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National Centre for Radio Astrophysics, (TIFR), Pune, India	**A Control and Monitoring system for the GMRT : Description and Requirements**	**Prepared by :**	**J. Kodilkar, R. Balasubramanian**
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A Control and Monitoring system for the GMRT
Description and Requirements

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LIST OF ABBREVIATIONS

ABC .....Antenna Base Computer
ADC .....Analogue To Digital Converter
ANTCOM .....Antenna Computer
AZ .....Azimuth
BB .....Base band
CEB .....Central Electronic Building
CMS ..... Control and Monitoring System
COMH .....Communication Handler
CSQ .....Central Square Antenna
DAS .....Data Acquisition System
DEC .....Declination
E Arm .....Eastern Arm Antenna
EL .....Elevation
FE .....Front end
FPS .....Feed Positioning System
FSK .....Frequency shifting Keying
FSTC .....Fractional Sampling Time Correction
GCC .....GMRT Coordination Committee
GMRT .....Giant Metre wave Radio Telescope
GMRT_RQ ..... GMRT Requirement
GSB .....GMRT Software Back end
GTAC .....GMRT Time Allocation Committee
HDLC .....High level Data Link Control
IA .....Incoherent Array
IF .....Intermediate Frequency
LO .....Local oscillator
LTA .....Long Term Accumulation
MAC .....Multiplier And Accumulator
MCM .....Monitor and Control Module
M&C .....Monitoring and Control System
NCRA ..... National Centre For Radio Astrophysics & Astronomy
OF .....Optical Fibre
ONDISP ..... ONLINE DISPLAY
PA .....Phased Array
RA .....Right Ascension
RFI .....Radio Frequency Interference
RF ..... Radio Frequency
S Arm .....Southern Arm Antenna
SDLC .....Synchronous Data Link Control
SSC .....Servo Station Computer
SUBAC ..... Sub-array controller
TDM .....Time Division Multiplexing
TIFR .....Tata Institute of Fundamental Research
W Arm .....Western Arm Antenna

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1. INTRODUCTION

1.1 Purpose and Scope of the Document

GMRT Control and Monitoring system developed around 1991 to 1996, has gone through many modifications , evolution and maintenance stages as per the need realized from various categories of the users (viz: Astronomers, Engineers, Operators and Coordination personnel) as well as the requirements from the development of GMRT systems to enhance the performance. This document describes the perspective of the present GMRT Control and monitoring systems along with listing out it's capabilities/features which fulfils the functional and non-functional requirements to run the GMRT observatory. This document also aims to add as a supportive document for the SKA1 design concept and review [1] on the Control and Monitoring system (CMS).

1.2 Operational features available using the GMRT

It provides the human interface Telescope Operators, Scientists and maintenance personnel for proper operation of the antennas from CEB. It also controls and monitors all parts of the Telescope system for proper operation and alert the operator in case of any anomalous behaviour. In case of severe fault conditions, safety procedures have to be initiated locally. It also prevents human errors from placing the telescope in a dangerous situation. CMS try to meet all the points mentioned above. It uses a set of software modules running on UNIX work station to provide CMS functionality in real time.

The complete control of the telescope lies with the telescope operator. The user communicates the observing requirements to the telescope operator who will configure the various systems accordingly and conduct the observation.
Different modes of observations are continuum, spectral line and pulsar. Once the data acquisition starts, various display programs are uses to qualify the data in real time and off-line. All the 30 antennas can be further divided into sub-groups and up to 5 different experiments can co-exist. The user converts the data into FITS format and analyses it using the standard AIPS package.

Various tasks carried by CMS are listed below:

1. Rotate all the 30 antennas in AZ (horizontal) and Elevation (vertical) axis, and track celestial objects with offsets/corrections if any using Servo system.
2. Focus the required Feed like di-poles using the Feed Position system.
3. Tune the Receiver chain (Radio Frequency, Local Oscillator frequency,filters, and gain controllers) electronic systems to a desired observing Frequency band and optimize power level of received astronomical signal.
4. Select and configure the hardware/software back-Ends in various observing modes to process the astronomical signal.
5. Form multiple groups of antennas (Sub-arrays) for required observing projects.
6. Supervise, control and monitor all systems and sub-systems of the observatory.
7. Monitor the status of critical alarm and raise suitable alerts.
8. Monitor and Log various system parameters, retrieve the logged information.
9. Execute an observing session or perform engineering tests through an user created batch file or through manual operation.
10. Run all the above activities continuously 24 Hrs. X 7 days without any interruption.

Fig 1. Illustrates the various tasks executed by the GMRT control and monitoring system.

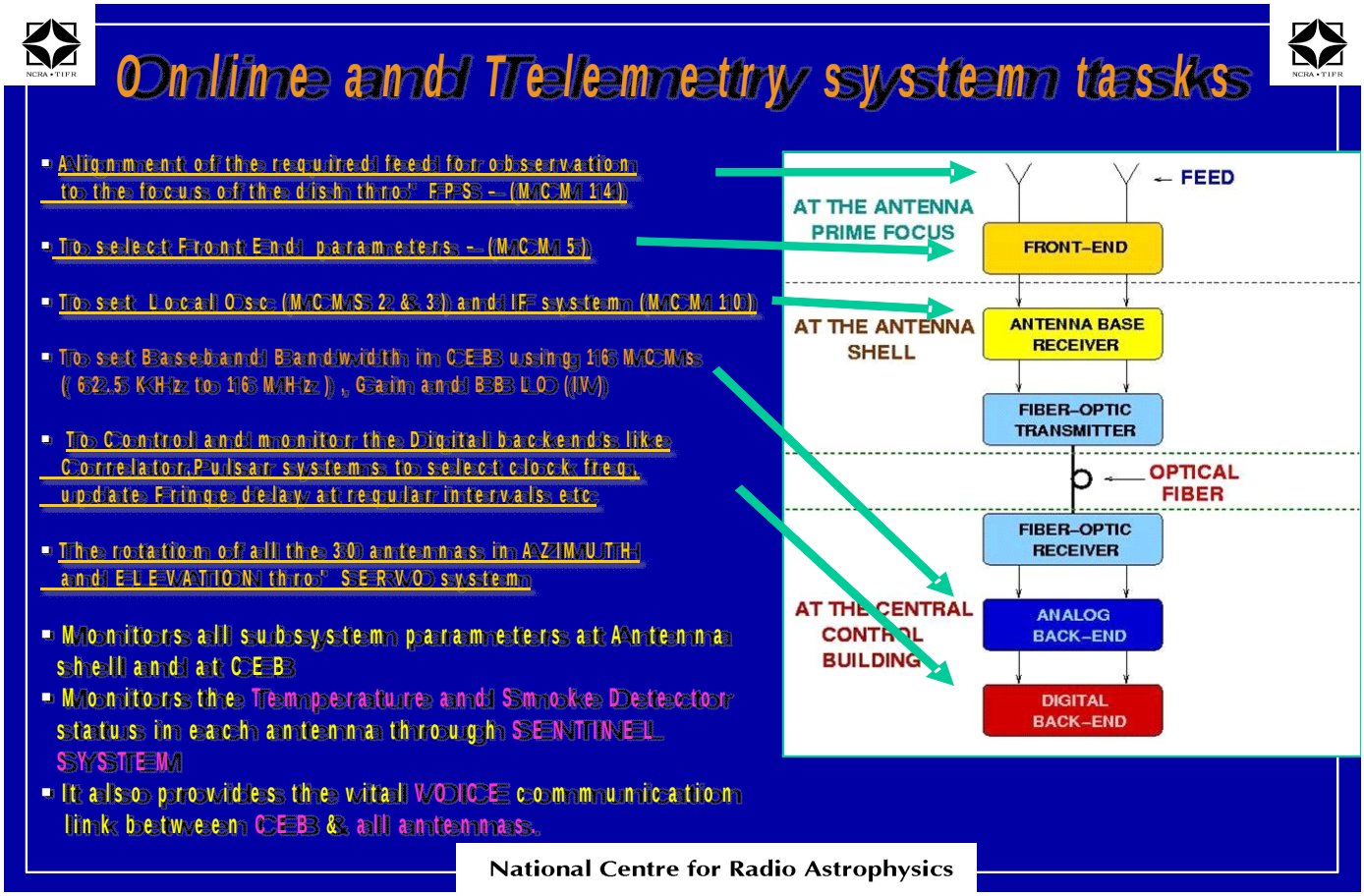

Fig 1 : Various tasks of the GMRT Control and Monitoring System

2. DESCRIPTION OF THE GMRT C&M SYSTEM COMPONENTS

The GMRT Control and Monitoring System comprises of several hardware and software systems as shown in Fig 2. The main blocks are the ONLINE system which runs on Unix workstation, supports user interfaces and required basic functionality for the observation, PC router which routes the packets between the ONLINE and Communication Handler (COMH) by converting the TCP/IP Ethernet packets into appropriate asynchronous serial data format and vice versa. The COMH broad-cast the command packets from the ONLINE to all antenna base computers and receives the responses and monitoring packets from all antennas in TDM mode. At the antenna base, ANTCOM acts as the master computer to control and monitor the servo via Servo Station Computer (SSC) and the receiver systems via Monitor and Control Modules (MCM). Also, ONLINE provides interfaces and controls several systems like GMRT software back end, Baseband systems etc. present in the central electronics building. All the blocks shown in Fig. 2 are described in more detail in the following sections.

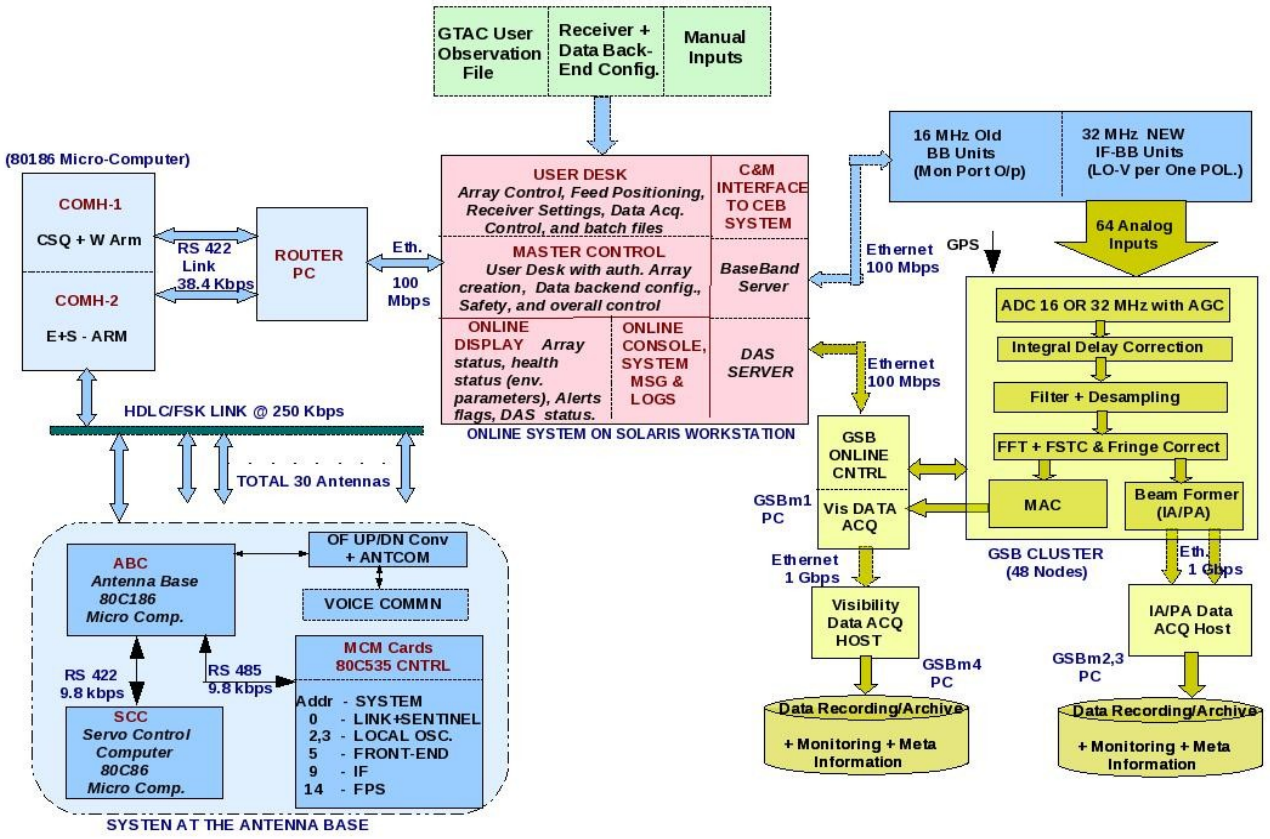

Fig 2 : Schematic Block diagram of the GMRT Control and Monitoring System

2.1 ONLINE :

The ONLINE is a central supervisory system which controls and monitor the GMRT's sub-systems like servo, antenna receiver, sentinel systems in the antennas and other sub-systems like baseband, software correlator configuration and data acquisition in CEB. The commands typed by the user are sent to the relevant antenna(s) by the telemetry system. The monitoring data from all the various GMRT sub-systems are also logged by ONLINE. Upon detection of any critical subsystem failure, ONLINE raises an appropriate alarm so that remedial action can be taken. The ONLINE software consists of a number of independent communication programs which runs on Unix workstation. These programs are developed in-house mainly using Fortran and C languages. ONLINE can form a number of sub-arrays (group of antennas) which can perform multiple observations simultaneously by allowing multiple user-terminals for either

executing the observing sessions or engineering test. Main components of the ONLINE are “ON Display” to monitor the health status of the arrays, observing information, master control to initiate multiple user and sub-array terminals, message and alarm consoles to display alerts/alarm raised upon the failure of critical system or upon exceeding the threshold limits of safety parameters like temperature, wind etc.

Specifications of PC used for ONLINE system :
Model : SUNW, A70 Sparc, Physical Memory 2 GB, CPU type UltraSPARC IIIi, SunOs 5.10.

Two Solaris workstations, installed with ONLINE Software, are working satisfactorily. One machine is used as Online machine for GTAC observation and the other one is kept as HOT standby and they are interchanged once in every GTAC cycle.

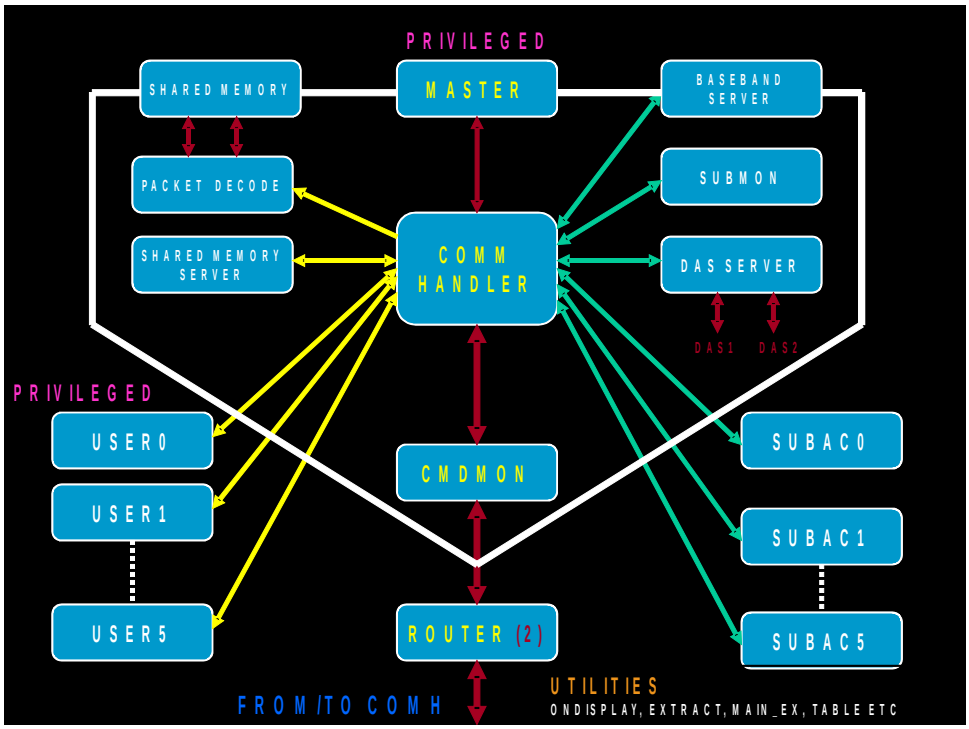

Fig 3 : Various software building blocks of the GMRT Control and Monitoring System

ONLINE programs : The ONLINE system configuration is defined in *onconfig.def* file. This file gives a list of processes needed to run ONLINE with all other details like process name, it’s port ID for the connection, process ID and executing permissions. Each process runs independently and communicate via Unix communication handler (also known as 'unixhub'). Unixhub process coordinates each process input/output where each process can restarted or halt for the debugging. The connectivity between the processes running on the ONLINE Solaris workstation is shown in the Fig 3. A brief information about each process block shown in the Fig.3 given below.

- **MASTER :** This is a main start-up program for ONLINE which initializes shared memory for online data structure, spawns requisite processes given in *onconfig.def* file , and establishes socket communication to unixhub. After all initial set up, MASTER and its links USER[0−5] programs invoke POPS command parser which takes input from user terminal and convert into the form that is recognized by final processor for execution.
- **COMMUNICATION HANDLER OR UNIXHUB :** As name suggests, this process works as a central hub which establishes communication with master, pktdecode, serialsock, and subac. Hence all communications of online system route via unixhub process. It receives packet from scctask and send it to pktdecode. Also, it takes commands from master/subac, parses it and forward to scctask.
- **PACKET DECODE :** Process waits for packets from unixhub, decodes it and write into shared memory. Thus, packet-decode establishes a shared memory area containing a structure with all information of the online system so that it can be accessible for other processes like displaying online status on screen or log it on a disk.
- **SUBMON :** This process mainly keeps track of overall sub-array status of antennas, this includes whether antennas in sub-array are configured or communicating, tracking status of array, servo computer status, wind speed etc. Submon process establishes communication with unixhub and decodes messages from it. The decoded status is written in shared memory for online display purposes as well as logged in SUMMARY.LOG

file.

- **SERIAL SOCKET (SCCTASK) :** Scctask connects to router PC via socket communication which talks to two communication handlers (called ComH-1 and ComH-2 used to broadcast commands to two sub-group of antennas), also it establishes contact with unixhub. This process handles routing of data/command packets between communication handler and unixhub.
- **SHARED MEMORY SERVER:** This process acts as a shared memory server, a client program can connect to this process over TCP/IP socket for reading and logging online data.
- **SUBAC :** Sub-array controller (subac) process mainly handles sub-array control and monitoring tasks which involves tracking a source, initialization of antenna tracking parameters, monitoring the status of antennas in the sub-array, and data acquisition command for subarray etc. Also, subac process can control activities of antenna through a command file. Subac receives all commands and messages from unixhub process.
- **ONDISPLAY :** This is a main online display for users which monitors all activities related to antenna and sub-array, this includes status of antenna base computer (ABC), servo computer, monitoring points of receiver chain (IF, LO, RF), telemetry system, wind status, and sentinel systems etc.

2.2 PC ROUTER :

This is used to convert the commands/responses of TCP/IP Ethernet stream at 100 Mbps from/to ONLINE system to/from asynchronous 8 bit - RS422 serial communication link at 38.4 Kbps of COMH. Linux based PC with suitable software in “C” is used to accomplish this task.

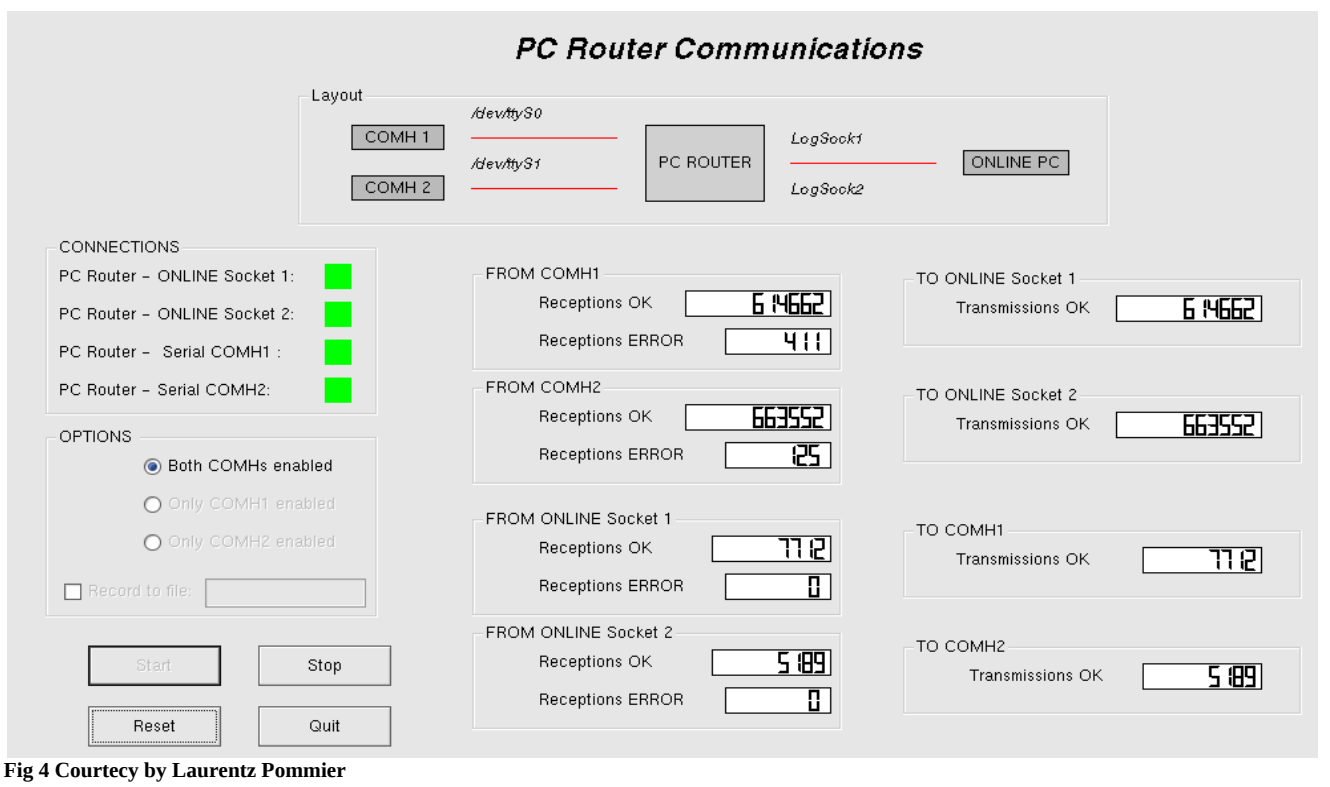

Fig 4 Courtecy by Laurentz Pommier

2.3 COMH

COMH is the **Com**munication **H**andler which handles all the communication between the UNIX workstation (ONLINE) which and all the 30 ANTCOMs. COMH can operate in TDM or broadcast mode. By default, it operates in TDM mode and sends the formatted user commands meant for the first antenna to the first antenna and then waits for an acknowledgement and responses from all the sub-systems in the antenna sent by ANTCOM. If it receives an error-free reply before the time-out period, it selects the next antenna and the operation continues. In case, COMH doesn’t get a reply before the time-out period or if the reception is erroneous then it tries the same antenna again. After a total of three failures, COMH passes on a Time-out or Checksum error information (as appropriate) to ONLINE and then moves on to the next antenna. COMH1 handles Central square and W arm antennas (20) and gets the antenna status in about 4 seconds, COMH2 handles E and S arm antennas (10) and gets the status in about 2 seconds.

But when it receives common commands from ONLINE for all the 30 antennas, it operates in broadcast mode ie. COMH sends the common commands to all the 30 antennas in one go and doesn't wait for any acknowledgement from the antennas. This ensures that all the antennas receive the commands with minimum delay. The return signals from all the 30 antennas are handled by 30 CEBCOMs and two MUX32s and sent to COMH1/2.

2.4 ANTCOM or ABC

There is an ANTCOM (also called an ABC) located in each and every antenna shell. All communication between the ONLINE/COMH and sub-systems in the antenna is routed through the ANTCOM in that antenna. The ANTCOM receives various parameters (commands) sent by ONLINE/COMH, performs some computations if necessary, and passes on the commands to the appropriate subsystem of the antenna. In detail, the ANTCOM has three communication links viz. (a) the main data link between COMH & ANTCOM which operates at 125 Kbps, (b) an asynchronous 9.6 Kbps, RS 422 communication link between ANTCOM and the Servo Station Computer (SSC) and (c) an asynchronous 9.6 Kbps, RS 485 communication link between ANTCOM and MCMs. ANTCOM can handle upto 16 MCMs in a cycle time of 1 sec. FPS is also configured as one of the MCMs (MCM address 15) and connected to the MCM bus.

ANTCOM's jobs in main loop of application layer are :

- Initialise ANTCOM in application mode : Tallies the command & response counters of ANTCOM to Unix, sets the real time of day for ANTCOM. Configure MCMs, set anamask, and load antenna specific tracking parameter.
- Handles three Communication links.
- Communication with configured MCMs, enable/disable specific MCM monitoring.
- Receive time dependent, source specific parameters and antenna parameters from ONLINE/COMH.
- Communication with Servo : generate periodic display command for ONLINE, Control tracking operation locally for the specified maximum duration.
- Auto parking of antenna (El : 90d, Az : 0d).
- Forming a response frame to COMH.
- Set various timing and communication parameters for ANTCOM -- COMH, MCMs & SERVO.

Details of ANTCOM/COMH card :

ANTCOM/COMH card has been developed using various ICs like 80C186 - 8 bit micro-controller, 85C30 – Dual communication controller used for SDLC/HDLC communication with COMH and asynchronous communication with Servo/PC router, 80C510 – communication controller for MCM, FSK MODEMs, VOICE codec etc. The total data rate used for communication between COMH and ANTCOM is 250 Kbps. The main data communication for sending/ receiving the Commands/responses uses SDLC/HDLC protocol at 125 Kbps. Voice for Telephone is digitized at 62.25 Kbps. Four auxiliary channels of 15.625 Kbps are used for various purposes like synchronization bytes, telephone dialling, ANTCOM remote reset etc. Bit interleaving techniques are used to combine all the digital information into a single 250 Kbps data stream. Since analog optical fiber link is used for linking all the antennas with CEB, this 250 Kbps digital data stream is converted into analog form using FSK techniques. The forward link uses 18 MHz and the return link uses 205.5 MHz carrier. Polynomial error detection – 16 bit checksum and ARQ techniques are used for validating the commands and responses. A remote reset facility using Telephone is also available to reset 80C186 used in the ANTCOM in case of any malfunctioning in any antenna.

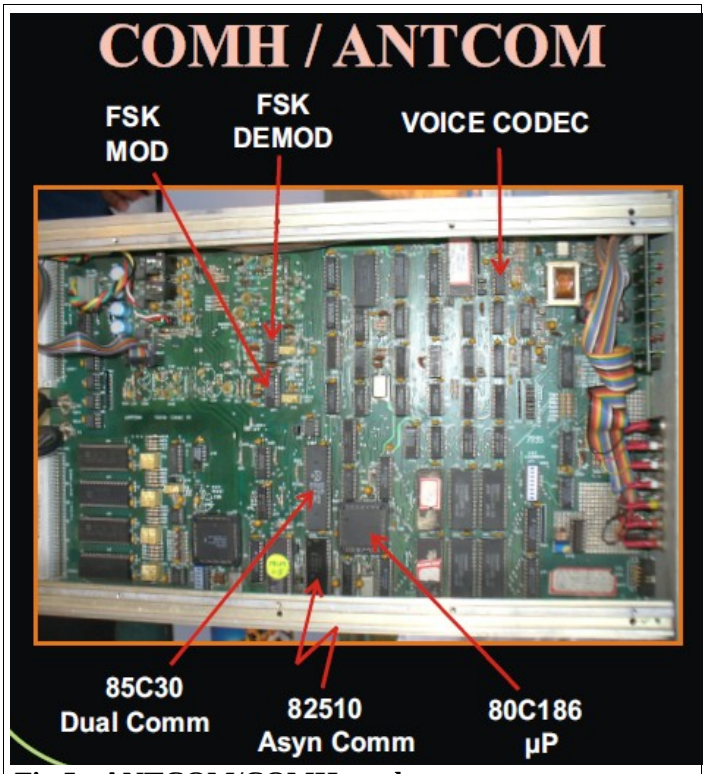

Fig 5 : ANTCOM/COMH card

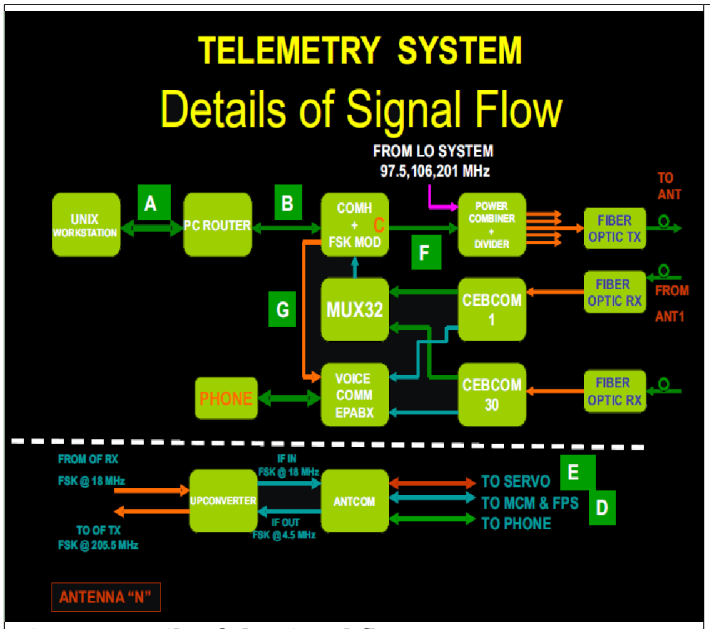

Fig. 6 : Details of the signal flow

(A) ETHERNET LINK -----> 100.0 Mbits /sec
(B) ASYNCHRONOUS -----> 38.4 Kbits/sec
RS232C LINK - 10 BITS
(C) SDLC/HDLC LINK -----> 125.0 Kbits/sec
(D) ASYNCHRONOUS -----> 9.6 Kbits/sec
RS 485 LINK - 11 BITS
(E) ASYNCHRONOUS -----> 9.6 Kbits/sec
RS 422 LINK - 10 BITS
(F) FSK MODEM LINK -----> 250.0 Kbits/sec
(G) VOICE COMM -----> 62.5 Kbits/sec

1. DATA (COMH - ANTCOM COMM) --> 125.000 Kbits/sec
2. VOICE (TELEPHONY VOICE) --> 62.500 Kbits/sec
3. DIAL (TELEPHONY SIGNALLING)--> 15.625 Kbits/sec
4. SYNC (SYNC PATTERN) --> 15.625 Kbits/sec
5. AUX1 (AUXILIARY CHANNEL1) --> 15.625 Kbits/sec
6. AUX2 (AUXILIARY CHANNEL2) --> 15.625 Kbits/sec

TOTAL DATA BIT RATE ---> 250.000 Kbits/sec

2.5 Monitor and Control Module (MCM)

MCMs are general purpose micro controller based cards which provide 16 TTL Control outputs and can monitor up to 64 analog signals of +/- 2.5V, +/- 5.0V or 0 to 5V ranges. These MCMs are used to set/monitor various system parameters of GMRT subsystems like FE, LO, BB etc. In detail, at each antenna, MCM 5 is the interface to the front end system, while MCMs 2,3, and 10 are the interface to the LO and IF systems and many MCMs are used for interface to BB system at CEB.
MCM card uses 80C535 8-bit micro-controller with 8 bit ADC built-in, four 16 bit analogue multiplexers etc. It uses 9 bit asynchronous protocol at 9.6 Kbps for communication with ANTCOM using RS485 differential two-wire communication link.
Polynomial error detection – 8 bit checksum and ARQ techniques are used for validating the commands and responses.

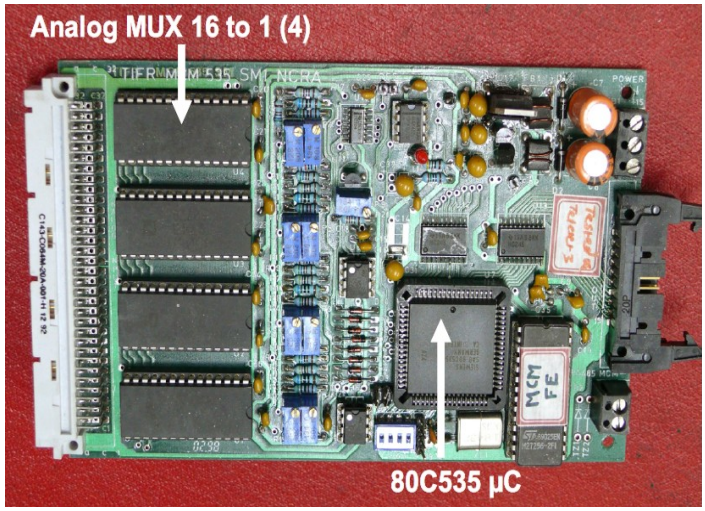

Fig 7 : MCM card

2.6 Servo Station Computer (SSC)

SSC uses 80C86 based micro-processor. It uses RS422 differential data link at 9.6 Kbps to communicate with ANTCOM and this link is used to send/receive various commands/responses to the electro-mechanical systems of GMRT.
SSC accepts the movement , tracking, apply/release brakes to the movement axis etc. commands from the ANTCOM/ ONLINE, checks that the command is sensible, and if so obeys it. It also returns the antenna status information periodically through the same link. This information is passed on by the ANTCOM to ONLINE and is displayed on a monitor in the control room.

2.7 Feed Positioning System (FPS)

FPS is used to rotate the feed turret to bring the desired feed to focus of the antenna. It is developed using 80C51 micro-controller and communicates with ANTCOM through MCM communication link using RS485 protocol at 9.6

Kbps.

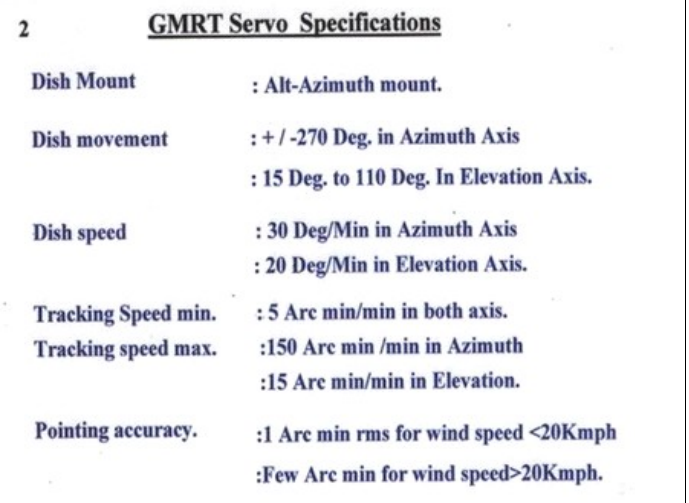

Fig 8 : Specifications of Servo system

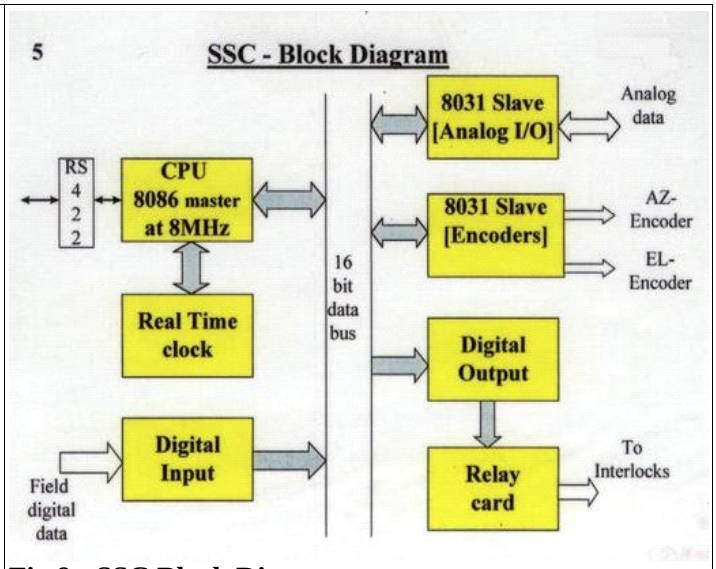

Fig 9 : SSC Block Diagram

2.8 Interface to the Data back-end systems

ONLINE provides the interface over the Ethernet network to the data back end systems like GMRT Software backend (GSB), baseband systems present in the central electronics building (CEB).

2.8.1 GMRT Software Back-End GSB :

The GMRT Software Back-end (GSB) is a full polar real-time software correlator with high time resolution incoherent and coherent array beam formation/processing back-end. The GSB takes ***32 antennae x 2 pols*** analog signals inputs either of **16 MHz** from existing Base-band (BB) unit or **32 MHz** Base Band output from new IF-BB conversion units. There are two main functional modes of the GSB - one is **`raw dump'** and other is **`real time'** mode. In ***raw-dump*** mode, 32 MHz base-band signals are recorded on the disk array for off-line read-back and computation purposes. In ***real-time*** mode, GSB gives final visibilities at ~ 2 sec integration time on **gsbm1** linux machine. This data is transferred to data host machine **gsbm4** in a *GMRT LTA (Long Term Acquisition) format* for recording and monitoring purpose. Along with interferometric data, Incoherent array (IA) and Phased array (PA) beam formation can take place simultaneously on GSB pulsar host machine **node33** and **node34** respectively. The pulsar data is processed (data marker checks, GPS time stamping etc.) and transferred to data host machines **node37 or 49** and **node38 or 50** for recording and monitoring purposes.
The ONLINE takes commands from the user terminal for the configuration of GSB and astronomical data acquisition from the GSB. These commands are passed to the GSB via data-acquisition server (das server) which accepts the client connection from the GSB. The GSB configuration file from the ONLINE is send as the GSB initialization and configuration part, after the successful initialization, user can acquire the data using the simple start and stop data acquisition command along with the observing project information. Online provide the RA, DEC and frequency information of the target source so that the GSB can use this information for the delay tracking and fringe stop.
Fig. 10 shows the overall flow diagram depicting from the user/astronomer input to the ONLINE (such as observing batch file, tuning receiver etc) up to GSB configuration and real-time data monitoring and data analysis.

2.8.2 Base band :

To control and monitor BB and GSB-LO systems through ONLINE, a 'bblocli' (Baseband GSBLO client) program which communicates with both the GSB-LO and old Baseband server. The 'gsblosrv' server and the baseband server program runs on two separate 'bbpc' and 'loconf' machine. By default, the 'bblocli' program communicates with both the servers. In case, user wants to communicate only one base-band system user can initiate the 'bblocli' program by giving options on the command line.

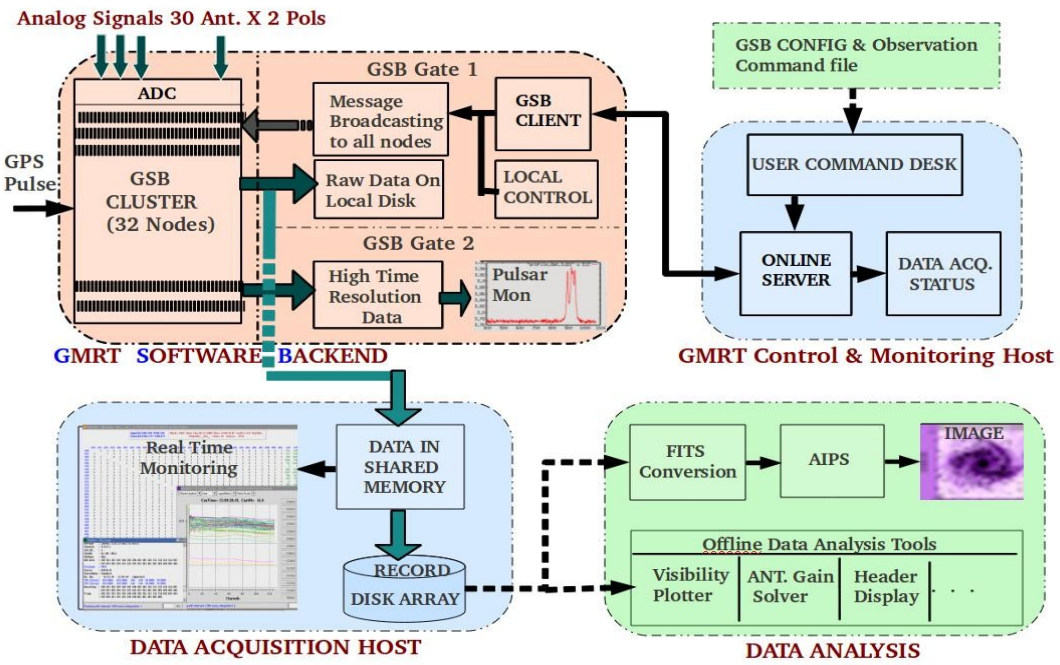

Fig. 10 Block Diagram of real time interface to the GSB

Available modes of the GSB

(Release Ver. 2.1 15 April 2011)

	Observation Type		Usage Mode	Input IF BW (MHz)	Acquisition BW or Final o/p BW (MHz)	Number of Channels	Output Time Resolution
1	Interferometry : Continuum		Total Intensity (32 MHz mode)	32,16,6	32	512, 256	2,4,8..(sec)
			Total Intensity (16 MHz mode)	16,6	16	512, 256	2,4,8..(sec)
						128	0.5,1,2..(sec)
						64, 32	0.25,0.5,1..(sec)
			Full Stokes (32 MHz mode)	32,16,6	32	512(*), 256	2,4,8..(sec)
			Full Stokes (16 MHz mode)	16,6	16	512, 256	2,4,8..(sec)
2	Interferometry : Spectral Line		Total Intensity (16 MHz and lower BW modes)	16,6	16 / N (N=4,8,16..128) (viz. 4, 2, 1, 0.5,0.25 & 0.125 MHz)	512, 256	2,4,8..(sec)
3	Array: Beams	IA	Total Intensity (32 MHz mode)	32,16,6	32	512, 256	Pre:2 (#) Post: 1,2,4
			Total Intensity (16 MHz mode)	16,6	16 / N (N=4,8,16) (viz. 4,2,1 MHz)	512, 256	Pre:1,2 ($) Post: 1,2,4
		PA	Total Intensity (32 MHz mode)	32,16,6	32	512, 256	Pre:2 (#) Post:1,2,4
			Total Intensity (16 MHz mode)	16, 6	16 / N (N=4,8,16) (viz. 4,2,1 MHz)	512, 256	Pre:1,2 ($) Post: 1,2,4
			Full Stokes (16 MHz mode)	16,6	16	512, 256	Pre:2 ($) Post:1,2,4
			Voltage Beam (32 MHz mode)	32,16,6	32	512, 256	15 nsec (@)
			Voltage Beam (16 MHz mode)	16,6	16	512, 256	30 nsec (@)
4	Raw Dump		Raw voltages from all antennas	16,6	16		30 nsec at 4 bits per sample

Notes :

(*) Released on trial basis : set lta-visibility pre-integration to 4sec and beam output 245.76 uSec.

(#) For 32 MHz modes : base integration is 61.44 uSec for 512 channels, 30.72 uSec for 256 channels. For Post Integration = 1, this gives 122.88 uSec and 61.44 uSec, respectively, as the sampling times.

($) For 16 MHz modes : base integration is 30.72 uSec for 512 channels, 15.36 uSec for 256 channels. For Post Integration = 1, this gives 61.44 uSec and 30.72 uSec, respectively, as the sampling times.

(@) Output data is in spectral voltage form; needs one inverse FT to get voltage time series with time resolution of 15 nsec for 32 MHz mode and 30 nsec for 16 MHz mode.

2.9 User Inputs

As per the observing schedule, ONLINE can accept and execute the observing batch files, accept the user inputs through command-line terminal having the AIPS (Astronomical Image Processing System) Shell environment. As the ONLINE user interface uses the customized AIPS shell environment, many of the its facilities are being used inherently like:

(i) User-terminal can accepts the customized input parameters given by the user.
(ii) User can use the standard procedure containing multiple commands and gets the execution status.
(iii) User can run the RUN-FILE in the ONLINE environment where predefined sequence of jobs are listed.
(iv) User can spawn a independent sub processes like 'TASKS' in aips in the background. For example, observing command/batch file can run in the background and the operator can use the user-terminal to handle the urgent or emergency situation.

3. FUNCTIONAL REQUIREMENTS EXECUTION BY THE CONTROL AND MONITORING SYSTEM

The functional requirements mainly addresses the system behaviour expected by users. For any astronomical observatory, main users can be categorized into - astronomers who uses the telescope for scientific purposes, engineers/technical staff who maintain and evolve/develop the telescope systems, and telescope operators who operate the telescope. This chapter list the functional requirements section wise and explain about the functional requirements execution in practice by the GMRT Control and Monitoring System.

3.1 Observational Requirements

3.1.1 Pre-observation requirements : source information, observing file etc.

ID	Requirement	CAM Execution
GMRT_RQ001	**Validation about the given target source is up in the sky**	**(i) GTAC observation schedule put the constraints of source rise and set time while allocating the observation time to the user (ii) Observatory has the tools to inform the rise-transit-set time for the given target source at specified day. (iii) If the target source not up in the sky or transiting the alert message is displayed in the ONLINE console. (iv) ONLINE system gives prior information about the target source's RA,DEC and epoch entered by the user, precessed RA, DEC to today's epoch along with the rise and set time.**
GMRT_RQ002	**Adding the new source catalogues and validation of the sources in the ONLINE.**	**(i) User can add up to maximum ten catalogue present. (ii) User get warning messages if the catalogue fields are invalid or not in the proper/correct GMRT observatory catalogue format. (iii) User can delete the excess/unwanted source catalogue.**
GMRT_RQ003	**Attributing the relevant code/tag to the celestial observing sources.**	**User can attribute the 'c' code for calibrator , 'p' for phase calibrators or 't' for the target sources as per the requirement. This information goes to the GMRT LTA format astronomical data which can be reused for further analysis.**
GMRT_RQ004	**Specifying the data acquisition time on the target/astronomical source**	**User can specify the required time for the data acquisition on the target celestial source in the ONLINE using the 'time x' command.**
GMRT_RQ005	**Scheduling the observation (requirement of batch-file)**	**User can schedule the observation using the batch-file with the following facilities : (i) User can open/close, start, pause the batch file as per the need. (ii) User can jump on some particular execution step by giving the line number. (iii) User can use all the commands supported by the ONLINE system (iv) User can repeat the observing commands in a loop or number of time as per the requirement.**
GMRT_RQ006	**Validation of the receiver settings**	**If the observation setting parameters to tune the receiver are outside the limits, the receiver setting programs gives warning about it and setting commands are not generated.**
GMRT_RQ007	**Ensure the required observing mode has been configured in the software data processing back-end (GSB)**	**ONLINE system send the configuration file to the GSB across the network. ONLINE get the configuration and initialization successful message.**

3.1.2 During the observing session

ID	Requirement	CAM Execution
GMRT_RQ008	**Pointing corrections for the given target field should be loaded dynamically.**	**The ONLINE system loads the pointing correction model as a function of target source's horizontal coordinates (Azimuth and Elevation) , time and the individual antenna position (Latitude,Longitude,Height). Before starting of the data acquisition scan each time the pointing corrections are loaded.**
GMRT_RQ009	**Tracking the source with OFF position**	**The ONLINE can track the target source with OFF positions in Right Ascension (RA), Declination (DEC) or (Azimuth) AZ and (Elevation) EL.**
GMRT_RQ010	**Tracking the source with the specified RA and DEC or EL and AZ rate**	**The ONLINE system can track the target source with given RA, DEC and EL,AZ rate. For e.g. For the planetary objects like SUN, MOON, JUPITER, antennas can track with given RA,DEC or AZ,EL rate.**
GMRT_RQ011	**Execution of the command at the predefined time**	**ONLINE can execute any supported command at the predefined time.**
GMRT_RQ012	**Scanning across the target source**	**ONLINE system can scan the target source with given angle for scanning and the on source time specified using the scan command in RA,DEC or AZ, EL.**
GMRT_RQ013	**Carrying out the multiple observations/ experiment**	**ONLINE system can form a group of antennas known as sub-array. Up to maximum 5 sub-array can be formed to carrying out the observing session and experiment/debugging simultaneously where authentication to control a group of antennas can be given to particular sub-array controller. Except the master program no other sub-array can control the unallocated antennas to the sub-array.**
GMRT_RQ014	**Changing the receiver settings during the observing session for the band pass calibration, gain calibration, sensitivity checks etc.**	**Using the batch-file, (i) astronomer can change the Rf centre frequency by mentioning the RF/LO related commands. This requirement is being used in the spectral-line observation for the bandpass calibration or to check the sensitivity of the whole RF-band/new feeds during the maintenance time. (ii) To check the sensitivity, polarisation isolation, various ONLINE commands can be issued in a batch file like noise on/ off, switching the noise level, swapping the RF channel.**
GMRT_RQ015	**Warning/Alert during the observing session**	**The ONLINE system logs and give the warning/alert messages in case of malfunctioning of any telescope systems or source not rise or set already.**
GMRT_RQ016	**Monitoring the progress of observation**	**The progress of the observation can be monitored using the (i) Sub-array status. (ii) Display of the target source under tracking and phase centre being used by the correlator for fringe stopping and delay tracking. (iii) Data acquisition status display. (iv) Meta-information about the running observation project like project code, title, observer's name, precessed RA/ DEC of the target source, receiver setting parameters etc. and (v) alarming messages during the start and stop of the data acquisition.**
GMRT_RQ017	**Start and stop the Data acquisition from the data processing back-end**	**ONLINE send the start or stop data acquisition commands to the GSB and get it's response whether successful execution of the command was done or failure with reasoning message.**
GMRT_RQ018	**Send the Target source information to the GSB for the delay tracking and fringe stop.**	**ONLINE send the Target source Apparent , mean RA and DEC information along with the RF, LO parameters to the GSB.**
GMRT_RQ019	**Provide the meta data information**	**ONLINE send the observing project code, title, observers name, phase centre, RF, LO parameters etc. project information to the GSB so that the astronomical data recording can incorporate this information in to the header.**

3.1.3 Post observation requirements : Meta-Data information

ID	Requirement	CAM Execution
GMRT_RQ020	ONLINE system should provide the telescope malfunctioning or non-working system information along with a time-stamps and duration so that the bad-data acquired during the observing run can be flagged.	ONLINE system runs the 'logflag' program which logs the information about malfunctioning and non-working system with time stamp and duration for which system/antenna was not working. This information used to flag the bad data while converting the GMRT LTA format conversion to the FITS format by the 'gvfits' program.
GMRT_RQ021	Observation Log	ONLINE system assist to understand the activities during the observing session by writing the telescope status log in the human readable format.

3.2 Antenna Control

3.2.1 Control System at the antenna base

ID	Requirement	CAM Execution
Antenna Base Computer (ABC)		
GMRT_RQ022	Initialize the systems at the antenna base	(i) ABC micro controller (80C186) load the firmware in 'application mode'. Get the time from Unix workstation and set the ABC time. (ii) Reset and tallies the command and response counter between ABC and Unix workstation (iii) Configure the required MCM, set the analog channel mask for reading the data from the receiver systems. (iv) Load antenna specific tracking parameters. (v) Set the Servo Station Computer (SSC) time and ABC time received from the UNIX workstation. (vi) Load the safety limits for lower and higher elevation, maximum wind speed limit
GMRT_RQ023	Enable or disable specific MCM (receiver sub-systems monitoring)	ABC communicates with the configured MCM, enable/disable specific MCM monitoring.
GMRT_RQ024	Generate the periodic commands to the sub-systems to check the health status.	ABC polls the MCM cards by sending the NULL packets on RS485 serial port and generate the servo monitoring commands to the servo system.
GMRT_RQ025	Antenna tracking	(i) Receive time dependent source specific parameters and antenna parameters (ii) Communicates with servo to generate periodic tracking command per 30 sec. (iii) Control tracking operation locally for the specified maximum duration.
GMRT_RQ026	Get the responses from the sub-systems at the antenna base	ABC form the response packet from all the sub-systems for the issued command and sub-systems' monitoring parameter packet. After forming the response frame it sends periodically to the ComH.
GMRT_RQ027	Get the Command from the Control room	ABC accepts the command with valid antenna address ID, and pass those commands to the sub-systems.
GMRT_RQ028	Tune the performance	(i) The Software on ABC Works on a 1 Sec. Cycle and handles three communication links : ABC to COMH @ 250 kbps, an asynchronous 9.6 kbps RS 422 communication between ABC and servo, and RS485 communication between ABC and MCMs. (ii) Set various timing and communication for ABC – COMH, MCMs and SERVO.
GMRT_RQ029	Enabling and disabling the sub-systems' communication	(i) ABC can enable/disable the servo communication link for the desired antenna. (ii) ABC can configure the MCM based sub-systems like FE, LO, IF, and FPS for the Control he and monitoring as well as deselect them from the configuration. (iii) Particular systems like Front-End sub-system can be

		switched off using the MCM based command/configuration by the ABC.
GMRT_RQ030	**Operating state of the ABC and telescope**	**ABC displays the it's operating state like whether it is in APPLICATION (Normal mode of working) , RESET and KERNEL mode (not yet initialized) . And the state of the antenna whether it is in track/position mode or idle.**
GMRT_RQ031	**Status of the sub-system at the antenna system**	**The ABC report the status of all sub-systems at the antenna base to the ONLINE workstation at control room to inform about (i) whether sub-system is communicating or giving time out. (ii) whether system is in application mode or reset mode etc. (iii) Form a monitoring and configuration parameter frame for each sub-system and send it to the ONLINE workstation in the central electronics building (CEB).**
Servo Station Computer (SSC)		
GMRT_RQ032	**Accept and execute operational Commands**	**SSC accepts the operational commands from ABC like release/ apply brakes of the axis, drive the specified axis to stow position (park the antenna), move the axis at desired position, axis to reach specified position at the specified time (track), reset the servo computer etc.**
GMRT_RQ033	**Send Command response**	**Servo response frames include the one byte code to indicating the reason for failure.**
GMRT_RQ034	**Send Event response**	**SSC sends an asynchronous events to ABC like brake released/ applied, motor current high, Axis limits lower/higher hits, wind speed high.**
GMRT_RQ035	**Display Commands**	**Display command reads encoder angles, analogue variables like wind, tacho, motor current etc., reads all digital variable flag, reads the configured parameters, status of axis and version of the SSC software.**
GMRT_RQ036	**Set Mode/System Configuration Commands**	**Set time of the day, set high and low s/w limits for the axis, set the maximum wind speed limit and set stow angle for the elevation axis.**
GMRT_RQ037	**Safety majors**	**(i) Upon wind speed high, SSC park the antenna on its own. (ii) Indicates the Axis limit hits and applies the brakes (iii) Indicate the motor current high. (iv) User can abort the SSC command under execution.**
GMRT_RQ038	**Servo operating mode**	**Servo station computer can operate in either REMOTE, AUTO or local (using hand-held terminal at the antenna base) mode.**
Monitor and Control Module (MCM)		
GMRT_RQ039	**Set Receiver Systems**	**Monitor and Control Module based on 80C535 micro controller being used to control and monitor the the receiver chain systems : Front-End, Common-Box, Local Oscillator (LO) and Intermediate Frequency (IF) system.**
GMRT_RQ040	**Interface to the Feed Positioning System**	**Monitor and control module also used to interface the Feed Positioning System (FPS) control (based on 80C51 micro-controller).**
GMRT_RQ041	**Read Analog channel (Monitoring system parameters)**	**Read all the 64 analog channels or only selected channels to monitor the system parameter.**
GMRT_RQ042	**Set digital/analog control word**	**(i) By setting the digital mask, MCM select which of 16 I/O switch should be turned ON/OFF (ii) By setting analog mask, MCM select and read the data and return values.**
GMRT_RQ043	**Enable/Disable monitoring**	**MCM can enable/disable the monitoring of particular system by setting MCM mode either SCAN/IDLE mode respectively.**
GMRT_RQ044	**Read Self Test result, program version**	**MCM can give the self test result , Program version loaded.**
GMRT_RQ045	**Read Analog/Digital Mask**	**MCM can display the information about the Digital or Analog mask set.**

GMRT_RQ046	**Handshake/Communication Command**	**After sending the NULL command from the ABC, MCM gives the values for previously selected channel if the MCM is operating in scan mode, otherwise it remain idle.**
GMRT_RQ047	**Monitor and Control Module State**	**MCM can be either in SCAN (monitoring) or IDLE state.**

3.2.2 Interface with the Engineering sub-systems in the CEB

ID	Requirement	CAM Execution
GMRT_RQ048	**ONLINE Communication with the Sub-systems in CEB**	**ONLINE system mainly uses the TCP/IP socket based application to communicate the old baseband, new LOFSW unit and the GMRT software back-end (GSB).**
GMRT_RQ049	**Control and Monitoring of the Sub-systems in CEB**	**ONLINE send the configuration, setting commands across the network to the Subsystems in CEB and gets the execution response as SUCCESS or FAILED along with the reason.**
GMRT_RQ050	**Configure the GSB in a desired observing mode**	**ONLINE send the GSB mode configuration i.e. Continuum, full-stokes, spectral-line etc mode using the ASCII file containing the configuration keywords. After sending the initialization command along with the ASCII key-word files by ONLINE, GSB report the execution status to the ONLINE. *(Refer Section 2.8 Interface to data back-end systems in the CEB)***

3.3 User Interface :

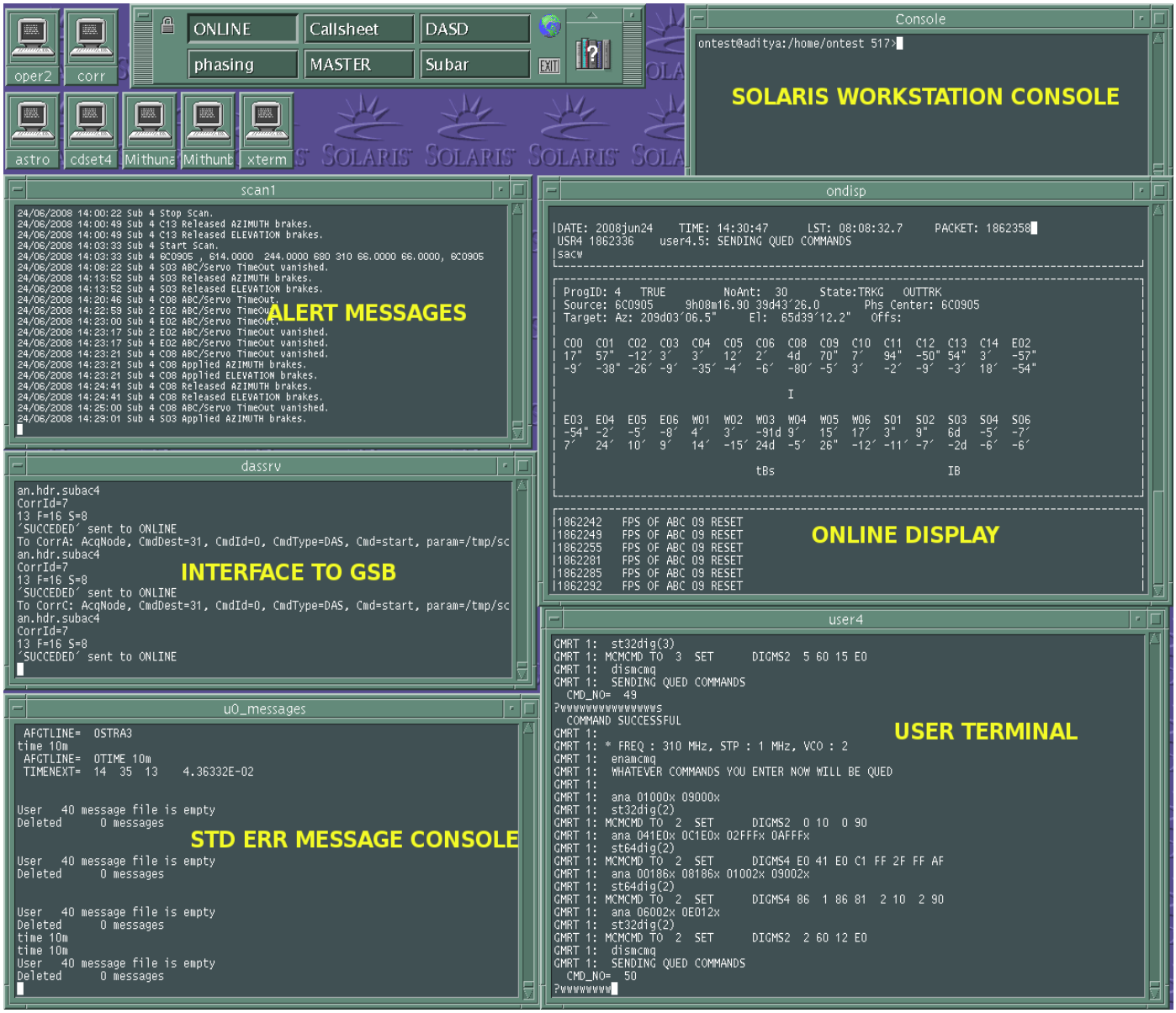

Fig 11 : ONLINE System User Interface

3.3.1 User Inputs – PROC, COMMANDS, BATCH MODE

ID	Requirement	CAM Execution
GMRT_RQ051	**User-terminal/Shell**	**ONLINE uses AIPS (Astronomical Image Processing System) POPS environment shell where user can issue the ascii text commands. The AIPS environment customized for the ONLINE so that new adverbs, VERB and task introduced which are specific to the ONLINE.**
GMRT_RQ052	**RUN FILES**	**(i) Number of predefined commands along with arguments (adverbs) are run using the RUN FILES in a AIPS shell, Like load pointing offset parameters, antenna location parameters, feed count parameters etc. (ii) Also, the receiver setting needs the control words as an argument for the basic MCM commands. The receiver setting program generate such control words along with basic mcm commands in a RUN file. Hence all the receiver settings command can be issued in a one go using the RUN file.**
GMRT_RQ053	**BATCH-command or procedure**	**(i) ONLINE AIPS shell environment combines multiple commands in to one command by using the AIPS's procedure syntax. (ii) Predefined algorithm can be built using the commands supported by ONLINE and conditional/loop statement syntax used in the AIPS to form a single *batch-command*. This method used in the grid pointing, initializing and configuring the ABC, servo and MCM in a one go.**
GMRT_RQ054	**Command validation**	**ONLINE user input shell does the command syntax check and if the arguments are not appropriate i.e. Within a threshold or particular mode enable/disable, it gives the message about non valid execution and abort the command.**
GMRT_RQ055	**Batch file**	**Observing session, calibration, maintenance/test activities can be schedule using the batch-file where batch file control can be start, stop or pause as per the user requirement**
GMRT_RQ056	**Loading of antenna specific individual parameters**	**As the individual antennas have specific setting parameters, ONLINE can pre-load the individual setting parameters like Feed counts, antenna offsets, stow positions . After configuring or loading the individual antenna/system parameters, only one command is suffice to broad-cast to all the antennas where arguments are retrieved for the command by the ABC for command execution.**
GMRT_RQ057	**Forming a sub-array (group of antennas)**	**User can form a group of antennas and get a separate terminal to control and monitor only those antennas allotted to him/her called 'sub-array'. Maximum up to 5 sub-array can be formed where antenna control can not be shared using the multiple sub-array.**
GMRT_RQ058	**Help on command syntax**	**Upon entering the wrong syntax/command , ONLINE system prompt for the correct command and syntax**
GMRT_RQ059	**Help on Command Info**	**Upon entering 'HELP <Command Name>' Online gives the information about command execution like argument types along with the explanation.**
GMRT_RQ060	**User Input terminal**	**ONLINE uses GNU *readline libraries* so that user can recall the history of commands issued, edit on command-line etc. using the standard command line syntax used in the shell like bash/csh etc.**

3.3.2 Monitoring

ID	Requirement	CAM Execution
GMRT_RQ061	**Monitoring of the firmware/software version**	**ONLINE system supports and read all the firmware/software versions running for each system/subsystem at the antenna base and ONLINE system version it-self. All the versions are displayed using the 'ONLINE DISPLAY' program.**
GMRT_RQ062	**Introspection of the Sub-systems**	**Each individual subsystem can be monitor and checked for : (i) How many commands were broadcast for that system, how many successful and failed. (ii)Which version of the firmware or software running. (iii) The operating state of the system.**
GMRT_RQ063	**Health status of the telescope i.e. Sub-array monitoring**	**Over all status of the telescope can be monitored using the '*sub- array window*' which gives the information about (i) Tracking of the antennas i.e. Target source, antenna offsets from the target source (ii) Flag indicator which indicates about the malfunctioning of the system (iii) Information about systems at the antenna base and antennas not communicating (giving time out) or is in reset mode etc.**
GMRT_RQ064	**Sentinel system monitoring**	**ONLINE DISPLAY window can monitor simultaneously wind, temperature and smoke status of all the antenna and flash the warning flag if antenna exceed the threshold limit.**
GMRT_RQ065	**Detail drill down monitoring of the sub-systems' parameters**	**Using the ONDISPLAY window user can drill down to check the detailed monitoring and configured parameters of individual antenna's subsystem.**
GMRT_RQ066	**Monitoring of the communication links**	**Monitoring window gives the continuous message if the communication link is giving time-out or system is reset. Continuous messages are flashed in the ONDISPLAY Console window.**
GMRT_RQ067	**Flag Indicators**	**ONLINE-DISPLAY uses flags which are nothing but the ASCII code like 'T' for ABC time out 't' for servo time out, m – mcm time-out, 'b/B' brakes applied, 'R' – ABC reset, 'I' antenna is in ideal position and S- antenna stowed.**
GMRT_RQ068	**Message and standard error console**	**ONLINE system uses separate message console which indicates over all activities and traffic like multiple commands fired at a time by the multiple sub-array. The command issued/response is shown with the time-stamp, antenna mask (selected antenna) along with the sub-system destination ID.**
GMRT_RQ069	**Remote display**	**ONLINE support the remote display by enabling the user to read the shared memory where online-dependent program can read the data and display on the web.**
GMRT_RQ070	**User friendly Monitoring UI**	**ONLINE-DISPLAY gives the HELP information about which command needed to select the particular window and for what purposes.**
GMRT_RQ071	**Raw data monitoring**	**ONLINE-DISPLAY support the raw data monitoring from the MCM by showing the raw voltage counts read by the 64 analog channel using the MCM card of particular sub-system.**

3.4 Logging and archiving

ID	Requirement	CAM Execution
GMRT_RQ072	**Control and Monitoring system activity log**	**ONLINE system logs all the raw data packets coming from the thirty antennas and their sub-systems along with it's own packet in a binary format.**
GMRT_RQ073	**Logical monitoring sensor or**	**ONLINE store the interpreted information or logical sensor**

	Interpreted data log	**data in a separate SUMMARY.LOG on monthly basis.**
GMRT_RQ074	**Storing of the asynchronous events**	**As the servo is important system in terms of safety of the telescope, ONLINE store all the asynchronous event generated by the Servo system.**
GMRT_RQ075	**System statistics log**	**To do statistical study, ONLINE store the about link status, temperature, wind, FPS counts etc in routine log files on daily basis.**
GMRT_RQ076	**To flag the bad astronomical data**	**ONLINE store a separate log-file for each observing session which reports about malfunctioning of the telescope. This file can be interpreted and Flag the bad data while converting the LTA data into FITS format.**
GMRT_RQ077	**Extract/select the real-time system data for logging and viewing**	**ONLINE system support to extract any monitoring parameter and log the data in ASCII format as per the required duration. ONLINE program 'table' show the control and monitor parameters for the selection and retrieve the selected parameter in a real-time for viewing, plotting etc.**

3.5 Alerts and Safety

ID	Requirement	CAM Execution
GMRT_RQ078	**Safety in High wind**	**SSC park the antenna if wind speed goes above 40 kmph.**
GMRT_RQ079	**Pre/Final antenna Elevation and Azimuth limit switch hit**	**Servo system applies the brakes if the pre or final limit switch hit for the elevation/azimuth axis.**
GMRT_RQ080	**Sentinel system security**	**Electrical power to all the sub-systems at the antenna base shut down if the high temperature or smoke detected.**
GMRT_RQ081	**Communication Link broken**	**(i) If the Communication link between the COMH i.e. Central building and antenna broken for more than half-an hour, ABC park the antenna to zenith. (ii) Even if the ABC don't receive any command from the Unix workstation for more than half an hour, ABC park the antenna.**
GMRT_RQ082	**Tuning of Safety Limits**	**ONLINE supports to set the software limits for (i) High wind limit (ii) Lower and Higher elevation limits**
GMRT_RQ083	**Warning and Alert messages for the parking of the antenna**	**(i) If the wind speed becomes high instantaneously, audio alarm raised against it to alert the telescope operator. (ii) If the one minute average of the wind speed on any of the arm or central square antenna goes beyond 40 kmph, a continuous message about parking of the antenna displayed. (iii) And if non of the antenna shows high wind for continuous 15 minutes, resume to track message is displayed.**
GMRT_RQ084	**Activity audio alerts**	**On each of important command or messages an audio alarm raised to pay the attention by the operator.**
GMRT_RQ085	**Sub-array control authentication**	**The user-terminal to control a sub-group of antennas is given after verifying the password which is generated by the master user-terminal.**
GMRT_RQ086	**Standby ONLINE system terminal**	**In case of ONLINE Solaris work station not working due to some reason, the ONLINE system can start on other stand by Solaris workstation without loosing any down time. The Standby ONLINE workstation alters every six months to keep it in sync with the ONLINE changes done over the period.**

3. 6 Maintenance and Debugging requirements

ID	Requirement	CAM Execution
GMRT_RQ087	**Extracting of the important events for the debugging.**	**Important asynchronous events send by the servo system can be extracted using the specific application program.**

GMRT_RQ088	**Daily log on system functioning statistics**	**ONLINE system store the system mode or status changes log in a separate daily logs which includes ABC status, Link status, FPS counts etc.**
GMRT_RQ089	**Command Log**	**Command issued either using the batch-mode or user-terminal, every command is stored in the CMD.LOG file. CMD.LOG is a human readable file, hence one can trace a sequence of the commands issued to the telescope.**
GMRT_RQ090	**Replaying or inspection of the past system status to debug**	**Using the ONLINE binary log packets and summary log, user can replay the data and inspect the situation during the problem occurrence. Replaying of the online logged data are done using application programs like *main_ex* and *extr*.**
GMRT_RQ091	**Debugging Mode of the system**	**Debug Mode of the ABC : ABC can dump the raw data from the ABC at UNIX workstation in control room where it can be viewed using the ABC DEBUG monitoring window.**
GMRT_RQ092	**SUMMARY and statistics for the long duration**	**Using the SUMMARY.LOG file which is getting acquired on monthly basis, Engineer can run the statistics to know about up time of the system, total antenna tracking done by the servo system etc.**
GMRT_RQ093	**System Time-outs and Reset status**	**ONLINE system promptly report the Antenna or sub-system Time Out (non-communicating) and reset status to the control and monitoring console so that problem can be noticed immediately.**
GMRT_RQ094	**Antenna under maintenance**	**Maintenance personnel can dis-connect the MCM cables or put the servo in Local mode so that the maintenance can carry out. In this situation ABC reports the servo status is in local mode, in such case servo can not be controlled from the ONLINE system.**
GMRT_RQ095	**Test and Maintenance activities**	**ABC support the maintenance activities like antenna pointing, stow position checking, deflection test for the antenna sensitivity etc.**

3.7 Performance Requirements

ID	Requirement	CAM Execution
GMRT_RQ096	**Command broad-cast to all antennas and receives it response in a real time**	**From Unix work-station to all the thirty antennas, COMH broad-cast the command packet to all thirty antenna and receives response frame from all the thirty antenna within a 2 to 4 sec.**
GMRT_RQ097	**Coordination and synchronization**	**(i) Antenna base computer coordinates all the sub-systems at antenna base (servo and total six systems based on MCM FE, FPS, LO, IF, Sentinel). (ii) ABC handles three communication links COMH, RS422 (servo) and RS 485 (MCM) within a 1 second cycle. (iii) ABC synchronize it's own and servo time with Unix workstation in control-room.**
GMRT_RQ098	**Exception handling**	**If the commands to the Servo not acknowledged, ABC try three time sending the command. If it failed in command execution after three try, it send Not Acknowledge status (NACK) to the ONLINE system.**
GMRT_RQ099	**Periodic command over long duration**	**ABC sends the track command in advance to the servo system along with target positions need to reach at specific time by the axis. ABC generates the track command for every 30 second and continues till the time duration specified for the tracking.**
GMRT_RQ100	**Prioritization of commands**	**ABC handles the command on priority basis.**
GMRT_RQ101	**Stability**	**ONLINE system runs continuously and Up over one week to to one-two months of time without any problem.**
GMRT_RQ102	**Receiving of asynchronous events**	**ONLINE receives any asynchronous events relating to safety immediately from the sub-systems as it occurs.**

GMRT_RQ103	**Minimizing the communication traffic**	**ONLINE system can configure or de configure the number of antennas, disable the ABC to servo link or disable the undesired monitoring data coming from the MCM to reduce the communication traffic.**
GMRT_RQ104	**Issuing of the commands when batch-file is running**	**User can issue any command during the batch-file run.**

4. SUMMARY

GMRT Control and Monitoring System has been reported to be continuously up and stable for more than a month period without any problem. This report covered the many useful aspects like the requirements realized as result of long tenure of usage and evolution of the CMS system as per the need arise by various categories of the users and system development as a part of the up-gradation. CMS is working reliably and satisfactorily for the last so many years and gives good support to the GTAC users.

Under the up-gradation process, the GMRT aiming seamless wide-band RF data to improve the sensitivity, antenna base computer (ABC), monitor and control module (MCM), servo station computers and fibre optic system along with the receiver chain systems will get replaced by the new systems using the latest technologies like Ethernet (TCP/IP) and Linux based PC and micro-controller cards, broad-band link etc. Hence to cope up with the advance technologies, GMRT control and monitoring system group working towards the up gradation of the CMS. In-house and industry collaboration efforts are moving in that direction.

APPENDIX

I. Specification of the GMRT Control and Monitoring system

i. ONLINE

Host name	**lenyadri , shivneri**
Model	**SUNW, A70**
CPU Type	**UltraSPARC IIIi**
Number of CPUs	**1**
Operating system	**SunOS 5.10**
Compilers	**Sun C 5.9 SunOS_sparc, Sun Fortran 95 8.3 SunOS_sparc**
Physical Memory	**2,048 MB**
Virtual Memory	**5,596 MB**
Clock Speed	**1,336 MHz**

ii. TELEMETRY SYSTEM

A. Details of the various communication links

TYPE	Subsystems Involved	Rate
Ethernet	**UNIX WS <===> PC ROUTER**	**100 Mbps**
Asynchronous RS 422 8 bit	**ROUTER <===> COMH**	**38.4 kbps**
SDLC/HDLC	**COMH <===> ANTCOM**	**125 kbps**
Asynchronous RS485 11 bit	**ANTCOM <===> MCM**	**9.6 kbps**
Asynchronous RS422 10 bit	**ANTCOM <===> SSC**	**9.6 kbps**
FSK MODEM	**COMH <====> ANTCOM**	**250 kbps**

B. Bit rates available for various services

#	Service	Bit Rate (kbps)
1	**DATA (COMH – ANTCOM COMM)**	**125.000**
2	**VOICE (TELEPHONY VOICE)**	**62.500**
3	**DIAL (TELEPHONY SIGNALING)**	**15.625**
4	**SYNC (SYNCHRONIZATION PATTERN)**	**15.625**
5	**AUX1 (AUXILIARY CHANNEL 1)**	**15.625**
6	**AUX2 (AUXILIARY CHANNEL 2)**	**15.625**
TOTAL BIT RATE		**250.000**

II. ONLINE commands

#	Command	Information
	ONLINE SYSTEM	
1.	STARTONL	start display and control programs & log pkt Automatically.
2.	SHUTDOWN	stop display and control programs
3.	DEFSUB(IPA)	define antennas associated with subarray IPA
4.	SHSUB(IPA)	show antennas associated with subarray IPA
5.	STRTPROC	starts specified process
6.	ABRTPROC	aborts starting of specified process
7.	HLTPROC	stops specified process
8.	USERCONN	Connect User to COMMHAND
9.	ONDBGUNIC	set debug on in unixcomh
10.	OFFDBGUNI	turn off debug in unixcomh
11.	LOGPKT(STRA3)	start pkts logging in file STRA3
12.	HLTPKTLOG(IPA)	stop logging packets for file no IPA
13.	SHLOGLIST	list opened log files for packet log
	SERVO SYSTEM	
14.	COLDSTART	Cold start of antenna
15.	MV(IPA,JPA)	Move antenna to az=xsv,el=ysv (astr)
16.	MVAZIM(IPA)	Move antenna to az=wsv (astr)
17.	MVELEV(IPA)	Move antenna to el=wsv (astr)
18.	AMV(IPA,JPA)	move antenna to az=xsv,el=ysv (antenna)
19.	AMVAZIM(IPA)	move antenna to az=xsv (antenna)
20.	GOINNER	request antenna to move on inner track
21.	GOOUTER	request antenna to move on outer track
22.	TRACK(IPA,JPA,KPA)	servo track , parms=2 angles & time
23.	TRKAZIM(IPA,JPA)	servo track , parms=azim and time
24.	TRKELEV(IPA,JPA)	servo track , parms=elev and time
25.	ATRACK(IPA,JPA,KPA)	servo track in ant cord, parms=azim elev& time
26.	ATRKAZIM(IPA,JPA)	servo track in ant cord, parms=azim and time
27.	HOLD	request servo to release brakes and hold
28.	HLDAZIM	release azim brakes and hold
29.	HLDELEV	release elev brakes and hold
30.	BRAKES	apply brakes on both axis
31.	BRKAZIM	apply brakes on azim axis
32.	BRKELEV	apply brakes on elev axis
33.	CLOSE	close down observations
34.	STOW	stow the antenna
35.	SWELEV	stow antenna in elev
36.	SWRELE	release antenna from stowed pos
37.	SWRELEL	release antenna elevation stow
38.	STOP	abort servo's previous command(to stop in moving both axes)
39.	ABRTSRVCMD	abort servo's previous command
40.	RDSRVSPC	read servo set param (in srvs, servo sp. window)
41.	RSTSERVO	reset servo computer
42.	STSRVTIM	set servo time IPA sec ahead
	ANTENNA BASE COMPUTER (ABC)	
43.	INITABCMD	Init abc cmd: tally cmd-resp counters, reset flag reset, stoptalk, rdabcv,
44.	STMCM	set MCM for ABC using mpa(I)
45.	STABCTIM	set ABC and Servo time, and set LST on ABC
46.	STABCDLY	set ABC delays to values set in TPARM(1-18)
47.	STABCDLY	set ABC default delays and cycle values

48. STABC3CYC set ABC delays and 3 sec cycle time
49. STABC4CYC set ABC delays and 4 sec cycle time
50. ENABCQ(IPA) start queuing ABC commands for dest=IPA
51. ENAMCMQ Enable mcm qued cmds
52. DISMCMQ Disable mcm cmd quing
53. STABCDBG(IPA) set ABC in Debug mode IPA
54. ABRTABCQ(IPA,JPA) abort JPA cmds fro IPA in ABC Q
55. TALK(IPA,OUTFIL) send talk message to ABC
56. RDABCVER read ABC program version
57. RDABCDBG read ABC error statistics
58. RDABCDLY read the values of ABC delay
59. DISSRVLNK Disable servo commuication for antenna
60. ENASRVLNK Enable servo communication for antenna
61. ABRTPRKANT Abort ante parking sequence
62. MCHABCCTR match cmd -resp counters for abc
63. GOABCAPPL Ask abc kernel to goto appln and execute
64. GOPROMAPPL Ask kernel to transfer from PROM and execute
65. STRTABCDNL Start ABC code down loading(obj.dat in current area)
66. RDQTIME Read abc q timing info
67. ENALO1MON Enable lo 1 monitor for antenna: MCM 2
68. ENALO2MON Enable lo 2 monitor for antenna MCM 3
69. DISLO1MON Disable lo 1 monitor for antenna
70. DISLO2MON Disable lo 2 monitor for antenna
71. ENAIFMON Enable if monitor for antenna
72. DISIFMON Disable if monitor for antenna
73. LDANTPARAM load ant specific param for local track(current hardcoded in proc in TPA array)
74. LDANTOFFS load ant offsets param for local track(current hardcoded in proc in TPA array)
75. LDSRCPARAM load src specific params for local track:IPA=1=OUT,JPA=trckg time
76. LDTIMTRK load time params for local track
77. STIFABC(IPA) Set IF attn loaded in ABC for IPA freq.
78. STRTLOCTRK START local track mode for ant or ants in sac
79. STPLOCTRK STOP local track mode for ant or ants in sac
80. ADDMCMS additionally configure MCMs defined in MPA array
81. DELMCMS for abc deselect only those MCMs defined in MPA array
82. GOABCKER ask abc to go to kernal mode
83. RSTABERR reset error counters of abc
84. RDANTPARA Read ant params for local track
85. RDSRCPARA Read src params for local track
86. RDTIMTRK Read time params for local track
87. STRTLOCTRK START local track mode for ant or ants in sac
88. INITABCMD Init abc cmd: tally cmd-resp counters, reset flag reset, stoptalk, rdabcv, stabct
89. ENAANCCMD Start accepting abc cmds for abcs (init abc after abc reset)

MONITOR AND CONTROL MODULE

90. NULLCMD(IPA) issue null command
91. STIDLTIM(IPA) set idle time for MCM IPA
92. STSCAN(IPA) set scan mode for MCM IPA
93. STMEAN(IPA) set mean mode for MCM IPA
94. STTHRMD(IPA) set threshold mode for MCM IPA
95. STANA(IPA) set analog mask for MCM IPA
96. ST16DIG(IPA) set 16 bit digital mask
97. ST32DIG(IPA) set 32 bit digital mask
98. ST64DIG(IPA) set 64 bit digital mask
99. RDANA(IPA) read analog values
100. RD16DIG(IPA) read 16 bit digital mask
101. RD32DIG(IPA) read 32 bit digital mask
102. RDMCMVER(IPA) read MCM program version
103. RD64DIG(IPA) read 64 bit digital mask
104. RDMODE(IPA) read current mode

105. RDTHRVAL(IPA) read threshold vals
106. FEEDSEL(IPA) feed select old
107. RBMCM(IPA) reboot MCM
108. FEEDSELM(IPA) feed select modified
109. MONFE FE-Box monitor box no IPA
110. MONCB Common Box monitor

ASTRONOMICAL FUNCTIONS

111. GTSRC get source ra,dec & precess
112. RISESET find rise/set time of source
113. POSN move antenna to current position of source
114. ADDLIST(OUTFIL) add source list in 'outfil' to default list
115. SHLIST show the path of source lists available
116. DELLIST(IPA) del source list by num IPA given by shlist

COMMUNICATION HANDLER (COMH)

117. STCOMANT set antennas to which COMH talks (CPARM)
118. SHCOMANT show antennas to which both comh units talk
119. STCOMTIM(IPA) set COMH cycle time from CPARM(1) for IPA comh/s
120. SHCOMERR get COMH error statistics
121. RDCOMVER read COMH version for both COMH
122. ONCOMDBG(IPA) set DEBUG ON in COMH IPA
123. OFFCOMDBG(IPA) set DEBUG OFF in COMH
124. RSTCRCNR(IPA) Reset cmd resp counters for comh IPA
125. ADDCOMANT(IPA) add ants to commun from ANTE=no_of_ant addr1 addr2 ... for comh IPA
126. DELCOMANT(IPA) deselect ants for COMH ipa from ANTE=no_of_ant addr1 addr2 ...
127. RSTCOMH(IPA) S/W reset for comh IPA
128. RSTCOERR(IPA) Reset error counters of comh IPA

COMMAND MONITOR (CMDMON)

129. STCMOFF(IPA) Set IPS sec as cmd mon offset
130. ENACMDMON Enable Command Monitor
131. DISCMDMON Disable Command Monitor
132. ENACMINFO Enable Command Monitor Info Log
133. DISCMINFO Disable Command Monitor Info Log
134. ABRTDNLD abort abc program down load
135. STDNLDPKT(IPA) aet abc program down load pkt size=IPA bytes

SUB ARRAY CONTROLLER (SUBAC)

136. SNDSACSRC send source coords to subarray controller modified to send trk/posn,TMAX
137. STSACTOLR set tolerance for subarray controller using cpa
138. SNDSACANT send antenna mask to subarray contrommer
139. SNDSACANT send antenna mask to subarray contrommer
140. SNDSACANT remove antenna mask to subarray contrommer
141. TRKSACSRC request subarray controller to track source
142. STPSACTRK request SAC to stop tracking source
143. GOSACOUT request SAC to track on outer track
144. GOSACINN request SAC to track on inner track
145. ONSACDBG request SAC to turn on debug mode
146. OFFSACDBG request SAC to turn off debug mode
147. TRKELOFF(IPA) track elevation offset by IPA
148. TRKAZOFF(IPA) track azimuth offset by IPA
149. TRKANTOFF(IPA,JPA) track azimuth, elevation offset by IPA,JPA
150. TRKRAOFF(IPA) track right ascension offset by IPA
151. TRKDEOFF(IPA) track declination offset by IPA
152. SCANELSRC(IPA,JPA) scan src in el with derv=ipa,ptime=jpa
153. SCANAZSRC(IPA,JPA) scan src in az with derv=ipa,ptime=jpa
154. SCANRASRC(IPA,JPA) scan src in ra with derv=ipa,ptime=jpa
155. SCANDEC(IPA,JPA) scan src in dec with derv=ipa,ptime=jpa
156. SNDSACCMD(OUTFIL) send local pops cmd to sac from outfil
157. STRTSACFIL start remote control for sac from opened file
158. STPSACFIL stop remote control for sac from opened file
159. OPSACFILE(OUTFIL) open a sac control file from OUTFIL

160. OPSACFILE(OUTFIL) close a sac control file
161. SHSACFILE show a sac control file which is open
162. SHSACLINE show current line of sac control file
163. REWSACFILE rewind the sac control file
164. MVSACCON(IPA) move control to point(ipa) in sac file
165. SKPSACLINE(IPA) skip n=ipa lines frmo sac coontrol file
166. STPSACLINE(IPA) step by one line frmo sac coontrol file

FEED POSITIONING SYSTEM (FPS)

167. NULLFPS issue null cmd
168. INITNFPS new init fps
169. STBRCNTDIFF(IPA) issue set brake count difference count cp(1) : pusles
170. STMAXANGLE(IPA) issue set Max angle cp(1)=max ang
171. STMINANGLE(IPA) issue set Min angle cp(1)=min ang
172. RDBRCNTDIFF issue read brake count difference count
173. RDRMPUPTMCNT issue read ramp up time count
174. RDMAXANGLE issue read Max angle
175. RDMINANGLE issue read Min angle
176. RDVERSION issue read version
177. RDUA0ANG issue read UA0 angle
178. RDUA0ANG get the first set UA0 angle
179. RDUA0ANG calibrate to UA0 angle CP=1=>Clkwise i.e. -10d side,0=>anticlkwise
180. RUNCLBRT issue run to calibrate
181. FREERUN10 issue free run towards -10deg lim s/w
182. FREERUN280 issue free run towards 280 deg lim s/w
183. RUNDPREST(IPA) issue run to preset, IPA target ang
184. RUNCPREST(IPA) issue run to preset, IPA target counts
185. FINECTUNE(IPA,JPA) issue run to preset,IPA is target counts, JPA is PWM counts
186. FINEDTUNE(IPA,JPA) issue run to preset,IPA is target ang,JPA is PWM counts
187. RUNPASSWD issue run passworded
188. FPSBOOT issue reboot fps
189. FPSSTOP issue stop fps
190. PRSTCFPS(IPA) preset known position of feed in counts
191. PRSTAFPS(IPA) preset known position of feed in angle
192. LDFPSPOS(IPA) Loads the fps counts in TPA
193. MVFPS610 Mv FPS to 610 to counts loaded by above command
194. MVFPS150 Mv FPS to 150 to counts loaded by above command
195. MVFPS1420 Mv FPS to 1420 to counts loaded by above command
196. MVFPS325 Mv FPS to 325 to counts loaded by above command
197. INITFPS Does add MCM 14,rdv, set min angle to -10d, stlrpm. respectively

CEB ABC

198. STABCTIM set CEBABC and Servo time, and set LST on ABC
199. STCEBMCM set MCM for ABC 0 from ANTE(I) array
200. STABCDBG set CEBABC in Debug mode
201. STABCDLY set CEBABC delays to values set in CPARM(1-9)
202. RDCEBDLY read the values of CEBABC delay
203. RDCEBVER read CEBABC program version
204. RDCEBDBG read CEBABC error statistics
205. MCHCEBCTR match cmd -resp counters for abc
206. GOCEBAPPL Ask ceb abc kernel to goto appln and execute
207. GOCEBPROM Ask ceb abc kernel to goto appln and execute
208. GOCEBKER ask CEB abc to go to kernal mode
209. RSTCEBERR reset error counters of ceb abc
210. ENACEBQ Enable mcm qued cmds for CEBABC
211. DISCEBQ Disable mcm cmd quing for CEBABC
212. INITCEBABC Init abc cmd: tally cmd-resp counters, reset flag reset, stoptalk, rdabcv, stabct
213. ADDCEBMCM additionally configure MCMs defined in NATE array
214. DELCEBMCM for abc deselect only those MCMs defined in ANTE array

DATA ACQUISITION SYSTEM

215. INITNDAS(OUTFIL) initialise DAS control using file OUTFIL

216. HLTNDAS end DAS session
217. LNKNDASQ init das cntrl for subarray IPA
218. STRTDASCAN start das scan for subarray
219. STPDASCAN start das scan for subarray
220. SNDASSTR(OUTFIL) send command thro string for das
221. INITPRJ(IPA,OUTFIL) start das project with Code in OUTFIL for IPA sideband
222. PRJTITLE(OUTFIL) set das project with Code in OUTFIL
223. PRJOBSERV(OUTFIL) set das observer with Code in OUTFIL
224. PRJTITLE set das frequencies (in tPARM) with Code in OUTFIL
225. LDSRCCODE(OUTFIL) set in outfil the source code

BASEBAND SYSTEM (BB)

226. INITBBSRV Init BB serv
227. STBBWGNALL(IPA,JPA) Set for both Pol and Sidebands:IPA BW and JPA Gain
228. STBBANDALL(IPA) Set for both Pol and Sidebands:IPA Bandwidth MHz
229. STBGAINALL(IPA) Set for both Pol and Sidebands:IPA Gain
230. STBNDGAIN(STRA2,STRA3,IPA,JPA)
231. Set for STRA2 Pol and STRA3 sideband:IPA BW and JPA Gain: stra2=130,175,both;
232. stra3=usb,lsb,both
233. STBBLO(STRA2,STRA3) Set baseband lo:STRA2=LO1,STRA3=LO2
234. INITGSBSRV Init GSB serv
235. STGSB16LO Set GSB LO for 16 Mhz bandwidth
236. STGSB32LO Set GSB LO for 32 Mhz bandwidth
237. STGSBLO(STRA2,STRA3) Set baseband lo:STRA2=LO1,STRA3=LO2
238. STBBLOSYN(STRA2,STRA3,IPA,JPA) Set base band
239. lo:STRA2=LO1,STRA3=LO2,SYN1=IPA,SYN2=JPA