# The Future of Cartography Satellites Data Acquisition and its Data Ingest Systems

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**Abstract: Remote sensing data provides much essential and critical information for monitoring many applications such as image fusion, change detection, and land cover classification. Remote sensing is an important technique to obtain information relating to the Earth's resources and environment. What popularized satellite data are the easily accessed online mapping applications like BHUVAN. From being simply able to find "where is my house" these applications have helped the GIS community in project planning, monitoring disasters and natural calamities, and guiding civil defence people. ISRO's BHUVAN (www.bhuvan.nrsc.gov.in) is a well known national geo-portal, which is being widely, used by the Government, public, NGOs and Academia. Bhuvan is developed with a clear focus of addressing Indian requirements of satellite Images and theme-oriented services to enable planning, monitoring and evaluation of stakeholder's activities in governance and development. All these data is taken from the Remote sensing satellites of Cartography application series Satellites, which are being tracked and data ingested disseminated from IMGEOS, NRSC Ground Station. The acquisition challenges and data ingest process will be discussed in this paper.**

**Keywords: Antenna systems, BHUVAN: Is a well known national geo-portal, Integrated Multi Mission Ground Station for Earth Observation Satellites (IMGEOS), RF systems, SERVO, Tracking systems.**

## I. Introduction

### *A. Data Acquisition from Cartography Satellites*

There are hundreds of applications for satellite imagery and remotely sensed data. From the Indian remote Sensing satellite Series, nations used to use information derived from the satellite imagery for spying on each other under the guise of scientific experiments, industry has grown in leap and bounds and today every sphere of life, government decision making, civil defence operations, police, you name the sphere of life, every one of which is influenced by satellite imagery in particular and Geographic Information Systems (GIS) in general.

Earth Observation by Remote Sensing Satellites [1] by NRSC began by commissioning an integrated facility with Data acquisition and Product generation at Shadnagar for Landsat MSS data in 1979. This was followed by development of LANDSAT-TM data processing and establishment of SPOT data processing & product generation facility.

Development of IRS Spacecraft Technology Remote sensing is a multi-disciplinary domain and substantial progress has been made in several technologies during the past few decades. As the demand for "four Resolutions" – Spatial, Spectral, Radiometric and Temporal increase, the complexity of imaging sensors and in turns the satellite systems. While reliability calls for heritage systems, lessons learnt and the new requirements warrant new technology developments. A brief overview on these technology developments is given in the following paragraphs.

Data Reception and Archival is located at Shadnagar Ground Station complex and has four data reception terminals, to receive Image data in X-Band and telemetry data in S band. These three terminals are configured to track and receive data from several National and international satellites (35-40) passes in a day. Configuration supports mission clashes and redundancy for important data reception. The Ground station has the capability to receive and demodulate the signals of up to 105 Mbps data rate. The feed and demodulators are upgraded for dual polarization and to cater for higher data rates. It has a Bore sight test facility to evaluate the total data reception chain for all three terminals.

Functionally data reception and auxiliary data processing consists of Antenna & Tracking pedestal, RF systems, Servo systems, Base band & Data acquisition systems and Ancillary data processing systems. Most of the sub-systems of antenna receive chain and interconnecting panels are not amenable for remote monitor and control. Hence they are to be manually set up for every data reception. There are Direct Archival & Quick Look Browse DAQLB systems for data archival and ancillary data processing from different satellites. Five of these support multi-mission operations for the current satellites. Operations of Data receive systems and DAQLB systems are manual.

Cartography Satellite, IRS-P5: Cartosat-1 is the first dedicated stereoscopic mission of ISRO, offering 2.5 m resolution in panchromatic band. Weighing 1560 kg at lift off, Cartosat-1 was launched into a 618 km Sun Synchronous Polar Orbit (SSPO) by PSLV-C6 on 5$^{th}$ May 2005. Cartosat-1 mission objectives are directed at geo-engineering (mapping) application, for high resolution panchromatic imagery with high pointing accuracies. The spacecraft features two high-resolution panchromatic cameras for in-flight stereo imaging.

## II. Brief Description of the Ground Station for Data Reception from IRS-P5

The ground station system configuration is explained with reference to the block diagram in Fig. 2. The system consists of a diametric parabolic reflector antenna with cassegrain feed, mounted over an Elevation over Azimuth driven pedestal. The feed and front-end system realizes single channel monopulse signal tracking and data reception in X-Band frequencies. The sum and difference channel signals from the front-end system are fed to a five channel synthesized down converter are driven to the control room, wherein, after the amplitude equalization, the sum channel is fed to the data demodulation while the difference channel signal is fed to the tracking receiver. The data and clock signals from the demodulator and Bit synchronisers are fed to the archival systems during the pass. The tracking video output, corresponding to the antenna offset information in Azimuth and Elevation axes, from the tracking receiver is fed to the antenna control unit. The antenna control unit has several operational modes to control the antenna movement. The unit drives the antenna in auto track mode during the satellite pass with programme tracking mode operating as backup. The servo system [11] is a dual drive system with torque bias arrangements to avoid antenna backlash during tracking.

Initially the systems for receiving data from:

CartoSat-1 - formerly IRS-P5 (Indian Remote Sensing Satellite-P5)

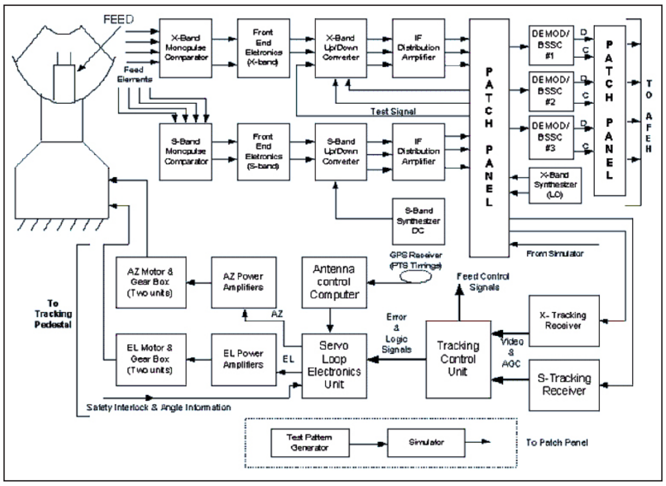


Fig. 1: Ground Station Block Diagram

IRS-P5 is a spacecraft of ISRO (Indian Space Research Organization), Bangalore, India. The objectives of the IRS-P5 mission are directed at geo-engineering (mapping) applications, calling for high-resolution panchromatic imagery with high pointing accuracies. The spacecraft features two high-resolution panchromatic cameras that may be used for in-flight stereo imaging. Prior to launch, ISRO renamed the IRS-P5 spacecraft to CartoSat-1, to describe more aptly the application spectrum of its observation data. In this mission, the high resolution of the data (2.5 m GSD) is being traded at the expense of multispectral capability and smaller area coverage, with a swath width of 30 km. The data products are intended to be used in DTM (Digital Terrain Model) / DEM (Digital Elevation Model) generation in such applications as cadastral mapping and updating, land use as well as other GIS applications.

## *A. Present Ground Station Scenario (IMGEOS)*

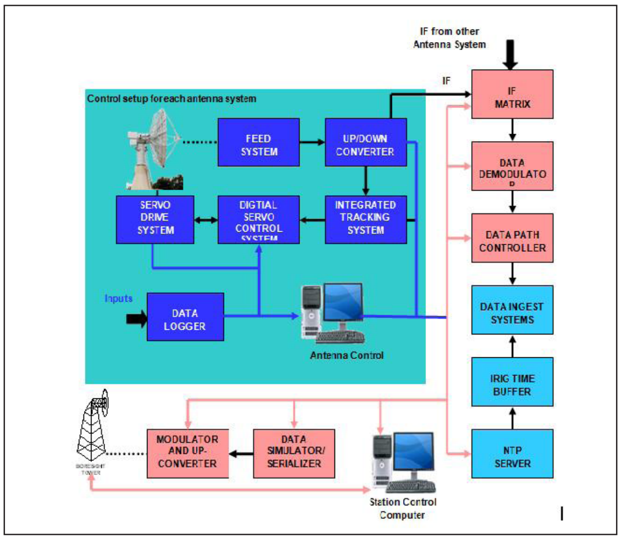


Fig. 2: Present Ground Station Block Diagram

As the numbers of remote sensing missions have increased, and the scopes of supporting emergency requirements and disaster monitoring have increased, present mission specific model has several short comings. Hence there is a need to process re-engineer the entire chain, adopting an integrated multi-mission approach in order to minimize the satellite launch-to-product delivery and for improving the turn-around-time from data acquisition to product delivery to the user in near real time. To meet these objectives, an Integrated Multi-mission Ground segment for Earth Observation Satellites (IMGEOS) is proposed to be implemented at Shadnagar complex of NRSC.

The ground station configuration is shown in Fig. 2. Four 7.5 meter antenna systems are used to track and receive data from different remote sensing satellites. There will be one antenna control computer (ACC) for each antenna systems and common station control computer (SCC) to perform the ground station operations.

Payload pass schedules & state vectors will be received through Sky-link on to SCC. After resolving the clashes, the SCC will assign the antenna systems for all scheduled passes after subjecting to acquisition strategies and archival policies. The SCC will configure base band systems automatically as per the schedules for all the four antenna systems and communicates its readiness to the ACC of the respective antenna system. The ACC in turn will configure the RF and IF sub systems before satellite pass tracking.

In real-time, the SCC and ACC monitor the required parameters from the base band and RF & IF systems respectively. The ACC will monitor all the parameters pertaining to RF & IF chain. In addition, it does program tracking which acts as a backup to the auto track mode. Subsequently it sends acquisition status to the SCC after the pass. During real-time, the Data Receivers log the data on to SAN based RAID system after doing demodulation and frame synchronization. The pre-processing system will provide the sub sampled quick look display in real-time. The station operations are planned to implement in fully automated environment aiming towards unmanned operations. The main objectives of the station automation are

- Visibility clash and elevation analysis.
- Providing centralized control & configuration of the station.
- Monitoring and control of the sub systems.
- Building up of operational database.
- Modularity for easy upgradeability to future missions.

In multi-mission scenario, around 20 passes will be acquired covering both Indian and foreign satellites from four different Antenna Systems. These antenna systems will be operated simultaneously to acquire the data from different / same satellites based on the clash scenario. In the operational scenario, it is required to reconfigure the chain and get ready for the next pass within 2 minutes. Around 25 parameters shall be monitored / configured on various subsystems for each pass. Some of these important parameters are:

Configuration Parameters

- Local oscillator frequency and its output level of Down converter.
- Gradient selection from Tracking servo control system.
- Digital Phase shifter selections.
- Routing of IF to different Data demodulators.
- Demodulator, clock lock, polarity, data rate, output level, output mode.

## *B. System Configuration*

The configuration has been worked out keeping in view of the simultaneous operations of all four antenna systems to track different satellites and is shown in Fig. 3. Automation point of view, the total sub systems in the Data Reception System are divided into two categories - RF & IF systems (all the sub systems up to down converter in the data receive chain) and base band systems (from IF matrix onwards).

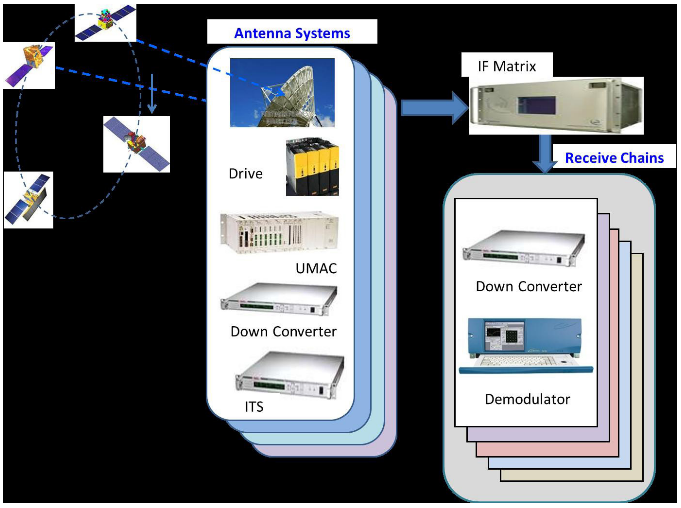


Fig. 3: Station Automation Configurations

The RF & IF systems are dedicated to one antenna systems and there will not be any switching between the antenna systems in the operations scenario. The automation of these systems is carried out by the antenna control computer of the respective antenna system along with the program tracking of the satellite. Similarly, station control computer carries out the automation of base band systems. These systems include IF matrix, Data Demodulators, Data Simulators etc.

## III. CARTOSAT-3 Series Satellites in Ka Frequency Band

Indian Space Research Organization (ISRO) is planning to launch next generation remote sensing satellites for cartographic applications, the first in the series being Cartosat-3 followed by Cartosat-3A & Cartosat-3B. These satellites transmit data to ground in Ka-band (25.5-27.0 GHz) and X band (7.8-8.5 GHz) with signals in Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP) simultaneously. NRSC has the responsibility for acquisition of data from Cartosat-3/3A/3B Satellites, data processing, data product generation, dissemination as well as application development and capacity building.

The proposed antenna system is a 7.5 m diameter shaped cassegrain type reflector with Monopulse feed assembly mounted on Elevation over Azimuth mount. Elevation over Azimuth Pedestal is equipped with Train axis. The three axes of rotation are arranged as elevation over azimuth over train with a 7° wedge (Tilt pedestal) between train and azimuth. Provision is made to orient the tilt in the designated direction anywhere in 360° as per the satellite pass requirements to avoid keyhole during overhead passes. The antenna is capable of ±360° in azimuth, -2° to 182° in Elevation and ±180° in Train axis coverage. This system is being under R&D.

### A. Data Ingest

Station workflow manager will initiate data ingest operation for archival of satellite data based on Payload pass schedules. For each antenna systems one data ingest system is configured. One additional ingest system is also configured as standby. Ingested satellite data will be qualified for quality in terms of data losses. Data ingest systems in the context of ancillary data processing and storage systems are shown in Fig. 4.

### B. Ancillary Data Processing

In near real time, the ancillary data processing systems (shown in Fig. 4) will generate ADIF, Browse and Histogram files for each pass. The generated ADIF will be populated on to the respective database for subsequent access and pre processing of data. The browse images are screened for quality & cloud automatically with a provision for manual certification before putting on to the Internet.

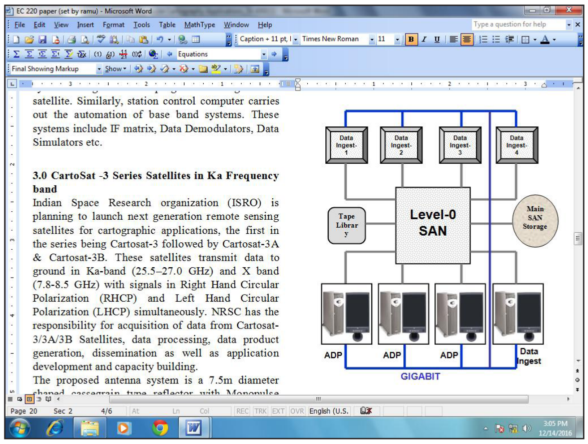


Fig. 4: Ancillary Data Processing Systems Configuration

## IV. Storage Architecture

The Storage sub system is a Storage Area Network having an estimated storage of 25.0 TB for acquisition & Level-0 processing, 15 TB for DP working area and around 720 TB of existing data of all satellites is archived on DLT/SDLT media (as on 31-Dec-2008).

Data is stored online in 3 tier SAN storage. Provision is made for 100 TB (usable) accounting for three months of all satellites data in high performance storage. 400 TB (usable) accounting for 18 months data in medium performance SATA storage. All the data acquired and available archived data will be stored in Tape library in duplicate for backup and one more copy for vaulting. This 3 tier configuration is optimized for product generation and for data availability.

The following points are considered for selection of tiered storage:

- For online processing or archival.
- High performance vs. cost effectiveness.
- Write once / read many or continuous read / write.
- Frequently accessed or infrequently accessed.
- File data or RDBMS data.
- Heterogeneous platform access.
- Multiple users or single user / limited users.
- Scenarios.
- Data acquisition processes and data processing chains require high performance storage suitable for online processing etc.
- Archival data is mainly write-once read-many.
- The past one year archival data is being accessed more frequently than earlier years' data.
- The storage is scalable to meet ever increasing data volumes with time. Storage architecture is shown in Fig. 5.

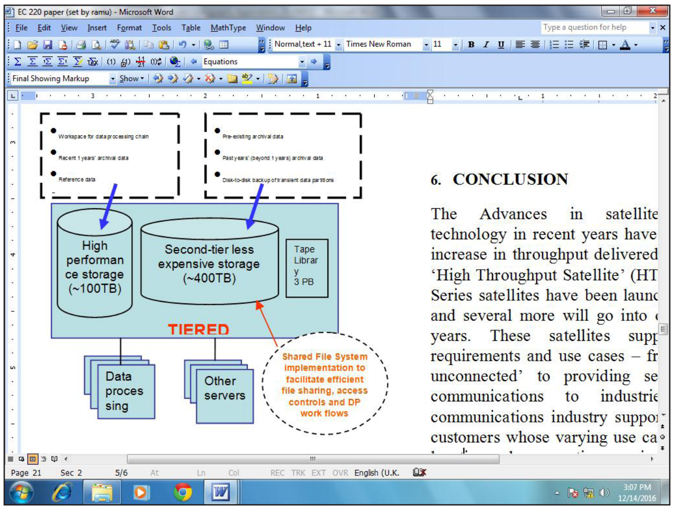


Fig. 5: Storage Implementation-Main Storage

## V. Data Archival for One Day

| Carto. Sat | Data Rate | Streams | Total Volume Data Acquired |
|---|---|---|---|
| Cartosat-01 | 105 Mbps | Two | 33.075 |
| Cartosat-02 | 105 Mbps | Two | 14.175 |
| Cartosat-2A | 105 Mbps | Two | 3.938 |
| Cartosat-2B | 105 Mbps | Two | 33.075 |
| Cartosat-2C | 105 Mbps | Two | 33.075 |

CARTOSAT-3 TRANSMIT PARAMETERS IN Ka BAND

| | | |
|---|---|---|
| Orbit Height | : | 450 Km |
| Modulation Scheme | : | 8 PSK |
| Dual Polarization | : | RCP & LCP |
| Transmission Data Rate | : | 3.8 Gbps |

## VI. Conclusion

The Advances in satellite communications technology in recent years have led to a significant increase in throughput delivered from a raft of new 'High Throughput Satellite' (HTS) systems. Carto 2 Series satellites have been launched in recent years and several more will go into orbit in the coming years. These satellites support diverse user requirements and use cases-from 'connecting the unconnected' to providing secure and resilient communications to industries. The satellite communications industry supports a wide range of customers whose varying use cases and deployment locations place exacting requirements that must be fulfilled. Connectivity must be delivered to consumers located beyond the reach of traditional terrestrial networks and yet also to business and corporate clients requiring bespoke systems to support critical communications needs.

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## References

1. M. Krishnaswamy, "Sensors and platforms for high resolution imaging for large scale mapping applications - Indian scenario," *Indian Cartographer,* pp. 1-6, 2002.
2. M. Krishnaswamy, and S. Kalyanaraman, "Indian remote sensing satellite CartoSat-1: Technical features and data products," Paper presented at Map Asia 2002 conference, 7-9 August 2002, Bangkok, Thailand. Available: http://www.gisdevelopment.net/technology/rs/techrs023.htm (accessed 29 January, 2008).
3. "CartoSat-1 - A global IRS Mission for large scale mapping and terrain modeling applications," NRSA (National Remote Sensing Agency) Data Center, Hyderabad, India. Available: URL: http://bhuvan-noeda.nrsc.gov.in/download/download/tools/document/Cartosat_1_brochure.pdf
4. S. Kocaman, K. Wolff, A. Gruen, and E. Baltsavias, "Geometric validation of cartosat-1 imagery," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* Beijing, vol. 37, 2008.
5. R. S. Ramayanam, "Indian remote sensing satellites resources at-1 (IRS P6) & cartosat-1 (IRS P5)," Available: http://www.pecad.fas.usda.gov/pdfs/USDA_Workshop_Presentation2_DrRao.pdf
6. F. Barner, R. Haydn, H. Maass, and L. N. R. Murthy, "Contribution of the Indian IRS program to the European data requirements through Euromap," ESA Living Planet Symposium, Bergen, Norway, June 28 to July 2, 2010, Special Publication SP-686. Available: http://www.euromap.de/pdf/1872905_Barner_ConIRSEUDataReqEM_v1.1_20100628.pdf