Agenda Item 2.2

INDIAN MEOLUT SYSTEM STATUS

1. ACTION REQUIRED

The EWG is invited to note the Indian participation in the development of the MEOSAR ground system and the status of the development.

2. INTRODUCTION

India is actively working on the development of the MEOSAR system and shall participate in Demonstration & Evaluation (D&E) phase. It is planned to have six antenna operational MEOLUT systems operating on L-band. Initial system validation, testing and participation in D&E phase will be undertaken using the existing four 10 m antennae systems available with ISRO.

3. STATUS

Baseline design document is ready and system configuration is finalized. It is planned to establish L-band MEOLUT system with six 2.4 m antenna at Bangalore by mid of 2011. Survey is being carried out for procurement of L-band antenna and RF systems. For receiving data from DASS in S-band and testing the system is planned using existing S-band antennae systems at ISRO, which will be time shared with regular tracking requirements of Indian remote sensing satellites. Beacon processing system is being developed to receive and process beacon signal from DASS in S-band. It is expected to realize S-band processing system by end of 2009.

A summary of the Indian MEOLUT design is provided at Attachment 1.

4. CONCLUSION

India may be considered as one of the MEOLUT developing agency, and request Cospas-Sarsat to share necessary documents and information related to MEOLUT system development, and involve in related deliberations.

India will be interested in networking the MEOLUT system with other interested countries for optimizing the system configuration and further improvement of the system performance.

Would appreciate EWG for expert technical comments on the Indian system design with a view to improve system further.

Attachment 1

Indian MEOSAR Ground System

1. Introduction

The main role of a MEOLUT is to track MEOSAR satellite(s), measure the time and frequency of beacon bursts relayed by MEOSAR satellites, possibly interface with other MEOLUTs to obtain additional beacon burst time and frequency measurements, calculate the location of 406 MHz beacons, and provide distress alert messages from active 406 MHz beacons to the MEOLUT's associated MCC. THE MEOLUT is essentially a ground receiving station that detects, characterizes, and locates 406 MHz emergency beacons, and sends them to Mission Control Centre for further dissemination to Rescue Coordination Centre (RCC). The Block Diagram of MEOLUT is shown in **Figure 1**.

The basic functional requirements for the MEOLUT are to:

- maintain satellite ephemeris, acquire, track and receive the downlink signal from up to six MEO satellites simultaneously
- demodulate the beacon message received in the downlink signal from each GPS satellite utilizing the information contained in "Specification for Cospas-Sarsat 406 MHz Distress Beacons" (C/S T.001), and process the beacon message data
- calculate beacon locations using TOA and FOA measurements whenever enough reliable data is available
- maintain and update required system time and frequency references
- maintain and update a database of relevant information pertaining to each detected beacon
- provide interfaces for local and remote command, control and data access.
- calculate the location of interfering signals operating in the 406.0 to 406.1 MHz band, and report interference data.
- provide the resultant data to the MCC in accordance with the requirements of the document "Cospas-Sarsat MCC Standard Interface Description" (C/S A.002).

The MEOLUT is divided into two parts:

i) Antenna and RF System
ii) Data Processing System.

The Antenna System shall track satellites and provide the resulting RF signals to the Processor System. The MEOLUT will receive L-Band downlink up to six MEO (GPS/ Galileo/Glonass) satellites that are equipped with the SAR payloads.

MEOSAR location accuracy performance is dependent upon the accuracy of the measurements of beacon burst time and frequency by the MEOLUT, which in turn are affected by the beacon carrier to noise density ratio available at the MEOLUT processor.

2. Antenna and RF System

- In Operational Phase the Frequency of Operation is in **L-Band** (1400-1600 MHz), 1540 MHz to 1550.0 MHz precisely.
- As per the details provided by DASS, All the initial experimentation of MEOLUT will be done in S-Band (2226.47234 MHz Centre frequency), and later in operational phase, same will be shifted to L-Band (1544 MHz - 1545 MHz). The Galileo and Glonass are expected to provide L-band downlink during both initial and normal phase.
- It is proposed to use ISRO’s existing four 10m antennae systems operating on S-band for tracking Indian remote sensing satellites on time sharing basis during Proof of Concept. The entire processing system and its performance will be tested and validated using S-band system. The Indian S-band employing 10m antenna system will have sufficient link margin for processing the beacon signal. Detailed calculation for 10 m antenna is not included here.
- For operational phase, it is proposed to build a MEOLUT system using six antennae of 2.4 meter diameter with respective L-band down link chains.
- All the six antenna systems will have Antenna Drive & Control Units with Manual, Slew and Program mode of Operation.
- Each Antenna system will have the capability of receiving both types of Polarizations (RHCP and LHCP) for Data reception by selecting one polarization at a time through configuration files.
- All the antenna coverage will be 360 degrees in Azimuth and 0 – 90 degrees in elevation.
- Reception and processing of Video data received, and detection of the Distress signals are to be performed in real time using processing hardware and associated software.

Based on the given onboard MEOSAR P/L specifications, the downlink receive chain configuration is worked out for “L” and “S” Bands both.

(A) Onboard details of MEOSAR (as provided in document C/S R.012):

S.No.	Parameter	Units	S-Band Proof of concept Phase	L-Band Operational Phase Scenario-1	L-Band Operational Phase Scenerio-2
1.	Down link frequency	MHz	2226.5	1544 -1545	1544 - 1545
2.	Satellite Tx EIRP	dBW	10	15	20
3.	Range	KM	24000	26292 ~ 27,000	26292 ~ 27,000
4.	Fading loss	dB	0.2	1.0	1.0
5.	Polarization loss	dB	0.9	1.0	1.0
6.	Power sharing loss	dB	10.0	10.0	10.0
7.	Path loss	dB	187.04	184.6	184.6
8.	**Required G/T**	**dB/ ^{o}K**	**10.54***	**4.0**	**-1.0**
9.	Down Link C/No	dBHz	51.0	51.0	51.0
10.	Down Link C/Io (estimated)	dBHz	51.0	51.0	51.00
11.	Down link C/(No+Io)	dBHz	48.0	48.0	48.0
12.	Overall C/(No+Io)	dBHz	37.4	37.4	37.4

* Because EIRP is 10 dBW during proof of concept as compared to 15 dBW for operational phase.

(B) Required C/No:

S.No.	Parameter	Units	Value	Remarks
1.	Theoretical Eb/No for required BER	dB	8.8	Theoretical for BPSK at 5 x 10 $^{-5}$
2.	Beacon data modu-lation loss for 1.1 rad	dB	1.0	Bi-phase-L used in beacon relative to BPSK
3.	Coding gain	dB	2.0	BCH decoding
4.	Modem imple. loss	dB	1.0	
5.	Required Eb/No on coded channel	dB	8.8	
6.	Bit rate (400BPs)	dB	26.0	
7.	Required C/(No+Io)	dB	34.8	
8.	**Margin available**	**dB**	**2.6**	As per the details provided

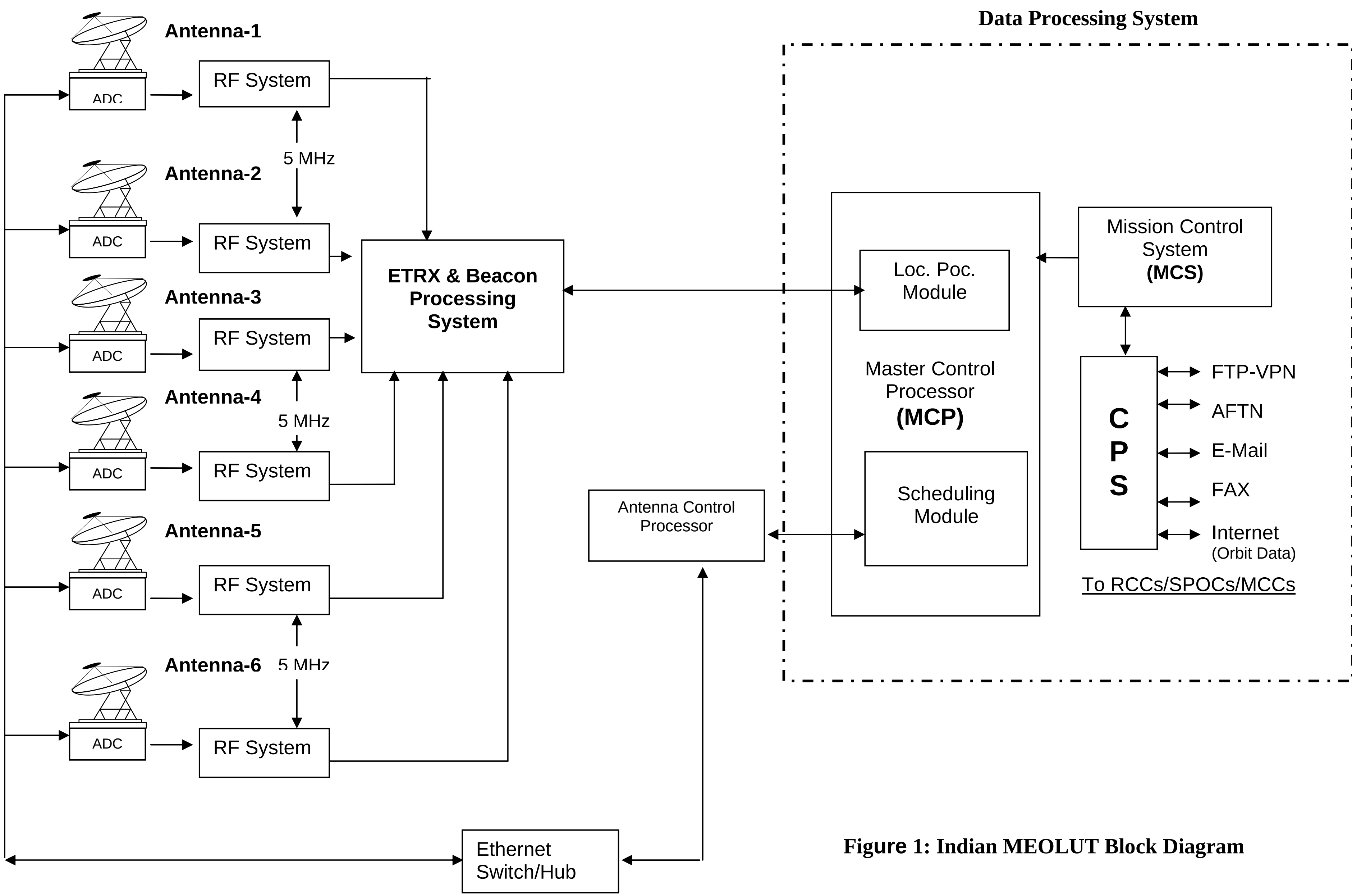


Figure 1: Indian MEOLUT Block Diagram

2.1 Antenna System Specifications

As per the functional Requirements, the following Specifications are arrived based on the SAR transponder specifications. These specifications are for operational phase with L-Band downlink.

1.	Frequency of Operation	:	1544 MHz - 1545 MHz (L-Band)
2.	Diameter of the antennae	:	2.4 meters
3.	Gain of each antenna	:	28.32 dB for L-Band
4.	G/T (minimum required)	:	4 dB/^{o}K for L-Band
	G/T (minimum required)	:	10.54 dB/oK for S-Band
	G/T computed (L-band)	:	6.15 dB/oK
	G/T computed (S-Band)	:	9.76 dB/oK
5.	Feed	:	Mono pulse Prime Focus (Receive only)
6.	Polarization	:	RHCP and LHCP
7.	Mount	:	EL over AZ
8.	Antenna Movement	:	AZ =0 – 360 degrees EL = 1 – 90 degrees
9.	Tracking Modes	:	Manual, Slew and Program
10.	Tracking Rates	:	< 1 deg per second
11.	Antenna Velocity	:	3 0 /sec for satellite change over
12.	Pointing Accuracy	:	0.22 deg.
13.	Frequency Conversion	:	L-Band to 70 MHz
14.	Total number of Rx. Chains	:	6

2.2 RF System for L-Band (Operational Phase)

As per the details available, **Frequency of operation = 1544 to 1545 MHz.** In scenario-1 the minimum required G/T should be **4 dB/^{o}K** and scenario-2, it should be **-1 dB/ ^{o}K (**wherein the **onboard EIRP is yet to be decided).** In this study, Scenario–1 only is taken in to account so that it will take care of scenario–2 (and the margin available will increase by 5 dB if scenario – 2 is implemented). The link model used is

C/No = Onboard EIRP – Path loss – Misc losses + G/T – K

:. G/T = C/No - Onboard EIRP +Path loss + Misc losses + K

Summary of computed link margins for “L” and “S” bands are given in **Table 1**.

Table 1: Summary of Link Margin for L-Band & S-Band with Different Antenna Sizes (at 15^0 elevation)

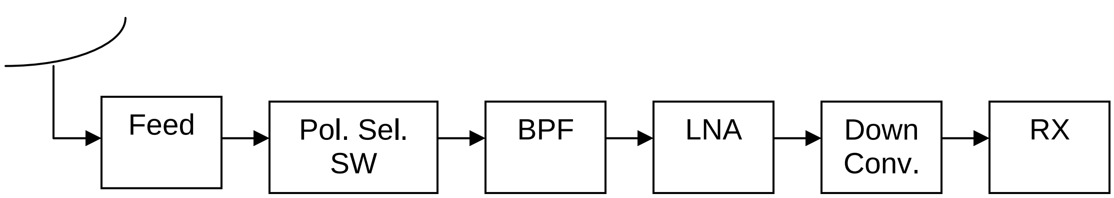
For L-Band					For S- Band				
Diameter of the ant. (mtrs)	**Gain (dB)**	**Noise temp.**	**G/T dB/^{o} K**	**Link Margin (dB)**	**Dia. of the ant. (mtrs)**	**Gain (dB)**	**Noise temp.**	**G/T dB/ ^{o} K**	**Link Margin (dB)**
2.0	26.74	165.09 deg K (22.17 dBK)	4.57	3.17	2.0	29.91	149.19 deg K (21.73 dBK)	7.18	-0.64
2.3	27.95	165.09 deg K (22.17 dBK)	5.78	4.38	2.3	31.12	149.19 deg K (21.73 dBK)	9.39	1.59
2.4	***28.32***	165.09 deg K (22.17 dBK)	***6.15***	***4.75***	***2.4***	***31.49***	149.19 deg K (21.73 dBK)	***9.76***	***1.96***
2.5	28.67	165.09 deg K (22.17 dBK)	6.50	5.10	2.5	31.85	149.19 deg K (21.73 dBK)	10.12	2.34
3.0	30.26	165.09 deg K (22.17 dBK)	8.09	6.69	3.0	33.43	149.19 deg K (21.73 dBK)	11.70	3.9

Note:

- Antenna Noise Temp from 1544 to 1545 MHz (L-Band) : 70 deg K
- Antenna Noise Temp at 2226.5 MHz (S-Band) : 50 deg K
- Feed loss + BPF loss + Polarization selection switch loss = 1.0 dB,
- LNA Gain : 50 dB, LNA Noise Temp : 40 deg K.
- Front end system NT = T sys = 165.09^0 K = 22.17 dB at 1545 MHz (L-Band) and 149.19^0 K = 21.73 dB at 2226.5 MHz (S-Band)
- By incorporating RADOME, the overall G/T will reduce by 0.5 dB

Proposed RF System configuration

The proposed RF system configuration is given below in **Figure 2**:



Feed loss + Pol.Sel.Sw.loss +BPF Loss = 1.0 dB G1=50 dB G=20 dB

T_{LNA}=40 deg K NF_{DC}=10dB

Figure 2: RF System Configuration

Detailed calculations of RF system on L and S band are given in **Annexure 1 and Table 1.**

3. Data Processing System

The processing subsystem shall contain all the necessary software modules to estimate accurate position data using TOA/FOA for 406 MHz beacons and send alert messages to RCCs/MRCCs/SPOCs. It is proposed to build separate MCC system exclusively for processing MEOLUT data. Following are main functions of MEOLUT system:

i) Orbit Maintenance and Scheduling Subsystem

It is required to keep very accurate orbit information for all MEO satellites (GPS, Galileo and GLONASS), which in turn is used for location estimation. This function is to be performed by this module by receiving the orbital data from the source agencies or through Internet from identified web-locations. Using the orbital elements, satellite predictions and look angles are generated, and optimal scheduling is carried out. The look angles are supplied to Antenna Control Processing subsystem for satellite tracking.

ii) Antenna Control Processing Subsystem

For estimating the position information from beacon emergency signal, MEOLUT needs simultaneous tracking of minimum 4 different satellites by 4 different antennae. This module is required to ensure smooth control of simultaneous tracking of 6 antennae with the help of six independent ADCs.

iii) Beacon Signal Processing Subsystem

Detection of valid 406 MHz beacon messages and CW interfering signals. Verifying whenever possible that the beacon identification and encoded position information are valid as per Cospas-Sarsat specifications.

iii) Location Estimation Subsystem

- Properly selecting data points from multiple satellites and using resulting FOA and TOA measurements to calculate beacon and CW interference locations. An algorithm is being developed and tested by an identified task team.
- Provide the resultant data to the MCC in accordance with the requirements of documents C/S A.002, and the Cospas-Sarsat MCC Standard Interface Description;
- Maintain and update a database of relevant information pertaining to each detected beacon.

iv) Mission Control Center Subsystem

Receives and processes incident data from Indian MEOLUT and other MEOLUTs, geo-sorts the locations and transmit MEOSAR alert messages to Indian RCCs/SPOCs or other MCCs as per the standard Data Distribution Procedures.

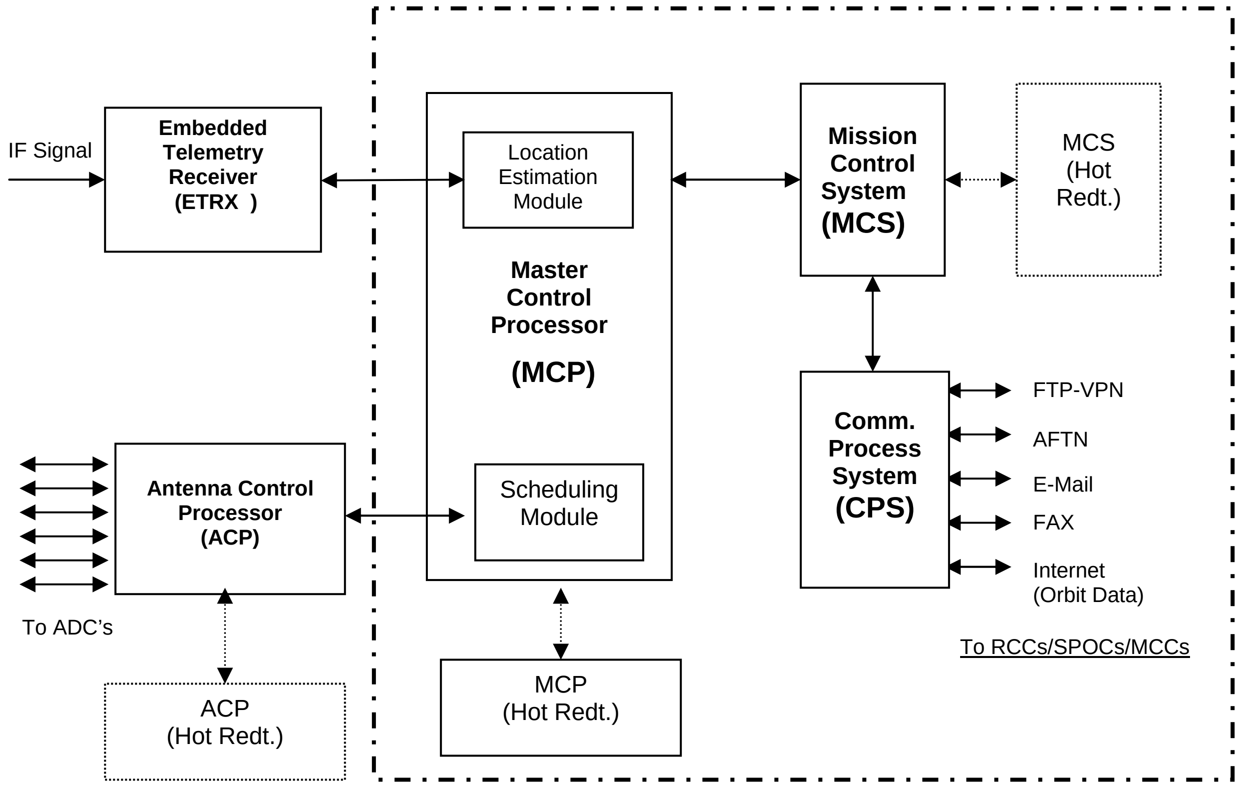


Figure 3: Data Processing System Block Diagram

All the above data processing functions are realized using the following processing modules, system block diagram is given in **Figure 3.**:

3.1 Master Control Processor (MCP)

All processing and communications at the MEOLUT are performed under the direction of Master Control Processor (MCP). One of the major functions of MEOLUT MCP is receiving alert messages from beacon signal processing module (Embedded Telemetry Receiver - ETRX) and estimating the position information.

MCP functions are summarized below:

- Communication with INMCC for information exchange (alert messages, orbital vectors and operational messages).
- Responsible for optimum schedule generation for 6 antennae, downloading schedule and look angles to ACP once a day at pre-defined time.
- Time synchronization with GPS timing source.
- Initiating diagnostics for MEOLUT system functionality verification with test source.
- Interface with Antenna/RF system, Time Reference system and Test source (directly or indirectly).
- Providing graphical user interface for carrying out manual operations at MEOLUT.

- Estimating position information for the alert signals received from beacon signal processing module (ETRX) using FOA, TOA and location estimation algorithm.
- Transmission of emergency position information to INMCC.
- Logging of emergency location information to database server.
- Provision for manual re-processing and re-transmission of emergency position information from database server.
- Overall LUT monitoring, status checks and information logging are conducted regularly to insure data processing integrity.

3.2 Embedded Telemetry Receiver (ETRX)

Receive MEOSAR downlink signal at 70 MHz after down conversion, process the beacon signal and extract valid beacon information and provides accurate FOA and TOA data. This module is designed such that additional satellite receiver system conventionally used in LEO and GEO LUTs is eliminated from the configuration. Function of this system is done by software processing of the signal at 70 MHz.

3.3 Antenna Control Processor (ACP)

Antenna Control Processor (ACP) responsible for collecting satellite schedules, target designations from MCP for 6 antennae and ensuring simultaneous satellite tracking at MEOLUT with six antenna drives and control units. Simultaneous control of 6 different antennae, tracking 6 different satellites is the criticality of this subsystem. The target designations (TDSN) received by scheduling subsystem for 6 different antennae to be stored with unique ID and to be used during the pass without any clash.

3.4 Mission Control System (MCS)

Mission Control System (MCS) is the interface between Indian Mission Control Center (INMCC) and the external world.

MCS functions are summarized below:

- Receive incident data from Indian MEOLUT and other MEOLUTs and send to MCS for carryout matching and merging.
- Geo-sort the resultant alert location and transmit MEOSAR alert messages to Indian RCCs/SPOCs or other MCCs as per the standard Data Distribution Procedures.
- Receive orbital elements for active MEOLUT satellites from nodal agency or specified web-location and forwarding to MCP for orbit maintenance and scheduling.
- Receiving two-line elements from INTERNET and forwarding to MCP.
- Remote MEOLUT monitoring and control.
- Mission Control Center monitoring and control.
- MEOSAR system monitoring.
- Supports incoming and outgoing communication through CPS

3.5 Communication Processing System (CPS)

- Works under the control of MCS
- Handles external and internal communications
- Transmission and reception of alert data/messages to/from external SAR agencies (RCCS/MRCCs/SPOCs/MCCs)

4. MEOLUT Communications

Within the MEOLUT, most of the systems will communicate through LAN. For the equipments where LAN interface is not possible, GPIB or RS-232/422 interface can be implemented for communication. Alert data transfer to INMCC is via LAN. MEOLUT communication block schematic is given in **Figure 4**.

At the Indian Mission Control Center (INMCC), communication with MEOLUT will be through LAN. Communication with external agencies will be taken care by a dedicated Communication Processor System (CPS) through WAN, AFTN, FAX etc.

Since both networks exist on a single system, suitable security system must be implemented at INMCC.

Virtual Private Network (VPN), a promising and cheaper technology may be implemented at MCC.

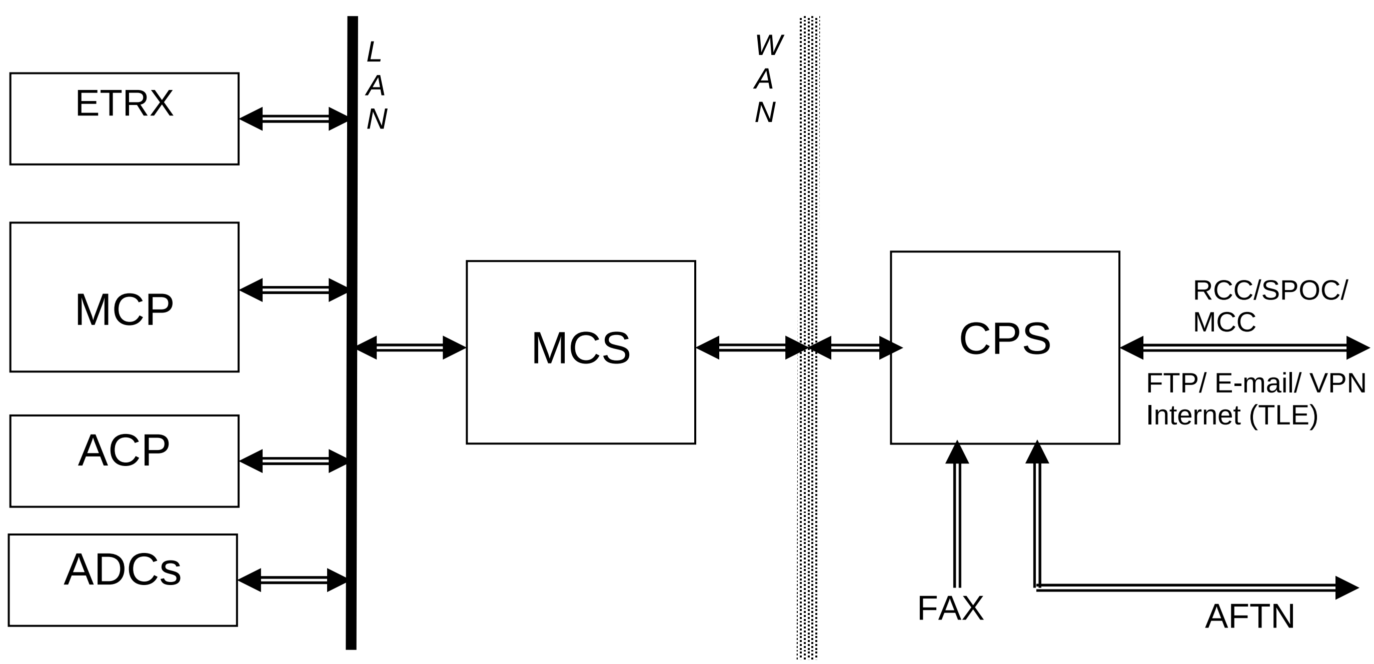
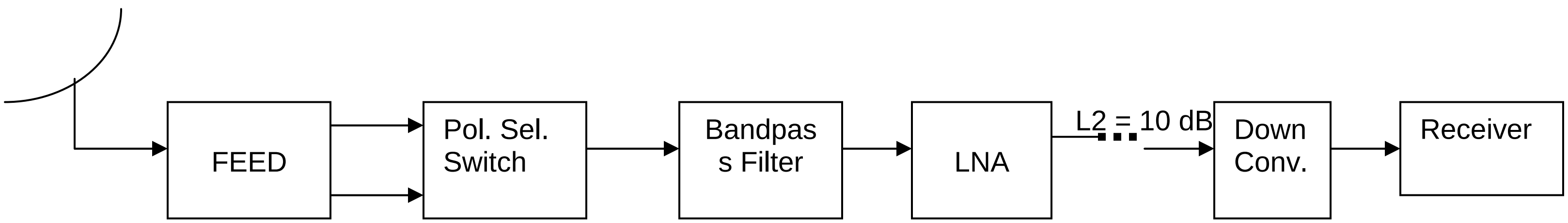


Figure 4: MEOLUT Network Architecture

ANNEXURE 1

(A) PROPOSED RF SYSTEM CONFIGURATION FOR MEOLUT IN L-BAND

Antenna Diameter = 2.4 m



Feed loss + pol.sel. switch loss + BPF Loss = 1.0 dB

$F1 = T1 = 40^0$ K, G1 = 50 dB

F2=10 dB

F3 = 10 dB

Total System Noise Temperature calculation in L-Band:

$$Ts = \frac{Ta}{Lf} + \frac{(Lf-1)\ To}{Lf} + Trx$$

Where

$$Trx = T1 + \frac{T2}{G1} + \frac{T3}{G1G2} + \frac{T4}{G1G2G3}$$

$$\text{Ie.,}\quad 40 + \frac{(L2-1)\ To}{G1} + \frac{(F2-1)\ To}{G1G2} + \frac{(F3-1)\ To}{G1G2G3}$$

$$\text{Ie.,}\quad 40 + \frac{(10-1)\ 323}{100000} + \frac{(10-1)\ 323 \times 10}{100000} + \frac{(10-1)\ 323 \times 100}{100000}$$

$$= 40 + 0.029 + 0.29 + 2.9 = 43.219 \text{ degrees.}$$

:. Receive system Noise temperature = 43.219 deg.

Ta = Antenna Noise temperature in L-Band = 70^0 K S Band = 50^0 K
Lf = Feed loss = 0.1dB
L1 = Pol. Sel. Switch + BPF loss = 0.9 dB
To = 323^0 K = Absolute temperature in deg K.
Trx = Receive system noise temperature (from LNA onwards)
T1 = Noise Temperature of LNA= 40^0 K
T2 = Noise Temperature of the D/C = (F2-1)To
T3 = Noise temperature of the Receiver = (F3-1) To

G1 = Gain of the LNA = 50 dB = 100000 in ratio
G2 = Gain/Loss of the Cable 10 dB = 10 in ratio = L2
G3= Noise figure of the Down converter = 10 dB = F2 10 in ratio

Now,

$$Tsys = T = \frac{Ta}{Lf} + \frac{(Lf-1)\ To}{Lf} + Trx$$

$$\text{Ie.,}\ \frac{70}{1.258} + \frac{(1.258-1)\ 323}{1.258} + 43.219$$

$$= 55.64 + 66.24 + 43.219 = 165.09 = 22.17\ \text{dBK}$$

for L – Band (1544.5 MHz)

The gain of the antenna G = 28.32 dB Tsys or T = 22.17 dBK

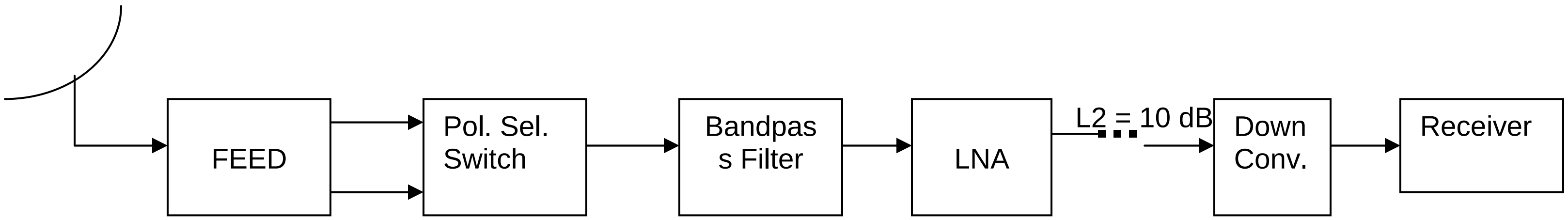
:. G/T = 6.15 dB/ ^{0}K

So, the G/T for L-Band for the above proposed configuration is = 6.15 dB/ ^{0}K

The link margin available for the data reception = 4.89 dB

(B) PROPOSED RF SYSTEM CONFIGURATION FOR MEOLUT IN S-BAND

Antenna Diameter = 2.4 m



Feed loss + Pol. Sel.Switch loss + BPF Loss = 1.0 dB   F1=T1=40^0 K, G1 = 50 dB   F2=10 dB   F3 = 10 dB

<u>Total System Noise Temperature calculation in S-Band:</u>

$$Ts = \frac{Ta}{Lf} + \frac{(Lf-1)\ To}{Lf} + Trx$$

Where

$$Trx = T1 + \frac{T2}{G1} + \frac{T3}{G1G2} + \frac{T4}{G1G2G3}$$

$$\text{Ie., } 40 + \frac{(L2-1)\ To}{G1} + \frac{(F2-1)\ To}{G1G2} + \frac{(F3-1)\ To}{G1G2G3}$$

$$\text{Ie., } 40 + \frac{(10-1)\ 323}{100000} + \frac{(10-1)\ 323 \times 10}{100000} + \frac{(10-1)\ 323 \times 100}{100000}$$

=40 + 0.029 + 0.29 + 2.9 = 43.219 degrees.

:. Receive system Noise temperature = 43.219 deg.

Ta = Antenna Noise temperature in S-Band = 50^0 K
Lf = Feed loss = 0.1 dB
L1 = Pol. Sel. Switch + BPF loss = 0.9 dB
To = 323^0 K = Absolute temperature in deg K.
Trx = Receive system noise temperature (from LNA onwards)
T1 = Noise Temperature of LNA= 40^0 K
T2 = Noise temperature of the DC = (F2-1) To
T3 = Noise temperature of the Receiver = (F3-1) To

G1 = Gain of the LNA = 50 dB = 100000 in ratio
G2 = Gain/Loss of the Cable 10 dB = 10 in ratio = L2
G3= Noise figure of the Down converter = 10 dB = F2 10 in ratio

Now,

$$Tsys = T = \frac{Ta}{Lf} + \frac{(Lf-1)\ To}{Lf} + Trx$$

$$\text{Ie., } \frac{50}{1.258} + \frac{(1.258-1)\ 323}{1.258} + 43.219$$

$$= 39.74 + 66.24 + 43.21 = 149.19 = 21.73 \text{ dBK}$$

The gain of the antenna G = 31.49 dB Tsys or T = 21.73 dBK

:. G/T = 9.76 dB/ ^{0}K

So, the G/T for S-Band with the above proposed configuration is = 9.76 dB/ ^{0}K

:. C/N available = EIRP – PATHLOSS – POLARISATION LOSS – POWER SHARING LOSS – K + G/T =

40.0 - 186.9 - 1.1 - 10.0 + 198.6 + 9.76 = 50.36 dBHz
(24000 KM/15 deg EL)

D/L C/No = 50.36 dB D/L C/Io = 50.36 dB :. D/L C/No + Io = 47.36 dBHz

Overall C/No = 36.76 dBHz Required C/No = 34.8 So Link margin available = 36.76 – 34.8 = +1.96 dB (at 15 deg EL)

:. The Link Margin availability for the Proof of concept phase will be as follows:

a) At 15 deg Elevation where the range is 24000 KM the link margin available is = +1.96 dB (path loss = 186.9 dB)
b) At 30 deg Elevation where the range is 22700 KM the link margin available is = +2.26 dB (path loss = 186.51 dB)
c) At 40 deg Elevation where the range is 21900 KM the link margin available is = +2.66 dB (path loss = 186.19dB)
d) At 50 deg Elevation where the range is 21270 KM the link margin available is = +2.96 dB (path loss = 185.94dB)

Table 1: Gain of Antenna at L- and S-Band Frequencies

GAIN OF ANTENNA AT S BAND FREQUENCY (2226.5 MHz)												
GAIN OF THE ANTENNA = 4(22/7)Ae/L*L												
		Radius	4 (PIE)	c3*c3*b3	4(22/7)* Ae	c in meters	f in Hz	L in meters	L square	GAIN RATIO	efficiency	Gain in dB
4	3.142857143	1	12.57142857	3.142857143	39.51020408	299800000	2226500000	0.134650797	0.018130837	2179.171522	980.627185	29.91503929
4	3.142857143	1.15	12.57142857	4.156428571	52.2522449	299800000	2226500000	0.134650797	0.018130837	2881.954338	1296.879452	31.12899609
4	3.142857143	1.2	12.57142857	4.525714286	56.89469388	299800000	2226500000	0.134650797	0.018130837	3138.006992	1412.103146	31.49866421
4	3.142857143	1.25	12.57142857	4.910714286	61.73469388	299800000	2226500000	0.134650797	0.018130837	3404.955504	1532.229977	31.85323955
4	3.142857143	1.5	12.57142857	7.071428571	88.89795918	299800000	2226500000	0.134650797	0.018130837	4903.135925	2206.411166	33.43686447
4	3.142857143	1.6	12.57142857	8.045714286	101.1461224	299800000	2226500000	0.134650797	0.018130837	5578.679097	2510.405594	33.99743894
4	3.142857143	1.75	12.57142857	9.625	121	299800000	2226500000	0.134650797	0.018130837	6673.712787	3003.170754	34.77580026
4	3.142857143	1.85	12.57142857	10.75642857	135.2236735	299800000	2226500000	0.134650797	0.018130837	7458.214535	3356.196541	35.25847385
4	3.142857143	2	12.57142857	12.57142857	158.0408163	299800000	2226500000	0.134650797	0.018130837	8716.686089	3922.50874	35.9356392
	GAIN OF THE ANTENNA AT L-BAND FREQUENCY (1545.1 MHz)											
4	3.142857143	1	12.57142857	3.142857143	39.51020408	299800000	1545100000	0.194032749	0.037648708	1049.443836	472.2497261	26.74171715
4	3.142857143	1.15	12.57142857	4.156428571	52.2522449	299800000	1545100000	0.194032749	0.037648708	1387.889473	624.5502628	27.95567395
4	3.142857143	1.2	12.57142857	4.525714286	56.89469388	299800000	1545100000	0.194032749	0.037648708	1511.199124	680.0396056	28.32534207
4	3.142857143	1.25	12.57142857	4.910714286	61.73469388	299800000	1545100000	0.194032749	0.037648708	1639.755994	737.8901971	28.67991741
4	3.142857143	1.5	12.57142857	7.071428571	88.89795918	299800000	1545100000	0.194032749	0.037648708	2361.248631	1062.561884	30.26354233
4	3.142857143	1.6	12.57142857	8.045714286	101.1461224	299800000	1545100000	0.194032749	0.037648708	2686.57622	1208.959299	30.8241168
4	3.142857143	1.75	12.57142857	9.625	121.0	299800000	1545100000	0.194032749	0.037648708	3213.921747	1446.264786	31.60247812
4	3.142857143	1.85	12.57142857	10.75642857	135.2236735	299800000	1545100000	0.194032749	0.037648708	3591.721528	1616.274688	32.08515172
4	3.142857143	2	12.57142857	12.57142857	158.0408163	299800000	1545100000	0.194032749	0.037648708	4197.775343	1888.998905	32.76231706

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