# CURRENT AND FUTURE SATELLITE PROGRAMS AND SYSTEMS IN INDIA

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## ABSTRACT

This paper describes the technical details and status of currently operational satellites of INSAT series. The last satellite of INSAT-1 series (INSAT-1D) was deactivated on 14 May 2002 after providing useful services for about 12 years. A new dedicated meteorological satellite (KALPANA-I) has been successfully commissioned recently. The last satellite of INSAT-2 series (INSAT-2E) has also been providing useful cloud imagery data in 3-channels of CCD - payload at 1 km resolution. **.** Another Indian Geostationary multipurpose satellite, INSAT-3A, with VHRR, CCD and DRT payloads has become operational since April 2003**.** The other communication based operational services being derived from INSAT series of satellites are also described in this paper, along with the activities of India Meteorological Department related to application of satellite products in day-to-day operational use. Details of bilateral collaboration program with USA for exchange of INSAT data are also given.

## Introduction

INSAT is an operational multipurpose satellite system catering to the needs of three different services - Television & Radio Broadcasting, Communications and Meteorology. The INSAT project is a joint venture of the Department of Telecommunications (DOT), the India Meteorological Department (IMD), Doordarshan and All India Radio (AIR). The responsibility for overall management and coordination of the INSAT system among the user agencies rests with the INSAT co-ordination committee (ICC).

The first satellite INSAT-1A of the INSAT-1 series was launched in April 1982 and it ceased to function totally from 6 September 1982 as a result of major anomaly on the satellite. The second satellite (INSAT-1B) was launched on 30 August 1983 and it became operational on 15 October 1983. It was the main operational satellite all through the 1980s and provided very good services during its entire mission life. It was deorbited in July 93. The third satellite of the series (INSAT-1C) was launched on 22 July 1988. Due to some technical problem it lost control on 22$^{nd}$ November 1989 after which it was not available for operational services. The last satellite of INSAT-1 series (INSAT-1D) was launched on 12 June 1990 and became operational on 17 July 1990. After having provided services for nearly 12 years, INSAT-1D reached its end of life on 13$^{th}$ May 2002.

The 2$^{nd}$ generations of INSAT satellites (INSAT-2 series) were started from July 1992 with the successful launch of the first satellite of the series (INSAT-2A) on 10$^{th}$ July 92. The 2$^{nd}$ satellite of INSAT-2 program (INSAT-2B) was also launched successfully on 22 July 1993. All INSAT satellites are three-axis body stabilized spacecrafts. The last satellite of INSAT-2 series i.e., INSAT-2E was launched successfully on 3 April 1999. It is operational from May 1999. It has a new payload, called Charged Coupled Device (CCD) capable of taking 1 km resolution images in 3 bands. The meteorological imaging capability has also been upgraded on this satellite, as compared to its predecessors, by providing a water vapor channel with 8 km resolution in the VHRR, the imaging instrument of the satellite. However, on account of some limitations, the VHRR data is of limited use. A new satellite KALPANA-I has been launched on 12$^{th}$ Sept. 2002 and has been declared operational with effect from 25$^{th}$ Sept. 2002. This satellite has VHRR (Vis, IR & Water vapor) and Data Relay Transponder (DRT) on board

and is exclusively dedicated to Meteorological services of the country. Recently INSAT-3A was launched in April 2003 that is having identical payloads as INSAT-2E.

## 1.1 Current operational status

The imaging mission is working satisfactorily with KALPANA-I satellite and it continues to be used operationally from 74$^{o}$E longitude position. High resolution (1km) images in 3 channels are also available operationally from CCD camera onboard INSAT-2E. The activities like image processing, derivation of meteorological products, data archival and dissemination of products to field stations for operational use are being done on an operational routine basis.

VHRR images are normally received at three- hourly intervals. More frequent images are taken for monitoring the development of special weather phenomena such as tropical cyclones and adverse weather conditions as and when the situation demands. CCD images from 2E are also being taken every three hours for operational use during daytime. More frequent images are also taken if situation demands. However, due to some anomaly in scan mechanism VHRR onboard INSAT-2E is not currently available for operational use and INSAT-3A that was launched in April 2003 is expected to takeover the INSAT-2E operational jobs after the validation of the products is completed. For the derivation of CMVs half hourly triplets at 00 UTC is also received from KALPANA-I and data processed operationally. The KALPANA-I derived CMVs are available on GTS. The details of present and past satellites of INSAT-1 and INSAT-2 series are given in Table 2 and 3.

## 1.2 Characteristics of VHRR payload

THE VHRR onboard KALPANA-I includes:

A visible channel operating in the spectral wavelength of 0.55-0.75 microns.
Infrared (IR) channel operating in 10.5-12.5 microns.
Water Vapor channel operating at 6.7 microns.

Main differences between INSAT-1, INSAT-2 and KALPANA-I are in VHRR resolution; scan time, data rate and frequency of transmission that are given in Table-1.

INSAT-2E is located at 83 deg E longitude and provides imaging capability at 1 km resolution in 3 channels of visible, Near IR and Short-wave infrared. INSAT data are being processed at IMD facility “INSAT Meteorological Data Processing System (IMDPS)” located in IMD’s campus at Lodi Road, New Delhi.

The processing system is configured around eight VAX Computers in a clustered network, with a number of other peripheral devices attached. The processed data and products are stored for database. Users can access the database in real-time through four workstations connected to the system. Imagery data of main synoptic hours are being archived as hard copies. Processed 8 bit imagery data are also archived on magnetic tapes at 6250 BPI for later use in R&D related works. Quantitative products such as OLR, QPE and SSTs are also archived on magnetic tapes. Photographic recorders of three different types are also connected to the system for generation of B& W and color photographic pictures in real- time for the users.

## 1.3 METEOROLOGICAL DATA DISSEMINATION (MDD)

The processing system is also being used for generating analogue type of cloud imagery data which are transmitted through INSAT-2C to field stations using S-band broadcast capability of the satellite along with other conventional meteorological data and FAX charts. This scheme is called Meteorological Data Dissemination (MDD).

There are about 90 MDD receiving stations in the country being operated by different agencies. Two MDD receiving stations are also operating in neighboring countries at Sri Lanka and Male under bi-lateral agreement. In general, the processed images are sent to these stations every three hours and every hour during cyclone

periods. These stations are receiving direct broadcasts of cloud imagery, weather facsimile charts and meteorological data on an operational basis.

The frequency of transmission from ground to satellite (Uplink) is 5899.225 MHz and downlink is at 2599.225 MHz.

## 1.4 DATA COLLECTION PLATFROM (DCP)

The Data Relay transponder (DRT) on board INSAT is being used for collection of meteorological, hydrological and oceanographic data from remote and inaccessible areas. The DCP data are received through KALPANA-I. IMD has installed 100 Data Collection Platforms (DCPs). Other agencies have also installed about 70 DCP stations, which are operational with KALPANA-I.

Characteristics of DCPs.

| | |
|---|---|
| Frequency of transmission | 402.75 MHz (uplink) |
| Downlink frequency | 4504.1 MHz |
| Bit rate | 4.8 kbps |
| EIRP (uplink) | 16.5 dbw |
| Mode of transmission | Burst mode |
| Burst length | 87 milliseconds |
| Number of sensor | 10 (7 analog & 3 digital) |
| Number of bits in one frame | 422 bits |

## 1.5 CYCLONE WARNING DISSEMINATION SYSTEM (CWDS)

For quick dissemination of warnings against impending disaster from approaching cyclones, IMD has installed specially designed receivers within the vulnerable coastal areas for direct transmission of warnings to the officials and people in general using broadcast capability of INSAT satellite. IMD's Area Cyclone Warning Centers (ACWC) generates these special warning bulletins and transmits them every hour in local languages to the affected areas. IMD in the field areas has installed 250 such receivers in the field areas. CWDS has proved very effective system of warning people during the cyclone affecting the coastal areas. For this service the frequency of transmission from ground to satellite (uplink) is 5859.225 MHZ and Downlink is at 2559.225 MHz. Recently this technology has been upgraded to include digital transmission instead of analogue. Initially 100 numbers of new Digital Cyclone Warning Dissemination Systems (DCWDS) have been deployed in the coastal areas of Andhra Pradesh for reception of cyclone warnings.

## 1.6 RECEPTION OF NOAA SATELLITE DATA

The data from NOAA series of polar orbiting satellites are received and processed by IMD at Delhi and Chennai. Both AVHRR and TOVS data are processed in real time and the weather forecasters are utilizing cloud imagery and derived products operationally. The derived products are archived for distribution on demand basis to the scientists for use in research work. Based on a limited study done by IMD, the vertical temperature and moisture profiles derived from the NOAA satellite have shown positive impact on forecasts generated with numerical models. The old HRPT receiving station at New Delhi has been replaced with a new system, which is also capable of receiving data from new generation of NOAA satellites (K, L, M and N series).

## 1.7 PDUS for METEOSAT-5 data reception

A PDUS receiving station had been installed in early 2000 at IMD, New Delhi for reception of high resolution imagery data from METEOSAT-5 satellite located at 63 deg E over the Indian Ocean. This system continues to be used operationally for providing cloud imagery data to the forecasters.

## 1.8 INDO–US data Exchange Centre

Under the bilateral programme of co-operation with USA, an INDO-US data Exchange Centre has been established at IMD, New Delhi in Nov. 99 for exchange of satellite data with USA. Processed INSAT imagery data is being transmitted every three hours to the USA. GOES imagery data is also being received from USA. Data exchange takes place through dedicated communication links.

## 2. Future Indian Satellite missions

Future missions planned to meet the requirements of the Indian Meteorology/Oceanography community are given in Table.4. The INSAT-3D, to be launched during the year 2006 will carry an improved 6-channel imager and a 19-channel sounder for temperature/humidity profiles. The Megha-Tropiques mission slated for 2006 is a joint effort of ISRO, India and CNES, France for study of the water cycle and deep convection in the tropical region. The unique payloads of the Megha-Tropiques are MADRAS (5 channel multi-frequency microwave radiometer – including 157 GHz), ScaRaB (radiation budget - for both short and long wavelengths) and SAPHIR (humidity sounder). The mission will operate in an inclined equatorial orbit of $20^0$ for repetitive coverage of tropical ocean areas.

**Table –1: Main differences between INSAT-1, INSAT-2 and KALPANA-I**

| | INSAT-1D | | INSAT-2B | | KALPANA-I | | |
|---|---|---|---|---|---|---|---|
| Parameter | Visible | IR | Visible | IR | Visible | IR | WV |
| Spatial Resolution in Km | 2.75 | 11 | 2.0 | 8.0 | 2.0 | 8.0 | 8.0 |
| Scanning lines | 4548 | 1137 | 6240 | 1560 | 6240 | 1560 | 1560 |
| Quantization level | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Field of view (μr) | 76.8 | 307 | 56 | 224 | 56 | 224 | 224 |
| Detectors | Silicon photodiodes | HgCdTe | Si | HgCdTe | Si | HgCdTe | HgCdTe |
| Location | Deorbited | | 111.5 Deg E | | 74 deg E | | |
| Modes of Operation | Full Frame 20 X 20<br>Sector Scan<br>20 E-W X 5 N | | FF 20 X 20<br>Normal Scan<br>20 EW X 14 NS<br>Sector Scan 20 EW X 4.5 NS | | FF 20 X 20<br>Normal Scan<br>20 EW X 14 NS<br>Sector Scan 20 EW X 4.5 NS | | |

**Table –2: INSAT-1 Geostationary Satellite Series**

| **Satellite** | **Launch Date** | **Met. Payload with Wavelength Bands** | **Major Applications** | **Active / Inactive** |
|---|---|---|---|---|
| INSAT-1A | April10, 1982 | Very High Resolution Radiometer (VHRR)<br><br>Visible 0.55- 0.75μm<br>IR 10.5 - 12.5μm | • Monitoring cyclones & monsoon<br>• CMV Winds<br>• OLR<br>• Rainfall Estimation | Inactive |
| INSAT-1B | August 30, 1983 | -do- | -do- | -do- |
| INSAT-1C | July 22, 1988 | -do- | -do- | -do- |
| INSAT-1D | June12, 1990 | - do- | -do- | -do- |

**Table –3: INSAT-2 and 3 Geostationary Satellite Series**

| Satellite | Launch Date | Met. Payload with Wavelength Bands | Major Applications | Active/ Inactive |
|---|---|---|---|---|
| INSAT- 2A | July10, 1992 | Very High Resolution Radiometer (VHRR)<br>Bands: 0.55 - 0.75μm<br>10.5 - 12.5μm | • Monitoring cyclones & monsoon<br>• CMV Winds<br>• OLR<br>• Rainfall Estimation<br>• Mesoscale features<br>• Flood/intense precipitation advisory<br>• Snow detection | Inactive |
| INSAT-2B | July23, 1993 | Very High Resolution Radiometer (VHRR)<br>Bands: 0.55 - 0.75μm<br>10.5 - 12.5μm | -do- | Inactive |
| INSAT-2E | April, 1999 | 1. VHRR: As above + WV Band: 5 - 7.1μm<br>2. CCD Payload<br>Bands: 063 - 0.79μm<br>0.77 - 0.86μm<br>1.55 - 1.70μm | -do- | Active |
| KALPANA-I | 12 Sept.2002 | Very High Resolution Radiometer (VHRR)<br>Bands: 0.55 - 0.75μm<br>10.5 - 12.5μm<br>WV Band: 5.7 -7.1μm | • Monitoring cyclones & monsoon<br>• CMV Winds<br>• OLR<br>• Rainfall Estimation | Active |
| INSAT-3A | 10 April, 2003 | Same as INSAT-2E above | Same as INSAT-2E above | Active |

**Table –4: FUTURE SATELLTE PROGRAM**

| Satellite | Launch Date | Met. Payload with Wavelength Bands | Major Applications | Active/Inactive |
|---|---|---|---|---|
| INSAT- 3D | Around 2006 | 1. 6 channel Imager Band: 0.55 – 0.75μm (Vis- 1 km), 1.55 – 1.70μm (IR- 1km), 3.70-3.95μm(Mid Wave IR- 4 km), 6.5- 7.10 μm (Thermal IR- 4 km), 10.3-11.3μm (T IR- 4 km), 11.3-12.5μm(WV- 5 km)<br><br>2. Sounder Bands: 19 channels between 0.69-4.71 μm | Monitoring cyclones & monsoon<br>CMV Winds<br>OLR<br>Rainfall Estimation<br><br>Temperature and Humidity profiles in the atmosphere. | ---- |
| **Megha-Tropiques (**A joint project by ISRO and CNES, France with the objective of studying the water cycle and energy exchanges in the tropics) | Around 2006 | 1.SAPHIR 6 bands around 183 GHz (10 km Res.)<br><br>2. SCARAB Radiation instrument in short & long wave (40 km Res.)<br><br>MADRAS 89 & 157 GHz radiometer<br>10, 18 & 37 GHz radiometer (10 km Res.) | Water vapor profile up to 12 km<br><br>Radiation budget<br><br>Ice particles in cloud tops, cloud liquid water and precipitation; sea surface wind speed. 23 GHz: Integrated water vapor | ---- |

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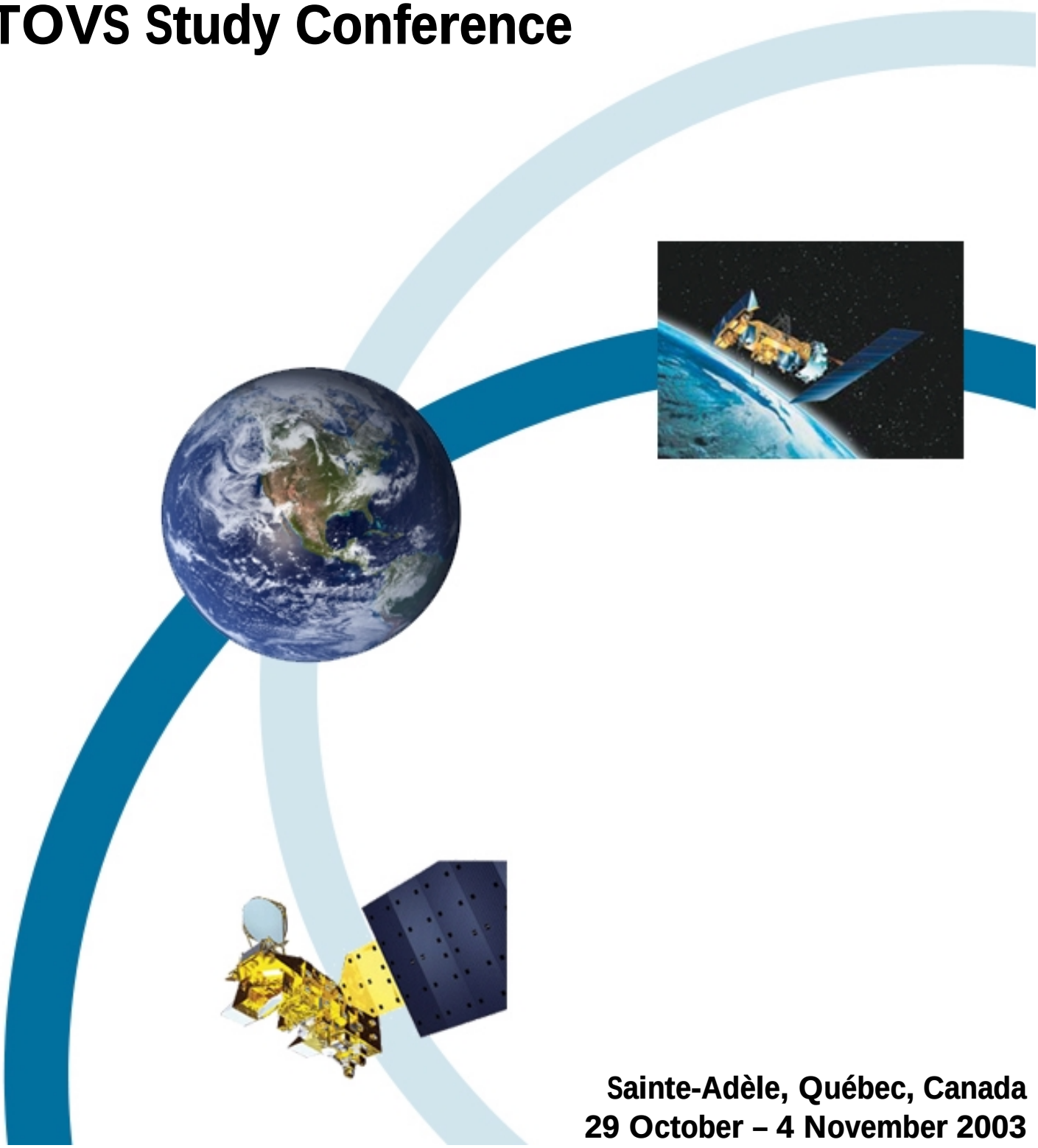

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