

SENSORS FOR SPACE

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Deputy Director ISRO

Courtesy Dr TK Alex

Classification of SENSORS for Space



Launch Vehicle

**Control, Guidance
and Navigation**

**Instruments for
Health / Performance monitoring**

**Instrumentation
on ground**



Spacecraft

**Spacecraft
Instrumentation**

**Attitude &
Orbit
Navigation**

**Health
Parameters**

**Life-Support /
Crew health /
Environment**

**Landing/
Rovers**

**Remote
Sensing
Instruments**

Cameras

Radiometers

Spectrometres

**Radar /
Lidar**

**Space
Science
Instruments**

**Electric /
Magnetic Field
Charge/Particle**

RF instruments

**Cosmic Ray,
Gamma Ray/
X-Ray, UV/**

**Biological /
Astro-biology**



Instrumentation for Launch Vehicles

Control, Guidance and Navigation

Rate gyro
Dynamically-Tuned Gyro
Ring Laser Gyro
MEMS Rate Gyro
Servo-Accelerometer
Ceramic-Accelerometer
MEMS accelerometer...

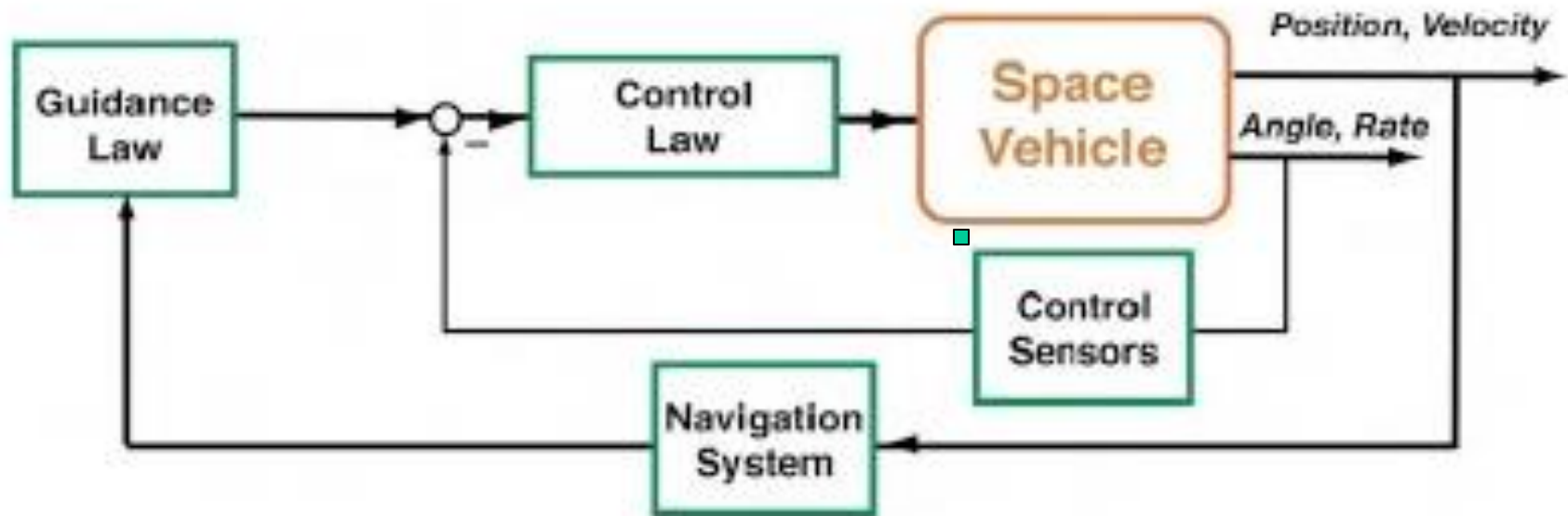
Instruments for Health / Performance monitoring

Temperature sensors
Pressure sensors
Strain
Vibration
Position sensors
Level sensors
Acoustic sensors
Video Imaging..

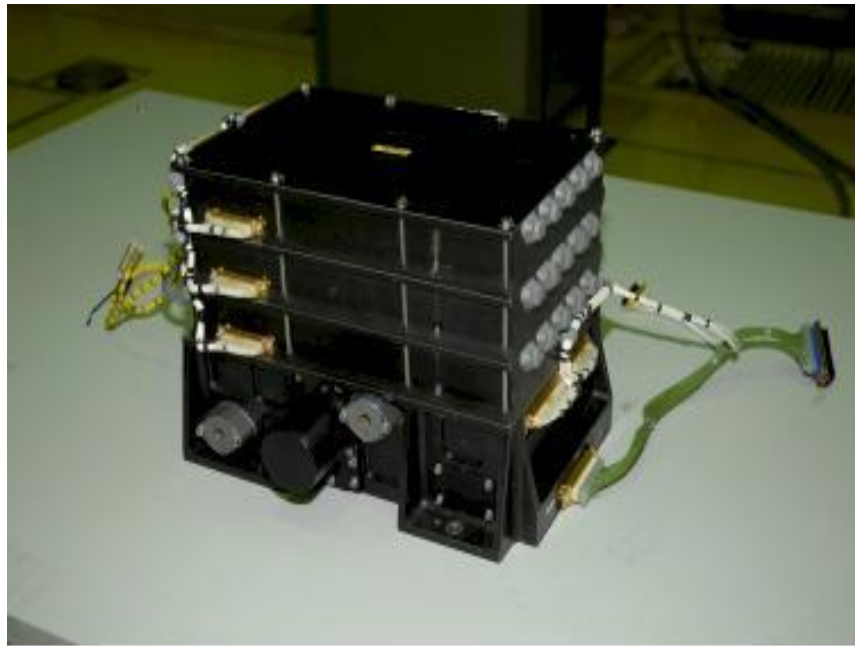
Instrumentation on ground

Temperature
Pressure
Load Cells
Vibration
Shock
Vacuum
Heat Flux
Wind Tunnel
Hypersonic Measurements
Schlieren Viewer
Dynamic Simulators
Mech / Thermal / Chemical property measurements

Guidance, Navigation, and Control



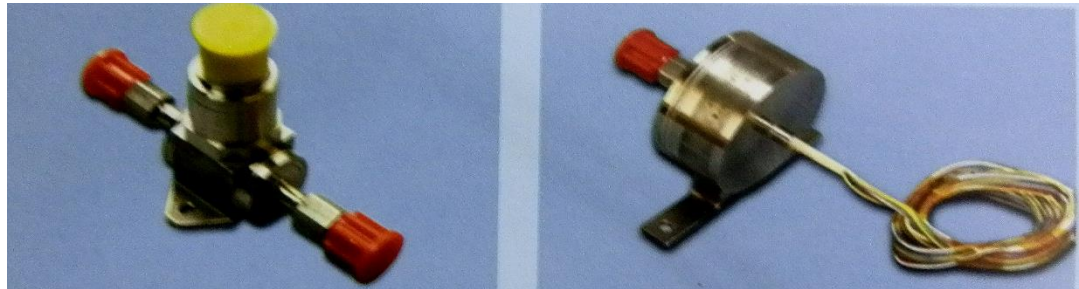
- **Navigation**: Where are we?
- **Guidance**: How do we get to our destination?
- **Control**: What do we tell our vehicle to do?



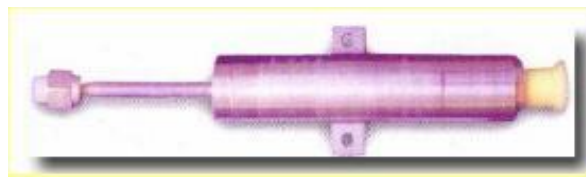
**Redundant
Navigation
System**



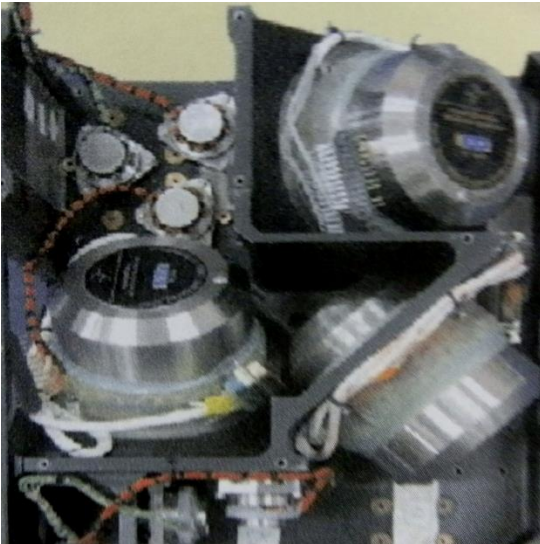
**Video Imaging camera
on Launch Vehicle**



Pressure Transducers

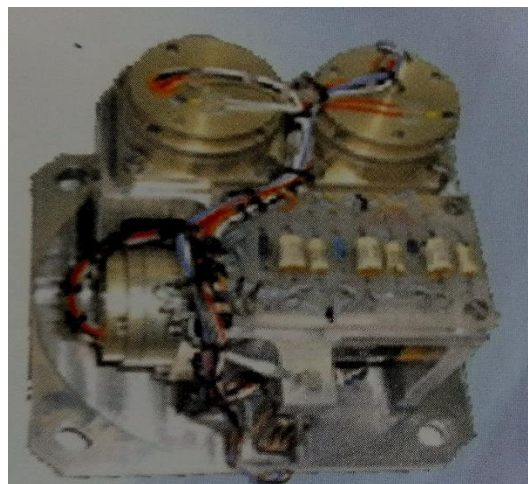


Instrumentation for Launch vehicles

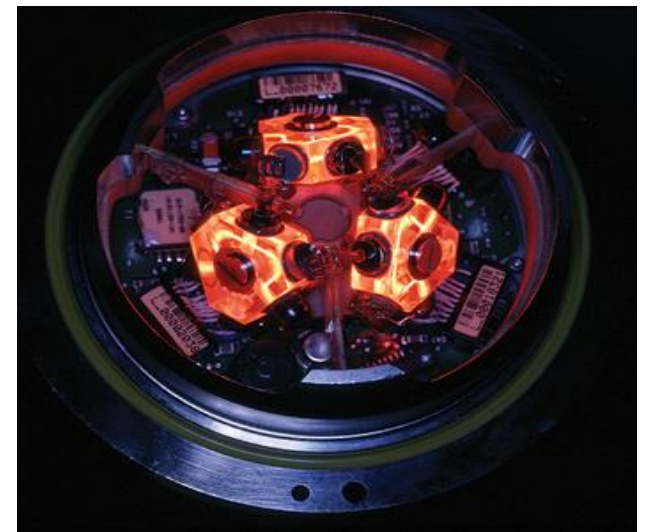


**Cluster of
DTGs**

**Miniature
DTG& MWA**



**Rate Gyro
Package**



RLG

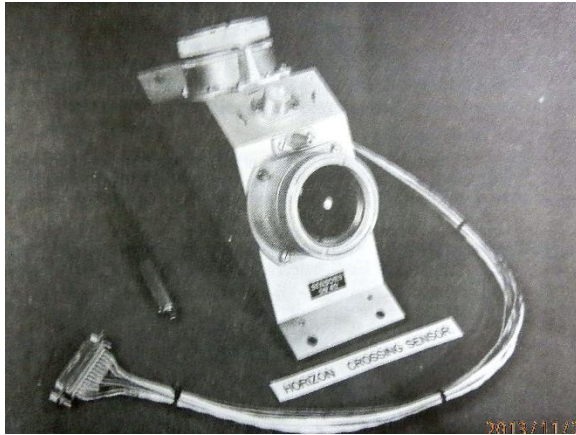
Instrumentation for Satellites



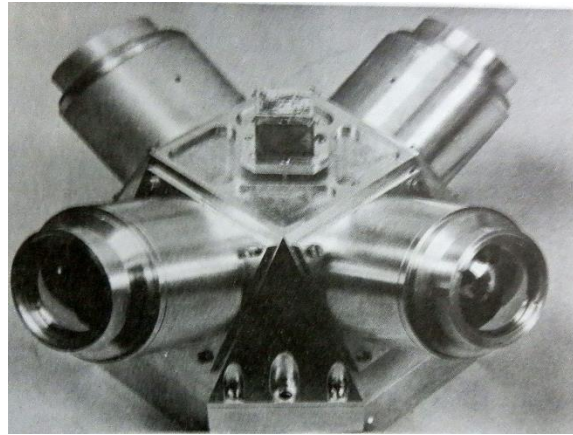
Sensors for

- **Attitude**
(**Direction & Angular rates**)
- **Acceleration**
- **Vibration**
- **Temperature**
- **Pressure**
- **Strain**
- **Radiation**
- **Sensors for Docking**

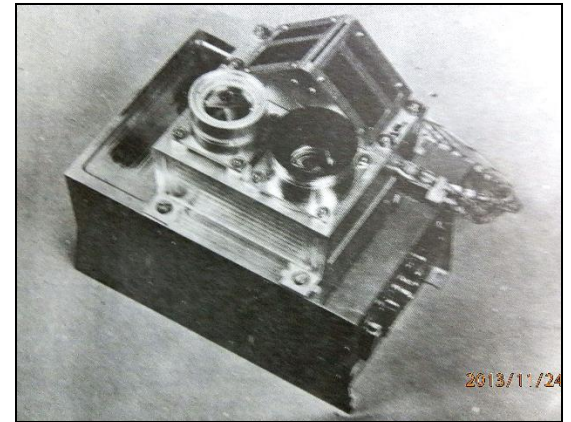
Satellite Sensors



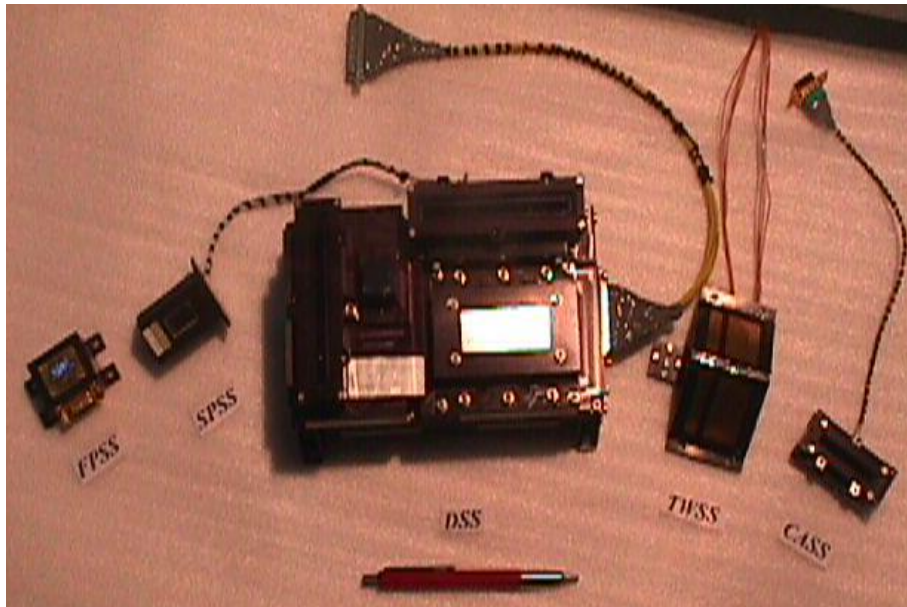
Bhaskara Horizon Sensor



IRS Static Earth Sensor



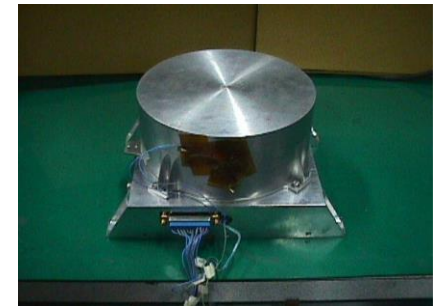
Rohini Smart Sensor



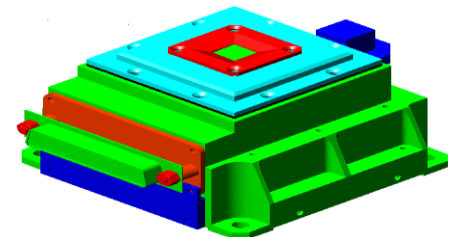
SUN SENSORS



MAGNETIC
SENSOR

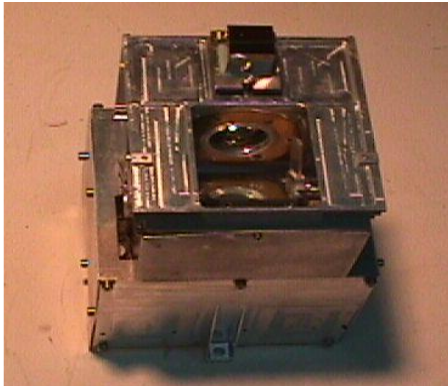


FIBER-OPTIC GYRO

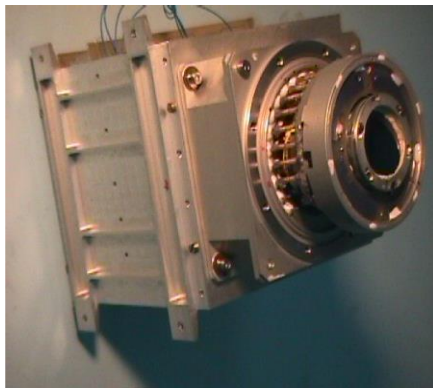


APS-SUN
SENSOR

Electro-Optic Sensors for Space

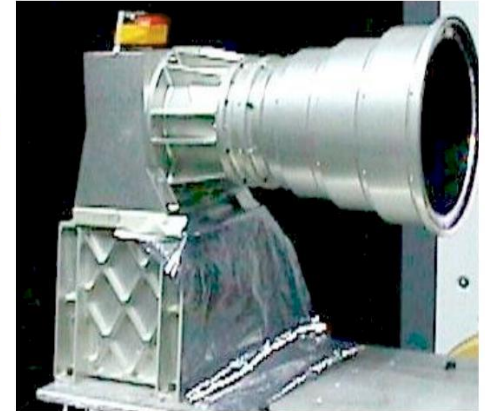
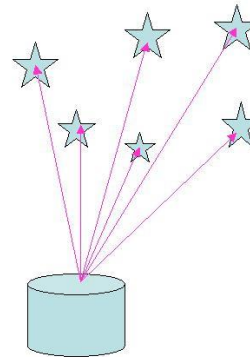


SCANNING
INFRARED
EARTH SENSOR



CONICAL
SCANNING
EARTH SENSOR

STAR TRACKER
FOR HIGH
ACCURACY
ATTITUDE SENSING



Altimeter



Remote Sensing Instruments

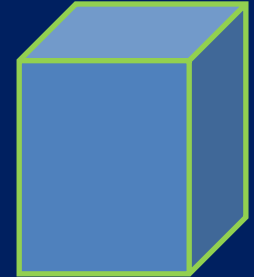
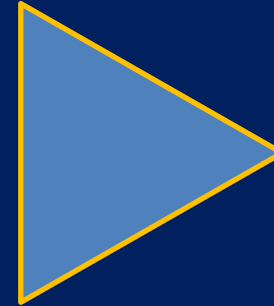
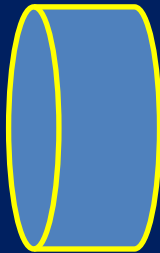
- **LISS CAMERAS(I,II,III,IV)**
- **HIGH RESOLUTION CAMERA:Cartosat**
- **AWiFS CAMERA**
- **Hyperspectral Camera**
- **VHRR**
- **SOUNDER**
- **OCM**

- **MICROWAVE INSTRUMENTS**
- **RADIOMETER**
- **SCATTEROMETER**
- **S/C/X BAND SAR**
- **PAYLOADS FOR CHANDRAYAAN & MOM**

AIR-BORNE INSTRUMENTS

ELEMENTS OF AN OPTICAL SENSOR

MEASURANT PARAMETER



**LIGHT
SOURCE**

**LIGHT
COLLECTING
OPTICS**

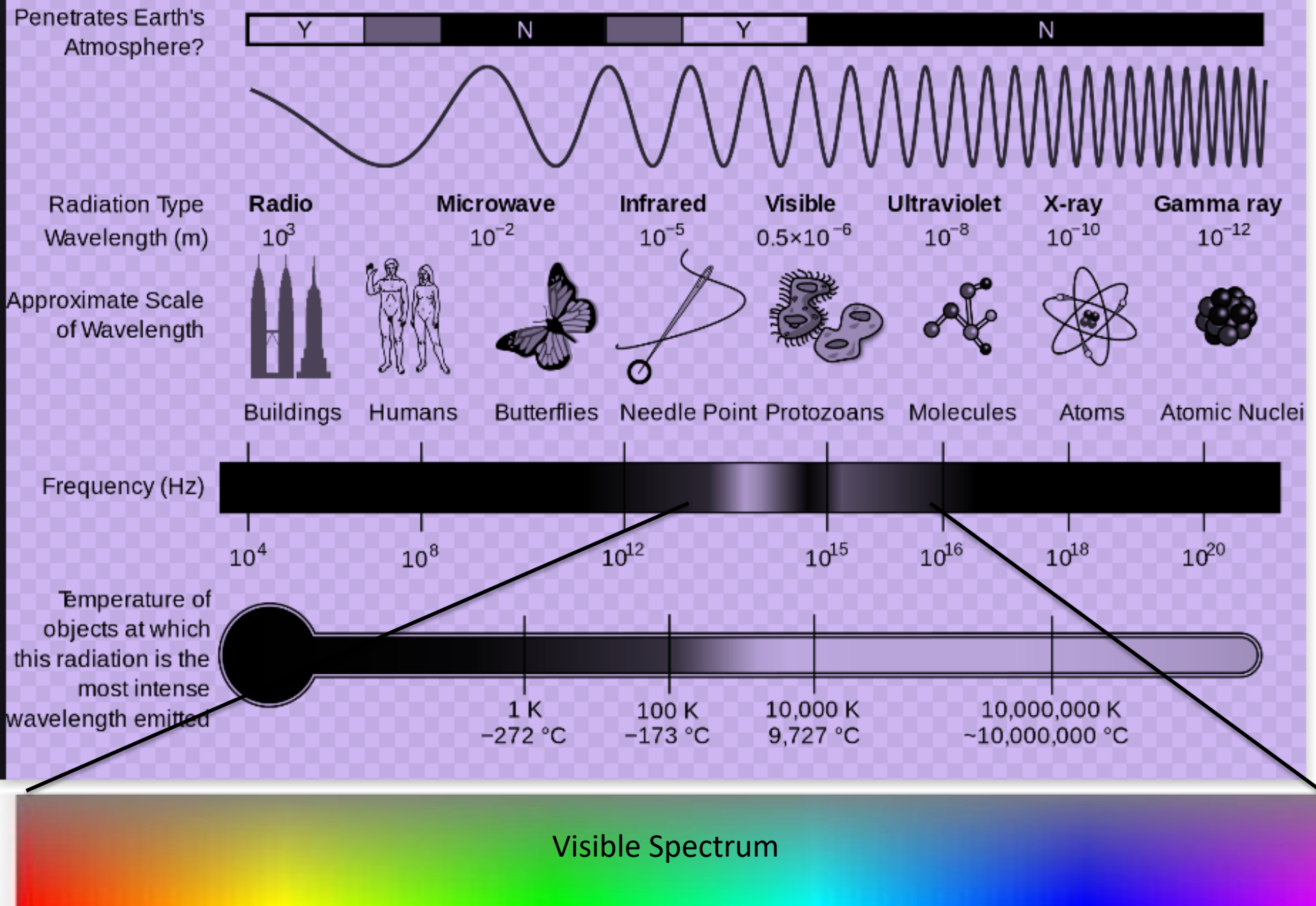
**OPTICAL
SUB-
SYSTEMS**

DETECTOR

**SIGNAL
PROCESSING**

**DATA
ACQUI-
SITION**

Electromagnetic Spectrum



Brahmaputra River



Satellite imagery Vienna

(Cartosat + Resourcesat)



2013/11/24

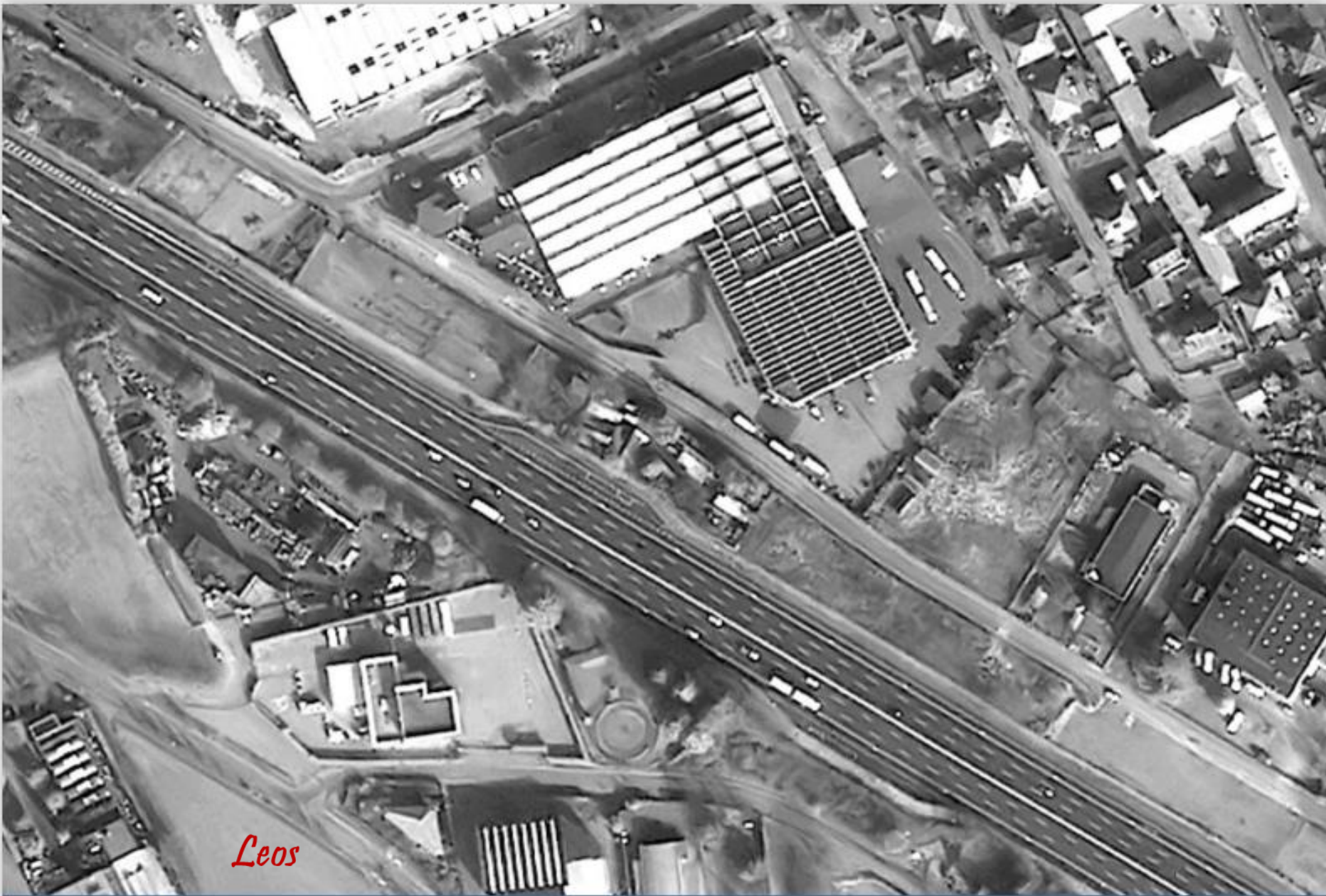
Baghdad, IRAQ



DOHA: Image by Cartosat-2S



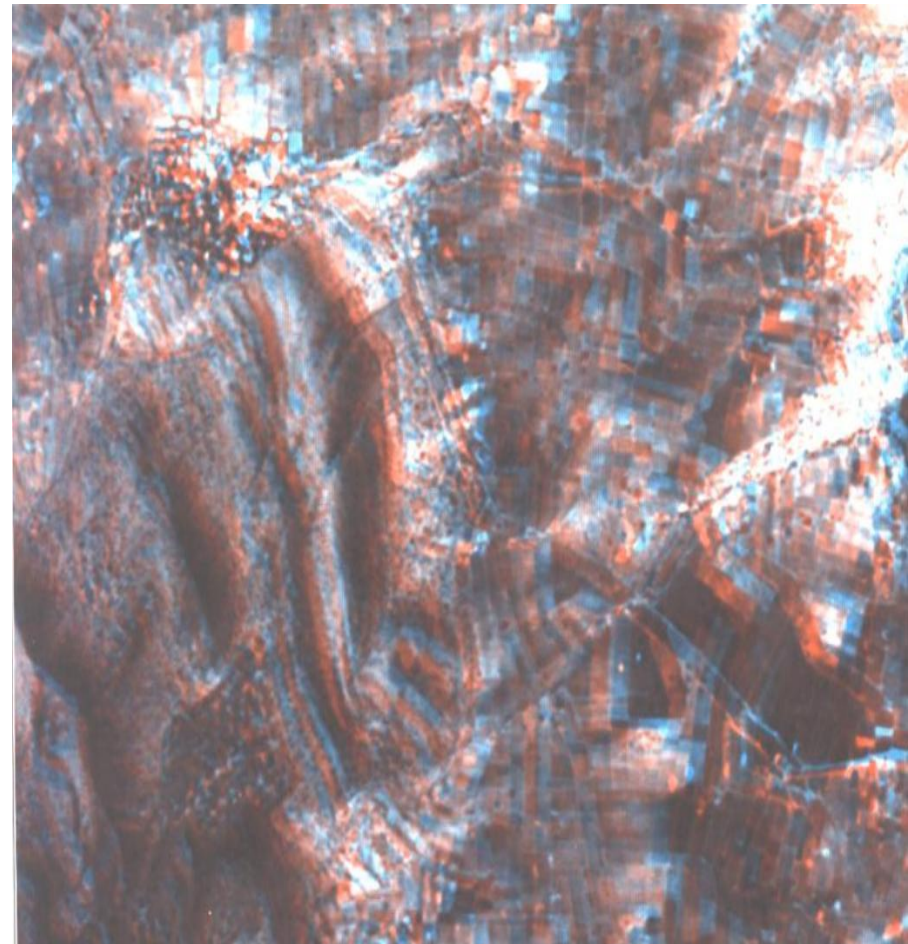
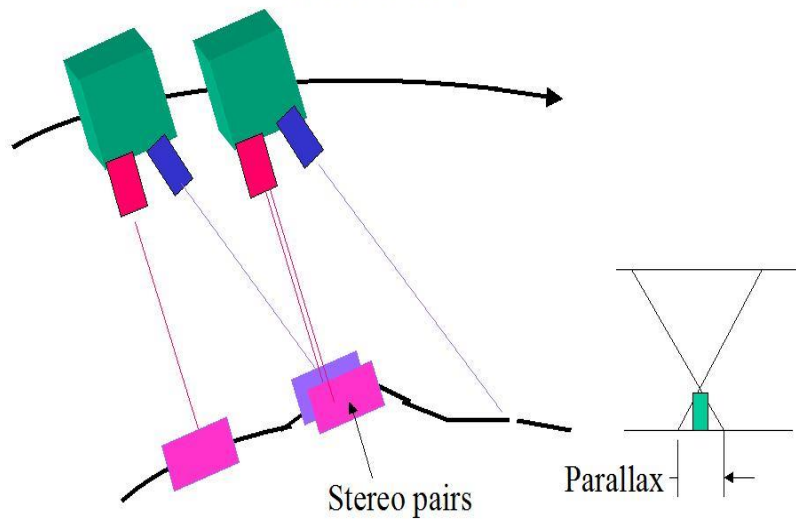
An Italian City : Imaged by Cartosat-2S

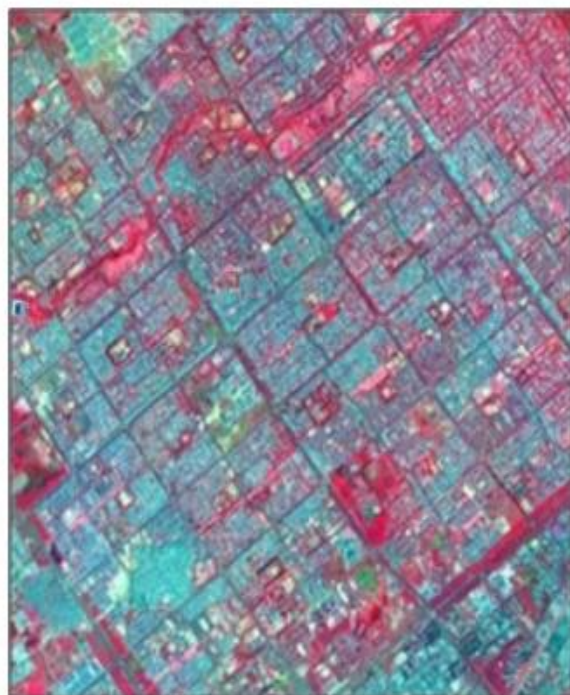


Leos

STEREO IMAGING:

FORE & AFT CAMERAS
CARTOSAT-1





PAN sharpened 2.5m imagery

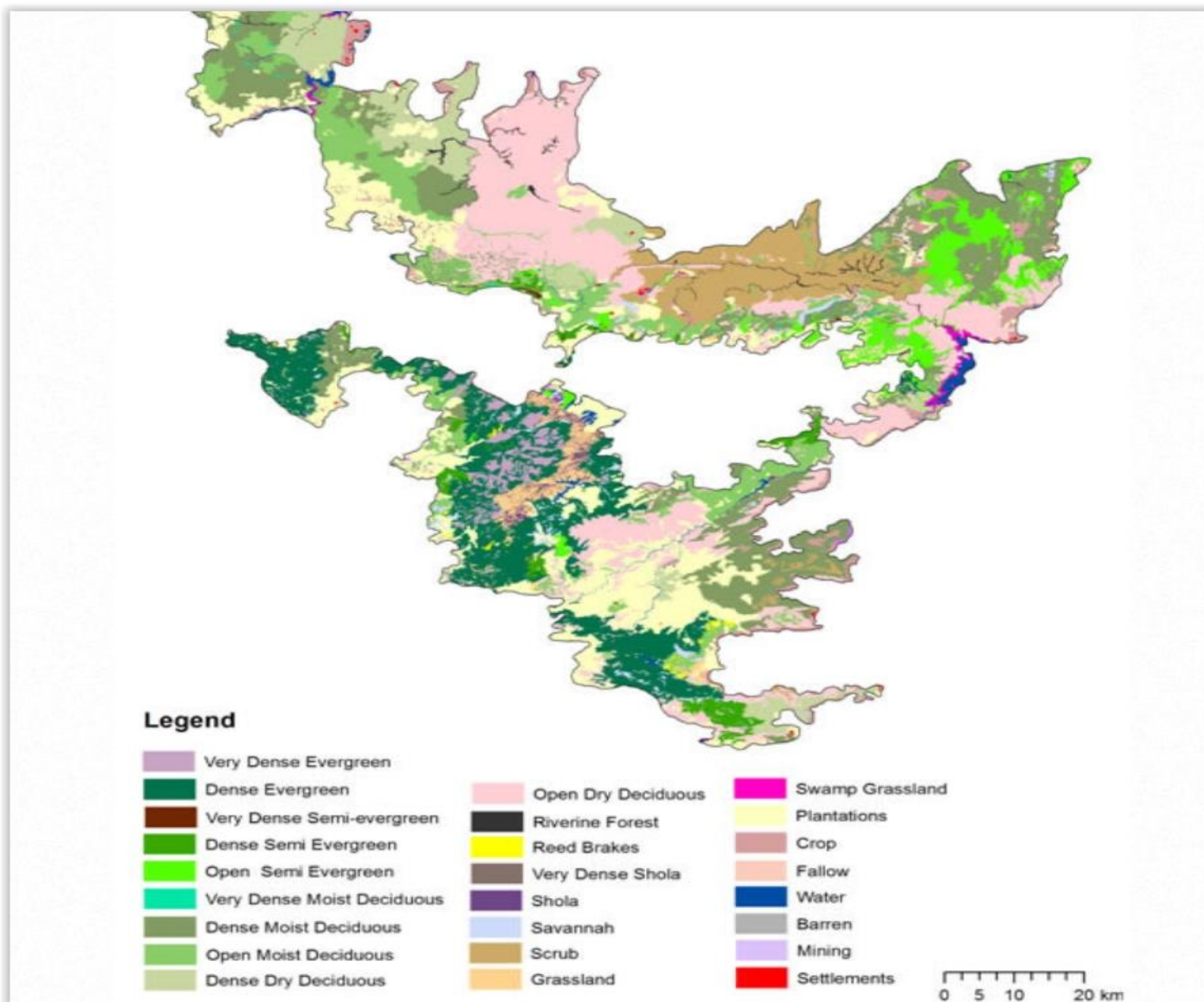


Land Use Map of Part of Chandigarh City

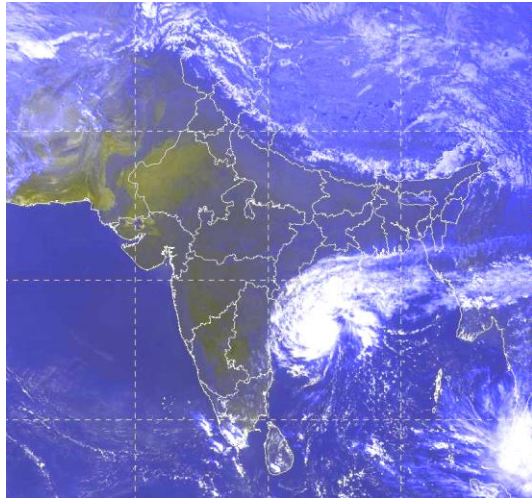


Urban Land Use

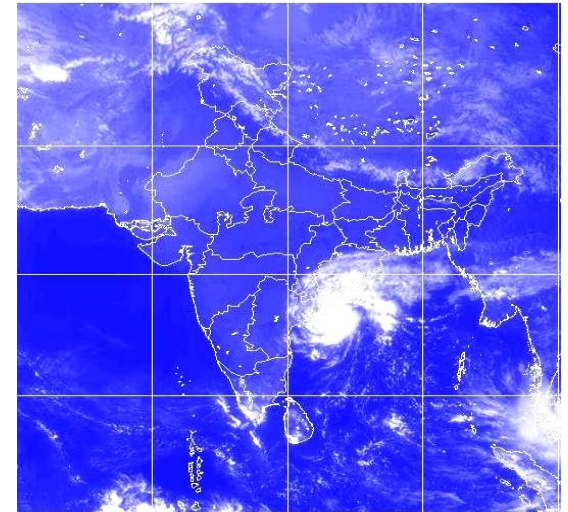
BIOSPHERE MONITORING



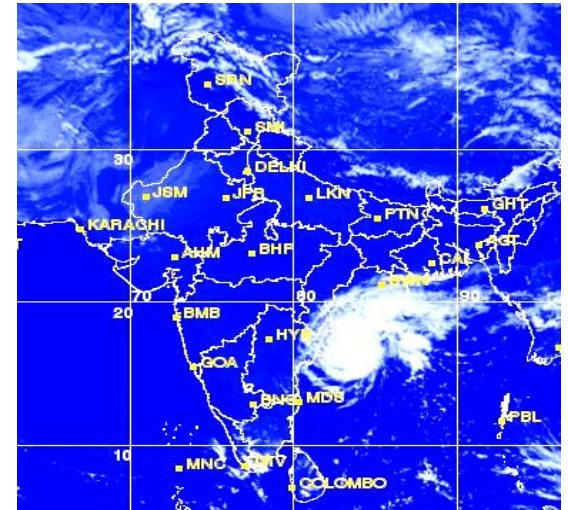
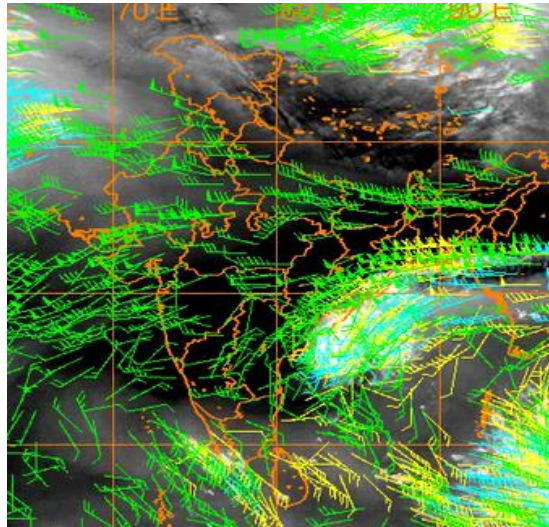
Instrumentation for Weather and Atmospheric Studies



INSAT-3D

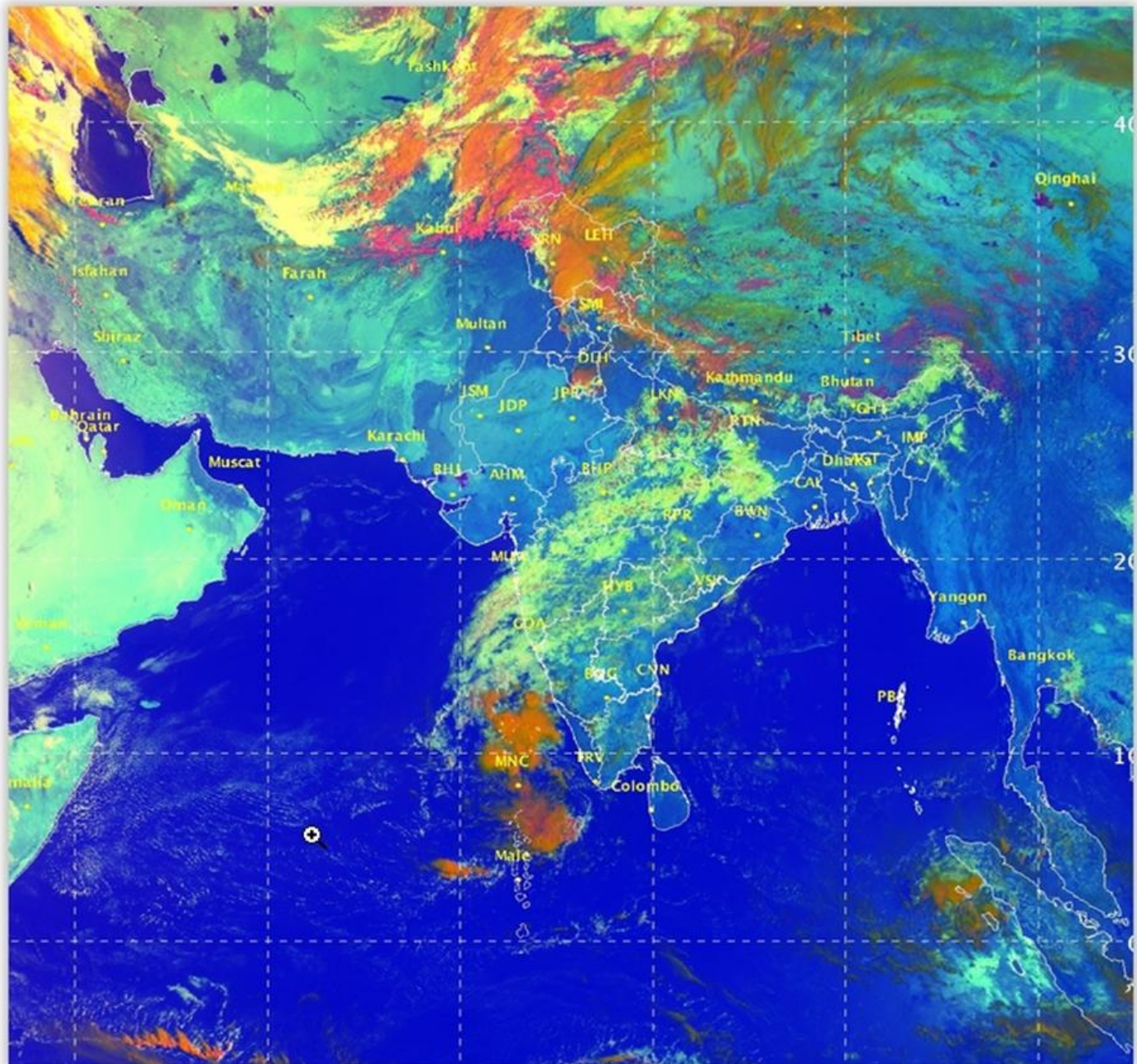


KALPANA



INSAT-3A

INSAT-3D: March-2018

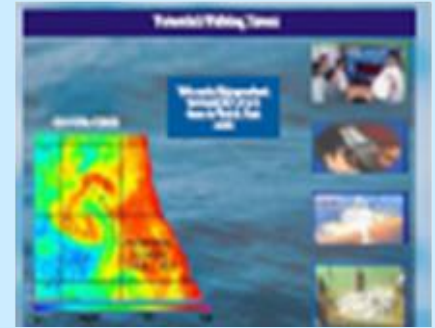
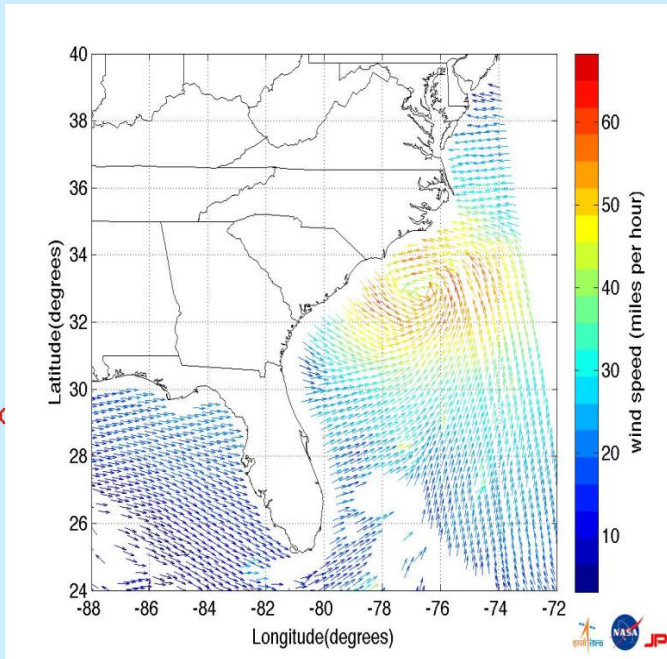
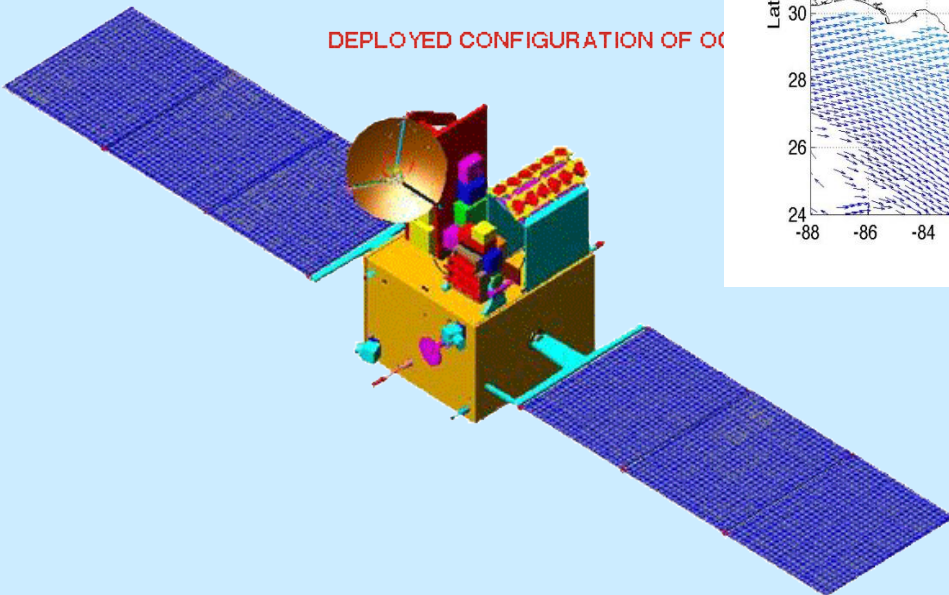


Leos

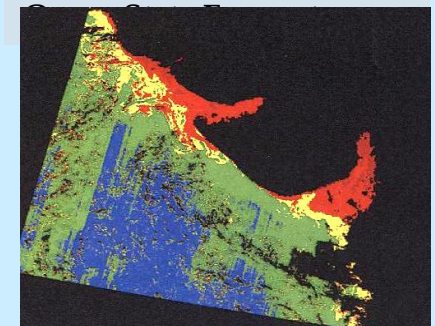
OCEANSAT-2

INSTRUMENTS:

- OCEAN COLOR MONITOR
- SCATEROMETER.



PFZ



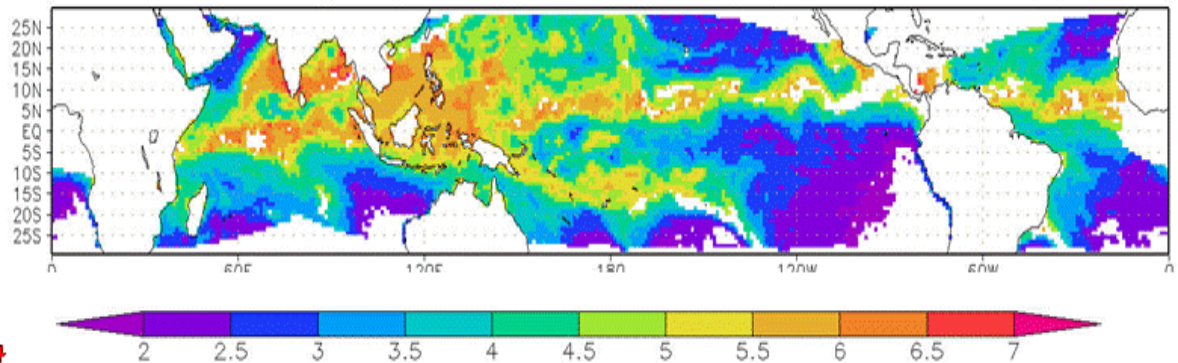
MEGHATROPIQUES



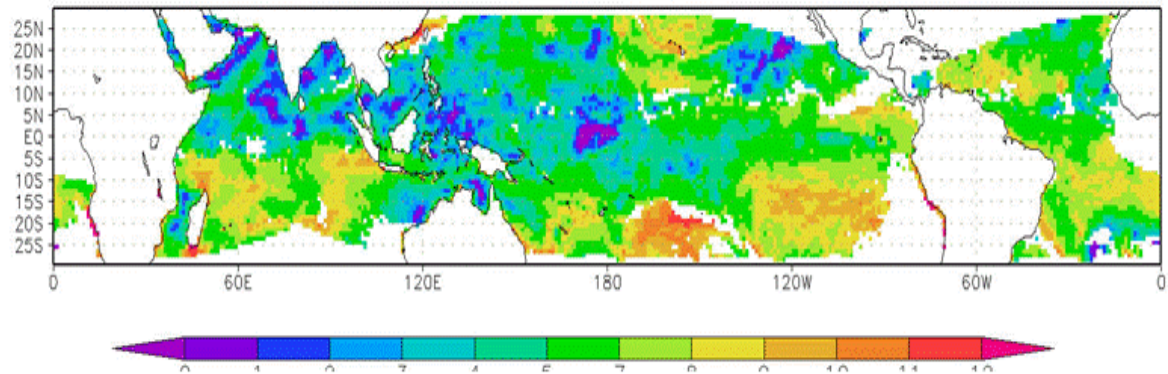
Payloads:

MADRAS
SAPHIR
ScaRaB
ROSA

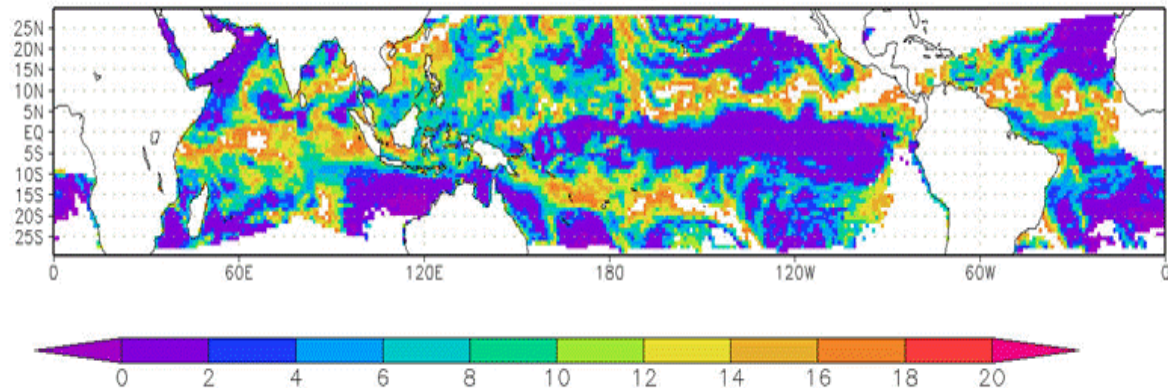
MT-MADRAS Integrated Water Vapour (g/cm^2) - 15 Oct. 2011



MT-MADRAS Wind Speed (m/s) - 15 Oct. 2011



MT-MADRAS Cloud Liquid (mg/cm^2) - 15 Oct. 2011



Instruments for Space Science Studies

- Instruments in Balloon Experiments
- **Sounding Rocket Experiments**
- Satellite based experiments
- Lunar and **Interplanetary missions**

Instruments for study of :

**Upper Atmosphere, Aerosol,
Ionosphere, Weather and Climate,
Environment, Ocean, microgravity,
Astro-biology**

A SUIT OF INSTRUMENTS IN CHANDRAYAAN-1



- a) Terrain Mapping Camera (TMC)
- b) Hyper Spectral Imager (HySI)
- c) Lunar Laser Ranging Instrument (LLRI)
- d) High Energy X - ray Spectrometer (HEX)
- e) Moon Impact Probe(MIP)



- f) Chandrayaan-I X-ray Spectrometer (C1XS)
- g) Near Infrared Spectrometer (SIR - 2)
- h) Sub keV Atom Reflecting Analyzer (SARA)
- i) Miniature Synthetic Aperture Radar (Mini SAR)
- j) Moon Mineralogy Mapper (M3)
- k) Radiation Dose Monitor (RADOM)

Chandrayaan-1 coverage

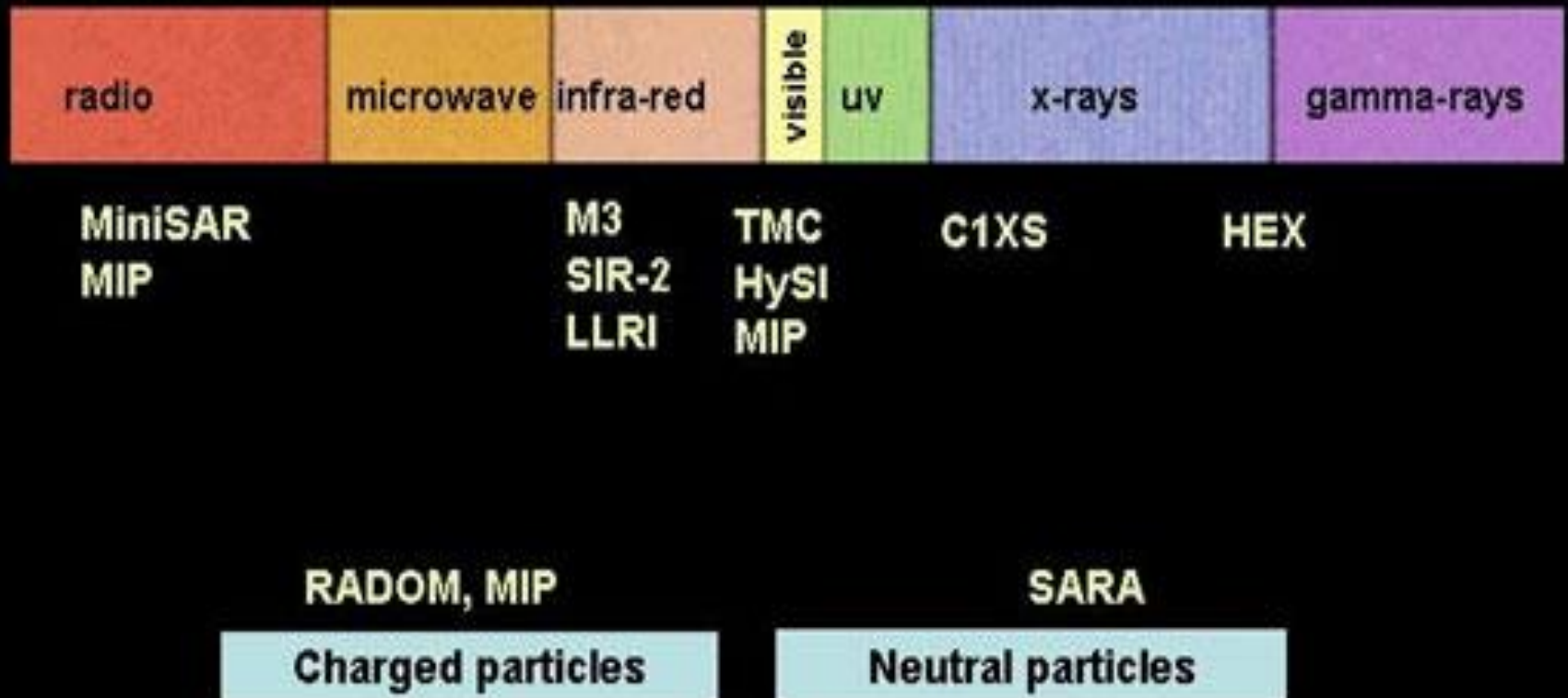
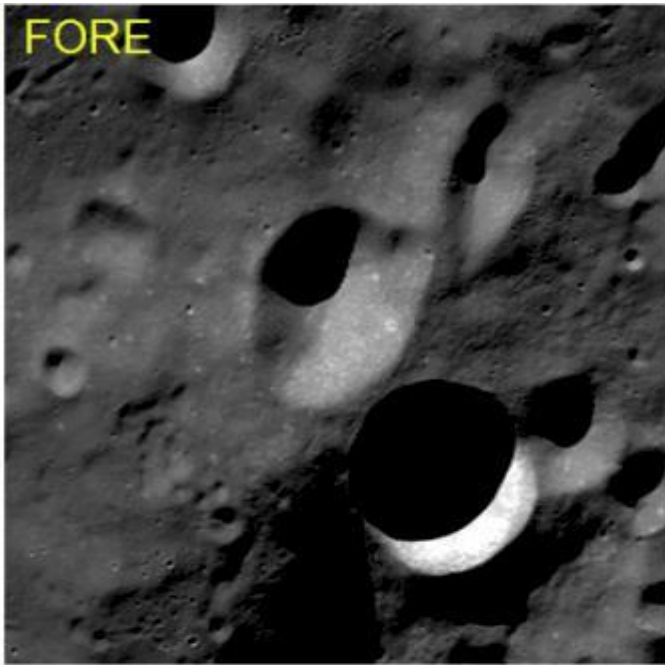




Image of South Pole Region by MIP- Chandrayan-1

FORE

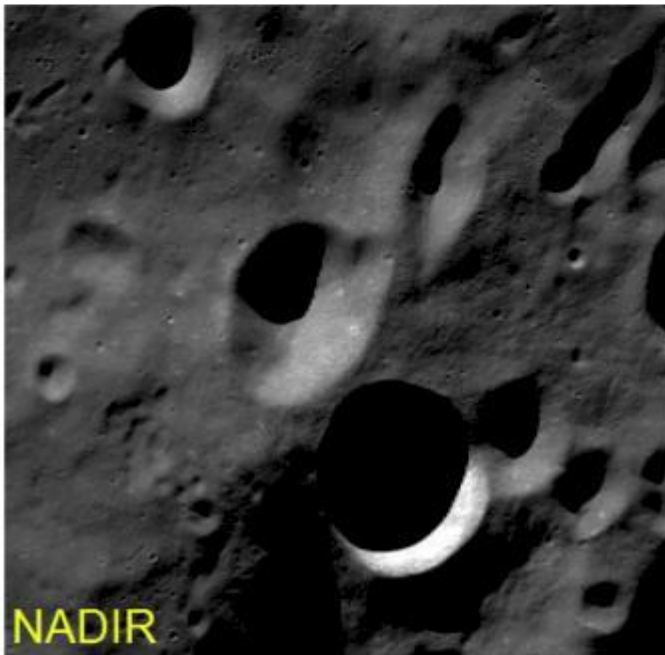


Craters from Polar Region
Viewed by Chandrayaan-1 TMC
from 200 km
Orbit No.:2336;
DOP: 20-05-2009;

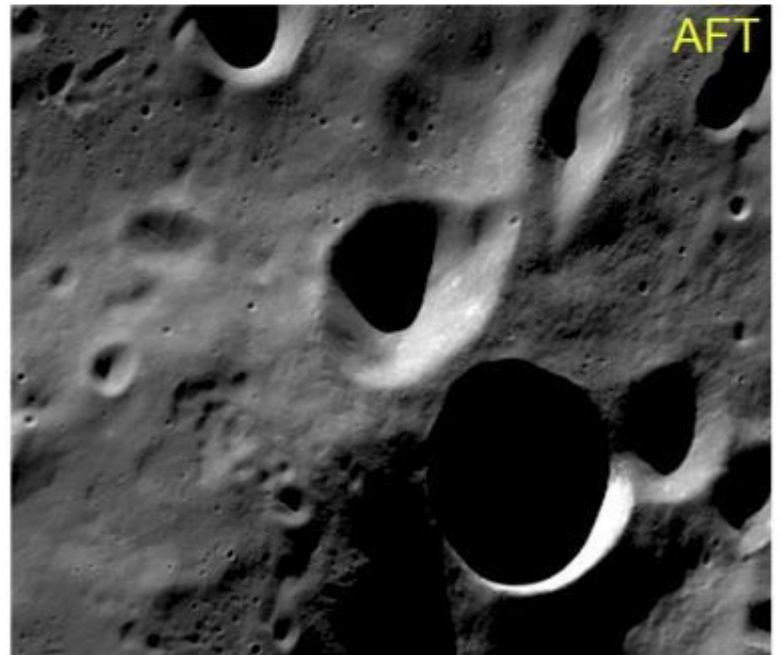
Scale

0

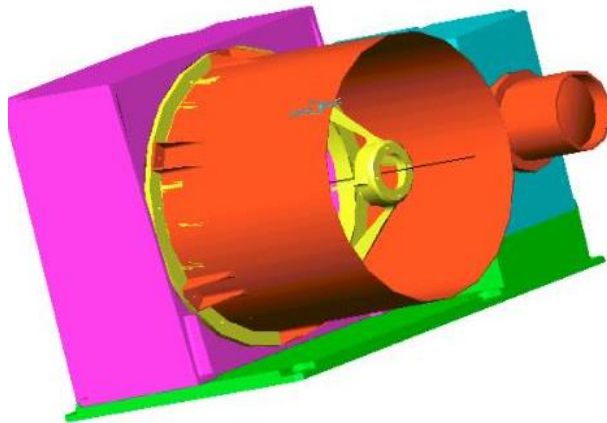
20 km



NADIR

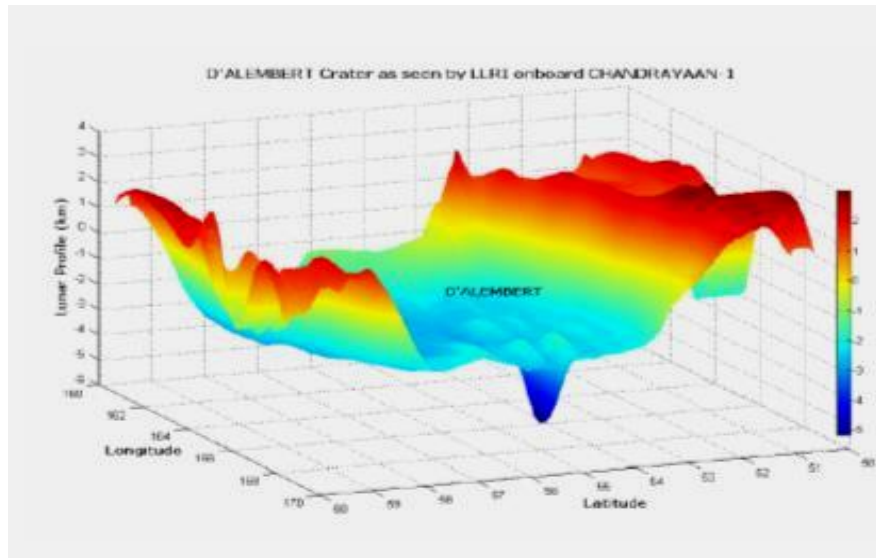


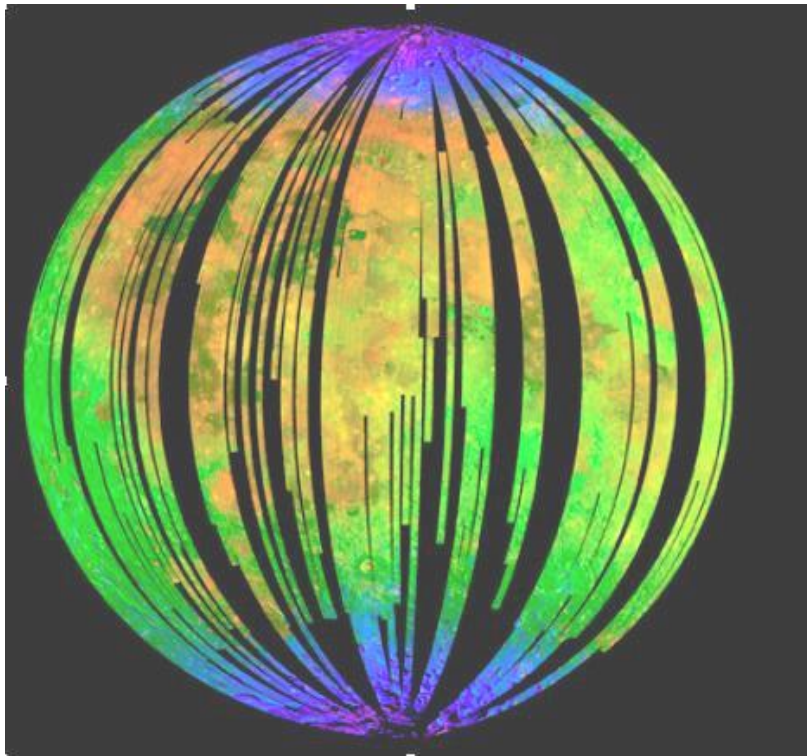
AFT



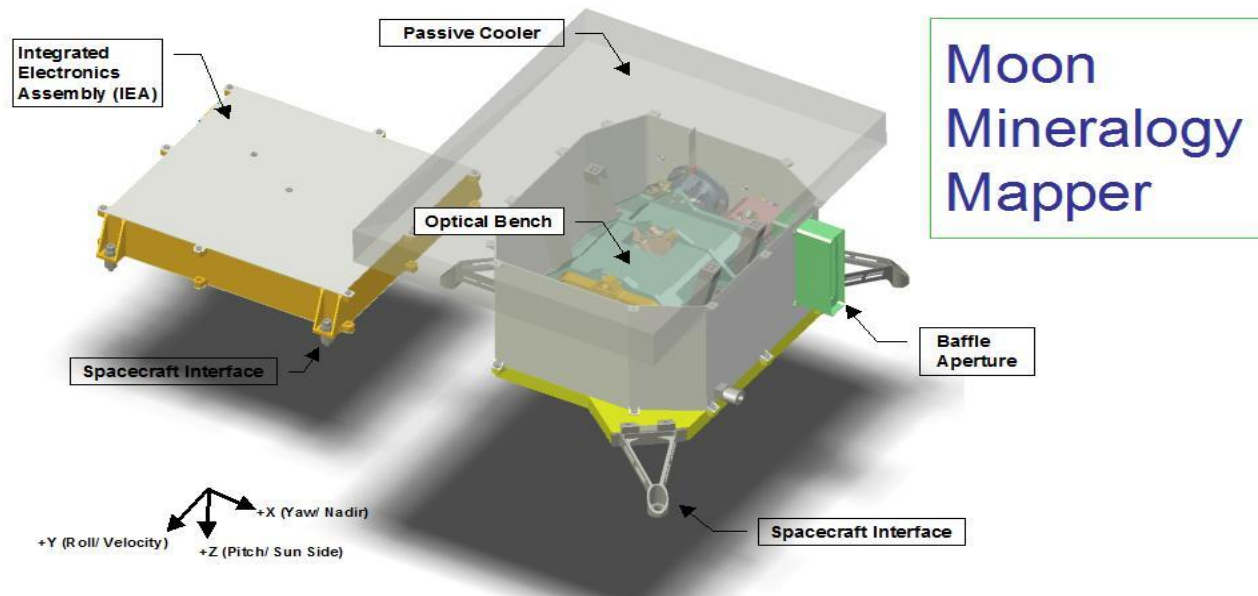
Leos

LASER ALTIMETER- FOR LUNAR TERRAIN MAPPING:

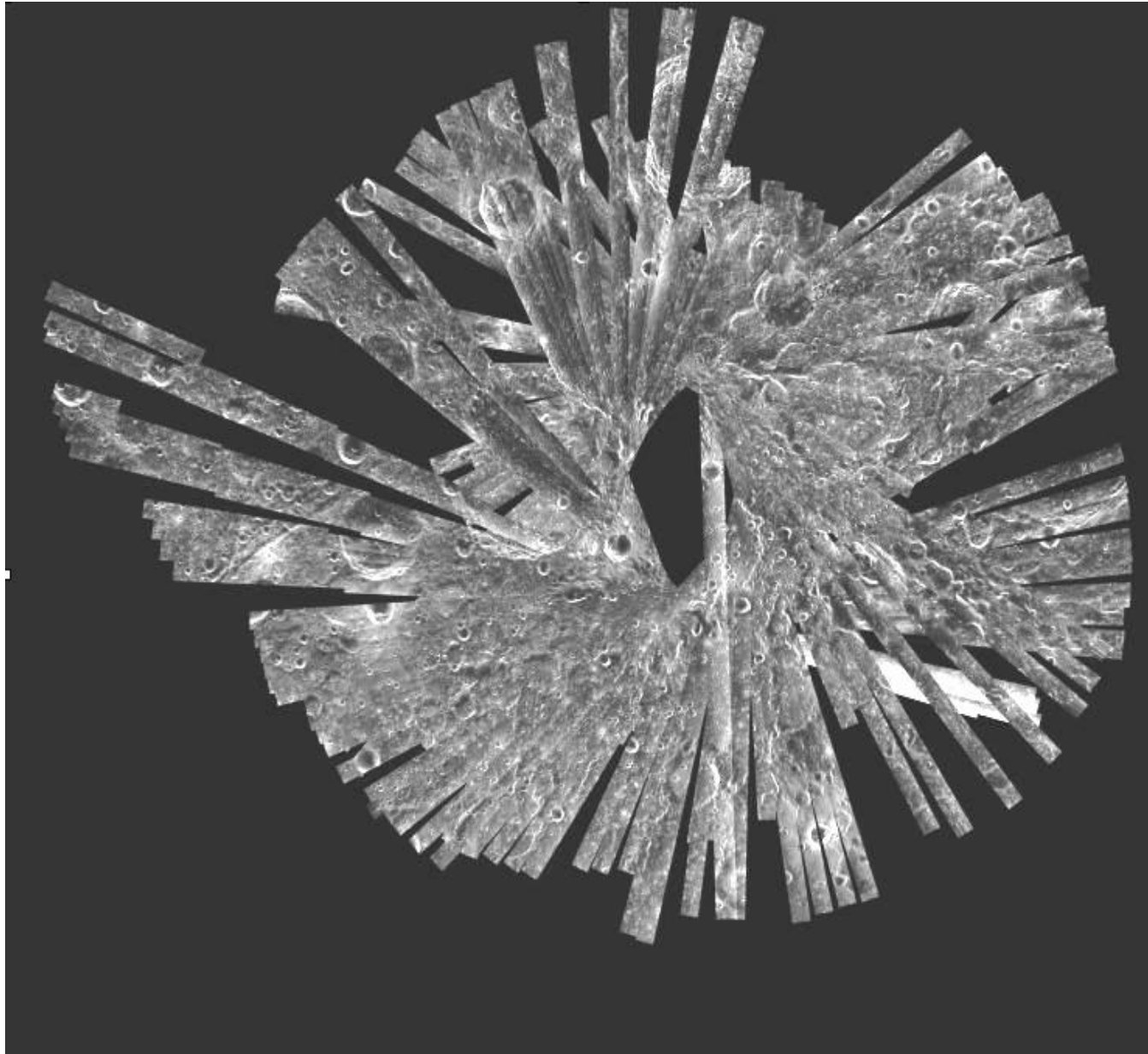




**DISCOVERED
WATER ON
MOON**

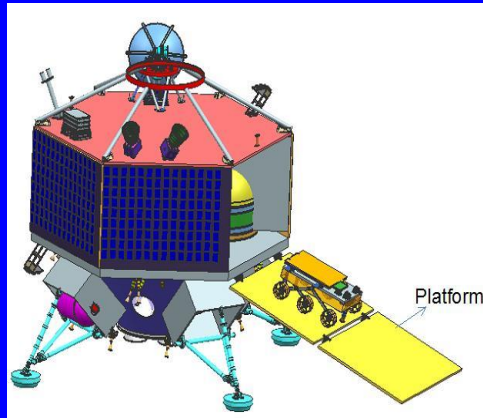


RADAR IMAGERY OF POLAR REGION OF MOON BY CHANDRAYAAN-1

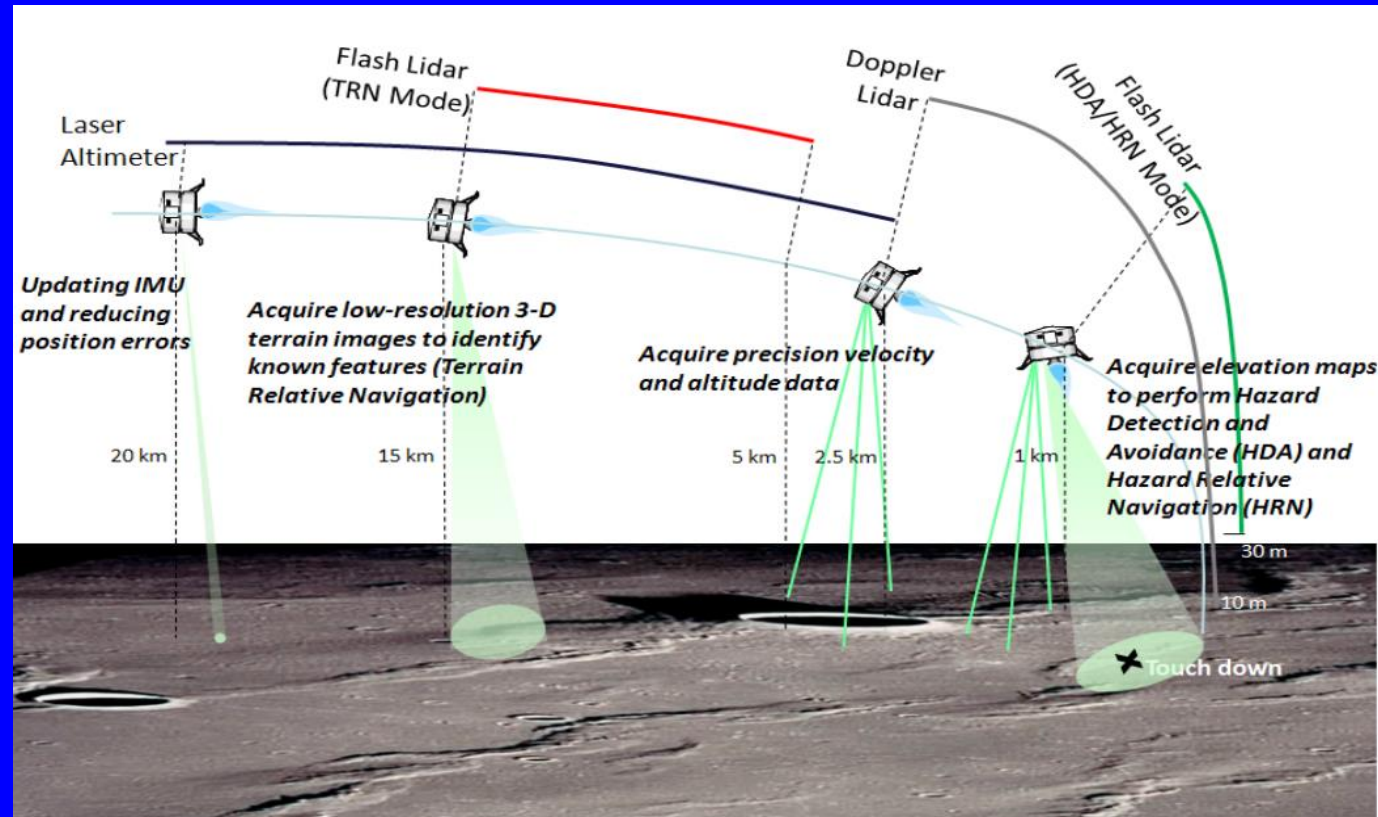


Chandrayaan-2

Instruments for Lander and Rover



- Altimeter
- Accelerometer
- Lidar
- Hazard identification
- Scientific instruments
- Navigation sensors for rover
- Laser ablation



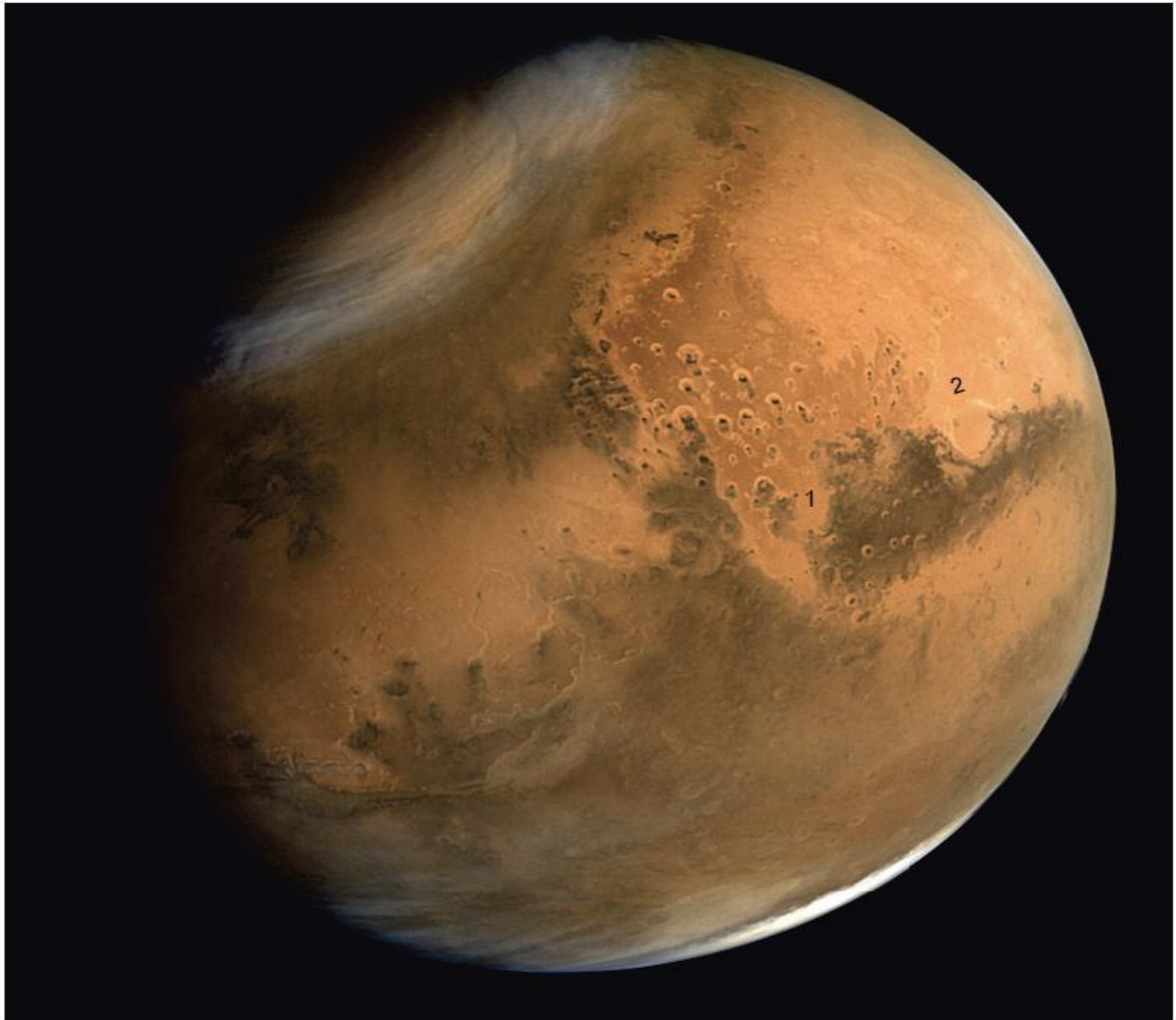
Scientific
Instruments



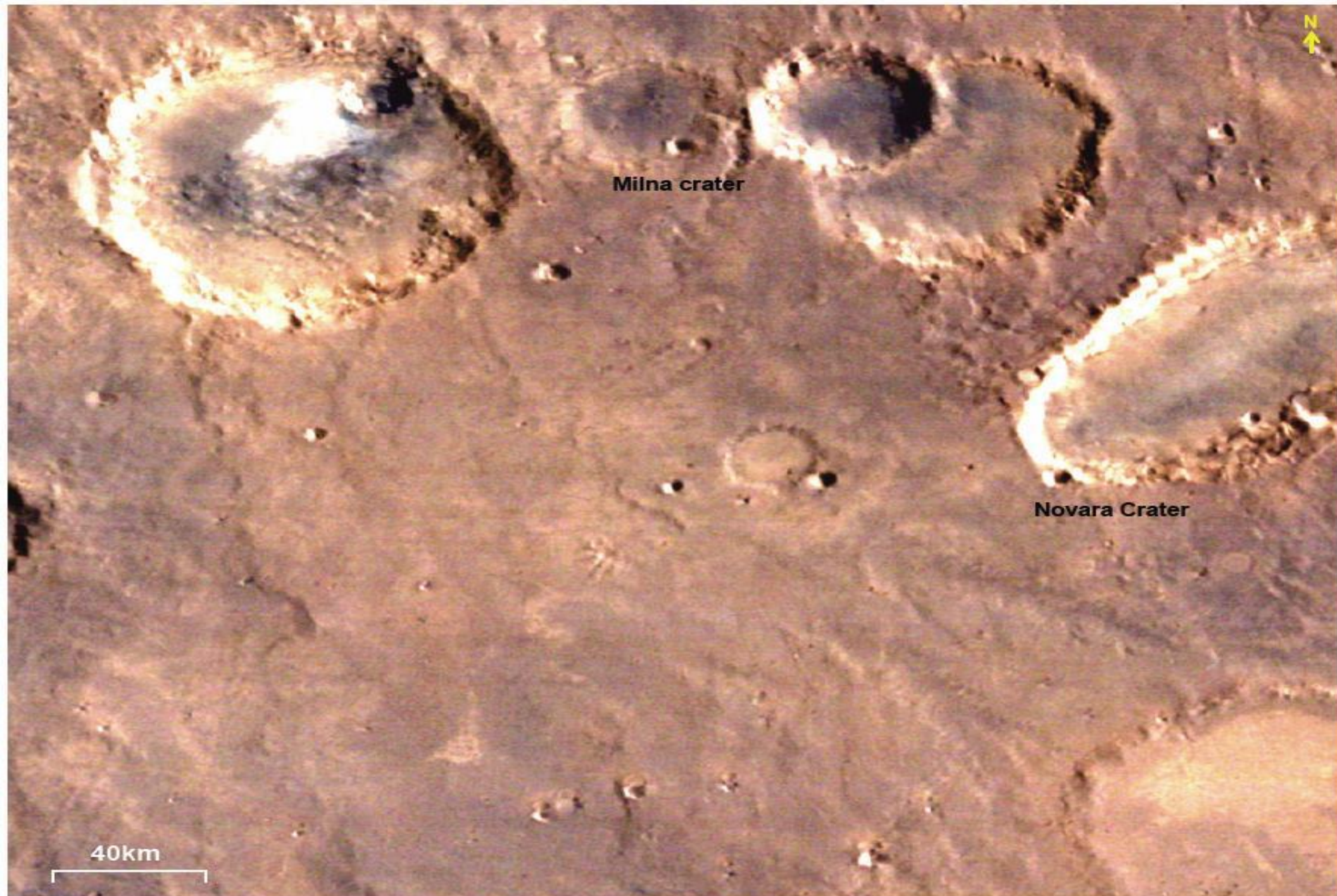
- Thermal Profile of Lunar
- Dust Dynamics Study
- IR spectral study- H₂O/OH
- Lunar ionosphere & variability
- Gravitational Penetrator
- In-Situ Thermal properties
- Seismology

MARS ORBITAL
MISSION :
MANGALAYYAN-1

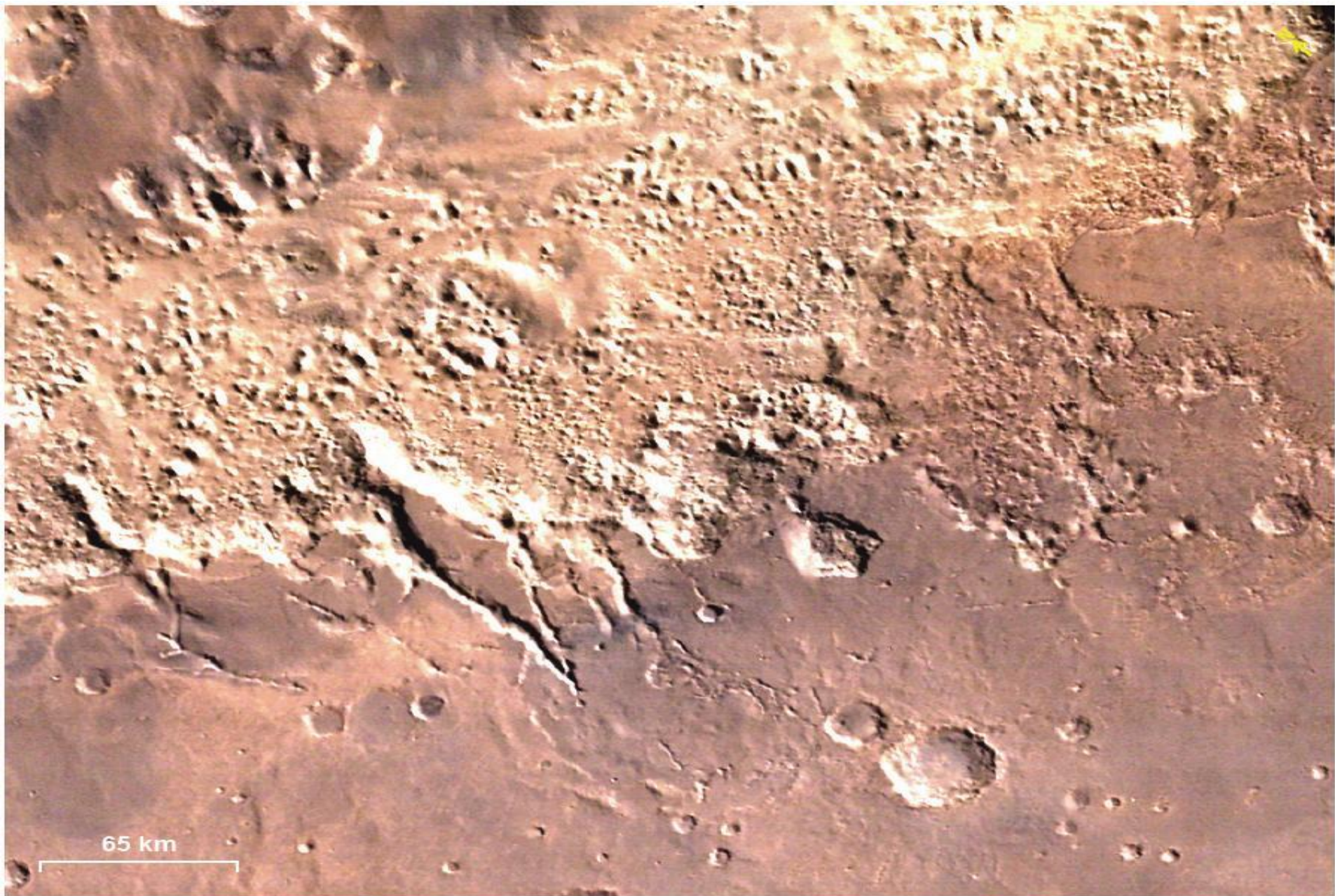
Mangalyaan-1 Image



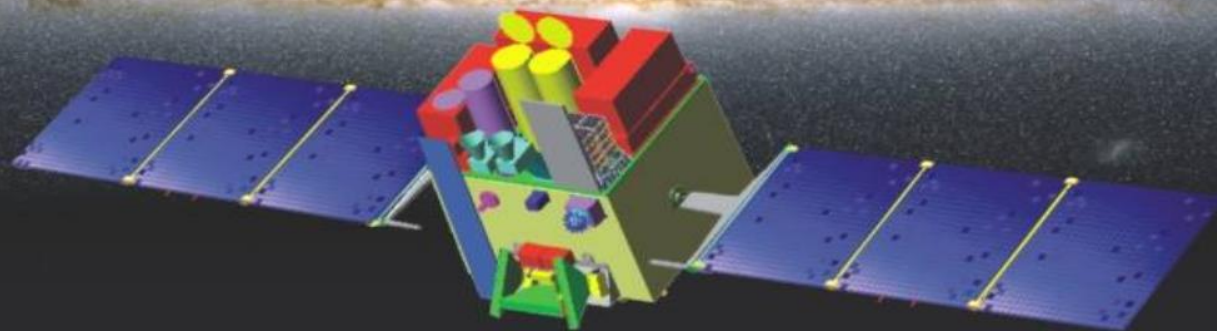
Mangalyaan-1 Image



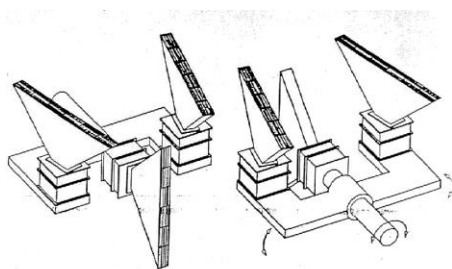
Mangalyaan-1 Image



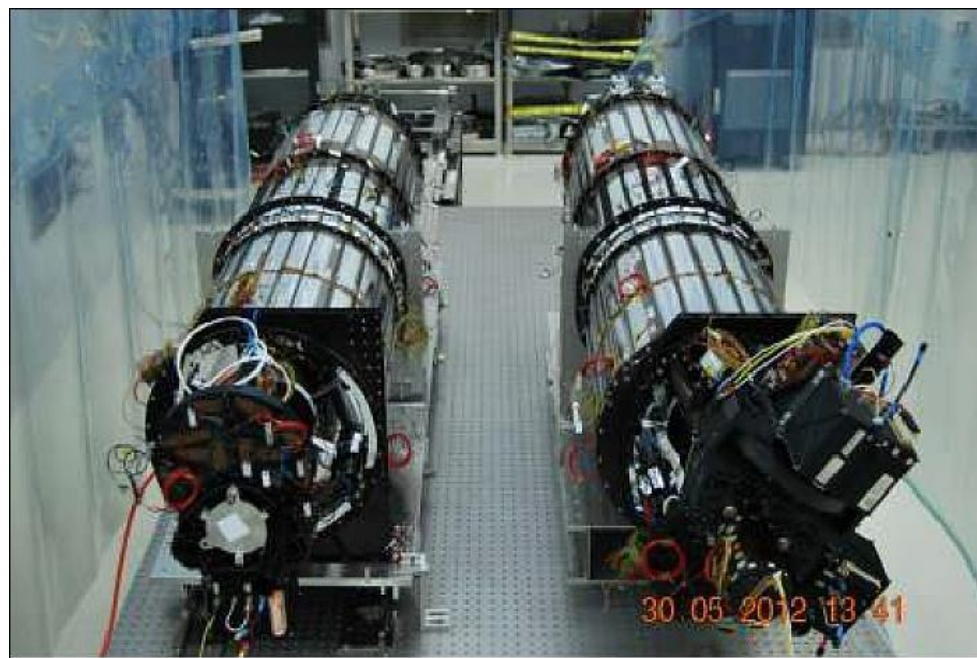
Instruments in ASTROSAT



LARGE AREA XENON
PROPORTIONAL COUNTER



SCANNING X-RAY DETECTOR



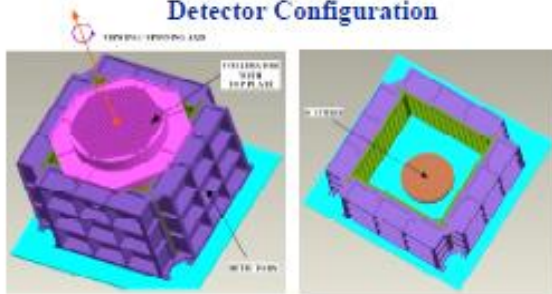
UV-Telescopes *Leos*

Stars in a Galaxy viewed in UV: Astrosat



X-RAY POLARIMETER -RRI

Detector Configuration



Fabricated Engineering Model Detector



Fabricated Prototype Collimator



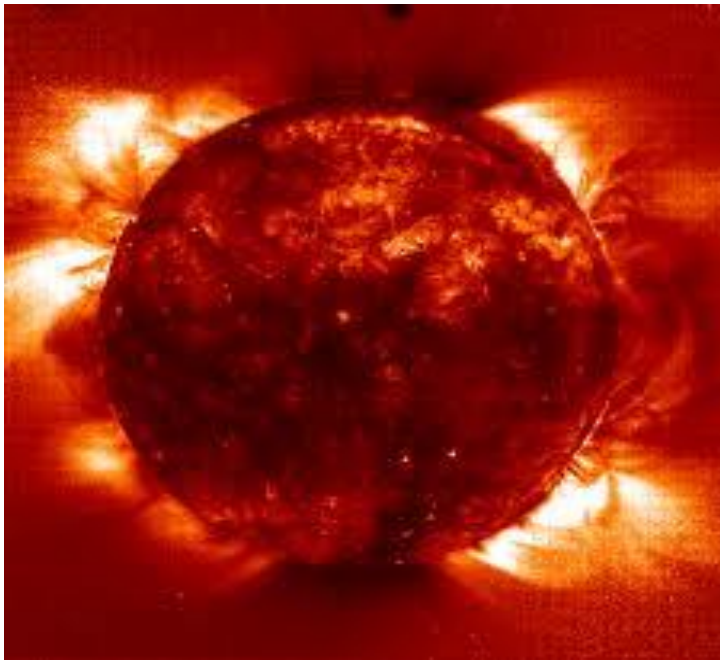
Electronics for Engineering Model



Front-end electronics



Processing electronics



Solar Mission at L1

**ENHANCED VISIBLE EMISSION
LINE CORONOGRAPH**

**HIGH ENERGY L1 ORBITING
X-RAY SPECTROMETER**

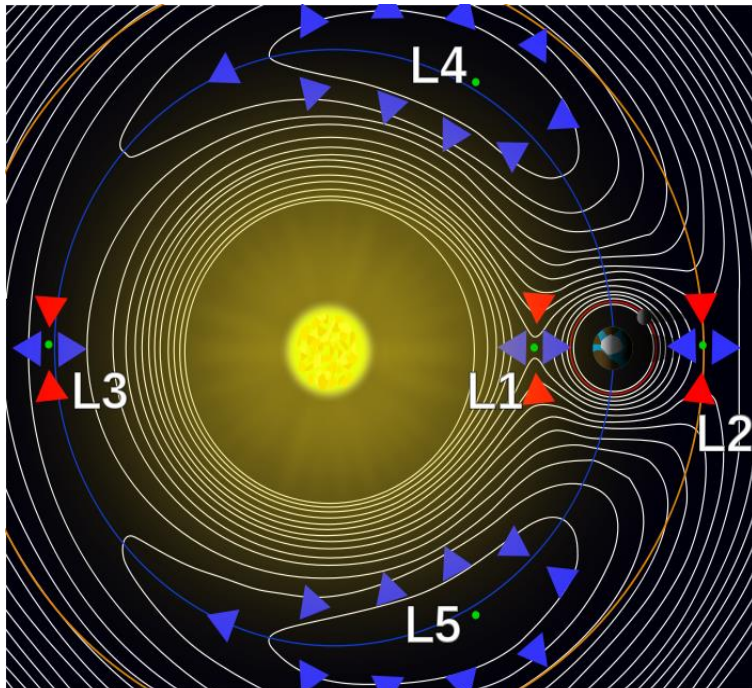
**SOLAR LOW ENERGY X-RAY
SPECTROMETER**

**SOLAR ULTRAVIOLET
IMAGING TELESCOPE**

**PLASMA ANALYSER
PACKAGE FOR ADITYA**

**LOW FREQUENCY RADIO
EXPERIMENT**

**SOLAR HYPERSPECTRAL
IMAGING POLARIMETER**



FUTURE MISSIONS

CHANDRAYAAN-2

ADITYA

MISSION TO VENUS

L & S BAND RADAR MISSION

HYPERSPECTRAL IMAGING

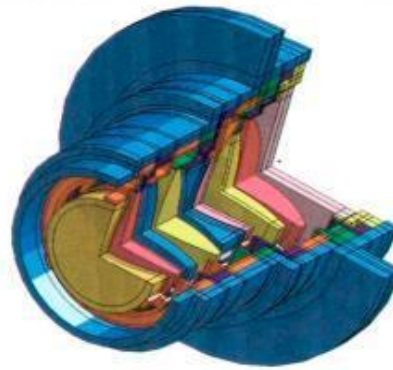
CARTOSAT-3

GISAT

SCIENCE MISSIONS..

ENABLING TECHNOLOGIES FOR SENSORS

Optics for space

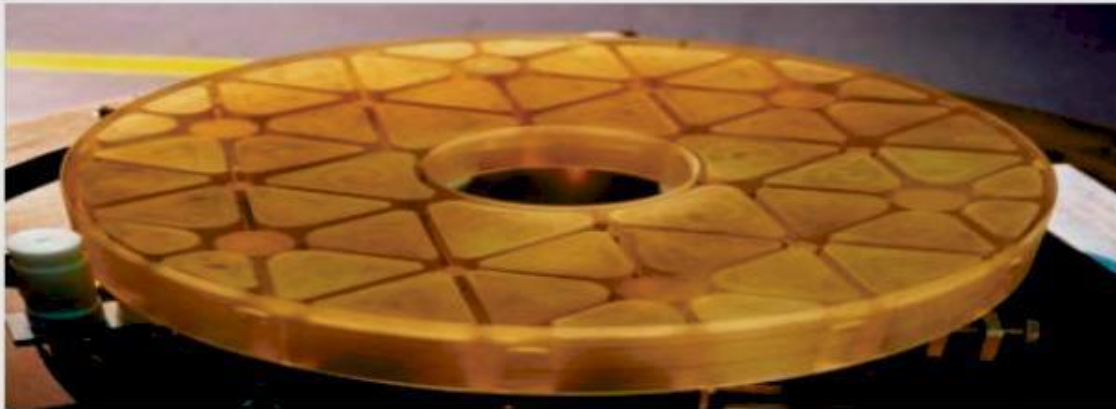


Multi-Element Lens

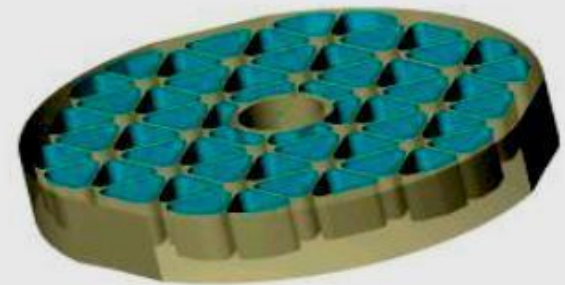
Secondary



Primary



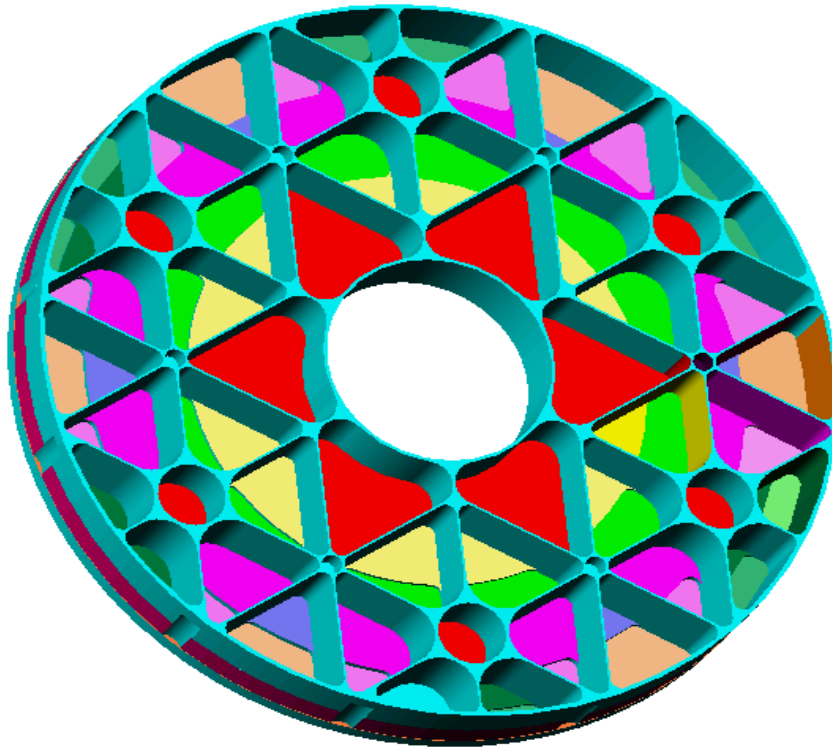
700 mm dia. Telescope
CARTOSAT-2



AVHRR- TELESCOPE:
INSAT-3D

Primary Mirror for 1.2 m Dia. Reflective

Telescope



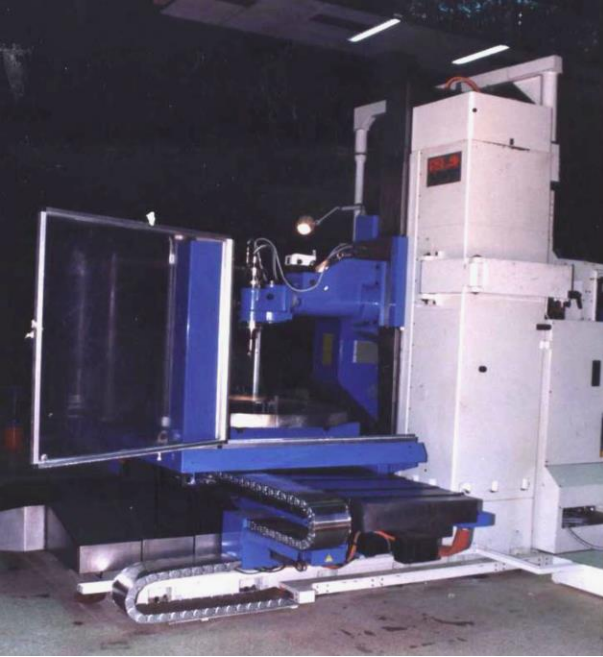
Light
weighted
backside of
Primary:

Material:
Zerodur

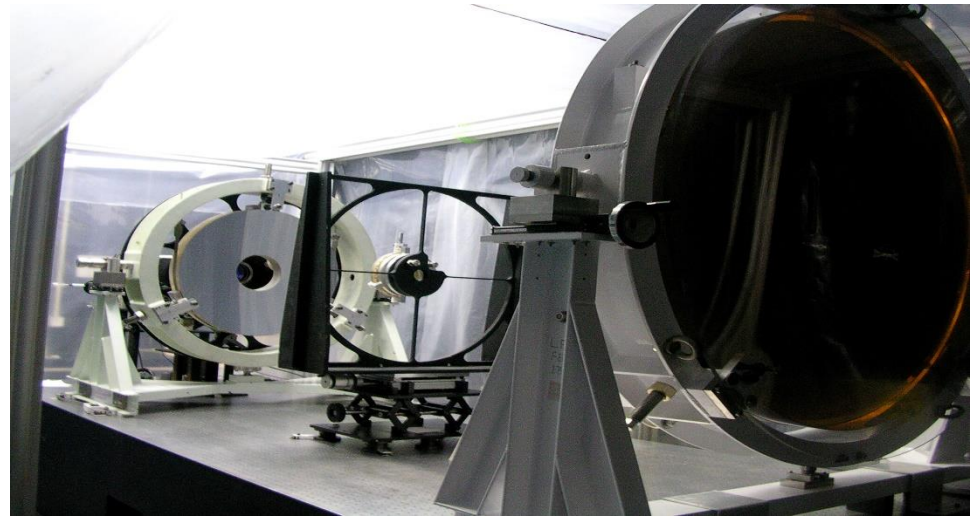
CHALLENGES FOR OPTICS FOR SPACE

- **Large Size:** More than 1 meter diameter
- **Gravity effect during testing :** Light weighting
- **Geometrical accuracy:** Hyperbola / Other Conics
Lamda / 50 rms (0.001 micrometer)
- **Surface finish:**
10 angstroms : Cartosat 2
5 Angstroms: Astrosat
2 Angstroms: Aditya
1 Angstrom = 0.0001 micrometer
- **Special Materials :** Zerodur , Silicon Carbide

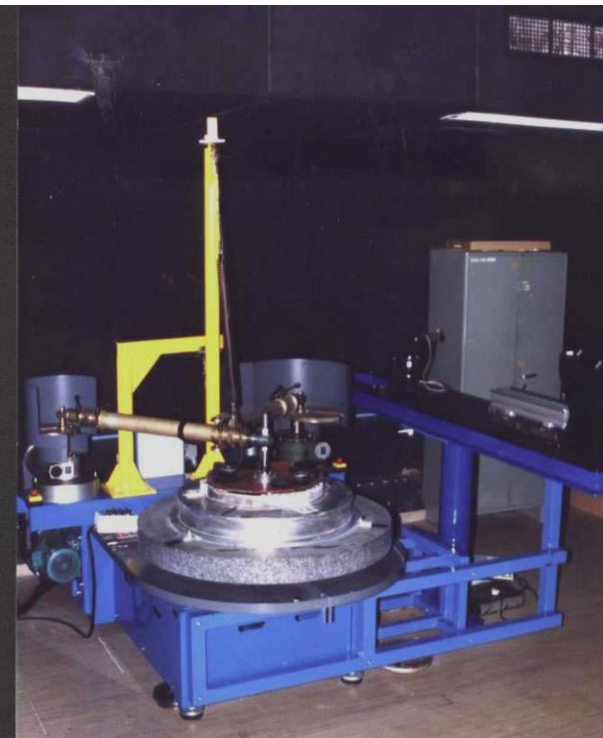
Optics Fabrication & Testing



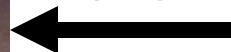
Light
weighting



Testing of Optics

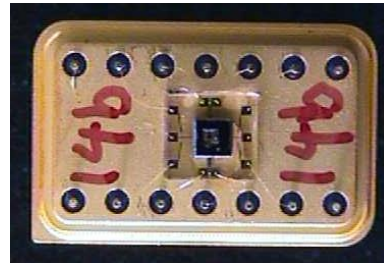
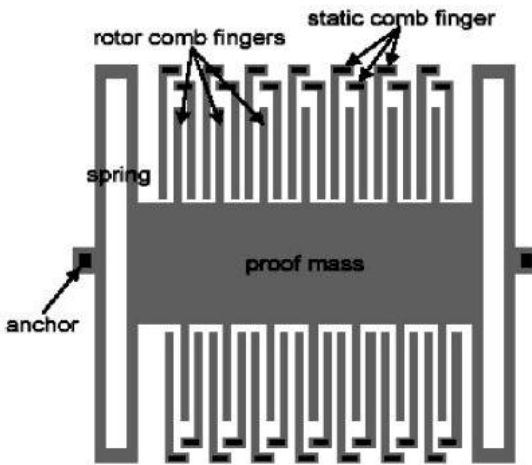


Computer
Controlled
Polishing

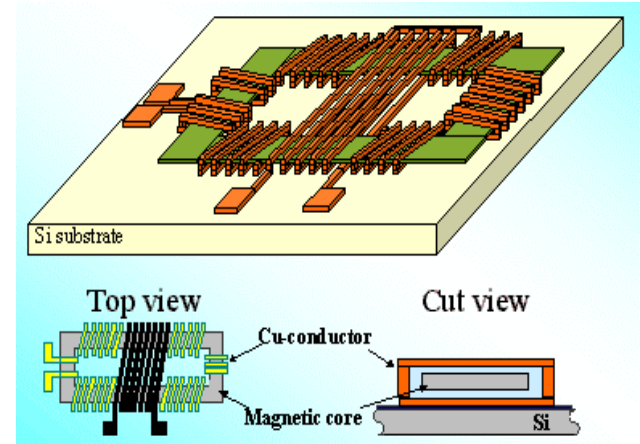


MEMS AND MOEMS

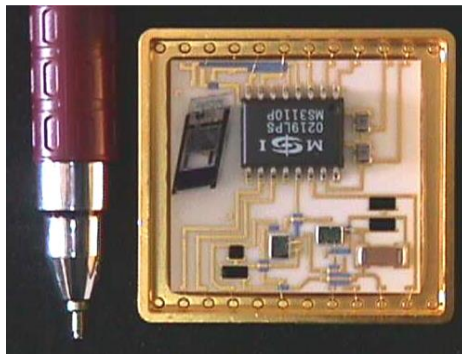
MEMS



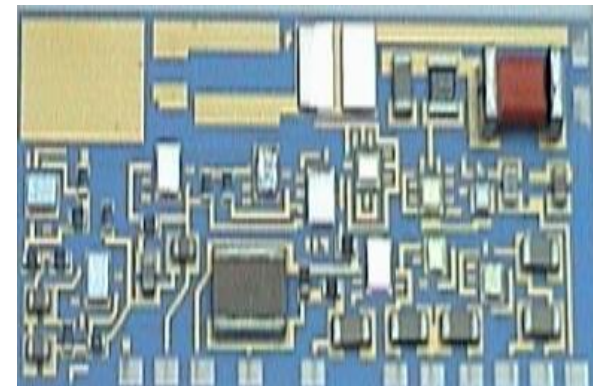
RF SWITCH



MAGNETOMETER

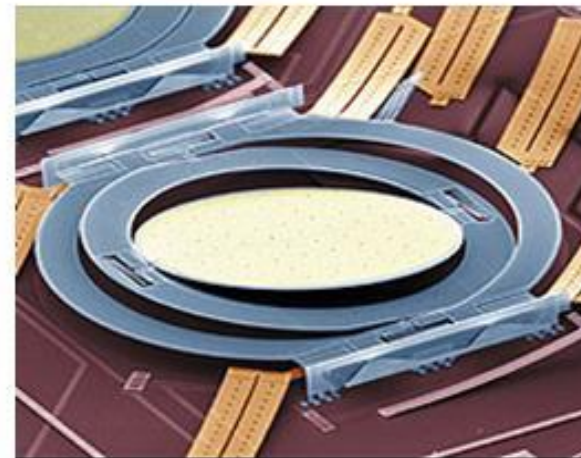
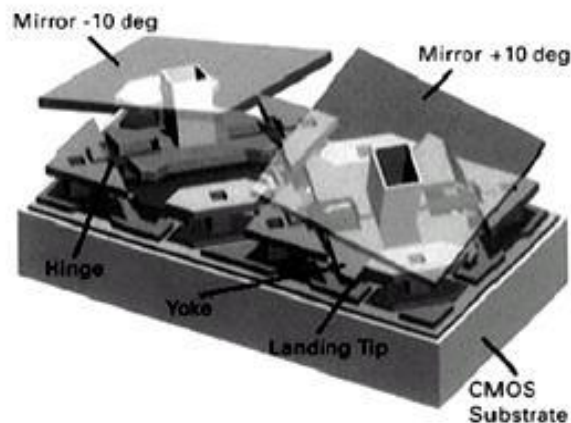
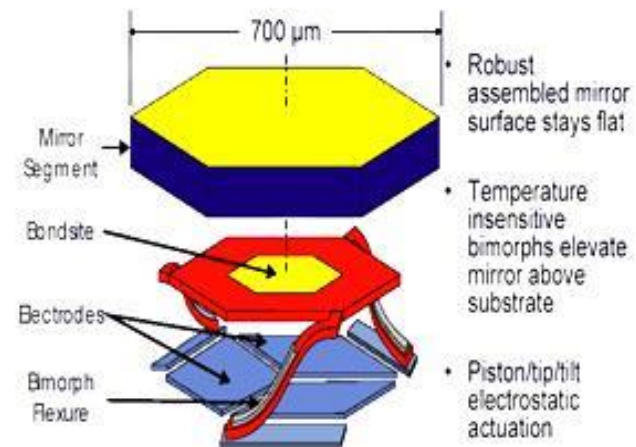
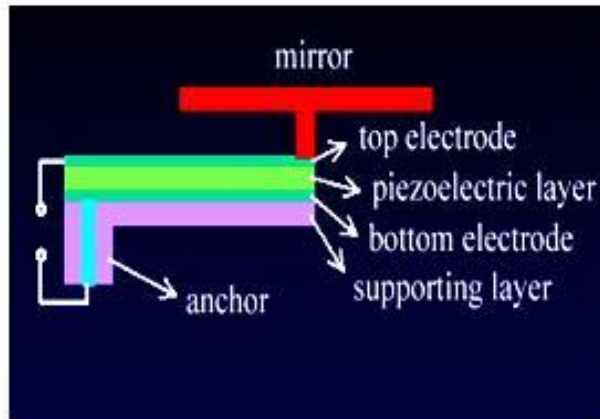


ACCELEROMETER



MEMS Micro scanning mirrors find application in laser scanners, Display systems etc.

MICRO MIRRORS



Leos

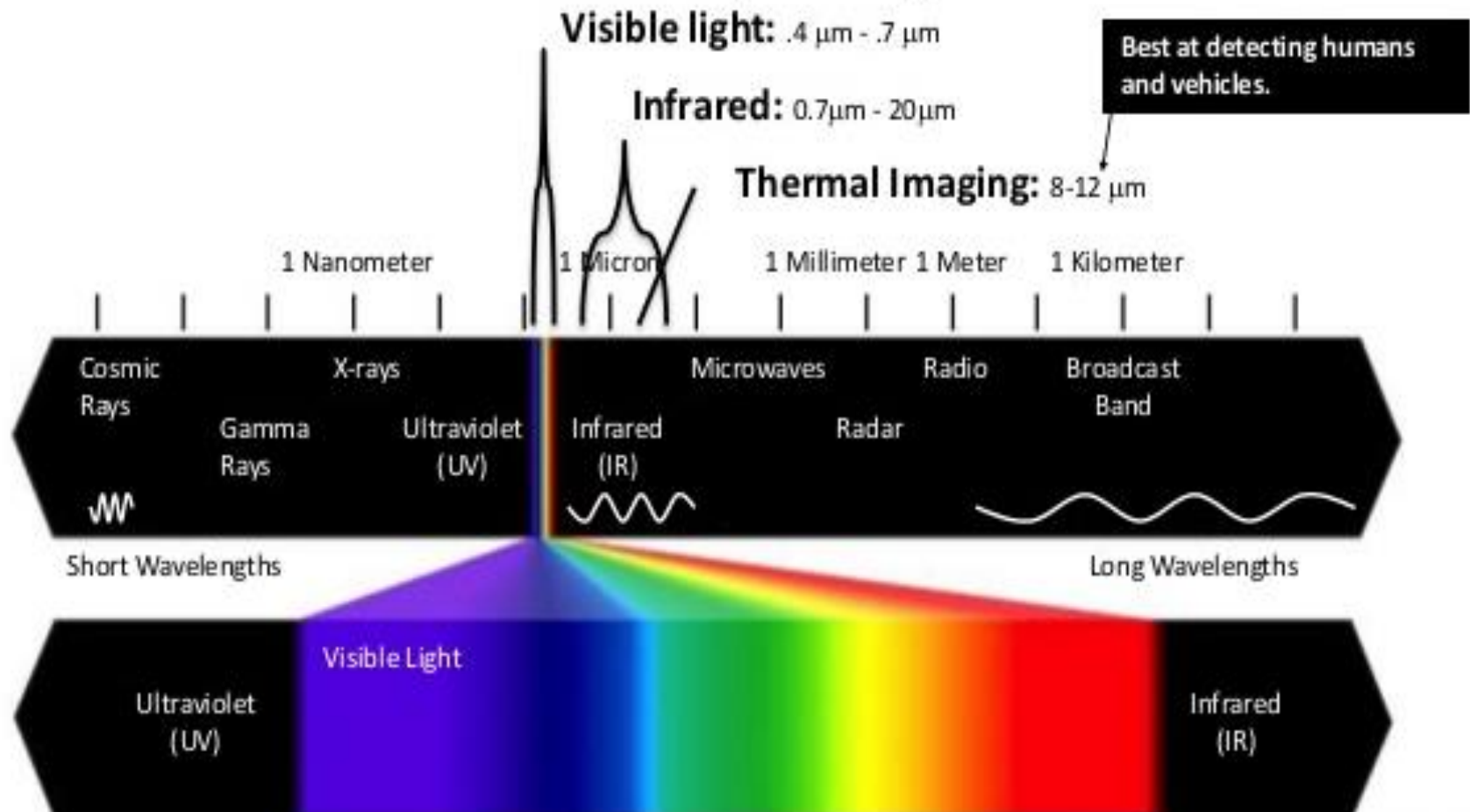
DETECTORS

CCD, IR ,

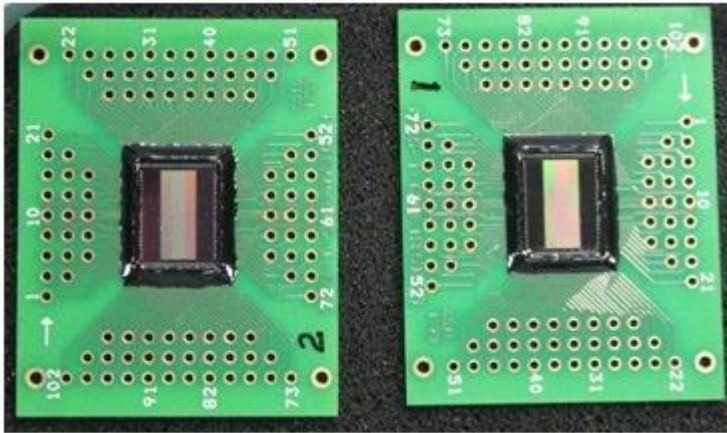
COOLERS

INFRARED CAMERA

A camera that sees part of the electromagnetic spectrum that is invisible to humans -- it sees heat, NOT light.



DETECTORS DEVELOPED BY SCL, ISRO



DETECTOR ARRAY FOR
HYPER SPECTRAL
IMAGING



12k, TDI DETECTOR
ARRAY FOR IMAGING

OTHER APPLICATIONS OF SENSORS

- DEFENSE
- INDUSTRY
- MEDICAL
- AUTOMOBILIES
- HOME SECURITY
- AGRICULTURE AND FOOD PROCESSING

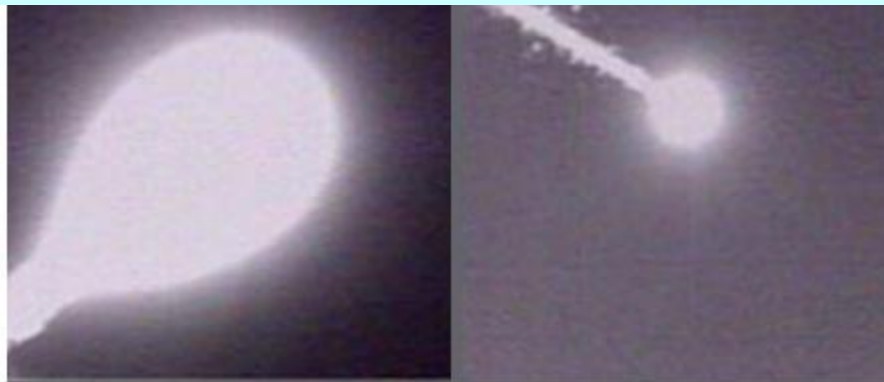
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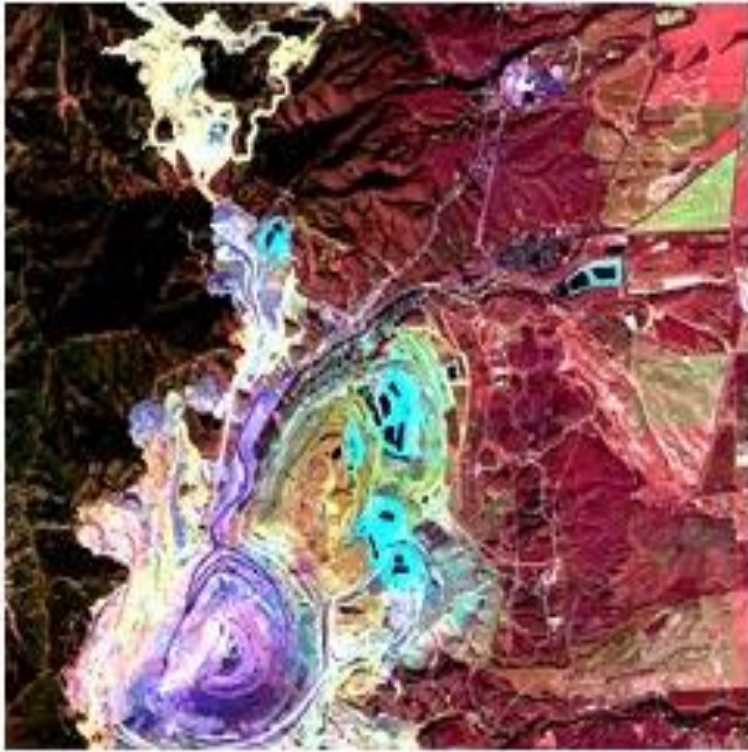
THERMAL IMAGING



NIGHT VISION
CAMERA



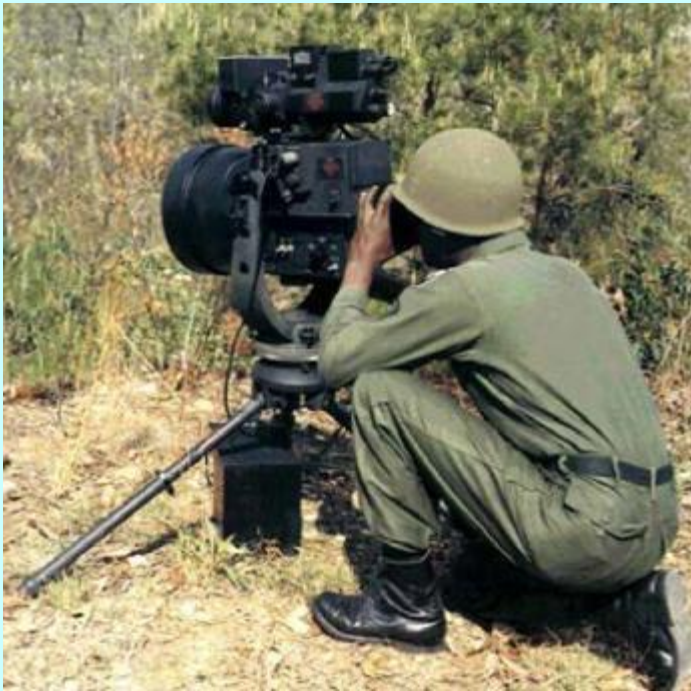
MISSILE DETECTION



**HYPERSPECTRAL
CAMERA FOR DEFENSE**



**MULTISPECTRAL
AIRBORNE SENSOR SUITE**



Field IR sights



Rear mounted IR sensor
(above aircraft engine)



Laser designators, Range finder

SEISMIC SENSOR: MEMS

MEMS based Seismic sensor developed for Chandrayaan -2 finds application for seismic security systems.

It can detect small movements :

Ex: walking/running/crawling person or a small underwater vehicle-that moves on the surface, underground, and/or in the water. It can also detect large size objects- i.e. heavy vehicles, trucks etc.

CONCLUSION

- Different types of sensors used in launch vehicles and spacecraft are presented.
- Success of the missions depends upon the ability to develop these sensors meeting stringent requirements of accuracy and reliability.
- In many critical areas, self reliance is the key to success in the area of sensors.

Thank you