18 and 4.19, where the Most Significant Bit (MSB) of Word 0 is transmitted first. All words contains 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 $a = \dfrac{1}{2^{19} \times 624} \approx 3.05664845002 \times 10^{-9}$;

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

$F_r \approx 5\ 203\ 205$ 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 4.18, 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 4.17: Example of a Sarsat SARP-2 Output Message

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

Figure 4.18: 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 4.19: 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

4.2.3 Sarsat SARP-3

The functional diagram of the SARP 3 Processor is shown in Figure 4.20.

SARP-3 parameters given in Table 4.5 are in addition to those given in section 2.

Table 4.5: Sarsat SARP-3 Parameters

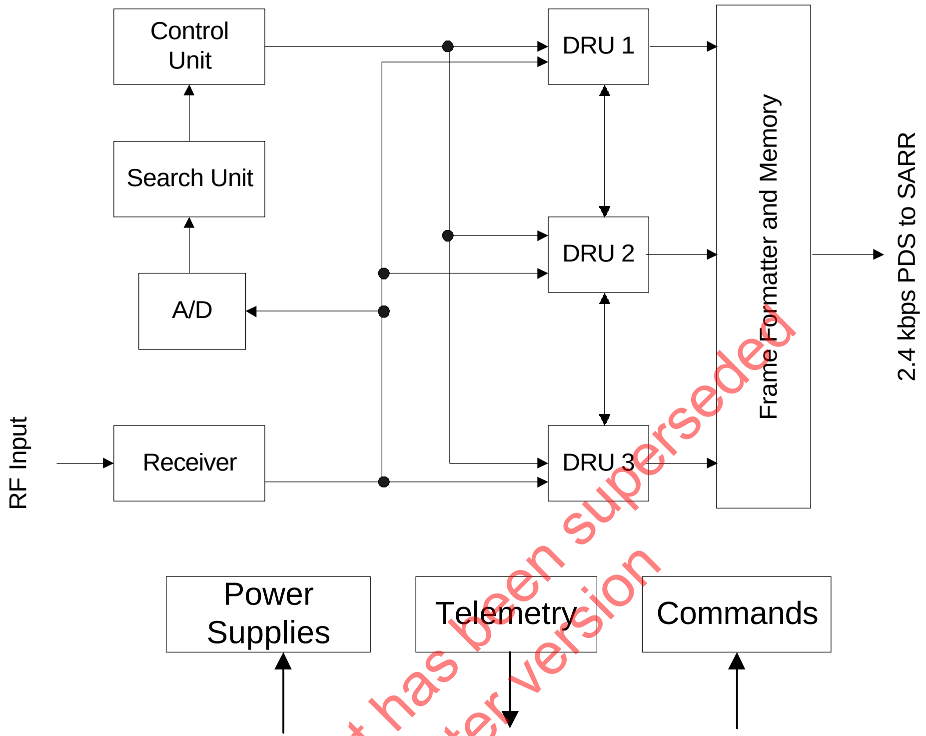
Parameters		Unit	Values
Receiver Centre Frequency - (selectable)	Mode 1 Mode 2 Mode 3	MHz	406.0235 406.0300 406.0500
Receiver Bandwidth (1 dB) - (selectable)	Mode 1 Mode 2 Mode 3	kHz	27 40 80
Receiver Dynamic Range		dBW	-161 to -138
Bit Error Rate[1]		N/A	$< 1 \times 10^{-5}$
Output Data Rate		bps	2409
Time Measurement Increment		ms	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[2] 400k approx.
Message Types Supported		N/A	Short and long

Notes: 1. BER applies for signal level of -161 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 4.20: Sarsat SARP-3 Functional Diagram



4.2.3.1 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 4.24.

4.2.3.2 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 4.21.

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 4.22 and 4.23, 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:

$$T = T_o + 2^{23}ks + s(M_d + 1)$$

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.

Word 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 compliment

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 4.21: Example of a Sarsat SARP-3 Output Message

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

Figure 4.22: 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 4.23: 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
000	32.3 (31 ≤ S/No < 33.7)
001	34.8 (33.7 ≤ S/No < 35.9)
010	37.5 (35.9 ≤ S/No < 39.2)
011	41.1 (39.2 ≤ S/No < 43.0)
100	45.2 (43.0 ≤ S/No < 47.4)
101	50.1 (47.4 ≤ S/No < 52.8)
110	55.5 (52.8 ≤ S/No < 58.3)
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 4.24: 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, three antennas (two 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 (SRA for 121.5 MHz and SPA for 406 MHz) have the following characteristics:

Polarisation	- LHCP for 121.5 MHz; RHCP for 406 MHz
Gain	- as shown in Figures 5.2 and 5.3
Axial ratio	- as derived by the maximum and minimum contours on gain Figures.
Frequency	- 121.5 MHz ±20 kHz - 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 Figure 5.4
Axial ratio	- as stated in gain Figure
Frequency	- 1544.5 MHz ±500 kHz

Figure 5.1: Cospas Antenna System Functional Diagram

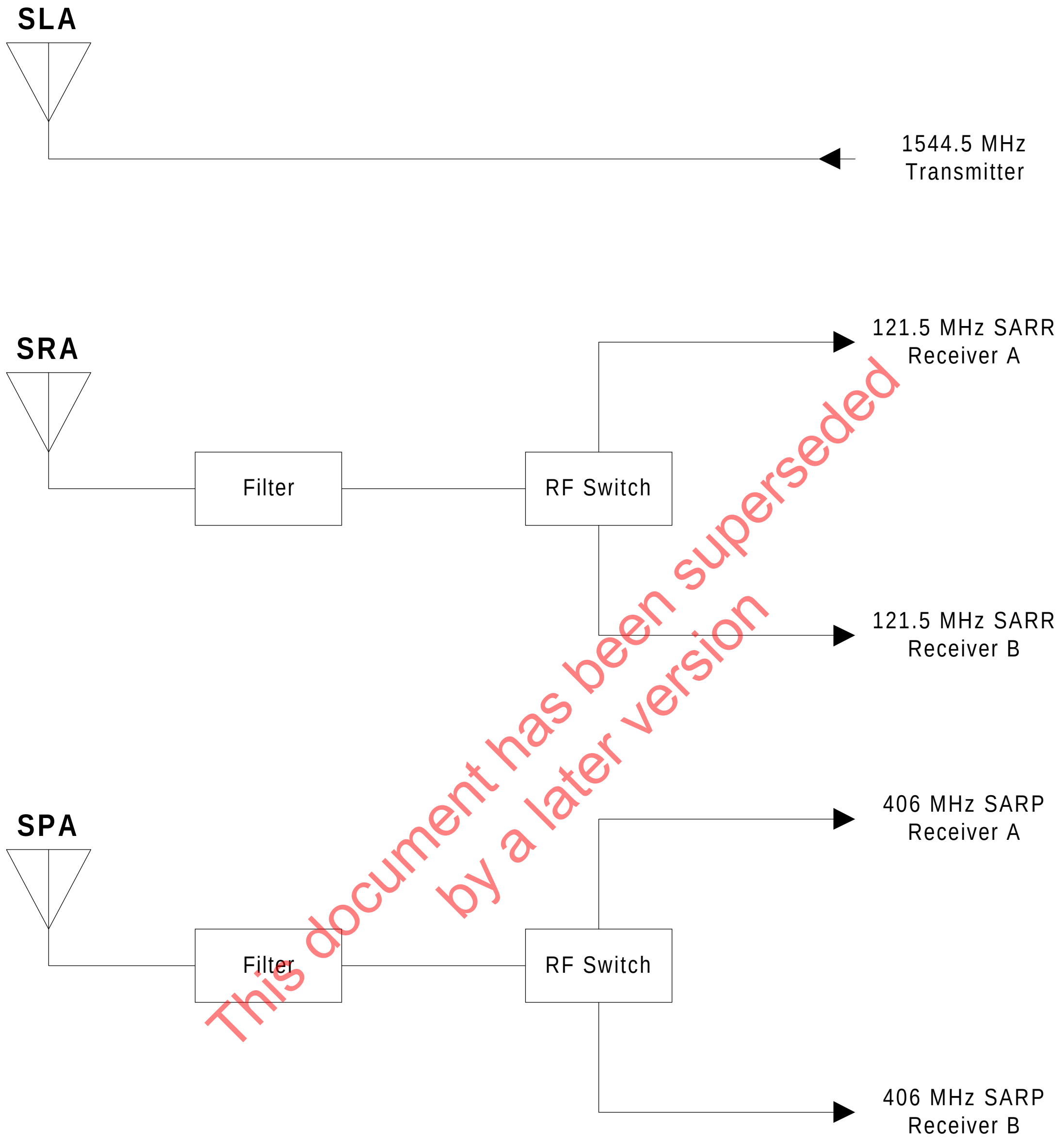
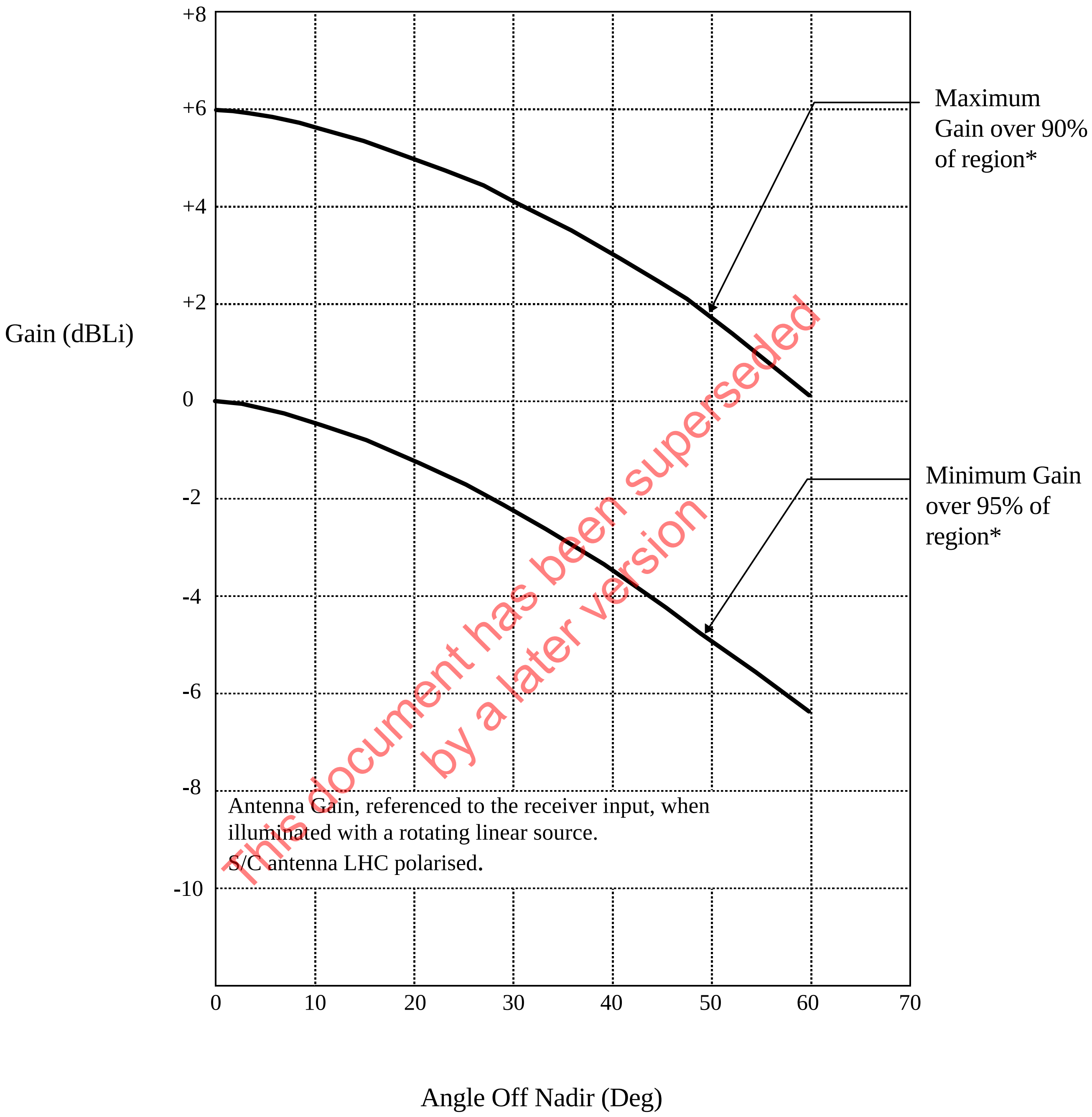
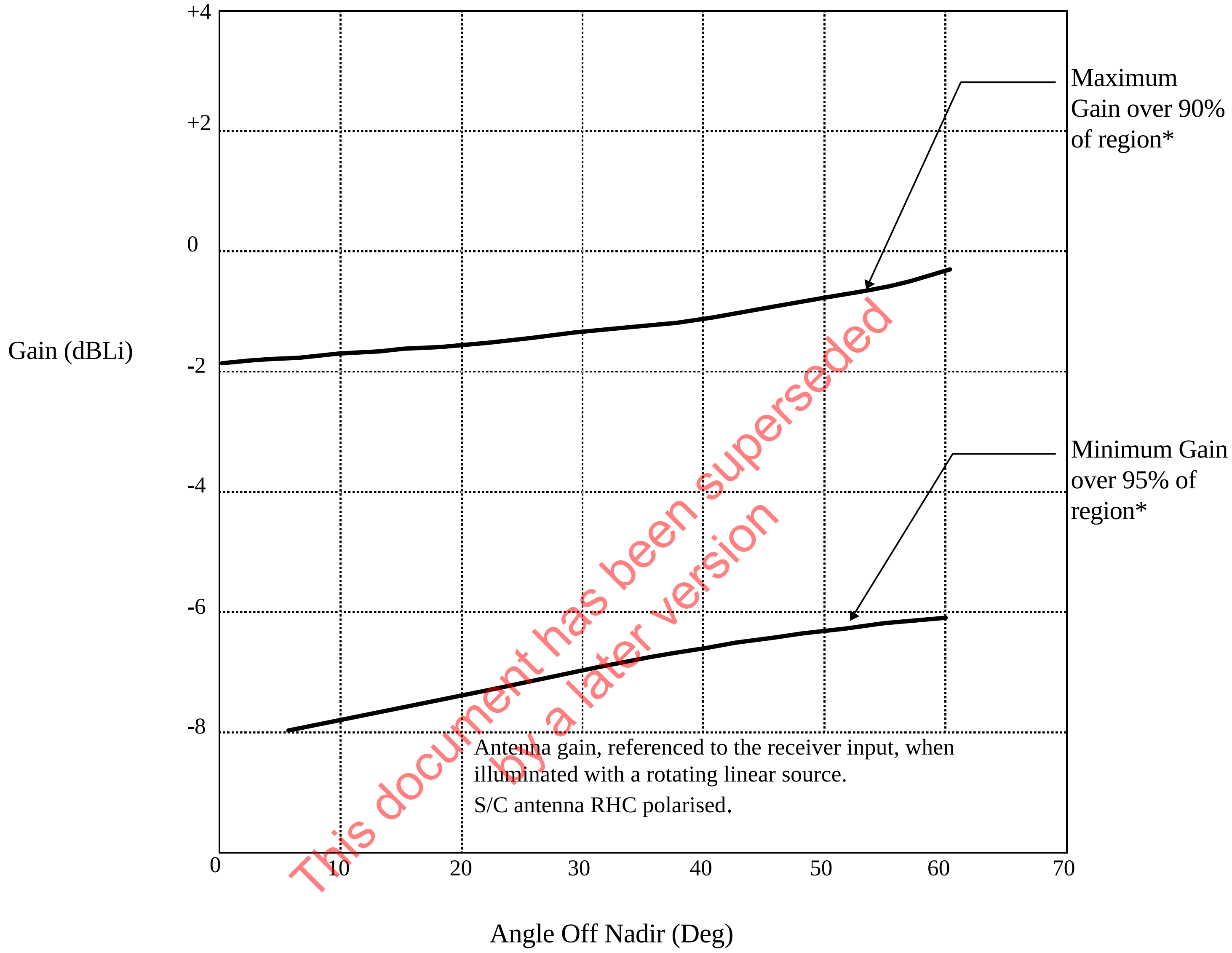


Figure 5.2: Cospas 121.5 MHz Receive Antenna (SRA) Gain Pattern



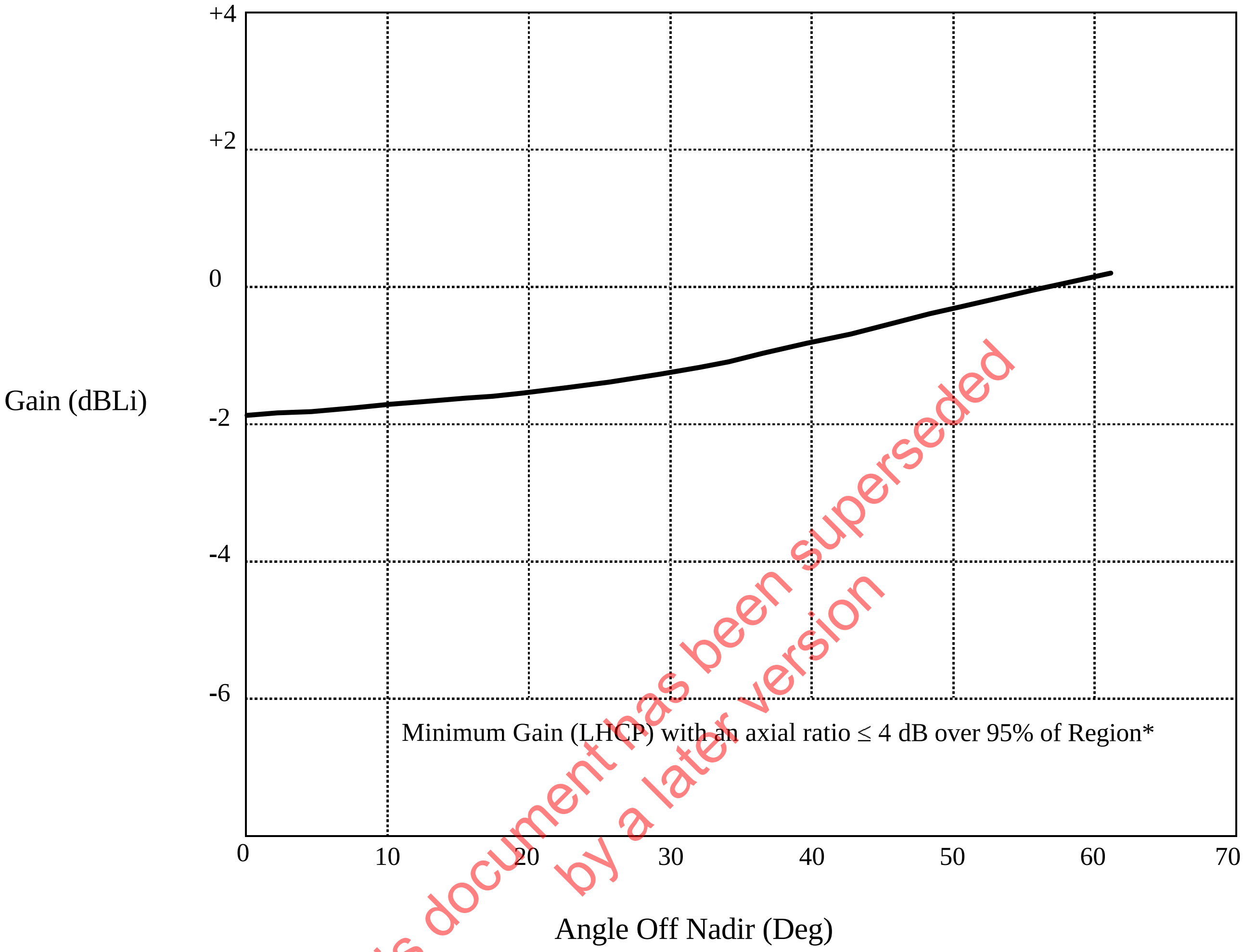
* Region defined by 0° ≤ azimuth ≤ 360° and by 0° ≤ nadir ≤ 60°

Figure 5.3: Cospas SARP Receive Antenna (SPA) Gain Pattern



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

Figure 5.4: Cospas SARP 1544.5 MHz Transmit Antenna (SLA) Gain Pattern



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

5.2 Sarsat Antennas

As shown in Figure 5.5, four antennas (three 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 Receive Antennas

The SARR Receive Antenna (SRA) consist of two coaxial quadrifilar antennas. The outer quadrifilar is used for the 121.5 and 243 MHz receivers while the inner one is used for the 406.05 MHz receiver.

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

Sarsat receive antennas have the following characteristics:

Polarisation	- RHCP
Gain	- as shown in Figures 5.6 to 5.9 inclusive
Axial ratio	- as derived by the maximum and minimum contours on gain Figures.
Frequency:	
SARR:	- 121.5 MHz ±20 kHz
	- 243.0 MHz ±30 kHz
	- 406.05 MHz ±50 kHz
SARP	- 406.05 MHz ±50 kHz

5.2.2 Sarsat 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 Figure 5.10
Axial ratio	- as stated in gain Figure
Frequency	- 1544.5 MHz ±500 kHz

Figure 5.5: Sarsat Antenna System Functional Diagram

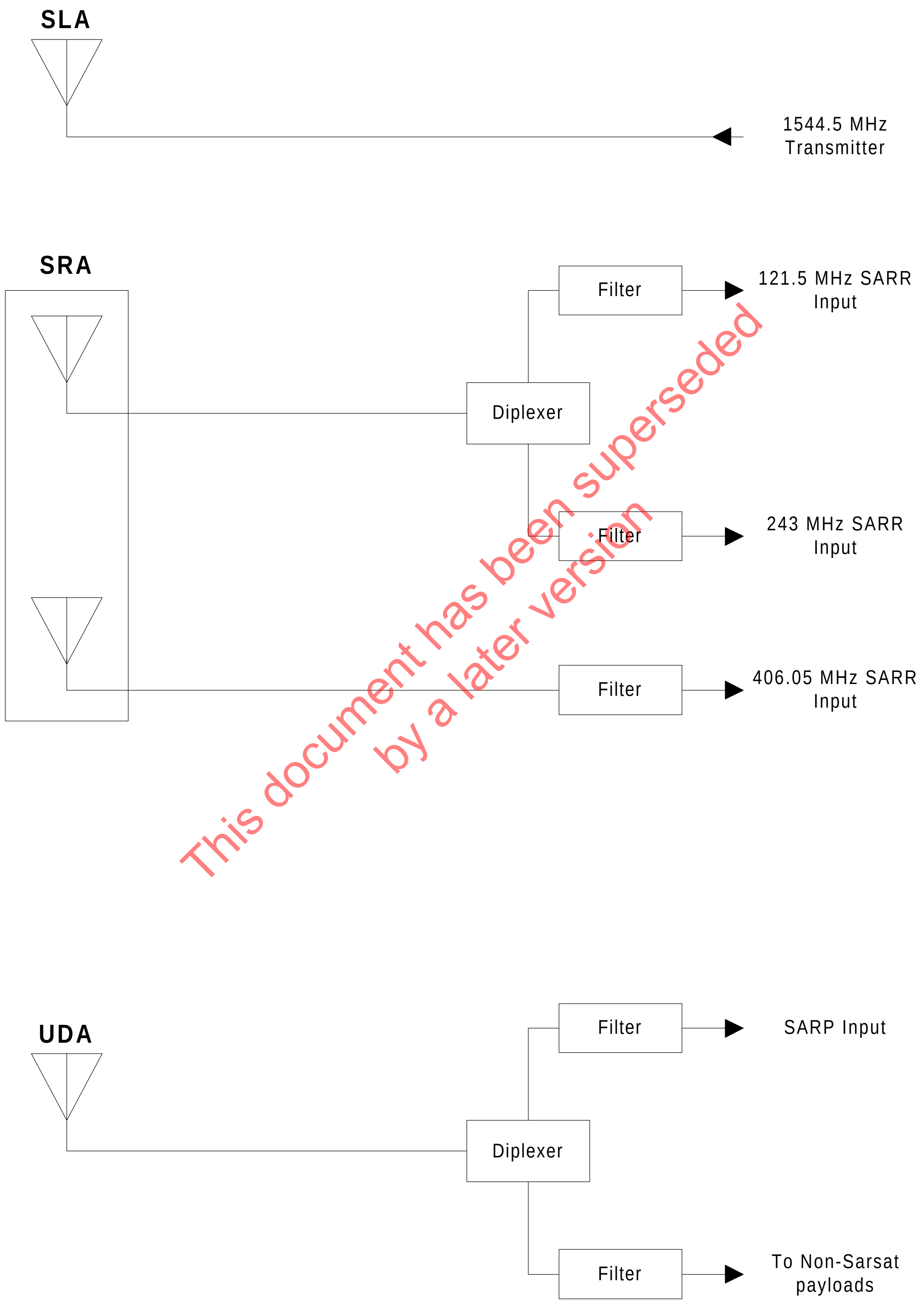
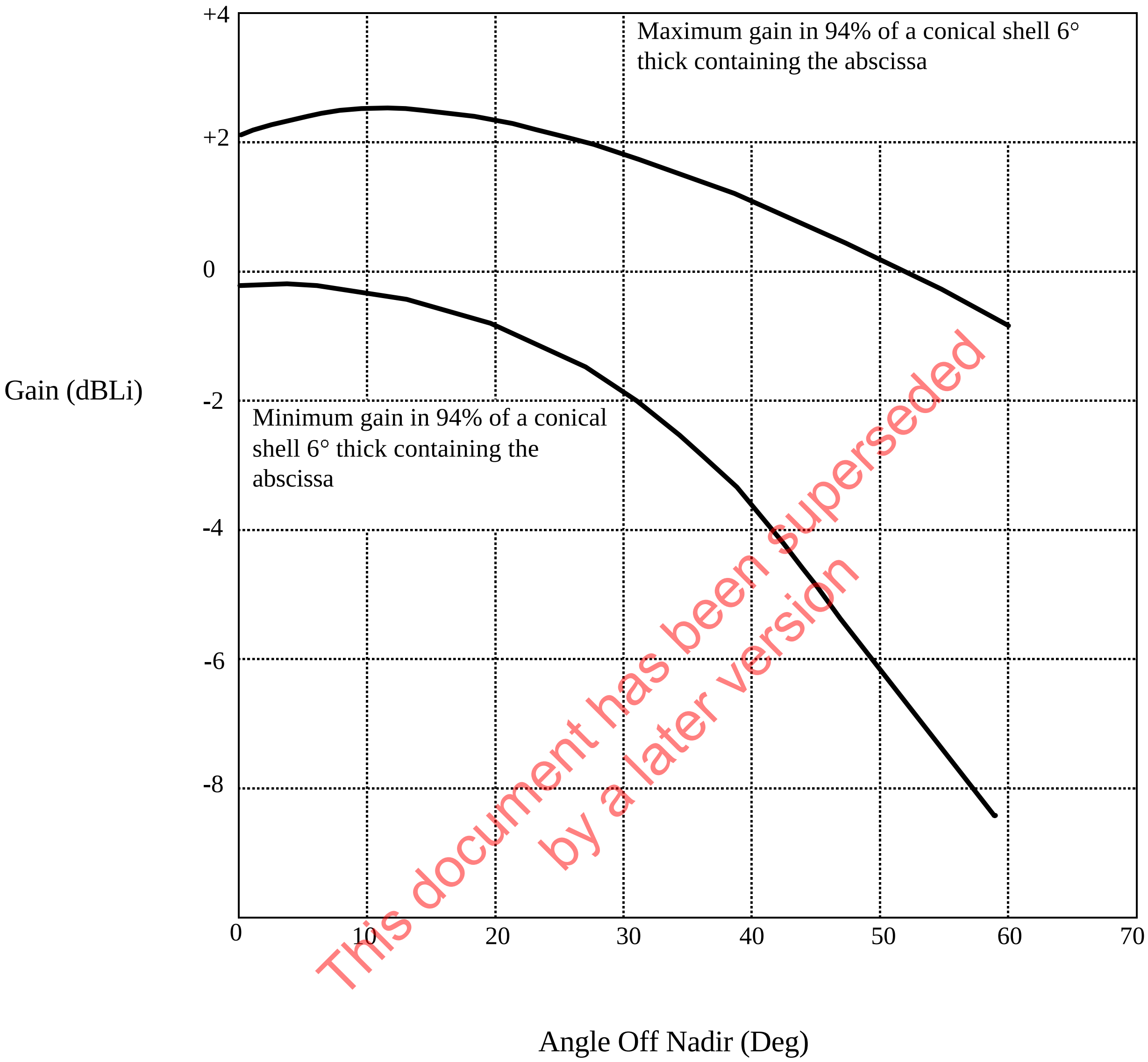
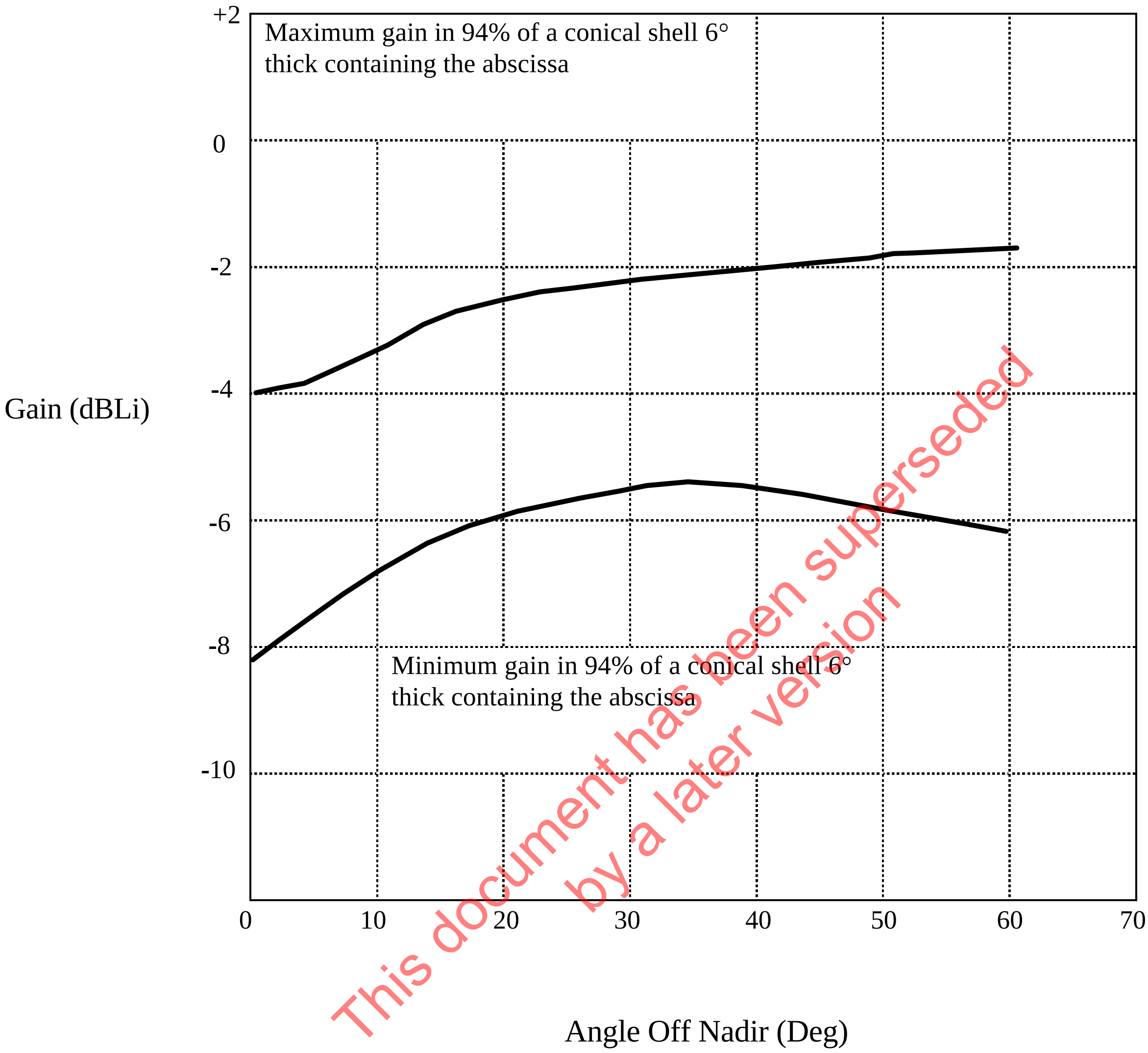


Figure 5.6: Sarsat 121.5 MHz Receive Antenna (SRA) Gain Pattern (at receiver input)



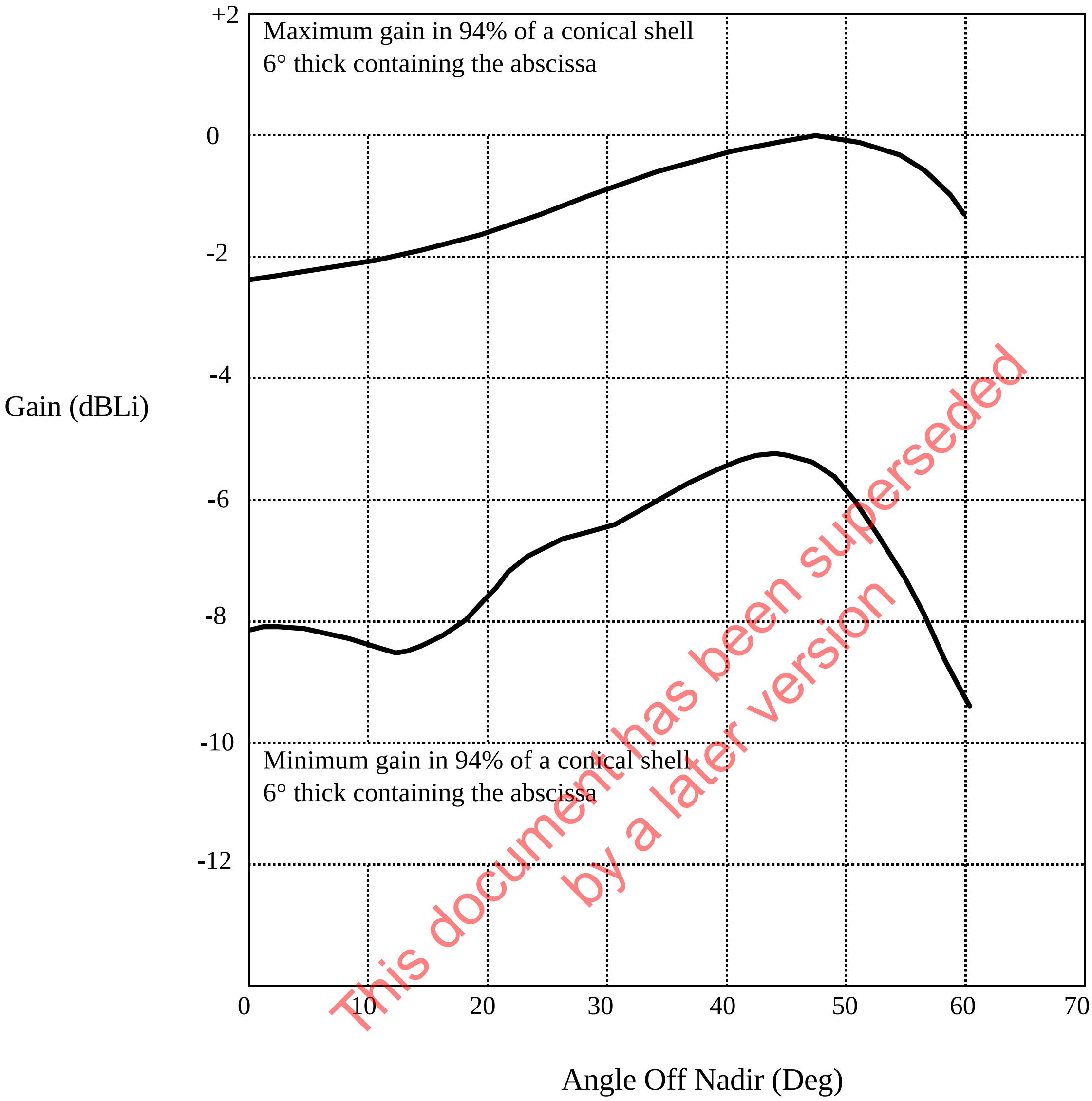
Antenna gain referenced to the receiver input, when illuminated with a rotating linear source. Spacecraft antenna is RHC polarised.

Figure 5.7: Sarsat 243 MHz Receive Antenna (SRA) Gain Pattern (at receiver input)



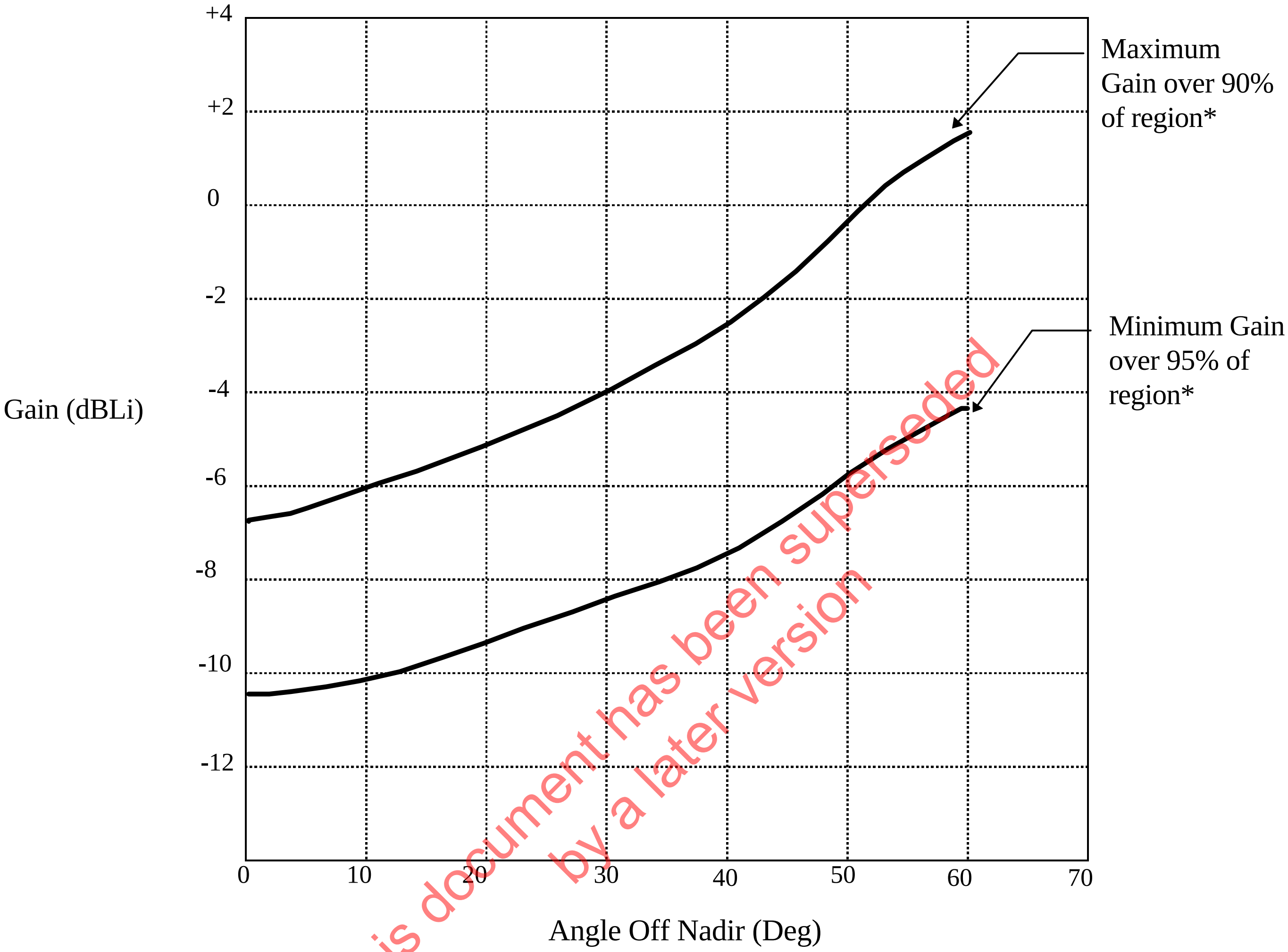
Antenna gain referenced to the receiver input, when illuminated with a rotating linear source. Spacecraft antenna is RHC polarised.

Figure 5.8: Sarsat 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.

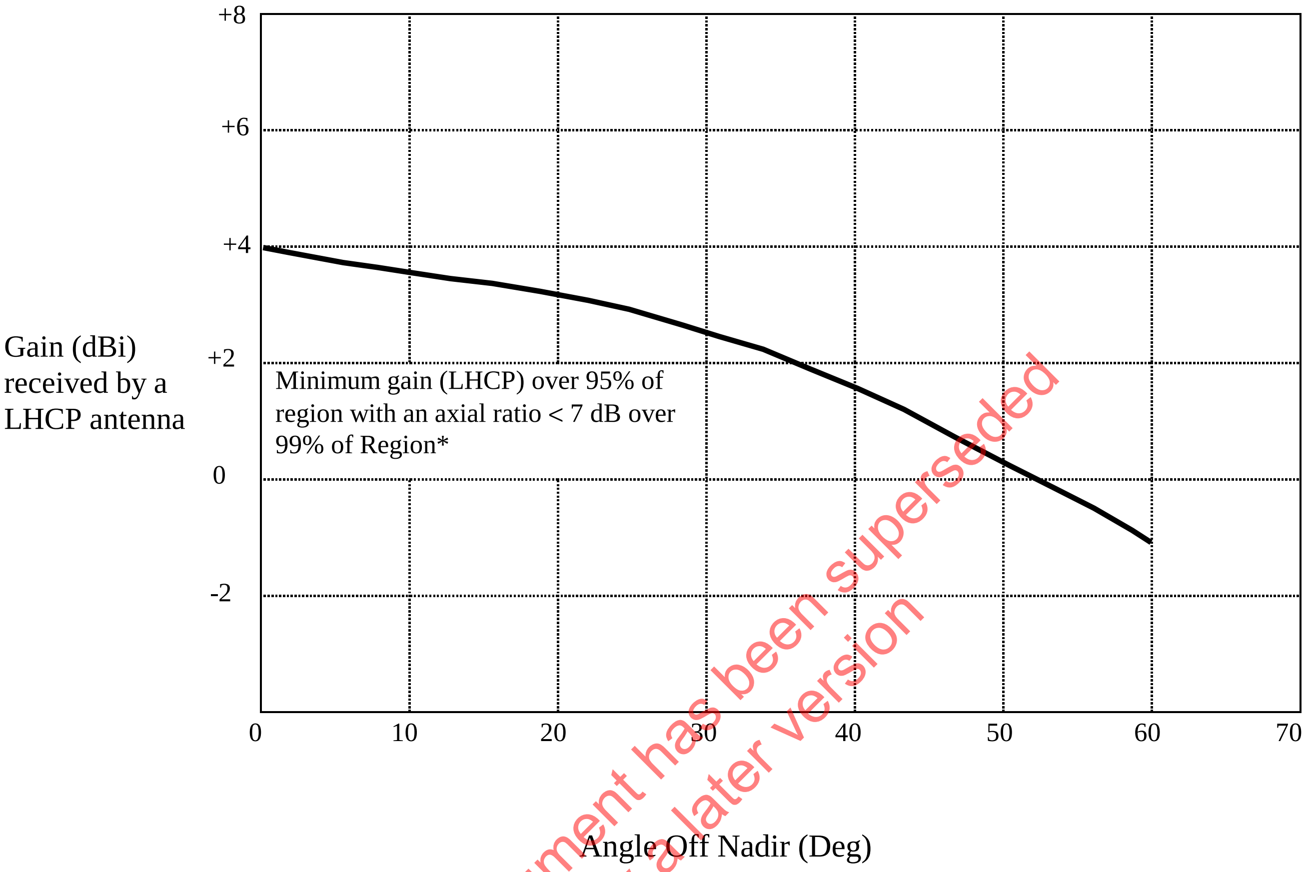
Figure 5.9: Sarsat SARP Receive Antenna (UDA) Gain Pattern (at receiver input)



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 5.10: Sarsat 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 5.11, 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 antenna with two concentric helixes. One helix operating at 406 MHz and connected to both SARR and SARP instruments, the other helix at dual frequencies 121.5 MHz and 243 MHz and connected to the SARR instrument only.

The CRA Antenna is deployable.

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

Polarisation	-	RHCP
Gain	-	as shown in Figures 5.12 to 5.15 inclusive
Axial ratio	-	as derived by the maximum and minimum contours on gain Figures.

Frequency:

SARR:	- 121.5 MHz ±20 kHz
	- 243.0 MHz ±30 kHz
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 Figure 5.15
Axial ratio	- as stated in gain Figure
Frequency	- 1544.5 MHz ±500 kHz

Figure 5.11 : Sarsat-Metop Antenna System Functional Diagram

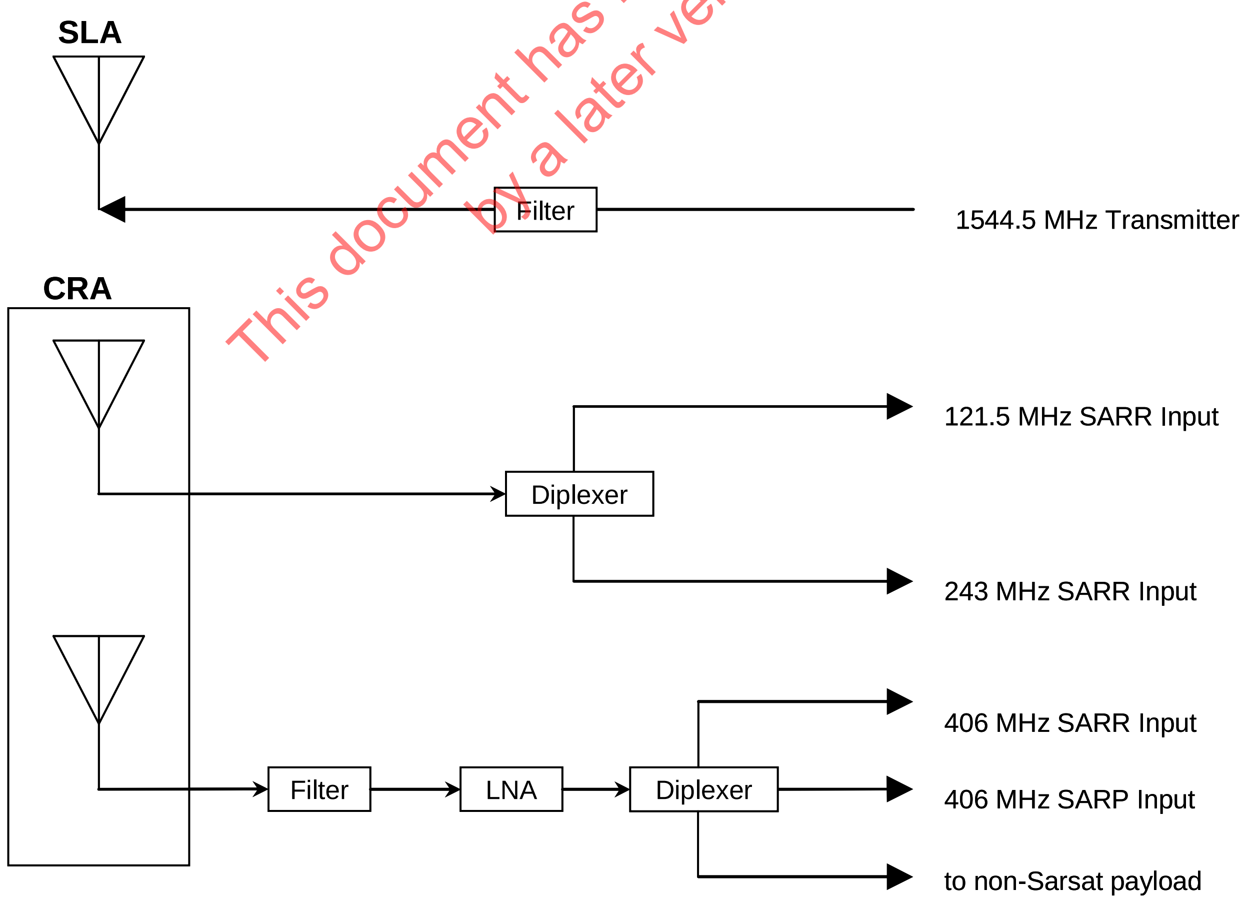


Figure 5.12: Sarsat-Metop 121.5 MHz Receive Antenna (CRA) Gain Pattern (at receiver input)

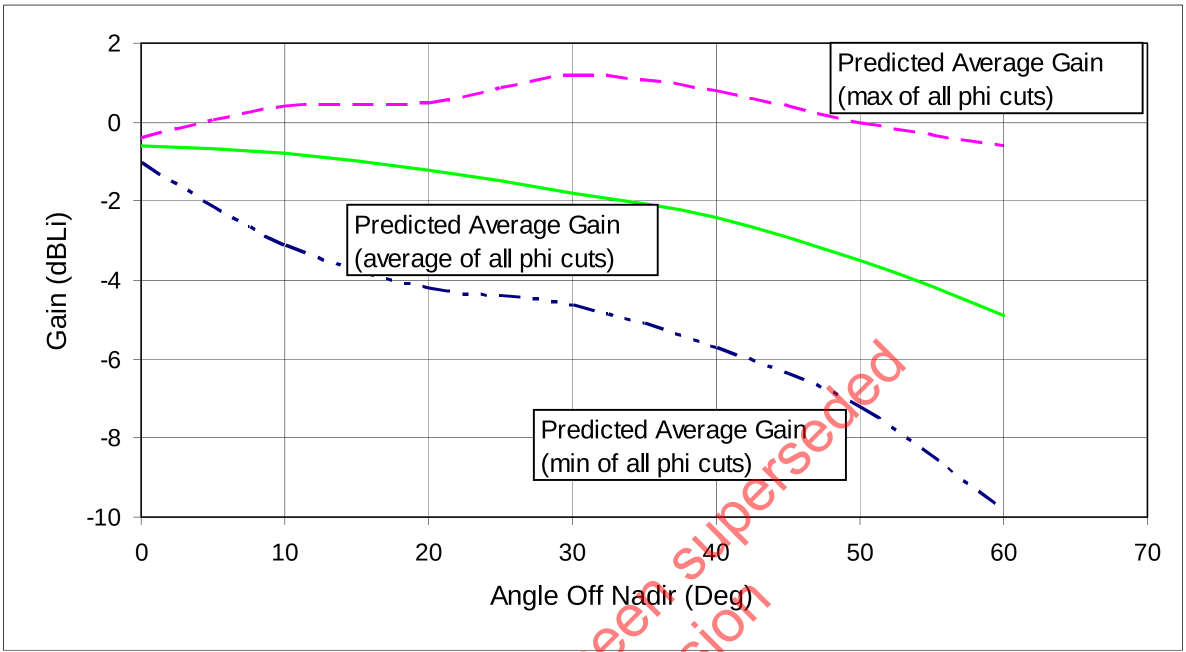


Figure 5.13 : Sarsat-Metop 243 MHz Receive Antenna (CRA) Gain Pattern (at receiver input)

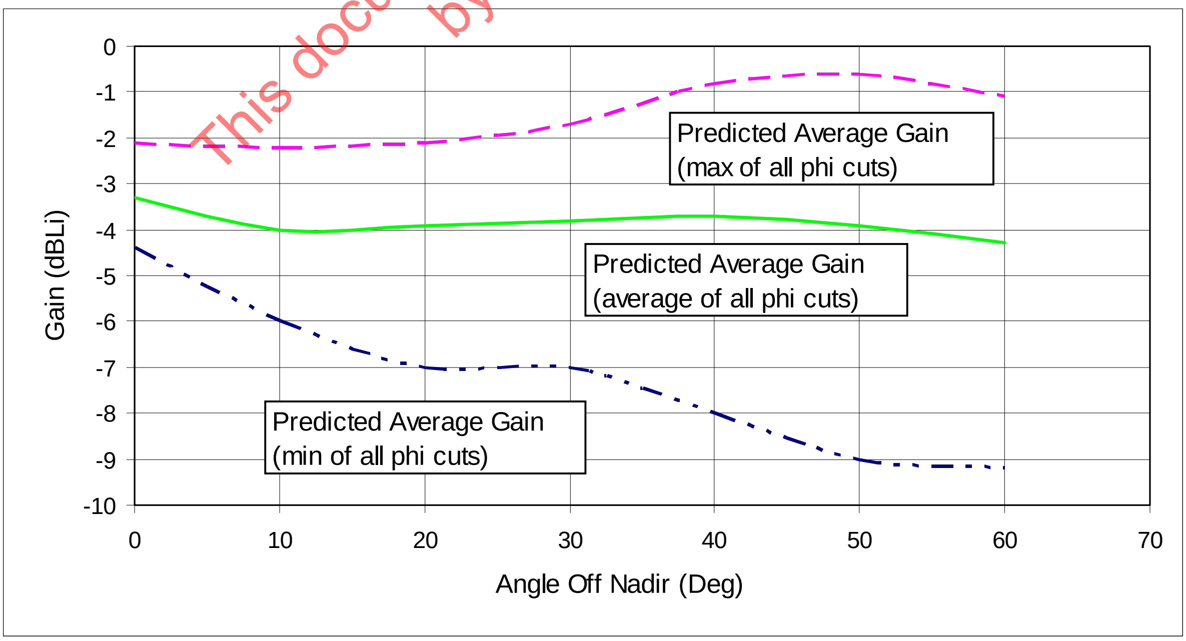


Figure 5.14 : Sarsat-Metop 406 MHz SARP and SARP Receive Antenna (CRA) Gain Pattern (at receiver input)

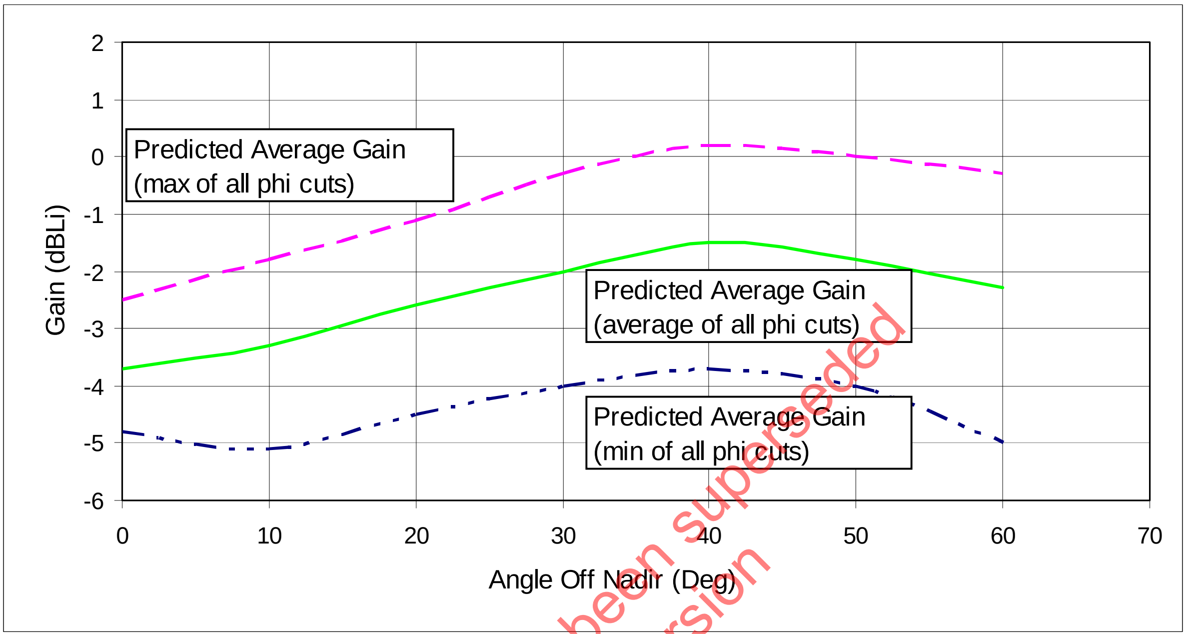
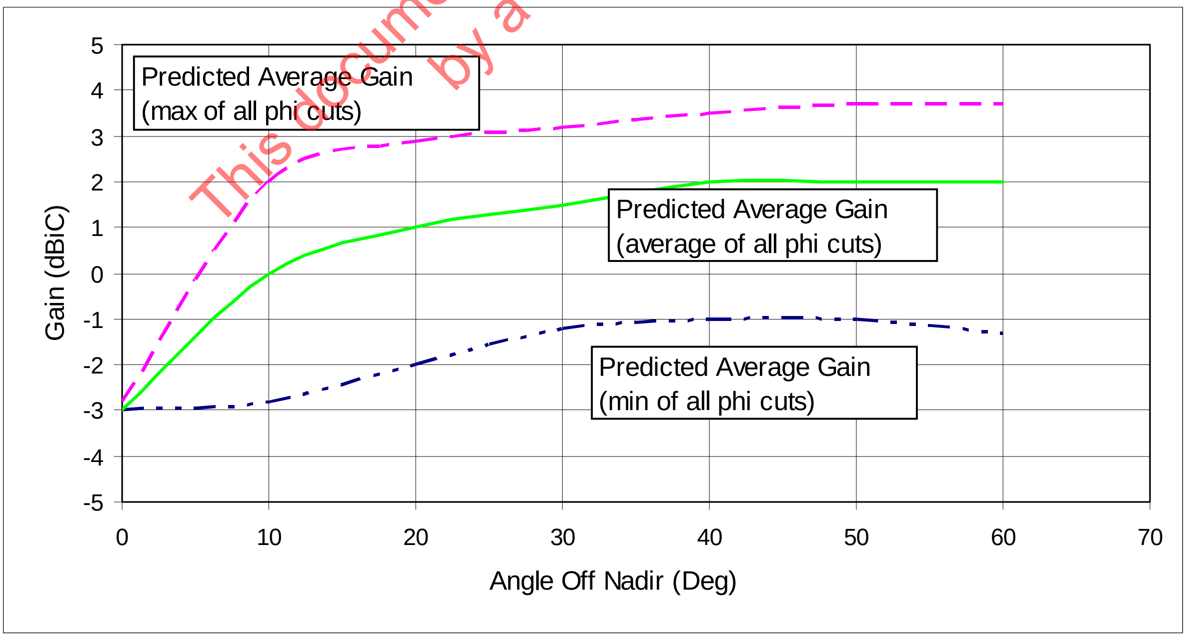


Figure 5.15 : Sarsat-Metop 1544.5 MHz Transmit Antenna (SLA) Gain Pattern



- END OF SECTION 5 -

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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
MIRP	Manipulated Information Rate Processor (on NOAA satellite)
MSB	Most Significant Bit
N/A	not applicable
NOAA	National Oceanic and Atmospheric Administration (USA)
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
SARR	Search And Rescue Repeater
SARSAT	Search And Rescue Satellite Aided Tracking
SBA	NOAA S-band transmit antenna
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)
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

UNIQUE CHARACTERISTICS OF PARTICULAR COSPAS-SARSAT SATELLITES

Due to design or production changes over the years, some Cospas-Sarsat satellites have particular parameters which are not consistent with the standard values given in this document, as follows:

Maximum Modulation Index Level of Sarsat 121.5, 243 and 406.05 MHz receivers:

the modulation index limiter for each SARR receiver is set to:

- 1.8 radians peak for each channel on Sarsat 3;
- 1.6 radians peak for each channel on Sarsat-4;
- 1.3 radians peak for each channel on Sarsat-5 onwards (as shown in section 3).

Noise Temperature of Sarsat 406.05 MHz receiver:

- 600 K on Sarsat-3 to Sarsat-5;
- 350 K on Sarsat-6 onwards (as shown in section 2).

Non-redundant Sarsat 406.05 MHz receivers:

- Sarsat-3 and Sarsat-4 do not have redundant 406.05 MHz receivers on-board.

Medium-term frequency stability of Sarsat receivers:

- Sarsat-3 to Sarsat-6 SARR receivers have a medium-term frequency stability mean slope of $\leq 1 \times 10^{-8}$ /minute.

- END OF ANNEX B -

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ANNEX C

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 121.5/243 and/or 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 C.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 C.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
121.5 MHz 243 MHz 406.05 MHz	100 kHz 100 kHz 100 kHz	S5.199 S5.199 S5.266 & S5.267	1544.5 MHz	1000 kHz	S5.354 & S5.356

-END OF ANNEX C-

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