SATELLITE MONITORING
AND
SIGNAL ANALYSES SYSTEM

PRODUCT SPECIFICATION

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Content

1 INTRODUCTION

1.1 Scope of document

This document describes the main components for analysing the visible satellite spectrum and monitoring and recording communications on Intelsat carriers. It consists of 2 systems:

1) Satellite signal analyser

2) Zebra capture unit for Intelsat carriers complete with soft DCME.

NB: The Satellite signal analyzer is under development and the final specifications and features may differ somewhat from those in this document.

1.2 Confidentiality and distribution

This document is provided in confidence and is authorized for distribution only to the parties indicated on page ii.

1.3 Applicable document

The Satellite Signal Analysis system, and the Intelsat Monitoring system, as described in this document, form part of the MMS system as described in the MMS specification in document "J-LA-001-SSP-01 LA System Specification". Please refer to "J-LA-001-SSP-01 LA System Specification" further detail.

2 Satellite Signal Analyser

A number of satellite technologies bear communications for commercial, government and military use. Satellite signal carriers are modulated. (Modulate means to vary the frequency, amplitude, phase or other characteristics of a radio wave or another carrier wave in order to transmit information).

In telecommunications modulation and demodulation standards are applied to ensure inter-operability. The satellite signal analyser:

- scans the satellite frequency spectrum used for commercial communications
- identifies available signals
- classifies signals according to their modulation parameters.

The system can be configured and managed over a LAN. The SSA classifies satellite signals according to the parameters required to demodulate the specific signal for example Hughes VSAT networks of DAMA and TDMA types.

Once classified, signals are automatically demodulated allowing users to analyse the content. Users can identify and catalogue the specific carriers being utilised by different countries for future reference.

The SSA provides intelligence agencies with the ability to analyse and classify a large variety of satellite carriers. This includes the interception and processing of “outbound” VSAT signals. Outbound VSAT signals often contain sufficient information for evaluating call content.

The user can evaluate new carriers in the satellite spectrum to determine the specific satellite carriers used by different countries. All collected information is stored in a SQL database. The user can retrieve configuration data immediately for setting up target signals for specific customer driven tasks. Content analysis of “inbound” VSAT carriers can optionally be implemented with additional hardware and software.

3 SSA COMPONENTS

The satellite signal analyser comprises hardware and software. Demodulators, digital receivers and wideband digital receivers are custom developed modules. All other components are commercial of the shelf hardware.

The system input is an L-Band RF signal from a satellite antenna via a signal splitter for distribution of the L-Band signal to all the necessary components. The major components of a satellite signal analyser are:

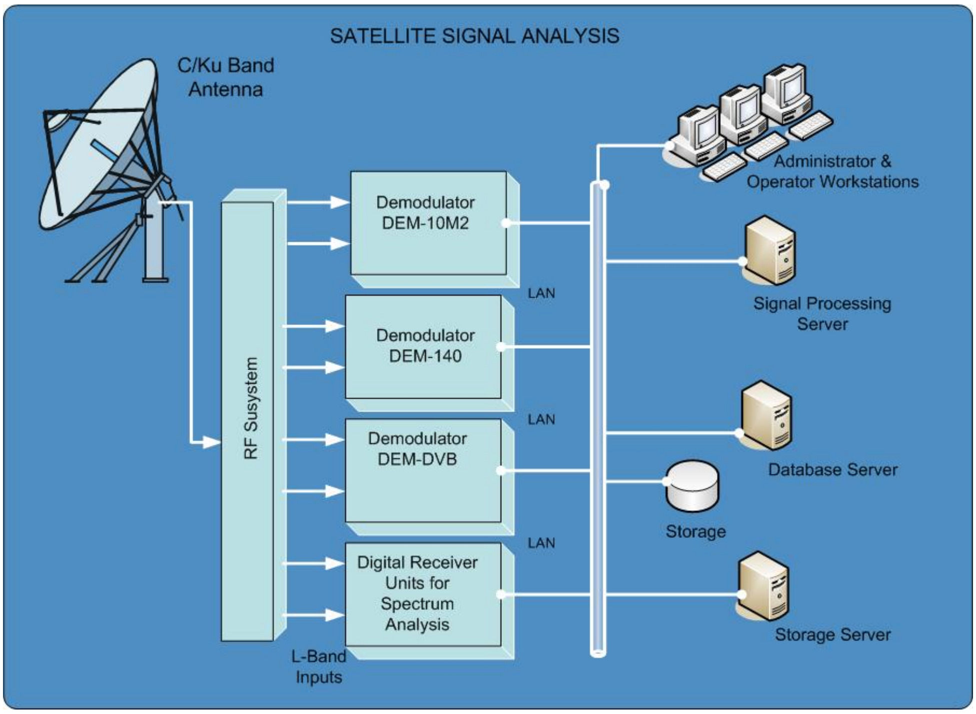

Figure 1: - SSA architecture and components

3.1 Signal processor

This server receives and accurately tunes the frequency of signals from the digital receiver and wideband digital receivers. It then selects the required bandwidth (e.g. 75MHz or 140 MHz) for the signal and sets filters with the specific steepness to correctly receive the data for processing. The server pre-processes the information and provides a data stream to the network interface for additional processing.

The digital carrier reception and analysis sub-unit (receiver and software) also operates in multi-mode as a spectrum analyser. In this mode the signal processing server can identify the following main carrier parameters:

- Type of carrier
- Type of modulation
- Centre frequency of carrier
- Signal to Noise ratio
- Symbol rate

3.2 Database server

The database server stores all necessary information about satellite channels and VSAT Networks (Centre frequency of carrier, polarization, speed, modulation type, decoder and descrambler types, data rate, symbol rate, digital trunk characteristics and information about their load and session related information for stored sessions). All stored information can be accessed from the user workstation.

3.3 Storage server

This server manages long term storage of information about satellite carriers and VSAT networks. The server can export information for analysis and processing by other applications.

3.4 Administrator workstation

This workstation is used for system configuration and management, functionality monitoring and maintenance.

The System Administrator controls access rights, target lists, user groups and users and determines their tasks and workload.

The administrator workstation is used for configuring system hardware and software. Parameters are stored in the system database from where it is available to other system components.

3.5 User workstation

This application provides a graphical user interface for users to perform tasks. The main tasks that can be performed are:

- Provides access to information about carriers and VSAT Networks in the database
- Analysis of carrier and channel information;
- Viewing of all parameters in the database of all analyzed signals
- Selection (from a list) of actions to be performed for a particular session
- Analysis of session files by viewing text data or listening to voice channels with the possibility of transcribing
- Sorting and querying of all sessions
- Reports on the content of session files after listening or viewing

3.6 Demodulators

The satellite signal analyser may be equipped with different demodulators. The Dem-10M2 can receive and demodulate satellite signals up to 2 Mb/s using the various demodulation and coding techniques. The DEM-140D can receive and demodulate satellite signals from 64 kbps up to 140,000 kbps. The DEM-DVB can receive DVB satellite signal from 128 kbps up to 45,000 kbps. This demodulator can demodulate and decode all types of known DVB satellite signals.

3.6.1 10M2 Demodulator

This demodulator is for lower speed satellite signals up to 9312 kbps. This demodulator accepts two L-Band inputs (dual channel) from the satellite reception and distribution systems.

Each of the DEM-10M2 channels has the following characteristics:

- input frequency range – 0,95-2,05 GHz
- input signal dynamical range, not less ± 20 dB
- input signal speeds for **BPSK** 32 – 1024 kbps, QPSK 64 – 9312 kbps
- non-systematic convolutional decoding Intelsat Viterbi and DVB Viterbi with ½, ¾, $^{7}/_{8}$ convolutions and code distance K=7
- systematic convolutional decoding with ½, ¾ convolutions with maximum input signal speed not more than 2144 kbps
- descrambling (descrambler type V.35), with the ability to switch off this function (bypass mode) and inversion of bit-stream
- removing of IDR additions for the whole speed range

- framing of the output streams according to G.704 recommendations with ability of filtering of any time-slot or group of time-slots for all speeds included into recommendations
- removing of IBS additions and scramblers A(14,15), P(1,18), P(3,20) overhead 1/15 according to Intelsat recommendations for the whole speeds range
- separation of E2 and T2 trunks into separate E1 and T1trunks (the selection of 0_E1 – 3_E1 trunk or their time-slots from E2 trunk should be provided, the same for T2 trunk)
- decoding Reed-Solomon code according to DVB (204,188,8) recommendations
- decoding Reed-Solomon code with arbitrary set coefficient and interlacing from 2 to 16 according to Intelsat recommendations
- Reed-Solomon decoding according to Intelsat recommendations with coefficients (219,201,9), (194,178,8), (225,205,10), (126,112,7) with interlacing depth 4 and 8 (modes with or without error correction)
- Reed-Solomon decoding with coefficients configurable up to 255 with interlacing 4 and 8 as per Intelsat recommendations.

3.6.2 140D Demodulator

This demodulator identifies the following carrier parameters:

- Data Rate
- Coding and Spectrum inversion
- Scrambling and Frame structure
- Type of FEC
- Interleaving

3.6.2.1 140D Specification

Description	Specification
Input frequency range	0,95 - 2,05 GHz
Input signal dynamic range	not less than ± 20 dB
Input signals speeds	BPSK 64 – 32000 kbps QPSK / OQPSK 64 – 64000 kbps 8PSK 64 – 110000 kbps 16QAM 64 – 140000 kbps

3.6.2.2 Decoding capability

The system is capable of demodulation and decoding the following:

Type	FEC Coding	Coding rate	Modulation
DVB-S	RS + Viterbi	1/2 2/3 3/4 5/6 7/8	QPSK, OQPSK " " " "
DVB-DSNG	RS + Viterbi	2/3 5/6 8/9	8PSK " "
DVB-DSNG DVB-DSNG	RS + Viterbi RS + Viterbi	3/4 7/8	16QAM "
Standard carrier	Viterbi	1/2 3/4 7/8	BPSK, QPSK, OQPSK " "
Standard carrier	Trellis	2/3	"

Standard carrier	TPC	2/5 (32,26)(32,26)(16,11)	“
Standard carrier	TPC	3/5 (64,57)(64,57)(4,3) 21/44 (28,22)(32,26)(4,3) 3/4 (64,57)(46,39)	BPSK, QPSK, OQPSK, 8PSK, 16QAM BPSK,QPSK, OQPSK QPSK, OQPSK, 8PSK, 16QAM
Standard carrier	eTPC	8/9 (128,120)(128,119) 19/20 (128,128)(128,126) 7/8 (128,120)(128,120) 3/5 (64,57)(64,56) 19/20 (64,63)(62,61)	BPSK, QPSK, OQPSK, 8PSK, 16QAM BPSK, QPSK, OQPSK, 8PSK, 16QAM QPSK, OQPSK, 8PSK, 16QAM BPSK, QPSK, OQPSK, 8PSK, 16QAM QPSK, OQPSK, 8PSK

The demodulator can do the following:

- Systematic convolution decoding with ½, ¾ convolutions with maximum input signal speed not more than 2144 kbps
- Descrambling (descrambler type V.35), with the ability to switch this function off (bypass mode) and inversion of bit-stream
- Removing of IDR additions for the whole speed range
- Framing of the output streams according to G.704 recommendations with ability to filter on any time-slot or group of time-slots for all speeds included in ITU recommendations

- Removing of IBS additions overhead according to Intelsat recommendations for the whole speed range
- Removing of EDMAC channel for the whole speed range
- Descrambling A(14,15), A(9,11), P(1,18), P(3,20) scramblers
- Separation of E2 trunks into separate E1 trunks (the selection of up to 4 x E1 trunks or individual time slots directly from E2 carriers – this means de-multiplexing of E2 carriers and providing up to 4 x E1 trunks as output on a LAN)
- Decoding of Reed-Solomon code according to DVB (204,188,8) recommendations
- Decoding of Reed-Solomon code with arbitrary set coefficient and interlacing 4 and 8 according to Intelsat recommendations.

3.6.3 DVB Demodulator

The DEM-DVB can identify the following DVB carrier parameters:

- Data Rate
- Coding and Spectrum inversion
- Scrambling and Frame structure
- Type of FEC

3.6.3.1 DVB Specification

Description	Specification
Input frequency range	0,95 - 2,05 GHz
Input signal dynamic range	not less ± 20 dB
Input symbol rate	DVB-S 16 – 45000 kbps DVB-S, DVB-DSNG 128 – 45000 kbps Modulation: QPSK, OQPSK, 8PSK, 16QAM, 16APSK

The system is capable of demodulation and decoding of the following:

Type	FEC Coding	Coding rate	Modulation

DVB-S	RS + Viterbi	1/2 2/3 3/4 5/6 7/8	QPSK, OQPSK " " " "
DVB-DSNG	RS + Viterbi	2/3 5/6 8/9	8PSK " "
DVB-DSNG	RS + Viterbi	3/4 7/8	16QAM "

3.6.3.2 DVB-S2 with normal FEC frame:

DVB-S2	1/4	QPSK, OQPSK, 8PSK,16APSK
	1/3	"
	2/5	"
	1/2	"
	3/5	"
	2/3	"
	3/4	"
	4/5	"
	5/6	"
	8/9	"
	9/10	"

3.6.3.3 DVB-S2 with short FEC frame:

DVB-S2	1/4 1/3	QPSK, OQPSK "

	2/5	“
	1/2	“
	3/5	QPSK, OQPSK, 8PSK,16APSK
	2/3	“
	3/4	“
	4/5	“
	5/6	“
	8/9	“

3.7 AquaSat

AquaSat consists of digital hardware for the reception, demodulation and processing of inbound carriers from VSAT carriers. This system is capable of processing up to 16 inbound carriers from Hughes VSAT carriers and extracts all the signal parameters and content of the inbound carriers for analysis purposes. The typical information that is available from the analysis of a VSAT carrier is the following:

- Type of carrier
- Type of modulation
- Centre frequency of carrier
- Signal to Noise ratio
- Symbol rate
- Data rate
- Coding and spectrum inversion
- Scrambling and frame structure
- Type of FEC
- Interleaving
- Access method
- Topology of network
- Size of network, number of terminals in the network
- Identification of burst mode transmission
- Signaling and control information

- Link layer and access control protocol
- Channel assignment processes/protocol
- Link establishment processes
- Information on encryption used
- Voice encoding
- Compression algorithms

In most cases the system will be able to define the parameters automatically. In cases where the system is not able to automatically detect the parameters, the operator, using the tools, supplied with the system will be able to detect them manually. Once the parameters are defined, they will be stored into the database and in future the signals with the same parameters will be detected automatically by the system. There will be no need for manual operations for the same satellite signals of previous detected parameters.

3.8 Software Utilities

The following processing utilities are part of the total signal analysis solution:

3.8.1 DCME Analyser

This utility identifies DCME types used on satellite carriers. These include Celtic 3G, OKI TC2000, DTX 240 (D, E, and F), DTX 360 (LDCELP), IESS 501, DTX 600 (G.768), DX 3000 and DX 7000 (G.768). This utility can decompress a mono DCME stream up to the audio level to enable analysts to determine the language and country of the carrier. DTX 600 and DX 700 for G.769 is not included in this offer but will be released after development.

3.8.2 Internet processor

This utility analyses internet traffic and processes internet sessions from a satellite carrier. It decodes the following protocols and provides the content of the Internet signal to the customer for further content analysis.

- HTML
- MIME
- SMTP
- SMTP/MIME over HTTP
- POP 3

- IMAP 4
- FTP
- IRC
- ICQ
- AOL Messenger
- Yahoo Messenger
- MSN MessengerTelnet

3.8.3 Voice, Fax/Modem

Analysts can record voice channels from a satellite carrier to determine which channels contain speech, fax or modem information. This software analyses VoIP carriers. The software decodes the incoming data, extracts voice channels, decodes fax and modem channels and provides the content for evaluation purposes. The software is capable of demodulating and decoding the following fax/modem protocols:

3.8.3.1 Supported Fax Protocols

Supported inputs	Originating side A-law, µ-law 8KHz PCM data Both sides as two A-law, µ-law 8KHz PCM data	
Fax Protocols	V.34HD	33,600 bps 31,200 28,800 26,400 24,000 21,600 19,200 16,800 14,400 12,000 9,600 7,200 4,800 2,400
	V.17	14,400

		12,000 9,600 7,200
	V.29	7,200 9,600
	V.27ter	2,400 4,800
Output Format	Multi page Tiff file Binary file of original fax Session log file containing all parameters	
Page Compression	**G.3/T.4:** • 1D (MH) • 2D (MR) **G.4/T.6** • MMR T.85 JBIG T.42 JPEG	

3.8.3.2 Supported Modem Protocols

Supported inputs	Originating side A-law, μ-law 8KHz PCM file Both sides as two A-law, μ-law 8KHz PCM files
Demodulation for dial-up modem protocols	V.92 V.90 V.34 V.32 and V.32bis V.23 V.22 and V.22bis V.21 Bell103

	Bell212 XMODEM, XMODEM-CRC, XMODEM-1K, XMODEM-1K-G YMODEM, YMODEM-G ZMODEM KERMIT
Decompression for Error Correction	V.42 MNP2, 3, 4 V.14
Decompression for Data Compression	V.44 V.42bis MNP5
Output Format	Demodulated data after error correction and data compression—PPPD format X, Y, Z-modem and Kermit files—The same format as the transferred file format Log file

4 SSA RACK DIMENSIONS

Figure 2 provides an indication of the rack dimensions of the SSA.

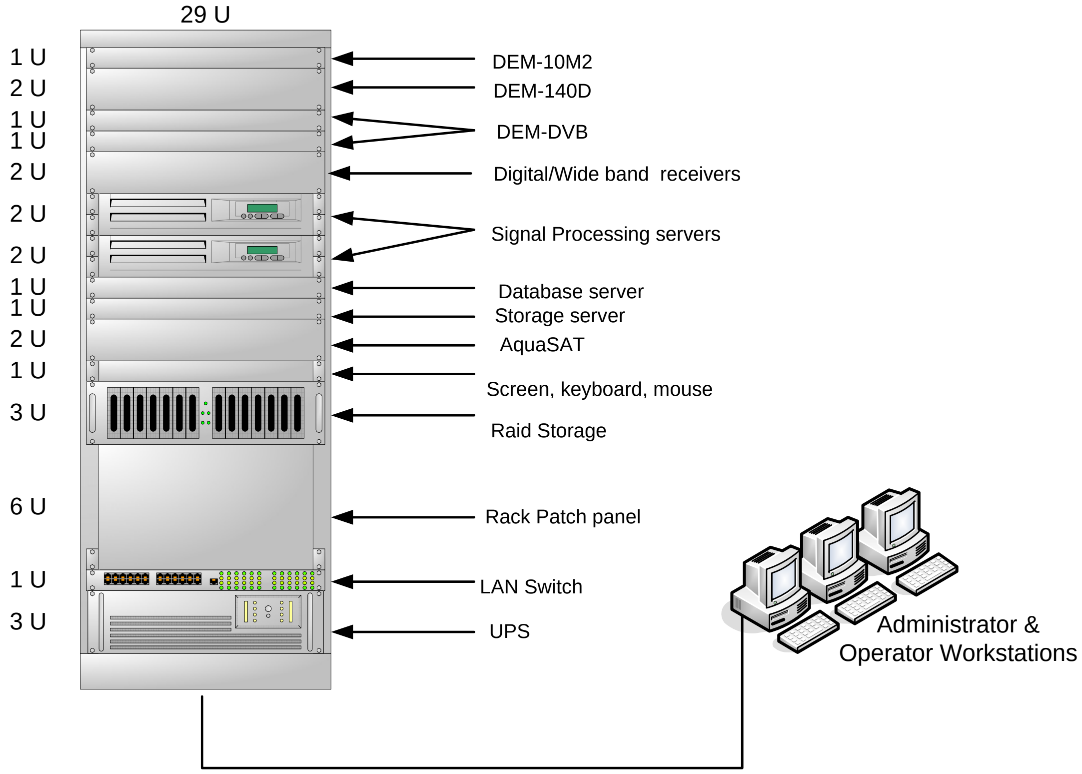

Figure **2**: Rack dimensions

5 ZEBRA SATELLITE MONITORING SYSTEM

The Zebra can monitor telephone circuits on signals carried by Intelsat communications satellites. The solution provides for digital 2Mb/s carriers either in open communication mode (non-compressed,) or in compressed mode where the signals are sent over satellite after compression by Digital Circuit Multiplication Equipment (DCME).

This system capacity is specified to monitor the signals of two countries communicating to each other via satellite. The system design is generic and the system can be expanded to cater for multiple 2 Mb/s carriers offering seamless future expansion if required.

5.1 Intelsat Components

Intelsat system components include:

- RF Front End
- Intelsat Receivers, Down Converters and Modems

- Digital Circuit Multiplication Equipment
- Zebra System
- CIC Mapper
- User Work Stations

The solution typically consists of a 9 or 11 meter antennas complete with all the required receiver and modem hardware to receive signals from any two countries from any Intelsat satellite, visible from the customer's location.

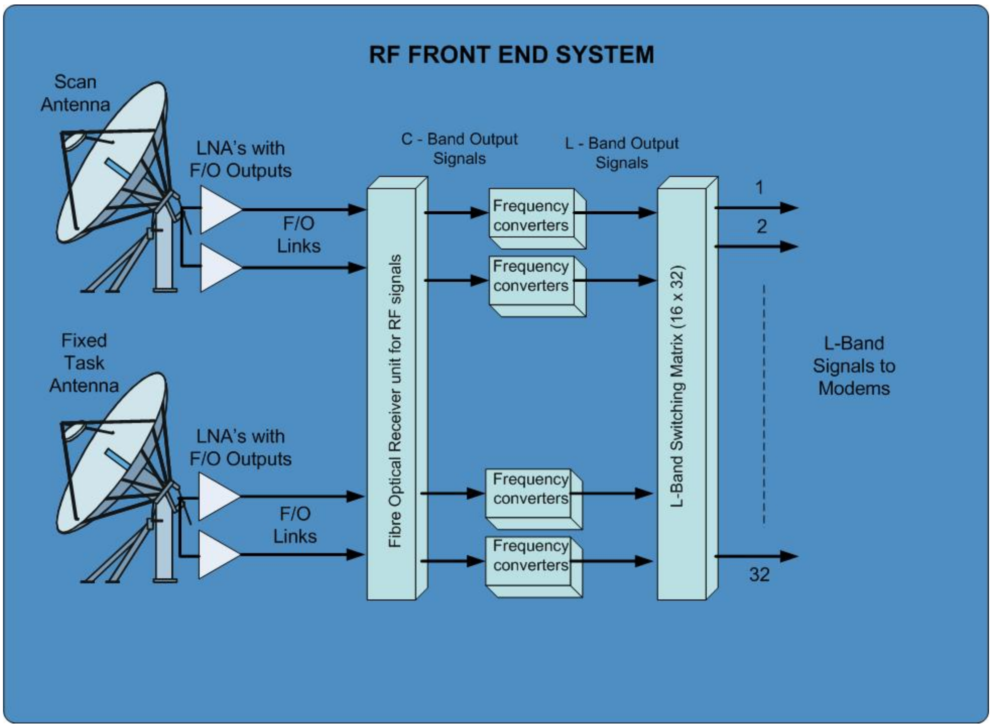

Figure 3 : Intelsat solution RF front end

The hardware is capable of receiving and demodulating 2Mb/s digital satellite signals. The output conforms to ITU standards for 2Mb/s PCM streams.

5.1.1 Interface to Zebra Capture Units at Central Site C1

The 2Mb/s streams are connected to the Zebra Gateway at the Intelsat Interception site (Site B1). The Zebra Gateway transmits all the intercepted 2Mb/s streams, according to Ethernet protocol, to the Zebra Capture Unit at the Central Site C1 via an optical fibre (dark fibre to be provided by the CUSTOMER according to VASTech specifications).

At the Central Site C1 further processing of the output is dependent on the type of signal. If the 2Mb/s digital PCM streams are in compressed mode, the DCME equipment will decompress the signals to standard ITU specified 2Mb/s PCM streams. In decompressed mode the proposed system will provide a minimum of 32 stereo 2Mb/s data streams consisting of 992 stereo telephone channels simultaneously.

The Zebra Capture Unit will detect activity on all stereo channels, decode the telephone numbers on any R2, R5 or SS7 signalling system, distinguish between fax, modem or speech traffic and record all incoming communications (speech, fax and modem).

Channels carrying fax and modem traffic are automatically decoded to provide the original fax images or raw modem data for viewing. Due to the vast amount of proprietary protocols used by dial-up modems, not all modem protocols can be handled by the system. The software is however capable of handling dial-up modem sessions and can provide web page images and e-mail sent or received by the target.

The system operates automatically once the E1 streams are connected and the system is configured.

5.1.2 RF Front End

The RF Front End consists of:

- 9 m C-Band antenna
- Beacon receiver, RF splitters, driving systems & satellite tracking devices
- Dehydrator for C-Band antenna feed system
- C-Band receivers

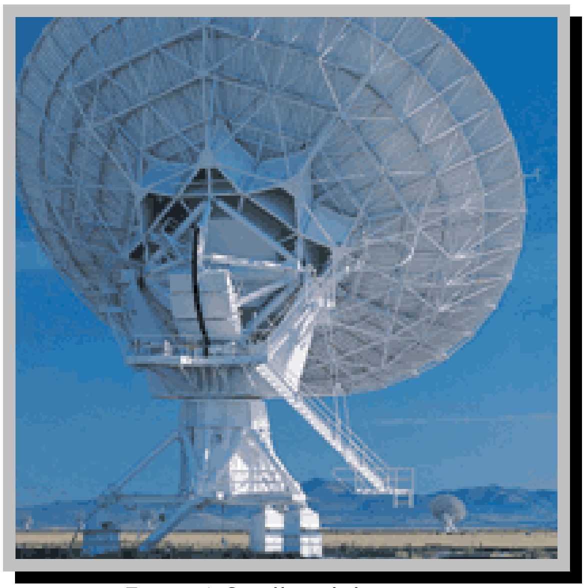

Figure 4 Satellite dish

5.1.3 Satellite Receivers

The satellite receivers (down-converters) operate from 3.4 GHz to 4.2 GHz (extended C-Band) with both 70 MHz and 140 MHz outputs to handle the digital as well as analogue FDM/SCPC signals on satellite.

The system includes an IF distribution network, a controller and a power supply module.

5.1.4 Satellite Modems

The modems receive a 140 MHz IF output from the satellite receivers and demodulate the signals and output a standard ITU specified 2Mb/s data stream for further processing.

The modems have the capability for sequential decoding, Biterbi decoding, Reed Solomon decoding, Trellis decoding as well as V35 scrambling. The modems normally provided are for 2Mb/s carriers on satellite, but higher speed modems are also available.

5.1.5 Digital Circuit Multiplication Equipment

There are numerous DCME systems used internationally. The basic compression systems are DTX 240F, DTX 360 IESS 501 standard, DTX 360 LD-CELP, DTX 600, Mitsubishi DX 3000, Mitsubishi DX 6000, OKI ADPCM and NEC 501.

5.2 Zebra Deployment Units

DCME decompression is integrated in the Zebra Capture Units that are provided at the Central Site C1. Actual capturing, demodulation, storage management and operator access will be done at the Central Site C1. See “J-LA-001-SSP-01 LA System Specification” for detail and functionality of the Zebra Capture Units that form part of the MMS system.

6 GLOSSARY

CONVOLUTION	See 6.1.1.1.
DAMA	Demand Assigned Multiple Access
DCME	Digital Circuit Multiplication Equipment
TDMA	Time Division Multiple Access
VSAT	Very Small Aperture Terminals
GUI	Graphical User Interface
FEC	Forward Error Correction
DVB-S	Digital Video Broadcast - Satellite
DVB-S2	Digital Video Broadcast – Satellite 2nd Generation
DVB-DSNG	Digital Video Broadcast – Digital Satellite News Gathering
EDMAC	Embedded Distant-end-Monitor and Control
RS	Reed Solomon coding
TPC	Turbo Product Code
eTPC	enhanced Turbo Product Code

6.1.1 Convolutional codes

Convolutional codes improve the performance of digital radio, mobile phones, satellite links, and Bluetooth implementations. Viterbi Algorithm (VA) decoders are used in cellular phones which is probably the largest number in any application. However, the largest current consumer of VA processor cycles is probably digital video broadcasting.

Forward error correction (FEC) is used to improve the capacity of a channel by adding some carefully designed redundant information to the data being transmitted through the channel. The process of adding this redundant information is known as channel coding. Convolutional coding and block coding are the two major forms of channel coding

A **convolutional code** is an error-correcting code in which (a) each *m*-bit information symbol (each *m*-bit string) to be encoded is transformed into an *n*-bit symbol, where *m*/*n* is the code *rate* (*n* ≥ *m*) and (b) the transformation is a function of the last *k* information symbols, where *k* is the constraint length of the code.

Convolutional coding with Viterbi decoding has been the predominant FEC technique used in space communications, particularly in geostationary satellite communication networks, such as VSAT networks. The most common variant used in VSAT networks is rate 1/2 convolutional coding using a code with a constraint length K = 7. With this code, you can transmit binary or quaternary phase-shift-keyed (BPSK or QPSK) signals with at least 5 dB less power than you'd need without it. That's a reduction in Watts of more than a factor of three! This is very useful in reducing transmitter and/or antenna cost or permitting increased data rates given the same transmitter power and antenna sizes.

Convolutional coding with Viterbi decoding has been supplemented in the geostationary satellite communication arena with Reed-Solomon coding. The two coding techniques are usually implemented as serially concatenated block and convolutional coding. Typically, the information to be transmitted is first encoded with the Reed-Solomon code, then with the convolutional code. On the receiving end, Viterbi decoding is performed first, followed by Reed-Solomon decoding. This is the technique that is used in most if not all of the direct-broadcast satellite (DBS) systems, and in several VSAT products as well.

http://pweb.netcom.com/~chip.f/Viterbi.html