



Status of Indian EO Missions and Opportunities for participation for Indian Industries



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1. Background

Earth Observation (EO) Sector has evolved significantly in the recent decades. Insights derived from high resolution satellite data, provides comprehensive understanding of the earth surface & its dynamic processes. ISRO has led the technological advancements in optical, microwave, stereo and hyperspectral Satellite Missions, through its fleet of Indian Remote Sensing Satellites ranging from series of IRS, Resourcesat, Cartosat, Oceansat & RISAT satellites & its applications.

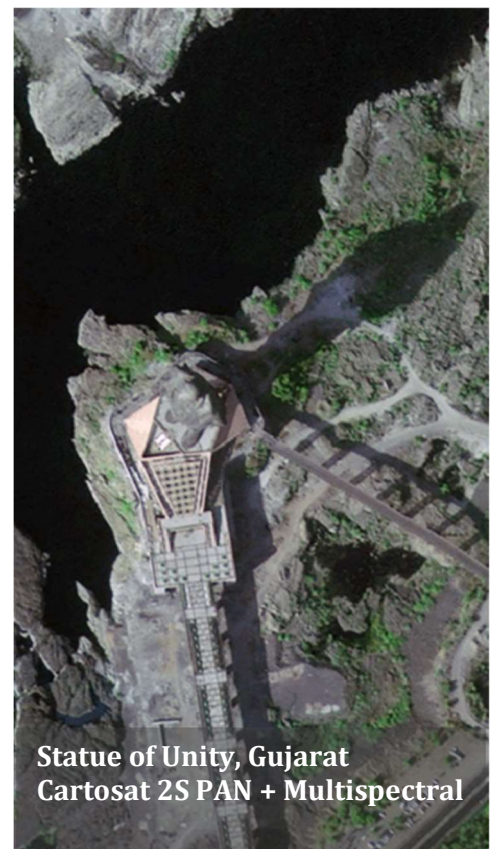
Considering (a) geospatial projects executed by Government & Industry, (b) requirements from research community and the (c) overall penetration of geospatial technology in various sectors in the country, there is an increase in the demand, for high resolution satellite data at regular intervals. It is proposed to meet this demand, by realization of additional satellite constellations through Industry.

With a vision of (1) attaining self-reliance (आत्मनिर्भर) in EO sector, in the country and (b) positioning India as a leading global geospatial service provider, an analysis of the availability of the datasets from Indian satellite missions, was carried out by IN-SPACe & ISRO and this consultation paper is published. This consultation paper describes (a) the present state of the EO data from Indian Missions, (b) the likely data demand & requirements for the future (c) a plan to realize additional satellite constellations to meet these requirements. You are requested to review this consultation paper and share your responses online, by visiting www.inspace.gov.in/inspace?id=inspace_eo_consultation

Satellite data & its applications

Satellite data is used in wide range of applications including agriculture, natural resources management, environmental monitoring, forestry, crop insurance, maritime, transport and logistics, disaster response, urban development & cultural heritage, energy & power, engineering & infrastructure, weather forecasting & climate services, defense & security, academic & research and so on.

These datasets can be broadly categorized into (a) Optical imagery, (b) Microwave data (c) Thermal images (d) Hyperspectral and (e) Atmospheric data. These datasets along with, drone data, GNSS datasets, LiDAR data, ground measurements & socio-economic survey data provide comprehensive understanding about the earth systems, to the researchers, policy makers, general public and industry.



The satellite data & its applications are listed in table below

Spatial Resolution	Satellite Data & Applications
< 1m	Regular monitoring of a specific region, Master Plan preparation, cadastral mapping, property tax solutions, land records & asset mapping, urban & rural development, infrastructure projects like pipeline, development of sewerage, road & rail networks etc., large scale agriculture & irrigation, monitoring of waterbodies & watersheds, post disaster mitigation, encroachment studies, mining etc.
≥ 1m & ≤ 6 m	Resource mapping, crop condition & phenology assessment, estimation of agriculture yield, monitoring of surface water bodies, forest fire studies, snow cover monitoring, evapo-transpiration, geological applications etc..
> 6m & ≤ 50m	Urban & rural studies, infrastructure development, agriculture studies, drought condition assessment, water resources, land use / cover mapping, forest monitoring, Disaster Management support, geological applications etc.
> 50m	Natural Resources inventory, developmental planning, Disaster Management support for larger area, agriculture studies, drought assessment, surface water bodies layers, land use / cover mapping, forest mapping etc.
Microwave	Crops, forestry, soil moisture, snow & glaciers, land subsidence, slope stability monitoring, high resolution Digital Elevation Model, biomass extraction for forest, Ocean State Forecast, oil spill studies, cryosphere etc.
Hyperspectral	Water quality estimation, crop condition & stress, crop insurance related activities, mineral mapping, hydrocarbon exploration, forest species mapping etc.
Stereo	Digital Elevation Model, cartography, urban planning, volume studies, landforms & flood, hydrological modelling etc.
Oceanography	Potential fishing zone, oil spill studies, sea ice, coastal zone, ocean state forecast, sea surface temperature, marine biology, ice elevation assessment, improved sea ice thickness & volume, sea surface height etc.
Atmosphere	Numerical Weather Prediction including monsoon prediction, now-casting, cyclone, thunderstorm etc., inland applications like water level, flood mapping etc., Disaster Management support etc.

While timely data helps in taking swift actions, cumulative data helps to assess & plan the developments in the long term.

NRSC, ISRO is the nodal agency to provide the satellite data from the missions launched by ISRO. NRSC also carry out geospatial applications. Other satellites data service providers in the country are Maxar, Planet Labs, Airbus etc.

Satellite data market plays key role in space economy, providing valuable data & services to a range of industries and sectors. Rising demand for data analytics services including image processing, feature extraction, digital models, predictive analysis & other geospatial services would boost the market.

The satellite data services market was valued at USD 5.9 billion in 2021 & is projected to reach USD 16.7 billion by 2026, at a CAGR of 23% from 2021 to 2026. (www.marketsandmarkets.com). The key drivers of satellite data market are (a) increased launch of small and cube satellites & growth of imagery, (b) advancements in spatial resolution & analytics with the introduction of AI and big data analytics and (c) democratization of the space industry and increased private sector participation.

The National Geospatial Policy (NGP) 2022 is aimed at overall national development and private sector participation through continued enhancements of doing business in the sector. While the guidelines 2021 deregulated acquiring and producing geospatial data services, NGP 2022 laid down an overarching framework for holistic development of the geospatial technology.

An analysis of current state of Earth Observation (EO) datasets from Indian EO satellite missions & the future need of the data, was carried out and this consultation paper is published to seek views from the EO Community. You are requested to review this consultation paper and share your responses by visiting www.inspace.gov.in/inspace/inspace_eo_consultation.

Chapter 1 of this consultation provides background information on satellite data and its applications. Chapter 2 describes the present state of Indian EO Missions & data. Chapter 3 examines the data demand and opportunities for the Indian industry. Chapter 4 describes the possible approaches for meeting the demand. Chapter 5 describes the plan for realization. Chapter 6 summarizes the objectives & the expectation from readers.

2. Present state of Indian EO satellite missions and data

Indian Space Programme is driven by applications. India has developed & launched series of EO satellites equipped with advanced imaging systems viz. Series of Resourcesat, Cartosat, Oceansat, RISAT satellites etc. The Indian Remote Sensing satellites have provided valuable data for a wide range of applications, benefiting various sectors of the Indian economy. The data plays a crucial role in supporting India's sustainable development, resource planning, and disaster management efforts.

The Indian Remote Sensing program started in 1988 with launch of IRS-1A & IRS-1B followed by IRS -1C/ IRS-1D/ IRS-P3, Oceansat 1/2, Cartosat 1/2, Resourcesat 1/2, RISAT 1 etc. Each satellite had specific capabilities & instruments to cater to different needs by capturing data in various spectral bands viz. visible, near-infrared, microwave etc. The Cartosat series of satellites provides high-resolution images for cartographic applications. Cartosat 1 is stereo imaging satellite. CARTODEM, the Digital Elevation Model generated from the stereo pairs, is a great source for terrain mapping, urban planning etc. The Resourcesat satellites, capable of multi spectral imaging & wide swath coverage cater to the natural resource mapping, environmental monitoring & other applications. Resourcesat-3S/3SA, Resourcesat 3/3A, RISAT-1B, NISAR, TRISHNA etc. are the upcoming EO missions.

The satellites launched by ISRO currently in orbit & catering to civilian needs of EO are:

Type	Payload, Spatial Resolution & Satellite
< 1m	<ul style="list-style-type: none">60 cm panchromatic data from Cartosat 2S.30 cm panchromatic data from Cartosat 3.
≥ 1m & ≤ 6 m	<ul style="list-style-type: none">5.8m multi spectral LISS IV data with 70 Km swath providing 28 days repetivity from Resourcesat 2 / 2A.3-6m Fine Resolution Stripmap from EOS-4/RISAT 1A.1.6m multi spectral data at 10Km swath from Cartosat 2S.1.1m multi spectral data from Cartosat 3.
> 6m & ≤ 50m	<ul style="list-style-type: none">Systematic collections are done using this class of satellites.23.5m LISS III data from Resourcesat 2 / 2A with repetivity of 11 days together25m Medium Resolution Stripmap from EOS-4/RISAT 1A.
> 50m	<ul style="list-style-type: none">56m multi spectral AWiFS at 740 Km swath providing 5 days repetivity from Resourcesat 2 / 2A.50m Coarse Resolution Stripmap from EOS-4/RISAT 1A.
Oceansat 3	<ul style="list-style-type: none">Ocean Color Monitor (OCM) 3 & Scatterometer data from EOS-6/Oceansat 3.
SARAL	<ul style="list-style-type: none">Data from High-resolution single frequency altimeter (Ka-band)

The archived data from the satellites which are decommissioned & catering to the EO needs are listed in Table below: Apart from the data mentioned in below table, the data archived from SARAL, Scatsat 1, IMS-1 etc. are also available.

Type	Satellite, Payload & Spatial Resolution
$\geq 1\text{m} \ \& \ \leq 6\text{m}$	<ul style="list-style-type: none"> • 3-6m Fine Resolution Stripmap from RISAT 1. • 1m panchromatic Cartosat 2 data acquired during Apr 2007 - May 2019. • 2.5m panchromatic Cartosat 1 data acquired during May 2005 - Feb 2019. • 5.8 m multi spectral LISS IV Resourcesat 1/2/2A data acquired during Dec 2003 - Oct 2019. • 5.8 m mono LISS IV Resourcesat 1/2/2A data acquired during Dec 2003 - Oct 2019. • 5.8 m panchromatic LISS IV data from IRS-1D/1C & Images from IRS 1B/1A/P2/P3.
$> 6\text{m} \ \& \ \leq 50\text{m}$	<ul style="list-style-type: none"> • 25m Medium Resolution Stripmap from RISAT 1. • 23.5 m multi spectral LISS III Resourcesat 1/2/2A data acquired during Dec 2003 - Oct 2019. • 23.5 m multi spectral data from IRS 1C/1D & Images from IRS 1B/1A/P2/P3. • 37m multi spectral 4 bands data from IMS-1
$> 50\text{m}$	<ul style="list-style-type: none"> • 50m Coarse Resolution Stripmap from RISAT 1. • 56 m AWiFS multi spectral data from Resourcesat 1/2/2A . • 188 m WiFS multi spectral data from IRS 1D during Jan 1998 - Sep 2002. • 188 m WiFs multi spectral data from IRS 1C & Images from IRS 1B/1A/P2/P3.
Stereo	<ul style="list-style-type: none"> • Cartosat-1 stereo data acquired during May 2005 - Feb 2019
Oceansat 1/2	<ul style="list-style-type: none"> • Ocean Color Monitor (OCM) data from Oceansat 1 & 2 & Scatterometer data from Oceansat 2. • OCM data is of 360 m spatial resolution with 2 days repetivity & 1Km global data with 8 days repetivity.

The following are the approved Missions planned by ISRO in near future:

Satellite	Mission Details
Resourcesat Sampler – 3S / 3SA	<ul style="list-style-type: none"> • 1.25 m Panchromatic data with a revisit of 4 days. • 2.5 m multispectral data with a revisit of 4 days.
Resourcesat - 3 & 3A	<ul style="list-style-type: none"> • ALISS-3 sensor data of 20m spatial resolution with 4 days revisit • ALISS-3 sensor data of 10m spatial resolution and 11 days revisit • ATCOR 0.4-1 μm spectral resolution data & 240m spatial resolution
RISAT-1B	<ul style="list-style-type: none"> • S-band (5.35 GHz) Single, Dual & Circular (Hybrid) supporting various modes like strip map, CRS, MRS and spotlight of varied

	spatial resolutions viz. 3-6m, 25m and 50 m with 25 days repetivity & full polarimetry. This mission is a continuity mission of RISAT-1.
TRISHNA (Joint ISRO-CNES Program)	<ul style="list-style-type: none"> 4 bands (8.6 to 11.5 μm) image from Thermal Infrared Instrument of CNES 6 bands (485 to 2130 nm) image from VNIR Instrument of 50 m Spatial Resolution
NISAR (Joint NASA ISRO Program)	<ul style="list-style-type: none"> L & S band SAR global coverage every 12 days
GISAT 1R (Geostationary orbit)	<ul style="list-style-type: none"> 6 bands Multi-spectral (MX) VNIR of 42 m spatial resolution 3 bands each of MX & Thermal Infra Red of 1.5 km resolution 158 bands Hyper-spectral VNIR of 192 m resolution. 256 bands Hyper-spectral SWIR of 192m resolution.
Oceansat 3A	<ul style="list-style-type: none"> Ocean Color Monitor (OCM) data, Scatterometer data & Sea Surface Temperature Monitor (SSTM) data. OCM data is of 360 m spatial resolution with 2 days repetivity & 1Km global data with 8 days repetivity

Some of the missions launched or planned, by Indian Private Sector is mentioned below:

NGE	Missions Planned / Launched *
GalaxEye	High resolution multi payload microsatellite constellation, comprising optical and SAR payloads enabling data fusion using Drishti Sensors targeting environmental, Illegal Vessel Monitoring, insurance applications etc. The first satellite Dhrishti mission is expected to launch in 2023 Q4.
Pixxel	A hyperspectral imaging satellite named "Sakunthala" with capability of beaming images of 10m spatial resolution was launched by Pixxel during April 2022 aiming at deforestation, crop health monitoring and climate change applications. Pixxel's first commercial phase satellites is planned to be launched in 2023 comprising six satellites covering any point on the globe every 48 hours.
Dhruva Space	Dhruva space has scheduled launch of Hyperspectral mission in Q1 2024.
Azista BST Aerospace Pvt Ltd`	Azista BST Aerospace Pvt Ltd has launched its first remote sensing satellite in 2023 ABA First Runner (AFR) capable of providing panchromatic image with five metre spatial resolution with a Swath of 70km.
KaleidEO	Satsure's subsidiary KaleidEO has planned a Constellation of 4 satellites to provide images of 1 meter spatial resolution.

*The above List of Private Sector launches is as per the information available at IN-SPACe at this point of time and hence the list may not be complete.

Points for consultation

Q1. Are you aware of the availability of the above data sets? Please share your views.

Q2. Is this data adequately available to you in terms of quality and continuity? If not what improvements are expected?

Q3. In terms of continuity of data for a defined spatial and temporal resolution what improvements are expected for the data available from ISRO's EO missions?

3. EO data demand

High resolution images provide rich texture, shape & spatial distribution information of remotely sensed objects. This enables detailed mapping & extraction of accurate insights. Feedback was invited from EO community to understand the data demand. The data demand for datasets of various spatial resolution is listed below. It is proposed to meet, the additional data demand, by realization of the high resolution EO satellite constellation, through private sector participation.

Spatial Resolution	Demand
< 1m	There is a high demand for sub meter satellite images with better repetivity providing atleast weekly coverages of specific area & state wise, pan India & larger area of interest. Currently there are two < 1m, panchromatic payloads of Cartosat 3 & 2S in orbit & these resources are inadequate to meet demand for very high resolution data.
$\geq 1m \text{ \& } \leq 6m$	There is a high demand for daily coverage of 1m spatial resolution data.
> 6m & $\leq 50m$	In this category, we have 23.5m LISS III data with a repetivity of 11 days RS 2/2A together. Weekly coverage of full India is the requirement.
> 50m	Systematic coverage of 56m AWiFS data, atleast every three days is of high demand for mapping at coarser scale and for disaster mitigation applications. Better temporal resolution is the requirement.
Stereo	For stereo data, full India coverage every two years is of high demand. Currently the demand is met from archived datasets of Cartosat 1 acquired during 2005 – 2019 supplemented by foreign satellites.
Thermal payload	We need thermal infrared sensor coverage atleast every 3 days which can provide valuable insights into various phenomena viz. land surface temperature estimation, vegetation health assessment, urban heat island, fire detection, environmental monitoring etc.
Microwave	50 cm SAR with wide swath for flood mapping is needed for disaster studies.
Hyperspectral	Hyperspectral data @ 30 m resolution with flexible spectral bands is requirement.

Points for consultation

Q4. Do you agree with the above requirements of EO data. Please share your views.

4. Possible approach for meeting the demand

The major requirements listed in previous chapter are prioritized as (a) 30 cm or better spatial resolution, (b) 1m spatial resolution & (c) high resolution DEM better than 1m. Other requirements will be considered for implementation in a phased manner.

Type	Requirements
30cm or better	<ul style="list-style-type: none"> • 30 cm or better spatial resolution • Weekly or fortnightly full India coverage. • Bands: R, G, B & NIR • Geometric Fidelity & Radiometric Quality shall be decided. • Orbit, altitude & inclination, swath & no: of Satellites shall be decided by the implementing entity. • Agile Platform with adequate storage to store data.
1m	<ul style="list-style-type: none"> • 1m spatial resolution • Full India coverage every three days • Bands : R, G, B & NIR • Geometric Fidelity & Radiometric Quality shall be decided. • Orbit, altitude & inclination, swath & no: of Satellites shall be decided by the implementing entity. • Agile Platform with adequate storage to store data.
1m stereo	<ul style="list-style-type: none"> • High resolution DEM with 1m resolution or better • Minimum one coverage of India every two years • Geometric Fidelity & Radiometric Quality shall be decided. • Orbit, altitude & inclination, swath & no: of Satellites shall be decided by the implementing entity. • Agile Platform with adequate storage to store data.
50m Thermal payload	<ul style="list-style-type: none"> • Thermal Infrared at 50m • Full India coverage every three days full India • Geometric Fidelity & Radiometric Quality shall be decided. • Orbit, altitude & inclination, swath & no: of Satellites shall be decided by the implementing entity. • Agile Platform with adequate storage to store data.
Hyperspectral	<ul style="list-style-type: none"> • 400 – 2500nm @ 10 nm spectral interval • SNR, Geometric Fidelity & Radiometric Quality will be decided. • Orbit, altitude & inclination, swath & no: of Satellites shall be decided by the implementing entity. • Agile Platform with adequate storage to store data.
Oceansat	<ul style="list-style-type: none"> • To ensure assured continuity of Oceansat 3 mission. • Agile Platform with adequate storage to store data.
Microwave	<ul style="list-style-type: none"> • To ensure assured continuity of RISAT mission. • Agile Platform with adequate storage to store data.

Points for consultation

Q5. Is the above proposal adequate to address the data requirements, in-terms of spatial, spectral and temporal resolution? Please share your views.

Q6. Please share your views on the prioritization towards realization of EO satellite constellation missions.

5. The plan for realization

India has a great opportunity to become geospatial hub. As geospatial technology is being adopted as mainstream in almost all the sectors, in the country, the demand for very high and high-resolution data at frequent intervals, is increasing.

In-order to meet the additional requirements of the data, it is proposed to build, launch & maintain, the satellite constellation, through private sector participation. As Indian Space Industry is at its early stages, Government of India may become an assured customer for the data, acquired through these new constellations.

Public Private Partnership (PPP) model may be followed, for funding, where the NGE participating in building EO Constellation & the user Government departments may jointly fund the activity. The participating industry, shall clearly mention their revenue generation model.

- *The overall requirements are prioritized and split into three major categories (a) Very high-resolution 30cm or better data (b) High resolution 1m data and (c) stereo data of 1m resolution. This consultation paper describes the present state of EO data, demand and the proposed constellation and is published seeking opinion from EO community.*
- *The requirements for the EO constellations, illustrated in this consultation paper will be revised based on the responses sought during the consultation*
- *This paper intends to understand the interest of the private sector based on the responses received from Industry for this consultation paper & meetings with private sector. IN-SPACe and ISRO will determine whether industry would have the desire to build EO constellation and accordingly next step would be taken under this activity.*

Points for consultation

Q7. Do you agree to above approach for realization of the satellite constellation? Please share your views.

Q8. Will your company/ organization be interested in participation in this opportunity?

Q9. Please share your recommendations for making India, Atma Nirbhar in EO sector & to position India as global geospatial service provider?

Q10. Please share possible PPP models for the project

6.Summary & Way Forward

Earth Observation data and geospatial applications has proven to be of great value to the society, as a means of infrastructure planning, achieving sustainable goals, e-governance, weather prediction, climate monitoring, disaster preparedness & mitigation etc. India's geospatial economy is expected to cross ₹63,000 crore by 2025, growing at a rate of 12.8%, and to provide employment to more than 10 lakh people mainly through geospatial startups. As an endeavor to position India as a global geospatial hub, Government of India has released new geospatial policy as a stepping stone towards boosting country's economy and advance in self-reliance in geospatial domain.

With an objective to achieve self-reliance in earth observation sector, an analysis was carried to understand the current state of the earth observation data from Indian EO missions and the additional demand for the satellite data. We have published our views on the availability on earth observation data and the various approaches to meet the demand, in this consultation paper.

Hope you found this consultation paper interesting. You are requested to review this consultation paper and share your responses online with detailed justifications by visiting www.inspace.gov.in/inspace?id=inspace_eo_consultation

Consolidated Points for consultation

- Q1. Are you aware of the availability of the above data sets? Please share your views.
- Q2. Is this data adequately available to you in terms of quality and continuity? If not what improvements are expected?
- Q3. In terms of continuity of data for a defined spatial and temporal resolution what improvements are expected for the data available from EO missions of ISRO?
- Q4. Do you agree with the above requirements of EO data. Please share your views.
- Q5. Is the above proposal adequate to address the data requirements, in-terms of spatial, spectral and temporal resolution? Please share your views.
- Q6. Please share your views on the prioritization towards realization of EO satellite constellation missions.
- Q7. Do you agree to the approach for realization of the satellite constellation? Please share your views.
- Q8. Will your company/ organization be interested in participation in this opportunity?
- Q9. Please share your recommendations for making India, Atma Nirbhar in EO sector & to position India as global geospatial service provider?
- Q10. Please share possible PPP models for the project