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Ku-BAND SATELLITE TRACKING and DATA RECEPTION

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ABSTRACT

In this paper discusses the issues involved in selecting for tracking system for geostationary earth orbit (GEO) of the GISAT (Geo-Imaging Satellite) tracking and data reception systems to meet National Disaster Management requirements. Geo-Imaging spacecraft was conceived with the objective " To tap new functionalities hitherto not covered by existing LEO and GEO Missions like fast revisit capability, real time monitoring, high resolution multi spectral and Hyper spectral imaging all on a single, agile, jitter free platform ". Basic applications of Payload include Disasters, Natural hazards, Calamities episodic and Short term events etc. Casting of spectral signatures for agriculture, forestry, mineralogy, oceanography, meteorological is the other important applications.

Keywords: GISAT, Ku-band, LEO, GEO and Hyper spectral Imaging.

INTRODUCTION

A constellation of GEOs can only see earth stations with latitudes less than 81°, the use of polar orbits allows a LEO constellation to communicate with all points on the globe.[1] The disadvantages of a LEO satellite are that the earth station must spatially track the satellite across the sky and compensate for Doppler frequencies that are quite large.

GEO - Geostationary Earth Orbit [1].

In order to overcome Earth's gravity, and remain stationary in the sky, synchronized with the rotation of the earth, geostationary satellites must maintain an orbit of 22,300 miles (37,000Km) above the equator, spaced just 2 degrees apart, and often even less. This results in the satellite orbiting the earth at exactly the same rate that the earth revolves, thus appearing to the observer to be stationary in the sky.

The principle of satellite communications based on this concept of geostationary orbit was originated by Arthur C. Clarke [14].The Main advantage of geostationary satellite being the permanent contact between the ground segment and the satellite with fixed directional antennas at both the ground station and the satellite. The Table-1 outlines the salient features, advantages and disadvantages of Geostationary Satellite Orbit (GSO). It shows the outline features of GEO Orbit.

A perfect geostationary orbit is a mathematical abstraction that could be achieved only by a spacecraft orbiting around a perfectly symmetric earth and no other forces are acting on the spacecraft other than the central gravitational attraction from the earth.

GISAT Communication Payload-Overview

GISAT (Geo Imaging Satellite) [2] consists of a state of the art meteorological payload as a main payload designed for enhanced meteorological observation and monitoring of land and ocean surfaces for weather forecasting & disaster warning on a continuous basis. The spacecraft has to be agile with large scanning capability about pitch & roll axis. Due to large S/C orientation changes during scanning period, a Phased Array Antenna (PAA) is the most suitable for image data transmission. The major subsystems of GISAT communication payload are: High Data Rate (HDR)QPSK Modulator, Up-converter and Local Oscillator, Driver Amplifier, Solid State Power Amplifiers(SSPA), Power divider network, Antenna, Beam Steering Unit (BSU) and Electronic Power Conditioners(EPC). ystems form on-board data transmitter. The objective is to transmit high resolution imagery data from Geo stationary satellite to the earth stations. The proposed data rate from the imagery payload is likely to be 200 MBPS. The frequency band from 12.25 to 12.45 GHz with centre frequency as 12.35 GHz in Ku-band is allocated by ISRO HQ. The spacecraft location is decided as 93.50 east. For receiving the imagery data ground station antenna diameter is planned as 11 mt. The incoming data from Camera Electronics (CE) is in digital form. A modulation scheme suitable for digital data

Table 1: Outline features of GEO Orbit

Attitude	35,786 km.
Period	23 Hr. 56 min. 4.091 sec. (One sidereal day)
Orbit inclination.	0^0
Velocity	3.075 km per sec.
Coverage	42.5% of earth's surface.
Sub satellite point	On equator.
Area of no coverage	Beyond 81^0 North and South latitude. (77º if angle of elevation below 5º are eliminated)
Advantages	Simple ground station tracking.
	No hand over problem
	Nearly constant range
	Very small Doppler shift
Disadvantages	Transmission delay of the order of 250 msec.
	Large free space loss
	No polar coverage

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Transmission as QPSK [4] with 7/8 Forward Error Correction (FEC) is selected. The end to end link is designed for 1x 10^{-8} Bit Error Rate. The spacecraft EIRP downlink is specified as 45 dBW. In a fair weather condition the link will provide almost error-free data transmission.

THE CHALLENGES INVOLVED IN DEVELOPMENT OF GISAT

National Remote Sensing Centre (NRSC-ISRO), Hyderabad has undertaken the task of setting up a Ku- band Ground station at NRSC, Hyderabad (Lat: 17.06° and Long: 78.21°). The implementation of the project includes design/development, supply of hardware & software and installation & commissioning. For commissioning of one Ku-band Ground station system and describes all aspects of the system, the proposed specifications are listed in Table.2, which helps to understand the scope of work, design, development, quality assurance and acceptance test requirements of the proposed Ground station. In this paper, authors are worked on this Ku-band requirement by analyzing the ground station parameters with respect to existing Remote sensing Ground station [3] which is functioning on frequency bands like L, S and X band range. By the results, what parameters will affect the Ground station is envisaged to have the following important features in Table: 2. and also a proposed Ground Station block diagram also shown in Figure: 1.

Table 2: Design specifications of Ground Station

Parameters	Specifications
Antenna in Ku-Band G/T	Better than 38dB/deg K @ 20deg Elevation (at mid band frequency).
Reflector	Aluminum alloy, Stretched formed and shaped.
Surface Accuracy (Main)	Better than 0.3mm RMS
Surface Accuracy (Sub reflector)	Better than 0.05mm.
Antenna Optics	Cassegrain system.
Antenna Mount	EL over AZ
Servo Drive	Motorized Drive
Operational Modes	Manual/ Slew/Auto Track/ Step Track/Program mode.
Azimuth Travel	0 to 270Deg Continuous
Elevation Travel	0 to 90 Deg Continuous
Velocity	Min: 0.01deg/sec: Max: 0.25deg/sec
Antenna Mount	EL over AZ
Servo Drive	Motorized Drive
LNA System	Tri - redundant configuration.
LNA Noise Temp.	Individual: Less than 60degK. Tri - redundant LNA system: Less than 90degK
Pointing Error	Max. $1/5^{th}$ of the 3dB beam width at operational Wind and occasional Gust.
Tracking Error	$1/10^{th}$ of the 3dB Beam Width
Feed configuration	Mono pulse
Polarization	Simultaneous Linear Vertical and Horizontal orientable.
Feed VSWR	1.3:1(Max)
Frequency Range	10.7 GHz to 12.75 GHz.
C/No to Tracking	35dBHz Minimum.
Modulation Type	QPSK with convolution coding. FEC 7/8 and RS (255,239) decoders
Data rate	Min. 228 Mbps Option 1: 250Mbps max. Option 2: 320Mbps max.
BER Performance	1x 10^{-8} @ 7db Eb/No
Wind Speed	Operational: 70kmph Survival: 200Kmph
Rain	Upto100mm per hour
Humidity	100%
All sub system Interfaces	Local/Remote (TCP/IP)

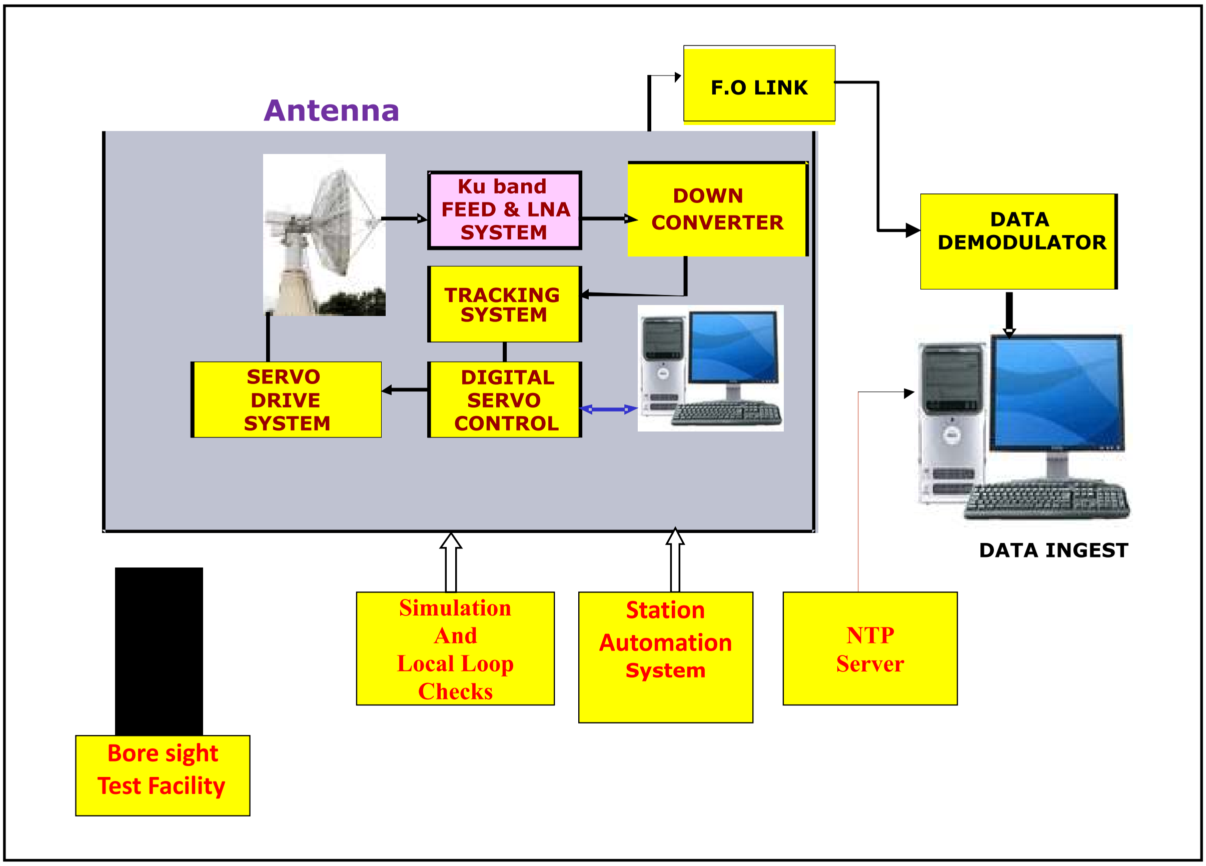
LINK BUDGET [8]

Transmission of information between the Satellite and Earth Station in the contest of geostationary satellites, and examines the essential aspects such as the link budget, modulation techniques and characteristics of the transmission medium [7]. The link budget is a calculation of the signal/noise power ratio at the receiving side of a transmission link considering the transmission medium and the transmitter/receiver characteristics. This calculation is achieved by totaling the signal power gains and losses and taking into consideration the contribution of noise at the receiver input. The GISAT EIRP budget is given in Table-3.

Table-3 : GISAT Link Budget details

Parameter	Values
Transmit Antenna Input	14.09dBW
Transmit Antenna Gain	31.65 dBi
Estimated EIRP	45.74dBW
Data rate	200 Mbps
Modulation	QPSK
FEC	7/8
BER	1X 10^{-8}
Implementation margin	2dB
Path loss	205.68dB
Rain Attenuation	6dB
Pointing loss	1 dB
Pointing loss	1 dB
System Margin	2 dB
Ground Station Antenna Diameter	11m
Ground Station Antenna Diameter	11m
Satellite EIRP	43dBW (11m)

Figure: 01 : Proposed Ground Station Block Diagram



Received Signal Power

The received signal power is a function of the transmitted power, taking into account the distance between transmitter and receiver and the characteristics of the transmitting and receiving antenna.

The authors have made several calculations depends on the mission requirements and came down to the ground station specifications for reception of Geo orbital satellite data in ku band. This research paper is analyzed the requirements of the Ku-band Remote Sensing Ground Station for GEO Imaging satellite**.** Based on the information provided in this paper, Ku-band Remote Sensing Ground Station intended to be established.

RESULTS

There are two types of satellites – Communication satellites and the Remote sensing satellites.

- Commercial communications satellites today primarily transmit over two sets of radio frequencies. They are:

C-band offers a lower transmission power over wide geographic areas and typically requires a larger reception Antenna.

Ku-band offers a higher transmission power over wide geographic areas and typically requires smaller reception Antenna.

- Remote sensing satellites use X and S band for their operation. Generally, longer the wavelength, the more penetrating is the beam. Radar methods are invaluable for remote sensing under conditions of dark, clouds, rain, even snow and hail may be penetrated if the wave length is long enough. On the other hand, rain, snow and hail will reflect the shorter wavelength radiation. For this reason remote sensing systems make use of the longer wave length or obtain imaginary of the earth and sea. Meteorological systems use shorter wavelength for forecasting the weather, storms, etc [9].

Ground Station Specification Comparison with respect to existing Antenna system:

Parameters	X-band	S-band	Ku-band (Proposed)
Frequency of operation	8.025 – 8.4 GHz	2.2 – 2.3 GHz	**10.7 GHz to 12.75 GHz.**
System G/T	32dB/deg K	22dB/deg K	**Better than 38dB/deg K @ 20deg Elevation (at mid band frequency).**
LNA Gain	50dB	45dB	**60dB Min**

After Comparative Analysis based on the following:

- The ground station antenna is a vital link between the satellite and Ground station electronic equipment.
- The Antenna must provide a reliable high receiving gain and the pattern having sufficiently low wide angle side lobe.
- The receiving gain (G) is an important parameter, as it decides the important parameter 'G' in “Figure of Merit” (G/T) [13].
- While designing the Antenna we have to primarily meet the RF Requirements, in addition proper consideration is necessary towards “Control Systems Requirements” and Pointing & Tracking accuracy requirements.
- Factors Affecting Antenna: Amplitude Illumination, Spillover, Aperture Blockage, Reflector Surface, Defocusing, Cross Polarization. Feed Losses etc.
- RF Requirements: Frequency of operation, Receive Gain, Beam Width, First Side Lobe, VSWR, Polarization and Axial Ratio, FEED System, Tracking FEEDS.
- The authors are arrived at Table 2: Design specifications of Ground Station.

CONCLUSION

The GISAT mission objectives are arrived at to tap the new functionalities not covered by existing Polar observation missions, like fast revisit capability of any location within satellite visibility, real time monitoring, multispectral and Hyper spectral imaging and inclusion of moderately high resolution IR channels- all on the same platform. The conflicting requirements of high temporal and spectral resolutions and short re visit time are met by various operating modes, made possible by a highly agile spacecraft [18].

The tracking chain is used to track the Satellite and align the Antenna in the direction of the satellite correspondingly [17] to its antenna moments. The NRSC existing Ground station makes use of microwave frequencies and especially of X-band (8.2 to 8.4 GHz) and S- band (2.2 to 2.3 GHz) for the data acquisition.

For Ku-band (10.7 GHz to 12.75 GHz), after analysis came to conclusion in Table: 2.

The prime applications of this mission are:

1. To map Indian land mass and coastal areas with high spatial resolution, multispectral Visible and Near IR (VNIR) imaging for quick monitoring of disasters, natural hazards & calamities, episodic events and any short-term events during the Sun shine period.
2. To map the Indian subcontinent and the Earth disk visible from GEO in Thermal Infrared (TIR) bands for meteorological applications on 24 hour basis.
3. To generate Hyper spectral imageries in VNIR and Shortwave Infrared (SWIR) bands to generate spectral signatures / fingerprinting for agriculture, forestry, mineralogy, oceanography and other such remote sensing applications over a limited area.

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