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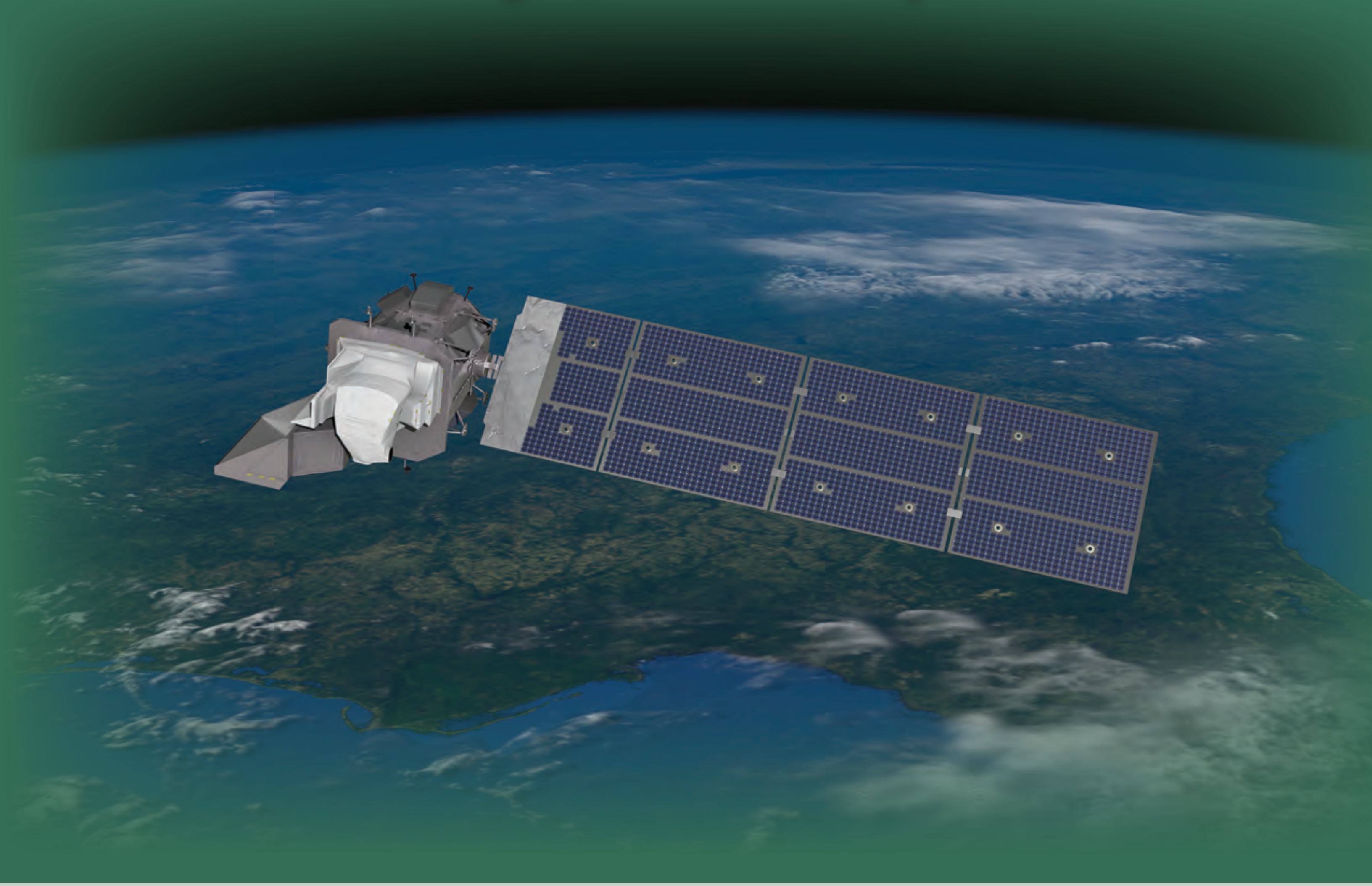
2020 Joint Agency Commercial Imagery Evaluation—
Remote Sensing Satellite Compendium



Joint Agency Commercial Imagery Evaluation
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JACIE

Circular 1468
Version 1.1, October 2020

U.S. Department of the Interior
U.S. Geological Survey

Cover. An artist's conception of the Landsat 9 spacecraft, the ninth satellite to be launched in the long-running Landsat program, high above the U.S. Gulf Coast. National Aeronautics and Space Administration's (NASA's) Goddard Space Flight Center/Conceptual Image Laboratory.

Facing page. The Ganges River forms an extensive delta where it empties into the Bay of Bengal. The delta is largely covered with a swamp forest known as the Sunderbans, which is home to the Royal Bengal Tiger. It is also home to most of Bangladesh, one of the world's most densely populated countries (image from NASA, acquired by Landsat 7's Enhanced Thematic Mapper plus [ETM+] sensor on February 28, 2000).

2020 Joint Agency Commercial Imagery Evaluation—Remote Sensing Satellite Compendium

By Shankar N. Ramaseri Chandra, Jon B. Christopherson, and Kimberly A. Casey

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Supersedes USGS Circular 1455

U.S. Department of the Interior
U.S. Geological Survey

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Preface

The U.S. Geological Survey (USGS) National Land Imaging Program (NLIP) has responsibility for providing Earth science data to support scientific, operational, resource management, and other national needs. The USGS NLIP gathers details on the scientific and operational Earth observation sensor needs of users around the world and applies these metrics towards various Earth observation sensor and data development efforts. The USGS NLIP operates and provides data for the Landsat series of satellites and their more than 48-year data record of our changing planet.

To understand and quantify Earth observation scientific and operational user needs, the Requirements, Capabilities, and Analysis for Earth Observation (RCA–EO) Project has been established. One of the missions of the RCA–EO Project is to identify and catalog existing and planned capabilities for measuring and monitoring the Earth. The RCA–EO Project also supports the Joint Agency Commercial Imagery Evaluation (JACIE) mission and has developed this compendium as one of the USGS contributions to the JACIE effort.

This publication was produced by the USGS NLIP RCA–EO Project Team at the USGS National Center and Earth Resources Observation and Science Center.

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Acknowledgments

Decades ago, the former director of the National Aeronautics and Space Agency's (NASA's) Earth Observation Programs began a satellite list of his own, offering basic facts about a variety of commercial and civilian orbiters. Affectionately known as the "Bill Stoney list," the publication served as a template for the USGS Earth Resources Observation and Science (EROS) Center-produced compendium released over the summer. Three of the EROS staffers who worked on the book had the chance to hand Mr. Stoney a copy of it in 2019 during their visit to Reston, Virginia, for the annual Joint Agency Commercial Imagery Evaluation (JACIE) workshop—an event Stoney spoke at 12 years ago.

Stoney remains a well-known figure within the JACIE community; however, Stoney's legacy is further reaching than his postretirement contributions to satellite tracking. Stoney began his career in 1949, before NASA had the name it has come to be known by. He worked on pilotless aircraft and led the development of the Scout rocket that was responsible for launching satellites aloft from 1961 through 1994.

In 2017, NASA called the rocket "one of the most successful boosters in NASA history" in the piece titled "Ten People You Wish You Met," where Stoney is featured.

Jon Christopherson (center) and Greg Stensaas (right) handing over the first edition of the compendium to Mr. Stoney (left), September 2019.

Stoney also served as the head of the spacecraft technology division at the Manned Spaceflight Center in Houston, Texas, from 1963 to 1968 and director of engineering for the Apollo Program Office. In 1969, he was awarded the NASA Exceptional Service Medal, but he was not finished. He was named director of Earth Observation Programs in 1973, where he worked with the Landsat program.

Artistic rendering of the Terra satellite and its five sensors onboard: ASTER, CERES, MISR, MODIS, and MOPITT.

In addition, this year we give a special acknowledgement to the NASA Terra mission. Auspiciously, with this 2020 compendium release, Terra has passed its 20th year of continuous monitoring of several of Earth's atmosphere, land, and aquatic characteristics. The Terra mission, roughly the size of a small school bus and launched on December 18, 1999, has been crucial in providing a myriad of data to study the Earth, allowing for analysis of data spanning many years and now decades. Terra is considered a flagship mission of the NASA Earth Observing System. Earth science data from the Terra mission have resulted in ground-breaking science, represented in over 20,000 peer-reviewed science publications. The five sensors aboard Terra (ASTER, CERES, MISR, MODIS, and MOPITT) yield an impressive span of data that can be harnessed to improve our understanding of Earth and its processes.

Compendium Coverage, Conventions, and Caveats

• This edition of the compendium provides data sheets for the numerous Chinese and Russian Systems.

• Many sources were mined for the data and information in this compendium. Appendixes 1 and 2 list those sources and how we harvested information from them.

• The data sheets in appendix 4 are arranged alphabetically by satellite or constellation name with their respective sensors behind each satellite. Sometimes satellites are known by more than one name.

• In cases where data are not available or unknown, we have used a dash "—" to indicate this lack of information.

• The compendium focuses heavily, but not exclusively, on land imaging satellites and measuring sensors. Satellites carrying multiple instruments (for example, Terra or Aqua) describe only the instruments aboard with significant land imaging or measuring capabilities.

Because of the rapid changes in the industry, the information presented in this compendium will change, and some of it will likely be out of date by the time of publication. Information in this compendium was gleaned from numerous sources to the best of the abilities of the authors.

Contents

JACIE

JACIE

JACIE

Figures

JACIE

Tables

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
kilometer (km)	0.6214	mile (mi)
	Mass	
kilogram (kg)	2.205	pound avoirdupois (lb)

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Abbreviations

ABI	Advanced Baseline Imager
AHI	Advanced Himawari Imager
Airbus DS	Airbus Defence and Space
ARD	Analysis Ready Data
CEOS	Committee on Earth Observation Satellites
CNES	Centre National D'Etudes Spatiales
COM	European Commission
EO	Earth observation or Earth observing
EORES	Earth Observation Requirements Evaluation System
EROS	Earth Resources Observation and Science
ESA	European Space Agency
FAIR	Findable, Accessible, Interoperable, and Reusable
FY	Fengyun
GEO	Group on Earth Observations
GOES	Geostationary Operational Environmental Satellite
JACIE	Joint Agency Commercial Imagery Evaluation
NASA	National Aeronautics and Space Administration
NGA	National Geospatial-Intelligence Agency
NLIP	National Land Imaging Program
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Office
OSCAR	Observing Systems Capability Analysis and Review Tool
RCA–EO	Requirements, Capabilities, and Analysis for Earth Observation
SEVIRI	Spinning Enhanced Visible and Infrared Imager
U	unit
USGS	U.S. Geological Survey
WMO	World Meteorological Organization
WSP	World Meteorological Organization Space Programme

Image of the SpaceX Starlink Mission satellite launch, taken June 3, 2020 (image licensed under the Creative Commons Attribution-Noncommercial 2.0 Generic license).

2020 Joint Agency Commercial Imagery Evaluation—Remote Sensing Satellite Compendium

By Shankar N. Ramaseri Chandra, Jon B. Christopherson, and Kimberly A. Casey

Introduction

The Joint Agency Commercial Imagery Evaluation (JACIE) is a collaborative multiagency group that began in 2000 between the National Aeronautics and Space Administration (NASA), the National Geospatial-Intelligence Agency (NGA), and the U.S. Geological Survey (USGS) to assess the quality and capabilities of newly launched commercial high-resolution Earth observation (EO) satellites. Each agency had potential interest in the use of these commercial datasets in fulfilling their missions and were interested in determining if imagery from these new systems had the quality, accuracy, and repeatability necessary to support EO science, land management, and other Government needs. In the initial years, JACIE assessed the data capabilities of Space Imaging's IKONOS, Digital Globe's QuickBird, and ORBIMAGE's Orbview-3. The JACIE agencies shared the results of their individual assessments with each other, the satellite owners/operators, and the public. JACIE's assessments have helped satellite owners improve the data quality from their commercial satellites. Since these early efforts, two more agencies have joined JACIE: the U.S. Department of Agriculture and the National Oceanic and Atmospheric Administration (NOAA). Each agency brings their own needs and strengths to the JACIE mission.

The JACIE group hosts an annual workshop to present results of their findings and to characterize results from universities, satellite owners, and others. Methods for satellite data assessment and calibration are presented and discussed. Plans for future systems, data products, and related information are welcomed for presentation at JACIE.

The Compendium of Land Remote Sensing Satellites

In recent years, the JACIE group has been impressed with the growing number of remote sensing satellites being launched. This growing wave of new systems, particularly the rapid growth in commercial satellites being planned and launched, created a need for a single reference for land remote sensing satellites that can provide basic system specifications and links to any JACIE assessments that may have been done on orbiting systems. This report and online Earth Observation Requirements Evaluation System (EORES) database have been assembled by the Requirements, Capabilities, and Analysis for Earth Observation Project within the USGS National Land Imaging Program as a contribution to the JACIE group. This report represents the second assembly of such a compendium; it is envisioned that the JACIE compendium will be updated annually, and that the EORES database will be updated and enhanced continuously, as resources allow. The EORES database can be found at https://remotesensing.usgs.gov/eores_app/.

This report consists of two major parts—the body of the document and individual sensor data sheets, providing sensor specifications on more than 100 EO satellite systems. The body of the document contains articles relating to the history and growth of land remote sensing from space and a discussion of the status and primary drivers behind the growth in government, commercial, and international remote sensing efforts. Also included in this report are short articles giving a brief overview of the EO programs by governments internationally, data quality and interoperability, and a description of the advanced geostationary imagers for EO.

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The appendixes contain a list of acronyms, a listing of recent and future satellites launched, graphics, data sheets on more than 100 land remote sensing satellites and systems and a list of helpful EO satellite and data resources. Assessment results on individual systems are viewable on the USGS Earth Resources Observation and Science Calibration Center of Excellence website (https://www.usgs.gov/land-resources/eros/calval), which is linked to on the individual data sheets.

Earth Observation Satellite Trends—Smaller and Smaller?

Because the number of satellites launched per year has grown in the last decade, the terms “smallsat” and “cubesat” have become buzzwords in popular media, with many people using the terms interchangeably. Are satellites getting smaller, and is that true for all satellites? This article explores some of the history of EO satellites, examines recent trends in average mass for these satellites, and prognosticates on the future trends for mass and size of EO satellites.

To begin any discussion on satellite mass/size, it is beneficial to clarify terminology. The chart in table 1 gives the structure to the terminology used for satellites of various masses. Note that “cubesat” is a term describing a satellite’s volume, not mass, with a 10-centimeter (cm) x 10-cm x 10-cm cube being the basic unit of volume and denoted as 1 unit (U). Cubesats larger than 1 U are described by the equivalent volume they take up, as illustrated in figure 1.

Table 1. Classes of satellites by mass (modified from Federal Aviation Administration Office of Commercial Space Transportation, 2018).

	Satellite class by mass	
	Group name	**Mass, in kilograms**
	Extra heavy	Greater than 7,000
	Heavy	5,400–7,000
	Large	4,200–5,400
	Intermediate	2,500–4,200
	Medium	1,200–2,500
	Small	600–1,200
Smallsats	Mini	200–600
Smallsats	Micro	10–200
Smallsats	Nano	1–10
Smallsats	Pico	0.1–1.0
Smallsats	Femto	Less than 0.1 (100 grams)

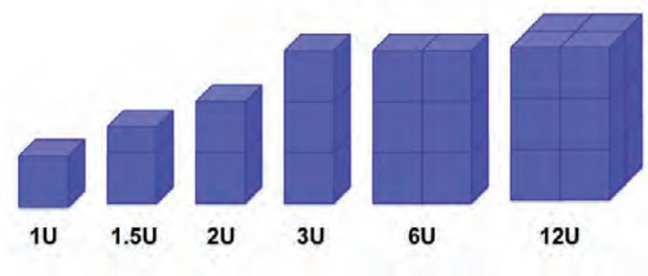

Figure 1. Various sizes of cubesats and their nomenclature (image from National Aeronautics and Space Administration). [U, unit]

Human entry into space began with satellites that would today be classified as smallsats. Sputnik-1, the first artificial satellite, weighed 83.6 kilograms (kg; 184.3 pounds [lb]) when it launched on October 4, 1957. The first U.S. satellite to achieve orbit, Explorer-1, launched on January 31, 1958 (fig. 2), was even smaller at 13.9 kg (30.8 lb), and the next U.S. satellite, Vanguard-1C, at 1.47 kg (3.2 lb), was tiny! The Soviets followed Sputnik-1 with Sputnik-2 (508 kg; 1,121 lb) and, in 1958, launched Sputnik-3, which weighed a whopping 1,327 kg (2,926 lb). At the time, Russian launch technology was capable of much heavier lifts than the Americans, who continued launching small satellites through 1958 (Encyclopedia Astronautica [Wade, 2019]).

By the time the first civilian land imaging satellite, Landsat 1, launched in 1972, launch capabilities had expanded to handle much larger satellites. The expanded capability was needed because the technology required to image the Earth at useful spatial and spectral resolutions, store data, and transmit data to the Earth, all while maintaining precise orbital positioning and Earth pointing, required a satellite of considerable complexity and size using the available technologies of the time. As capabilities of EO satellites grew, so did their mass, complexity, and cost. The 953 kg (2,100 lb) mass of Landsat 1 grew with each successive satellite until Landsat 8, at 2,071 kg (4,566 lb), was launched in 2013. Similarly, France’s SPOT series of satellites grew from the1,800 kg (3,968 lb) mass of SPOT-1 in 1986 to the 3,000 kg (6,614 lb) mass of SPOT-5 when it launched in 2002 (World Meteorological Organization [WMO], 2020).

Launch costs are a factor when designing satellites. Before the late 1990s, satellites were typically launched one at a time, thus incurring the entire cost of launch. Satellites were equipped with redundant systems in case of failure and carried ample fuel supplies to maximize operational time in orbit, thus spreading the satellite and launch costs over longer operational life. Rather than launching multiple satellites, each measuring different properties, satellites were made even larger in order to carry multiple instruments on a single satellite, thus sharing launch and satellite costs across multiple science missions. In the civilian EO world, the peak was reached with the launch of the European Space Agency’s (ESA’s) Envisat in 2002 (fig. 3). This highly capable satellite, carrying nine assorted scientific

Figure 2. Jet Propulsion Laboratory director William Pickering, scientist James Van Allen, and National Aeronautics and Space Administration's Wernher von Braun (from left to right) hold an engineering model of the Explorer-1 satellite over their heads at a news conference announcing its successful launch the night before (image from National Aeronautics and Space Administration).

instruments, tipped the scales at 8,100 kg (17,857 lb) when it launched in 2002.

The trend toward larger and larger satellites began to ebb at the beginning of the 21st century. The general trend toward lower mass EO satellites beginning in the late 1990s and accelerating in the most recent decade is shown in figure 4. Though many large satellites of high mass continue to be launched, beginning around 2013 they are offset by the launch of many smaller, less massive satellites. It is notable that the y-axis scale in this chart is logarithmic and that the trend line is still curving, indicating an accelerating trend toward lower average mass of EO satellites launched.

Several technological developments began in the 1990s and continued over the next two decades, providing new philosophies to guide the design of some satellites. The ability to launch multiple satellites on a single launch vehicle, sometimes into separate orbits, allowed the cost of a launch to be split among multiple satellites. Technological improvements introduced smaller yet more capable subsystems for guidance, detectors and electronics, power, and propulsion, yielding reduction in size and mass while maintaining the performance capabilities of their larger predecessors. This combination of reducing the size and launching multiple satellites aboard the same launch vehicle culminated in the remarkable launch of 104 satellites, 103 were smallsats, aboard an Indian Polar Satellite Launch Vehicle rocket on February 15, 2017. Today, the launch of a single EO satellite on a launch vehicle is the exception rather than the rule.

The trend toward reduced mass has been seen in recent "flagship" missions as well. Europe's Copernicus Sentinel satellites, a joint program of the European Commission (COM) and ESA, with more modest mass; for example, the Copernicus Sentinel-2 and Sentinel-3 series of satellites, which are all at roughly 1,200 kg (2,646 lb). France's SPOT satellites, which had grown to 2,750–3,000 kg (6,063–6,614 lb) with SPOT-4 and -5, respectively, dropped to a mere 712 kg (1,570 lb) each for SPOT-6 and -7, although with changed capabilities. The U.S. Landsat 9 mission will launch at 2,984 kg (6,579 lb), similar to the 2,623 kg (5,783 lb) launch mass of Landsat 8, both comparatively larger satellites than present-day European counterparts. There is speculation, though, that the follow-on mission to Landsat 9, which has not yet been announced, will also be of reduced mass.

Figure 3. ENVISAT during assembly and test. Note the personnel below the satellite for scale (image from European Space Agency/A. Van Der Geest).

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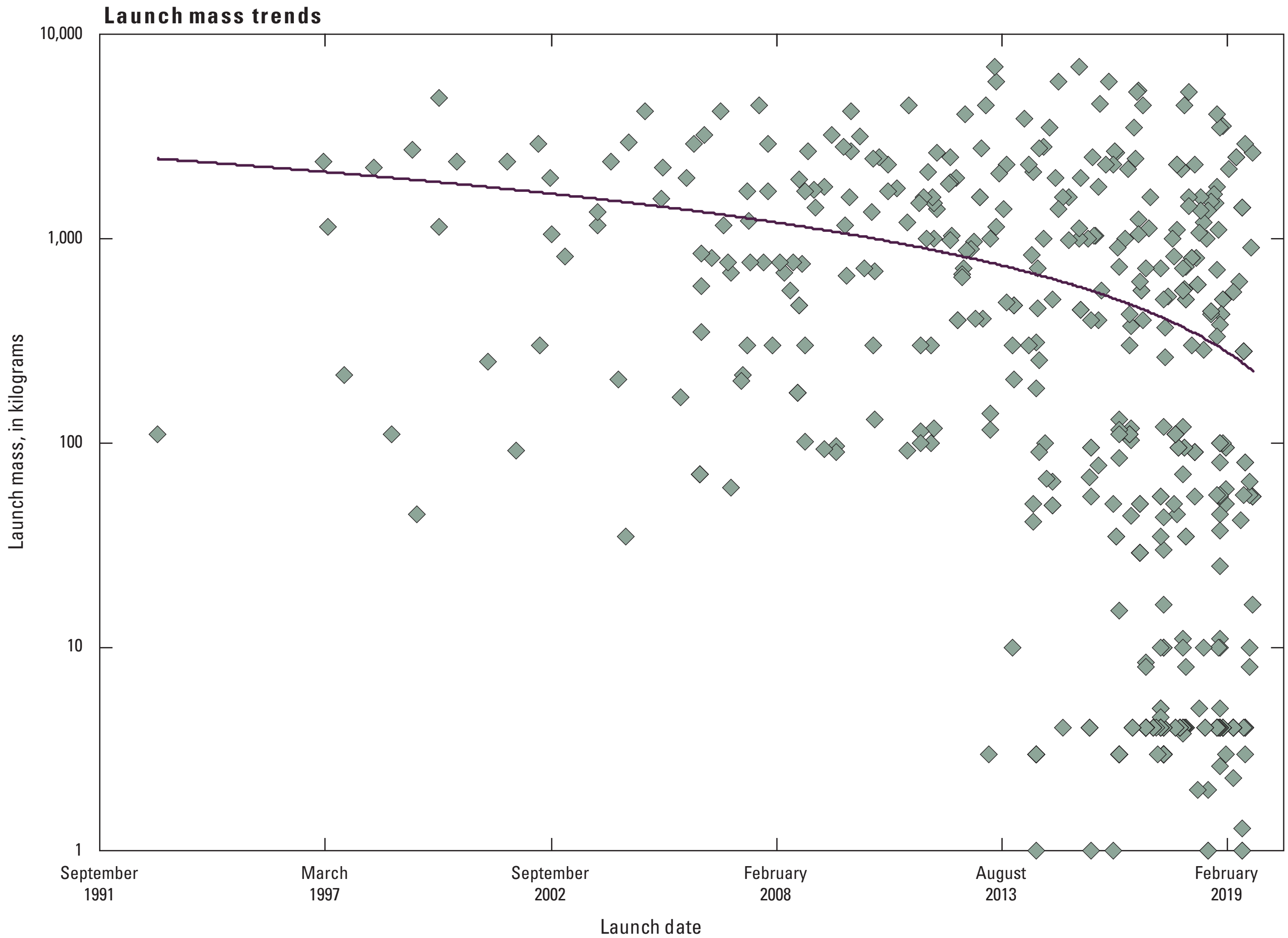

Figure 4. Trend of Earth observation satellite launch mass through mid-2019 (author-generated plot using data from the Union of Concerned Scientists Satellite Database).

The most striking reduction in mass for EO satellites has been seen in university research satellites and especially with commercial satellites. Reducing the mass of satellites allows for more satellites to be lofted in a single launch, resulting in a lower per-satellite fractional cost of the launch; a strong cost-saving impetus for any business. Some commercial firms also are moving toward shorter operating lifespans, reducing the need for redundancy and fuel, both factors that drive mass upward. Shorter operational lifetimes do require replacement more often, but commercial business sees opportunity in that also, allowing them to launch newer, more capable satellites using newer technologies.

Planet, Inc., (formerly Planet Labs, hereafter referred to as "Planet") is the best known example of these EO satellite philosophies. Their Dove satellites weigh 5.8 kg (12.8 lb), the opposite end of the mass "spectrum." Each Dove is a 3-U cubesat, with 30-cm x 10-cm x 10-cm stowed dimensions. The three cofounders of Planet are shown in figure 5 holding one of their Dove satellites to illustrate its small size. The first prototype Doves were launched in April 2013, followed by at least 20 more successful launches in the 7 years since then, each carrying a "flock" of multiple Dove satellites, for a total of more than 360 Dove satellites launched into orbit. Planet has used this frequent launch cadence to launch at least 17 "builds" or generations of Doves with various technological and operating improvements in each build. This has resulted in continual advancement in capability in the 7 years since the launch of the first Dove.

Will this trend toward ever-smaller EO satellites continue? Although it is possible to build satellites even smaller, there are indications that cubesats, such as Planet's Doves, are near the operational limit of what will be launched because of policy and technical limitations. The United States and other national licensing regimes require satellites to be at least 1 U in size, or 10-cm cubes, so that existing ground tracking radars can monitor their orbits. For Earth imaging, the physics of diffraction limitation require larger telescope apertures to resolve smaller and smaller features on the Earth. Smaller apertures

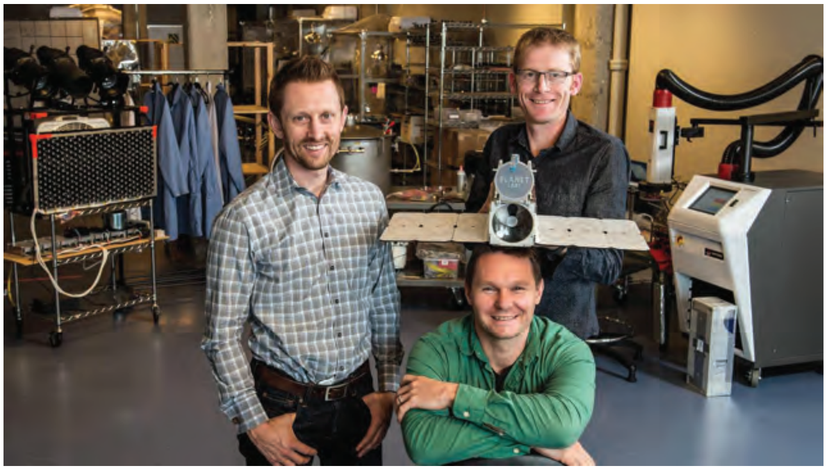

Figure 5. Planet, Inc., cofounders (from left to right) Chris Boshuizen, Robbie Schingler (kneeling), and Will Marshall with a full-scale Dove satellite (image from Deanne Fitzmaurice).

also collect fewer photons, resulting in lower signal-to-noise ratios and constraining the utility of the data. Also, cubesats such as Planet's Doves typically sacrifice propulsion to maintain size, weight, and risk profiles, preventing them from maintaining orbital positioning and longer orbital lifetimes.

These factors also enter into satellite design decisions. As new constellations are announced, it seems that the rush toward cubesats for commercial business may have peaked, with no recent announcements of new commercial cubesat constellations. It is worth noting that other firms beginning to launch commercial constellations are launching larger platforms. As an example, BlackSky Global launched its first Pathfinder prototype in 2016 and began launching the BlackSky Global constellation of EO smallsats in 2019, each with a larger form factor and a mass of 56 kg (123 lb).

The quest to make satellites smaller has been tested and explored in orbit. Size and mass are but two factors that enter consideration in satellite design, with operational features, propulsion, launch costs, and more also entering the trade space when determining satellite architecture. The downward curving trend line shown in figure 4 will likely flatten and perhaps rise.

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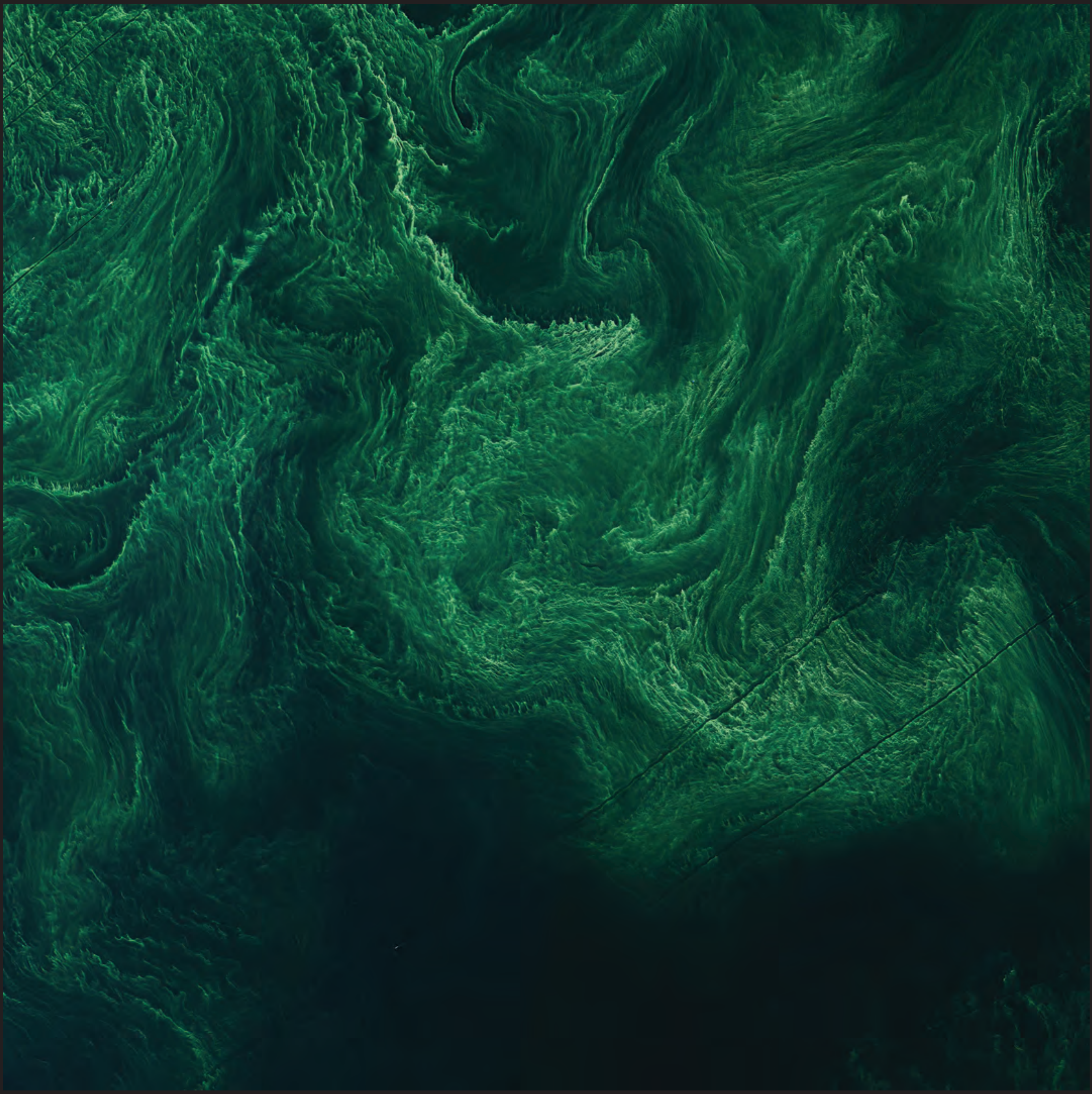
JACIE

Nearly every summer, colorful blooms of phytoplankton flourish in the Baltic Sea. And nearly every summer, satellite images detect art-like patterns as the phytoplankton trace the sea's currents, eddies, and flows. But like the whorls of fingerprints, no two phytoplankton blooms are exactly alike.

These natural-color images, acquired on August 15, 2020, with the Operational Land Imager (OLI) on Landsat 8, show a late-summer phytoplankton bloom swirling in the Baltic Sea. The images feature part of a bloom located between Öland and Gotland, two islands off the coast of southeast Sweden. Note the dark, straight lines crossing the detailed image: these are the wakes of ships cutting through the bloom (image from NASA).



Data Quality and Interoperability

From the beginnings of EO from space, scientists and other users were provided few choices and scarce EO data to use for their varied investigations. Now, decades later, the situation has changed considerably, with more EO data available than ever before. With many new sources of data, each with their own characteristics, scientists and other users have more data to choose from than ever, giving rise to two general questions: How well can data from each source meet their needs, and can they use data from different sources together? JACIE, the U.S. interagency governmental working group, was born out of a need to answer the first question and is actively addressing both questions now.

Quality

The first question, "Will these data meet my needs?" focuses on the quality of the data. For this discussion, we will focus on optical Earth imagery because it has been at the core of the JACIE investigations, but the same questions are being asked of light detection and ranging (more commonly known as "lidar"), radar, and other types of EO data.

Earth images are not just pictures, they are measurements. Each pixel within the image is a specific measurement with several qualities about it, including

- *Geometric*—the accuracy of the geolocation of each pixel.
- *Radiometric*—the accuracy with which the radiance or reflectance from the Earth within that pixel is measured.
- *Spatial*—the precision that the measurements above are contained within that pixel and not from adjacent pixels (colloquially referred to as "blur").

These are the core technical qualities of every pixel within an image. Other qualities, beyond these core technical qualities, affect the overall utility of the image. These qualities can include frequency of measurement, timely availability, data formats, and other factors that affect the usefulness of an image to science or other applications.

JACIE was formed to help understand these assorted qualities and to be able to readily find an accurate characterization of the core technical qualities. Formed in the early 2000s to aid in understanding the quality of the first commercial high-resolution satellites, JACIE continues to investigate the many new systems becoming available and the data they generate and to provide that information to potential users of those data and evaluate such EO data sources relative to existing civil EO data sources (for example, Landsat).

These EO data characterization findings are presented at the annual JACIE workshop and then made available on the USGS JACIE website (https://www.usgs.gov/land-resources/eros/calval/jacie). Efforts are underway to present results in a clearer, more concise, and easier to find manner. JACIE is also aware of related efforts around the world and is exploring cooperation with those entities to promote better understanding and awareness of the data quality of EOs. Of particular interest to JACIE are the ESA-sponsored Earth Data Assessment Pilot and the Very High-Resolution Radar and Optical Data Assessment. The Very High-Resolution Radar and Optical Data Assessment workshop, first convened in 2019, has similar goals to the annual JACIE workshop and is an excellent venue for exploring EO data quality in Europe (https://earth.esa.int/web/sppa/meetings-workshops/hosted-and-co-sponsored-meetings/vh-roda).

Using Data from Multiple Systems

The growing number of data sources offers many potential benefits to scientific and other analyses. Adding more data streams offers the possibility of improving the frequency of measurements, increasing the opportunity for cloud-free measurements, and (or) offering observations with improved spatial or spectral resolutions. As is often the case, the difficulty is in the details when trying to use multiple datasets together. Are two datasets truly equivalent? Are they even of similar accuracy and reliability?

Data Processing Levels

An important first step in understanding the potential to use datasets together is to understand how they have been processed. "Raw" data from the satellite are received as a data stream with no resemblance to an image or other useful product without considerable processing applied. Each "level" of processing that the data stream is subjected to renders it more usable for analysis, turning raw, base data into usable measurements. At the next level, these measurements are converted to actual geophysical properties, such as converting from top-of-atmosphere radiance to surface reflectance or surface temperature through the application of atmospheric correction algorithms as shown in figure 6. These algorithms may use internal system data only or apply data gathered from other sources. It must be noted that, at these lower levels of processing, a dataset retains its sensor-specific characteristics, such as the combinations of spectral bands it measures, the specific wavelengths and percentages of each wavelength measured, ground sample distance, and orientation (look angle).

At the highest levels of processing, which are referred to by different names or "levels" by different organizations, data are transformed into actual geophysical information and lose their sensor-specific content. Examples of these products include the Landsat Level-3 Dynamic Surface Water Extent, Fractional Snow Covered Area, and Burned Extent products offered by the USGS as illustrated in figure 7. The chart in figure 8 gives a brief description of these multiple data product

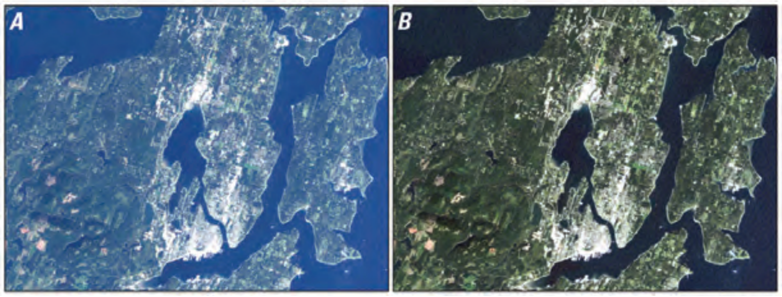


Figure 6. Landsat 5 Collection 2 images. *A*, top of atmosphere reflectance image (bands 4, 3, 2); *B*, atmospherically corrected surface reflectance image for an area over Bremerton, Washington, path 47, row 27 acquired on October 6, 2010 (images from Michelle A. Bouchard, U.S. Geological Survey).

levels and their implications (USGS, 2020). Generally, most data products available from government or commercial sources have descriptions available regarding the processing that has been applied to their data.

Analysts need to know the levels of processing applied to any data used in their work and understand the effects that processing may have on the data. Corrections may be needed to different data to make them more usable together. At lower levels of processing, data still retain their own sensor characteristics, limiting their ability to be used interchangeably. Only at the highest levels of processing can data begin to be truly interoperable, and only if the processes performed on them are well understood by the analyst.

The Quest for Interoperability

In this new EO data environment where scientists and others have many new data streams, a "sea of data" available to them, there has been much discussion and effort made to help make data more usable together. This has engendered several new terms, including "Analysis Ready Data (ARD)," "data harmonization," and "interoperable data." Each of these terms speaks to the desire to use data, including data from multiple sources, more easily and reliably; however, the waters remain murky because the implications of these various terms and efforts can be interpreted differently. For what kind(s) of analysis can ARD be used? What does "harmonized" mean? Does "interoperable" mean interchangeable? These questions only grow with time as more datasets become available and the potential uses and users of these data grow.

JACIE, ESA, the multigovernmental Committee on Earth Observation Satellites (CEOS) community, academia, and private industry all are attempting to deal with these terms and the common desires driving them. CEOS has developed its own CEOS ARD for Land standard (Lewis and others, 2018), NASA is working on Harmonized Landsat/Sentinel-2 data (Claverie and others, 2018), and Planet has sponsored an ARD workshop in Silicon Valley since 2018. Other efforts and discussions are underway around the globe, all attempting to deal with the tsunami of data available now. As these turbid waters begin to settle, greater clarity from this data deluge will begin to emerge.

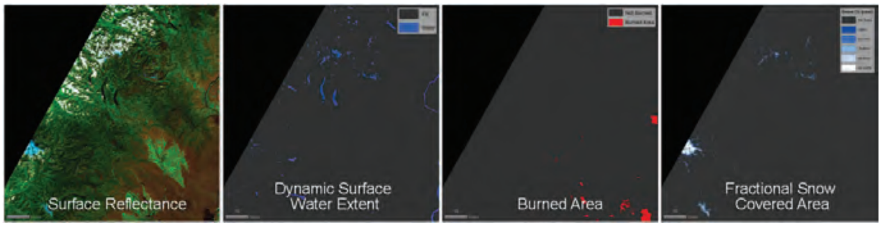


Figure 7. Examples of Surface Reflectance and three Landsat Level-3 products available from the U.S. Geological Survey (images from U.S. Geological Survey).

Processing level	Brief description
Raw data	These are raw, unprocessed data as streamed from the satellite. They are not usable without processing.
Level 0	This is one step up from Raw. Data have been processed into bare minimum to be recognized as an image. Also not usable for analysis without further processing.
Level 1	Level-1 data have had radiometric and geometric corrections applied and have become the first level of usable Earth observation data. Data products are still in sensor units but can be converted to top-of-atmosphere radiance by applying supplied calibration coefficients. There are often system-specific steps within the broad category of Level-1 data, such as Level-1A, -1B, -1C, with varying degrees of utility. See the system owner's specifications for exact details about these product levels.
Level 2	Data are processed to geophysical values, typically surface reflectance for imagery products, after application of atmospheric correction algorithms, often obtained from external sources. Data retain sensor-specific characteristics.
Higher order products (often Level 3 or Level 4)	Data are processed to geophysical values, typically surface reflectance for imagery products, after application of atmospheric correction algorithms, often obtained from external sources.

Data retain some sensor-specific characteristics

Data are sensor independent

Data are not usable for analysis

Data are not usable for analysis

Data may be mapped on a grid in tiles of uniform size. (Some schemes attribute this as Level 3, others begin this at Level 2)

Figure 8. Generalized chart of Earth observation data processing levels.

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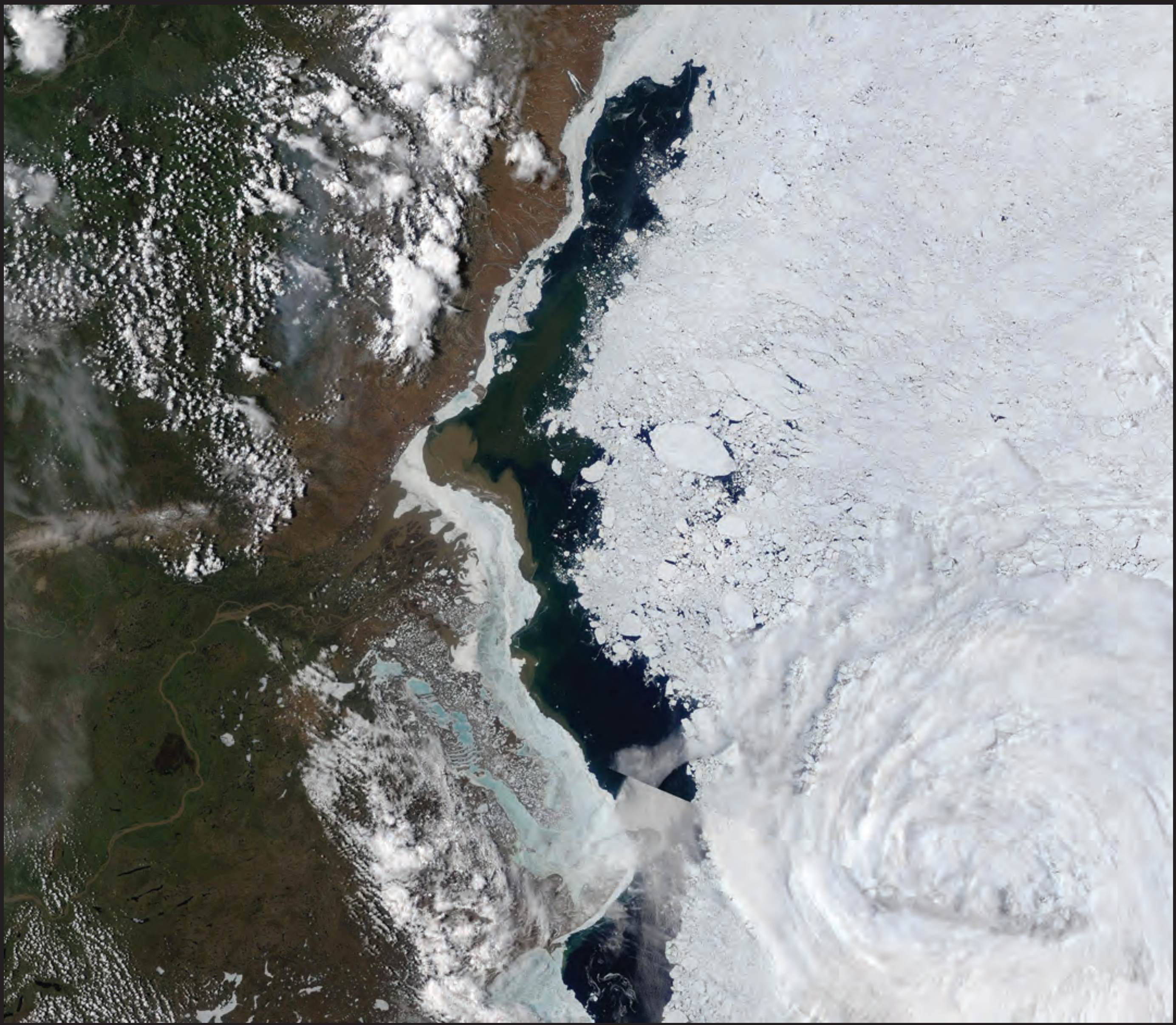
Mackenzie Bay sits in the Canadian Arctic, close to the border of Yukon Territory, Canada. Each winter, a thick coating of ice solidifies over the Bay while deep snow coats the landscape. As temperatures rise in spring, the Mackenzie River, which flows from the warmer south into Mackenzie Bay, swells with meltwater. As it flows towards the Bay, the rushing of warmer meltwater aids in breaking up the ice clinging to the river and aids in spurring sea ice retraction from the shoreline. Spring melt also fills the river with sediment, which is carried to and dumped into the chilly waters of Mackenzie Bay. Eventually, increasing temperatures of spring and the flow of warmer fresh water prevail over the layer of sea ice and by summer the river flows freely into Mackenzie Bay and from there into the Beaufort Sea.

On June 11, 2020, the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired a true-color image of Mackenzie Bay. A layer of sea ice, broken and retreating, covers the waters of the Bay away from shore and a layer of fast ice clings to the Canadian coastline. The Mackenzie River, swollen with spring meltwater and sediment, curls through the scene from the bottom (south) and flows northward. On the river's delta, fingers of sediment can be seen encroaching on the ice, while copious muddy-brown sediment spills into the Bay underneath the ice (image from MODIS Land Rapid Response Team, NASA Goddard Space Flight Center).



Directions of Governmental Programs Nationally and Internationally

United States Earth Observation Efforts

In the United States, planned EO operation and development efforts are mandated by the National Academies of Sciences, Engineering, and Medicine Space Studies Board interagency organized and scientific community written 2017–27 decadal survey, formally titled "Thriving on Our Changing Planet—A Decadal Strategy for Earth Observations from Space" (hereafter referred to as the "Decadal Survey"; National Academies of Sciences, Engineering, and Medicine, 2018). This most recent Decadal Survey prioritized hyperspectral remote sensing as the most pressing need to address a myriad of Earth monitoring and characterization efforts, including quantifying the hydrologic and carbon cycles, biodiversity, and ecosystem function and characterizing geological resources (table 2). Other EO priorities recommended by this Decadal Survey after the current program of record include missions targeted at observing surface deformation and change; mass change, aerosols and clouds. National EO missions forthcoming in the current program of record include the operation of existing missions through the prime period of operation (the initial mission performance lifetime), as well as the launches of NASA's Plankton, Aerosol, Cloud, Ocean Ecosystem Mission (summarized in Werdell and others [2019]); Landsat 9 (see Markham and others [2019]), planned NOAA Joint Polar Satellite System missions, and NASA's Surface Water and Ocean Topography mission (see Vaze and others, 2018).

There is a considerable effort among U.S. Government agencies towards calibration and validation, and ensuring the highest data quality standards continue to be met. Specifically, the JACIE program, with involvement from NASA, the NGA, NOAA, the U.S. Department of Agriculture, and the USGS, seeks to not only provide evaluation and recommended standards for commercial imaging EO mission and data streams, the JACIE program also encourages and provides a framework for civil EO mission evaluations and characterizations. Efforts are also underway to update and improve global topographic data and continue essential Earth science climate data records, such as surface reflectance, snow extent, atmospheric optical depth, and surface temperature.

Table 2. The Decadal Survey report prioritizes targeting these observable variables in the coming years (modified from National Academies of Sciences, Engineering, and Medicine, 2018).

[lidar, light detection and ranging; IR, infrared]

Targeted observable	Science/applications summary	Candidate measurement approach
Aerosols	Aerosol properties, aerosol vertical profiles, and cloud properties to understand their effects on climate and air quality	Backscatter lidar and multichannel/multiangle polarization imaging radiometer flown together on the same platform.
Clouds, convection, and precipitation	Coupled cloud-precipitation state and dynamics for monitoring global hydrological cycle and understanding contributing processes including cloud feedback	Radar(s), with multifrequency passive microwave and submillimeter radiometer.
Mass change	Large-scale Earth dynamics measured by the changing mass distribution within and between the Earth's atmosphere, oceans, groundwater, and ice sheets	Spacecraft ranging measurement of gravity anomaly.
Surface biology and geology	Earth surface geology and biology, ground/water temperature, show reflectivity, active geologic processes, vegetation traits, and algal biomass	Hyperspectral imagery in the visible and shortwave infrared, multi-, or hyperspectral imagery in the thermal IR.
Surface deformation and change	Earth surface dynamics from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction.

International

In the following sections, we summarize some key developments of international space agency remote sensing national programs, spaceborne missions, data acquisition goals and collaborations.

Strengthening of National Programs

Overall, we note an initiation and or strengthening of national space EO programs in many countries. Some examples of countries that have advanced their national space capabilities in the last few years include Canada, China, India, Italy, Germany, Russia, and Japan. The first EO mission launches were completed by programs in Egypt, Korea, and United Arab Emirates. In 2019, with the help of the Chinese government, Ethiopia and Sudan also launched their first EO remote sensing missions.

Civil and commercial partnerships also remain important in carrying out national EO data collection goals. For example, civil and commercial partnership missions highlight how a nation can acquire needed EO governance data and commercial partners can market sensors toward fulfilling additional industry goals while generating profit. Examples of such EO missions include the Canadian remote sensing RADARSAT commercial missions overseen by the Canadian Space Agency; the jointly operated U.S. Teledyne Brown Engineering and German Aerospace Center (DLR) Earth Sensing Imaging Spectrometer currently installed on the International Space Station; and the ICEYE, a Polish and Finnish commercial radar satellite technology offering.

International Collaborations

International EO mission partnerships are also advancing Earth science and operational goals. Some key international EO partnership missions underway include the U.S. Teledyne Brown Engineering and German Aerospace Center Earth Sensing Imaging Spectrometer (DESIS) hyperspectral imager deployed on the International Space Station (fig. 9), the China/France Oceanography Satellite (CFOSAT), the U.S./Indian NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Mission in planning, the Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment (TRISHNA) mission by India and France, and the joint Israel and Italy Spaceborne Hyperspectral Applicative Land and Ocean Mission (SHALOM).

Figure 9. Artistic rendering of jointly operated U.S. Teledyne Brown Engineering and German Aerospace Center DESIS sensor currently installed on the International Space Station (Teledyne Brown Engineering, 2018).

Effort to Provide and Steward Findable, Accessible, Interoperable, and Reusable (FAIR) Earth Observation Data

There is a strengthening commitment toward the provision of Findable, Accessible, Interoperable, and Reusable (“FAIR”) EO data and related data stewardship (see more details provided in Martone [2014] and references within). FAIR data must be easily readable by humans and machines. Countries and (or) space programs that are committed to the provision of free and open access to EO data include the United States, COM, India, and Brazil. FAIR data usage and principles have been presented and discussed at several remote sensing science user meetings (for example, American Geophysical Union Fall 2019, Ocean Sciences Winter 2020 meetings), as well as international policy programs (for example, World Meteorological Organization, October 2019 High Mountain Summit) to highlight the suggested data standard.

European Commission and European Space Agency

The COM and ESA show increasing strength and an ongoing commitment to EO missions; namely, via Europe’s Copernicus program, one of the most comprehensive EO programs ever (fig. 10). ESA has been receiving proposals for and funding a variety of EO missions via their Earth Explorer program. ESA’s Compact High Resolution Imaging Spectrometer (CHRIS), which can acquire as many as 63 spectral bands from 400 to 1,050 nanometers, provides a nearly two-decade record (2001–present) of high spectral resolution data. More than 10 years of synthetic aperture interferometric radar altimetry data are now provided by the ESA CryoSat EO mission. Additionally, nine Earth Explorers have been selected for implementation, and these missions focus on mapping Earth’s gravity, cryosphere, soil moisture content, ocean salinity,

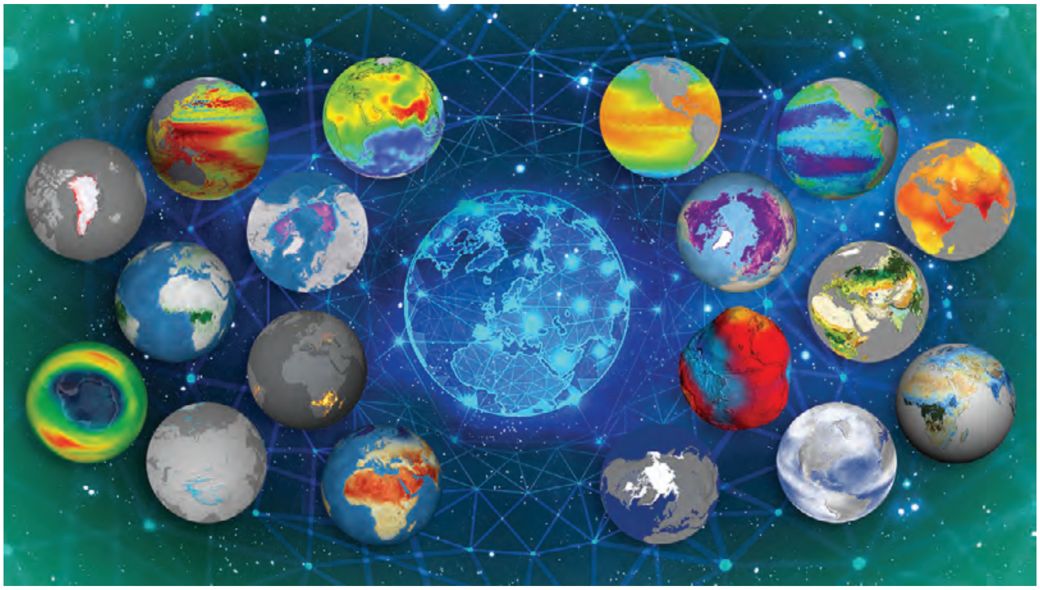


Figure 10. Conceptual diagram representing some of Europe's Copernicus program Earth observation mission concepts (European Space Agency, 2020).

magnetic field, atmospheric circulation, radiation budget, biomass, and plant photosynthesis. Three more EO mission concepts are in review, and the next round of Earth Explorer proposals and selections are in process.

Coordinated International Remote Sensing Efforts

There are a number of coordinated international EO remote sensing coordination groups. One of the most noted of these groups is CEOS. CEOS provides updates on the activities of the many participating space agencies and information on upcoming remote sensing and Earth data meetings and publications; CEOS also maintains an EO sensor handbook and database. This CEOS database is sortable by country, EO mission launch date, mission status, orbit characteristics, and other factors. The CEOS database is available at http://database.eohandbook.com/.

Similarly, the Group on Earth Observations (GEO) intergovernmental organization has a mission to improve the availability, accessibility, and usage of EO data. In GEO, there are more than 240 national governments and participating organizations that work toward comprehensive, continued EO records for the benefit of societal goals. GEO participates in and promotes many activities and initiatives, largely geared toward goals of sustainable development, meeting international emission agreements, and reducing disaster risks. A GEO Global Earth Observation System of Systems map-based data portal (https://www.geoportal.org/) aims to aid users in discovering and accessing EO data and resources. The GEO Strategic Plan for 2016–25 is available online at http://www.earthobservations.org/documents/GEO_Strategic_Plan_2016_2025_Implementing_GEOSS.pdf (GEO, 2015).

The WMO also has an organized community, the WMO Space Programme (WSP), which aims to facilitate EO remote sensing data acquisition and data distribution efforts to interested EO data users around the world and to provide a framework for EO capability planning (WMO, 2019). Examples of the WSP efforts include the Observing Systems Capability Analysis and Review Tool (OSCAR) and WMO Polar Space Task Group. OSCAR (https://www.wmo-sat.info/oscar/) provides a resource to guide scientists, engineers, planners, and users in sorting EO space-based capabilities, available data variables, applications, sensor characteristics, and global coordination efforts. The WMO Polar Space Task Group is a body of cryospheric remote sensing space agencies that meet to coordinate remote sensing data acquisition strategies and data distribution efforts and create science community EO user requirement documents. The WMO WSP also offers several training and awareness activities focused on advancing knowledge surrounding the use of available EO data; for example, see the WMO Virtual Laboratory for Education and Training in Satellite Meteorology at www.wmo-sat.info/vlab.

Ground Station Collaborations

There are a number of EO satellite ground station collaborations that exist. For example, for the Landsat missions, ground stations to facilitate the download and distribution of data operate in multiple locations across the globe (see fig. 11). Over time, important collaborations have been established and continue to be established for the greater good of the acquisition and provision of EO data.

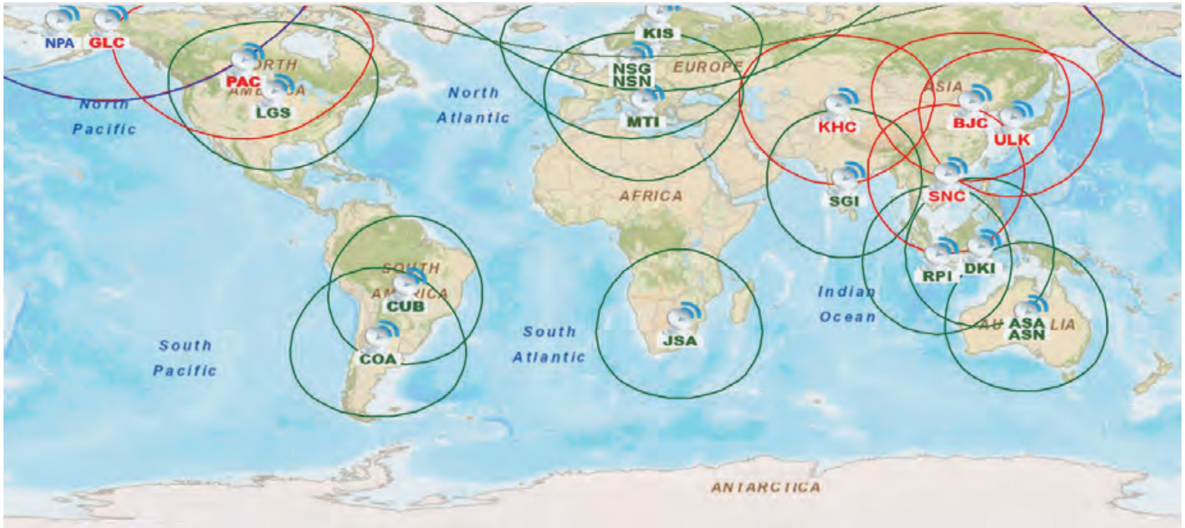


Figure 11. The currently active Landsat International Ground Station Network, which aids in the downlink and distribution of Earth observation data. Blue text indicates ground stations serving Landsat 7 data acquisition operations, red text indicates ground stations serving Landsat 8 data acquisition operations, and green text represents ground stations that serve Landsat 7 and Landsat 8 data acquisition operations (image from U.S. Geological Survey, 2020; https://www.usgs.gov/land-resources/nli/landsat/international-ground-stations-igs-network?qt-science_support_page_related_con=0#qt-science_support_page_related_con, last accessed June 16, 2020). [NPA, North Pole, Alaska; GLC, Gilmore Creek; PAC, Prince Albert, Canada; LGS, Sioux Falls, South Dakota; CUB, Cuiaba, Brazil; COA, Cordoba, Argentina; SGS, Svalbard, Norway; KIS, Kiruna, Sweden; NSG NSN, Neustrelitz, Germany; MTI, Matera, Italy; JSA, Hartebeesthoek, South Africa; KHC, KaShi, China; SGI, Shadnagar, India; BJC, Beijing, China; ULK, Ulsan, South Korea; SNC, SanYa, China; RPI, Rumpin, Indonesia; DKI, Parepare, Indonesia; ASA ASN, Alice Springs, Australia]

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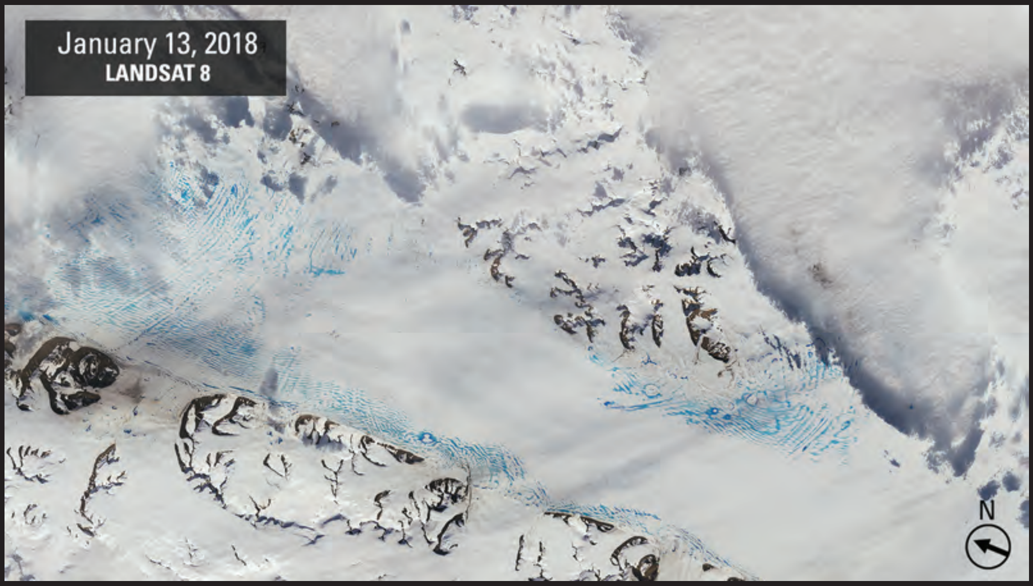
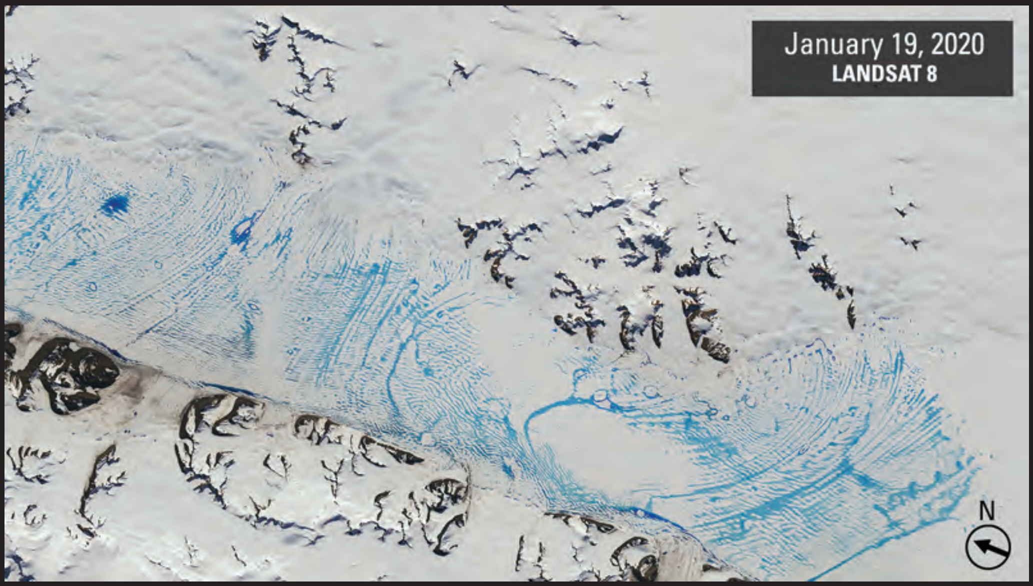
Landsat recently captured the most widespread meltwater pooling ever recorded on Antarctica's George VI Ice Shelf.

Some melting is expected during the Antarctic summer, but the sheer extent of the stunning aqua ponds that have appeared amid the continent's warmest summer on record is remarkable.

Ponds appeared two years earlier in some of the same locations, but most of the ice shelf remained frozen. In 2020, the pools stretched across some 90 miles by January 19th.

NASA scientists noted that the image represented the most extensive ponding captured across the nearly 50 year Landsat record (image from U.S. Geological Survey).





Commercial Earth Observation Constellations

The commercial EO remote sensing industry, for the most part, responds to the needs and requirements of national governments and is governed by national space policies. In the United States, NOAA along with NASA, the Department of Defense and other Government agencies document the long-term EO requirements that may drive the development of commercial remote sensing systems, whereas the USGS leads the near-term remote sensing data requirements process (USGS, 2005). These commercial systems are licensed by the U.S. Department of Commerce through NOAA, classifying them into three tiers based on the revised regulations published in May 2020 (NOAA, 2020). The NGA and the National Reconnaissance Office (NRO) continue to be the primary customers for commercial EO imagery. The U.S. Government agencies support intelligence efforts through NextView, ClearView, and EnhancedView contracts while providing researchers and scientists access to high-resolution imagery to monitor Earth's resources.

The characteristics of commercial EO satellite imagery—very high resolution and targeted data acquisition, greatly benefit the intelligence community. Internationally, commercial satellite missions like SPOT, RADARSAT, COSMO-SkyMed, Pleiades, WorldView, and others have demonstrated dual uses to provide EO imagery for commercial and military intelligence needs. According to the study published by Euroconsult in 2019, 60 percent of commercial satellite data are used by the defense industry, of which the U.S. defense industry is the primary customer (Puteaux and Najjar, 2019). The intelligence needs of the countries with no space assets are solely served by commercial EO firms. In the last decade, the use of commercial EO data by defense and nondefense industries has increased steadily because of the advancements in EO satellite technology.

The revolutionary advancements in the commercial EO industry can be attributed to three primary players, Airbus Defence and Space (Airbus DS), Maxar Technologies (DigitalGlobe merger, hereafter referred to as "Maxar"), and Planet.

As one of the primary players in the commercial EO industry, Maxar serves a wide range of customers nationally and internationally. With their next generation WorldView series of multispectral satellites, Maxar provides 30-cm high-resolution data in visible and infrared regions of the spectrum. With the extended EnhancedView contract through 2023 with NRO (a value of about $900 million U.S.) and the Global Enhanced GEOINT Delivery program ($44 million U.S.) with NGA, Maxar is the primary EO data provider for the U.S. Government (Maxar Technologies, 2018). The current Maxar constellation (fig. 12) consists of five operational satellites: Geoeye-1; WorldView-1, 2, and 3; and RADARSAT-2 operating in sun-synchronous orbits. Maxar is also developing the WorldView Legion constellation for launch in 2021 to supplement the existing fleet of satellites and monitor the Earth by revisiting any target 15 times per day from sun-synchronous and inclined orbits. Additionally, the company has made contracts with Saudi Arabia's King Abdul Aziz City for Science and Technology Space Research Institute to jointly build the WorldView Scout constellation of small satellites. The detailed specifications for each satellite are provided in appendix 4. The Maxar satellites are individually tasked, and data are available at https://www.digitalglobe.com/products/satellite-imagery.

The longest operating commercial EO operator, Airbus DS, operates a fleet of optical and radar satellites. Beginning with SPOT-1, Airbus DS currently operates Pleiades high resolution satellites, wider swath SPOT-6 and -7 satellites, and X-band imagery satellites TerraSAR-X/TanDEM-X. The Vision-1 and NovaSAR satellites launched in 2018 provide Airbus DS with the capability of viewing the Earth through an optical-radar constellation. Under public/private partnerships, Airbus DS operates the Disaster Monitoring Constellation of satellites and the KazEOSat-1 satellite for its international partners. Airbus DS is developing a follow-on mission called Pleiades Neo, to be launched in 2020, that is capable of revisiting any target on the Earth twice daily at a 30-cm resolution (Jerome, 2019). Airbus DS is building a constellation of satellites called the Constellation Optique 3D (CO3D) for the French space agency, Centre National d'Etudes Spatiales (CNES), to generate a global high-resolution digital

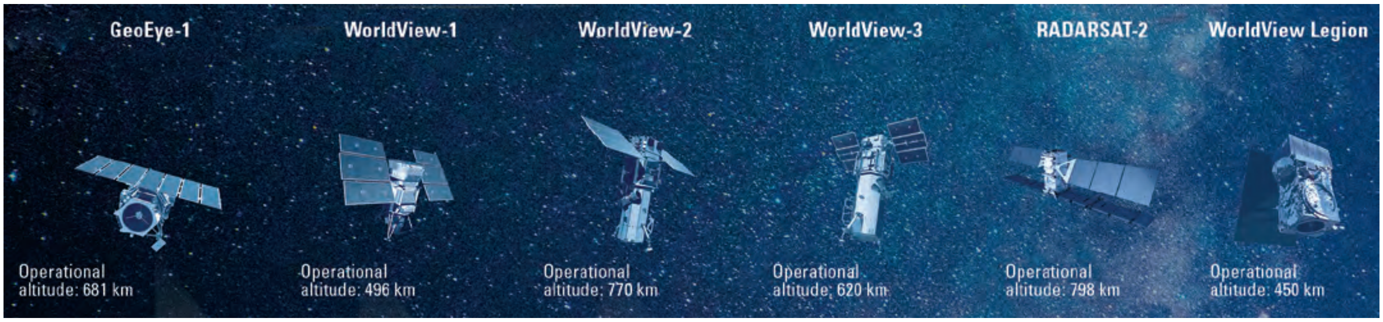


Figure 12. Maxar Technologies constellation (image modified from MAXAR technologies). [km, kilometer]

surface model (Airbus, 2019). Airbus DS is also entering into an agreement with NASA to provide commercial EO data through the Commercial Smallsat Data Acquisition Program. The Airbus DS EO satellite constellation is shown in figure 13. The satellites are individually tasked, and data are available through https://www.intelligence-airbusds.com/geostore/. Airbus DS and Maxar constellations will have similar capabilities, agile satellites to provide 30-cm very high resolution imagery for civil government and military customers nationally and internationally.

Another primary provider of commercial EO data is Planet. Founded by former NASA scientists, Planet's unique approach to develop a constellation of EO satellites to image the Earth daily at a high resolution, unlocked new markets and opportunities. Since 2013, Planet has launched over 360 satellites into low Earth orbit and has 150+ satellites currently in operation. The company operates more than 100 Dove satellites, 15 SkySats, and about 40 SuperDove satellites capable of providing high-resolution imagery with daily revisits to the users. Planet also operated high-resolution RapidEye satellites, which were decommissioned at the end of March 2020; however, archived data are still available for download. The company plans to launch more SkySats into low-altitude inclined orbits for better resolution data. Planet data are highly focused on creating value-added products to attract various markets. Like Maxar, Planet also holds contracts with agencies including NGA and NRO to deliver high-resolution optical data and data products from its Dove satellites. The currently operational Planet satellite orbits are shown in figure 14. Planet satellite data are available through Planet portal at https://www.planet.com/.

Although the commercial space industry is dominated by the previously mentioned companies, many other organizations have emerged in recent years. More than 40 commercial companies have launched remote sensing satellites in the last 10 years, of which 21 were startups founded between 2014 and 2020 (Bryce Space and Technology, 2020). U.S. companies BlackSky and Capella Space; Chinese companies Zhuhai Orbita Control Engineering, Ltd., and Chang Guang Satellite Company, Ltd.; Polish/Finnish company ICEYE; Argentinian company Satellogic, Inc.; and others have demonstrated their abilities to provide high-resolution optical and radar data. In recent years, commercial EO satellite launches clearly dominated the civil EO industry. It is predicted that 500–1,000 remote sensing EO satellites will be launched in the next 5 years with new sensors, new modalities, and new orbits and in multiple constellations (Bryce Space and Technology, 2020).

The commercial industry is turning towards cloud-based storage techniques to accommodate the vast amounts of data these satellites are collecting daily. Amazon Web Services, Google Cloud Platform, Microsoft Azure, and other architectures are being developed to not only store but also effectively query the data using advanced algorithms. The ultimate goal of the EO industry is to make the data readily available to the user with zero latencies, so called "permanent vision." As figure 15 indicates, more commercial organizations are moving towards

Figure 13. Airbus Defence and Space Earth observation satellite constellation (image from Airbus Defence and Space).

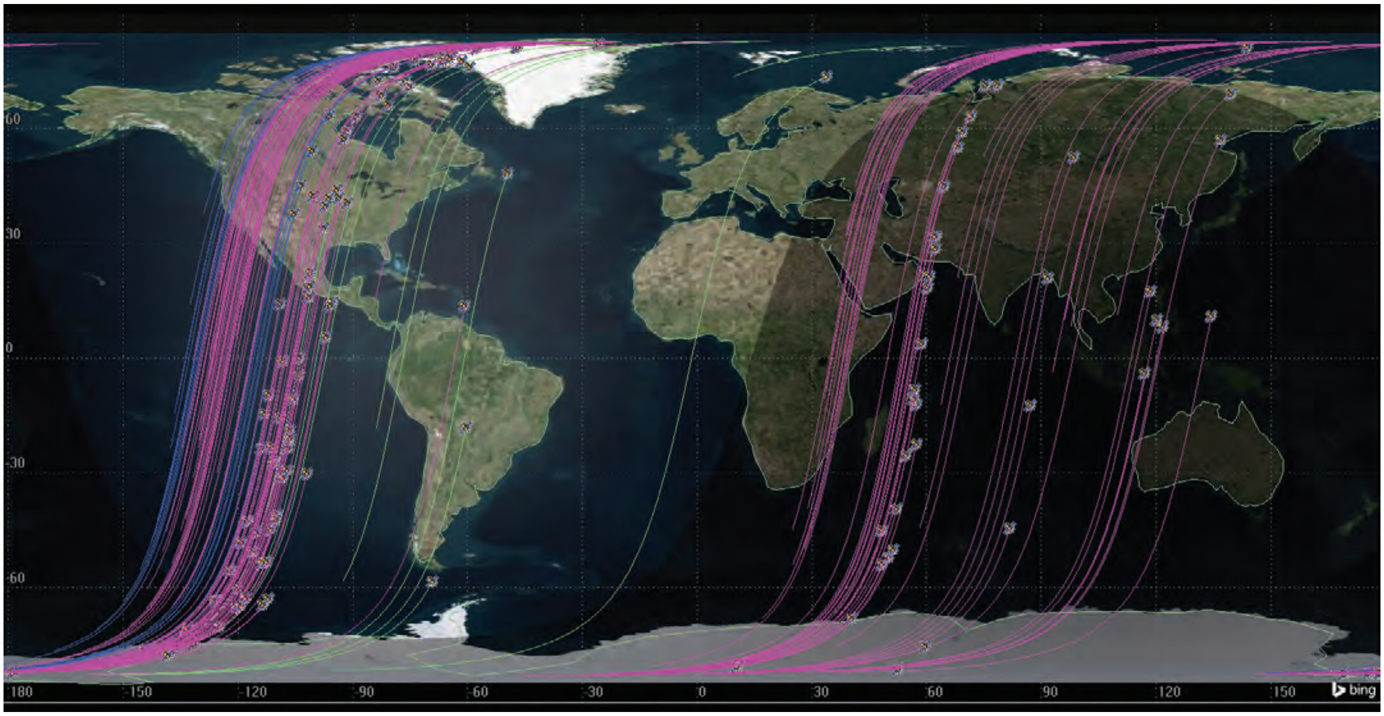


Figure 14. Operational fleet of satellites from Planet, Inc. Pink, Doves; green, SkySats; blue, SuperDoves (data from Planet, Inc., 2020).

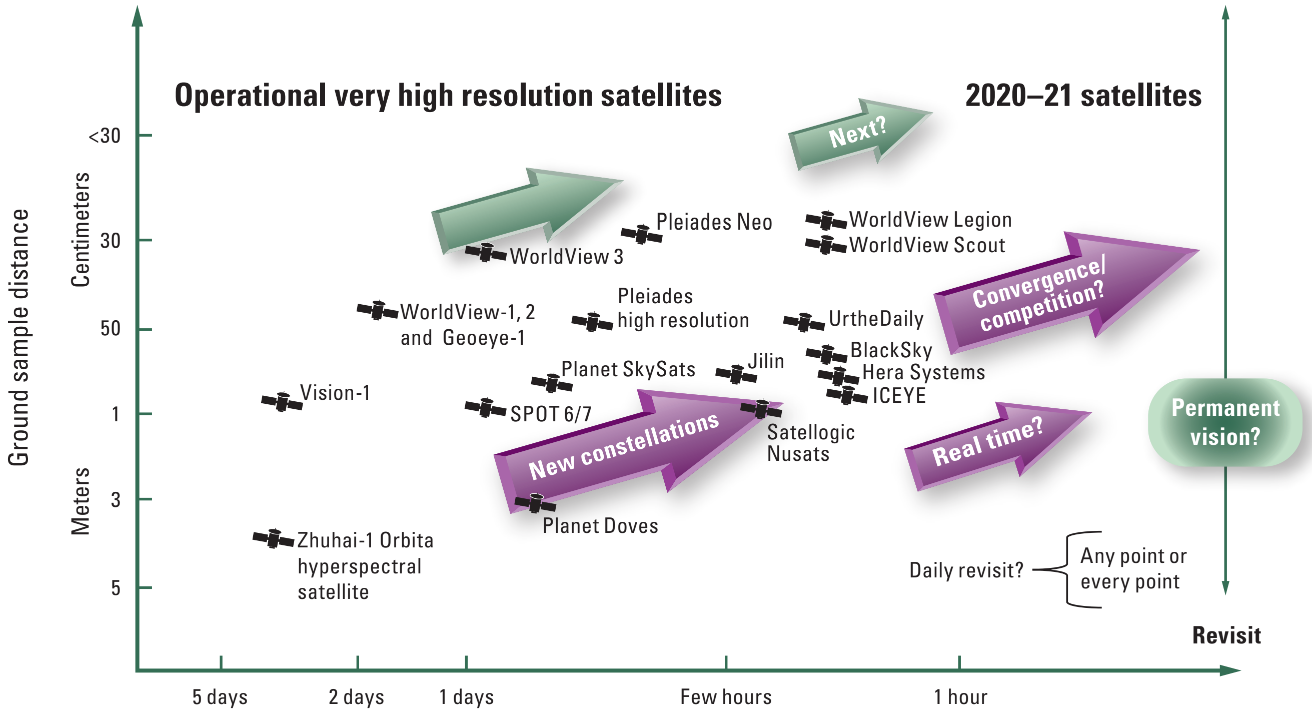


Figure 15. Trends in commercial imagery: two strategies showing resolution versus revisit (modified from Denis and others, 2017).

that goal with improved revisits and improved ground sample distance. EO data delivery through laser links is increasing. Airbus DS has partnered with ESA to develop the SpaceDataHighway, a system enabling users to transfer data from their low Earth orbit platforms through laser communications via the European Data Relay Satellites. Maxar, with its Global Enhanced GEOINT Delivery platform, claims to be able to deliver the data in less than 18 hours, and in less time for high priority locations (DigitalGlobe, 2016). The future satellite constellations BlackSky, WorldView Legion, and others are planning to operate agile satellites capable of revisiting any point on Earth multiple times per day. Although the current EO market demand is imaging targeted locations, the need and drive to image every location on Earth in very high temporal, spatial, and spectral resolution is growing.

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ICEYE is a constellation of high resolution synthetic aperture radar (SAR) satellites. The radar image shows Galesnjak, a heart-shaped island in Croatia, taken by an ICEYE SAR satellite on February 8, 2020 (image from ICEYE, used with permission).

Geostationary Imagers for Earth Observation

Geostationary Imaging Satellites

EO satellites in geostationary orbits provide a unique vantage point to monitor and study Earth's resources. Orbiting the Earth at an altitude of 36,000 kilometers (km), the geostationary satellites appear fixed relative to the Earth's rotation, which allows them to continuously monitor a large area of interest at very high temporal resolution. However, because of the much greater distance from Earth, 50 times higher in altitude compared to a typical EO satellite, the spatial resolution achievable is much coarser (Christopherson and others, 2019). The near real-time data acquired by the geostationary EO satellites enable the study of Earth's land and oceans for monitoring hurricanes, storms, forest fires, agricultural features, and many other surface processes and dynamics.

The early images of Earth from geostationary orbit were taken by Application Technology Satellite-1 (known as "AST-1"), launched in 1966, and the Synchronous Meteorological Satellite series in the early 1970s. The first operational geostationary orbit imaging is attributed to the Geostationary Operational Environmental Satellite (GOES) series, started in 1975 by NOAA. The GOES series continues operating with its fourth generation of satellites in orbit. Following the United States, other space-faring nations also operated geostationary imaging satellites at the end of the 20th century. These early satellites carried imagers/sounders with very few spectral bands capable of imaging at very low ground resolutions (for example, Meteosat-1 with three bands in visible and infrared, 2,500/5,000 m, respectively). As the technology improved into the 21st century, geostationary imagers with more spectral bands and higher resolutions were developed (for example, GOES-17 with 16 bands in visible and infrared, 250/500/1,000 m).

Today, several international missions are being planned or currently flown in geostationary orbit with an advanced imager onboard (see table 3), including Russia's Electro-L series; Japan's Geostationary Meteorological Satellite series; Korea's Communication, Oceanography, and Meteorology Satellite (COMS) series; China's Fengyun series; the Indian National Satellite System series; and the ESA's Meteosat (second generation/third generation) series (Schmit and others, 2018). The orbit positions of current operational geostationary imagers are shown in figure 16. Most of these satellites carry a 10–16 spectral band imager in the visible and infrared region of the spectrum with varying ground resolutions ranging from 250 to 8,000 meters (m).

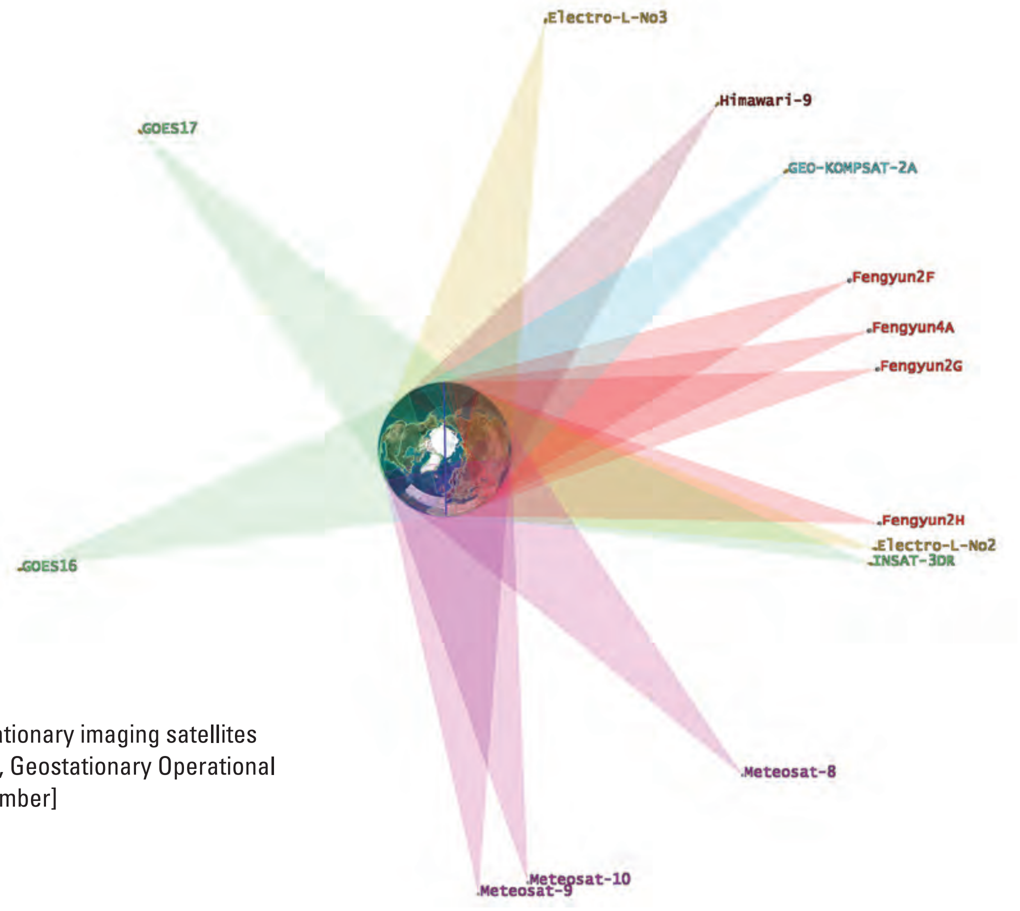

Figure 16. Operational geostationary imaging satellites (2020) form a "georing." [GOES, Geostationary Operational Environmental Satellite; No, number]

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The advanced imagers on the operational satellites in geostationary orbit around the world represent a major technological advancement in environmental and meteorological remote sensing (table 3; Schmit and others, 2018). They form the space-based infrastructure to provide data for the WMO Integrated Global Observing System to facilitate the production of weather and climate services and products for agriculture and food security, disaster risk reduction, energy, health, and water (WMO, 2020).

Geostationary Sensors for Earth Observation

The geostationary imagers on the previously mentioned satellites (table 3) have improved spectral and spatial characteristics from their legacy geostationary orbit imagers. These advanced geostationary orbit imagers collect data over more than two-thirds of the Earth's surface at high temporal frequencies and spectral resolutions by forming a "georing" (Kalluri and others, 2019). The capabilities of each of these sensing elements are discussed below and shown in figure 17.

Advanced Baseline Imager

The Advanced Baseline Imager (ABI), the primary sensor on the GOES-R series, is an improved version of its predecessor flown on the previous generation of GOES satellites. The ABI instrument views Earth in 16 spectral bands and provides three times more spectral information, four times the spatial resolution, and five times greater temporal coverage than previous GOES imagers. Schmit and others (2018) point out that the improvements in spatial, spectral, and temporal resolutions and improved navigation and registration, dynamic range, and calibration in the ABI imager have resulted in the improvement of data quality by 100 times compared to the legacy GOES imager.

The ABI instrument captures an image of the conterminous United States every 3 minutes and the entire Earth's disk every 12 minutes. This instrument is hosted on two satellites currently being flown, GOES-16 and GOES-17, and two more satellite, GOES-T and GOES-U, that are planned for launch in 2021 and 2024, respectively. ABI carries 2 visible, 4 near

Table 3. Details of currently operating operational geostationary imagers.

[GOES, Geostationary Operational Environmental Satellite; °, degree; W, west; NOAA, National Oceanic and Atmospheric Administration; NASA, National Aeronautics and Space Administration; ABI, Advanced Baseline Imager; E, east; EUMETSAT, European Organization for the Exploitation of Meteorological Satellites; ESA, European Space Agency; SEVIRI, Spinning Enhanced Visible and Infrared Imager; INSAT, Indian National Satellite System; ISRO, Indian Space Research Organisation; GOMS, Geostationary Operational Environmental Satellite; FY, Fengyun; CMA, China Meteorological Administration; S-VISSR, Stretched Visible and Infrared Spin Scan Radiometer; COMS, Communication, Oceanography, and Meteorology Satellite; AGRI, Advanced Geostationary Radiation Imager; KARI, Korea Aerospace Research Institute; KMA, Korea Meteorological Administration; GOCI, geostationary ocean color imager; MI, Meteo Imager; AMI, Advanced Meteorological Imager; JMA, Japan Meteorological Association; AHI, Advanced Himawari Imager]

Satellites	Sector/longitude	Operator	Launch date	Imager
GOES-17	East Pacific/137.2° W.	NOAA/NASA	03-01-2018	ABI
GOES-16	West Atlantic/75.2° W.	NOAA/NASA	11-19-2016	ABI
Meteosat-9	East Atlantic/3.5° E.	EUMETSAT/ESA	07-15-2015	SEVIRI
Meteosat-10	East Atlantic/9.5° E.	EUMETSAT/ESA	07-05-2012	SEVIRI
Meteosat-8	Indian Ocean/41.5° E.	EUMETSAT/ESA	09-15-2016	SEVIRI
INSAT-3DR	Indian Ocean/74° E.	ISRO	09-08-2016	INSAT Imager
Electro-L N2	Indian Ocean/76° E.	Roscosmos	12-11-2015	GOMS
FY-2H	Indian Ocean/79° E.	CMA	06-05-2018	S-VISSR
INSAT-3D	Indian Ocean/82° E.	ISRO	07-25-2013	INSAT Imager
FY-2G	Indian Ocean/99.5° E.	CMA	12-31-2014	S-VISSR
FY-4A	Indian Ocean/105° E.	CMA	12-10-2016	AGRI
FY-2F	West Pacific/112° E.	CMA	01-13-2012	S-VISSR
COMS	West Pacific/128.2° E.	KARI/KMA	06-26-2010	GOCI, MI
GEO-KOMPSAT-2A	West Pacific/128.2° E.	KARI/KMA	12-04-2018	AMI
GEO-KOMPSAT-2B	West Pacific/128.2° E.	KARI/KMA	02-18-2020	GOCI-II
Himawari-8	West Pacific/140.7° E.	JMA	10-07-2014	AHI
Himawari-9	West Pacific/140.7° E.	JMA	11-02-2016	AHI
Electro-L N3	Indian Ocean/165.8° E.	Roscosmos	12-24-2019	GOMS

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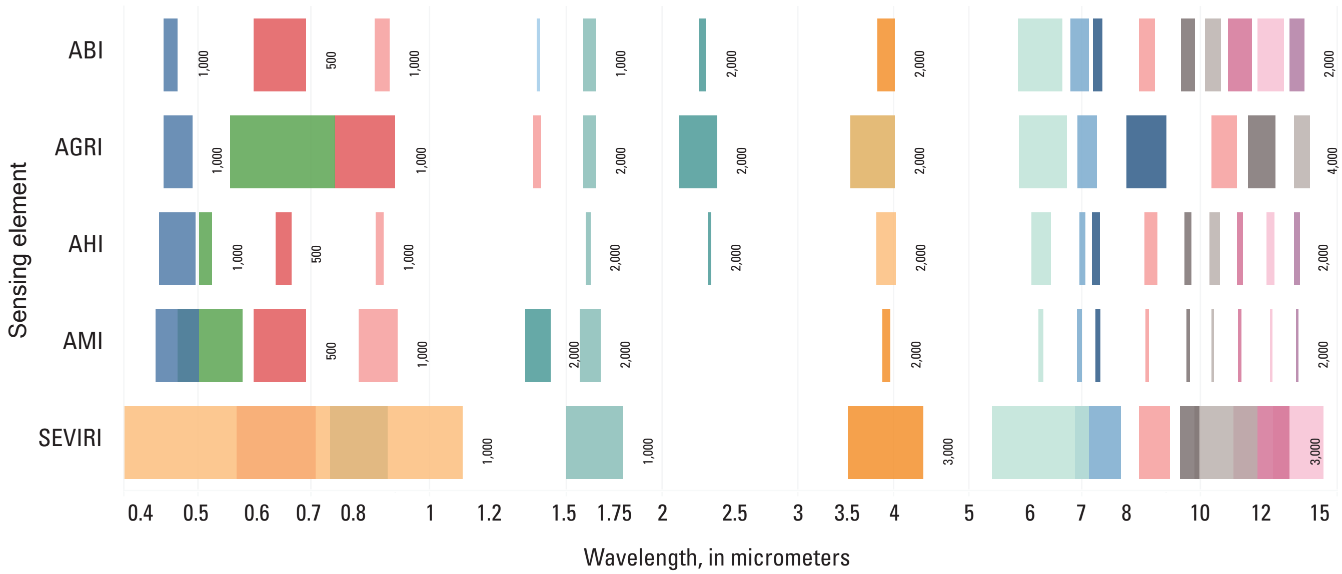

Figure 17. Spectral band and spatial information for the operational geostationary imagers.

infrared (near infrared and shortwave infrared), 1 midwave infrared, 3 water vapor, and 6 thermal infrared bands for a total of 16 spectral bands (Schmit and others, 2018).

Advanced Geosynchronous Radiation Imager

The Fengyun (FY)-4 is the next generation geostationary meteorological/imaging satellite series planned for operations by the China Meteorological Administration. The first experimental satellite, FY-4A, was launched in 2016 with the Advanced Geosynchronous Radiation Imager, which has 14 spectral bands, an improvement from 5 bands on the FY-2 satellite. The FY-4 operational series, with 18 spectral bands, is planned for launch starting in 2020 (Yang and others, 2017). The spatial resolution of the AGRI was also enhanced to provide improved and additional products.

Advanced Himawari Imager

The Advanced Himawari Imager (AHI) on Geostationary Meteorological Satellites, otherwise known as Himawari-8/9 satellites operated by the Japan Meteorological Agency, is comparable to the ABI instrument on GOES-R satellites. The AHI instrument does not carry a cirrus band like ABI but instead carries a green band to create false color images. AHI on Himawari 8/9 satellites can capture a fresh image of Earth's disk every 10 minutes and can revisit any sectored location every 2.5 minutes (Bessho and others, 2016).

Advanced Meteorological Imager

The GEO-KOMPSAT-2A is the operational satellite in the South Korean Meteorological series operated by the Korea Meteorological Administration. It carries the Advance Meteorological Imager (AMI) instrument with 16 spectral bands in visible and infrared regions collecting data at 1-km and 2-km resolutions at a subsatellite point. AMI can collect the full Earth's disk every 10 minutes (CEOS, 2016). The GEO-KOMPSAT-2B satellite carries a geostationary ocean color imager-II with 13 spectral bands and an improved resolution of 250 m.

Spinning Enhanced Visible and Infrared Imager

The Spinning Enhanced Visible and Infrared Imager (SEVIRI) is a 12-band line scanning radiometer onboard the Meteosat second generation series of satellites operated by the European Organization for the Exploitation of Meteorological Satellites. The SEVIRI instrument collects data in 2 visible and 10 infrared channels at a ground resolution of 1 km and 3 km, respectively. SEVIRI is an advanced imager that provides 20 times more data compared to the previous generation of imagers by capturing an image of Earth every 12.5 minutes (Schmid, 2000). The third generation of Meteosats will carry a Flexible Combined Imager (FCI) with 16 spectral bands and an improved spatial resolution of 500 m (European Organization for the Exploitation of Meteorological Satellites, 2020).

Geostationary Orbit Applications and Advantages

As described in the previous section, advanced geostationary imagers are multichannel visible and infrared radiometers built for meteorological purposes that also serve nonmeteorological applications including but not limited to agriculture, ecological, and forest fire monitoring (fig. 18; Kalluri and others, 2019). The geostationary orbit imagers ABI, AHI, and AMI were built by L3 Harris Technologies and are identical to one another except for minor differences in spectral bands. Each of the sensors has 16 spectral bands capable of imaging a ground resolution of 0.5–2 km. The Advanced Geostationary Radiation Imager, SEVIRI, and Flexible Combined Imager have similar ground resolutions to ABI but differ from ABI because they carry more spectral bands in visible and infrared regions. Some of the many applications made possible by fusing these geostationary orbit datasets are described in the CEOS report titled "Non-meteorological applications for Next Generation Geostationary Satellites" (CEOS, 2016).

It is important to note that most of the meteorological data are derived from the geostationary imagers, although the polar-orbiting sensors (that is, the Moderate Resolution Imaging Spectroradiometer) contribute to some key operational meteorological data. Factors such as greater area and fixed view area, higher temporal frequency, and hence, higher probability of cloud-free measurements make geostationary imagers advantageous to polar imagers. The ability of geostationary imagers to image the entire disk of the Earth in 15 minutes enables early detection of forest fires, storms, flash floods, and coastal upwelling (CEOS, 2016). The geostationary imagers used or planned to be used to derive atmospheric, ocean, and land products are listed in table 4. With the advanced technology, these geostationary imagers offer opportunities not only for meteorological purposes but also for several nonmeteorological applications. These sensors are expected to serve a wide variety of new applications across the world in the near future.

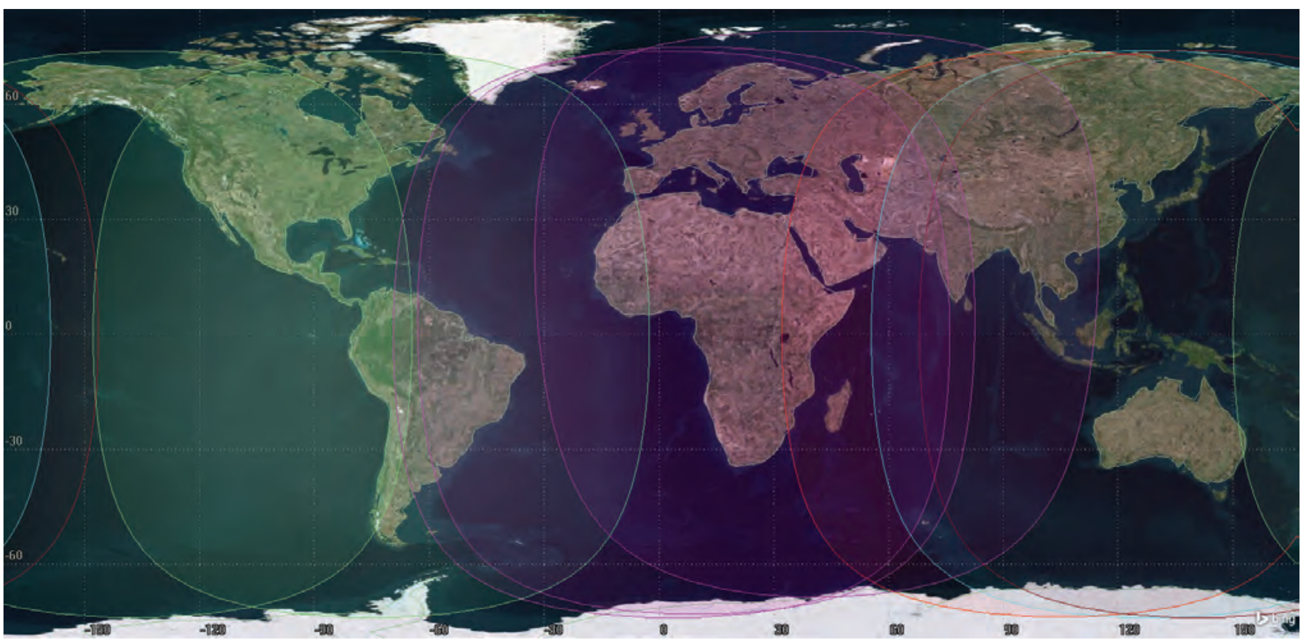

Figure 18. Spatial coverage from the advanced geostationary imagers.

Table 4. Parameters derived from advanced imagers (modified from Committee on Earth Observation Satellites, 2016).

[ABI, Advanced Baseline Imager; AHI, Advanced Himawari Imager; AMI, Advanced Meteorological Imager; AGRI, Advanced Geostationary Radiation Imager; FCI, Flexible Combined Imager; SEVIRI, Spinning Enhanced Visible and Infrared Imager; Y, yes; —, not applicable]

Geophysical parameter	ABI	AHI	AMI	AGRI	FCI	SEVIRI
Aerosol optical depth	Y	Y	Y	Y	Y	—
Dust/smoke	Y	—	Y	Y	Y	Y
Volcanic ash	Y	Y	Y	—	Y	Y
Sea surface temperature	Y	Y	Y	Y	—	—
Fires	Y	Y	Y	Y	Y	Y
Vegetation index	Y	Y	Y	—	—	—
Snow cover	Y	Y	Y	—	—	—

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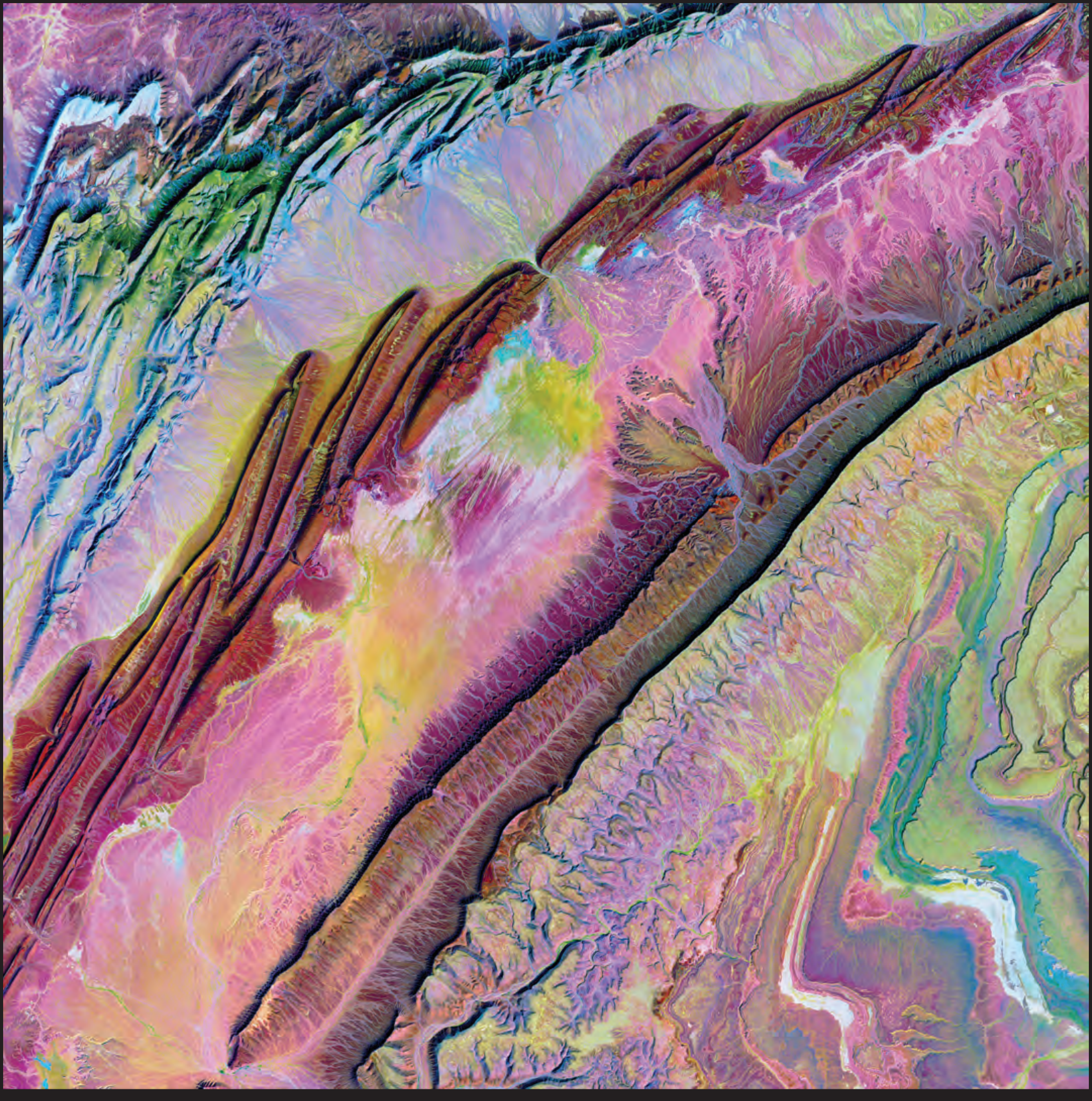
Schmid, J., 2000, The SEVIRI instrument—Proceedings of the 2000 EUMETSAT Meteorological Satellite, May 29–June 2, 2000: Darmstadt, Germany, EUMETSAT, p. 13–32.

Schmit, T.J., Lindstrom, S.S., Gerth, J.J., and Gunshor, M.M., 2018, Applications of the 16 spectral bands on the Advanced Baseline Imager (ABI): Journal of Operational Meteorology, v. 6, no. 4, p. 33–46. [Also available at https://doi.org/10.15191/nwajom.2018.0604.]

World Meteorological Organization [WMO], 2020, WMO Integrated Global Observing System (WIGOS): WMO web page, accessed April 2020 at https://public.wmo.int/en/about-us/vision-and-mission/wmo-integrated-global-observing-system.

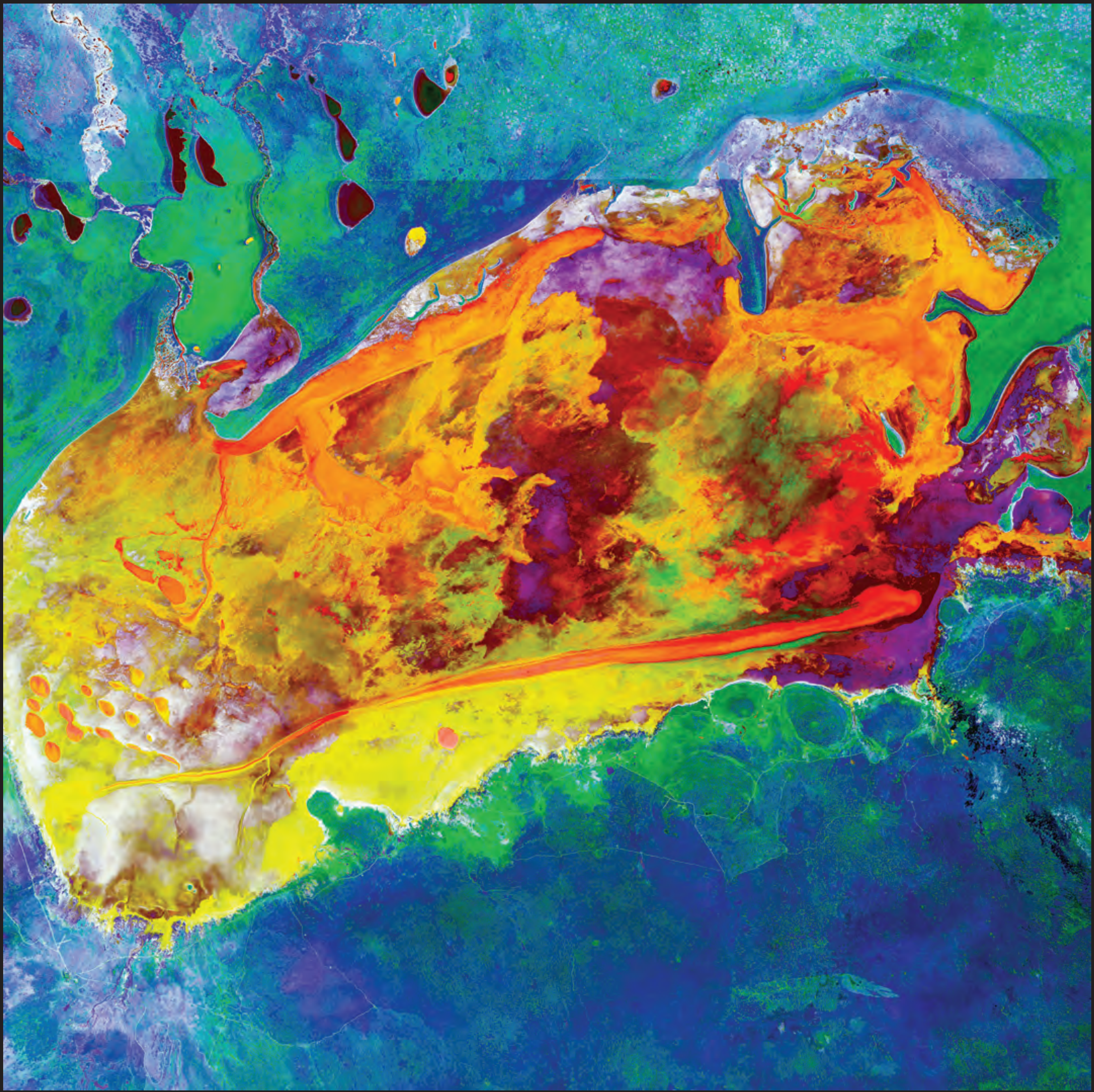
Yang, J., Zhang, Z., Wei, C., Lu, F., and Guo, Q., 2017, Introducing the new generation of Chinese geostationary weather satellites, Fengyun-4: Bulletin of the American Meteorological Society, v. 98, p. 1637–1658. [Also available at https://doi.org/10.1175/BAMS-D-16-0065.1.]

Rock folding on a tectonic scale occurred in northwestern Africa. These motley ribbons dancing across the desert in Morocco are folds caused by the prolonged collision of tectonic plates. The long continuous line is Jbel Ouarkziz, a ridge that rises 200–300 meters above the valley floors (image from U.S. Geological Survey, accessed February 6, 2019).



Appendix 1. References Cited

A vast, open expanse in Namibia is one of the largest salt pans in the world. The pan is within Etosha National Park, protected since 1907. The horizontal line across the image is the national park fence. The wild patterns in this infrared interpretation are from numerous episodes of water evaporation following seasonal rains. The salt from the water is rearranged into new patterns every time the shallow water dries out. The surrounding blue shades are dry bushland savanna (image from the U.S. Geological Survey, accessed April 4, 2014).



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Appendix 1. References Cited

Many different data sources were used in the process of assembling this compendium. We attempt to provide the best data available at the present time. These data sources at times provided conflicting information; in such circumstances, we attempted to contact mission organizers to provide the best information available. Information obtained directly from the satellite manufacturer or associated space agency, when available, was given precedence over other sources. Several satellites—particularly those still under development or from less established space agencies—had little public information. Fields of the data sheets in appendix 4 with a "—" indicate unknown information. Listed below are frequently used space mission resources.

Space Mission Resources

Bryce Space and Technology, 2020, Reports: Bryce Space and Technology web page, accessed June 2020 at https://brycetech.com/reports.

Committee on Earth Observation Satellites, 2020a, CEOS Visualization Environment (COVE)—Harnessing the power of satellite data: Committee on Earth Observation Satellites web page, accessed June 2020 at https://ceos-cove.org/en/.

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Appendix 2. Additional Resources

Most of the water in Lake Balkhash comes from the Ili River, which pours in through the southeastern shore. The expansive delta and estuary—still dark brown in this image thanks to Central Asia's harsh winters—is nevertheless an oasis for life year round. Hundreds of plant and animal species make a home here, including dozens that are threatened or endangered (NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey; story by Adam Voiland. Image acquired by Landsat 8 on March 7, 2020).

Appendix 2. Additional Resources

The following references provide useful information related to usage of satellite remote sensing data. The various resources aid users in visualizing data and understanding orbit coincidence and spectral response of instruments and remote sensing data training options. All hyperlinks are continuously updated by their respective owners and were active as of August 2020.

Remote Sensing Data Resources

Acta Astronautica—This journal, sponsored by the International Academy of Astronautics, provides original contributions in the fields of engineering, life, social space sciences and space technology. [Available at https://www.journals.elsevier.com/acta-astronautica.]

Copernicus Open Access Hub—This portal provides complete, free, and open access to Sentinel-1, Sentinel-2, Sentinel-3, and Sentinel-5P user products. [Available at https://scihub.copernicus.eu/.]

Group on Earth Observations (GEO) Global Earth Observation System of Systems (GEOSS) Portal—The international GEOSS Portal is an online tool for users to find and access various satellite, airborne, drone, and in situ remote sensing datasets. [Available at https://www.geoportal.org/.]

Landsat Spectral Characteristics Viewer—This website allows users to investigate various optical imager satellite sensor spectral response functions and links to spectral library options. [Available at https://landsat.usgs.gov/spectral-characteristics-viewer.]

National Aeronautics and Space Administration (NASA) Applied Remote Sensing Training—This resource offers various education and training programs to familiarize users with various remote sensing data capabilities. [Available at https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing/.]

NASA EarthData—A website aimed at helping users find, visualize, and get started with various Earth science and remote sensing data. [Available at https://earthdata.nasa.gov/.]

United Nations Biodiversity Lab—This resource provides a central location for many diverse remote sensing datasets with the aim to facilitate data viewing and analysis. [Available at https://www.unbiodiversitylab.org/.]

World Metrological Organization (WMO) Coordination Group for Meteorological Satellites (CGMS) Virtual Laboratory—The WMO CGMS offers the Virtual Laboratory for Training and Education in Satellite Meteorology to provide training in the successful use of remote sensing data. [Available at http://www.wmo-sat.info/vlab/.]

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Appendix 3. Recent and Future Launches of Government and Commercial Satellites

Indian Space Research Organization's (ISRO's) Polar Satellite Launch Vehicle C-37 rocket carrying 104 satellites marks the launch of record number of satellites. Out of 104 satellites, 3 were owned by ISRO and the remaining 101 copassenger satellites carried were international customer satellites from the United States (96), the Netherlands (1), Switzerland (1), Israel (1), Kazakhstan (1) and United Arab Emirates (1). Planet's Flock-3p, containing 88 satellites, was launched on this rocket (image from ISRO, used with permission).

Appendix 3. Recent and Future Launches of Government and Commercial Satellites

Table 3.1 Earth observation satellite launches of 2019.

[U.S., United States; Inc., Incorporated; RISAT, Radar Imaging Satellite; HR, High Resolution; RCM, RADARSAT Constellation Mission; OHS, Orbita hyperspectral satellite; OVS, Orbita video satellite; SRSS, Sudan Remote Sensing Satellite; GF, Gaofen; ISS-HISUI, International Space Station Hyperspectral Imager Suite; 1HOPSat TD, first generation High Optical Performance Satellite Technical Demonstrator; SAR, synthetic aperture radar; CSG, COSMO-SkyMed second generation; CBERS, China–Brazil Earth Resources Satellite; ETRSS, Ethiopia Remote Sensing Satellite; No., Number]

Launch date	Spacecraft	Instrument type	Country/owner	User
01/21/2019	Jilin-1 Spectrum-01	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
01/21/2019	Jilin-1 Spectrum-02	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
01/21/2019	Lingque 1A	Optical imager	China/ZeroG Lab	Commercial
01/24/2019	Microsat-R	Optical imager	India	Government/civil
02/21/2019	Egyptsat-A	Optical imager	Egypt	Government/civil
03/21/2019	PRISMA	Optical imager	Italy	Government/civil
03/27/2019	Lingque 1B	Optical imager	China/ZeroG Lab	Commercial
04/01/2019	Flock-4a (20)	Optical imager	U.S./Planet, Inc.	Commercial
04/29/2019	Tianhui II-01	Optical imager	China	Government/civil
04/29/2019	Tianhui II-02	Optical imager	China	Government/civil
05/22/2019	RISAT-2B	Synthetic aperture radar	India	Government/civil
06/05/2019	Bufeng-1A	Radar	China	Government/civil
06/05/2019	Bufeng-1B	Radar	China	Government/civil
06/05/2019	Jilin-1 HR 03A	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
06/12/2019	RCM-1	Synthetic aperture radar	Canada	Government/civil
06/12/2019	RCM-2	Synthetic aperture radar	Canada	Government/civil
06/12/2019	RCM-3	Synthetic aperture radar	Canada	Government/civil
06/29/2019	BlackSky Global-3	Optical imager	U.S./BlackSky Global	Commercial
07/05/2019	ICEYE-X4	Synthetic aperture radar	Finland/ICEYE	Commercial
07/05/2019	ICEYE-X5	Synthetic aperture radar	Finland/ICEYE	Commercial
08/17/2019	Xingshidai-5	Optical imager	China/Guoxing Aerospace Technology	Commercial
08/18/2019	BlackSky Global-4	Optical imager	U.S./BlackSky Global	Commercial
09/12/2019	Ice Pathfinder	Optical imager	China	Government/civil
09/12/2019	Zi Yuan-1-02D	Optical imager	China	Commercial
09/19/2019	Zhuhai-1 OHS-3A	Optical imager	China/Zhuhai Orbita Control Engineering Company, Ltd.	Commercial

Table 3.1 Earth observation satellite launches of 2019.—Continued

[U.S., United States; Inc., Incorporated; RISAT, Radar Imaging Satellite; HR, High Resolution; RCM, RADARSAT Constellation Mission; OHS, Orbita hyperspectral satellite; OVS, Orbita video satellite; SRSS, Sudan Remote Sensing Satellite; GF, Gaofen; ISS-HISUI, International Space Station Hyperspectral Imager Suite; 1HOPSat TD, first generation High Optical Performance Satellite Technical Demonstrator; SAR, synthetic aperture radar; CSG, COSMO-SkyMed second generation; CBERS, China–Brazil Earth Resources Satellite; ETRSS, Ethiopia Remote Sensing Satellite; No., Number]

Launch date	Spacecraft	Instrument type	Country/owner	User
09/19/2019	Zhuhai-1 OHS-3B	Optical imager	China/Zhuhai Orbita Control Engineering Company, Ltd.	Commercial
09/19/2019	Zhuhai-1 OHS-3C	Optical imager	China/Zhuhai Orbita Control Engineering Company, Ltd.	Commercial
09/19/2019	Zhuhai-1 OHS-3D	Optical imager	China/Zhuhai Orbita Control Engineering Company, Ltd.	Commercial
09/19/2019	Zhuhai-1 OVS-3A	Optical imager	China/Zhuhai Orbita Control Engineering Company, Ltd.	Commercial
09/25/2019	Yunhai-1 02	Optical imager	China	Government/civil
10/04/2019	Gaofen 10R	Optical imager	China	Government/civil
10/16/2019	Palisade	Optical imager	U.S./Astro Digital, Inc.	Commercial
11/03/2019	Gaofen-7	Optical imager	China	Government/civil
11/03/2019	SRSS-1	Optical imager	Sudan	Government/civil
11/03/2019	Huangpu-1	Optical imager	China	Government/civil
11/12/2019	Jilin-1 GF-02A	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
11/12/2019	Ningxia-1 (5)	Optical imager	China/Ningxia Jingui Information Technology Company, Ltd.	Commercial
11/27/2019	Cartosat-3	Optical imager	India	Government/civil
11/27/2019	Flock-4p (12)	Optical imager	U.S./Planet, Inc.	Commercial
11/28/2019	Gaofen-12	Synthetic aperture radar	China	Government/civil
12/05/2019	ISS-HISUI	Optical imager	Japan	Government/civil
12/07/2019	Jilin-1 GF-02B	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
12/07/2019	Spacety 16	Optical imager	China/Spacety, Inc.	Commercial
12/07/2019	Spacety 17	Optical imager	China/Spacety, Inc.	Commercial
12/11/2019	RISAT-2BR1	Synthetic aperture radar	India	Government/civil
12/11/2019	1HOPSat TD	Optical Imager	U.S./Hera Systems	Commercial
12/11/2019	QPS-SAR1	Synthetic aperture radar	Japan/QPS, Inc.	Commercial
12/18/2019	CSG-1	Synthetic aperture radar	Italy	Government/civil
12/20/2019	CBERS-4A	Optical imager	China	Government/civil
12/20/2019	CBERS-4A	Optical imager	Brazil	Government/civil
12/20/2019	ETRSS-1	Optical imager	Ethiopia	Government/civil
12/24/2019	Electro-L No. 3	Optical imager	Russia	Government/civil

Table 3.2 Earth observation satellite launches of 2020 and beyond.

[U.S., United States; ALOS, Advanced Land Observing Satellite; JAXA, Japan Aerospace Exploration Agency; EROS, Earth Resources Observation Satellite; IAI, Israel Aerospace Industries; RISAT, Radar Imaging Satellite; ESA, European Space Agency; Airbus DS, Airbus Defence and Space; EnMAP, Environmental Mapping and Analysis Program; SAOCOM, Satélite Argentino de Observación Con Microondas; CSG, COSMO-SkyMed second generation; JPSS, Joint Polar Satellite System; CBERS, China–Brazil Earth Resources Satellite; HRSAT, High Resolution Satellite; SWOT, Surface Water and Ocean Topography; NISAR, National Aeronautics and Space Administration-Indian Space Research Organisation Synthetic Aperture Radar; PACE, Plankton, Aerosol, Cloud, and ocean Ecosystem; ISS EMIT, International Space Station Earth Surface Mineral Dust Source Investigation; SHALOM, Spaceborne Hyperspectral Applicative Land and Ocean Mission; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; FLEX, FLuorescence EXplorer; CLARREO, Climate Absolute Radiance and Refractivity Observatory; NASA, National Aeronautics and Space Administration; TRISHNA, Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment; CHIME, Canadian Hydrogen Intensity Mapping Experiment; No., Number; LSTM, Land Surface Temperature Monitoring; CIMR, Copernicus Imaging Microwave Radiometer; SBG, Surface Biology and Geology]

Launch date	Spacecraft	Instrument type	Country/owner	User
01/15/2020	Jilin-1 Kuanfu-01	Optical imager	China	Commercial
01/15/2020	Nusat-7	Optical imager	Argentina	Commercial
01/15/2020	Nusat-8	Optical imager	Argentina	Commercial
02/18/2020	Geo-KOMPSAT 2B	Optical imager	Japan	Government/civil
05/31/2020	Gaofen-9 02	Optical imager	China/Chang Guang Satellite Technology Company	Government/civil
06/10/2020	Haiyang-1D	Optical imager	China	Government/civil
06/13/2020	SkySat-16	Optical imager	U.S./Planet Inc.	Commercial
06/13/2020	SkySat-17	Optical imager	U.S./Planet Inc.	Commercial
06/13/2020	SkySat-18	Optical imager	U.S./Planet Inc.	Commercial
06/17/2020	Gaofen-9 03	Optical imager	China	Government/civil
07/03/2020	Gaofen Duomo	Optical imager	China	Commercial
07/10/2020	Jilin-1 GF-02E	Optical imager	China/Chang Guang Satellite Technology Company	Commercial
07/25/2020	Zi Yuan-3-03	Optical imager	China	Civil/commercial
08/06/2020	Gaofen-9 04	Optical imager	China	Government/civil
08/07/2020	BlackSky Global-7 and 8	Optical imager	U.S./BlackSky Global	Commercial
08/07/2020	Gaofen-9 05	Optical imager	China	Government/civil
08/18/2020	SkySats-19 to 21	Optical imager	U.S./Planet Inc.	Commercial
08/28/2020	SAOCOM 1B	Synthetic aperture radar	Argentina	Government/civil
08/29/2020	Sequoia	Synthetic aperture radar	U.S./Capella Space	Commercial
2020	Landmapper-BC 5 and 6	Optical imager	U.S./Astro Digital	Commercial
2020	Nusat-6	Optical imager	Argentina/Satellogic	Commercial
2020	Ingenio	Optical imager	Spain	Government/civil
2020	Nusat-9 to 21	Optical imager	Argentina/Satellogic	Commercial
2020	ALOS-3	Optical imager	Japan	Government/civil
2020	Hai Yang 2C	Altimeter/microwave imager	China	Government/civil

Table 3.2 Earth observation satellite launches of 2020 and beyond.—Continued

[U.S., United States; ALOS, Advanced Land Observing Satellite; JAXA, Japan Aerospace Exploration Agency; EROS, Earth Resources Observation Satellite; IAI, Israel Aerospace Industries; RISAT, Radar Imaging Satellite; ESA, European Space Agency; Airbus DS, Airbus Defence and Space; EnMAP, Environmental Mapping and Analysis Program; SAOCOM, Satélite Argentino de Observación Con Microondas; CSG, COSMO-SkyMed second generation; JPSS, Joint Polar Satellite System; CBERS, China–Brazil Earth Resources Satellite; HRSAT, High Resolution Satellite; SWOT, Surface Water and Ocean Topography; NISAR, National Aeronautics and Space Administration-Indian Space Research Organisation Synthetic Aperture Radar; PACE, Plankton, Aerosol, Cloud, and ocean Ecosystem; ISS EMIT, International Space Station Earth Surface Mineral Dust Source Investigation; SHALOM, Spaceborne Hyperspectral Applicative Land and Ocean Mission; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; FLEX, FLuorescence EXplorer; CLARREO, Climate Absolute Radiance and Refractivity Observatory; NASA, National Aeronautics and Space Administration; TRISHNA, Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment; CHIME, Canadian Hydrogen Intensity Mapping Experiment; No., Number; LSTM, Land Surface Temperature Monitoring; CIMR, Copernicus Imaging Microwave Radiometer; SBG, Surface Biology and Geology]

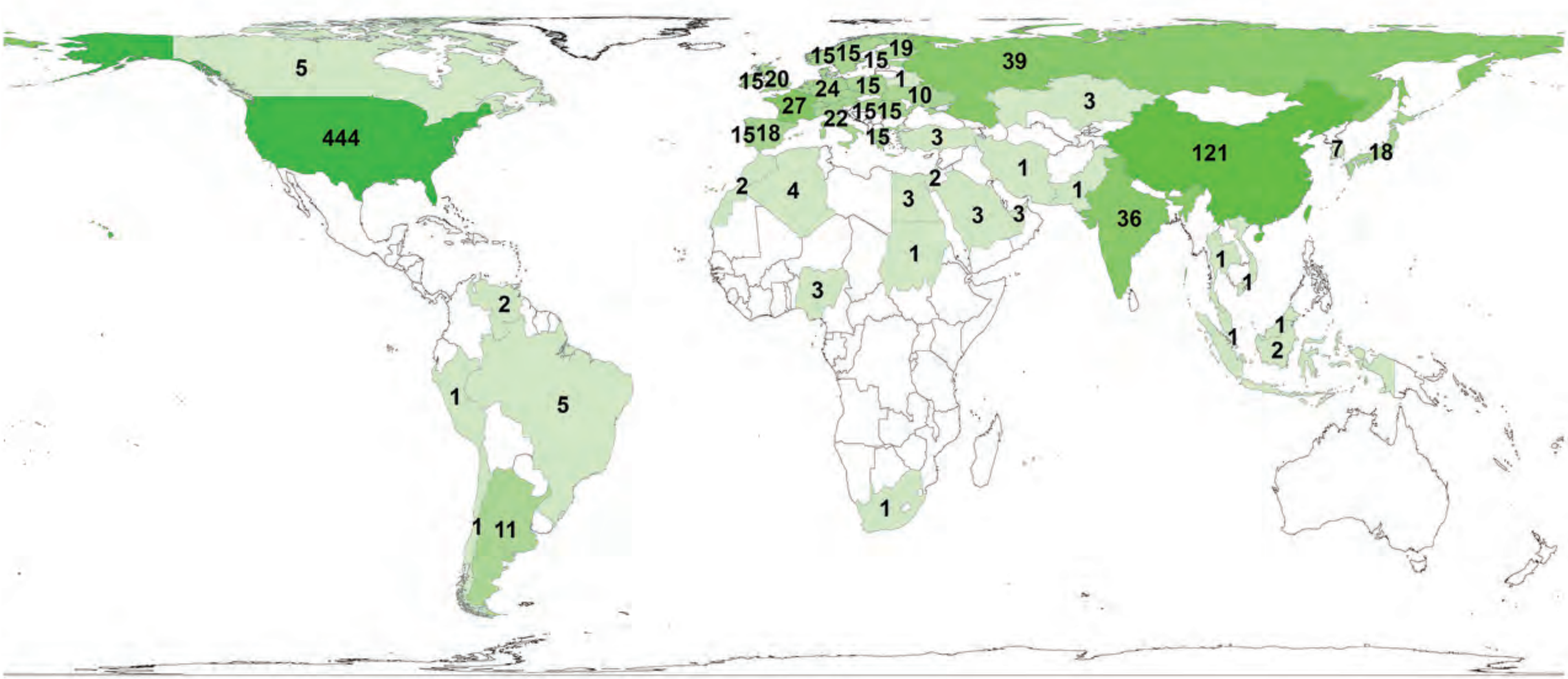
Launch date	Spacecraft	Instrument type	Country/owner	User
2020	Strix-Alpha	Synthetic aperture radar	Japan/Synspective Inc.	Commercial
2020	EROS-C	Optical imager	Israel/IAI	Commercial
2020	OceanSat-3/3A	Optical imager	India	Government/civil
2020	RISAT-1A	Synthetic aperture radar	India	Government/civil
2020	Flock—Superdoves	Optical imager	U.S./Planet	Government/civil
2020	Sentinel-6A	Altimeter	ESA	Government/civil
2020	Pléiades Neo-1/2	Optical imager	France/Airbus DS	Commercial
2020	TELEOS-2	Optical imager	Singapore	Government/civil
2020	EnMAP	Optical imager	Germany	Government/civil
2021	CSG-2	Synthetic aperture radar	Italy	Government/civil
2021	Pléiades Neo-3/4	Optical imager	France/Airbus DS	Commercial
2021	WorldView Scout Constellation	Optical imager	U.S./Maxar	Commercial
2021	RISAT-1B	Synthetic aperture radar	India	Government/civil
2021	WorldView Legion Constellation	Optical imager	U.S./Maxar	Commercial
2021	Landsat-9	Optical imager	U.S.	Government/civil
2021	JPSS-2	Optical imager	U.S.	Government/civil
2021	Kompsat-6	Synthetic aperture radar	Republic of Korea	Government/civil
2021	CARTOSAT-3A	Optical imager	India	Government/civil
2021	Hai Yang 3A	Synthetic aperture radar	China	Government/civil
2021	ALOS-4	Synthetic aperture radar	Japan	Government/civil
2021	Resourcesat 3S	Optical imager	India	Government/civil
2021	Sentinel-2C	Optical imager	ESA	Government/civil
2021	Sentinel-3C	Optical imager	ESA	Government/civil
2021	CBERS-5	Optical imager	China, Brazil	Government/civil
2021	Resurs-P N4	Optical imager	Russia	Government/civil
2021	Sentinel-1C	Synthetic aperture radar	ESA	Government/civil

Table 3.2 Earth observation satellite launches of 2020 and beyond.—Continued

[U.S., United States; ALOS, Advanced Land Observing Satellite; JAXA, Japan Aerospace Exploration Agency; EROS, Earth Resources Observation Satellite; IAI, Israel Aerospace Industries; RISAT, Radar Imaging Satellite; ESA, European Space Agency; Airbus DS, Airbus Defence and Space; EnMAP, Environmental Mapping and Analysis Program; SAOCOM, Satélite Argentino de Observación Con Microondas; CSG, COSMO-SkyMed second generation; JPSS, Joint Polar Satellite System; CBERS, China–Brazil Earth Resources Satellite; HRSAT, High Resolution Satellite; SWOT, Surface Water and Ocean Topography; NISAR, National Aeronautics and Space Administration-Indian Space Research Organisation Synthetic Aperture Radar; PACE, Plankton, Aerosol, Cloud, and ocean Ecosystem; ISS EMIT, International Space Station Earth Surface Mineral Dust Source Investigation; SHALOM, Spaceborne Hyperspectral Applicative Land and Ocean Mission; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; FLEX, FLuorescence EXplorer; CLARREO, Climate Absolute Radiance and Refractivity Observatory; NASA, National Aeronautics and Space Administration; TRISHNA, Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment; CHIME, Canadian Hydrogen Intensity Mapping Experiment; No., Number; LSTM, Land Surface Temperature Monitoring; CIMR, Copernicus Imaging Microwave Radiometer; SBG, Surface Biology and Geology]

Launch date	Spacecraft	Instrument type	Country/owner	User
2021	Kompsat-7	Optical imager	Republic of Korea	Government/civil
2021	HRSAT	Optical imager	India	Government/civil
2021	SWOT	Radar	U.S.	Government/civil
2021	NISAR	Synthetic aperture radar	India/U.S.	Government/civil
2022	PACE	Optical imager	U.S.	Government/civil
2022	ISS EMIT	Optical imager	U.S.	Government/civil
2022	SHALOM	Optical imager	Italy/Israel	Government/civil
2022	Resurs-P N5	Optical imager	Russia	Government/civil
2022	SABIA-Mar 1	Optical imager	Argentina/Brazil	Government/civil
2022	FLEX	Optical imager	ESA	Government/civil
2022	CLARREO Pathfinder	Optical imager	U.S.	Government/civil
2022	Tandem-L	Synthetic aperture radar	Germany	Government/civil
2022	Biomass	Synthetic aperture radar	ESA	Government/civil
2023	Sentinel-1D	Synthetic aperture radar	ESA	Government/civil
2023	Sentinel-2D	Optical imager	ESA	Government/civil
2023	Sentinel-3D	Optical imager	ESA	Government/civil
2024	TRISHNA	Optical imager	France/India	Government/civil
2023	Sentinel-6B	Optical imager	ESA	Government/civil
2026	CHIME	Optical imager	ESA	Government/civil
2025	Kanopus-V No.7/8	Optical imager	Russia	Government/civil
2025	LSTM	Optical imager	ESA	Government/civil
2026	CIMR	Optical imager	ESA	Government/civil
2027	SBG	Optical imager	U.S.	Government/civil

JACIE



Map showing countries with Earth observing satellites with numbers launched.

JACIE

Appendix 4. Remote Sensing Satellite Data Sheets

On June 13, 2020, SpaceX launched a set of 58 Starlink satellites and 3 Planet Skysats to orbit via a Falcon 9. Mere minutes later, the Falcon 9 rocket then successfully descended tail-first and landed on the SpaceX offshore drone ship, "Of Course I Still Love You" using a single engine (image licensed under the Creative Commons Attribution-Noncommercial 2.0 Generic license).

1HOPSat

United States
Commercial
Future

JACIE

Platform Overview

Hera System's first-generation High Optical Performance Satellites (1HOPSat) are high-resolution, multispectral satellites for monitoring change. The 1HOPSat satellites are being developed within the Hera Systems company, based in San Jose, California. The 1HOPSat satellites are based on a 12U cubesat envelope. Their high-altitude airborne testing program is scheduled to begin late 2018 with initial launches to follow in 2019. The constellation is designed to consist of 50 satellites. With broad daily coverage, the constellation is proposed to enable data-purchasing organizations to monitor Earth changes at any location on the globe. The first satellite in the constellation, 1HOPSAT Technology Demonstration, was launched in 2019 onboard a LauncherOne rocket from Cape Canaveral. The next batch of eight satellites are planned for launch starting November 2020.

[Abbreviations in tables: km, kilometer; —, no data; GSD, ground sample distance; m, meter]

Launch date	12/11/2019
Design lifetime	0.5 year
Platform owner	Hera Systems
Altitude	500 km
Orbit period	—
Inclination	41–45 degrees
Crossing time	—
Nadir repeat	—
Status	Operational
System website	http://www.herasys.com/

Artistic rendering of 1HOPSat in orbit (image from Hera Systems Inc., 2019, used with permission).

Sensor Information

	1HOPSat Imager
GSD (m)	1
Swath (km)	—
Data portal	—

1HOPSat Imager

The imager aboard the 1HOPSat satellites will provide 1-meter (m) ground sample distance (GSD) imagery with 8 bands. The 1-m GSD imagery will be sold for $1.00 per square kilometer.

ALOS-2

Japan
Civil/Government
Operational

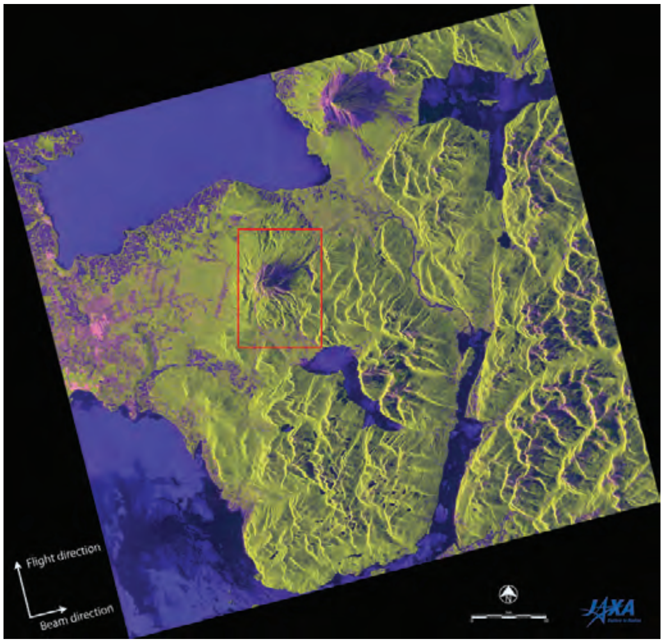
Platform Overview

Advanced Optical Satellite (ALOS)-2 is a follow-on Synthetic Aperture Radar (SAR) satellite of the ALOS mission launched in 2014 by the Japan Aerospace Exploration Agency (JAXA) on an H-IIA launch vehicle from Tanegashima Space Center for Earth resources monitoring. This is the second satellite in the ALOS mission. The ALOS-2 satellite was developed by Mitsubishi Electric Corporation (MELCO) for JAXA. It carries an advanced L-band radar to continue observations of the ALOS Phased Array type L-band SAR (PALSAR). While imaging with SAR, ALOS-2 uses a Compact Infrared Camera (CIRC) to aid the detection of wildfires.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; H, horizontal; V, vertical; TIR, thermal infrared]

Launch date	05/24/2014
Design lifetime	5 years
Platform owner	JAXA
Altitude	628 km
Orbit period	97.26 min
Inclination	97.9°
Crossing time	12:00 DN
Nadir repeat	14 days
Status	Operational
System website	http://www.eorc.jaxa.jp/ALOS-2/en/about/overview.htm

Artistic rendering of ALOS-2 in orbit (image from JAXA, used with permission).



PALSAR-2 image over Mt. Calbuco volcano region, Chile (image from JAXA, used with permission).

Sensor Information

	PALSAR	CIRC
GSD (m)	3–100 (selectable)	200
Swath (km)	25–350 (selectable)	—
Data portal	https://www.asf.alaska.edu/sar-data/palsar/	

ALOS-2—Continued

Japan
Civil/Government
Operational

PALSAR

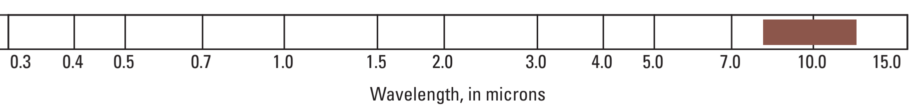
The Phases Array L-band Synthetic Aperture Radar-2 (PALSAR-2) is a proven design by MELCO used on ADEOS and ALOS-1. PALSAR-2 operates based on Active Array Phased Technology (APAA), allowing various observation modes in single, dual, full, and compact polarizations. PALSAR operates in the L-band with a selectable frequency of 1,236.5 megahertz (MHz) (λ = 24.2 centimeters [cm]), 1,257.5 MHz (λ = 23.8 cm), or 1,278.5 MHz (λ = 23.4 cm). The sensor can cover a wide range of incidence angles from 8 to 70 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight	Single	HH, HV, VV	25 x 25	3 x 1
Stripmap (ultra-fine)	Single	HH, HV, VV	50	3
	Dual	HH/HV, VV/VH		
Stripmap (high-sensitive)	Single	HH, HV, VV	50	6
	Dual	HH/HV, VV/VH		
	CP	Circular, 45° linear		
	Quad	HH/HV/VV/VH	30	
Stripmap (fine)	Single	HH, HV, VV	70	10
	Dual	HH/HV, VV/VH		
	CP	Circular, 45° linear		
	Quad	HH/HV/VV/VH	30	
ScanSAR	Single	HH, HV, VV	350	100
	Dual	HH/HV, VV/VH		

CIRC

The Compact Infrared Camera (CIRC) is a single band thermal infrared demonstration instrument of JAXA developed as a COTS product by MELCO. CIRC provides infrared imagery for wildfire detection. The resolution of CIRC is less than 200 meters at nadir.

Band	Lower	Center	Upper	GSD (m)
TIR	8.000	10.000	12.000	200



ALOS-3

Japan
Civil/Government
Future

Platform Overview

Advanced Optical Satellite (ALOS)-3 is an Earth-resource-monitoring high-resolution, hyper- and multispectral satellite of the ALOS series by the Japan Aerospace Exploration Agency (JAXA) planned for launch in 2020. This is the third satellite in the ALOS mission. The ALOS-3 satellite is being developed by Mitsubishi Electric Corporation (MELCO) for JAXA based on the ALOS-2 bus with some modifications. It carries an advanced Panchromatic Remote-Sensing Instrument for Stereo Mapping-2 (PRISM-2) and a Multispectral Imager (MSI) sensor for high- and medium-resolution land imaging, respectively.

Artistic rendering of ALOS-3 in orbit (image from JAXA, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; CA, coastal aerosol; NIR, near infrared]

Launch date	2020 (Planned)
Design lifetime	7 years
Platform owner	JAXA
Altitude	669 km
Orbit period	98.12 min
Inclination	98.06°
Crossing time	10:30 DN
Nadir repeat	35 days
Status	Development
System website	http://global.jaxa.jp/projects/sat/alos3/

Sensor Information

	PRISM-2	MSI
GSD (m)	0.8	3.2
Swath (km)	70	70
Data portal	—	

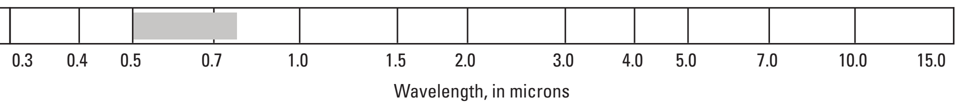
ALOS-3—Continued

Japan
Civil/Government
Future

PRISM-2

The PRISM-2 is a proven design by MELCO used on ALOS-1. The instrument will acquire stereo pair images from two telescopes for stereo mapping and digital surface models. PRISM-2 will be able to collect high-resolution images with high geolocation accuracy without ground control points. PRISM-2 data will be commercially available.

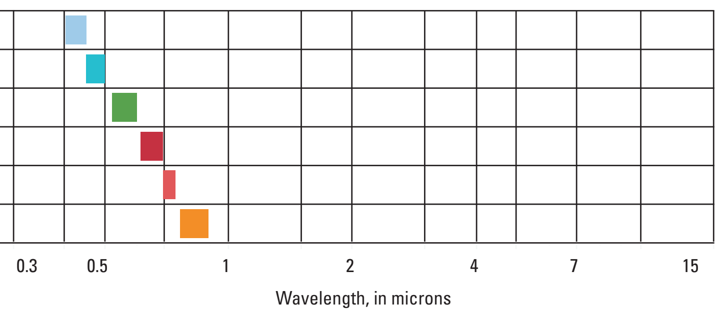
Band	Lower	Center	Upper	GSD (m)
Pan	0.500	0.635	0.770	0.8



MSI

The multispectral imager on ALOS-3 is being developed to operate in visible and near-infrared parts of the spectrum. ALOS-3's steerability of up to 60 degrees can help achieve a revisit of 1 day anywhere.

Band	Lower	Center	Upper	GSD (m)
CA	0.400	0.425	0.450	3.2
Blue	0.450	0.475	0.500	3.2
Green	0.520	0.560	0.600	3.2
Red	0.610	0.650	0.690	3.2
Red Edge	0.690	0.715	0.740	3.2
NIR	0.760	0.825	0.890	3.2

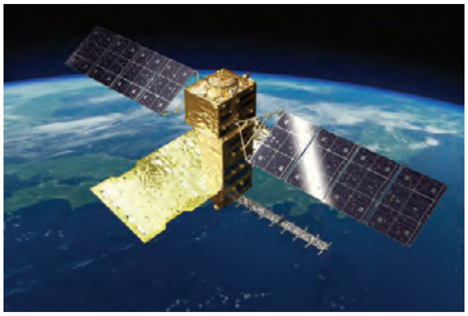


ALOS-4

Japan
Civil/Government
Future

Platform Overview

Advanced Optical Satellite (ALOS)-4 is a synthetic aperture radar (SAR) satellite under development by the Japan Aerospace Exploration Agency (JAXA) for Earth resources monitoring. It is the fourth satellite of the ALOS mission and is designed to replace ALOS-2. The ALOS-4 platform is being developed by Mitsubishi Electric Corporation (MELCO). ALOS-4 carries the Phased Array L-band Synthetic Aperture Radar-3 (PALSAR-3) instrument to continue observations of the ALOS PALSAR instruments. ALOS-4 will also carry a Space based Automatic Identification System Experiment (SPAISE3) receiver to monitor oceans for ships.



Artistic rendering of ALOS-4 in orbit (image from JAXA, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data]

Launch date	2022 (Planned)
Design lifetime	7 years
Platform owner	JAXA
Altitude	628 km
Orbit period	97.26 min
Inclination	97.9°
Crossing time	12:00 DN
Nadir repeat	14 days
Status	Development
System website	http://global.jaxa.jp/projects/sat/alos4/

Sensor Information

	PALSAR-3
GSD (m)	1–10 (selectable)
Swath (km)	35–700 (selectable)
Data portal	—

PALSAR-3

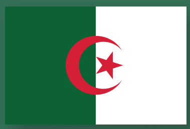
The PALSAR-3 instrument is a proven design by MELCO used on ADEOS, ALOS-1, and ALOS-2. PALSAR-3 uses Active Array Phased Technology, allowing various observation modes in single, dual, full, and compact polarizations. The instrument operates in the L-band, which has a center frequency of 1.5 gigahertz (λ = 20.0 centimeters). The angle of incidence is 8–70 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Stripmap	—	—	100–200	3, 6, 10
ScanSAR	—	—	700	25
Spotlight	—	—	35 x 35	1 x 3

JACIE

AlSat-1B

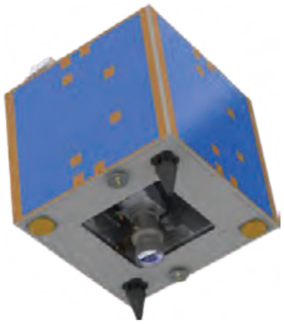
Algeria
Civil/Government
Operational



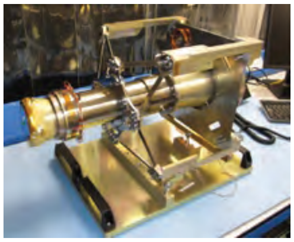
Platform Overview

Algeria Satellite-1B (AlSat-1B) is a medium-resolution, panchromatic, and multispectral microsatellite launched in 2016 on the Polar Satellite Launch Vehicle. Its primary mission is to ensure the continuity of the national coverage provided by AlSat-1 and the collective coverage of the Disaster Monitoring Constellation (DMC).

AlSat-1B was built by Surrey Satellite Technology Limited (SSTL) and the Algerian Space Agency (ASAL), with ASAL's engineers undertaking the integration and test phases in Algeria. The microsatellite is based on the SSTL-100 platform. VNIR imagery is captured at 24-meter (m) resolution by the Algerian Imager Telescope (ALITE) and is used by the Algerian Government.



Artistic rendering of AlSat-1B (image from ASAL, used with permission).



ALITE sensor model (image from ASAL, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

Launch date	09/26/2016
Design lifetime	5 years
Platform owner	ASAL
Altitude	690 km
Orbit period	97.7 min
Inclination	98.2°
Crossing time	10:30 AN
Nadir repeat	5 days
Status	Operational
System website	http://www.asal.dz/Alsat-1B.php

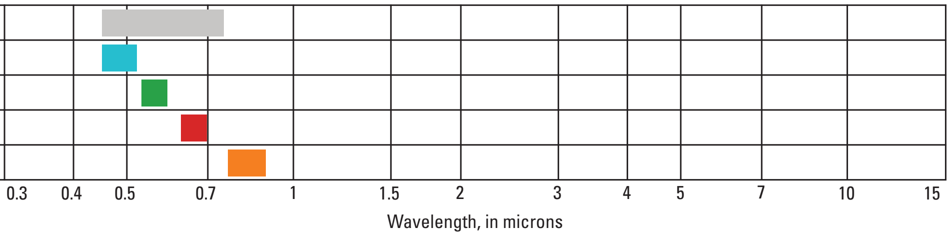
Sensor Information

	ALITE
GSD (m)	12, 24
Swath (km)	140
Data portal	—

ALITE

The ALITE aboard AlSat-1B is a new design developed by SSTL and ASAL. By combining the 24-m multispectral data and the 12-m panchromatic data, AlSat-1B can capture 12-m enhanced multispectral images.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.598	0.745	12
Blue	0.450	0.485	0.520	24
Green	0.530	0.560	0.590	24
Red	0.625	0.660	0.695	24
NIR	0.760	0.825	0.890	24



AlSat-2A and 2B

Algeria
Civil/Government
Operational

Platform Overview

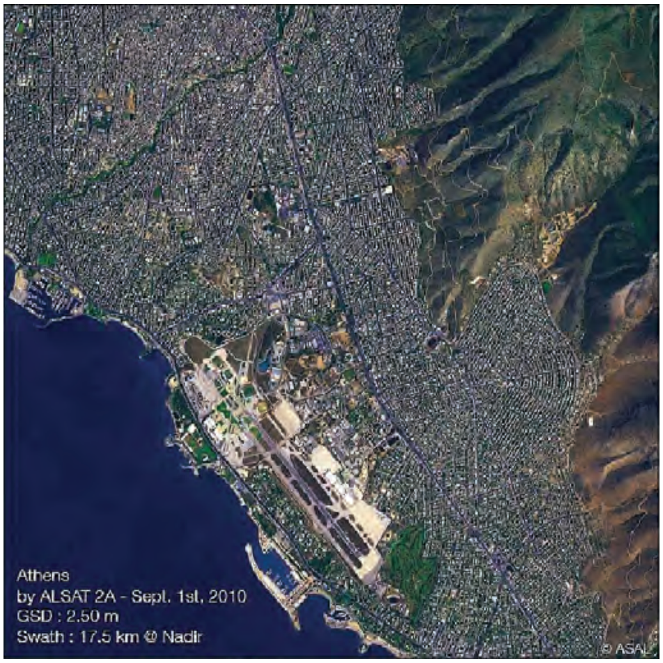
Algeria Satellite (Alsat)-2A and AlSat-2B are high-resolution, panchromatic, and multispectral satellites for Earth observation. AlSat-2A was launched in 2010 aboard the Polar Satellite Launch Vehicle (PSLV)-C15 followed by AlSat-2B in 2016 aboard the PSLV-C35 launch vehicle. AlSat-2 is the first satellite system to use the AstroSat-100 (AS-100) platform, which was based on the Myriade platform from the French National Centre for Space Studies.

Algerian Space Agency (ASAL) signed an agreement with European Aeronautics Defense and Space (EADS) Astrium SAS to design and build the two AlSat-2 satellites. AlSat-2B was successfully integrated by ASAL's engineers in Algeria. AlSat-2A and 2B carry the New AstroSat Optical Modular Instrument (NAOMI) sensor for high-resolution imaging.

Artistic rendering of AlSat-2A in orbit (image from Airbus DS, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

	AlSat-2A	AlSat-2B
Launch date	07/12/2010	09/26/2016
Design lifetime	5 years	
Platform owner	ASAL	
Altitude	670 km	720 km
Orbit period	98 min	99.19 min
Inclination	98.23°	98.1°
Crossing time	9:30 DN	8:45 AN
Nadir repeat	14 days	2 days
Status	Operational	
System website	http://www.asal.dz/Alsat-2A.php	http://www.asal.dz/Alsat-2B.php



Athens, Greece, captured by AlSat-2A (image from ASAL, used with permission).

Sensor Information

	NAOMI
GSD (m)	1.5, 6
Swath (km)	17.5
Data portal	—

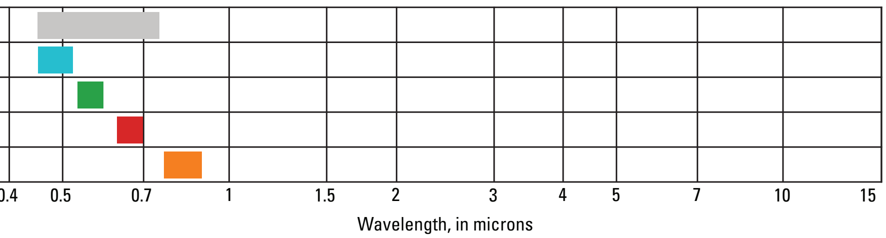
AlSat-2A and 2B—Continued

Algeria
Civil/Government
Operational

NAOMI

The NAOMI sensor is a high-resolution imager developed by EADS Astrium SAS for AlSat-2. The pushbroom imager has four visible and near-infrared bands and a panchromatic band. Data are for use by the Algerian government.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.598	0.745	1.5
Blue	0.450	0.485	0.520	6
Green	0.530	0.560	0.590	6
Red	0.625	0.660	0.695	6
NIR	0.760	0.825	0.890	6

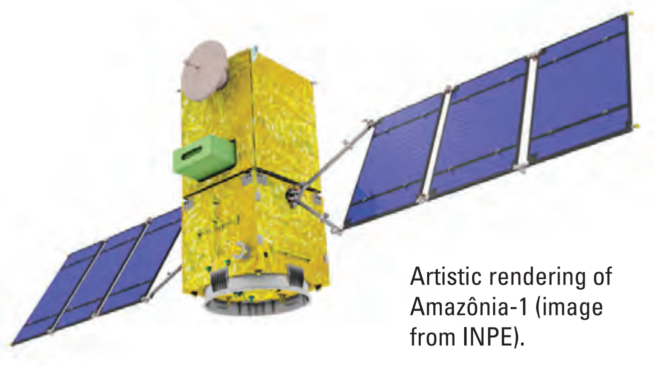


Amazônia-1

Brazil
Civil/Government
Future

Platform Overview

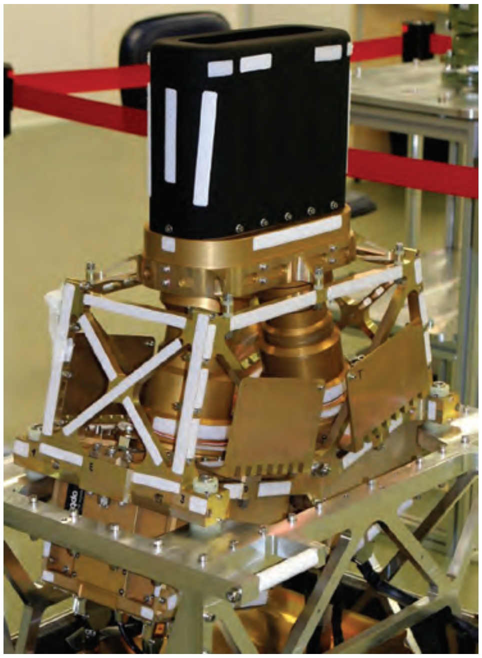
Amazônia-1 is a medium-resolution multispectral satellite to be launched in late 2020 by National Institute of Space Research (INPE) on a Polar Satellite Launch Vehicle for monitoring deforestation, especially in the Amazon region. Amazônia-1 is the first satellite to be completely designed, integrated, and tested in Brazil. The satellite utilizes the Multi-Mission Platform designed by the Brazilian Space Agency. Amazônia-1 will carry the Wide Field Imager (WFI)-2 sensor for medium-resolution land imaging.



Artistic rendering of Amazônia-1 (image from INPE).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared]

Launch date	09/xx/2020
Design lifetime	2 years
Platform owner	INPE
Altitude	752 km
Orbit period	99.9 min
Inclination	98.4°
Crossing time	10:30 DN
Nadir repeat	26 days
Status	Development
System website	http://www3.inpe.br/amazonia-1/



WFI-2 sensor model (image from INPE).

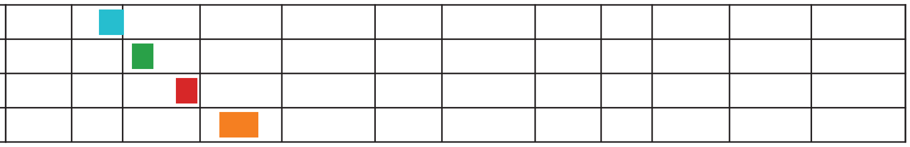
Sensor Information

	WFI-2
GSD (m)	60
Swath (km)	740
Data portal	—

WFI-2

The WFI-2 is the same sensor as the WFI sensors aboard the China–Brazil Earth Resources Satellites; however, since they are at different altitudes, the resolutions are different.

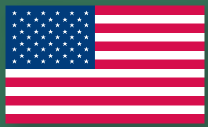
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.475	0.500	60
Green	0.520	0.545	0.570	60
Red	0.630	0.660	0.690	60
NIR	0.760	0.830	0.900	60



JACIE

Aqua

United States
Civil/Government
Operational



JACIE

Platform Overview

Aqua is a moderate-resolution multispectral satellite launched in 2002 by the National Aeronautics and Space Administration (NASA) on a Delta-II rocket from Vandenberg Air Force Base for Earth resources monitoring. Formerly named Earth Observing System (EOS) PM, signifying its afternoon crossing time, Aqua is the second satellite in the EOS mission.

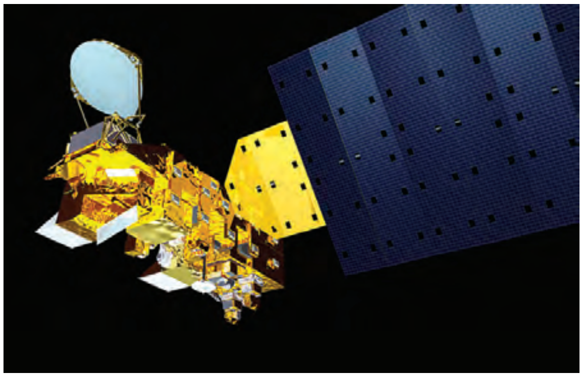
The Aqua satellite was built by Northrop Grumman Corp. based on their modular, standardized T330 bus for NASA. Aqua carries six instruments: Atmospheric Infrared Sounder (AIRS), Advanced Microwave Sounding Unit (AMSU-A), Clouds and the Earth's Radiant Energy System (CERES), Moderate-Resolution Imaging Spectroradiometer (MODIS), Advanced Microwave Scanning Radiometer for EOS (AMSR-E), and Humidity Sounder for Brazil. For this compendium of land remote sensing satellites, only MODIS details are provided.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared, MWIR, midwave infrared; WV, water vapor; TIR, thermal infrared]

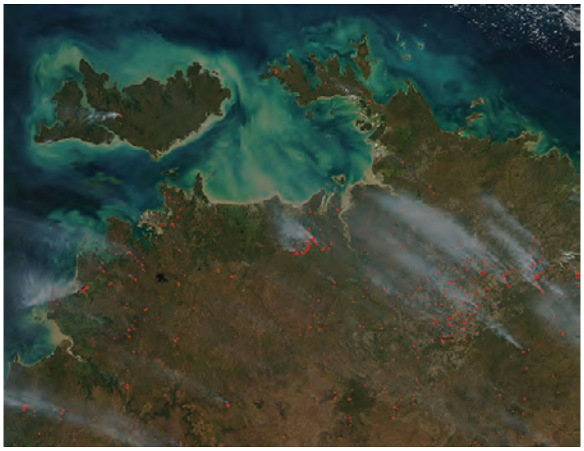
Launch date	05/04/2002
Design lifetime	6 years
Platform owner	NASA
Altitude	705 km
Orbit period	98.8 min
Inclination	98.2°
Crossing time	13:30 AN
Nadir repeat	16 days
Status	Operational
System website	https://aqua.nasa.gov/

Sensor Information

	MODIS
GSD (m)	250; 500; 1,000
Swath (km)	2,230
Data portal	https://earthexplorer.usgs.gov/ https://glovis.usgs.gov/app



Artistic rendering of Aqua in orbit (image from NASA).



Aqua MODIS image of northwest Australia showing forest fires (image from NASA).

Aqua—Continued

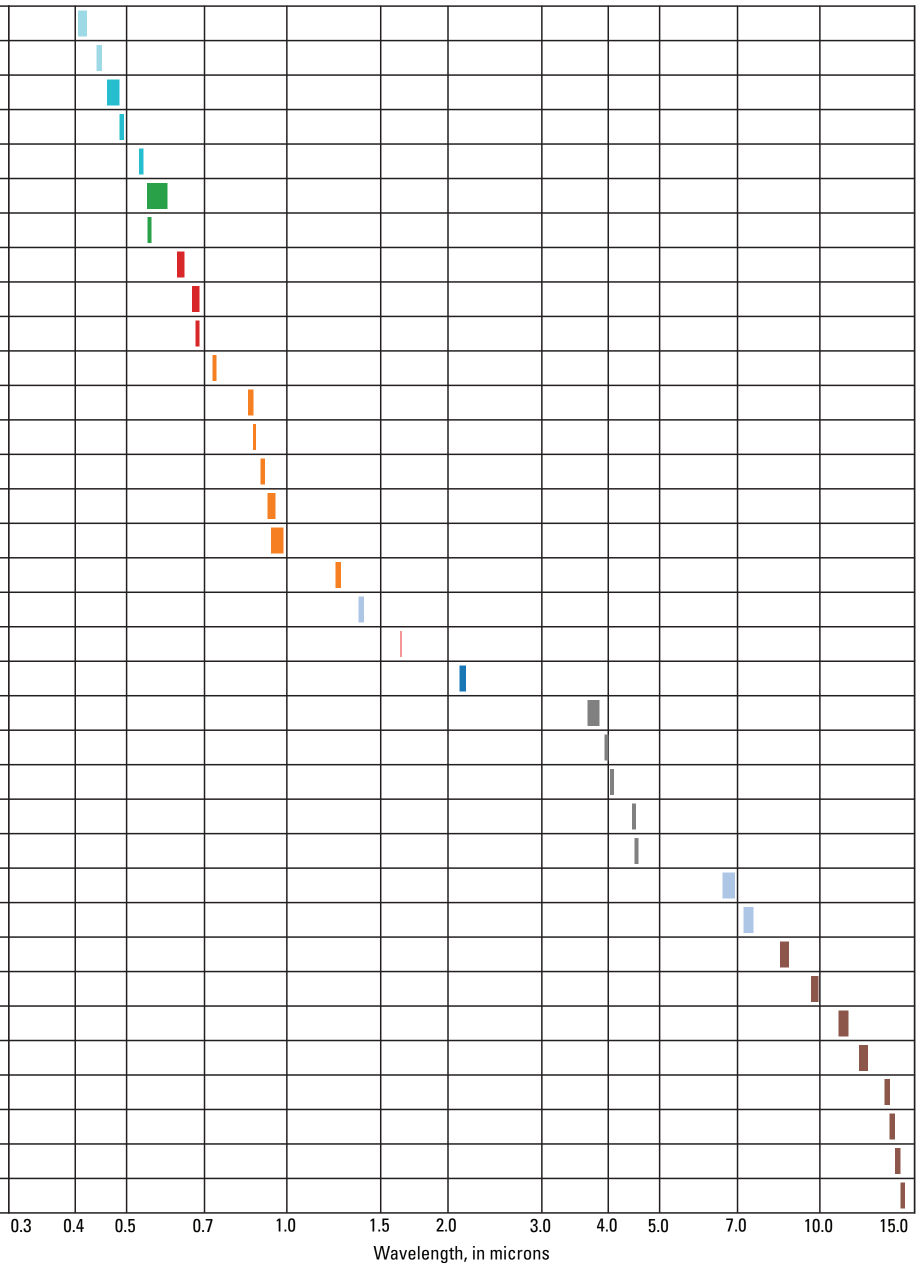
United States
Civil/Government
Operational

JACIE

MODIS

The MODIS sensor is a proven design built by NASA Goddard Space Flight Center and is a heritage of Radiation Sounder, Landsat Thematic Mapper, and Coastal Zone Color Scanner. MODIS, which is on board the Terra and Aqua satellites, is a 36-band spectroradiometer measuring visible and infrared radiation. The MODIS sensors are widely regarded as among the best calibrated imaging instruments in space. MODIS data are freely available.

Band	Lower	Center	Upper	GSD (m)
CA	0.405	0.413	0.420	1,000
CA	0.438	0.443	0.448	1,000
Blue	0.459	0.469	0.479	500
Blue	0.483	0.488	0.493	1,000
Blue	0.526	0.531	0.536	1,000
Green	0.545	0.555	0.565	500
Green	0.546	0.551	0.556	1,000
Red	0.620	0.645	0.670	250
Red	0.662	0.667	0.672	1,000
Red	0.673	0.678	0.683	1,000
NIR	0.743	0.748	0.753	1,000
NIR	0.841	0.859	0.876	250
NIR	0.862	0.870	0.877	1,000
NIR	0.890	0.905	0.920	1,000
NIR	0.915	0.940	0.965	1,000
NIR	0.931	0.936	0.941	1,000
NIR	1.230	1.240	1.250	500
Cirrus	1.360	1.375	1.390	1,000
SWIR 1	1.628	1.640	1.652	500
SWIR 2	2.105	2.130	2.155	500
MWIR	3.660	3.750	3.840	1,000
MWIR	3.929	3.959	3.989	1,000
MWIR	4.020	4.050	4.080	1,000
MWIR	4.433	4.466	4.498	1,000
MWIR	4.482	4.516	4.549	1,000
WV-1	6.535	6.715	6.895	1,000
WV-2	7.175	7.325	7.475	1,000
TIR	8.400	8.550	8.700	1,000
TIR	9.580	9.730	9.880	1,000
TIR	10.780	11.030	11.280	1,000
TIR	11.770	12.020	12.270	1,000
TIR	13.185	13.335	13.485	1,000
TIR	13.485	13.635	13.785	1,000
TIR	13.785	13.935	14.085	1,000
TIR	14.085	14.235	14.385	1,000

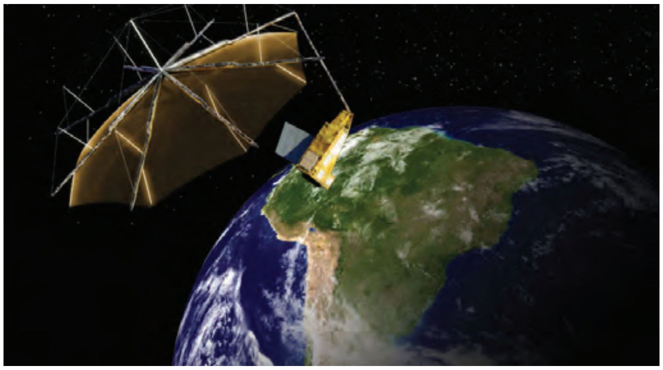


Biomass

European Space Agency
Civil/Government
Future

Platform Overview

Biomass is a low-resolution Synthetic Aperture Radar (SAR) satellite to be launched in 2022 to determine the amount of biomass and carbon stored in forests. Biomass will be European Space Agency's seventh Earth Explorer. The satellite will be built by Airbus Defence and Space. Biomass will carry the P-band SAR (P-SAR) sensor for low-resolution radar data.



Artistic rendering of Biomass in orbit (image from Airbus DS, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data]

Launch date	2022 (Planned)
Design lifetime	5 years
Platform owner	ESA
Altitude	660 km
Orbit period	97.93 min
Inclination	97.97°
Crossing time	6:00 AN
Nadir repeat	17 days
Status	Development
System website	http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Future_missions/Biomass

Sensor Information

	P-SAR
GSD (m)	200
Swath (km)	50
Data portal	—

P-SAR

The P-SAR instrument will be built by Airbus DS. Harris Corporation has been selected to provide the 12-meter reflector and boom assembly, a major component of the instrument. P-SAR will operate in the P-band at 435 megahertz (λ = 68.9 centimeters). The angle of incidence will be 23–35 degrees. Details of the beam modes are not yet available.

Beam mode	Polarization	Nominal swath width (km)	Approximate resolution (m)
—	—	—	—

RCA-EO; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

BlackSky Constellation

United States
Commercial
Operational/Future

Platform Overview

The BlackSky constellation includes high-resolution Earth observing satellites developed by Spaceflight Industries for BlackSky. The first satellite, Pathfinder, was intended for technology demonstration. The Global (Block-2) satellites are the operational fleet of satellites intended for commercial Earth observation. The Next Gen (Block-3) satellites would improve the spatial resolution with a modular secondary sensor.

The Pathfinder-1 satellite was launched in 2016 onboard India's Polar Satellite Launch Vehicle (PSLV) for technology demonstration. The operational Global (Block-2) satellites started with the launch of Global-1 in 2018. The Global (Block-2) satellites of the BlackSky constellation were launched starting in November 2018. The first of 60 satellites in the constellation, Global-1, was launched on a PSLV rocket from India. The satellite carries a SpaceView-24 imaging system built by Harris Corporation's Exelis for high-resolution Earth imaging. The Global satellites are developed and built by Spaceflight Services based on their SCOUT bus.

Global-2 was launched on the Falcon-9 Smallsat Express (SSO-A) mission in December 2018. It was followed by the launch of Global-3 and Global-4 on the Electron-KS rocket in 2019. The rest of the 60 satellites are planned for launch before 2023.

A model of the BlackSky Satellite (image from BlackSky).

[Abbreviations in tables: —, no data; km, kilometer; min, minute; °, degree; SV-24, SpaceView-24; GSD, ground sample distance; m, meter]

	Pathfinder-1	Global-1	Global-2	Global-3	Global-4
Launch date	09/26/2016	11/29/2018	12/03/2018	06/29/2019	08/19/2019
Design lifetime	3 years				
Platform owner	BlackSky				
Altitude	—	500 km			
Orbit period	—	94.3 min			
Inclination	—	97.4°			
Crossing time	—				
Nadir repeat	—				
Status	Retired	Operational			
System website	https://www.blacksky.com/				

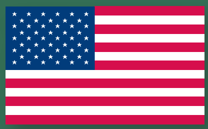
Sensor Information

	SV-24
GSD (m)	1
Swath (km)	6
Data portal	—

JACIE

BlackSky Constellation—Continued

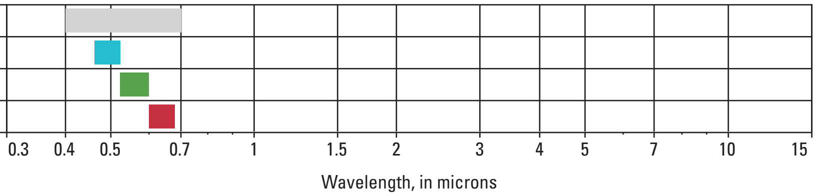
United States
Commercial
Operational/Future



SpaceView-24

The SpaceView-24 camera on the BlackSky satellites was developed and built by Harris Corporation's Exelis with an aperture of 24 centimeters. It has a ground resolution of 0.9–1.1 meters from an orbital height of 500 kilometers. The sensor can measure Earth's radiation in panchromatic and red-green-blue bands. The sensor on Block-1 satellites is capable of capturing still images, whereas the Block-2 can also capture video at 1 frame per second.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.400	0.550	0.700	1
Blue	0.460	0.490	0.520	1
Green	0.520	0.560	0.600	1
Red	0.600	0.640	0.680	1



Cartosat-2, -2A, and -2B

India
Civil/Government
Operational

Platform Overview

Cartosat-2, -2A, and -2B are high-resolution satellites launched in 2007, 2008, and 2010, respectively, by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center for Earth resources monitoring. These missions continue the Cartosat series that has been in continual operation since the launch of Cartosat-1 in 2005.

The Cartosat-2, -2A, and -2B satellites were designed and built by ISRO and use the Indian Remote Sensing Satellite (IRS)-1 bus and two panchromatic cameras. Panchromatic imagery is gathered on a global scale to provide stereo pairs required for generating digital elevation models, Ortho Image products, and value-added products for various GIS applications.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; Pan, panchromatic; GSD, ground sample distance; m, meter]

	Cartosat-2	Cartosat-2A	Cartosat-2B
Launch date	01/10/2007	04/28/2008	07/12/2010
Design lifetime	5 years		
Platform owner	ISRO		
Altitude	635 km		
Orbit period	97.4 min		
Inclination	97.87°		
Crossing time	9:30 DN		
Nadir repeat	310 days		
Status	Operational		
System website	https://www.isro.gov.in/Spacecraft/cartosat-2-0		

Model of Cartosat-2 (image from ISRO, used with permission).

A 1-meter panchromatic Cartosat-2 image of Bangalore, India (image from ISRO, used with permission).

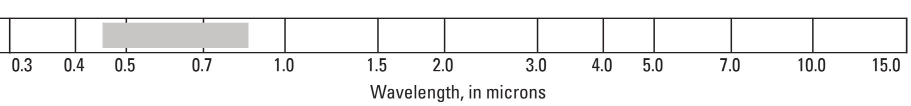
Pan

The panchromatic camera (Pan) is a design from ISRO. The camera is a nadir-pointing pushbroom charge coupled device instrument observing in the spectral range of 0.5–0.85 micrometer with a swath of 9.6 kilometers providing a ground sample distance of less than 1 meter at nadir.

Sensor Information

	Pan
GSD (m)	0.8
Swath (km)	9.6
Data portal	http://uops.nrsc.gov.in:33333/ImgeosUops/FinalImgeosUops/FinalImgeosUops.html

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.650	0.850	0.8



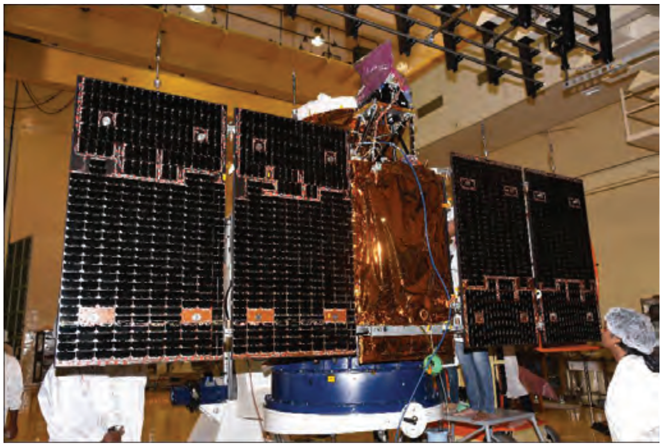
Cartosat-2C, -2D, -2E, and -2F

India
Civil/Government
Operational/Future

Platform Overview

Cartosat-2C, -2D, -2E, and -2F are high-resolution satellites launched between 2016 and 2018 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center for Earth resources monitoring. These missions continue the Cartosat series that has been in continual operation since the launch of Cartosat-1 in 2005.

The Cartosat-2C, -2D, -2E, and -2F satellites were designed and built by ISRO and use the Indian Remote Sensing Satellite (IRS)-1 bus and two imagers: a high-resolution multispectral camera and a panchromatic imager. Imagery in panchromatic and visible and near-infrared bands is gathered on a global scale for cartographic applications.



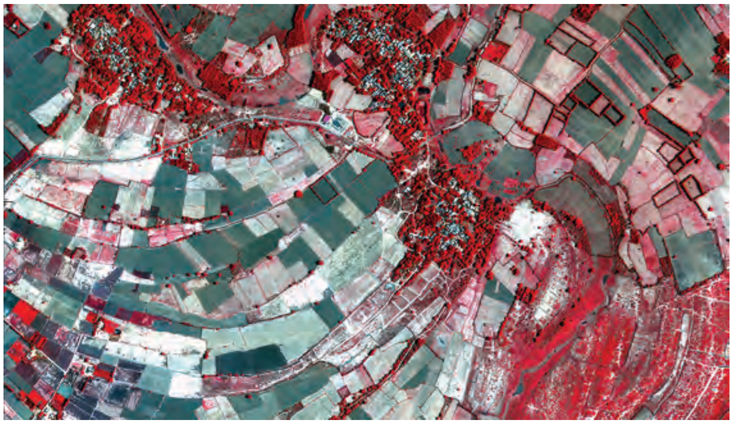
Cartosat-2E undergoing solar panel deployment test (image from ISRO, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared; Pan, panchromatic]

	Cartosat-2C	Cartosat-2D	Cartosat-2E	Cartosat-2F
Launch date	06/22/2016	02/15/2017	06/23/2017	01/12/2018
Design lifetime	5 years			
Platform owner	ISRO			
Altitude	500 km			
Orbit period	97.4 min			
Inclination	97.87°			
Crossing time	9:30 DN			
Nadir repeat	310 days			
Status	Operational			
System website	https://www.isro.gov.in/Spacecraft/cartosat-2-series-satellite-2			

Sensor Information

	HRMS	Pan
GSD (m)	2	0.65
Swath (km)	10	9.6
Data portal	http://uops.nrsc.gov.in:33333/ImgeosUops/FinalImgeosUops/FinalImgeosUops.html	



Multispectral Cartosat-2 imagery of Bhidaurya, Uttar Pradesh, India (image from ISRO, used with permission).

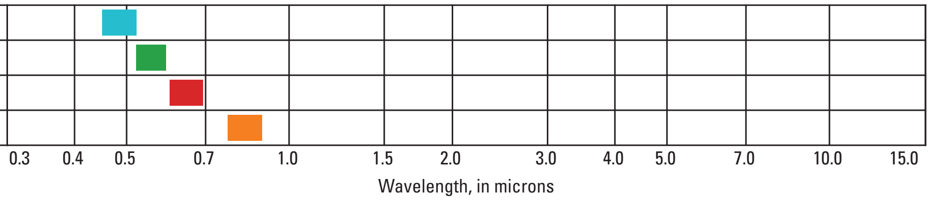
Cartosat-2C, -2D, -2E, and -2F—Continued

India
Civil/Government
Operational/Future

HRMX

The High Resolution multispectral (HRMX) sensor is a design by ISRO. The four-channel radiometer has a 10-kilometer swath width at a ground sample distance (GSD) of 2 meters (m) in multispectral mode.

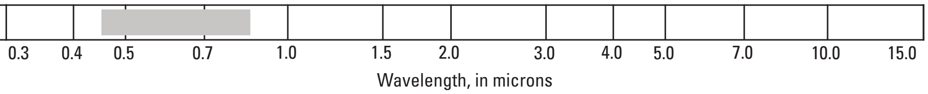
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	2
Green	0.520	0.555	0.590	2
Red	0.600	0.645	0.690	2
NIR	0.770	0.830	0.890	2



Pan

The panchromatic imager (Pan) was built by ISRO and has a similar swath to the previous Cartosat-2 satellites but with higher revisit capability. It provides panchromatic imagery at a GSD of 0.65 m for stereoscopic applications.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.650	0.850	0.65



Cartosat-3

India
Civil/Government
Future

Platform Overview

Cartosat-3 is a high-resolution multispectral satellite launched in 2019 on a Polar Satellite Launch Vehicle (PSLV)-47 mission by the Indian Space Research Organization (ISRO) for Earth resources monitoring. This mission continues the Cartosat series that has been in continual operation since the launch of Cartosat-1 in 2005. Cartosat-3 was developed by ISRO as the ninth unit in the Cartosat series and carries the multispectral imager (MSI) and panchromatic (Pan) sensor for high-resolution imaging. The overall mass of the satellite is 1,625 kilograms.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; Pan, panchromatic]

Launch date	11/27/2019
Design lifetime	5 years
Platform owner	ISRO
Altitude	509 km
Orbit period	94.8 min
Inclination	97.5°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—

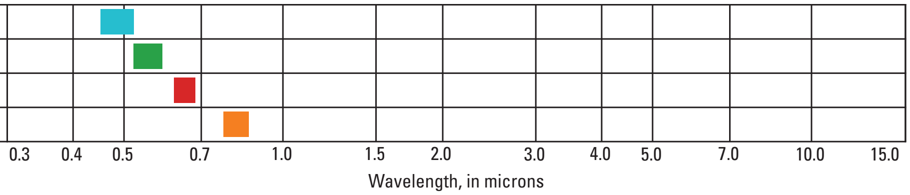
Sensor Information

	MSI	Pan
GSD (m)	1.14	0.28
Swath (km)	16	16
Data portal	—	

MSI

The sensor has bands with a ground sample distance (GSD) of approximately 1 meter (m), an improvement from Cartosat-2's 2-m GSD.

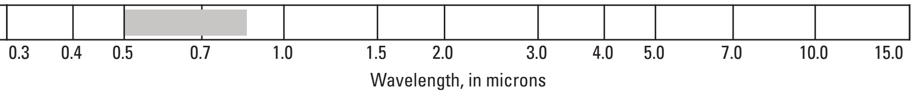
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	1.14
Green	0.520	0.555	0.590	1.14
Red	0.620	0.650	0.680	1.14
NIR	0.770	0.815	0.860	1.14



Pan

The Pan imager has an improved 0.28-m GSD compared to Cartosat-2's 0.65-m GSD.

Band	Lower	Center	Upper	GSD (m)
Pan	0.500	0.675	0.850	0.28



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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CAS500-1 and -2

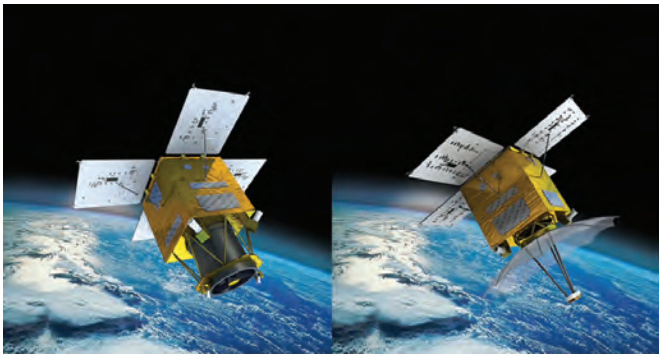
South Korea
Civil/Government/Commercial
Future

Platform Overview

Compact Advanced Satellite (CAS) 500-1 and -2 are high-resolution panchromatic and multispectral satellites to be launched in 2020 for Earth observation. The first satellite, CAS500-1, is being developed by the Korean Aerospace Research Institute (KARI). The medium-sized platform is designed to be commercialized to reduce cost. CAS500-2 will be developed by domestic industry and utilize the technology developed for CAS500-1. CAS500 satellites will carry the Advanced Earth Imaging Sensor System (AEISS-C) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; —, no data; AN, ascending node; GSD, ground sample distance; m, meter]

	CAS500-1	CAS500-2
Launch date	2020 (Planned)	
Design lifetime	4 years	
Platform owner	KARI	
Altitude	528 km	
Orbit period	94.62 min	
Inclination	—	
Crossing time	10:50 AN	
Nadir repeat	28 days	
Status	Development	
System website	https://www.kari.re.kr/eng/sub03_02_03.do	



Artistic renderings of CAS500-1 and -2 in orbit (image from KARI, used with permission).

Sensor Information

	AEISS-C
GSD (m)	0.5, 2
Swath (km)	12
Data portal	—

AEISS-C

The AEISS-C is based on the AEISS sensors aboard Kompsat-3 and -3A. Detailed spectral information is not available.

JACIE

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CBERS-4

China, Brazil
Civil/Government
Operational

Platform Overview

The China–Brazil Earth Resources Satellite (CBERS)-4 is a high-resolution multispectral satellite launched in 2014 by the China National Space Agency/National Institute of Space Research (CNSA/INPE) on a Chang Zheng 4B rocket from Taiyuan Satellite Launch Center for Earth resources monitoring. This is the fifth satellite in the CBERS mission. The CBERS-4 satellite was designed and built by China Academy for Space Technology/INPE and uses the Phoenix-Eye 1 bus. CBERS-4 carries four sensors: Infrared Multispectral Scanner (IRMSS), Multispectral Camera (MUX-Cam), Panchromatic and Multispectral Camera (PANMUX), and Wide Field Imager (WFI) for medium-resolution land imaging.

Artistic rendering of CBERS-4 in orbit (image from INPE).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; AN, ascending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared]

Launch date	12/07/2014
Design lifetime	3 years
Platform owner	INPE/CNSA
Altitude	778 km
Orbit period	100.26 min
Inclination	98.5°
Crossing time	10:30 DN
Nadir repeat	26 days
Status	Operational
System website	http://www.cbers.inpe.br/

CBERS-4 image of Brasilia (image from INPE).

Sensor Information

	IRMSS	MUX	PANMUX	WFI
GSD (m)	40, 80	20	5, 10	64
Swath (km)	120		60	866
Data portal	http://www.dgi.inpe.br/CDSR/			

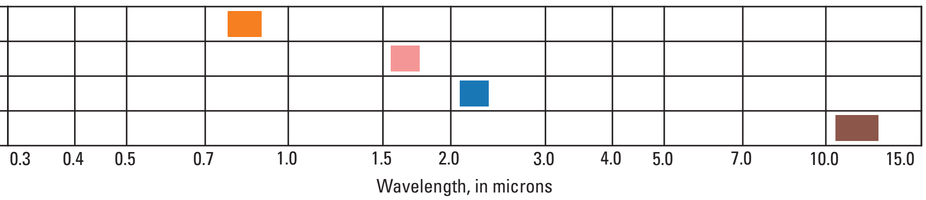
CBERS-4—Continued

China, Brazil
Civil/Government
Operational

IRMSS

The IRMSS sensor is a proven design from CNSA used on CBERS-1 and -2. This sensor on CBERS-4 offers an improvement in the spatial resolution with a ground sample distance of 40 meters (m) in shortwave infrared and 80 m in thermal infrared. The swath and the spectral bands remain the same as the previous versions. IRMSS data are freely available.

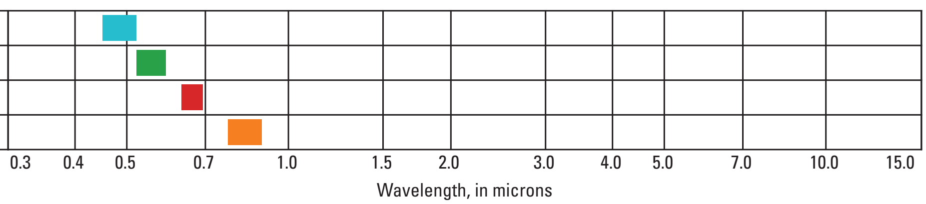
Band	Lower	Center	Upper	GSD (m)
NIR	0.770	0.830	0.890	40
SWIR 1	1.550	1.650	1.750	40
SWIR 2	2.080	2.215	2.350	40
TIR	10.400	11.450	12.500	80



MUX

The MUXCam was developed by INPE in Brazil. It is the same design used on previous satellites in the CBERS series. MUX data are freely available.

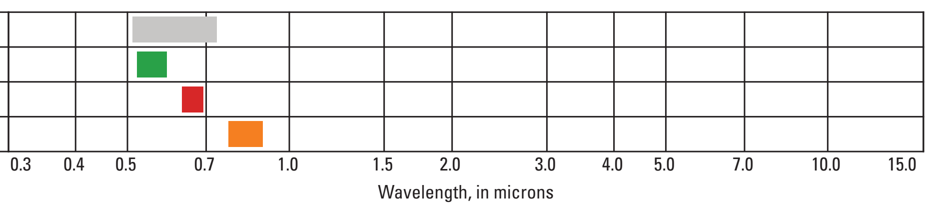
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	20
Green	0.520	0.555	0.590	20
Red	0.630	0.660	0.690	20
NIR	0.770	0.830	0.890	20



PANMUX

The PANMUX is a three-band visible and near-infrared and panchromatic camera designed by INPE. PANMUX data are freely available.

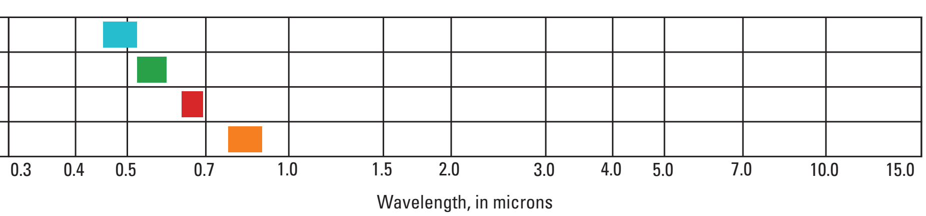
Band	Lower	Center	Upper	GSD (m)
Pan	0.510	0.620	0.730	5
Green	0.520	0.555	0.590	10
Red	0.630	0.660	0.690	10
NIR	0.770	0.830	0.890	10



WFI

The WFI is a proven design by INPE flown on previous CBERS satellites. The sensor adds blue and green bands and an improved resolution of 64 m. The swath width is reduced to 690 kilometers, and the operational capability remains the same. WFI data are freely available.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	64
Green	0.520	0.555	0.590	64
Red	0.630	0.660	0.690	64
NIR	0.770	0.830	0.890	64



CBERS-4A

China, Brazil
Civil/Government
Operational

Platform Overview

China–Brazil Earth Resources Satellite (CBERS)-4A is a multiresolution multispectral satellite launched in 2019 by the China National Space Agency/National Institute of Space Research (CNSA/INPE) on a Chang Zheng 4B rocket from Taiyuan Satellite Launch Center for Earth resources monitoring. This mission continues the CBERS mission that has been in continual operation since the launch of CBERS-1 in 1999.

The CBERS-4A satellite was designed and built by CAST/INPE and uses the Phoenix-Eye 1 bus. CBERS-4A carries the Multispectral Camera (MUXCam) and Wide Field Imager (WFI) sensors for medium-resolution land imaging and the Wide Swath Panchromatic and Multispectral camera (WPM) sensor for high-resolution land imaging.

Artistic rendering of CBERS-4 in orbit (image from INPE).

[Abbreviations in tables: km, kilometer; min, minute; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared; Pan, panchromatic]

Launch date	12/19/2019
Design lifetime	5 years
Platform owner	CNSA/INPE
Altitude	629 km
Orbit period	97.3 min
Inclination	97.9°
Crossing time	10:30 DN
Nadir repeat	31 days
Status	Operational
System website	http://www.cbers.inpe.br/lancamentos/cbers04a.php

Sensor Information

	MUX	WPM	WFI
GSD (m)	16	2, 8	55
Swath (km)	90	90	690
Data portal	http://www.inpe.br/dados_abertos/		

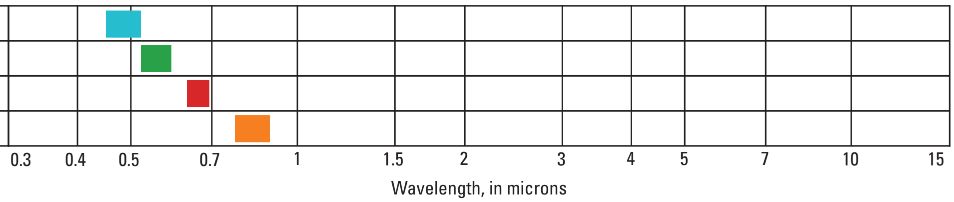
CBERS-4A—Continued

China, Brazil
Civil/Government
Operational

MUXCam

The MUXCam was developed by INPE in Brazil. It is a multispectral radiometer with nadir viewing, capable of imaging the entire Earth every 31 days. It provides a swath width of 90 kilometers. MUX data are freely available.

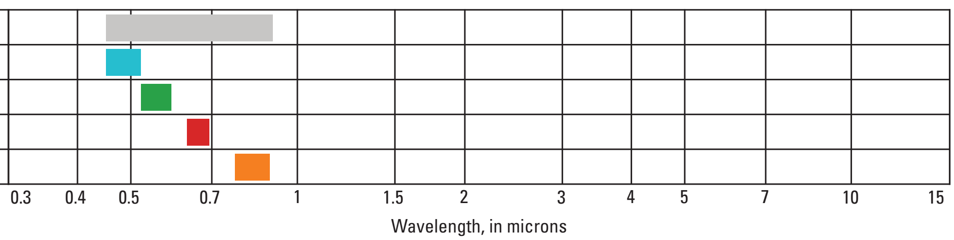
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	16
Green	0.520	0.555	0.590	16
Red	0.630	0.660	0.690	16
NIR	0.770	0.830	0.890	16



WPM

The WPM is a four-band visible and near-infrared and panchromatic camera designed by INPE. WPM data are freely available.

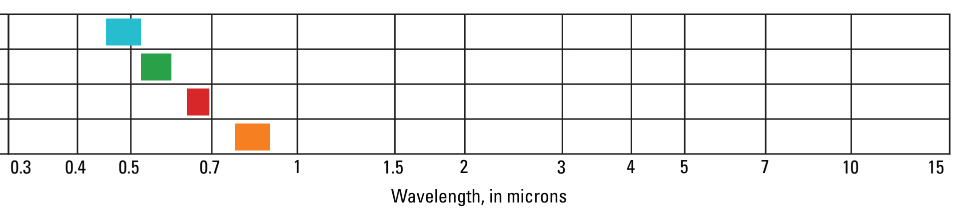
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	2
Blue	0.450	0.485	0.520	8
Green	0.520	0.555	0.590	8
Red	0.630	0.660	0.690	8
NIR	0.770	0.830	0.890	8



WFI

The WFI is a proven design by INPE flown on previous CBERS satellites. The sensor adds blue and green bands with an improved resolution of 55 meters. The swath width and the operational capability remain the same as previous CBERS WFI sensors. WFI data are freely available.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	55
Green	0.520	0.555	0.590	55
Red	0.630	0.660	0.690	55
NIR	0.770	0.830	0.890	55



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CHIME

European Space Agency
Civil/Government
Future

Platform Overview

The Copernicus Hyperspectral Imaging Mission for the Environment (CHIME) is a hyperspectral imaging mission planned by the European Space Agency (ESA) for launch in the 2025–30 timeframe. It is part of the ESA Sentinel Expansion program to monitor Earth's natural resources. CHIME is expected to carry a hyperspectral imager measuring Earth's radiation in visible to shortwave infrared bands at moderate resolution.

[Abbreviations in tables: —, no data; GSD, ground sample distance; m, meter; km, kilometer]

Launch date	2025
Design lifetime	5 years
Platform owner	ESA
Altitude	—
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Planned
System website	https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates

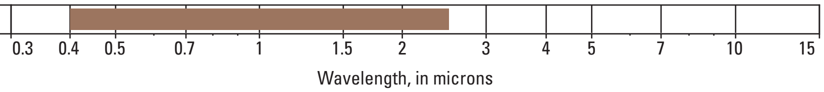
Sensor Information

	Hyperspectral imager
GSD (m)	20
Swath (km)	—
Data portal	—

Hyperspectral Sensor

CHIME is anticipated to carry a hyperspectral imager operating between 400 and 2,500 nanometers (nm) with 10-nm contiguous bands. CHIME will image the Earth's surface at a 20- to 30-meter ground resolution.

Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.400	1.450	2.500	20



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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CIMR

European Space Agency
Civil/Government
Future

Platform Overview

The Copernicus Imaging Microwave Radiometer (CIMR) is a multifrequency microwave radiometer planned for launch in 2026 by the European Space Agency (ESA). It is a part of ESA's High Priority Candidates for the Copernicus program. The satellite carries a microwave radiometer for studying Earth's seas.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data]

Launch date	2026
Design lifetime	5 years
Platform owner	ESA
Altitude	817 km
Orbit period	101.2 min
Inclination	98.7°
Crossing time	06:00 DN
Nadir repeat	29 days
Status	Planned
System website	https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates

Sensor Information

	CIMR sensor
GSD (m)	5,000
Swath (km)	1,900
Data portal	—

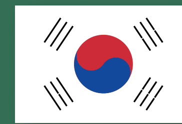
CIMR Sensor

The CIMR sensor will provide sea surface temperature, sea surface salinity, and sea ice concentration in Ka, K, X, C, and L bands with a spatial resolution of 15, 55, and 5 kilometers.

JACIE

COMS

South Korea
Civil/Government
Operational



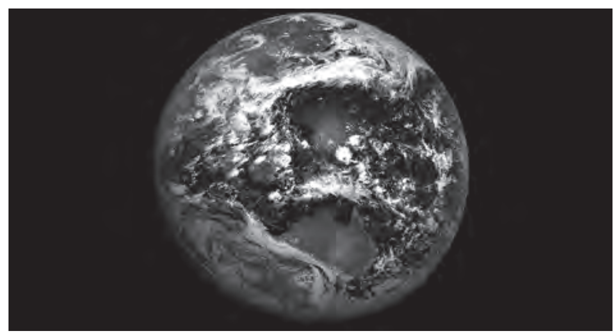
Platform Overview

The Communication, Ocean and Meteorological Satellite (COMS), also known as GEO-KOMPSAT-1, is a low-resolution, multispectral, geostationary satellite launched in 2010 by the Korean Aerospace Research Institute (KARI) on an Ariane-5ECA launch vehicle for meteorology, ocean observation, and communications. COMS was Korea's first geostationary satellite, was designed and built by Airbus for KARI, and was based on the Eurostar-3000 bus. COMS carries the Geostationary Ocean Color Imager (GOCI) and Meteorological Imager (MI) sensors for multiresolution land imaging.

Artistic rendering of COMS in orbit (image from KARI, used with permission).

[Abbreviations in tables: km, kilometer; °, degree; E, east; —, no data; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; MWIR, midwave infrared; TIR, thermal infrared]

Launch date	06/27/2010
Design lifetime	7 years
Platform owner	KARI
Altitude	36,000 km
Orbit period	24 hours
Longitude	128.2° E
Crossing time	—
Nadir repeat	—
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_02.do



COMS imagery of Earth (image from KARI, used with permission).

Sensor Information

	GOCI	**MI**
GSD (m)	500	1,000; 4,000
Swath (km)	2,500	—
Data portal	—	

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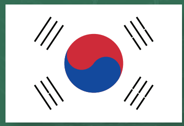
COMS—Continued

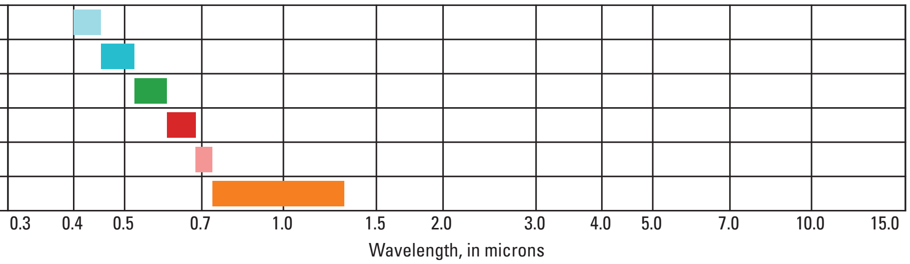
South Korea
Civil/Government/
Operational



GOCI

The GOCI was the first sensor to measure ocean data from a geostationary orbit.

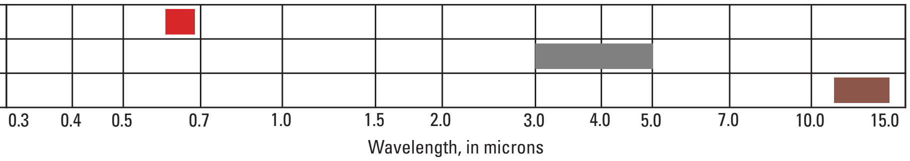
Band	Lower	Center	Upper	GSD (m)
CA	0.400	0.425	0.450	500
Blue	0.450	0.485	0.520	500
Green	0.520	0.560	0.600	500
Red	0.600	0.640	0.680	500
Red Edge	0.680	0.705	0.730	500
NIR	0.730	1.015	1.300	500



MI

The MI is an off-the-shelf sensor from the U.S company ITT Inc.

Band	Lower	Center	Upper	GSD (m)
Red	0.600	0.640	0.680	1,000
MWIR	3.000	4.000	5.000	4,000
TIR	11.000	12.500	14.000	4,000



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Constellation Optique 3D (CO3D)

France
Civil/Government
Future

Platform Overview

Constellation Optique 3D (CO3D) are high-resolution satellites planned for launch by CNES in 2022 to develop a global high-resolution digital surface model (DSM). The project was awarded to Airbus Defence and Space for development and operations.

The CO3D constellation will feature four satellites like the Pléiades-Neo satellites. They carry a multispectral sensor with blue, green, and red bands capable of imaging at a ground resolution of 50 centimeters and a near infrared band capable of imaging at 2 meters.

Stereo pair of CO3D satellites [Source: Copyright of Airbus, used with permission]

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance]

Launch date	2022
Design lifetime	10 years
Platform owner	CNES, Airbus DS
Altitude	502 km
Orbit period	94.65 min
Inclination	97.4°
Crossing time	—
Nadir repeat	—
Status	Planned
System website	—

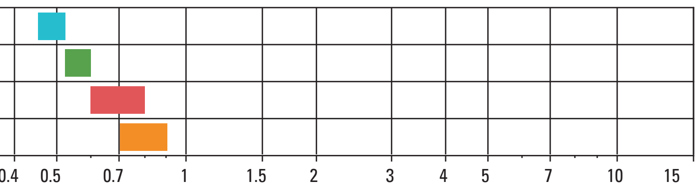
Sensor Information

	Stereo Imager
GSD (m)	0.5/2
Swath (km)	14
Data portal	—

CO3D Stereo Imager

The four CO3D satellites carry four band (RGB, NIR) multispectral imagers capable of imaging at 50 centimeters resolution in RGB and 2 meters in NIR.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	0.5
Green	0.520	0.560	0.600	0.5
Red	0.600	0.700	0.800	0.5
NIR	0.700	0.800	0.900	2



COSMO-SkyMed-1 to -4

Italy
Civil/Government
Operational

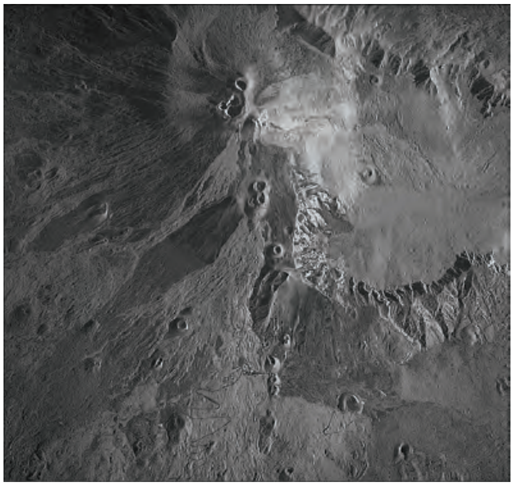
Platform Overview

The Constellation of small Satellites for Mediterranean basin Observation (COSMO-SkyMed) satellites are multiresolution synthetic aperture radar (SAR) satellites for Earth observation. The four satellites were launched on Delta-7420-10C launch vehicles. The COSMO-SkyMed (CSK) satellites are based on the Piattaforma Riconfigurabile Italiana Multi-Applicativa (PRIMA) bus. The satellites are identical, and all carry the SAR-2000 instrument for high-resolution radar data.

Artistic rendering of a COSMO-SkyMed satellite in orbit (image from ASI, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	CSK-1	CSK-2	CSK-3	CSK-4
Launch date	06/08/2007	12/09/2007	10/25/2008	11/06/2010
Design lifetime	5 years			
Platform owner	ASI			
Altitude	620 km			
Orbit period	97.1 min			
Inclination	97.8°			
Crossing time	6:00 AN			
Nadir repeat	16 days			
Status	Operational			
System website	http://www.e-geos.it/cosmo-skymed.html			



Summit of Mount Etna captured by COSMO-SkyMed (image from ASI, used with permission).

Sensor Information

	SAR-2000
GSD (m)	1–600 (selectable)
Swath (km)	10–200 (selectable)
Data portal	http://catalog.e-geos.it/

SAR-2000

The SAR-2000 instrument was developed and built by Thales Alenia Space Italia. The SAR instrument operates in the X-band at 9.6 gigahertz (λ = 3.1 centimeters). The angle of incidence is 18–59.5 degrees. SAR-2000 data are commercially available.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight	Single	HH, VV	10	1
Stripmap Himage	Single	HH, HV, VH, VV	40	5
Stripmap Ping Pong	Alternating	HH/VV, HH/HV, VV/VH	30	20
ScanSAR Wide Region	Single	HH, HV, VH, VV	100	30
ScanSAR Huge Region	Single	HH, HV, VH, VV	200	100

CryoSat-2

European Space Agency
Civil/Government
Operational

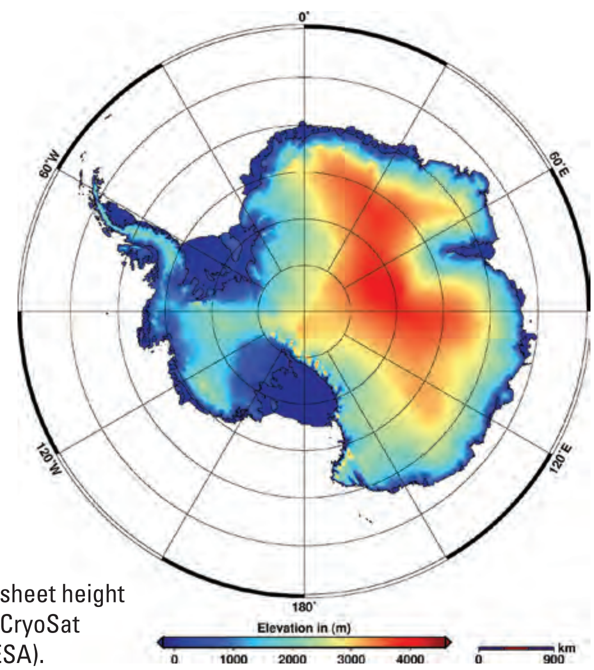
Platform Overview

CryoSat-2 is a low-resolution radar altimeter satellite launched in 2010 on a Dnepr launch vehicle for monitoring ice thickness. CryoSat-2 replaces CryoSat, which was lost because of a launch failure in 2005. CryoSat-2 was built and integrated by European Aeronautics Defense and Space Astrium. CryoSat-2 carries the Synthetic Aperture Radar Interferometer Radar Altimeter (SIRAL) sensor for low-resolution altimetry data.

[Abbreviations in tables: ESA, European Space Agency; km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	04/08/2010
Design lifetime	3.5 years
Platform owner	ESA
Altitude	717 km
Orbit period	100 min
Inclination	92°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	http://www.esa.int/Our_Activities/Observing_the_Earth/CryoSat

Artistic rendering of CryoSat-2 in orbit (image from ESA).



Antarctic ice sheet height measured by CryoSat (image from ESA).

Sensor Information

	SIRAL
GSD (m)	250
Swath (km)	15
Data portal	https://earth.esa.int/web/guest/-/how-to-access-cryosat-data-6842

SIRAL

The SIRAL instrument was designed and developed by Thales Alenia Space. SIRAL is of Poseidon-2 heritage and was based on existing equipment. The sensor operates in the Ku-band at 13.575 gigahertz ($\lambda = 2.21$ centimeters). SIRAL data are freely available.

Beam mode	Polarization	Nominal swath width (km)	Approximate resolution (m)
LRM (Low Resolution Mode)	—	—	—
SARM (Synthetic Aperture Radar Mode)	—	—	—
SARIn (SAR Interferometric)	—	—	—

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CSG-1 and -2

Italy
Civil/Government
Future

Platform Overview

CSG-1 and -2 (COSMO-SkyMed second generation) are high-resolution synthetic aperture radar (SAR) satellites developed by the Italian Space Agency (ASI) for civil and defense use. The CSG satellites provide continuity of the COSMO-SkyMed (CSK) first generation satellites. The CSG satellites are being built by Thales Alenia Space, use the PRIMA bus, and will carry the CSG-SAR sensor for high-resolution radar data.

CSG-1 was launched in 2019 on a Soyuz rocket; CSG-2 is planned for launch in 2021.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	CSG-1	CSG-2
Launch date	12/18/2019	2021 (Planned)
Design lifetime	7 years	
Platform owner	ASI	
Altitude	620 km	
Orbit period	97.1 min	
Inclination	97.8°	
Crossing time	6:00 AN	
Nadir repeat	16 days	
Status	Operational/development	
System website	—	

Sensor Information

	CSG-SAR
GSD (m)	0.8–6 (selectable)
Swath (km)	10–200 (selectable)
Data portal	—

CSG-SAR

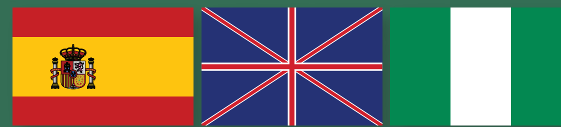
The CSG-SAR sensor is based on the SAR sensor aboard the CSK satellites. CSG-SAR provides improved capabilities and data continuity for the CSK constellation. CSG-SAR operates in the X-band at 9.6 gigahertz (λ = 3.12 centimeters). The angle of incidence is unavailable. Data are expected to be commercially available.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight-2A	Single	HH, HV, VV, VH	10 x 10	0.8 x 0.8
Spotlight-2B	Dual	HH/HV, VV/VH	10 x 10	1 x 1
Stripmap	Single	HH, HV, VV, VH	40 x 2,500	3 x 3
	Dual	HH/HV, VV/VH		
Pingpong	Burst dual	HH/HV, VV/VH	30 x 2,500	5 x 20
Quadpol	Quad	HH/HV/VV/VH	15 x 2,500	3 x 3
ScanSAR-1	Dual	HH/HV, VV/VH	100 x 2,500	4 x 20
ScanSAR-2	Dual	HH/HV, VV/VH	200 x 2,500	6 x 20

JACIE

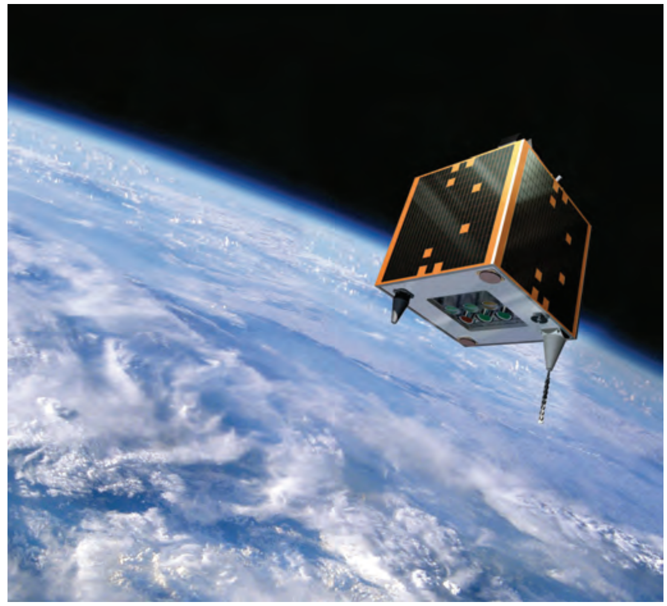
Deimos-1, UK-DMC-2, NigeriaSat-X

Spain, United Kingdom, Nigeria
Civil/Government
Operational



Platform Overview

The second generation of Disaster Monitoring Constellation (DMC) satellites, Deimos-1, UK-DMC-2, and NigeriaSat-X, provide medium-resolution, multispectral imagery. (NigeriaSat-2 is also a part of the DMC second generation but is described elsewhere in this document.) Deimos-1 and UK-DMC-2 were launched together in 2009 on a Dnepr-1 launch vehicle for disaster monitoring. NigeriaSat-X was launched with NigeriaSat-2 in 2011 on a Dnepr-1 launch vehicle. These three satellites were intended to provide continuity to the first generation of the DMC with enhanced imaging capabilities. The satellites were built by Surrey Satellite Technology, Ltd., (SSTL) and are of SSTL-100 heritage. These satellites carry the improved Surrey Linear Imager Multispectral 6 channels (SLIM6) sensor for medium-resolution land imaging.



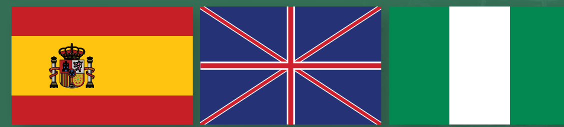
Artistic rendering of Deimos-1 satellite in orbit (image from Urthecast, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

	Deimos-1	UK-DMC-2	NigeriaSat-X
Launch date	07/29/2009	07/29/2009	08/17/2011
Design lifetime	5 years	5 years	7 years
Platform owner	Deimos Imaging SL	SSTL	Nigerian National Space Research and Development Agency
Altitude	661 km	686 km	680 km
Orbit period	97.7 min	97.7 min	98 min
Inclination	98°	98.13°	98.25°
Crossing time	10:30 AN	10:30 AN	10:15 AN
Nadir repeat	5 days	5 days	—
Status	Operational	Operational	Operational
System website	https://www.deimos-imaging.com/satellites#1	http://www.sst-us.com/missions/uk-dmc-2--launched-2009	http://nasrda.gov.ng/en/

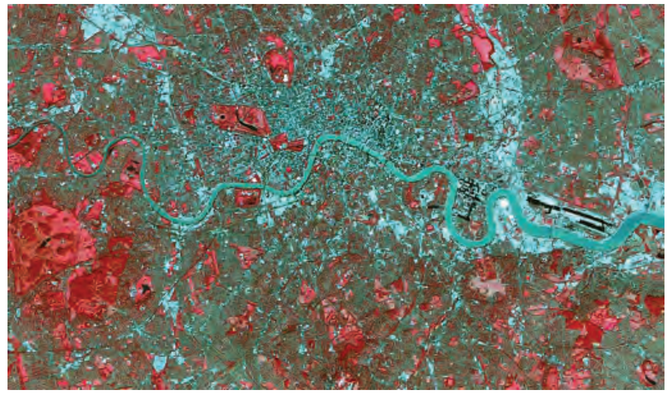
Deimos-1, UK-DMC-2, NigeriaSat-X—Continued

Spain, United Kingdom, Nigeria
Civil/Government
Operational



Sensor Information

GSD (m)	22
Swath (km)	650
Data Portal	http://www.dmcii.com/

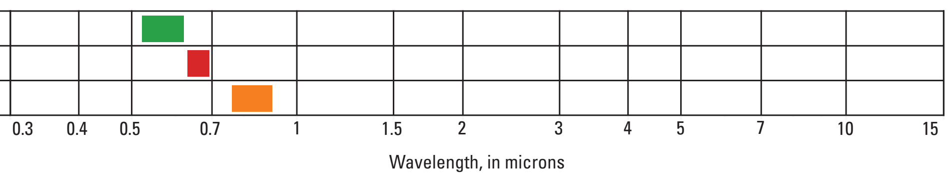


London, UK-DMC Constellation, UK-DMC2 image (image from Airbus DS, 2011, used with permission).

SLIM6 (22 meters)

The SLIM6 sensing element flown on the DMC second-generation satellites is an improved model of the first SLIM6 sensor. The ground sample distance was improved from 32 meters (m) to 22 m while maintaining the same swath width by using longer dimension arrays. The signal-to-noise ratio (SNR) was also improved in this generation of SLIM6 imagers. The SLIM6-22 imagers can image in 8-bit or 10-bit quantization, although the higher quantization limits the potential swath length of collectible data. SLIM6 data are commercially available.

Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.570	0.620	22
Red	0.630	0.660	0.690	22
NIR	0.760	0.830	0.900	22



JACIE

Deimos-2

Spain
Commercial
Operational

Platform Overview

Deimos-2 is a high-resolution, multispectral minisatellite launched in 2014 on a Dnepr-1 launch vehicle for Earth observation. Deimos-2 follows on the Deimos-1 mission, providing enhanced resolution and agility.

The satellite was built by Deimos Satellite Systems of Spain and Satrec Initiative (SI) of Korea. Deimos-2 utilizes SI's SpaceEye-1 platform (also known as SI-300) and is nearly identical to DubaiSat-1. Deimos-2 carries the High Resolution Advanced Imaging System (HiRAIS) sensor for high-resolution panchromatic and visible and near-infrared imaging.

Deimos-2 satellite (image from UrtheCast, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	06/19/2014
Design lifetime	10 years
Platform owner	Deimos Imaging
Altitude	620 km
Orbit period	97.3 min
Inclination	98°
Crossing time	10:30 AN
Nadir repeat	4 days
Status	Operational
System website	https://www.deimos-imaging.com/

Image of Stade de France captured by Deimos-2 satellite (image from UrtheCast, used with permission).

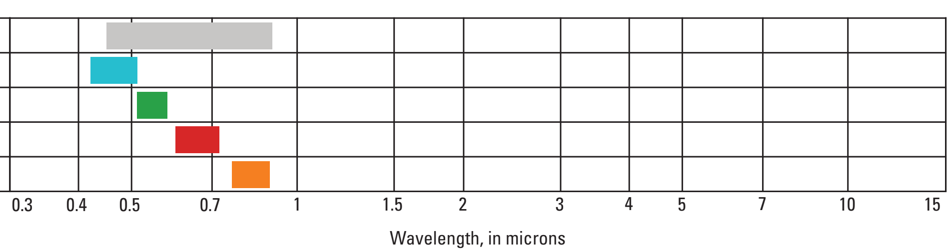
Sensor Information

GSD (m)	1, 4
Swath (km)	12
Data portal	https://www.deimos-imaging.com/catalogue

HiRAIS

The HiRAIS aboard Deimos-2 is a proven design with substantial heritage with DubaiSat-1 and 2. The sensor was designed and developed by SI in Korea. HiRAIS data are commercially available.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	1
Blue	0.420	0.465	0.510	4
Green	0.510	0.545	0.580	4
Red	0.600	0.660	0.720	4
NIR	0.760	0.825	0.890	4



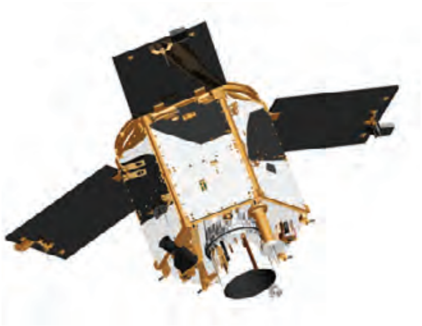
JACIE

DubaiSat-1

United Arab Emirates
Civil/Government
Operational

Platform Overview

DubaiSat-1 is a high-resolution multispectral satellite launched in 2009 by the Mohammed Bin Rashid Space Center (MBRSC) on a Dnepr rocket for Earth resources monitoring. This mission is the first satellite of the DubaiSat series. The DubaiSat-1 satellite was designed and built by Satrec Initiative Co. for the MBRSC and uses the SI-200 bus. DubaiSat-1 carries the DubaiSat Medium Aperture Camera (DMAC) sensor for high-resolution land imaging.



Artistic rendering of DubaiSat-1 (image from Satrec Initiative, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	07/29/2009
Design lifetime	5 years
Platform owner	MBRSC
Altitude	680 km
Orbit period	97.7 min
Inclination	98.13°
Crossing time	10:30 AN
Nadir repeat	8 days
Status	Operational
System website	—

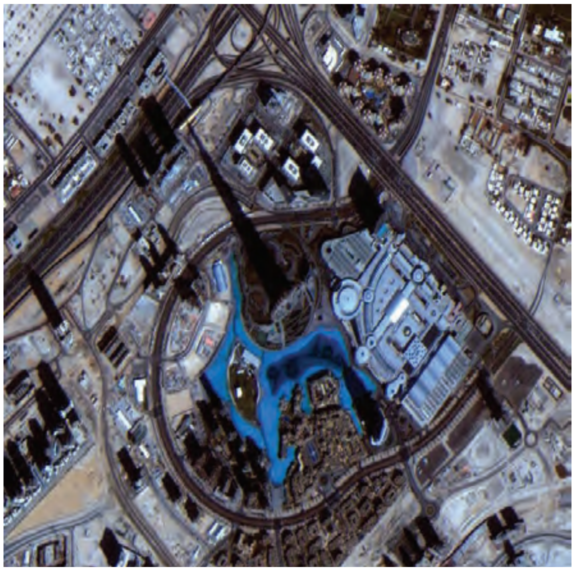


Image of Burj Khalifa, Dubai, captured by DubaiSat-1 (image from MBRSC, used with permission).

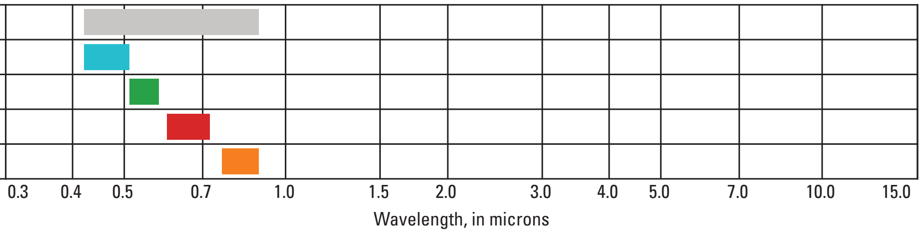
Sensor Information

	DMAC
GSD (m)	2.5, 5
Swath (km)	20.1
Data portal	—

DMAC

The DMAC is an optical pushbroom type camera imaging the Earth in visible and near-infrared bands.

Band	Lower	Center	Upper	GSD (m)
Pan	0.420	0.655	0.890	2.5
Blue	0.420	0.465	0.510	5
Green	0.510	0.545	0.580	5
Red	0.600	0.660	0.720	5
NIR	0.760	0.825	0.890	5



DubaiSat-2

United Arab Emirates
Civil/Government
Operational

Platform Overview

DubaiSat-2 is a high-resolution multispectral satellite launched in 2013 by the Mohammed Bin Rashid Space Center (MBRSC) on a Dnepr rocket from Dombarovsky for Earth resources monitoring. This mission continues the DubaiSat series that has been in continual operation since the launch of DubaiSat-1 in 2009.

The DubaiSat-2 satellite was designed and built by Satrec Initiative Co. for the MBRSC and uses the SI-300 bus. DubaiSat-2 carries the High Resolution Advanced Imaging System (HiRAIS) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	11/21/2013
Design lifetime	5 years
Platform owner	MBRSC
Altitude	600 km
Orbit period	96.69 min
Inclination	97.81°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—

Artistic rendering of DubaiSat-2 in orbit (image from MBRSC, used with permission).

Image of Abu Dhabi, United Arab Emirates, by DubaiSat-2 (image from MBRSC, used with permission).

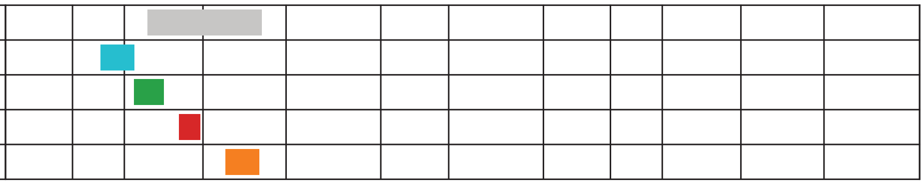
Sensor Information

	HiRAIS
GSD (m)	1, 4
Swath (km)	12
Data portal	—

HiRAIS

The HiRAIS is an improved version of the DMAC sensor flown on DubaiSat-1. The sensor offers a major improvement in image quality with a larger mirror diameter. The spectral bands, ground sample distance, swath width, and operating model remain the same as previous members of the DubaiSat family. HiRAIS data are gathered for paying customers only on a prepaid, prescheduled basis.

Band	Lower	Center	Upper	GSD (m)
Pan	0.550	0.725	0.900	1
Blue	0.450	0.485	0.520	4
Green	0.520	0.555	0.590	4
Red	0.630	0.660	0.690	4
NIR	0.770	0.830	0.890	4



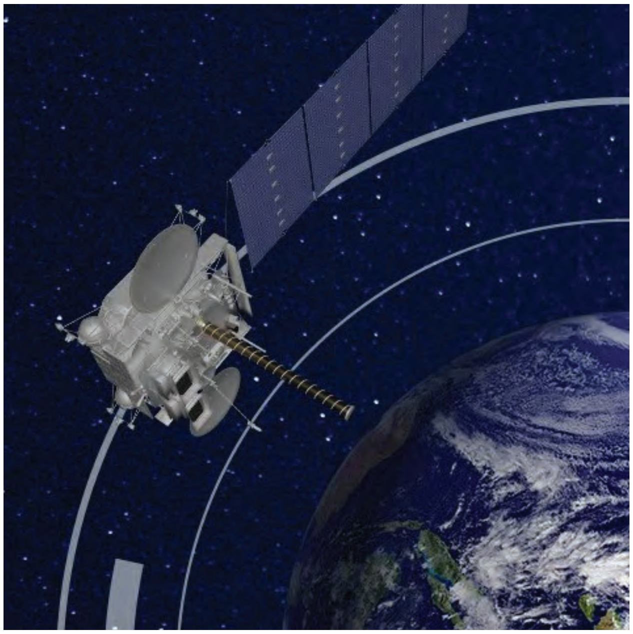
Electro-L

Russia
Civil/Government
Operational/Future

Platform Overview

Electro-L, also referred to as the Geostationary Operational Meteorological Satellite (or GOMS), is a series of low-resolution geostationary meteorological satellites operated by Russia. A total of three satellites, Electro-L No. 1, No. 2, and No. 3, were launched in 2011, 2015, and 2019, respectively, from Baikonur Cosmodrome. Electro-L No. 4 and No. 5 are planned for launch in 2021 and 2022, respectively. Electro-L satellites were developed by NPO Lavochkina Joint Stock Company (JSC) based on their Navigator bus. The satellites are operated by the Scientific Center for Operational Earth Monitoring JSC Russian Space Systems.

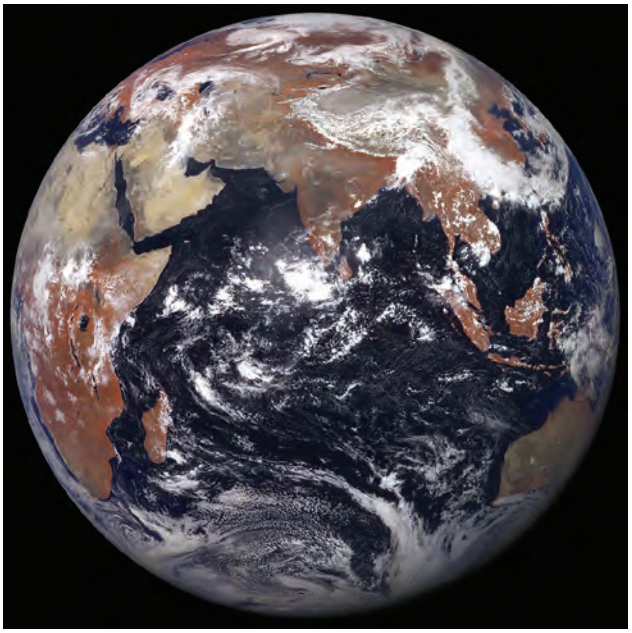
Electro-L satellites carry a multizone scanning hydrometeorological support device (MSD) to obtain multispectral images of clouds and Earth's surface, a heliogeophysical instrument to detect solar flares, and an airborne radio complex for the International COSPAS-SARSAT emergency call system.



Artistic rendering of Electro-L satellite in orbit (image from Roscosmos).

[Abbreviations in tables: km, kilometer; °, degree; W, west; E, east; GSD, ground sample distance; m, meter; —, no data; VNIR, visible and near infrared; MWIR, midwave infrared; TIR, thermal infrared]

	Electro-L No. 1	Electro-L No. 2	Electro-L No. 3
Launch date	01/20/2011	12/11/2015	12/24/2019
Design lifetime	10 years		
Platform owner	Roscosmos		
Altitude	36,000 km		
Orbit period	24 hours		
Longitude	14.5° W	76° E	165.8° E
Status	Operational		
System website	https://www.roscosmos.ru/24987/		



Electro-L image of Earth's disk (image from Roscosmos).

Sensor Information

	MSD
GSD (m)	1,000/4,000
Swath (km)	—
Data portal	https://gptl.ru/

JACIE

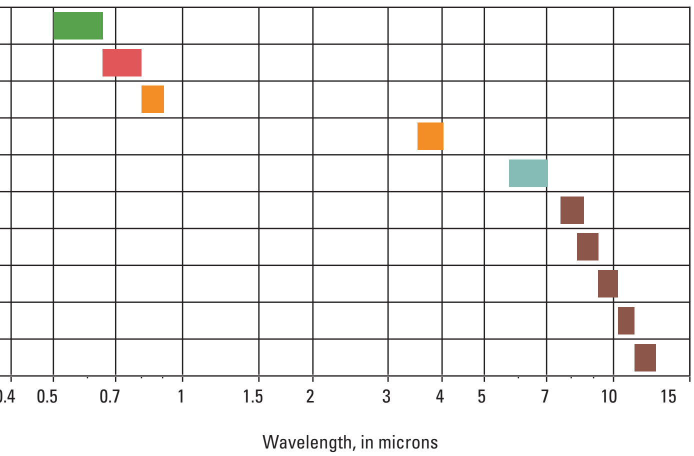
Electro-L—Continued

Russia
Civil/Government
Operational/Future

MSD

The MSD obtains multispectral images of clouds and the underlying surface within the visible disk of the Earth in the entire range of observation conditions in the visible and infrared parts of the spectrum.

Band	Lower	Center	Upper	GSD (m)
VNIR-1	0.500	0.575	0.650	1,000
VNIR-2	0.650	0.725	0.800	1,000
VNIR-3	0.800	0.850	0.900	1,000
MWIR-1	3.500	3.750	4.000	1,000
Water Vapor-1	5.700	6.350	7.000	4,000
Water Vapor-2	7.500	8.000	8.500	4,000
TIR-1	8.200	8.700	9.200	4,000
TIR-2	9.200	9.700	10.200	4,000
TIR-3	10.200	10.700	11.200	4,000
TIR-4	11.200	11.850	12.500	4,000

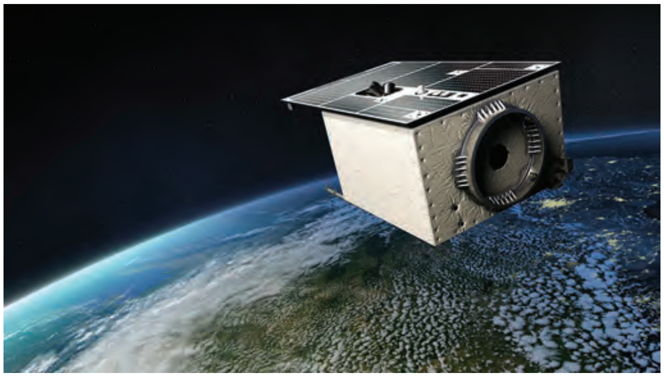


EnMAP

Germany
Civil/Government
Future

Platform Overview

Environmental Mapping and Analysis Program (EnMAP) is medium-resolution hyperspectral minisatellite to be launched in 2020 on a Polar Satellite Launch Vehicle for monitoring the condition of Earth's surface and the changes affecting it. EnMAP is based on the OHB-System of SAR-Lupe heritage. The bus of the system is referred to as LEOBus-1000. EnMAP will carry the Hyperspectral Imager (HSI) sensor for medium-resolution hyperspectral land imaging.



Artistic rendering of EnMAP in orbit (image from DLR).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Hyper, hyperspectral]

Launch date	2020
Design lifetime	5 years
Platform owner	German Aerospace Center (DLR)
Altitude	643 km
Orbit period	97 min
Inclination	98°
Crossing time	11:00 AN
Nadir repeat	21 days
Status	Development
System website	http://www.enmap.org/

Sensor Information

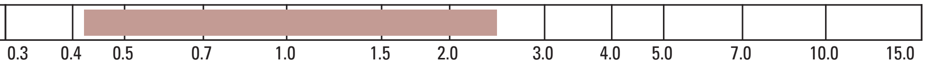
	HSI
GSD (m)	30
Swath (km)	30
Data portal	—

JACIE

HSI

The HSI sensor on EnMAP is a hyperspectral imager in visible and near infrared (VNIR) and shortwave infrared (SWIR). The imagery is acquired in 228 bands sampled at 5 nanometers (nm) in VNIR and at 10 nm in SWIR.

Band	Lower	Center	Upper	GSD (m)
Hyper	0.420	1.435	2.450	30

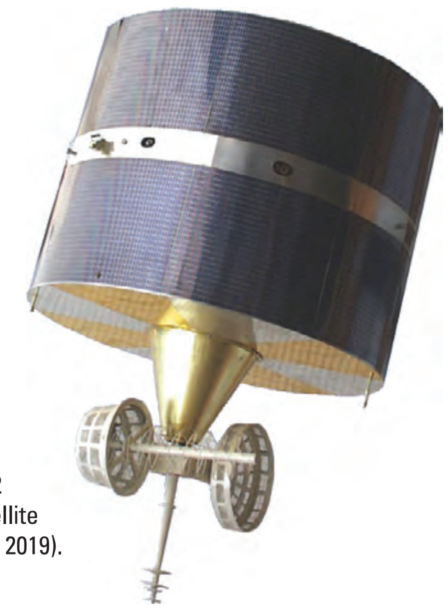


Fengyun-2

China
Civil/Government
Operational

Platform Overview

The Fengyun-2 (FY-2) series of Chinese first-generation geostationary meteorological satellites started with the launch of FY-2A in 1997.The FY-2 satellites, owned and operated by the China Meteorological Administration (CMA)/National Satellite Meteorological Center (NSMC), were launched onboard a Long March rocket from 1997 to 2018. FY-2E–2H are still operational. FY-2A and 2B carried a Visible and Infrared Spin Scanning Radiometer (VISSR), whereas FY-2C and 2H carried a Stretched-Visible and Infrared Spin Scanning Radiometer (S-VISSR). The FY-2 series has eight satellites launched to date to acquire Earth imagery to study weather and support vegetation and ocean studies.



Model of Fengyun-2 meteorological satellite (image from NSMC, 2019).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; E, east; GSD, ground sample distance; m, meter; VNIR, visible and near infrared; TIR, thermal infrared; MWIR, midwave infrared]

	FY-2A	FY-2B	FY-2C	FY-2D	FY-2E	FY-2F	FY-2G	FY-2H
Launch date	06/10/1997	06/25/2000	10/18/2004	12/08/2006	12/23/2008	01/13/2012	12/31/2014	06/05/2018
Design lifetime	3 years	3 years	3 years	3 years	3 years	3 years	4 years	4 years
Platform owner	CMA/NSMC							
Altitude	36,000 km							
Orbit period	1,440 min							
Longitude	105° E	105° E	105° E	86.5° E	86.5° E	112° E	105° E	79° E
Status	Retired	Retired	Retired	Retired	Retired	Operational	Operational	Operational
System website	http://www.cma.gov.cn/en2014/satellites/							

Sensor Information

	FY-2A and 2B VISSR	FY-2C–2H S-VISSR
GSD (m)	1,250/5,000	1,250/5,000
Swath (km)	—	—
Data portal	https://satellite.nsmc.org.cn/portalsite/default.aspx	https://satellite.nsmc.org.cn/portalsite/default.aspx

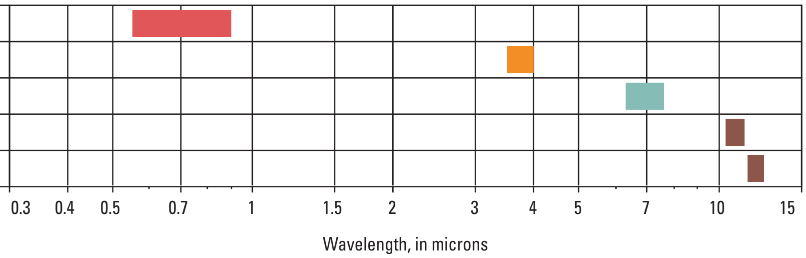
Fengyun-2—Continued

China
Civil/Government
Operational

FY-2A and 2B VISSR

The VISSR on FY-2A and 2B is a three-channel radiometer used to obtain daytime visible cloud images, day and night-time infrared cloud images, and water vapor distribution diagrams.

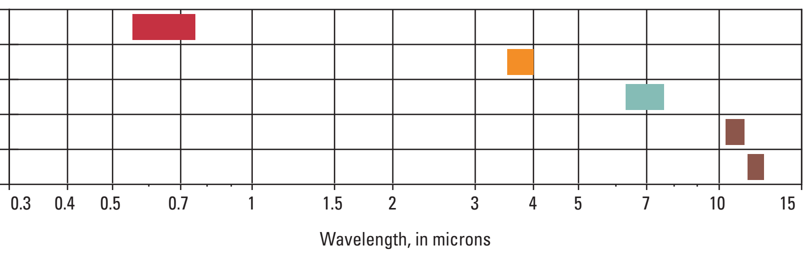
	Lower	Center	Upper	GSD (m)
VNIR	0.550	0.725	0.900	1,250
MWIR	3.500	3.750	4.000	5,000
Water vapor	6.300	6.950	7.600	5,000
TIR-1	10.300	10.800	11.300	5,000
TIR-2	11.500	12.000	12.500	5,000



FY-2C to 2H—S-VISSR

The S-VISSR on FY-2C-2H is a five-channel radiometer, an upgrade of the VISSR sensor on FY-2A and 2B, that supplies cloud images, radiation data, disaster warning, and environmental monitoring data.

Band	Lower	Center	Upper	GSD (m)
VNIR	0.55	0.65	0.75	1,250
MWIR	3.5	3.75	4	5,000
Water vapor	6.3	6.95	7.6	5,000
TIR-1	10.3	10.8	11.3	5,000
TIR-2	11.5	12	12.5	5,000



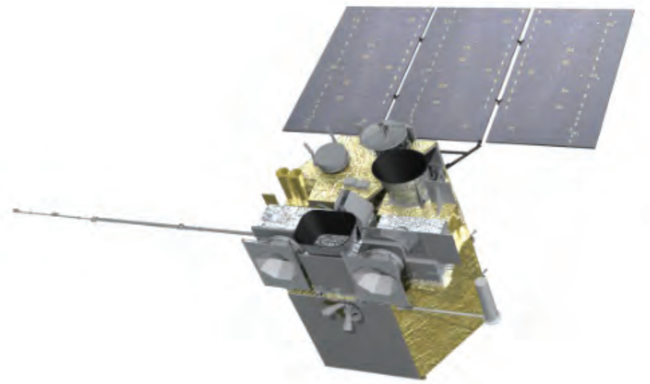
JACIE

Fengyun-4

China
Civil/Government
Operational/Future

Platform Overview

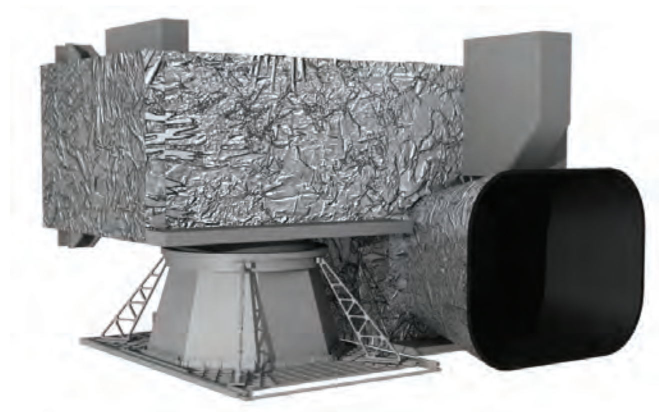
The Fengyun-4 (FY-4) series of Chinese second-generation geostationary meteorological satellites started with the launch of FY-4A in 2016. The FY-4A satellite, owned and operated by the China Meteorological Administration (CMA)/National Satellite Meteorological Center (NSMC), was launched onboard a Long March-3B rocket. FY-4A carries an Advanced Geostationary Radiation Imager (AGRI) to gather atmospheric, land surface, and sea surface data at a low resolution. FY-4B and beyond are planned for launch in the coming years.



Model of Fengyun-4A meteorological satellite (image from NSMC, 2019).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; E, east; NA, not applicable; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

	FY-4A
Launch date	12/10/2016
Design lifetime	10 years
Platform owner	CMA/NSMC
Altitude	36,000 km
Orbit period	1,440 min
Longitude	104.7° E
Crossing time	NA
Nadir report	NA
Status	Operational
System website	http://fy4.nsmc.org.cn/nsmc/en/theme/FY4A.html



Model of AGRI on FY-4A (image from NSMC, 2019).

Sensor Information

	AGRI
GSD (m)	500/2,000/4,000
Swath (km)	—
Data portal	http://fy4.nsmc.org.cn/data/en/data/realtime.html

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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eccoe@usgs.gov

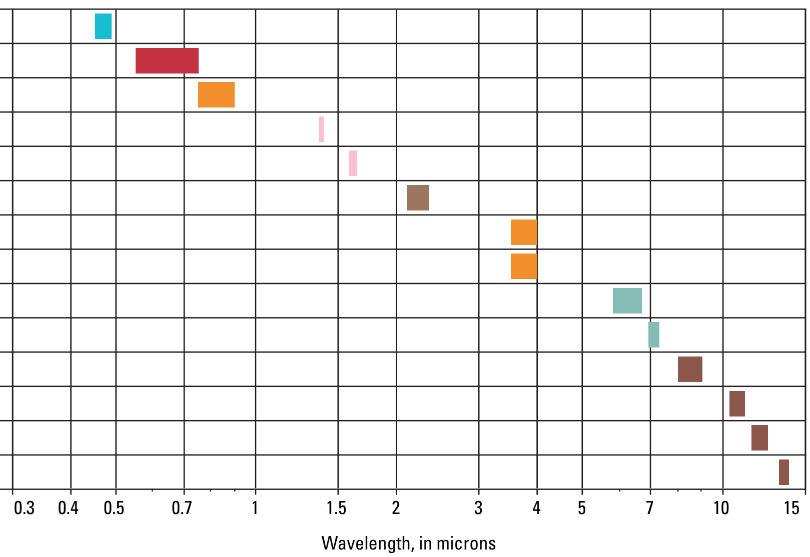
Fengyun-4—Continued

China
Civil/Government
Operational/Future

AGRI

AGRI is the primary instrument on the FY-4A satellite with 14 bands in visible and infrared regions of the spectrum. It is capable of imaging the entire disk in 15 minutes at a resolution of 500 meters in visible and 2–4 kilometers in infrared.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.470	0.490	1,000
Green	0.550	0.650	0.750	500
Red	0.750	0.825	0.900	1,000
NIR	1.360	1.375	1.390	2,000
SWIR1	1.580	1.610	1.640	2,000
SWIR2	2.100	2.225	2.350	2,000
MWIR-1	3.500	3.750	4.000	2,000
MWIR-2	3.500	3.750	4.000	2,000
Water vapor-1	5.800	6.250	6.700	4,000
Water vapor-2	6.900	7.100	7.300	4,000
Water vapor-3	8.000	8.500	9.000	4,000
TIR-1	10.300	10.700	11.100	4,000
TIR-2	11.500	12.000	12.500	4,000
TIR-3	13.200	13.500	13.800	4,000



FLEX

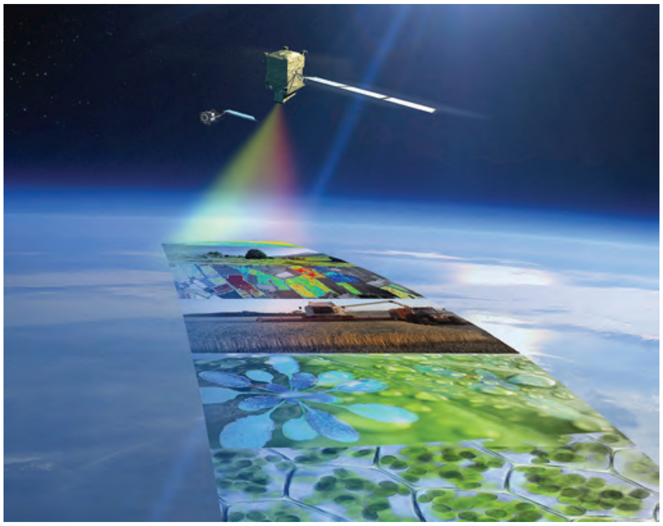
European Space Agency
Civil/Government
Future

Platform Overview

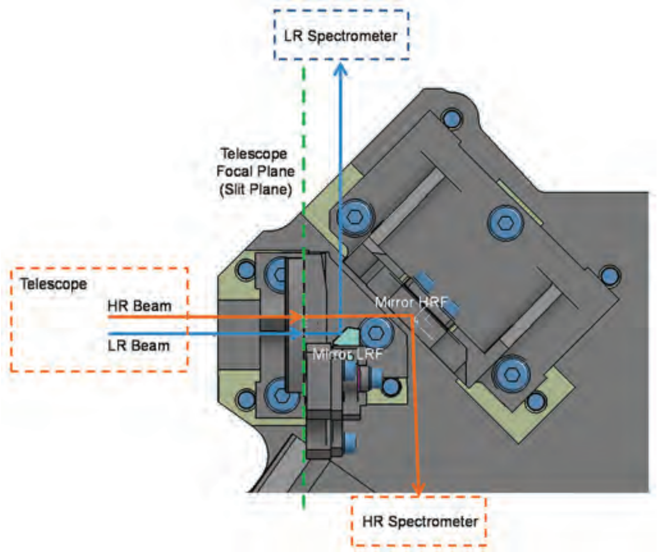
The Fluorescence Explorer (FLEX) is a European Space Agency (ESA) high-resolution imaging spectrometer satellite to be launched in 2022 for mapping vegetation fluorescence. FLEX was selected as the eighth Earth Explorer mission in 2015 and carries the FLuORescence Imaging Spectrometer (FLORIS) sensor for low-resolution land imaging, with an expected 500–800-nanometer (nm) spectral range.

[Abbreviations in tables: km, kilometer; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	2022 (Planned)
Design lifetime	5 years
Platform owner	ESA
Altitude	815 km
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Planned
System website	https://earth.esa.int/web/guest/missions/esa-future-missions/flex



Artistic rendering of FLEX in orbit (image from ESA).



FLORIS sensor illustration (image from ESA).

Sensor Information

	FLORIS
GSD (m)	300
Swath (km)	150
Data portal	—

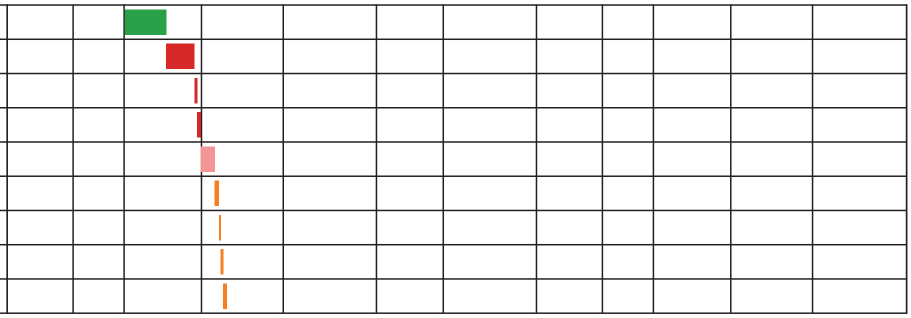
FLEX—Continued

European Space Agency
Civil/Government
Future

FLORIS

FLORIS, a pushbroom hyperspectral imager, will measure vegetation fluorescence in visible and near infrared (VNIR) at medium spatial resolution over a swath of 150 kilometers. The imaging spectrometer has two modules—one has very high spectral resolution (0.3 nm) with two oxygen absorption bands (O2A and O2B, shown as NIR here) and the other has lower spectral resolution (3 nm) for atmospheric and vegetation parameters.

Band	Lower	Center	Upper	GSD (m)
Green	0.500	0.550	0.600	300
Red	0.600	0.639	0.677	300
Red	0.677	0.682	0.686	300
Red	0.686	0.692	0.697	300
Red Edge	0.697	0.719	0.740	300
NIR	0.740	0.748	0.755	300
NIR	0.755	0.757	0.759	300
NIR	0.759	0.764	0.769	300
NIR	0.769	0.775	0.780	300



Gaofen-1

China
Civil/Government
Operational

Platform Overview

Gaofen-1 (GF-1) is a high-resolution multispectral satellite launched in 2013 by China on a Long March-2D rocket from the Jiuquan Satellite Launch Center. GF-1 is the first satellite in the China High-resolution Earth Observation System. The satellite is based on the China Academy of Space Technology-2000 bus built by the Shanghai Academy of Spaceflight Technology for the China National Space Administration (CNSA). GF-1 carries a panchromatic and multispectral camera-1 (PMC-1) and a wide field camera (WFC) for high-resolution Earth monitoring.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	04/26/2013
Design lifetime	8 years
Platform owner	CNSA
Altitude	631 km
Orbit period	97 min
Inclination	97.9°
Crossing time	10:30 DN
Nadir repeat	69 days
Status	Operational
System website	http://www.cresda.com/EN/satellite/7155.shtml

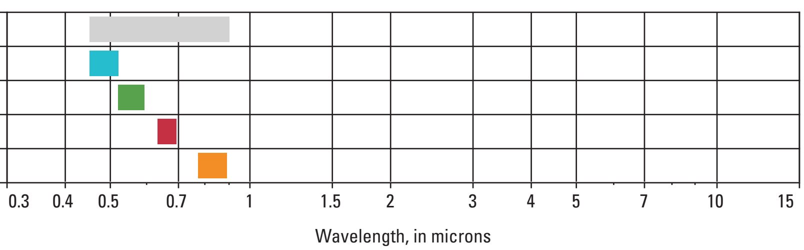
Sensor Information

	PMC-1	WFC
GSD (m)	2/8	16
Swath (km)	60	800
Revisit (days)	4	2
Data portal	http://www.cnsageo.com/#/	

PMC-1

The PMC-1 on the GF-1 satellite is a combination of two cameras attached together.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	2
Blue	0.450	0.485	0.520	8
Green	0.520	0.555	0.590	8
Red	0.630	0.660	0.690	8
NIR	0.770	0.830	0.890	8



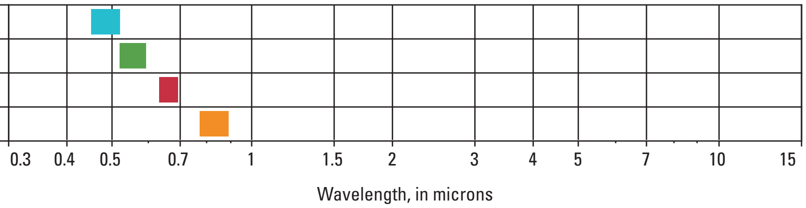
Gaofen-1—Continued

China
Civil/Government
Operational

WFC

The WFC provides an extended swath of 800 kilometers with four cameras stitched together.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	16
Green	0.520	0.555	0.590	16
Red	0.630	0.660	0.690	16
NIR	0.770	0.830	0.890	16



JACIE

Gaofen-1 02/03/04

China
Civil/Government
Operational

Platform Overview

The Gaofen-1 02, 03, and 04 (GF-1 02/03/04) satellites are the high-resolution multispectral satellites launched in 2018 by China on a Long March-4C rocket from the Taiyuan Satellite Launch Center. GF-1 02/03/04 satellites are the follow-on satellites based on the first satellite in the China High-resolution Earth Observation System GF-1. The satellites are based on the China Academy of Space Technology-2000 bus built by Shanghai Academy of Spaceflight Technology for the China National Space Administration (CNSA). GF-1 02/03/04 satellites carry a panchromatic and multispectral camera-1 (PMC-1) for high-resolution Earth monitoring.

A model of the Gaofen-1 02 satellite (image from Gunter's Space Page).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

Launch date	03/30/2018
Design lifetime	8 years
Platform owner	CNSA
Altitude	645 km
Orbit period	97.62 min
Inclination	98.05°
Crossing time	10:30 DN
Nadir repeat	41 days
Status	Operational
System website	http://www.cresda.com/EN/satellite/7155.shtml

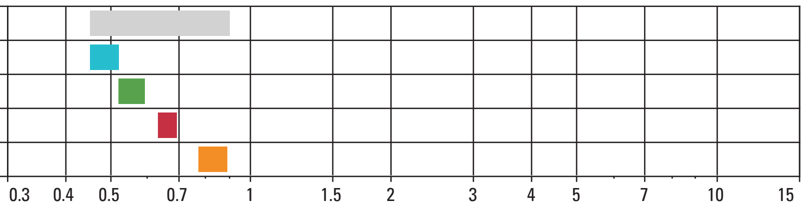
Sensor Information

	PMC-1
GSD (m)	2/8
Swath (km)	60
Revisit (days)	4
Data portal	—

PMC-1

The PMC-1 on the GF-1 02/03/04 satellites is a combination of two cameras attached together.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	2
Blue	0.450	0.485	0.520	8
Green	0.520	0.555	0.590	8
Red	0.630	0.660	0.690	8
NIR	0.770	0.830	0.890	8



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Gaofen-2

China
Civil/Government
Operational

Platform Overview

Gaofen-2 (GF-2) is a high-resolution multispectral satellite launched in 2014 by China on a Long March-4B rocket from the Taiyuan Satellite Launch Center. GF-2 is the follow-on satellite for GF-1 in the China High-resolution Earth Observation System. The satellite is based on the China Academy of Space Technology-2000 bus built by the Shanghai Academy of Spaceflight Technology for the China National Space Administration (CNSA). GF-2 carries a panchromatic and multispectral camera-2 (PMC-2) with an improved swath and resolution for high-resolution Earth monitoring. The GF-2 satellite can swivel on its axis 35 degrees to either side.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared]

Launch date	08/19/2014
Design lifetime	8 years
Platform owner	CNSA
Altitude	645 km
Orbit period	97.62 min
Inclination	98.05°
Crossing time	10:30 DN
Nadir repeat	41 days
Status	Operational
System website	http://www.cresda.com/EN/satellite/7155.shtml

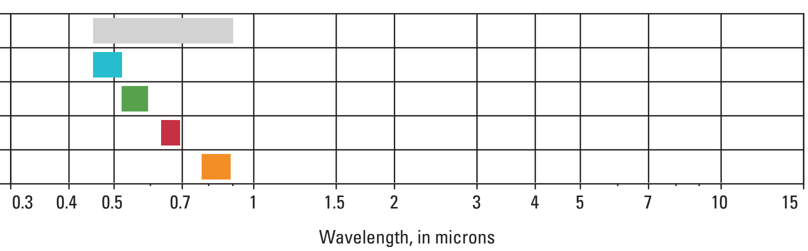
Sensor Information

	PMC-2
GSD (m)	0.8/3.24
Swath (km)	45
Revisit (days)	5
Data portal	—

PMC-2

The PMC-2 on the GF-2 satellite is a combination of two cameras attached together, imaging in panchromatic and multispectral bands.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	0.8
Blue	0.450	0.485	0.520	3.2
Green	0.520	0.555	0.590	3.2
Red	0.630	0.660	0.690	3.2
NIR	0.770	0.830	0.890	3.2



JACIE

Gaofen-3

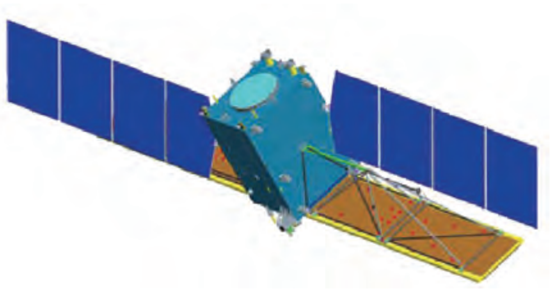
China
Civil/Government
Operational

Platform Overview

Gaofen-3 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2016 by China National Space Agency (CNSA) for Earth resources monitoring. GF-3 was designed and built by Shanghai Academy of Spaceflight Technology (SAST). It is the first radar satellite in the China High Resolution Earth Observing System (CHEOS). The satellite carries a C-band SAR for all-weather Earth imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

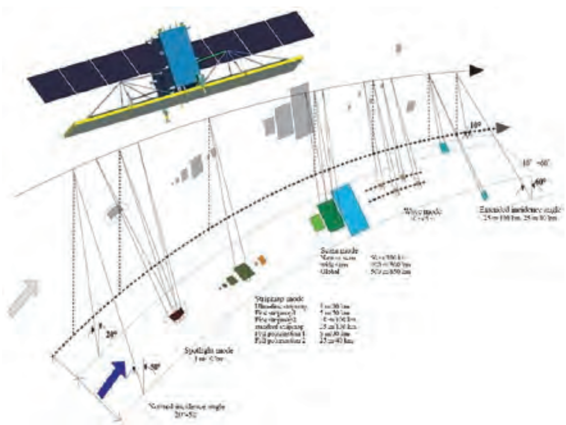
	GF-3
Launch date	08/09/2016
Design lifetime	8 years
Platform owner	CNSA
Altitude	758 km
Orbit period	99.98 min
Inclination	98.42°
Crossing time	06:00 DN
Nadir report	—
Status	Operational
System website	—



Artistic rendering of GF-3 satellite (image from China Academy of Spaceflight Technology).

Sensor Information

	SAR-C
GSD (m)	1–500
Swath (km)	650
Data portal	—



Gaofen-3 SAR-C imaging modes (image from China Academy of Spaceflight Technology).

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Gaofen-3—Continued

China
Civil/Government
Operational

SAR-C

C-band SAR on GF-3 operates in 12 imaging modes with an incidence angle of 10–60°. GF-12 also carries a similar C-band SAR.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight	Single	HH, VV	10	1
Ultra-fine stripmap	Single	HH, VV	30	3
Fine stripmap	Dual	HH/HV, VH/VV	50	5
Wide fine stripmap	Dual	HH/HV, VH/VV	100	10
Standard stripmap	Dual	HH/HV, VH/VV	130	25
Narrow ScanSAR	Dual	HH/HV, VH/VV	300	50
Wide ScanSAT	Dual	HH/HV, VH/VV	500	100
Global observation	Dual	HH/HV, VH/VV	650	500
Quad-pol stripmap	Quad	HH/HV/VH/VV	30	8
Wave	Quad	HH/HV/VH/VV	5	10
Expanded incidence angle	Quad	HH/HV/VH/VV	130	25
			80	25

Gaofen-4

China
Civil/Government
Operational

Platform Overview

Gaofen-4 (GF-4) is a medium-resolution multispectral satellite launched in 2015 from the Xichang Satellite Launch Center by the China National Space Administration (CNSA) for Earth resources monitoring. GF-4 is the only geosynchronous satellite in the China High-resolution Earth Observation System. GF-4 carries a multispectral imager with five bands in visible and near infrared (VNIR) and one band in midwave infrared. GF-4 can image the entire disk every 20 seconds.

[Abbreviations in tables: km, kilometer; min, minute; —, no data; °, degree; E, east; GSD, ground sample distance; m, meter; NIR, near infrared; MWIR, midwave infrared]

Launch date	12/29/2015
Design lifetime	8 years
Platform owner	CNSA
Altitude	36,000 km
Orbit period	1,440 min
Longitude	105.6° E
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Operational
System website	—

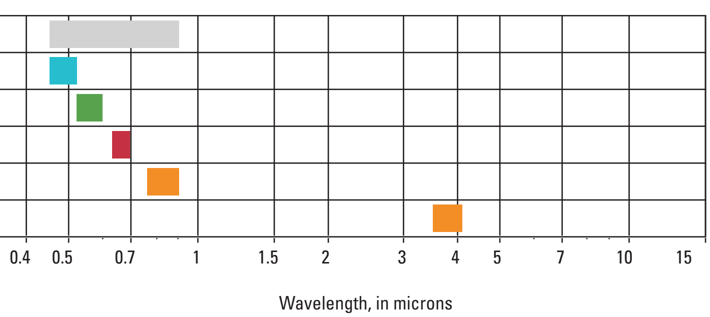
Sensor Information

	GF-4 Imager
GSD (m)	50/400
Swath (km)	400
Revisit (days)	—
Data portal	—

GF-4 Imager

The VNIR camera on GF-4 images the Earth every 20 seconds in VNIR bands at a ground resolution of 50 meters.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	50
Blue	0.450	0.485	0.520	50
Green	0.520	0.560	0.600	50
Red	0.630	0.660	0.690	50
NIR	0.760	0.830	0.900	50
MWIR	3.500	3.800	4.100	400



Gaofen-5

China
Civil/Government
Operational

Platform Overview

Gaofen-5 (GF-5) is a high-resolution hyperspectral satellite launched in 2018 by the China National Space Administration (CNSA) on the Long March-4C rocket for Earth resources monitoring. GF-5 carries six sensors onboard including Advanced Hyperspectral Imager (AHSI), Visual and Infrared Multispectral Sensor (VIMS), Greenhouse-gases Monitoring Instrument, Atmospheric Infrared Ultraspectral, Environment Monitoring Instrument, and Directional Polarization Camera for land imaging and air monitoring.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; AHSI, Advanced Hyperspectral Imager; VIMS, Visual and Infrared Multispectral Sensor; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

Launch date	05/08/2018
Design lifetime	8 years
Platform owner	CNSA
Altitude	708 km
Orbit period	98.8 min
Inclination	98.2°
Crossing time	13:30 AN
Nadir repeat	—
Status	Operational
System website	—

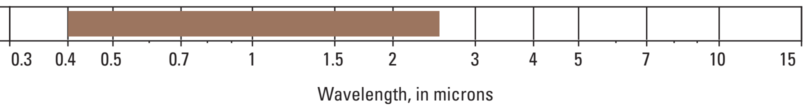
Sensor Information

	AHSI	VIMS
GSD (m)	30	20/40
Swath (km)	60	60
Revisit (days)	—	—
Data portal	—	—

AHSI

The AHSI sensor on GF-5 is the first large-width, wide-spectrum, and highly quantitative satellite hyperspectral imager in the world. It was developed by the Shanghai Institute of Technical Physics.

Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.400	1.450	2.500	30



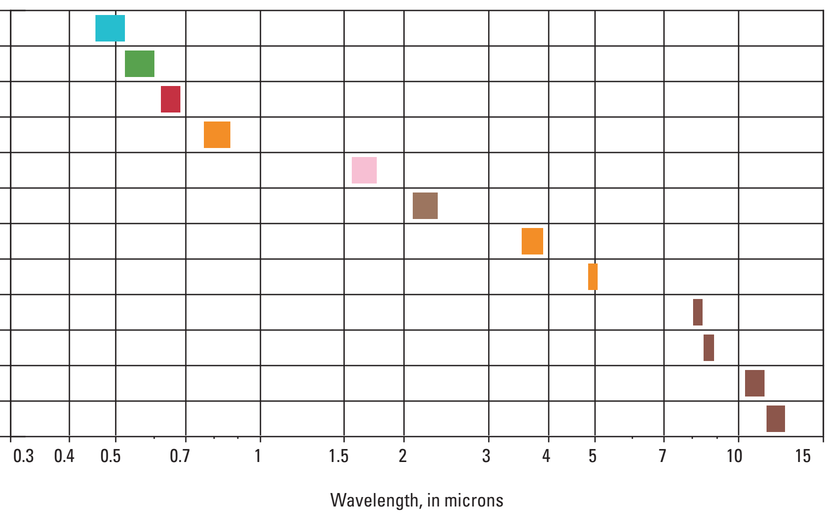
Gaofen-5—Continued

China
Civil/Government
Operational

VIMS

The VIMS is one of the primary payloads on GF-5. It is the second generation of the imager in the visible to thermal infrared spectrum.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	20
Green	0.520	0.560	0.600	20
Red	0.620	0.650	0.680	20
NIR	0.760	0.810	0.860	20
SWIR1	1.550	1.650	1.750	20
SWIR2	2.080	2.215	2.350	20
MWIR-1	3.500	3.700	3.900	40
MWIR-2	4.850	4.950	5.050	40
TIR-1	8.010	8.200	8.390	40
TIR-2	8.420	8.625	8.830	40
TIR-3	10.300	10.800	11.300	40
TIR-4	11.400	11.950	12.500	40



Gaofen-6

China
Civil/Government
Future

Platform Overview

Gaofen-6 (GF-6) is a high-resolution multispectral satellite launched in 2018 on a Long March rocket from the Jiuquan Satellite Launch Center by the China National Space Administration (CNSA) for Earth resources monitoring. GF-6 is a part of the China High-resolution Earth Observation System. The satellite is based on the China Academy of Space Technology-2000 bus built by the Shanghai Academy of Spaceflight Technology for the CNSA. GF-6 carries a panchromatic and multispectral camera-1 (PMC-1) and a wide field camera (WFC) for high-resolution Earth monitoring.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; CA, coastal aerosol]

Launch date	06/02/2018
Design lifetime	8 years
Platform owner	CNSA
Altitude	645 km
Orbit period	97.62 min
Inclination	98.05°
Crossing time	10:30 DN
Nadir repeat	41 days
Status	Operational
System website	—

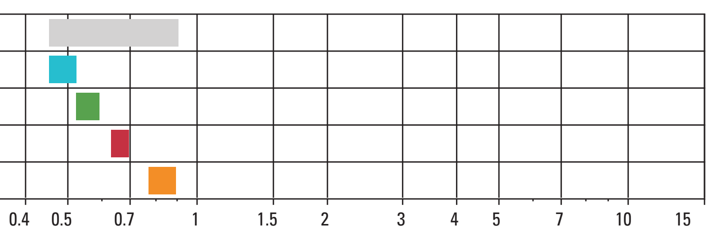
Sensor Information

	PMC-1	WFC
GSD (m)	2/8	16
Swath (km)	90	800
Revisit (days)	4	2
Data portal	www.cnsageo.com/#/	

PMC-1

The PMC-1 on the GF-6 satellite is a combination of two cameras attached together.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	2
Blue	0.450	0.485	0.520	8
Green	0.520	0.555	0.590	8
Red	0.630	0.660	0.690	8
NIR	0.770	0.830	0.890	8



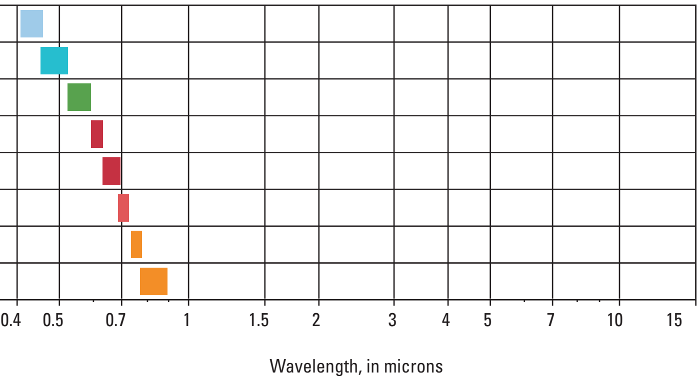
Gaofen-6—Continued

China
Civil/Government
Future

WFC

The WFC provides an extended swath of 800 kilometers with four cameras stitched together.

Band	Lower	Center	Upper	GSD (m)
CA	0.405	0.431	0.456	16
Blue	0.450	0.485	0.520	16
Green	0.520	0.555	0.590	16
Yellow	0.591	0.611	0.631	16
Red	0.630	0.660	0.690	16
Red Edge-1	0.685	0.704	0.723	16
Red Edge-2	0.731	0.752	0.773	16
NIR	0.770	0.830	0.890	16



Gaofen-8

China
Civil/Government
Operational

Platform Overview

Gaofen-8 (GF-8) is a high-resolution multispectral satellite launched in 2015 by China on the 205th flight of a Long March rocket from the Taiyuan Satellite Launch Center. GF-8 is the third satellite in the China High-resolution Earth Observation System. The satellite is based on the China Academy of Space Technology-2000 bus built by the Shanghai Academy of Spaceflight Technology for the China National Space Administration (CNSA). GF-8 carries a panchromatic and multispectral camera-2 (PMC-2) with an improved swath and resolution for high-resolution Earth monitoring.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	06/26/2015
Design lifetime	8 years
Platform owner	CNSA
Altitude	485 km
Orbit period	94.3 min
Inclination	97.3°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—

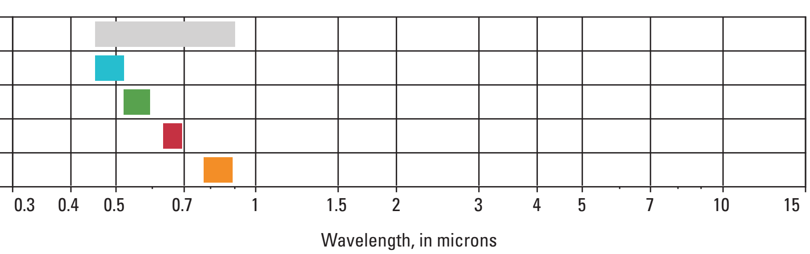
Sensor Information

	PMC-2
GSD (m)	0.8/3.24
Swath (km)	45
Revisit (days)	5
Data portal	—

PMC-2

The PMC-2 on the GF-8 satellite is a combination of two cameras attached together, imaging in panchromatic and multispectral bands.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	0.8
Blue	0.450	0.485	0.520	3.2
Green	0.520	0.555	0.590	3.2
Red	0.630	0.660	0.690	3.2
NIR	0.770	0.830	0.890	3.2



Gaofen-9

China
Civil/Government
Operational

Platform Overview

Gaofen-9 (GF-9) is a high-resolution multispectral satellite launched in 2015 by the China National Space Administration (CNSA) on the 209th flight of a Long March-2D rocket from the Jiuquan Satellite Launch Center for Earth resources monitoring. The GF-9 satellite was developed by the China Academy of Space Technology. It carries an improved panchromatic and multispectral camera-2 (PMC-2) for high-resolution imaging. GF-9 2 and GF-9 3 were launched in 2020 and carry an identical sensor as GF-9.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	09/14/2015
Design lifetime	8 years
Platform owner	CNSA
Altitude	650 km
Orbit period	97.5 min
Inclination	97.94°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—

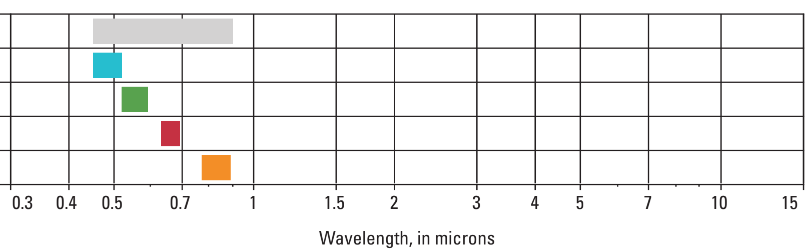
Sensor Information

	PMC-2
GSD (m)	0.8/3.24
Swath (km)	45
Revisit (days)	5
Data portal	—

PMC-2

The PMC-2 on the GF-9 satellite is a combination of two cameras attached together, imaging in panchromatic and multispectral bands.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	0.8
Blue	0.450	0.485	0.520	3.2
Green	0.520	0.555	0.590	3.2
Red	0.630	0.660	0.690	3.2
NIR	0.770	0.830	0.890	3.2



Gaofen-11

China
Civil/Government
Operational

Platform Overview

Gaofen-11 (GF-11) is a high-resolution multispectral satellite launched in 2018 by the China National Space Administration (CNSA) on a Long March-4B rocket from the Taiyuan Satellite Launch Center for Earth resources monitoring. The GF-11 satellite was developed by the China Academy of Space Technology as a part of the China High-resolution Earth Observation System. The satellite carries a panchromatic and multispectral camera-2 (PMC-2) to collect Earth data in the visible and near-infrared part of the spectrum.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	07/31/2018
Design lifetime	8 years
Platform owner	CNSA
Altitude	485 km
Orbit period	94.3 min
Inclination	97.4°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—

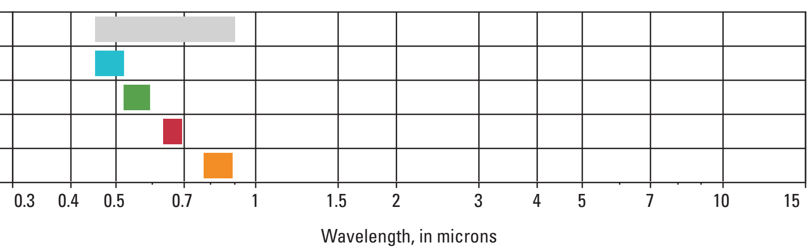
Sensor Information

	PMC-2
GSD (m)	0.8/3.24
Swath (km)	45
Revisit (days)	5
Data portal	—

PMC-2

The PMC-2 on the GF-2 satellite is a combination of two cameras attached together, imaging in panchromatic and multispectral bands.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	0.8
Blue	0.450	0.485	0.520	3.2
Green	0.520	0.555	0.590	3.2
Red	0.630	0.660	0.690	3.2
NIR	0.770	0.830	0.890	3.2



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Gaofen-12

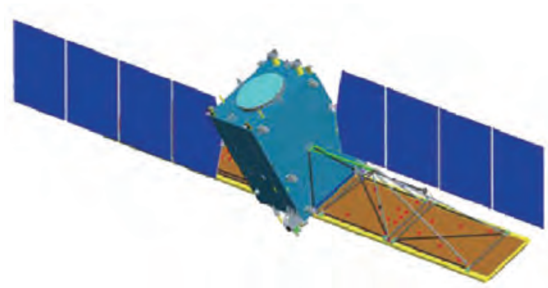
China
Civil/Government
Operational

Platform Overview

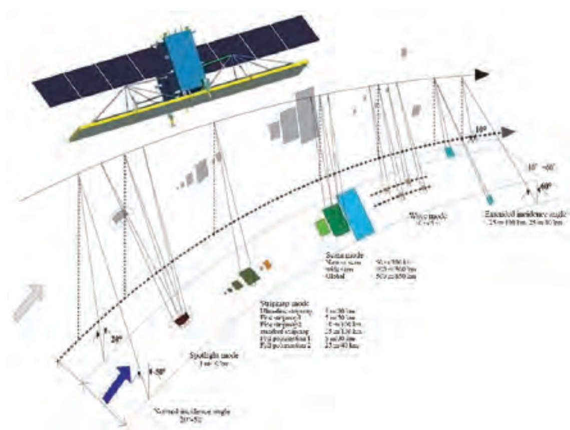
Gaofen-12 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2019 by China National Space Agency (CNSA) on a Long March-4C rocket from Taiyuan Satellite Launch Center (TSLC) for Earth resources monitoring. GF-12 was designed and built by Shanghai Academy of Spaceflight Technology (SAST). It is the latest radar satellite in the China High Resolution Earth Observing System (CHEOS). The satellite carries a C-band synthetic aperture radar (SAR) for all-weather Earth imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter ; H, horizontal; V, vertical]

Launch date	11/27/2019
Design lifetime	8 years
Platform owner	CNSA
Altitude	635 km
Orbit period	97.3 min
Inclination	97.8°
Crossing time	06:00 DN
Nadir repeat	—
Status	Operational
System website	—



Artistic rendering of GF-12 satellite (image from China Academy of Spaceflight Technology).



GF-12 SAR-C imaging modes (image from China Academy of Spaceflight Technology).

Sensor Information

	SAR-C
GSD (m)	1–500
Swath (km)	650
Data portal	—

Gaofen-12—Continued

China
Civil/Government
Operational

SAR-C

The C-band SAR on GF-12 operates in 12 imaging modes with an incidence angle of 10–60°. GF-3 also carries a similar C-band SAR.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight	Single	HH, VV	10	1
Ultra-fine stripmap	Single	HH, VV	30	3
Fine stripmap	Dual	HH/HV, VH/VV	50	5
Wide fine stripmap	Dual	HH/HV, VH/VV	100	10
Standard stripmap	Dual	HH/HV, VH/VV	130	25
Narrow ScanSAR	Dual	HH/HV, VH/VV	300	50
Wide ScanSAT	Dual	HH/HV, VH/VV	500	100
Global observation	Dual	HH/HV, VH/VV	650	500
Quad-pol stripmap	Quad	HH/HV/VH/VV	30	8
Wave	Quad	HH/HV/VH/VV	5	10
Expanded incidence angle	Quad	HH/HV/VH/VV	130	25
			80	25

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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GEO-CAPE

United States
Civil/Government
Future

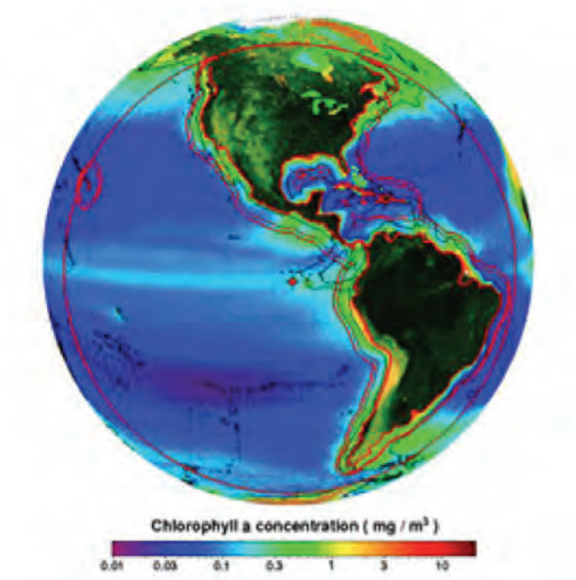
JACIE

Platform Overview

The GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission is planned to be launched in 2023 to measure tropospheric trace gases and aerosols, coastal ocean phytoplankton, water quality, and biogeochemistry. GEO-CAPE will be in a geostationary orbit near 95–100 degrees west to cover North and South America and their coasts. Specific sensors for GEO-CAPE have not yet been selected.

[Abbreviations in table: —, no data; km, kilometer; °, degree; NA, not applicable]

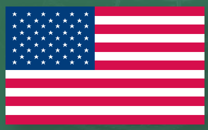
Launch date	2023 (Planned)
Design lifetime	—
Platform owner	NASA
Altitude	35,786 km
Orbit period	24 hours
Inclination	0°
Crossing time	NA
Nadir repeat	NA
Status	Development
System website	https://geo-cape.larc.nasa.gov/



Geostationary view from 95° W for the GEO-CAPE coastal ecosystem sensor overlain on the SeaWiFS chlorophyll-*a* mission composite (image from NASA).

GeoEye-1

United States
Commercial
Operational



Platform Overview

GeoEye-1 is a high-resolution panchromatic and multispectral satellite launched in 2008 on a Delta-II launch vehicle from Vandenberg Air Force Base for commercial Earth resources monitoring. DigitalGlobe acquired GeoEye Inc. in 2013, adding GeoEye-1 to their constellation of commercial satellites. GeoEye-1 was designed and developed at General Dynamics in the United States and uses the SA-200HP bus of Coriolis and SWIFT heritage. GeoEye-1 carries the GeoEye Imaging System (GIS) for high-resolution land imaging.

Artistic rendering of GeoEye-1 (image from Maxar Technologies, 2019, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	09/06/2008
Design lifetime	7 years
Platform owner	DigitalGlobe
Altitude	681 km
Orbit period	98 min
Inclination	98.12°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	https://www.digitalglobe.com/about/our-constellation/

GeoEye-1 image of Monopoli, Italy (image from Maxar Technologies, 2019, used with permission).

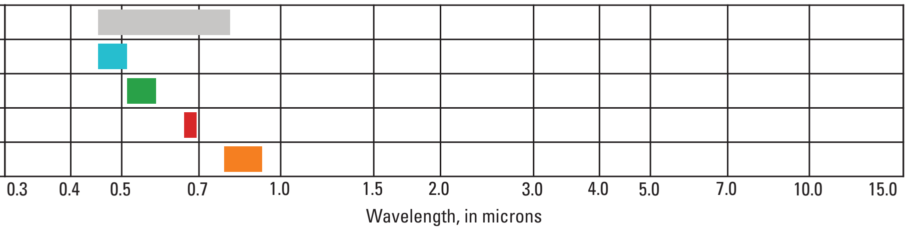
Sensor Information

	GIS
GSD (m)	0.41, 1.65
Swath (km)	15.3
Data portal	https://www.digitalglobe.com/products/collection-request

GIS

The GIS sensor is a pushbroom-style charge coupled device imager. The sensor was designed and developed by ITT in the United States and delivered to General Dynamics for integration. GIS data are commercially available.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.625	0.800	0.41
Blue	0.450	0.480	0.510	1.65
Green	0.510	0.545	0.580	1.65
Red	0.655	0.673	0.690	1.65
NIR	0.780	0.850	0.920	1.65



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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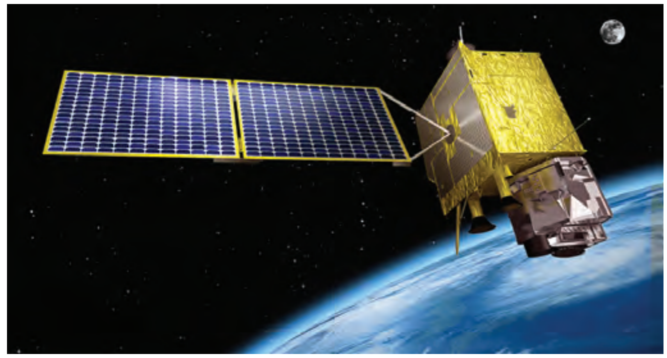
GEO-KOMPSAT-2A

South Korea
Civil/Government
Operational

Platform Overview

GEO-KOMPSAT-2A is a low-resolution, multispectral, geostationary satellite launched in 2018 by the Korean Aerospace Research Institute (KARI) on an Ariane-5ECA launch vehicle for meteorological monitoring. GEO-KOMPSAT-2A provides continuity for the Meteorological Imager aboard COMS. The platform used by GEO-KOMPSAT-2A is developed and built by KARI. GEO-KOMPSAT-2A carries the Advanced Meteorological Imager (AMI) sensor for low-resolution meteorological imaging.



Artistic rendering of GEO-KOMPSAT-2A in orbit (image from KARI, used with permission).

[Abbreviations in tables: km, kilometer; °, degree; E, east; NA, not applicable; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

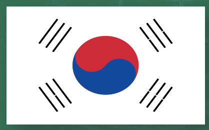
Launch date	12/05/2018
Design lifetime	10 years
Platform owner	KARI
Altitude	35,786 km
Orbit period	24 hours
Longitude	128.2° E
Inclination	0°
Crossing time	NA
Nadir repeat	NA
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_02.do

Sensor Information

	AMI
GSD (m)	500; 1,000; 2,000
Swath (km)	—
Data portal	https://nmsc.kma.go.kr/

GEO-KOMPSAT-2A—Continued

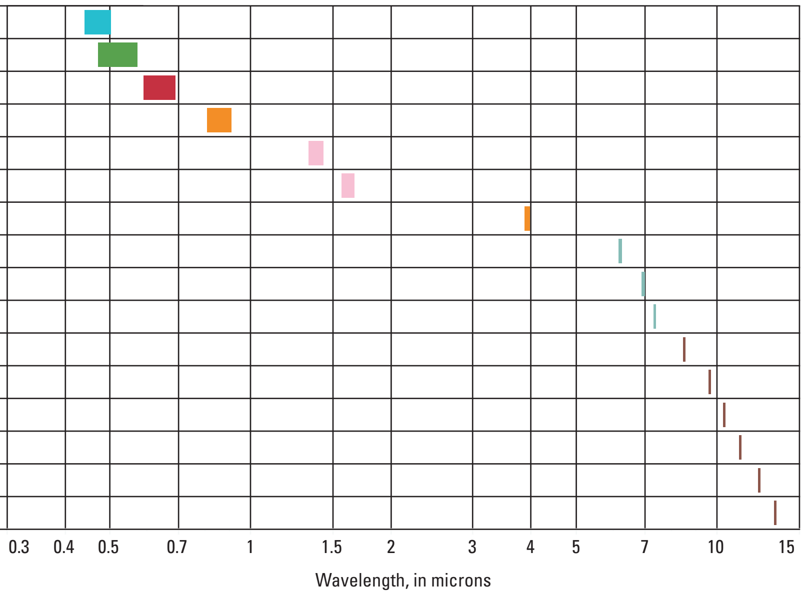
South Korea
Civil/Government
Operational



AMI

The AMI was developed by ITT Inc. in the United States. AMI is based on the Advanced Baseline Imager (ABI) flown on GOES-R. AMI has improved spectral, temporal, and spatial resolution compared to the imager aboard COMS.

Band	Lower	Center	Upper	GSD (m)
Blue	0.440	0.470	0.500	1,000
Green	0.470	0.520	0.570	1,000
Red	0.590	0.640	0.690	500
NIR	0.806	0.856	0.906	1,000
SWIR1-1	1.328	1.378	1.428	2,000
SWIR1-2	1.560	1.610	1.660	2,000
MWIR	3.850	3.900	3.950	2,000
Water Vapor-1	6.135	6.185	6.235	2,000
Water Vapor-2	6.900	6.950	7.000	2,000
Water Vapor-3	7.290	7.340	7.390	2,000
TIR-1	8.450	8.500	8.550	2,000
TIR-2	9.560	9.610	9.660	2,000
TIR-3	10.300	10.350	10.400	2,000
TIR-4	11.150	11.200	11.250	2,000
TIR-5	12.250	12.300	12.350	2,000
TIR-6	13.250	13.300	13.350	2,000



GEO-KOMPSAT-2B

South Korea
Civil/Government
Operational

Platform Overview

GEO-KOMPSAT-2B is a low-resolution, multispectral, geostationary satellite launched in 2020 by the Korean Aerospace Research Institute (KARI) on an Ariane-5ECA launch vehicle for ocean monitoring. GEO-KOMPSAT-2B provides continuity for the GOCI sensor aboard the Communication, Oceanography and Meteorological Satellite (COMS). The platform used by GEO-KOMPSAT-2B was developed and built by KARI. GEO-KOMPSAT-2B carries the Global Ocean Color Imager-II (GOCI-II) sensor for low-resolution ocean imaging.

Artistic rendering of GEO-KOMPSAT-2B in orbit (image from KARI, used with permission).

[Abbreviations in tables: km, kilometer; °, degree; E, east; NA, not applicable; GSD, ground sample distance; m, meter; —, no data; UV, ultraviolet; NIR, near infrared]

Launch date	02/18/2020
Design lifetime	10 years
Platform owner	KARI
Altitude	35,786 km
Orbit period	24 hours
Longitude	128.2° E
Inclination	0°
Crossing time	NA
Nadir repeat	NA
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_02.do

Sensor Information

	GOCI-II
GSD (m)	250
Swath (km)	—
Data portal	https://nmsc.kma.go.kr/

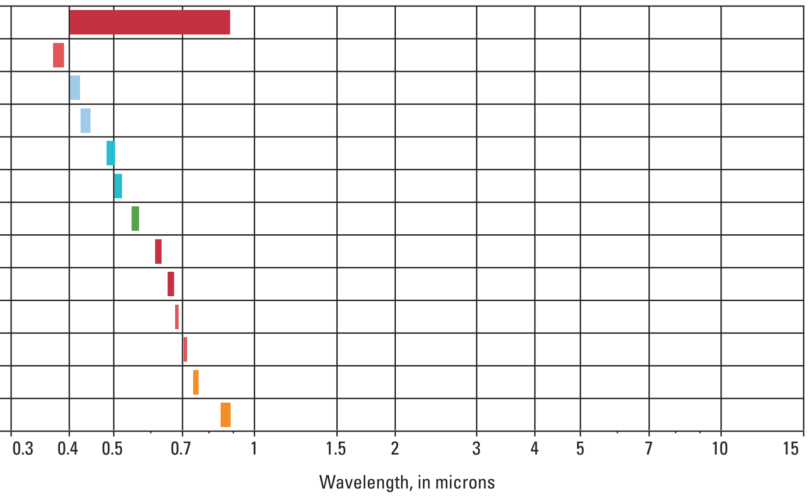
GEO-KOMPSAT-2B—Continued

South Korea
Civil/Government
Operational

GOCI-II

GOCI-II was developed by Airbus DS. GOCI-II has improved spectral, temporal, and spatial resolution compared to the imager aboard the COMS.

Band	Lower	Center	Upper	GSD (m)
Wide	0.402	0.644	0.885	250
UV	0.370	0.380	0.390	250
CA-1	0.402	0.412	0.422	250
CA-2	0.423	0.433	0.443	250
Blue-1	0.480	0.490	0.500	250
Blue-2	0.500	0.510	0.520	250
Green	0.545	0.555	0.565	250
Red-1	0.610	0.620	0.630	250
Red-2	0.650	0.660	0.670	250
Red Edge	0.675	0.680	0.685	250
NIR-1	0.704	0.709	0.714	250
NIR-2	0.735	0.745	0.755	250
NIR-3	0.845	0.865	0.885	250



GISAT

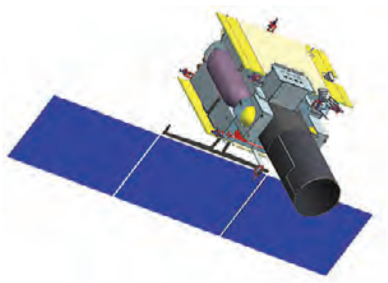
India
Civil/Government
Future

Platform Overview

GEO Imaging Satellite (GISAT) is a multiresolution geostationary satellite to be launched in 2020 on a Geo Stationary Launch Vehicle Mark-2A for continuous observation of India and quick monitoring of natural hazards and disasters. GISAT is based on the Indian Space Research Organization (ISRO) I-1K (I-1000) bus and carries the high resolution multispectral visible and near infrared (HRMX-VNIR) for medium-resolution land imaging and the high resolution multispectral thermal infrared (HRMX-TIR), hyperspectral shortwave infrared (HySI-SWIR), and hyperspectral visible and near-infrared (HySI-VNIR) sensors for low-resolution land imaging.

[Abbreviations in tables: km, kilometer; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	2020 (Planned)
Design lifetime	7 years
Platform owner	ISRO
Altitude	36,000 km
Orbit period	24 hours
Inclination	0°
Crossing time	—
Nadir repeat	—
Status	Development
System website	—



3-Dimensional model of GISAT (image from ISRO, used with permission).

Sensor Information

	HRMX-TIR	HRMS-VNIR	HySI-SWIR	HySI-VNIR
GSD (m)	1,500	50	320	192
Swath (km)	—	—	—	—
Data portal	—			

HRMX-TIR

The HRMX-TIR sensor has three bands in the TIR spectral range. The ground sample distance (GSD) is 1.5 kilometers. Spectral information is not yet available.

HRMX-VNIR

The HRMX-VNIR sensor has four bands in the VNIR spectral range. The GSD is 50 meters (m). Spectral information is not yet available.

HySI-SWIR

The HySI-SWIR sensor has 60 bands in the SWIR spectral range. The GSD is 320 m. Spectral information is not yet available.

HySI-VNIR

The HySI-SWIR sensor has 60 bands in the VNIR spectral range. The GSD is 192 m. Spectral information is not yet available.

GOES-16, -17, -T, and -U

United States
Civil/Government
Operational/Future

Platform Overview

The third-generation Geostationary Operational Environmental Satellites (GOES-16, -17, -T, and -U), commonly referred to as the GOES-R series, are low-resolution multispectral satellites for environmental monitoring. GOES-16 and -17 were launched in 2016 and 2018, respectively. GOES-T and -U are planned to be launched in 2021 and 2024, respectively. This mission continues the GOES series that has been in continual operation since the launch of GOES-1 in 1984. The GOES satellites have been built by the National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration. Lockheed Martin Space Systems Company was selected to build the third-generation spacecraft. The bus is based on the A2100 bus. The GOES-R satellites carry the Advanced Baseline Imager (ABI) sensor for low-resolution land imaging.

Artistic rendering of a GOES-R satellite in orbit (image from Lockheed Martin, used with permission).

[Abbreviations in tables: km, kilometer; °, degree; W, west; —, no data; NA, not applicable; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; WV, water vapor; TIR, thermal infrared]

	GOES-16	GOES-17	GOES-T	GOES-U
Launch date	11/19/2016	03/01/2018	2021 (Planned)	2024 (Planned)
Design lifetime	10 years			
Platform owner	NOAA			
Altitude	35,786 km			
Orbit period	24 hours			
Longitude	75.2° W	137.2° W	—	
Inclination	0°			
Crossing time	NA			
Nadir repeat	NA			
Status	Operational		Development	
System website	https://www.goes-r.gov/			

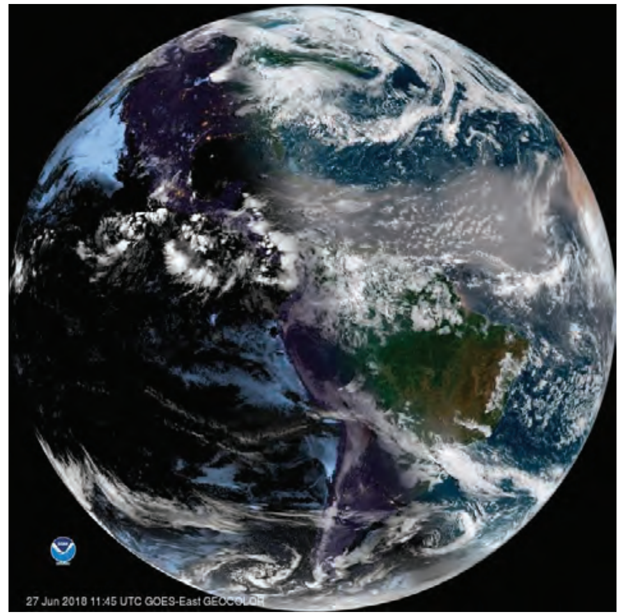
JACIE

GOES-16, -17, -T, and -U—Continued

United States
Civil/Government
Operational/Future

Sensor Information

	ABI
GSD (m)	500; 1,000; 2,000
Swath (km)	—
Data portal	https://www.ngdc.noaa.gov/stp/satellite/goes-r.html

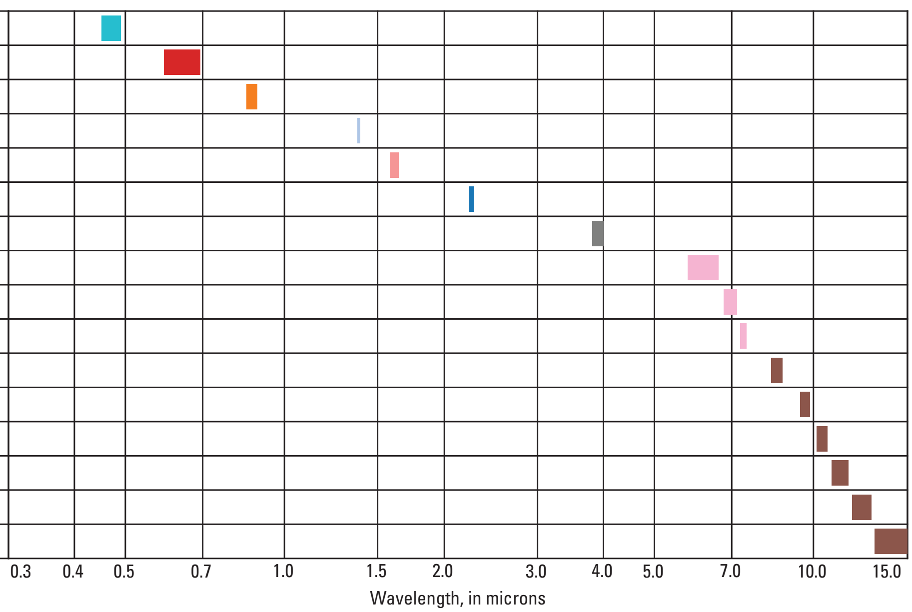


GOES-16 image of Earth (image from NOAA).

ABI

The ABI was designed and developed by ITT Inc. ABI greatly improved on the imager flown on the second-generation GOES satellites, featuring more spectral bands (16), faster imaging cycles, and higher spatial resolution. ABI data are freely available.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.470	0.490	1,000
Red	0.590	0.640	0.690	500
NIR	0.846	0.866	0.885	1,000
Cirrus	1.371	1.379	1.386	2,000
SWIR 1	1.580	1.610	1.640	1,000
SWIR 2	2.225	2.250	2.275	2,000
MWIR	3.800	3.900	4.000	2,000
WV	5.770	6.185	6.600	2,000
WV	6.750	6.950	7.150	2,000
WV	7.240	7.340	7.440	2,000
TIR	8.300	8.500	8.700	2,000
TIR	9.420	9.610	9.800	2,000
TIR	10.100	10.350	10.600	2,000
TIR	10.800	11.200	11.600	2,000
TIR	11.800	12.300	12.800	2,000
TIR	13.000	14.000	15.000	2,000



JACIE

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GOMX-4A and -4B

Denmark
Commercial
Operational

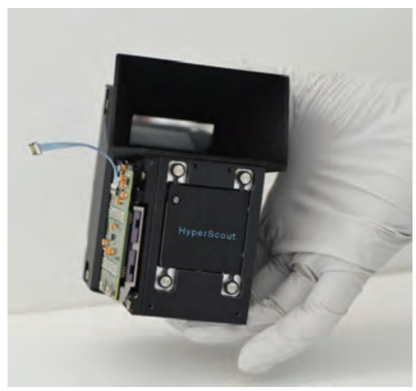
Platform Overview

GOMX-4A and -4B are medium-resolution hyperspectral satellites launched in 2018 on a Long March-2D rocket from Jiuquan Satellite Launch Center, China, to demonstrate constellation capability, intersatellite link, and station keeping; and for Earth resources monitoring. The GOMX-4 6U cubesats were designed and built by GomSpace as a part of their flight demonstration mission series. GomSpace partnered with the Danish Defense Acquisition and Logistics Organization, the Technical University of Denmark, and the European Space Agency. The two satellites are linked by the intersatellite link system. GOMX-4A carries an Automatic Identification System maritime tracking sensor with a 70-millimeter NanoCamera for monitoring arctic ice and maritime applications. GOMX-4B carries the HyperScout sensor for medium-resolution hyperspectral land imaging.

Artistic rendering of the GOMX-4 satellites in orbit (image from GomSpace, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Hyper, hyperspectral]

Launch date	02/02/2018
Design lifetime	3 years
Platform owner	GomSpace
Altitude	500 km
Orbit period	94.6 min
Inclination	97.32°
Crossing time	15:00 DN
Nadir repeat	5 days
Status	Operational
System website	https://gomspace.com/gomx-4.aspx https://hyperscout.nl/



HyperScout sensor (image from COSINE Measurement Systems (https://cosine.nl), used with permission).

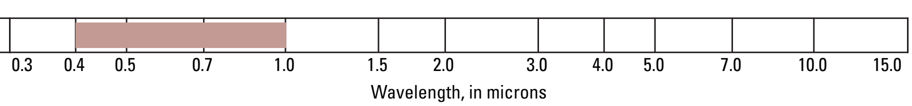
Sensor Information

	HyperScout
GSD (m)	70
Swath (km)	200
Data portal	—

HyperScout

The HyperScout sensor built by COSINE Measurement Systems in the Netherlands, is the first hyperspectral sensor for nanosatellites. It has 45 visible and near-infrared bands with a spectral resolution of 15 nanometers. The aim of this demonstration mission is to assess the quality of data acquired and consequent suitability to applications like crop water management, fire monitoring, and land use and change. HyperScout sensor is now available for purchase as a COTS component from COSINE.

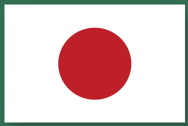
Band	Lower	Center	Upper	GSD (m)
Hyper	0.400	0.700	1.000	70



JACIE

GRUS Constellation

Japan
Commercial
Operational/Future

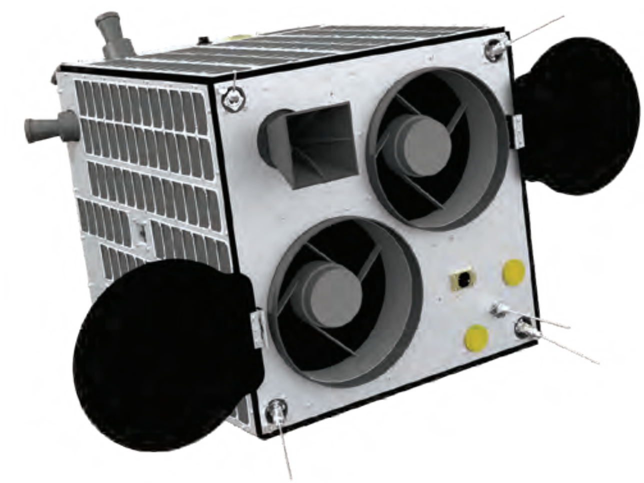


GRUS-1A

GRUS-1A is a high-resolution multispectral satellite launched in 2018 by Japan onboard a Soyuz-2 rocket from Vostochny Cosmodrome, a spaceport in Russia. It is the first of three satellites in the GRUS constellation. GRUS-1A carries a panchromatic and multispectral imager to image the Earth at 2.5-meter and 5-meter resolutions, respectively.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	12/27/2018
Design lifetime	5 years
Platform owner	Axelspace
Altitude	600 km
Orbit period	96.5 min
Inclination	97.7°
Crossing time	—
Nadir repeat	—
Status	Commissioning
System website	https://www.axelspace.com/en/solution_/grus/



Model of GRUS-1 satellite (image from Axelspace).

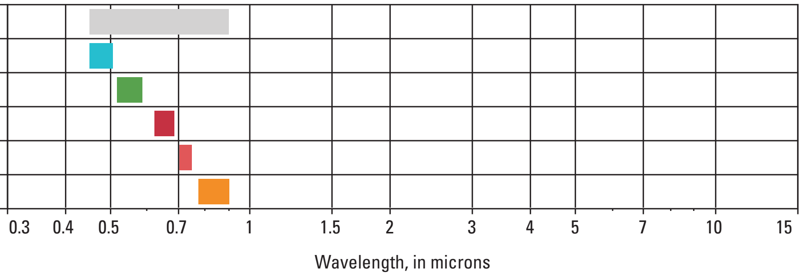
Sensor Information

	GRUS-1 Imager
GSD (m)	2.5/5
Swath (km)	57
Data portal	—

GRUS-1A Imager

The GRUS-1A Imager produces images in the panchromatic and multispectral parts of the spectrum with a swath of more than 50 kilometers, providing efficient coverage of the planet. It can image with off-nadir angles ranging between 5 and 40 degrees, providing a revisit of 1 day.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	2.5
Blue	0.450	0.478	0.505	5
Green	0.515	0.550	0.585	5
Red	0.620	0.653	0.685	5
Red Edge	0.705	0.725	0.745	5
NIR	0.770	0.835	0.900	5

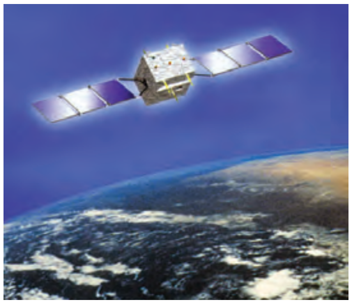


Haiyang-1A/1B

China
Civil/Government
Operational

Platform Overview

The Haiyang-1 (HY-1) series of low-resolution ocean color satellites started with the launch of HY-1A in 2002 on a CZ-4B rocket by China. HY-1A was followed by HY-1B in 2007, launched on a CZ-2C rocket. HY-1 satellites are based on the China Academy of Space Technology-968 platform bus developed by Hangtian Dongfanghong Satellite Company, Ltd and owned by National Satellite Ocean Application Service. The satellites carry a Chinese Ocean Color and Temperature Scanner (COCTS) and a Coastal Zone Imager (CZI) for low-resolution ocean imaging.



Model of Haiyang-1 satellite (image from NSOAS).

[Abbreviations in tables: NSOAS, National Satellite Ocean Application Service; km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared; TIR, thermal infrared]

	HY-1A	HY-1B
Launch date	05/15/2002	04/11/2007
Design lifetime	2 years	3 years
Platform owner	NSOAS	
Altitude	870/798 km	798 km
Orbit period	100.8 min	
Inclination	98.8°	
Crossing time	08:30/10:00 DN	10:30 DN
Nadir repeat	7 days	7 days
Status	Retired	Operational
System website	http://www1.nsoas.org.cn/NSOAS_En/Satellites/index.html	

Sensor Information

	COCTS	CZI
GSD (m)	1,100	250
Swath (km)	1,600	500
Data portal	http://www1.nsoas.org.cn/NSOAS_En/Products/index.html	

JACIE

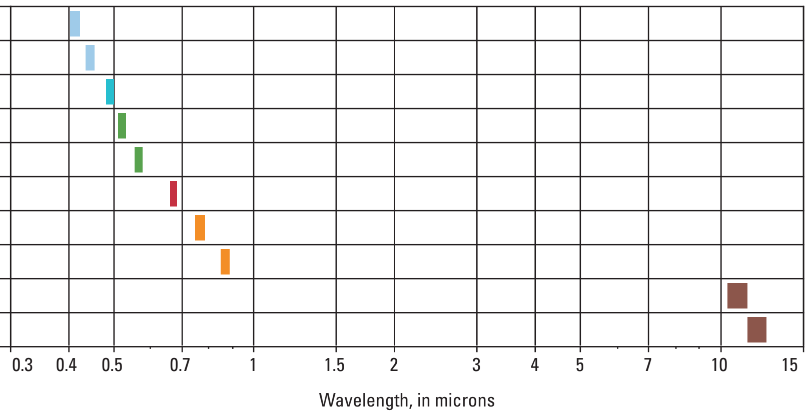
Haiyang-1A/1B—Continued

China
Civil/Government
Operational

COCTS

The COCTS sensor on the HY-1 satellites is a 10-band multispectral imager. It provides multispectral data in visible and near infrared (VNIR) through shortwave infrared at a ground sample distance (GSD) of 1.1 kilometers.

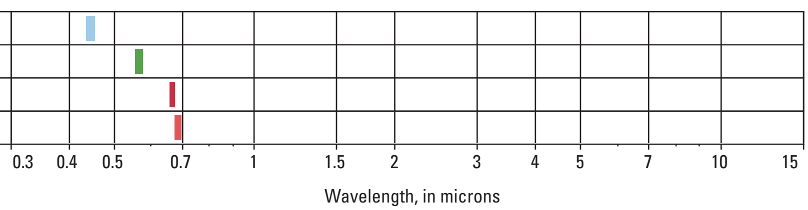
Band	Lower	Center	Upper	GSD (m)
CA-1	0.402	0.412	0.422	1,100
CA-2	0.433	0.443	0.453	1,100
Blue	0.480	0.490	0.500	1,100
Green-1	0.510	0.520	0.530	1,100
Green-2	0.555	0.565	0.575	1,100
Red	0.660	0.670	0.680	1,100
NIR-1	0.745	0.765	0.785	1,100
NIR-2	0.845	0.865	0.885	1,100
TIR-1	10.300	10.850	11.400	1,100
TIR-2	11.400	11.950	12.500	1,100



CZI

CZI is a 4-band VNIR imager on the HY-1 satellites providing images at a GSD of 250 meters.

Band	Lower	Center	Upper	GSD (m)
Blue	0.433	0.443	0.453	250
Green	0.555	0.565	0.575	250
Red	0.655	0.665	0.675	250
NIR	0.675	0.685	0.695	250

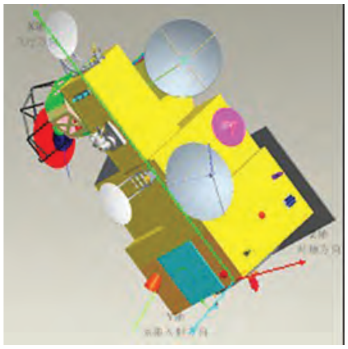


Haiyang-2

China
Civil/Government
Operational/Future

Platform Overview

The Haiyang-2 (HY-2) series of low-resolution ocean dynamic environment satellites started with the launch of HY-2A in 2011 on a CZ-4B rocket by China. HY-2A was followed by HY-2B in 2018. The HY-2 satellites are developed by the China Academy of Space Technology and owned by National Satellite Ocean Application Service. The HY-2 satellites carry a radar altimeter , a microwave scatterometer, a scanning microwave radiometer, and a calibration microwave radiometer to study ocean dynamics. The system is planned to be operational until 2030 with HY-2C through HY-2G satellites planned in the coming years.



Model of Haiyang-2 satellite (image from NSOAS).

[Abbreviations in tables: NSOAS, National Satellite Ocean Application Service; km, kilometer; min, minute; °, degree; DN, descending node; RM, scanning microwave radiometer; GSD, ground sample distance; m, meter; —, no data; GHz, gigahertz; MHz, megahertz; V, vertical; H, horizontal]

	HY-2A	HY-2B
Launch date	08/16/2011	10/24/2018
Design lifetime	3 years	
Platform owner	NSOAS	
Altitude	971 km	
Orbit period	104.50 min	
Inclination	99.34°	
Crossing time	06:00 DN	
Nadir repeat	14 days	
Status	Operational	
System website	http://www1.nsoas.org.cn/NSOAS_En/Satellites/index.html	

Sensor Information

	RM
GSD (m)	—
Swath (km)	1,600
Data portal	http://www.nsoas.gov.cn

Scanning Microwave Radiometer

The Scanning Microwave Radiometer (RM) on HY-2 satellites is mainly used to obtain global sea surface temperature, sea surface wind, atmospheric water vapor content, water content in cloud, sea ice and rainfall, and so on.

Central frequency (GHz)	Bandwidth (MHz)	Polarizations	Ground footprint (km)
6.6	350	VH	100
10.7	250	VH	70
18.7	250	VH	40
23.8	400	V	35
37.0	1,000	VH	25

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Haiyang-3

China
Civil/Government
Future

Platform Overview

The Haiyang-3 (HY-3) series of polar orbiting high-resolution ocean surveillance satellites are planned with the launch of HY-3A in 2020 by China. HY-3A will be followed by HY-3B and GEO-SAR, a geostationary ocean surveillance system. HY-3 satellites are being developed by the China Academy of Space Technology and owned by National Satellite Ocean Application Service. According to Lin and others (2015), the HY-3 satellites will carry a C-band synthetic aperture radar (SAR-C) and an Automatic Identification System to monitor ships, ice, oil spills, waves, ocean surface winds, and internal waves.

[Abbreviations in tables: NSOAS, National Satellite Ocean Application Service; —, no data]

	HY-3A	HY-3B
Launch date	2020	2022
Design lifetime	—	
Platform owner	NSOAS	
Altitude	—	
Orbit period	—	
Inclination	—	
Crossing time	—	
Nadir repeat	—	
Status	—	
System website	http://www1.nsoas.org.cn/NSOAS_En/Satellites/index.html	

SAR-C

HY-3 series satellites will carry a C-band SAR. Details of the instrument are not yet available.

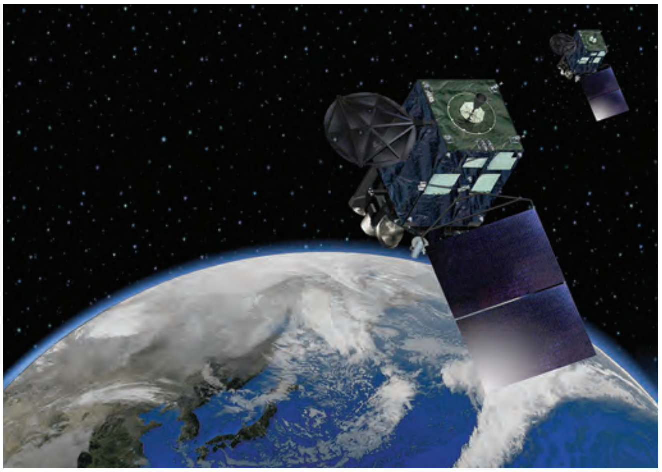
Himawari

Japan
Civil/Government
Operational/Future

Platform Overview

Himawari-8 and -9 are geostationary multispectral satellites launched in 2015 and 2016, respectively, by Japan aboard the Japan Aerospace Exploration Agency's H-11A vehicle from the Tanegashima Space Center for meteorology and weather monitoring.

The satellites were built by Mitsubishi Electric (ME) with assistance from Boeing based on ME's DS-2000 satellite bus. The satellites are owned and operated by the Japan Meteorological Agency (JMA). Himawari-8 and -9 carry an Advanced Himawari Imager (AHI) with similar spectral and spatial capabilities as the Advanced Baseline Imager on the National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellites (GOESs).



Artistic rendering of Himawari-8 and -9 in orbit (image from JMA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; E, east; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

	Himawari-8	Himawari-9
Launch date	07/07/2015	11/02/2016
Design lifetime	15 years	
Platform owner	JMA	
Altitude	36,000 km	
Orbit period	1,440 min	
Longitude	140° E	
Crossing time	—	
Nadir repeat	—	
Status	Operational	Standby
System website	http://www.jma.go.jp/jma/jma-eng/satellite/index.html	

Sensor Information

	AHI
GSD (m)	500/1,000/2,000
Swath (km)	—
Data portal	https://www.data.jma.go.jp/mscweb/en/himawari89/himawari_cast/himawari_cast.php

Full disk visible image of Earth taken by Himawari-9 (image from JMA).

JACIE

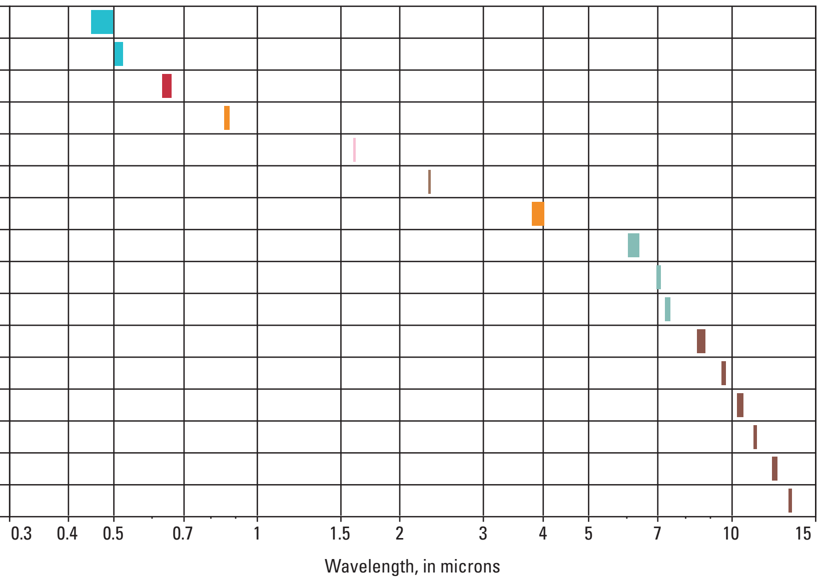
Himawari—Continued

Japan
Civil/Government
Operational/Future

AHI

The AHI is a multispectral imager with similar spatial and spectral characteristics as NOAA's GOES satellites. It was built by ITT Exelis for the JMA. It is capable of imaging the full disk every 10 minutes and imaging Japan every 2.5 minutes.

Band	Lower	Center	Upper	GSD (m)
Blue	0.445	0.470	0.495	1,000
Green	0.500	0.510	0.520	1,000
Red	0.629	0.644	0.659	500
NIR	0.850	0.860	0.870	1,000
SWIR1	1.590	1.600	1.610	2,000
SWIR2	2.290	2.300	2.310	2,000
MWIR-1	3.790	3.900	4.010	2,000
Water vapor-1	6.015	6.200	6.385	2,000
Water vapor-2	6.940	7.000	7.060	2,000
Water vapor-3	7.215	7.300	7.385	2,000
TIR-1	8.440	8.600	8.760	2,000
TIR-2	9.510	9.600	9.690	2,000
TIR-3	10.250	10.400	10.550	2,000
TIR-4	11.100	11.200	11.300	2,000
TIR-5	12.150	12.300	12.450	2,000
TIR-6	13.200	13.300	13.400	2,000



HRSAT 1A, 1B, 1C

India
Civil/Government
Future

Platform Overview

HRSAT 1A, 1B, and 1C are high-resolution multispectral satellites to be launched in 2020 by the Indian Space Research Organization (ISRO) for Earth observation. Limited information currently (2020) is available. The HRSAT satellites carry a multispectral camera (MX) and a panchromatic camera (Pan) for high-resolution land imaging.

Sensor Information

	MX	Pan
GSD (m)	2, 4	1
Swath (km)	15	20
Data portal	—	

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter]

	HRSAT 1A	HRSAT 1B	HRSAT 1C
Launch date	2020 (Planned)		
Design lifetime	—		
Platform owner	ISRO		
Altitude	660 km		
Orbit period	97.94 min		
Inclination	98.02°		
Crossing time	9:30 DN		
Nadir repeat	—		
Status	Development		
System website	—		

Pan and MX

The HRSAT carries a panchromatic and multispectral imager (four bands). The visible bands have a 2-meter ground sample distance (GSD) and the infrared band has a 4-m GSD. Detailed spectral information is not available at this time.

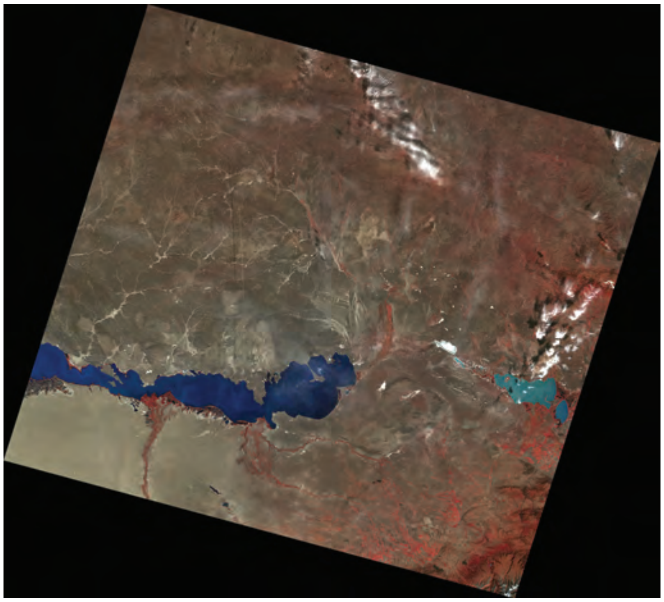
JACIE

Huanjing-1A/1B

China
Civil/Government
Operational

Platform Overview

Huanjing-1A (HJ-1A) and 1B are medium-resolution hyperspectral and multispectral satellites launched in 2008 onboard the CZ-2C rocket from the Taiyuan Satellite Launch Center by China for environment and disaster monitoring. The minisatellites are based on the CAST-968B bus of the Hangtian Dongfanghong Satellite Technology Company, Ltd., a subsidiary of the China Academy of Space Technology (CAST). The HJ-1 satellites are operated by the China Center for Resources Satellite Data and Application (CRESDA). Both satellites share the same orbit with a phase separation of 180 degrees. HJ-1A carries a hyperspectral imager, whereas HJ-1B carries an infrared scanner. They both carry a charge coupled device (CCD) camera for medium-resolution Earth imaging. The HJ-1A/1B CCD camera data are available for the Asia-Pacific Space Cooperation Organization for environment and disaster monitoring.



A 30-meter multispectral image of the Huanjing-1A satellite (image from CRESDA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

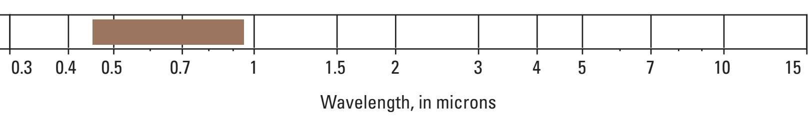
	HJ-1A	HJ-1B
Launch date	09/06/2008	
Design lifetime	3 years	
Platform owner	CAST/CRESDA	
Altitude	649 km	
Orbit period	97.56 min	
Inclination	97.95°	
Crossing time	10:30 DN	
Nadir repeat	31 days	
Status	Operational	
System website	http://www.cresda.com/EN/satellite/7117.shtml	

Sensor Information

	HJ-1A hyperspectral imager	HJ-1A/1B CCD camera	HJ-1B infrared scanner
GSD (m)	100	30	150/300
Swath (km)	50	700	720
Data portal		—	

HJ-1A Hyperspectral Imager

Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.450	0.700	0.950	100



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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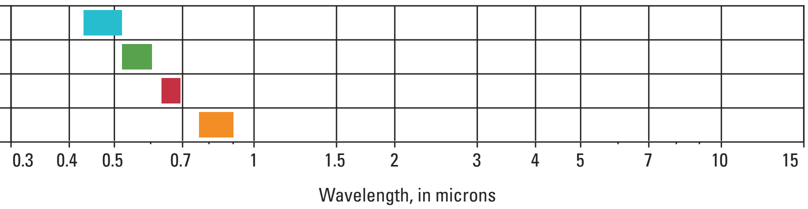
Huanjing-1A/1B—Continued

China
Civil/Government
Operational

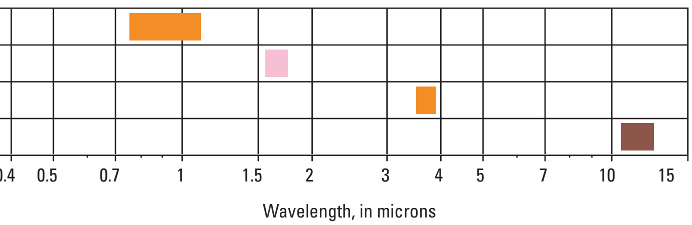
CCD Camera

Band	Lower	Center	Upper	GSD (m)
Blue	0.430	0.475	0.520	30
Green	0.520	0.560	0.600	30
Red	0.630	0.660	0.690	30
NIR	0.760	0.830	0.900	30



Infrared Scanner

Band	Lower	Center	Upper	GSD (m)
NIR	0.750	0.925	1.100	150
SWIR1	1.550	1.650	1.750	150
MIR	3.500	3.700	3.900	150
TIR	10.500	11.500	12.500	300



Huanjing-1C

China
Civil/Government
Operational

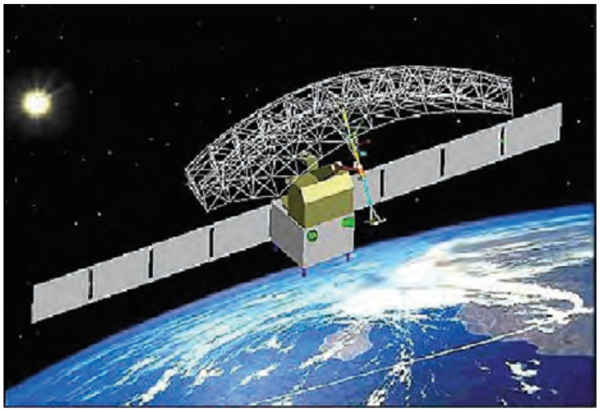
JACIE

Platform Overview

Huanjing-1C (HJ-1C) is a high-resolution synthetic aperture radar (SAR) satellite launched in 2012 on a Long March-2C rocket by China for environment and disaster monitoring. The HJ-1C satellite is based on the CAST-2000 bus developed by China Academy of Space Technology (CAST). It is the third satellite in the Huanjing constellation, following HJ-1A and HJ-1B. HJ-1C carries an S-band SAR (SAR-S) sensor for all-weather day/night imaging.

[Abbreviations in tables: CRESDA, China Center for Resources Satellite Data and Application; km, kilometer; min, minute;°, degree; DN, descending node; GSD, ground sample distance; m, meter; V, vertical]

	HJ-1C
Launch date	11/19/2012
Design lifetime	3 years
Platform owner	CAST/CRESDA
Altitude	499.2 km
Orbit period	94.6 min
Inclination	97.4°
Crossing time	06:00 DN
Nadir repeat	31 days
Status	Operational
System website	http://www.cresda.com/EN/satellite/7117.shtml



Artistic model of the Huanjing-1C satellite in orbit (image from China Academy of Space Technology).

Sensor Information

	SAR-S
GSD (m)	5/20
Swath (km)	40/100
Data portal	—

SAR-S

The SAR-S instrument on HJ-1C operates at 3.13 gigahertz, corresponding to a wavelength of 9.6 centimeters. The sensor has a revisit of 4 days.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Strip	Single	VV	40	20
Scan	Single	VV	100	5

HySIS

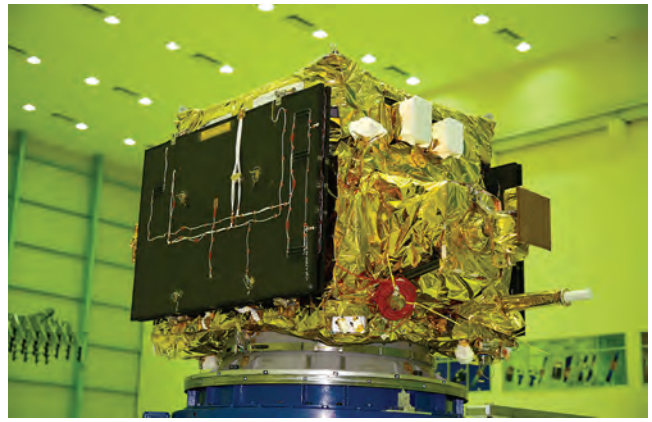
India
Civil/Government
Operational

Platform Overview

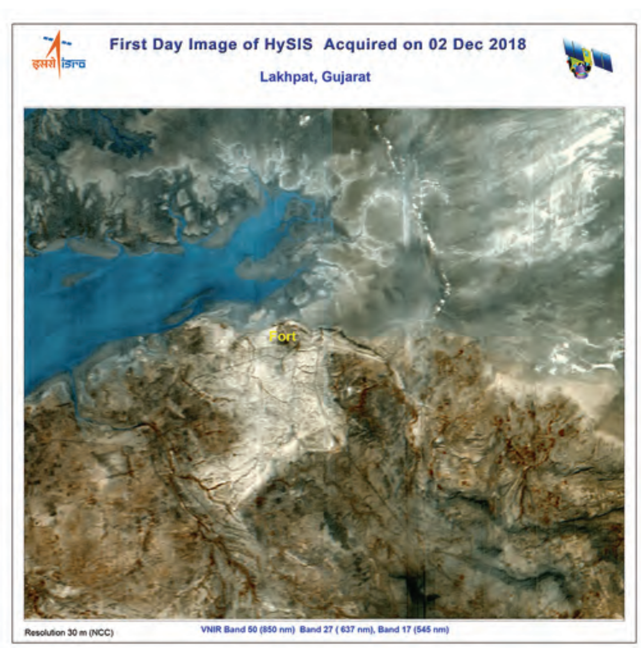
The HyperSpectral Imaging Satellite (HySIS) is a medium-resolution hyperspectral satellite launched by India aboard the Polar Satellite Launch Vehicle (PSLV) rocket in November 2018 for Earth resource monitoring. The primary satellite of the PSLV C-43 mission, HySIS, is built by the Indian Space Research Organization on its minisatellite (IMS-2) bus. HySIS carries two sensors for hyperspectral imaging in visible and near infrared (VNIR) and shortwave infrared (SWIR).

[Abbreviations in tables: ISRO, Indian Space Research Organization; km, kilometer; min, minute; °, degree; —, no data; VNIR, visible and near infrared; SWIR, shortwave infrared]

Launch date	11/29/2018
Design lifetime	5 years
Platform owner	ISRO
Altitude	636 km
Orbit period	97.43 min
Inclination	97.92°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	https://www.isro.gov.in/Spacecraft/hysis



HySIS in the clean room before launch (image from ISRO).



First day image of HySIS, Lakhpat, Gujarat (image from ISRO, used with permission).

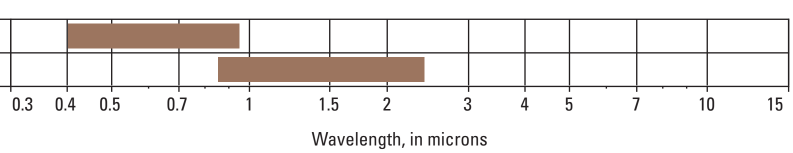
Sensor Information

	HySIS
GSD (m)	30
Swath (km)	30
Data portal	—

Hyperspectral Imaging System (HIS)

The hyperspectral imaging system is a pushbroom imager in VNIR and SWIR bands.

Band	Lower	Center	Upper	GSD (m)
Hyperspectral-VNIR	0.400	0.675	0.950	30
Hyperspectral-SNIR	0.850	1.625	2.400	30

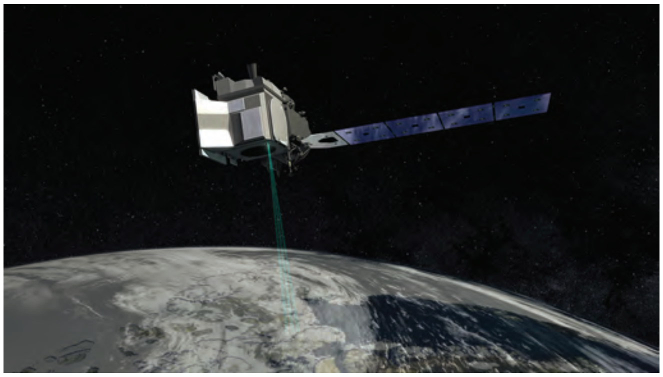


ICESat-2

United States
Civil/Government
Operational

Platform Overview

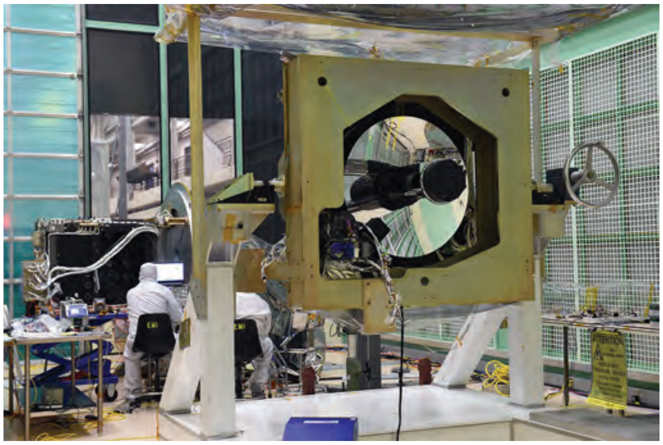
The Ice, Cloud, and land Elevation Satellite–2 (ICESat-2) is a high-precision laser altimeter satellite launched by the National Aeronautics and Space Administration (NASA) on a Delta-II launch vehicle from Vandenberg Air Force Base in California. ICESat-2's primary mission is to collect precise measurements of the heights of the Earth's ice, vegetation, land surface, water, and clouds. This mission continues and improves on the observations of the original ICESat satellite (and Operation IceBridge annual polar data collection aircraft campaigns). The ICESat-2 spacecraft bus was built by Orbital ATK and uses the LEOStar-3 bus used on Landsat 8 and GeoEye-1. ICESat-2 carries the Advanced Topographic Laser Altimeter System (ATLAS).



Artistic rendering of ICESat-2 in orbit (image from NASA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	09/15/2018
Design lifetime	3 years
Platform owner	NASA
Altitude	500 km
Orbit period	94.6 min
Inclination	92°
Crossing time	—
Nadir repeat	91 days
Status	Operational
System website	https://icesat-2.gsfc.nasa.gov/



ATLAS instrument model (image from NASA).

Sensor Information

	ATLAS
GSD (m)	0.7 (along track)
Swath (km)	0.013
Data portal	https://nsidc.org/data/icesat-2

ATLAS

The ATLAS is a new design from NASA's Goddard Space Flight Center (GSFC). Unlike the original ICESat's Geoscience Laser Altimeter System (GLAS), which used millions of photons to measure a single data point, ATLAS measures very few photons—a few dozen at most. The instrument has a vertical resolution of 4 millimeters. ATLAS splits its laser into nine beams and samples approximately every 70 centimeters on the ground. The laser has a frequency of 532 nanometers (visible green).

JACIE

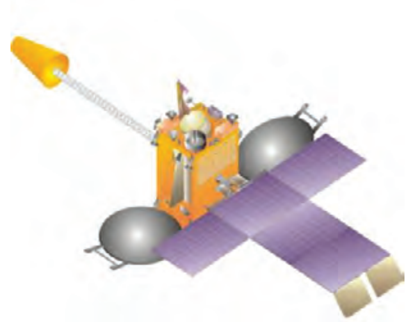
INSAT-3A

India
Civil/Government
Operational

Platform Overview

The Indian National Satellite–3A (INSAT-3A) is a low-resolution multispectral satellite launched in 2003 on an Ariane-5 launch vehicle from Kourou, French Guiana, by the Indian Space Research Organization (ISRO) for meteorological monitoring. INSAT-3A is in a geostationary orbit at 93.5 degrees east. The satellite is based on the I-3000 bus. INSAT-3A carries the Very High-Resolution Radiometer (VHRR) sensor and a charge coupled device (CCD) camera for meteorological monitoring.

[Abbreviations in tables: km, kilometer; °, degree; E, east; NA, not applicable; GSD, ground sampling distance; m, meter; —, no data; VIS, visible; WV, water vapor; TIR, thermal infrared; NIR, near infrared; SWIR, shortwave infrared]



3-Dimensional model of INSAT-3A (image from ISRO, used with permission).

Launch date	04/09/2003
Design lifetime	12 years
Platform owner	ISRO
Altitude	35,786 km
Orbit period	24 hours
Longitude	93.5° E
Inclination	0°
Crossing time	NA
Nadir repeat	NA
Status	Operational
System website	https://www.isro.gov.in/Spacecraft/insat-3a

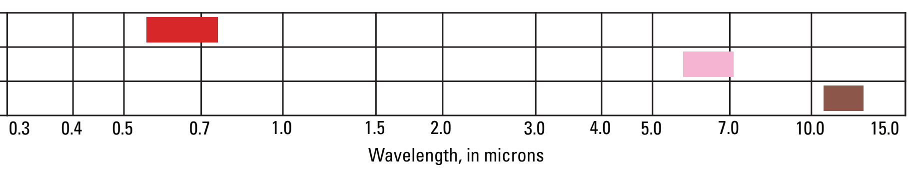
Sensor Information

	VHRR	CCD Camera
GSD (m)	2,000; 8,000	1,000
Swath (km)	—	—
Data portal	https://mosdac.gov.in/content/Mission/insat-3a	

VHRR

The VHRR sensor is identical to the VHRR sensor flown on Kalpana-1. The sensor can operate in Full scan mode with a 33-minute repeat; Normal scan mode with a 23-minute repeat; or Sector scan mode, which can scan an area three times in 23 minutes.

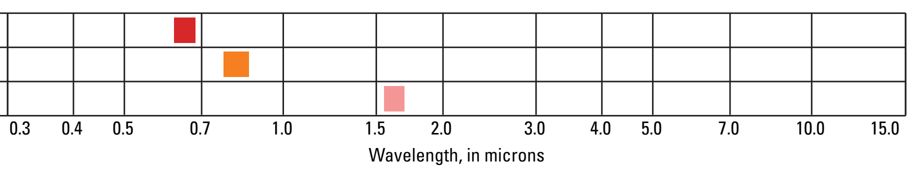
Band	Lower	Center	Upper	GSD (m)
VIS	0.550	0.650	0.750	2,000
WV	5.700	6.400	7.100	8,000
TIR	10.500	11.500	12.500	8,000



CCD Camera

The CCD camera is an experimental sensor for meteorological monitoring as well as vegetation mapping. The CCD camera was first introduced on INSAT-2E. Bands 1 and 2 provide vegetation index data and band 3 is used to measure snow cover.

Band	Lower	Center	Upper	GSD (m)
Red	0.620	0.650	0.680	1,000
NIR	0.770	0.815	0.860	1,000
SWIR 1	1.550	1.620	1.690	1,000



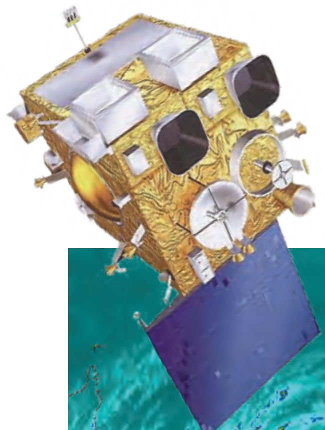
JACIE

INSAT-3D and -3DR

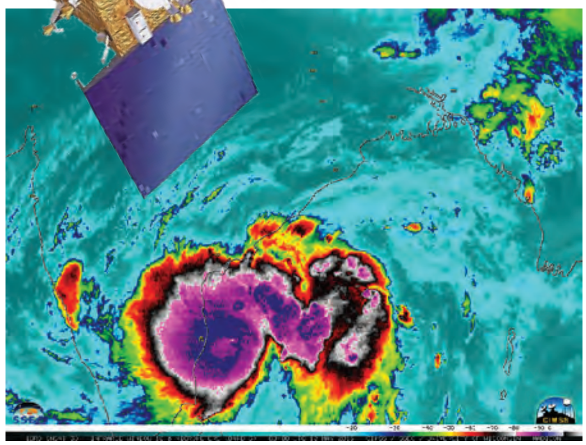
India
Civil/Government
Operational

Platform Overview

The Indian National Satellite–3D (INSAT-3D) is a low-resolution multispectral satellite launched in 2013 by the Indian Space Research Organization (ISRO) on an Ariane-5 launch vehicle from Kourou, French Guiana, for meteorological monitoring. This mission continues the INSAT-3 series of satellites with improved capabilities. INSAT-3D is in a geostationary orbit at 82 degrees east. INSAT-3DR was launched in 2016 featuring similar instruments. INSAT-3DR is in a geostationary orbit at 72 degrees east. INSAT-3D and -3DR carry the Multispectral Imager (MSI) for meteorological monitoring.



Artistic rendering of INSAT-3D (image from ISRO, used with permission).



INSAT-3D data of Cyclone Roanu, Indian Ocean (image from University of Wisconsin).

[Abbreviations in tables: km, kilometer; °, degree; E, east; NA, not applicable; GSD, ground sample distance; m, meter; —, no data; VIS, visible; SWIR, shortwave infrared; MWIR, midwave infrared; WV, water vapor; TIR, thermal infrared]

	INSAT-3D	INSAT-3DR
Launch date	07/25/2013	09/08/2016
Design lifetime	7.7 years	10 years
Platform owner	ISRO	
Altitude	35,786 km	
Orbit period	24 hours	
Longitude	72° E	
Inclination	0°	
Crossing time	NA	
Nadir repeat	NA	
Status	Operational	
System website	https://www.isro.gov.in/Spacecraft/insat-3d	https://www.isro.gov.in/Spacecraft/insat-3dr

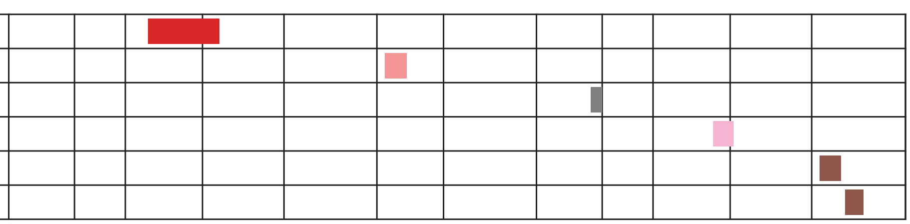
Sensor Information

	MSI
GSD (m)	1,000; 4,000; 8,000
Swath (km)	—
Data portal	https://www.mosdac.gov.in/

MSI

The MSI is an improved version of the Very High-Resolution Radiometer flown on Kalpana-1 and INSAT-3A. The imager includes three new bands: shortwave infrared, midwave infrared, and an additional thermal infrared band. The spatial resolution is also improved.

Band	Lower	Center	Upper	GSD (m)
VIS	0.550	0.650	0.750	1,000
SWIR 1	1.550	1.625	1.700	1,000
MWIR	3.800	3.900	4.000	4,000
WV	6.500	6.800	7.100	8,000
TIR	10.300	10.800	11.300	4,000
TIR	11.500	12.000	12.500	4,000



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ISS DESIS ON MUSES

United States
Civil/Government
Operational

Platform Overview

The Multiple User System for Earth Sensing (MUSES) is a commercially operated multiuser facility aboard the International Space Station (ISS) launched in June 2017 on a SpaceX Falcon 9 launch vehicle. MUSES was developed by Teledyne Brown Engineering. The facility is mounted on the starboard side of the ISS. MUSES currently hosts the DLR Earth Sensing Imaging Spectrometer (DESIS) sensor.

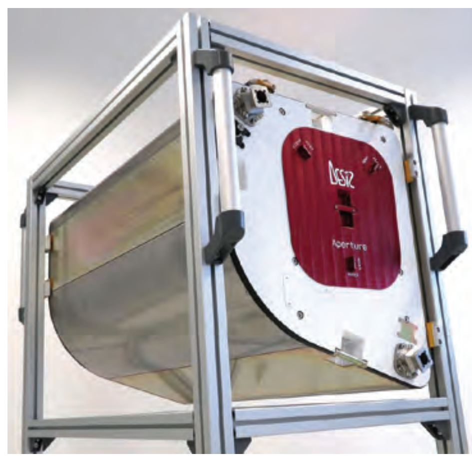
MUSES pointing platform (image from NASA).

[Abbreviations in tables: —, no data; km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter; Hyper, hyperspectral]

Launch date	06/03/2017
Design lifetime	—
Platform owner	NASA
Altitude	407 km
Orbit period	93 min
Inclination	51.6°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	https://www.nasa.gov/mission_pages/station/research/experiments/1282.html

Sensor Information

	DESIS
GSD (m)	30
Swath (km)	30
Data portal	https://teledyne.tcloudhost.com/

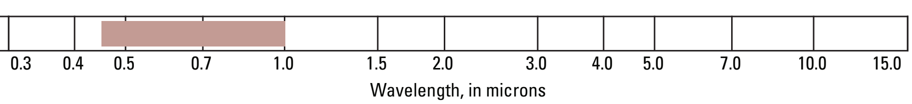


DESIS sensor model (image from DLR).

DESIS

The DESIS sensor was launched from Cape Canaveral, Florida, on June 29, 2018, as part of the SpaceX CRS-15 logistics flight to the ISS. DESIS was placed in the MUSES facility on the ISS for environmental monitoring. DESIS is a hyperspectral imager with as many as 235 bands built and designed by DLR and Teledyne Brown Engineering. DESIS data are commercially available through Teledyne.

Band	Lower	Center	Upper	GSD (m)
Hyper	0.450	0.725	1.000	30



JACIE

ISS JEM-EF/Kibo

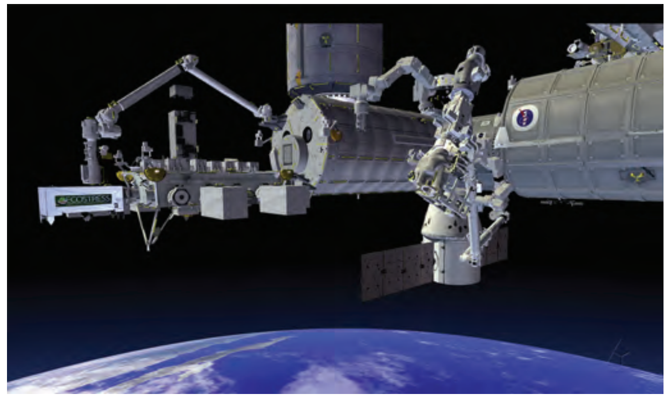
Japan
Civil/Government
Operational

Platform Overview

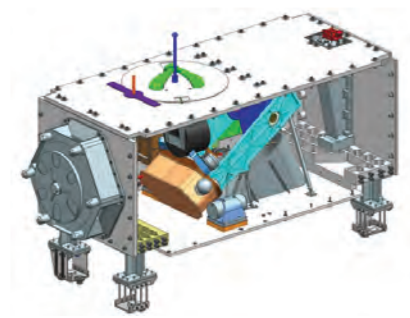
The Japanese Experiment Module Exposed Facility (JEM-EF) is a part of JEM (referred to as Kibo in Japan), launched in 2009 by the Japan Aerospace Exploration Agency (JAXA) on STS-127 with an emphasis on Earth observation instruments. JEM-EF will host the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) sensor.

[Abbreviations in tables: —, no data; km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter; SWIR, shortwave infrared; TIR, thermal infrared]

Launch date	07/15/2009
Design lifetime	—
Platform owner	JAXA
Altitude	407 km
Orbit period	93 min
Inclination	51.6°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	https://www.nasa.gov/mission_pages/station/research/experiments/JEM-EF.html



Artistic rendering of the ISS JEM-EF module with ECOSTRESS attached (image from NASA).



3-Dimensional model of ECOSTRESS (image from NASA).

Sensor Information

	ECOSTRESS	GEDI	HISUI	EMIT
GSD (m)	38	—	20	30
Swath (km)	384	—	20	40
Status	Operational	Operational	Operational	Planned
Data portal	https://ecostress.jpl.nasa.gov/data	https://gedi.umd.edu/data/download/	—	

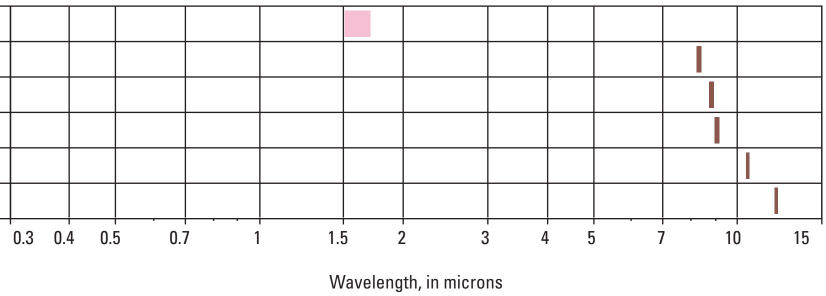
ISS JEM-EF/Kibo—Continued

Japan
Civil/Government
Operational

ECOSTRESS

The ECOSTRESS payload was launched to the International Space Station (ISS) in June 2018 on a Falcon 9 launch vehicle and installed on July 5, 2018. ECOSTRESS's central mission is to study the terrestrial biosphere, vegetation water use, and agricultural dynamics. ECOSTRESS is an implementation of the existing Prototype HyspIRI Thermal Infrared Radiometer developed by National Aeronautics and Space Administration (NASA). ECOSTRESS data will be freely available.

Band	Lower	Center	Upper	GSD (m)
SWIR1	1.500	1.600	1.700	38
TIR-1	8.180	8.280	8.380	38
TIR-2	8.690	8.790	8.890	38
TIR-3	8.960	9.060	9.160	38
TIR-4	10.400	10.500	10.600	38
TIR-5	11.950	12.050	12.150	38



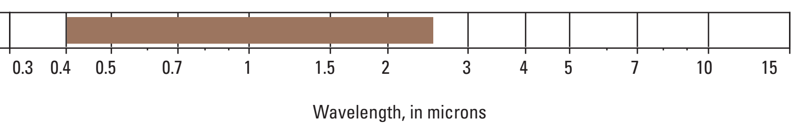
GEDI

Global Ecosystem Dynamics Investigation (GEDI) is a full waveform light detection and ranging (lidar) instrument that makes detailed measurements of the three-dimensional structure of the Earth's surface. It was built by the NASA Goddard Space Flight Center and has the highest resolution and densest sampling of any lidar ever put in orbit. GEDI was launched to the ISS in 2018 and operates from the Japanese Experimental module.

HISUI

The Hyperspectral Imager Suite (HISUI) is a spaceborne hyperspectral Earth imaging system developed by the Japanese Ministry of Economy, Trade, and Industry, launched in 2019 for hyperspectral Earth imaging visible through a shortwave infrared spectrum.

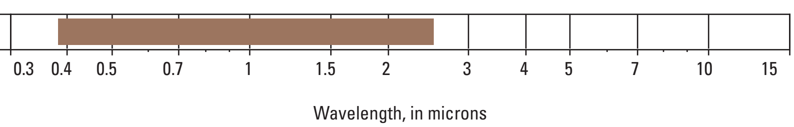
Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.400	1.450	2.500	20



EMIT

The Earth Surface Mineral Dust Source Investigation (EMIT) sensor will use a hyperspectral sensor mounted to the exterior of the ISS to determine the mineral composition of natural sources that produce dust aerosols around the world. The EMIT sensor is based in part on NASA's Moon Mineralogy Mapper instrument aboard the Indian Space Research Organization's Chandrayaan-1 spacecraft.

Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.380	1.445	2.510	30



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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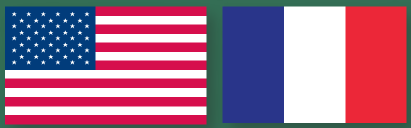
Jason-3

United States, France
Civil/Government
Operational



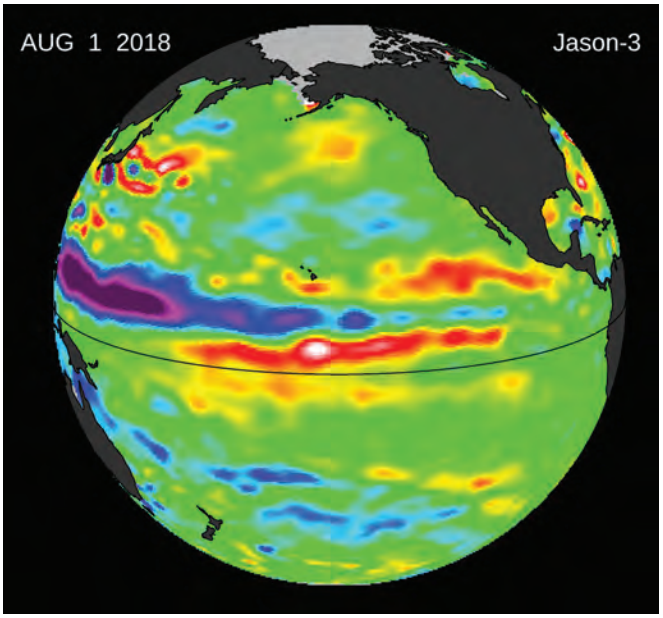
Platform Overview

Jason-3 is a radar altimeter satellite launched in January 2016 on a Falcon 9 launch vehicle from Vandenberg Air Force Base in California for oceanic observation. This mission is a follow-on to Jason-2 with a collaboration between the National Aeronautics and Space Administration (NASA) and French National Centre for Space Research (CNES). Thales Alenia Space was the prime contractor for the spacecraft and, like Jason-2, uses the Proteus bus. Jason-3 carries the Poseidon-3B instrument for collecting altimetry data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	01/17/2016
Design lifetime	5 years
Platform owner	NASA, CNES
Altitude	1,336 km
Orbit period	112.38 min
Inclination	66.04°
Crossing time	—
Nadir repeat	10 days
Status	Operational
System website	https://sealevel.jpl.nasa.gov/missions/jason3/

Artistic rendering of Jason-3 in orbit (image from NASA).



Sea surface data acquired by Jason-3 (image from NASA).

Sensor Information

	Poseidon-3B
GSD (m)	—
Swath (km)	—
Data portal	—

Poseidon-3B

The Poseidon-3B instrument is a proven design by Thales Alenia Space based on the Poseidon-3 instrument used on Jason-2. Poseidon-3B modestly improves on Poseidon-3 and operates in the C-band at 5.3 gigahertz (GHz) (λ = 5.66 centimeters [cm]) and Ku-band at 13.575 GHz (λ = 2.21 cm).

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Jilin-1 High-Resolution Satellites

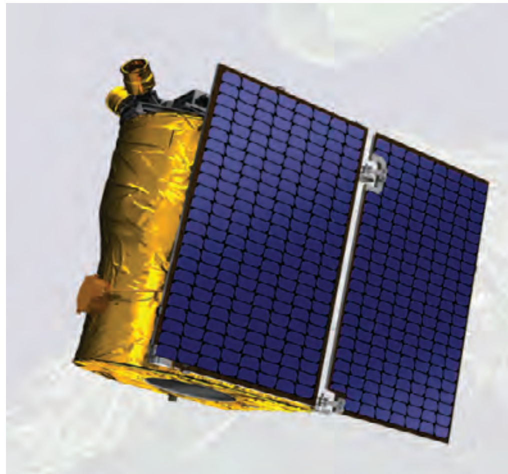
China
Commercial
Operational

Platform Overview

Jilin-1 Gaofen (GF) 02A, 02B, and 03A are high-resolution multispectral satellites launched in 2019 on Kuaizhou-1A and Long March-11 rockets, respectively, by China for Earth resources monitoring. They are the new generation optical satellites developed by Chang Guang Satellite Technology Company, Ltd., using innovative technologies. The satellites carry a panchromatic and multispectral imager and operate in a 45-degree inclined low Earth orbit.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

	Jilin-1 GF-02A	Jilin-1 GF-02B	Jilin-1 GF-03A
Launch date	11/13/2019	12/07/2019	06/05/2019
Design lifetime	3+ years		
Platform owner	Chang Guang Satellite Technology Company, Ltd.		
Altitude	572 km	535 km	535 km
Orbit period	96.1 min		
Inclination	45°		
Crossing time	—		
Nadir repeat	—		
Status	Operational		
System website	http://www.charmingglobe.com/EWeb/product_view.aspx?id=677		



A model of Jilin-1 high-resolution satellites (image from Chang Guang Satellite Technology Company, Ltd.).

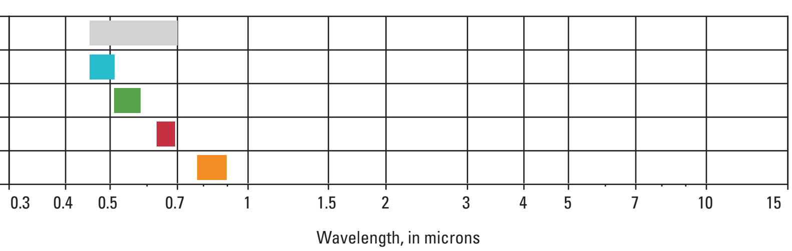
Sensor Information

	Jilin-1 GF-02 imager	Jilin-1 GF-03 imager
GSD (m)	0.75/3	1/4.2
Swath (km)	40	18.5
Revisit (days)	3.3	
Data portal	http://mall.charmingglobe.com/dataShow.html	

Jilin-1 GF-02 Imager

The pushbroom imager on GF-02 satellites images in panchromatic and multispectral bands at 0.75 meter (m) and 3 m, respectively.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.575	0.700	1.06
Blue	0.450	0.480	0.510	4.24
Green	0.510	0.545	0.580	4.24
Red	0.630	0.660	0.690	4.24
NIR	0.770	0.833	0.895	4.24



JACIE

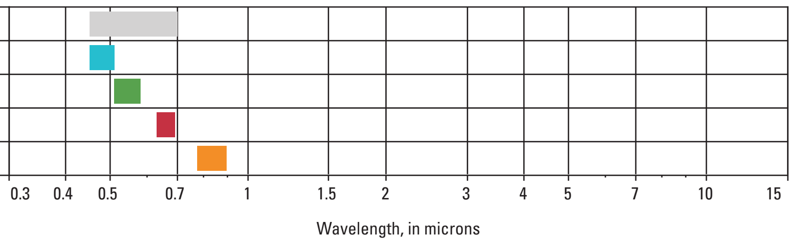
Jilin-1 High-Resolution Satellites—Continued

China
Commercial
Operational

Jilin-1 GF-03 Imager

The imager on GF-03 satellites images in panchromatic and multispectral bands at 1 m and 4.2 m, respectively.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.575	0.700	1.06
Blue	0.450	0.480	0.510	4.24
Green	0.510	0.545	0.580	4.24
Red	0.630	0.660	0.690	4.24
NIR	0.770	0.833	0.895	4.24



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Jilin-1 Optical A Satellite

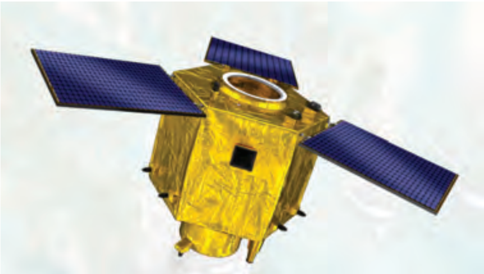
China
Commercial
Operational

Platform Overview

Jilin-1 Optical A is the first high-resolution multispectral satellite in the Jilin-1 series launched by China in 2015 aboard the CZ-2D rocket from the Jiuquan Satellite Launch Center for Earth resources monitoring. The satellite was developed by Chang Guang Satellite Technology Company, Ltd., a Chinese commercial satellite company. The Optical A satellite carries a panchromatic and multispectral imager (PMI) for high-resolution imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	10/07/2015
Design lifetime	3 years
Platform owner	Chang Guang Satellite Technology Company, Ltd.
Altitude	650 km
Orbit period	97.72 min
Inclination	97.98°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	http://www.charmingglobe.com/EWeb/product_view.aspx?id=25



A model of Jilin-1 Optical satellites (image from Chang Guang Satellite Technology Company, Ltd.).

Sensor Information

	PMI
GSD (m)	0.72/2.88
Swath (km)	11.6
Revisit	3.3 days
Data portal	http://mall.charmingglobe.com/index.html

Jilin-1 image of Setubal, Portugal, taken August 22, 2018 (image from Chang Guang Satellite Technology Company, Ltd.).

JACIE

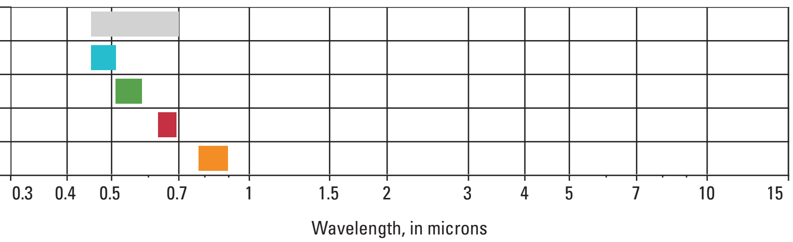
Jilin-1 Optical A Satellite—Continued

China
Commercial
Operational

PMI

The sensor on the Optical A satellite is capable of imaging the Earth at 0.72 meter (m) in panchromatic and 2.88 m in multispectral bands with a swath of 12 kilometers. The agility of the satellite allows it to image via conventional pushbroom, large-angle side sway, strip mosaic, and stereo imaging modes. A revisit of 3.3 days can be achieved because the maximum side-slip angle of plus or minus 45 degrees is used.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.575	0.700	0.72
Blue	0.450	0.480	0.510	2.88
Green	0.510	0.545	0.580	2.88
Red	0.630	0.660	0.690	2.88
NIR	0.770	0.833	0.895	2.88



Jilin-1 Smart Verification Satellite

China
Commercial
Operational

Platform Overview

The Jilin-1 Smart Verification Satellite (SVS) is a high-resolution technology demonstration satellite launched in 2015 aboard the CZ-2D rocket from the Jiuquan Satellite Launch Center for the development of new satellite technology. It was built by Chang Guang Satellite Technology Company, Ltd., and carries conventional pushbroom, gaze video, smart imaging, and stereo imaging sensors.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	10/07/2015
Design lifetime	3 years
Platform owner	Chang Guang Satellite Technology Company, Ltd.
Altitude	650 km
Orbit period	97.72 min
Inclination	97.98°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	http://www.charmingglobe.com/EWeb/product_view.aspx?id=155

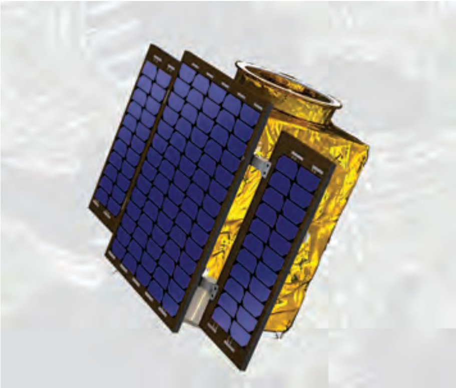


Image from Chang Guang Satellite Technology Company, Ltd.

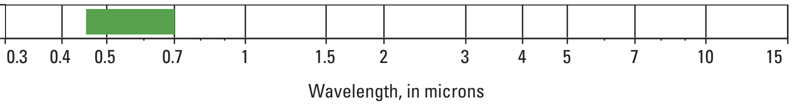
Sensor Information

	SVS imager
GSD (m)	4.7
Swath (km)	9.6
Data portal	http://mall.charmingglobe.com/index.html

SVS Imager

The imager on the SVS is a technology demonstration sensor imaging in multiple modes at a resolution of 4.7 meters covering a swath of 9.6 kilometers.

Band	Lower	Center	Upper	GSD (m)
Video/image	0.450	0.575	0.700	4.7



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Jilin-1 Spectrum Satellites

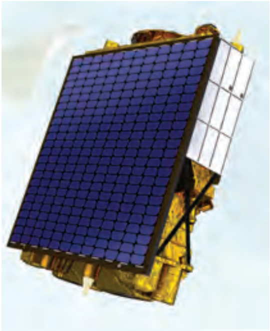
China
Commercial
Operational

Platform Overview

Jilin-1 Spectrum 01 and 02 are high-resolution optical satellites launched in 2019 on a CZ-11 rocket from the Jiuquan Satellite Launch Center for Earth resources monitoring. The satellites are built by Chang Guang Satellite Technology Company, Ltd., and carry a multispectral imager in visible, shortwave, midwave and longwave infrared spectral regions.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

Launch date	01/21/2019
Design lifetime	3+ years
Platform owner	Chang Guang Satellite Technology Company, Ltd.
Altitude	528 km
Orbit period	95.2 min
Inclination	97.54°
Crossing time	12:00 DN
Nadir repeat	—
Status	Operational
System website	http://www.charmingglobe.com/EWeb/product_view.aspx?id=676



A model of the Jilin-1 Spectrum satellite (image from Chang Guang Satellite Technology Company, Ltd.).

Sensor Information

	Spectrum imager
GSD (m)	5/100
Swath (km)	110
Revisit	2
Data portal	http://mall.charmingglobe.com/dataShow.html

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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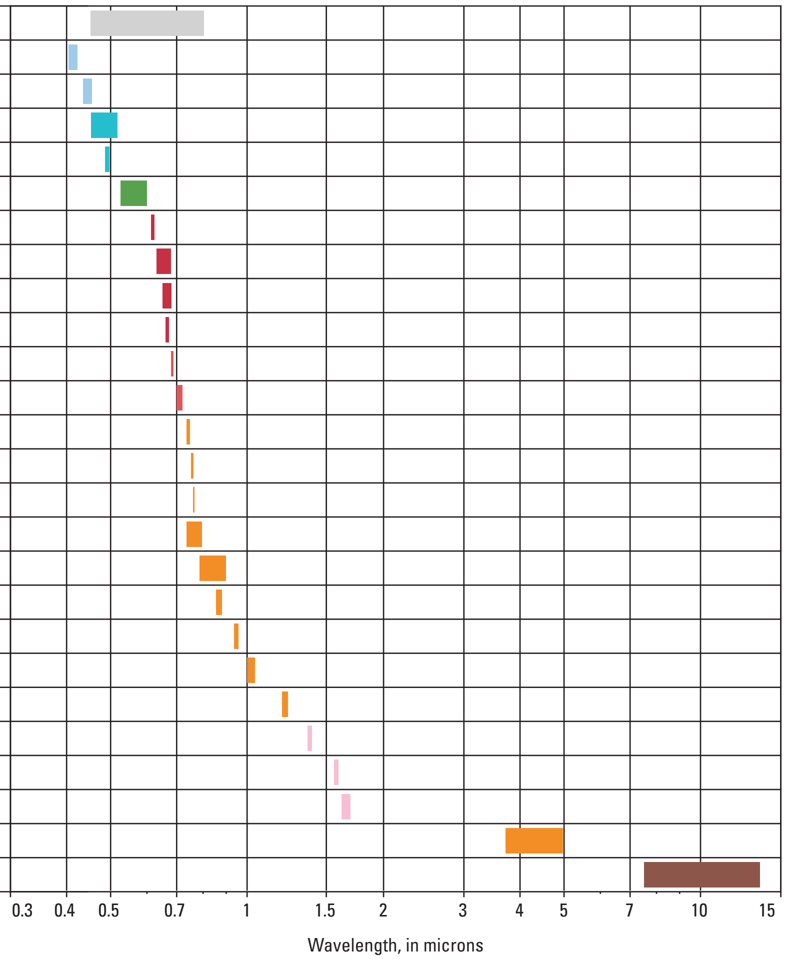
Jilin-1 Spectrum Satellites—Continued

China
Commercial
Operational

Spectrum Imager

The imager on the Spectrum satellites images the Earth in 26 spectral bands at a resolution of 5 meters with a swath of 110 kilometers.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.625	0.800	5
CA-1	0.403	0.413	0.423	5
CA-2	0.433	0.443	0.453	5
Blue-1	0.450	0.483	0.515	5
Blue-2	0.485	0.490	0.495	5
Green-1	0.525	0.563	0.600	5
Red-1	0.615	0.620	0.625	5
Red-2	0.630	0.655	0.680	5
Red-3	0.650	0.665	0.680	5
Red-4	0.660	0.665	0.670	5
Red Edge-1	0.678	0.681	0.685	5
Red Edge-2	0.699	0.709	0.719	5
NIR-1	0.733	0.740	0.748	5
NIR-2	0.750	0.754	0.758	5
NIR-3	0.759	0.761	0.763	5
NIR-4	0.733	0.763	0.793	5
NIR-5	0.785	0.842	0.900	5
NIR-6	0.855	0.865	0.875	5
NIR-7	0.935	0.945	0.955	5
NIR-8	1.000	1.020	1.040	5
SWIR1-1	1.195	1.210	1.225	100
SWIR1-2	1.360	1.375	1.390	100
SWIR1-3	1.550	1.570	1.590	100
SWIR1-4	1.610	1.650	1.690	100
MWIR	3.700	4.325	4.950	100
TIR	7.500	10.500	13.500	150



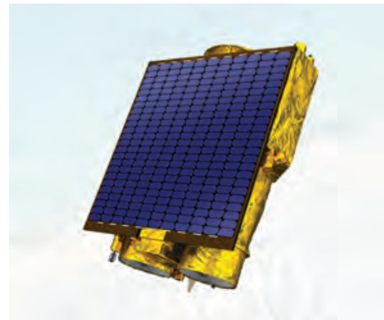
Jilin-1 Video Satellites

China
Commercial
Operational

Platform Overview

Jilin-1 Video 01/02 and Video 03 are high-resolution video satellites launched in 2015 and 2017, respectively, aboard a Long March rocket from the Jiuquan Satellite Launch Center for Earth resources monitoring. The satellites are built and operated by Chang Guang Satellite Technology Company, Ltd. Video 01/02 and Video 03 satellites carry a “gazing” video sensor to obtain dynamic imagery with image motion compensation capabilities.

Jilin-1 Video 04/05/06 and Video 07/08 are high-resolution video satellites launched in 2017 and 2018 respectively aboard a Long March rocket from Taiyuan Satellite Launch Center for Earth resources monitoring. The satellites are built and operated by Chang Guang Satellite Technology Company, Ltd. Jilin-1 Video 04/05/06 and Video 07/08 operate in gaze video imaging, pushbroom imaging, shimmer imaging, and inertial space imaging modes.



A model of the Jilin-1 Video satellite (image from Chang Guang Satellite Technology Company, Ltd.).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

	Video 01/02	Video 03	Video 04/05/06	Video 07/08
Launch date	10/07/2015	01/09/2017	11/21/2017	01/19/2018
Design lifetime	1+ years		3+ years	
Platform owner	Chang Guang Satellite Technology Company, Ltd.			
Altitude	650 km	535 km		
Orbit period	97.72 min	95.33 min		
Inclination	97.98°	97.53°		
Crossing time	—	—	—	—
Nadir repeat	—	—	—	—
Status	Operational			
System website	http://www.charmingglobe.com/EWeb/product_view.aspx?id=222			

Sensor Information

	Video 01/02 camera	Video 03 camera	Video 04–08 camera
GSD (m)	1.13	1	1
Swath (km)	4.6	11	19
Data portal	http://mall.charmingglobe.com/dataShow.html		

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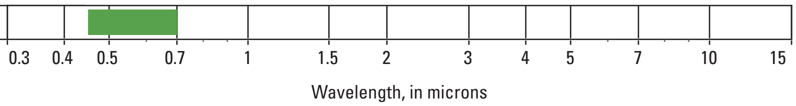
Jilin-1 Video Satellites—Continued

China
Commercial
Operational

Video 01/02 Camera

The video camera covers a swath of 4.6 kilometers (km), imaging in gaze mode at a resolution of 1.13 meters (m). It has the capability to acquire 4K high-definition color video images.

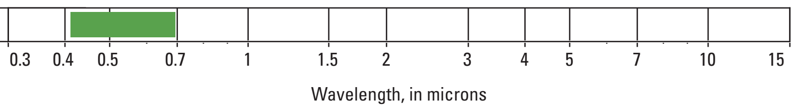
Band	Lower	Center	Upper	GSD (m)
Video	0.450	0.575	0.700	1.13



Video 03 Camera

The video camera covers a swath of 11 km, imaging in gaze mode at a resolution of 0.92 m.

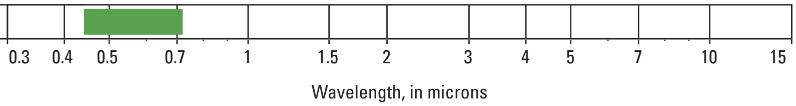
Band	Lower	Center	Upper	GSD (m)
Video	0.410	0.550	0.690	0.92



Video 04–08 Camera

The video camera covers a swath of 19 km, imaging in multiple modes at a resolution of 1 m.

Band	Lower	Center	Upper	GSD (m)
Video	0.440	0.580	0.720	1



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Kanopus-V

Russia
Civil/Government
Operational/Future

Platform Overview

The Kanopus-Vulcan (Kanopus-V) constellation of medium-resolution multispectral satellites was launched by Roscosmos, the Russian State Space Corporation, starting in 2012 on Soyuz rockets for Earth resources monitoring. A series of six satellites (Kanopus-V No. 1–No. 6) developed by VNIIEM Corporation are operated by the Scientific Center for Operational Earth Monitoring of Joint Stock Company Russian Space Systems. Kanopus-V No. 7 and No. 8 are planned for launch in 2025.

Kanopus-V satellites carry a panchromatic camera (Pan) and multispectral imager (MSS). Kanopus-V No. 2 (Kanopus-V-IK) carries a multichannel infrared radiometer (IR) along with the Pan and MSS.

Artistic rendering of Kanopus-V-No. 1 satellite in orbit (image from Roscosmos).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infra-red; MWIR, midwave infrared; TIR, thermal infrared]

	Kanopus-V satellites							
	No. 1	IK	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Launch date	07/22/2012	07/14/2017	02/01/2018		12/27/2018		2025	
Design lifetime	5 years							
Platform owner	Roscosmos							
Altitude	515 km							
Orbit period	94.8 min							
Inclination	97.5°							
Crossing time	12:00 AN							
Nadir repeat	—							
Status	Operational							
System website	https://www.roscosmos.ru/24985/							

Sensor Information

	Pan	IR	MSS
GSD (m)	2.7	200	12
Swath (km)	23	250	20
Data portal	https://gptl.ru/		

Image of Bahrain's Petal Beach captured by the Kanopus-V satellite (image from Roscosmos).

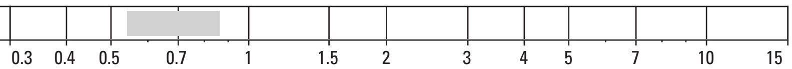
Kanopus-V—Continued

Russia
Civil/Government
Operational/Future

Pan Imager

The Pan imager was a Russian-built sensor capturing Earth data at a 2.7-meter (m) resolution with a swath of 23 kilometers (km) at nadir.

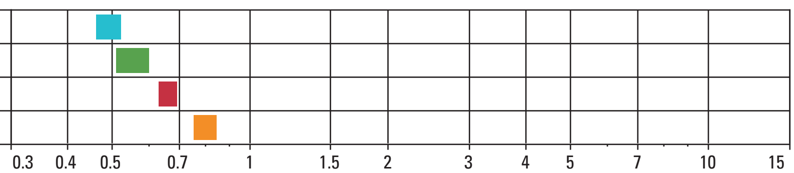
Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.540	0.700	0.860	2.7



MSS

The MSS on Kanopus-V satellites operates with a swath width of 20 km, capturing Earth data at a 12-m ground resolution.

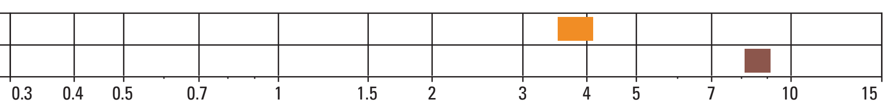
Band	Lower	Center	Upper	GSD (m)
Blue	0.460	0.490	0.520	12
Green	0.510	0.555	0.600	12
Red	0.630	0.660	0.690	12
NIR	0.750	0.795	0.840	12



IR

The IR on the Kanopus-V-IK satellite operates with a swath width of 250 km, capturing Earth data at a 25-m ground resolution to detect fires.

Band	Lower	Center	Upper	GSD (m)
MWIR	3.500	3.800	4.100	200
TIR	8.100	8.600	9.100	200



KazEOSat-1

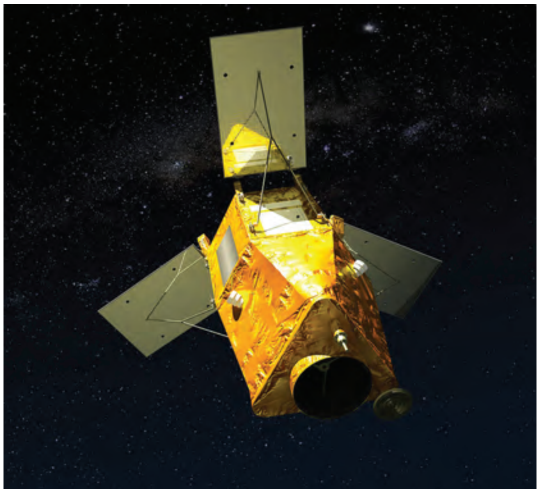
Kazakhstan
Civil/Government
Operational

Platform Overview

The Kazakhstan Earth Observation Satellite–1 (KazEOSat-1) is a high-resolution multispectral satellite launched in 2014 on a Vega launch vehicle from the Guiana Space Center, French Guiana, for Earth observation. KazEOSat-1 is part of a two-satellite Earth observation system. The Kazakhstan National Space Agency, Kazcosmos, charged the Joint Stock Company National Company Kazakhstan Gharysh Sapary with the development of the satellite system. KazEOSat-1 was built by Airbus and uses the AstroSat-250 bus with SPOT-6 and SPOT-7 heritage. KazEOSat-1 carries the New AstroSat Optical Modular Instrument (NAOMI) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	04/30/2014
Design lifetime	7.25 years
Platform owner	Kazcosmos
Altitude	759 km
Orbit period	100.0 min
Inclination	98.54°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	—



Artistic rendering of KazEOSat-1 (image from Airbus DS, used with permission).

Sensor Information

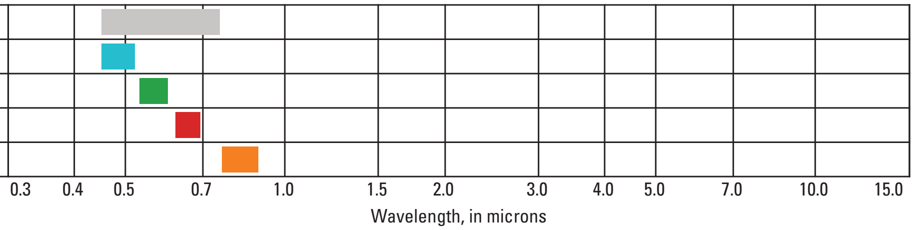
	NAOMI
GSD (m)	1, 4
Swath (km)	10
Data portal	—

KazEOSat-1 image of Singapore (image from Airbus DS, used with permission).

NAOMI

The NAOMI sensor is a proven design from Airbus used on AlSat-2, SSOT, VNREDSat-1A, SPOT-6, and SPOT-7.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.600	0.750	1
Blue	0.450	0.485	0.520	4
Green	0.530	0.565	0.600	4
Red	0.620	0.655	0.690	4
NIR	0.760	0.825	0.890	4



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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KazEOSat-2

Kazakhstan
Civil/Government
Operational

Platform Overview

The Kazakhstan Earth Observation Satellite–2 (KazEOSat-2) is a medium-resolution multispectral satellite launched in 2014 on a Dnepr-1 launch vehicle from the Yasny Cosmodrome in the Dombarovsky region of Russia for Earth observation. KazEOSat-2 is part of a two-satellite Earth observation system. The Kazakhstan National Space Agency, Kazcosmos, charged the Joint Stock Company National Company Kazakhstan Gharysh Sapary with the development of the satellite system. KazEOSat-2 was built by Surrey Satellite Technology, Ltd., (SSTL) and uses the SSTL-159 bus with Bejing-1 and RapidEye heritage. KazEOSat-2 carries the Kazakh Earth Imaging System (KEIS) for medium-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Launch date	06/19/2014
Design lifetime	7 years
Platform owner	Kazcosmos
Altitude	630 km
Orbit period	97.31 min
Inclination	98°
Crossing time	10:30 AN
Nadir repeat	—
Status	Operational
System website	—

Sensor Information

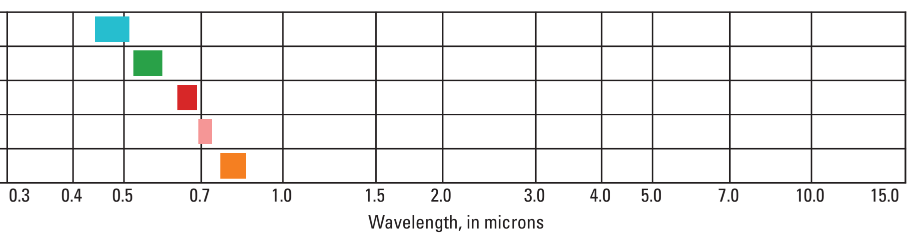
	KEIS
GSD (m)	6.5
Swath (km)	78
Data portal	—

JACIE

KEIS

The KEIS was developed by Jena-Optronik GmbH and is of RapidEye heritage. The instrument is also referred to as the Jena-Optronik Spaceborne Scanner-56 or the Multispectral Imager.

Band	Lower	Center	Upper	GSD (m)
Blue	0.440	0.475	0.510	6.5
Green	0.520	0.555	0.590	6.5
Red	0.630	0.658	0.685	6.5
Red Edge	0.690	0.710	0.730	6.5
NIR	0.760	0.805	0.850	6.5



KhalifaSat

United Arab Emirates
Civil/Government
Operational

Platform Overview

Khalifasat (formerly known as DubaiSat-3) is a high-resolution, multispectral satellite launched in 2018 onboard Japan's H-IIA rocket by the United Arab Emirates Mohammed bin Rashad Space Centre (MBRSC) on Japan's H-IIA rocket for Earth resources monitoring. This mission continues the DubaiSat series that has been in continual operation since the launch of DubaiSat-1 in 2009. Where DubaiSat-1 and DubaiSat-2 were built in cooperation with the South Korean satellite manufacturer Satrec Initiative, KhalifaSat is the first satellite developed entirely by MBRSC. KhalifaSat was designed and built by MBRSC and uses the SI-300 bus heritage of Dubaisat-2. KhalifaSat carries the KhalifaSat Camera System (KHCS) for high-resolution imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	10/29/2018
Design lifetime	5 years
Platform owner	MBRSC
Altitude	613 km
Orbit period	96.96 min
Inclination	98.13°
Crossing time	—
Nadir repeat	6 days
Status	Operational
System website	http://khalifasat-thejourney.com/

Image captured by Khalifasat on November 5, 2018, over Palm Jumeirah in Dubai, United Arab Emirates (image from MBRSC, used with permission).

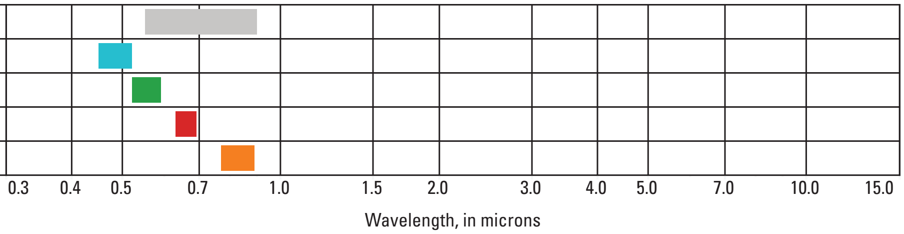
Sensor Information

	KHCS
GSD (m)	0.75, 3
Swath (km)	12
Data portal	—

KHCS

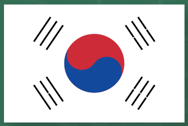
The KHCS is an improved version of the heritage HiRAIS pushbroom sensor previously flown on Dubaisat-2 and provides imagery in visible and near-infrared bands. The KHCS offers a major improvement in resolution and downlink capability. The four spectral bandwidths and the 12-kilometer swath width are the same as DubaiSat-2, although resolution is improved to a ground sample distance of 0.75 meter (m) in panchromatic and 3 m in multispectral mode. Data are collected at a radiometric resolution of 10 bits.

Band	Lower	Center	Upper	GSD (m)
Pan	0.550	0.725	0.900	0.75
Blue	0.450	0.485	0.520	3
Green	0.520	0.555	0.590	3
Red	0.630	0.660	0.690	3
NIR	0.770	0.830	0.890	3



Kompsat-2

South Korea
Civil/Government
Operational



Platform Overview

Kompsat-2 is a high-resolution multispectral satellite launched in 2006 by the Republic of Korea on a Rockot-KM launch vehicle from Plesetsk, Russia, for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since the launch of Kompsat-1 in 1999. The Kompsat-2 satellite was designed and built by the Korean Aerospace Research Institute (KARI) and uses the TRW bus of Kompsat-1 heritage. Kompsat-2 carries the Multispectral Camera (MSC) for high-resolution land imaging.

Artistic rendering of Kompsat-2 in orbit (image from KARI, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	07/28/2006
Design lifetime	3 years
Platform owner	KARI
Altitude	685 km
Orbit period	98.46 min
Inclination	98.13°
Crossing time	10:50 AN
Nadir repeat	28 days
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_01.do

Kompsat-2 image of Sydney, Australia (image from KARI, used with permission).

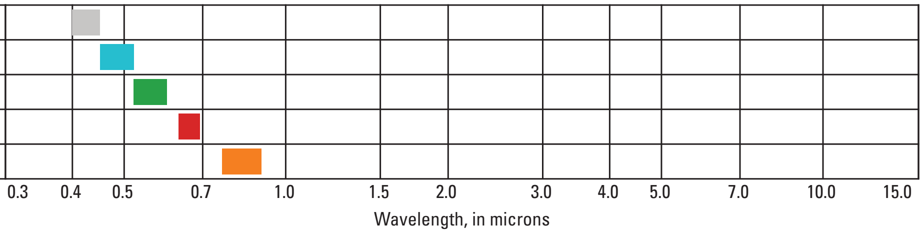
Sensor Information

	MSC
GSD (m)	1, 4
Swath (km)	15
Data portal	https://earth.esa.int/web/guest/-/kompsat-2-msc-bundle-5683

MSC

The MSC is a design from KARI built in cooperation with Electro Optics Industries and OHB-Systems. MSC provides global imagery with a revisit of 1 day.

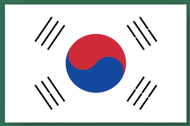
Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.425	0.450	1
Blue	0.450	0.485	0.520	4
Green	0.520	0.560	0.600	4
Red	0.630	0.660	0.690	4
NIR	0.760	0.830	0.900	4



JACIE

Kompsat-3

South Korea
Civil/Government
Operational



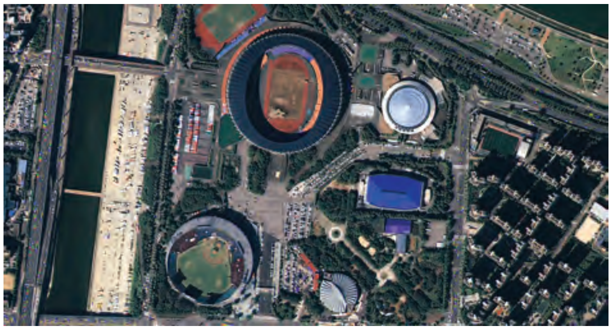
Platform Overview

Kompsat-3 is a high-resolution multispectral satellite launched in 2012 by the Republic of Korea on the H-IIA launch vehicle from Tanegashima Space Center of the Japan Aerospace Exploration Agency for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since the launch of Kompsat-1 in 1999. The Kompsat-3 satellite was designed and built by the Korean Aerospace Research Institute (KARI). It is the first satellite of Korea with submeter resolution. Kompsat-3 carries the Advanced Earth Imaging Sensor System (AEISS) sensor for high-resolution land imaging.

Artistic rendering of Kompsat-3 in orbit (image from KARI, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

Launch date	05/17/2012
Design lifetime	4 years
Platform owner	KARI
Altitude	685 km
Orbit period	98.5 min
Inclination	98.13°
Crossing time	13:30 AN
Nadir repeat	28 days
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_01.do



Kompsat-3 image of PyeongChang Olympic Stadium, South Korea (image from KARI, used with permission).

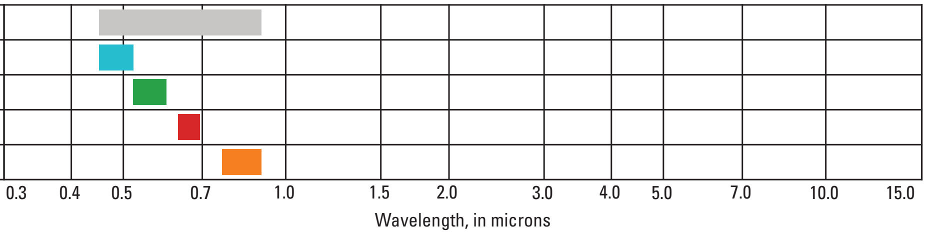
Sensor Information

	AEISS
GSD (m)	0.7, 2.8
Swath (km)	15
Data portal	—

AEISS

The AEISS is a pushbroom-style imager designed by KARI with support from European Aeronautics Defense and Space Astrium.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	0.7
Blue	0.450	0.485	0.520	2.8
Green	0.520	0.560	0.600	2.8
Red	0.630	0.660	0.690	2.8
NIR	0.760	0.830	0.900	2.8



Kompsat-3A

South Korea
Civil/Government
Operational

Platform Overview

Kompsat-3A is a high-resolution multispectral satellite launched in 2015 by the Republic of Korea on a Dnepr-1 vehicle from the Dombarovsky launch site in Russia for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since the launch of Kompsat-1 in 1999. The Kompsat-3A satellite was designed and built by the Korean Aerospace Research Institute (KARI) and uses the TRW bus similar to Kompsat-3 design. It carries the improved Advanced Earth Imaging Sensor System-A (AEISS-A) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared; MWIR, midwave infrared]

Launch date	03/25/2015
Design lifetime	4 years
Platform owner	KARI
Altitude	528 km
Orbit period	95.21 min
Inclination	97.51°
Crossing time	13:30 AN
Nadir repeat	28 days
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_01.do

Sensor Information

	AEISS-A	IIS
GSD (m)	0.55, 2.2	5.5
Swath (km)	12	
Data portal	—	

Artistic rendering of Kompsat-3A in orbit (image from KARI, used with permission).

Imagery of Dubai International Airport, United Arab Emirates, captured by Kompsat-3A (image from KARI, Distribution [SI Imaging Services, Republic of Korea], 2019, all rights reserved, used with permission).

JACIE

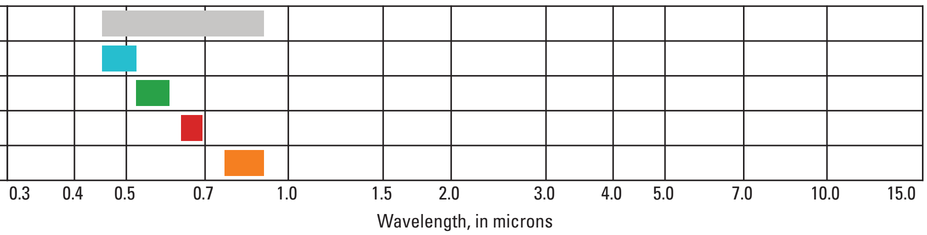
Kompsat-3A—Continued

South Korea
Civil/Government
Operational

AEISS-A

The AEISS-A is a design from KARI built with support from European Aeronautics Defense and Space Astrium on the heritage of AEISS.

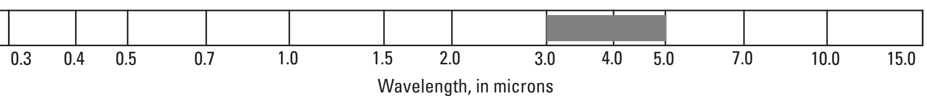
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	0.55
Blue	0.450	0.485	0.520	2.2
Green	0.520	0.560	0.600	2.8
Red	0.630	0.660	0.690	2.8
NIR	0.760	0.830	0.900	5.5



IIS

The Infrared Imaging System (IIS) on Kompsat-3A was built by AIM Infrarot-Module GmbH (AIM) in Heilbronn, Germany.

Band	Lower	Center	Upper	GSD (m)
MWIR	3.000	4.000	5.000	5.5



Kompsat-5

South Korea
Civil/Government
Operational

Platform Overview

Kompsat-5 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2013 by the Republic of Korea on a Dnepr-1 vehicle from the Dombarovsky launch site in Russia for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since the launch of Kompsat-1 in 1999. Kompsat-5 is also called a GIS, Ocean and Land management, Disaster and Environment monitoring (GOLDEN) mission. The Kompsat-5 satellite was designed and built by the Korean Aerospace Research Institute (KARI) with the support of private industries in Korea. Kompsat-5 carries the Corea SAR Instrument (COSI) sensor for high-resolution SAR data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter;—, no data; H, horizontal, V, vertical]

Launch date	08/22/2013
Design lifetime	5 years
Platform owner	KARI
Altitude	550 km
Orbit period	95.78 min
Inclination	97.6°
Crossing time	6:00 AN
Nadir repeat	28 days
Status	Operational
System website	https://www.kari.re.kr/eng/sub03_02_01.do

Artistic rendering of Kompsat-5 (image from ESA).

Kompsat-5 image of Abu Dhabi, United Arab Emirates (image from KARI, Distribution [SI Imaging Services, Republic of Korea], 2019, all rights reserved, used with permission).

Sensor Information

	COSI
GSD (m)	1–20 (selectable)
Swath (km)	5–100 (selectable)
Data portal	—

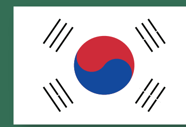
COSI

The COSI is a design by Thales Alenia Space for KARI. It provides high-resolution imagery in X-band at 9.66 gigahertz (λ = 3.1 centimeters). The angle of incidence is 20–55 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
High Resolution (HR)	Single	HH, HV, VH, VV	5	1
Standard (ST)	Single	HH, HV, VH, VV	30	3
Wide Swath (WS)	Single	HH, HV, VH, VV	100	20

Kompsat-6

South Korea
Civil/Government
Future

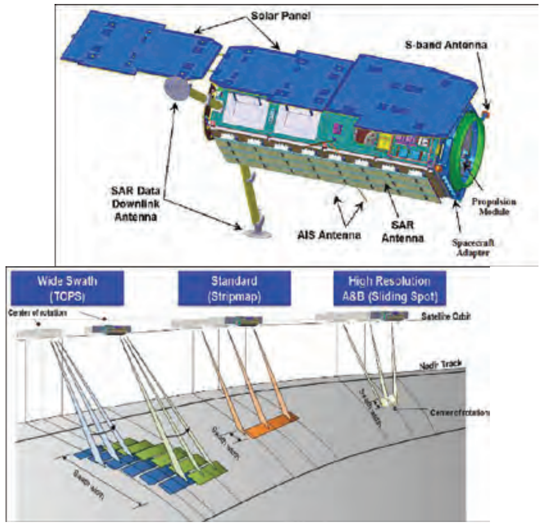


Platform Overview

Kompsat-6 is an all-weather, high-resolution synthetic aperture radar (SAR) satellite scheduled for launch in 2020 by the Republic of Korea on an Angara 1.2 launch vehicle from Plesetsk Cosmodrome in Russia for Earth resources monitoring. This mission continues the Kompsat series that has been in continuous operation since the launch of Kompsat-1 in 1999. The Kompsat-6 satellite is being built by LIG Nex1 Co., Ltd., of Korea and Airbus Defence and Space for the Korean Aerospace Research Institute (KARI). Kompsat-6 will carry the X-band SAR (X-SAR) sensor for high-resolution SAR data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; H, horizontal; V, vertical]

Launch date	2020 (Planned)
Design lifetime	5 years
Platform owner	KARI
Altitude	505 km
Orbit period	94.71 min
Inclination	97.6°
Crossing time	6:00 AN
Nadir repeat	11 days
Status	Development
System website	https://www.kari.re.kr/eng/sub03_02_01.do



Illustrations showing the Kompsat-6 on-orbit configuration and beam mode (image from KARI, used with permission).

Sensor Information

	X-SAR
GSD (m)	0.5–20 (selectable)
Swath (km)	5–100 (selectable)
Data portal	—

X-SAR

The X-SAR is a multimode instrument built by Airbus that operates at 9.66 gigahertz ($\lambda = 3.1$ centimeters). The angle of incidence is 20–60 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
High Resolution-A	Single	HH, HV, VV, VH	5	0.5
	Dual	HH/HV, VV/VH		
	Quad	HH/HV/VV/VH		
High Resolution-B	Single	HH, HV, VV, VH	10	1
	Dual	HH/HV, VV/VH		
	Quad	HH/HV/VV/VH		
Standard	Single	HH, HV, VV, VH	30	3
	Dual	HH/HV, VV/VH		
	Quad	HH/HV/VV/VH		
Wide Swath	Single	HH, HV, VV, VH	100	20
	Dual	HH/HV, VV/VH		
	Quad	HH/HV/VV/VH		

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Kompsat-7

South Korea
Civil/Government
Future

Platform Overview

Kompsat-7 is a high-resolution multispectral satellite scheduled for launch in 2021 by the Republic of Korea for Earth resources monitoring. This mission continues the Kompsat series that has been in continual operation since the launch of Kompsat-1 in 1999. The Kompsat-7 satellite is being built by an undisclosed Korean company using the Korean technologies for by the Korean Aerospace Research Institute (KARI). Kompsat-7 carries the improved Advanced Earth Imaging Sensor System-High Resolution (AEISS-HR) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared; MWIR, midwave infrared]

Launch date	2021 (Planned)
Design lifetime	4 years
Platform owner	KARI
Altitude	685 km
Orbit period	98.5 min
Inclination	98.1°
Crossing time	10:50 AN
Nadir repeat	28 days
Status	Planned
System website	https://www.kari.re.kr/eng/sub03_02_01.do

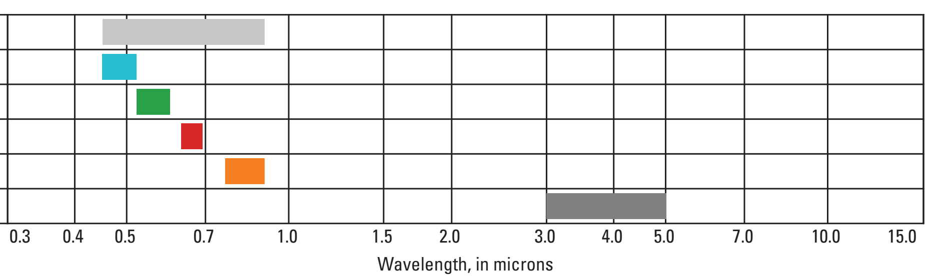
Sensor Information

	AEISS-HR
GSD (m)	0.3, 1.2, 4
Swath (km)	12
Data portal	—

AEISS-HR

AEISS-HR is a high-resolution multispectral imager on Kompsat-7 built by Korea. It is an improvement to the AEISS sensor flown on previous Kompsats. The ground sample distance is improved to 30 centimeters in panchromatic, 1.2 meters (m) in visible and near infrared, and 4 m in infrared.

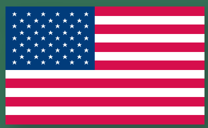
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	0.3
Blue	0.450	0.485	0.520	1.2
Green	0.520	0.560	0.600	1.2
Red	0.630	0.660	0.690	1.2
NIR	0.760	0.830	0.900	4
MWIR	3.000	4.000	5.000	4



JACIE

Landmapper-BC

United States
Commercial
Operational/Future



Platform Overview

The Landmapper-BC (Corvus-BC) satellites are medium-resolution, multispectral satellites for commercial Earth observation. Astro Digital, Inc., plans to have a constellation of 8 to 12 Landmapper-BC satellites to provide daily imaging of all Earth land areas. Landmapper 1 and 2 failed shortly after their July 2017 launch. Landmapper 3 and 4 were lost because of a launch failure in November 2017. Landmapper-BC 3, version 2, and Landmapper BC 4 were successfully launched in January and December 2018, respectively. The Landmapper-BC satellites are based on the Perseus-O satellites developed at Canopus Systems, Inc. The system captures medium-resolution imagery that is commercially available.

Artistic rendering of Landmapper-BC satellite (image from Astro Digital, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

	Landmapper-BC 3, versions 2	Landmapper-BC 4
Launch date	01/12/2018	12/03/2018
Design lifetime	5 years	
Platform owner	Astro Digital Inc.	
Altitude	500 km	590 km
Orbit period	94.8 min	96.3 min
Inclination	97.4°	97.7°
Crossing time	10:00 DN	10:00 DN
Nadir repeat	—	—
Status	Operational	
System website	https://www.astrodigital.com/	

Sensor Information

	Landmapper-BC Imager
GSD (m)	22
Swath (km)	220
Data portal	https://www.astrodigital.com/api/

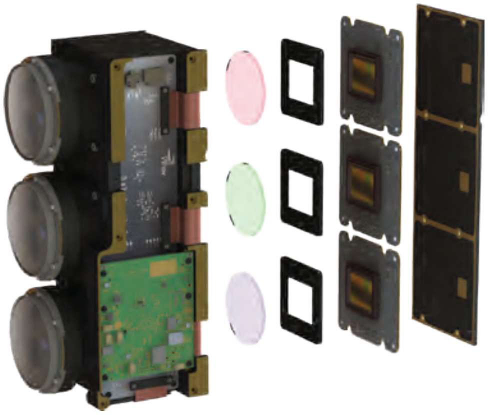


Image of Landmapper-BC imager (image from Astro Digital, used with permission).

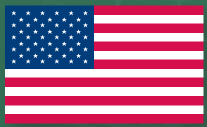
Landmapper-BC Imager

The imager consists of three separate cameras for green, red, and near-infrared bands similar to the SLIM6 imager used on the Disaster Monitoring Constellation systems. These bands are used to calculate the productivity of plants and estimate crop yields.

Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.560	0.600	22
Red	0.600	0.640	0.680	22
NIR	0.700	0.800	0.900	22

Landsat 7

United States
Civil/Government
Operational



Platform Overview

Landsat 7 is a medium-resolution multispectral satellite launched in 1999 by the National Aeronautics and Space Administration (NASA) and U.S. Geological Survey (USGS) on a Delta-II rocket from Vandenberg Air Force Base for Earth resources monitoring. This mission continues the Landsat series that has been in continual operation since the launch of Landsat 1 in 1972. The Landsat 7 satellite was designed and built by Lockheed Martin Missiles and Space for NASA and uses the TIROS-N bus. Landsat 7 carries the Enhanced Thematic Mapper Plus (ETM+) sensor for medium-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared]

Launch date	04/15/1999
Design lifetime	5 years
Platform owner	USGS/NASA
Altitude	705 km
Orbit period	98.98 min
Inclination	98.2°
Crossing time	10:00 DN
Nadir repeat	16 days
Status	Operational
System website	https://landsat.usgs.gov/landsat-7

Artistic rendering of Landsat 7 in orbit (image from NASA).

Landsat 7 imagery of Seattle, Washington (image from NASA).

Sensor Information

	ETM+
GSD (m)	15, 30, 60
Swath (km)	185
Data portal	https://earthexplorer.usgs.gov/ https://glovis.usgs.gov/app

JACIE

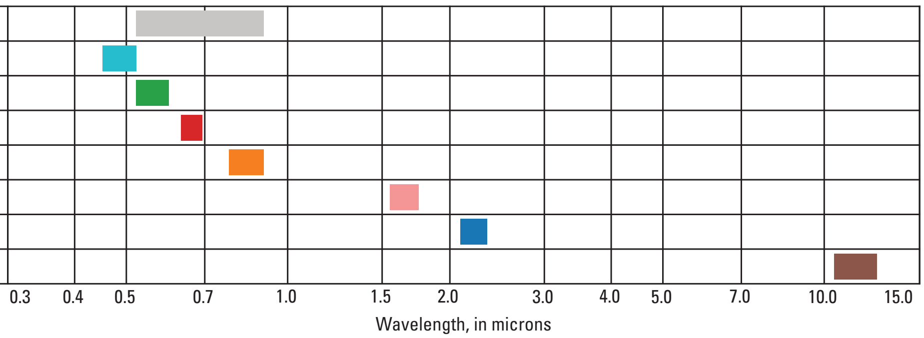
Landsat 7—Continued

United States
Civil/Government
Operational

ETM+

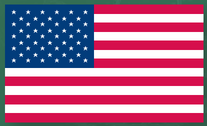
The ETM+ sensor was built by Hughes Santa Barbara Remote Sensing. This sensor was an improvement to the Thematic Mapper (TM) sensor on previous Landsat satellites with the addition of a 15-meter (m) resolution panchromatic band and a 60-m resolution thermal band replacing the 120-m band of TM. The 185-kilometer swath width is maintained from the TM sensor. The operational model is to continually map the Earth, gathering as much data as practical on every orbit. ETM+ data are freely available.

Band	Lower	Center	Upper	GSD (m)
Pan	0.520	0.710	0.900	15
Blue	0.450	0.485	0.520	30
Green	0.520	0.560	0.600	30
Red	0.630	0.660	0.690	30
NIR	0.775	0.838	0.900	30
SWIR 1	1.550	1.650	1.750	30
SWIR 2	2.090	2.220	2.350	30
TIR	10.400	11.450	12.500	60

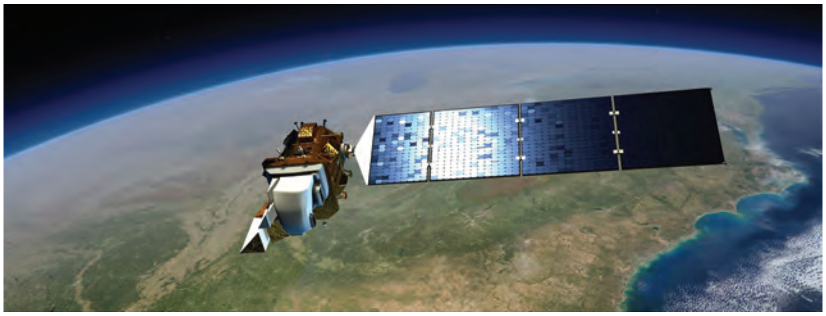


Landsat 8 and 9

United States
Civil/Government
Operational/Future



Platform Overview



Artistic rendering of Landsat 8 in orbit (image from NASA).

The Landsat 8 and 9 medium-resolution satellites continue the ongoing Landsat data record collected continuously since 1972 with the launch of the Earth Resources Technology Satellite, later renamed Landsat 1. Landsat 8, launched in 2013, will be joined by Landsat 9 following its planned 2021 launch date. Together they will provide continuous synoptic coverage of the Earth's land areas with a combined 8-day repeat. The Landsat program is managed jointly by National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS). NASA is responsible for procuring, integrating, and launching each mission, and providing on-orbit verification of performance. The USGS provides science and operational data user requirements during mission formulation and, following on-orbit verification of performance, is responsible for operations, data reception, archiving, and distribution for the remaining life of the mission.

The Landsat 8 satellite bus was designed and built by Orbital Sciences for NASA and uses the LEOStar-3 bus with the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensors. The Landsat 9 bus is being built by Northrup Grumman/Orbital ATK using modestly improved OLI-2 and TIRS-2 sensors.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic, CA, coastal aerosol; NIR, near infrared; SWIR, short wave infrared; TIR, thermal infrared]

	Landsat 8	Landsat 9
Launch date	02/11/2013	2021 (Planned)
Design lifetime	5 years	
Platform owner	NASA/USGS	
Altitude	705 km	
Orbit period	98.98 min	
Inclination	98.2°	
Crossing time	10:00 DN	
Nadir repeat	16 days	
Status	Operational	Development
System website	https://landsat.usgs.gov/landsat-8	https://landsat.usgs.gov/landsat-9-mission

Landsat 8 OLI image of Netherland's coast showing flower fields (image from NASA).

Sensor Information

	OLI	TIRS
GSD (m)	15, 30	100
Swath (km)	185	
Data portal	https://earthexplorer.usgs.gov/	https://glovis.usgs.gov/app

JACIE

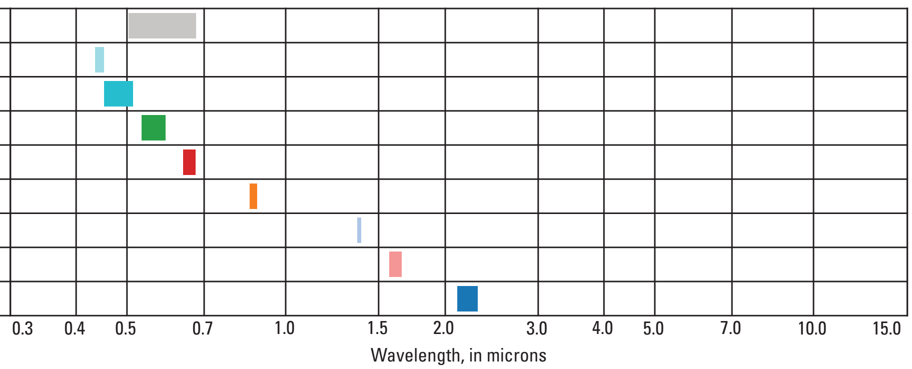
Landsat 8 and 9—Continued

United States
Civil/Government
Operational/Future

OLI

The OLI sensor aboard Landsat 8 and 9 was built by Ball Aerospace Technology Corp. based on technologies proven in the Advanced Land Imager aboard Earth Observing-1 (EO-1). The OLI sensor in Landsat 8 and 9 adds a coastal aerosol band as well as a cirrus band to complement the bands on the ETM+ sensor on Landsat 7. The 185-kilometer swath width is maintained from previous Landsat TM and ETM+ sensors. The operational model is to continually map the Earth, gathering as much sunlit land imagery as practical on every orbit. The 12 bit radiometric resolution of Landsat 8 is being increased to 14 bits with Landsat 9. OLI data are freely available.

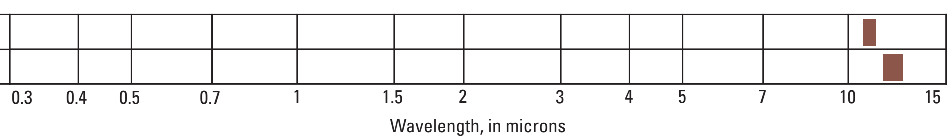
Band	Lower	Center	Upper	GSD (m)
Pan	0.503	0.590	0.676	15
CA	0.435	0.443	0.451	30
Blue	0.452	0.482	0.512	30
Green	0.533	0.562	0.590	30
Red	0.637	0.655	0.673	30
NIR	0.851	0.865	0.879	30
Cirrus	1.363	1.374	1.384	30
SWIR 1	1.566	1.609	1.651	30
SWIR 2	2.107	2.204	2.300	30



TIRS

The TIRS is a new design built by NASA Goddard Space Flight Center. The ground sample distance of 100 meters is provided with two spectral bands in the thermal infrared region. Landsat 9 will also carry a second-generation TIRS instrument of similar specifications and enhanced reliability. The 12-bit radiometric resolution of Landsat 8 is being increased to 14 bits with Landsat 9. TIRS data are freely available.

Band	Lower	Center	Upper	GSD (m)
TIR-1	10.600	10.895	11.190	100
TIR-2	11.500	12.005	12.510	100



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Lingque (Magpie) Constellation

China
Commercial
Operational/Future

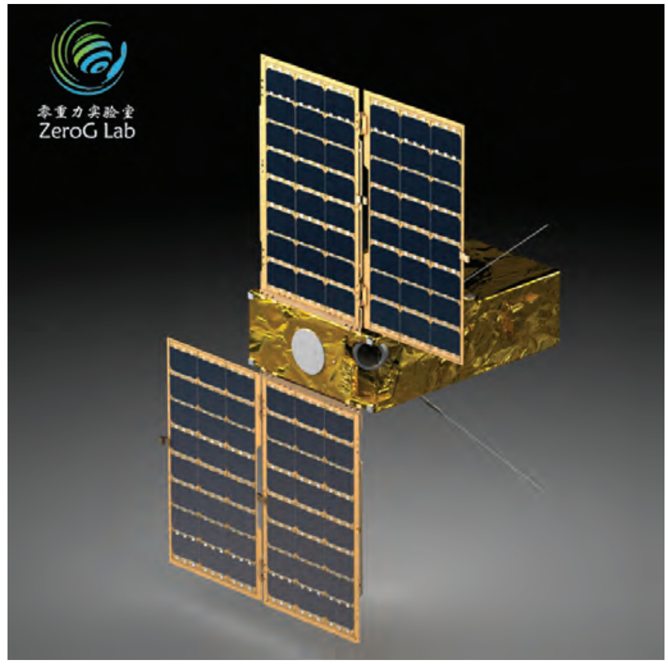
Platform Overview

The Lingque (or Magpie) constellation of high-resolution satellites developed by China's Zero Heavy Space Technology Company, Ltd. (also known as ZeroG Lab), started with the launch of Lingque 1A in 2019. Lingque 1B, launched in 2019 (failed), and Lingque 1C, planned for 2020, are also a part of the 132-satellite constellation planned for the first phase. The entire constellation is to consist of 378 satellites to provide 10-minute revisits of every region on Earth.

The Lingque satellites are based on a 6U platform developed by ZeroG Lab. The sensors on these satellites are believed to be similar to Planet Scope 1, flown on Planet's Dove satellites.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	01/21/2019
Design lifetime	—
Platform owner	ZeroG Lab
Altitude	520 km
Orbit period	95 min
Inclination	97.5°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	http://www.cubesatgarage.com/



A prototype of ZeroG Lab's 6U cubesat (image from ZeroG Lab).

JACIE

LSTM

European Space Agency
Civil/Government
Future

Platform Overview

The Land Surface Temperature Monitoring (LSTM) mission is a multispectral satellite, which is a concept of the European Space Agency (ESA) and is planned to be launched in the 2025 time frame for monitoring land surface temperature. LSTM satellites are planned to form a virtual constellation with the Landsat 9, SBG, and Trishna missions for providing high temporal data of Earth's land and coastal surfaces.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; MSS, multispectral imager; GSD, ground sample distance; m, meter]

Launch date	2025
Design lifetime	5 years
Platform owner	ESA
Altitude	640 km
Orbit period	97.5 min
Inclination	97.9°
Crossing time	13:00 DN
Nadir repeat	—
Status	Planned
System website	https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates

Sensor Information

	MSS
GSD (m)	30
Swath (km)	700
Revisit (days)	3
Data portal	—

Multispectral Imager

The multispectral imager on LSTM satellites will have 5 thermal infrared bands (goal) in an 8–12 micrometer range and 4 visible and near infrared and 2 shortwave infrared bands in a 0.4–2.5 micrometer range. It is planned to be a scanning sensor with a swath of around 700 kilometers.

Meteor-M

Russia
Civil/Government
Operational/Future

Platform Overview

The Meteor-M series of low-resolution multispectral and radar meteorological satellites was launched by Russia on Soyuz rockets from the Baikonur Cosmodrome. The satellites Meteor-M No. 1, No. 2, and No. 2-2, launched in 2009, 2014, and 2019, respectively, orbit the Earth in sun-synchronous orbits. The satellites were developed by VNIIEM Corporation and are operated by the Scientific Center for Operational Earth Monitoring of Joint Stock Company Russian Space Systems.

Meteor-M satellites carry low- and medium-resolution multispectral sensors and a Severyanin-M X-band radar for meteorological and agricultural studies. Meteor-M No. 2 also carries an infrared Fourier spectrometer for atmospheric data.

Artistic rendering of the Meteor-M satellite in orbit (image from Roscosmos).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; LRMSS, low-resolution multispectral sensor; MSU, medium-resolution multispectral sensor; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

	Meteor-M No. 1	Meteor-M No. 2	Meteor-M No. 2-2	Meteor-M No. 3
Launch date	09/17/2009	07/08/2014	07/05/2019	2022
Design lifetime	5 years			
Platform owner	Roscosmos			
Altitude	832 km			
Orbit period	101.5 min			
Inclination	98.85°			
Crossing time	12:00 AN			
Nadir repeat	—			
Status	Operational			Planned
System website	https://www.roscosmos.ru/24986/			

Sensor Information

	LRMSS	MSU-50	MSU-101/102
GSD (m)	1,000	120	60
Swath (km)	2,800	900	900
Data portal	https://pod.gptl.ru/		

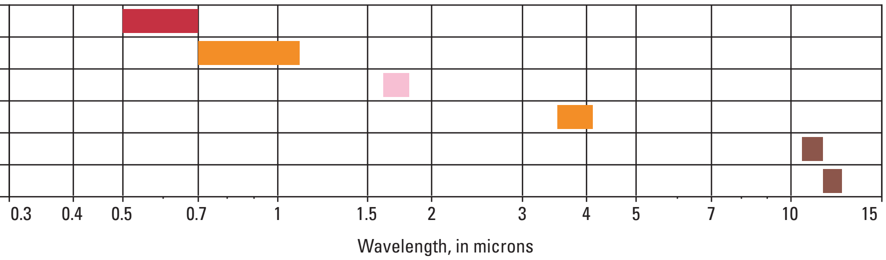
JACIE

Meteor-M—Continued

Russia
Civil/Government
Operational/Future

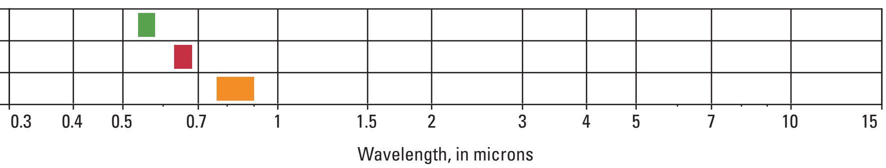
Low-Resolution Multispectral Sensor

Band	Lower	Center	Upper	GSD (m)
Red	0.500	0.600	0.700	1,000
NIR	0.700	0.900	1.100	1,000
SWIR1	1.600	1.700	1.800	1,000
MWIR	3.500	3.800	4.100	1,000
TIR-1	10.500	11.000	11.500	1,000
TIR-2	11.500	12.000	12.500	1,000



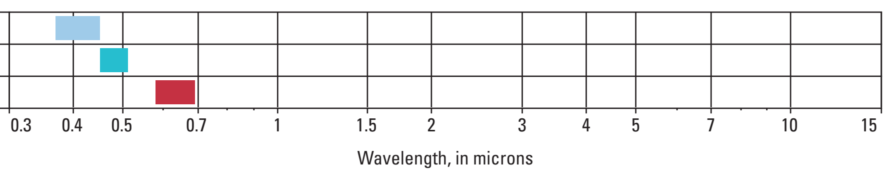
Medium-Resolution Multispectral Sensor-50

Band	Lower	Center	Upper	GSD (m)
Green	0.535	0.555	0.575	60
Red	0.630	0.655	0.680	60
NIR	0.760	0.830	0.900	60



Medium-Resolution Multispectral Sensor-101/102

Band	Lower	Center	Upper	GSD (m)
Ultra Violet	0.370	0.410	0.450	120
Blue	0.450	0.480	0.510	120
Red	0.580	0.635	0.690	120



Mohammed VI-A and -B

Morocco
Civil/Government
Operational

Platform Overview

Mohammed VI-A and -B are high-resolution, multispectral, and panchromatic satellites for mapping and land surveying developed by Royal Center for Remote Sensing (CRTS) in Morocco. Mohammed VI-A was launched in 2017 on a Vega launch vehicle. Mohammed VI-B was launched in 2018. The Mohammed VI satellite platforms were designed and built by Airbus and use the AstroSat-1000 bus. The Mohammed VI satellites carry the High-Resolution Imager (HiRI) sensor for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

	Mohammed VI-A	Mohammed VI-B
Launch date	11/08/2017	11/20/2018
Design lifetime	5 years	
Platform owner	CRTS	
Altitude	630 km	
Orbit period	97.5 min	
Inclination	98°	
Crossing time	10:30 DN	
Nadir repeat	26 days	
Status	Operational	
System website	—	

Artistic rendering of Pleiades satellite (identical to Mohammed-VIA satellite) in orbit (image from CNES, used with permission).

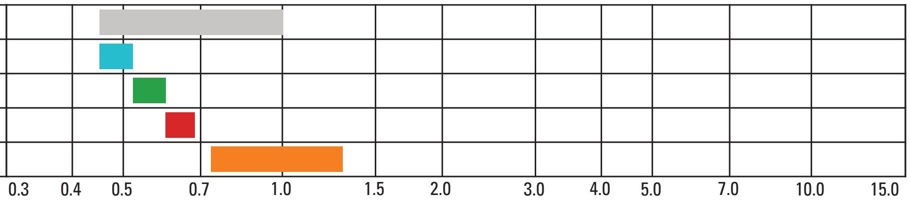
Sensor Information

	HiRI
GSD (m)	0.7, 2.8
Swath (km)	20
Data portal	—

HiRI

The HiRI aboard the Mohammed VI satellites was developed and built by Thales Alenia Space and is of Pleiades HiRI heritage.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.725	1.000	0.7
Blue	0.450	0.485	0.520	2.8
Green	0.520	0.560	0.600	2.8
Red	0.600	0.640	0.680	2.8
NIR	0.730	1.015	1.300	2.8



NigeriaSat-2

Nigeria
Civil/Government
Operational

Platform Overview

NigeriaSat-2 is a high-resolution, multispectral, and panchromatic imaging minisatellite launched alongside NigeriaSat-X in 2011 on a Dnepr-1 launch vehicle for Earth observation and disaster monitoring. NigeriaSat-2 is based on the newly developed SSTL-300 bus. The Nigerian National Space Research and Development Agency (NASRDA), in partnership with Surrey Satellite Technology, Ltd., (SSTL), built the satellite. NigeriaSat-2 carries the Very High-Resolution Imager (VHRI) and the Medium Resolution Imager (MRI) for land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	08/17/2011
Design lifetime	7.5 years
Platform owner	NASRDA
Altitude	715 km
Orbit period	99.8 min
Inclination	98.24°
Crossing time	10:30 AN
Nadir repeat	5 days
Status	Operational
System website	http://nasrda.gov.ng/en/

Sensor Information

	VHRI	MRI
GSD (m)	2.5, 5	32
Swath (km)	20	300
Data portal	http://www.dmcii.com/	

Salvador, State of Bahia, Brazil—NigeriaSat-2 satellite (image from NASRDA, 2014, all rights reserved, supplied by DMCii, used with permission).

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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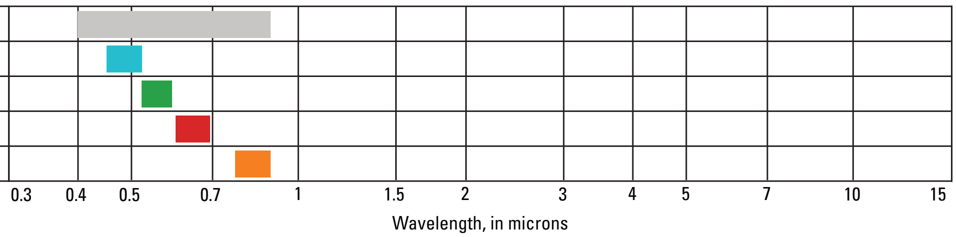
NigeriaSat-2—Continued

Nigeria
Civil/Government
Operational

VHRI

The VHRI was built by SSTL and is of CMT (China Mapping Telescope flown on Bejing-1) heritage. The VHRI is essentially a scaled-up version of CMT, giving it a wider aperture. The VHRI data are commercially available.

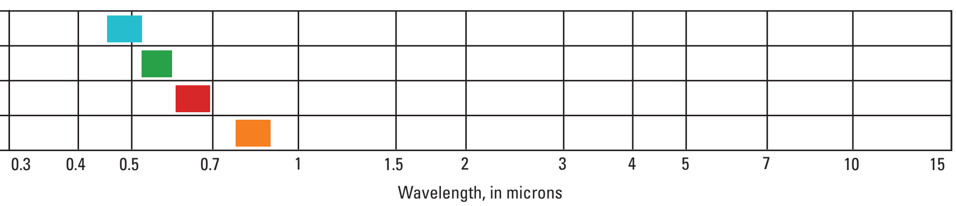
Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.645	0.890	2.5
Blue	0.450	0.485	0.520	5
Green	0.520	0.555	0.590	5
Red	0.600	0.645	0.690	5
NIR	0.770	0.830	0.890	5



MRI

The MRI is based on the SLIM6 sensor flown on NigeriaSat-1. The MRI provides continuity with Disaster Monitoring Constellation data and has one-half the swath width of SLIM6 and an additional spectral band (four total). NigeriaSat-2's swath can be artificially widened by taking advantage of the satellite's agility. The MRI data are commercially available.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	32
Green	0.520	0.555	0.590	32
Red	0.600	0.645	0.690	32
NIR	0.770	0.830	0.890	32



NISAR

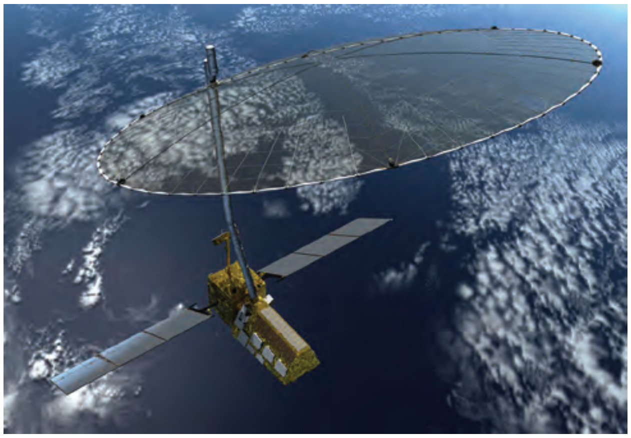
United States, India
Civil/Government
Future

Platform Overview

The National Aeronautics and Space Administration/Indian Space Research Organiziation (NASA/ISRO) Synthetic Aperture Radar satellite (NISAR) is planned to be launched in 2022 on the ISRO's Geo Stationary Launch Vehicle (GSLV)-II for Earth resource monitoring, disaster planning, and infrastructure monitoring. The NISAR satellite is being built jointly by NASA's Jet Propulsion Laboratory (JPL) and ISRO. ISRO is designing the I-3K (I-3000) bus, which has been used on geostationary satellites previously. NISAR will carry the L-band and S-band polarimetric synthetic aperture radar sensors for collection of high-resolution SAR data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; km, kilometer; —, no data; H, horizontal; V, vertical]

Launch date	2022 (Planned)
Design lifetime	3 years
Platform owner	NASA/IRSO
Altitude	747 km
Orbit period	98.5 min
Inclination	98.4°
Crossing time	6:00 DN
Nadir repeat	12 days
Status	Development
System website	https://nisar.jpl.nasa.gov/



Artistic rendering of NISAR in orbit (image from NASA).

Sensor Information

	L-band	S-band
GSD (m)	3–48 (selectable)	3–24 (selectable)
Swath (km)	240 (selectable)	
Data portal	—	

L-band/S-band

The L-band SAR and S-band instruments aboard NISAR are new instruments designed and built by ISRO and JPL. The SAR systems employ an innovation called SweepSAR—developed jointly with the German Space Agency (DLR)—which allows the instruments to provide wide area coverage and fine spatial resolution at the same time. The L-band instrument operates at 1.257 gigahertz (GHz) (λ = 23.85 centimeters [cm]). The S-band instrument operates at 3.2 GHz (λ = 9.37 cm). The angle of incidence for both instruments is 33–47 degrees. Data will be freely available.

Beam mode	Polarization		Nominal swath width	Approximate resolution
S-band	Single	HH, VV	240 km	Azimuth: 7 m Slant range: 3–24m
	Dual	HH/HV, VV/VH		
	Compact	RH/RV		
	Quasi-Quad	HH/HV, VH/VV		
L-band	Single	HH, VV	240 km	Azimuth: 7 m Slant range: 3–48m
	Dual	HH/HV, VV/VH		
	Compact	RH/RV		
	Quad	HH/HV/VH/VV		

ÑuSat-1 to -8

Argentina
Commercial
Operational/Future

Platform Overview

The Aleph-1 constellation of ÑuSat satellites consists of multiresolution multispectral satellites for commercial Earth imaging. The first five satellites (ÑuSat-1 to -5) were launched between 2016 and early 2018. ÑuSat-7 and -8 were launched in January 2020. Ñusat-6 is planned for launch in March 2020.

The ÑuSat satellites are developed, built, and operated by Satellogic, headquartered in Buenos Aires, Argentina. The satellites carry the Panchromatic (Pan) and Multispectral Imager (MSI) for high-resolution land imaging and the Hyperspectral Imager (HIS) and Thermal Infrared Imager (TIR) for medium-resolution land imaging.

Artistic rendering of a ÑuSat in orbit (image from Satellogic, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared; Hyper, hyperspectral; TIR, thermal infrared]

	Ñ-1	Ñ-2	Ñ-3	Ñ-4	Ñ-5	Ñ-6	Ñ-7	Ñ-8
Launch date	05/30/2016		06/15/2017	02/02/2018		2020 (Planned)	01/15/2020	
Design lifetime	3 years							
Platform owner	Satellogic							
Altitude	500 km							
Orbit period	94.62 min							
Inclination	97.5°							
Crossing time	10:30 AN							
Nadir repeat	—							
Status	Operational							
System website	https://www.satellogic.com/							

Sensor Information

	Pan	MSI	HSI	TIR
GSD (m)	1	1	30	90
Swath (km)	5	5	150	92
Data portal	https://www.satellogic.com/data-streams			

JACIE

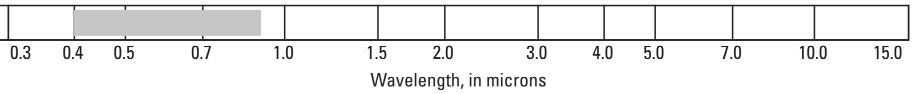
ÑuSat-1 to -8—Continued

Argentina
Commercial
Operational/Future

Pan

Pan data are commercially available from Satellogic.

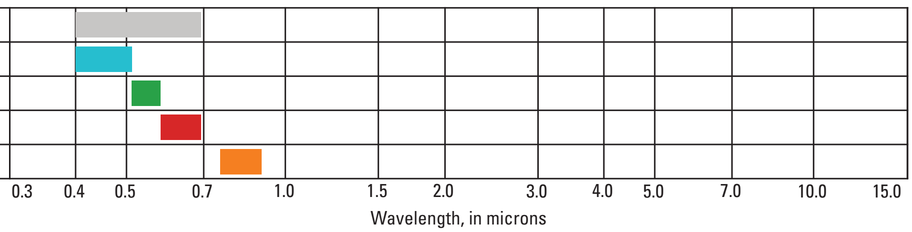
Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.650	0.900	1.00



MSI

MSI data are commercially available from Satellogic.

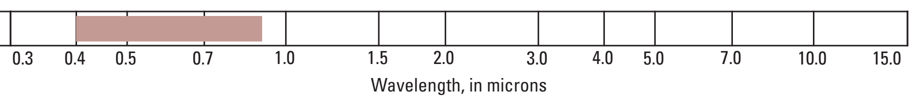
Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.545	0.690	1.00
Blue	0.400	0.455	0.510	1.00
Green	0.510	0.545	0.580	1.00
Red	0.580	0.635	0.690	1.00
NIR	0.750	0.825	0.900	1.00



HSI

HSI data are commercially available from Satellogic.

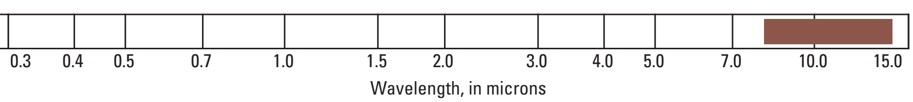
Band	Lower	Center	Upper	GSD (m)
Hyper	0.400	0.650	0.900	30.00



TIR

TIR data are commercially available from Satellogic.

Band	Lower	Center	Upper	GSD (m)
TIR	8.000	11.000	14.000	90.00



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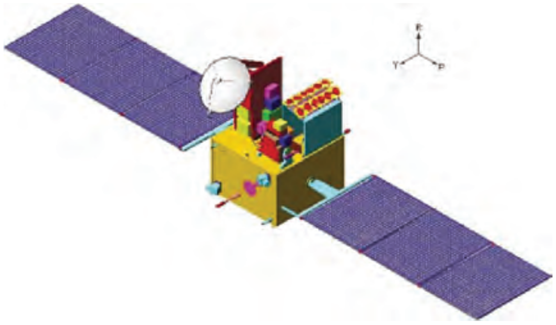
OceanSat-2

India
Civil/Government
Operational

Platform Overview

OceanSat-2 is a low-resolution multispectral satellite launched in 2009 on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center for ocean monitoring. This mission is a follow-on to OceanSat-1, which was launched in 1999. OceanSat-2 was designed and built by the Indian Space Research Organization (ISRO) and uses the proven Indian Remote-sensing Satellite bus. OceanSat-2 carries the Ocean Color Monitor–2 (OCM-2) sensor for low-resolution ocean imaging.



3-Dimensional model of OceanSat-2 (image from ISRO, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared]

Launch date	09/23/2009
Design lifetime	5 years
Platform owner	ISRO
Altitude	720 km
Orbit period	99.31 min
Inclination	98.28°
Crossing time	12:00 AN
Nadir repeat	2 days
Status	Operational
System website	https://www.isro.gov.in/Spacecraft/oceansat-2

OceanSat-2 image of the Irrawaddy River Delta, Bay of Bengal (image from ISRO, used with permission).

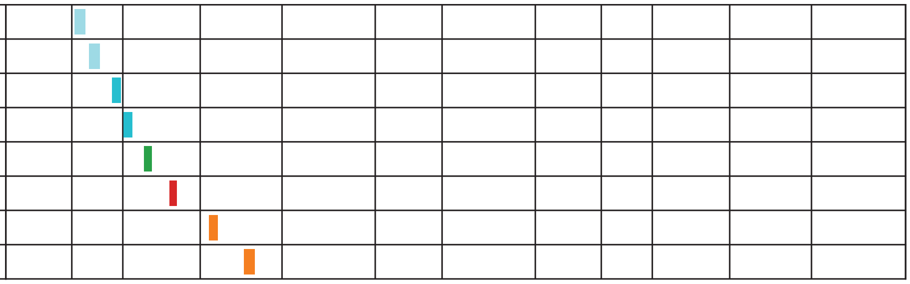
OCM-2

The OCM-2 sensor is a modestly improved version of the OCM sensor flown on OceanSat-1. OCM-2 is nearly identical to the original OCM sensor. One of the few changes is that bands 6 and 7 are slightly shifted. The ground sample distance and swath width remain the same as OCM. OCM-2 data are commercially available.

Sensor Information

	OCM-2
GSD (m)	360
Swath (km)	1,440
Data portal	http://uops.nrsc.gov.in:33333/ImgeosUops/FinalImgeosUops/FinalImgeosUops.html

Band	Lower	Center	Upper	GSD (m)
CA	0.404	0.414	0.424	360
CA	0.431	0.441	0.451	360
Blue	0.476	0.486	0.496	360
Blue	0.500	0.510	0.520	360
Green	0.546	0.556	0.566	360
Red	0.610	0.620	0.630	360
NIR	0.725	0.740	0.755	360
NIR	0.845	0.865	0.885	360



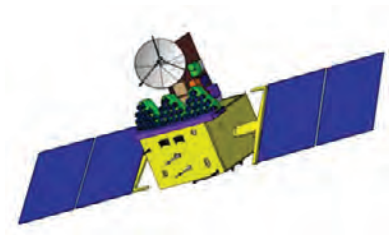
JACIE

OceanSat-3 and -3A

India
Civil/Government
Future

Platform Overview

OceanSat-3 and -3A are low-resolution multispectral satellites planned to be launched in 2020 and 2021, respectively, on Polar Satellite Launch Vehicles from the Satish Dhawan Space Center for ocean monitoring. OceanSat-3 and -3A are being designed and built by the Indian Space Research Organization (ISRO) and will use the proven Indian Remote-sensing Satellite bus. These missions will provide continuity for users of Ocean Color Monitor (OCM) data. OceanSat-3 and -3A also have an additional thermal sensor. The OceanSat series of satellites has been operational since the launch of OceanSat-1 in 1999. OceanSat-3 carries the OCM-3 sensor and the Sea Surface Temperature Monitor–1 (SSTM-1) sensor for low-resolution ocean imaging.



3-Dimensional model of OceanSat-3 (image from ISRO, used with permission).

[Abbreviations in tables: —, no data; GSD, ground sample distance; m, meter; km, kilometer; CA, coastal aerosol; NIR, near infrared; TIR, thermal infrared]

	OceanSat-3	OceanSat-3A
Launch date	2020 (Planned)	2021 (Planned)
Design lifetime	—	
Platform owner	ISRO	
Altitude	—	
Orbit period	—	
Inclination	—	
Crossing time	—	
Nadir repeat	—	
Status	—	
System website	—	

Sensor Information

	OCM-3	SSTM-1
GSD (m)	360	1,080
Swath (km)	1,400	
Data portal	https://www.isro.gov.in/Spacecraft/oceansat-2	

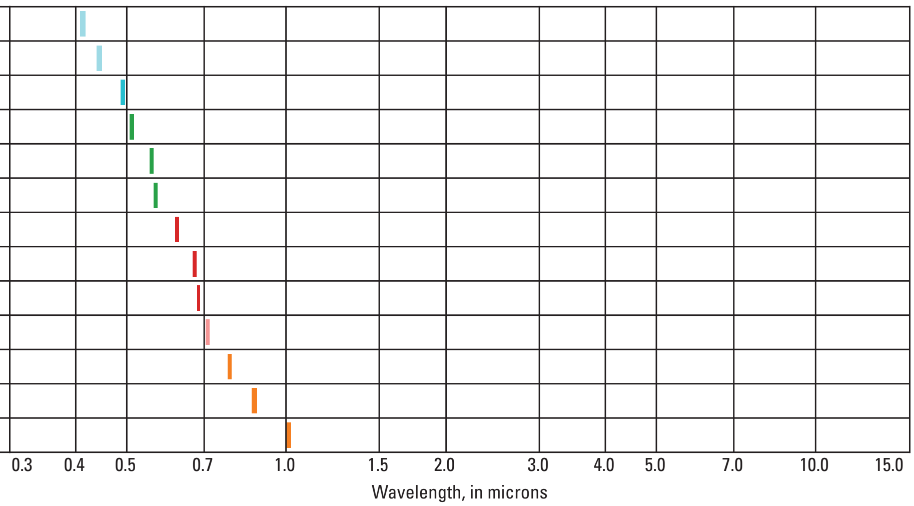
OceanSat-3 and -3A—Continued

India
Civil/Government
Future

OCM-3

The OCM-3 sensor is an improved version of the OCM-2 sensor flown on OceanSat-2. OCM-3 has five additional bands. The ground sample distance and swath width remain nearly the same as OCM-2. OCM-3 data will be commercially available.

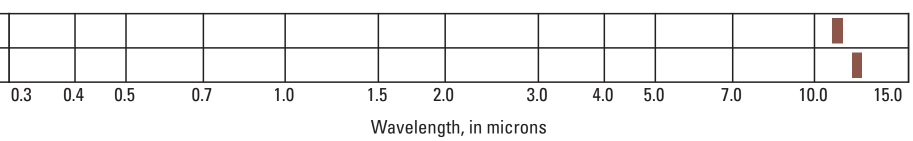
Band	Lower	Center	Upper	GSD (m)
CA	0.407	0.412	0.417	360
CA	0.438	0.443	0.448	360
Blue	0.485	0.490	0.495	360
Green	0.505	0.510	0.515	360
Green	0.550	0.555	0.560	360
Green	0.561	0.566	0.571	360
Red	0.615	0.620	0.625	360
Red	0.665	0.670	0.675	360
Red	0.677	0.681	0.685	360
Red Edge	0.705	0.710	0.715	360
NIR	0.775	0.780	0.785	360
NIR	0.860	0.870	0.880	360
NIR	1.000	1.010	1.020	360



SSTM-1

The SSTM-1 sensor is a new sensor introduced to the OceanSat series of satellites. SSTM-1 adds two thermal bands to OceanSat-3's capabilities. SSTM-1 data will be commercially available.

Band	Lower	Center	Upper	GSD (m)
TIR-1	10.750	11.000	11.250	1,080
TIR-2	11.750	12.000	12.250	1,080



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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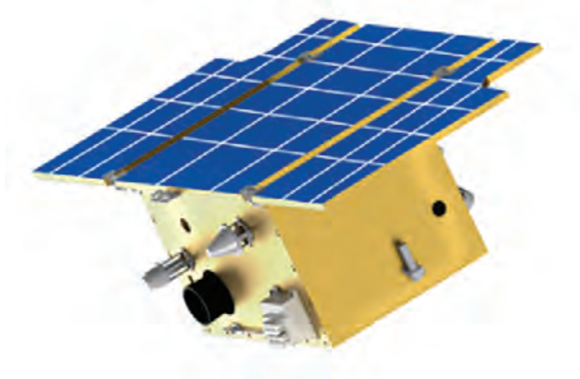
Orbita Hyperspectral Satellite

China
Commercial
Operational

Platform Overview

Orbita Hyperspectral Satellites (OHSs) are high-resolution hyperspectral satellites developed by the Chinese commercial company, Zhuhai Orbita Aerospace Science and Technology Company, Ltd. (also called “Orbita”). In 2018 and 2019, 2 batches of 4 satellites (OHS-2A/B/C/D and OHS-3A/B/C/D) were launched on a Long March-11 rocket from the Jiuquan Satellite Launch Center. They carry a hyperspectral sensor for imaging the Earth in visible and near-infrared (VNIR) parts of the spectrum.

OHS satellites are a part of the 34-satellite Zhuhai-1 constellation planned by Orbita to include video, synthetic aperture radar, and infrared satellites. At the end of 2019, 12 satellites were launched in the Zhuhai-1 constellation.



A model of hyperspectral nanosatellite in the Zhuhai-1 constellation (image from Orbita).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

	OHS-2A/B/C/D	OHS-3A/B/C/D
Launch date	04/26/2018	09/19/2019
Design lifetime	2 years	
Platform owner	Orbita	
Altitude	500 km	
Orbit period	94.6 min	
Inclination	97.4°	
Crossing time	11:30 DN	
Nadir repeat	—	
Status	Operational	
System website	https://www.myorbita.net/	

Sensor Information

	Hyperspectral sensor
GSD (m)	10
Swath (km)	150
Data portal	https://apollomapping.com

Orbita Hyperspectral Satellite—Continued

China
Commercial
Operational

Hyperspectral Sensor

The sensor on OHS satellites operates in 32 spectral bands in VNIR parts of the spectrum. The sensor can acquire hyperspectral images with an off-nadir capability of 30 degrees.

Band	Lower	Center	Upper	GSD (m)
Blue-1	0.463	0.466	0.468	10
Blue-2	0.477	0.479	0.481	10
Blue-3	0.497	0.500	0.502	10
Blue-4	0.517	0.520	0.522	10
Green-1	0.534	0.536	0.538	10
Green-2	0.547	0.550	0.552	10
Green-3	0.563	0.565	0.567	10
Green-4	0.578	0.580	0.582	10
Green-5	0.593	0.596	0.598	10
Red-1	0.607	0.609	0.611	10
Red-2	0.623	0.625	0.627	10
Red-3	0.637	0.640	0.642	10
Red-4	0.653	0.656	0.658	10
Red-5	0.668	0.670	0.672	10
RedEdge-1	0.683	0.685	0.687	10
RedEdge-2	0.697	0.700	0.702	10
RedEdge-3	0.713	0.716	0.718	10
RedEdge-4	0.727	0.730	0.732	10
NIR-1	0.743	0.746	0.749	10
NIR-2	0.756	0.759	0.762	10
NIR-3	0.773	0.776	0.779	10
NIR-4	0.780	0.787	0.794	10
NIR-5	0.802	0.805	0.808	10
NIR-6	0.816	0.819	0.822	10
NIR-7	0.832	0.836	0.840	10
NIR-8	0.845	0.848	0.851	10
NIR-9	0.863	0.865	0.867	10
NIR-10	0.877	0.880	0.882	10
NIR-11	0.894	0.897	0.899	10
NIR-12	0.907	0.910	0.912	10
NIR-13	0.923	0.926	0.928	10
NIR-14	0.938	0.940	0.942	10

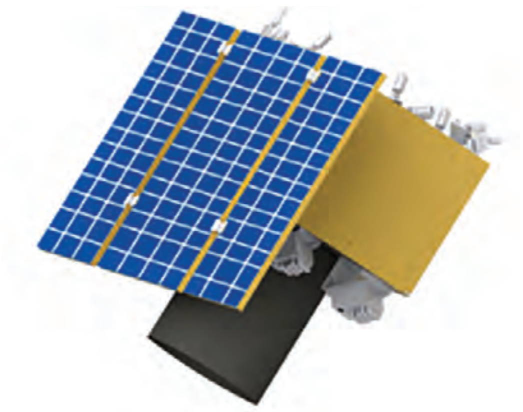
Orbita Video Satellite

China
Commercial
Operational

Platform Overview

Orbita Video Satellites (OVS) are high-resolution video satellites developed by the Chinese commercial company, Zhuhai Orbita Aerospace Science and Technology Company, Ltd. (also called "Orbita"). OVS-1A/1B, OVS-2A, and OVS-3A were launched in 2017, 2018, and 2019, respectively, on Long March rockets from the Jiuquan Satellite Launch Center. They carry a video camera for capturing high-definition videos of the Earth.

OVS satellites are a part of the 34-satellite Zhuhai-1 constellation planned by Orbita to include hyperspectral, synthetic aperture radar, and infrared satellites. At the end of 2019, 12 satellites were launched in the Zhuhai-1 constellation.



A model of the Zhuhai-1 Orbita Video Satellite (image from Orbita).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

	OVS-1A/1B	OVS-2A	OVS-3A
Launch date	06/15/2017	04/26/2018	09/19/2019
Design lifetime	5+ years		
Platform owner	Orbita		
Altitude	530 km	500 km	
Orbit period	95.23 min	94.6 min	
Inclination	43°	97.4°	
Crossing time	—	—	—
Nadir repeat	—	—	—
Status	Operational		
System website	https://myorbita.net		

Sensor Information

	OVS-1 video camera	OVS-2A/3A video camera
GSD (m)	1.98	0.9
Swath (km)	8	22.5
Data portal	https://myorbita.net	

PACE

United States
Civil/Government
Future

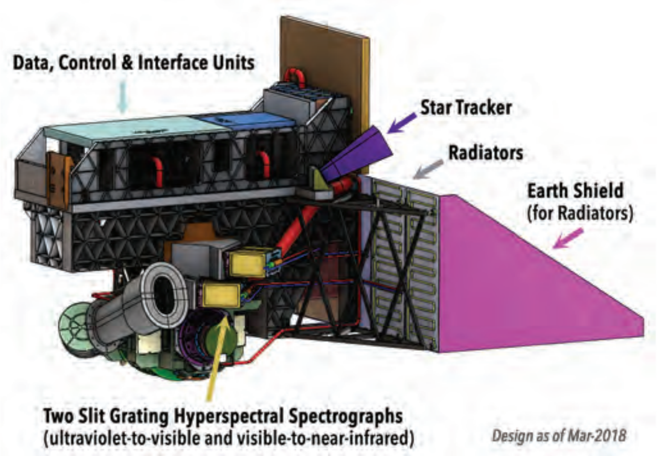
Platform Overview

The Plankton, Aerosol, Cloud, ocean Ecosystem satellite (PACE) is a low-resolution, wide swath hyperspectral satellite planned to be launched in 2022 for measuring atmospheric and hydrologic characteristics. PACE will extend and improve the National Aeronautics and Space Administration's (NASA's) satellite observation records of global ocean biogeochemistry, aerosols, and clouds. PACE is being developed by NASA's Goddard Space Flight Center and will carry the hyperspectral Ocean Color Instrument (OCI) optical spectrometer sensor for low-resolution imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data; UV, ultraviolet; CA, coastal aerosol; NIR, near infrared; SWIR, short wave infrared]

Launch date	2022 (Planned)
Design lifetime	3 years
Platform owner	NASA
Altitude	676.5 km
Orbit period	98 min
Inclination	98°
Crossing time	13:00 AN
Nadir repeat	2 days
Status	Development
System website	https://pace.oceansciences.org/

Artistic rendering of The Plankton, Aerosol, Cloud, ocean Ecosystem satellite (PACE) in orbit (image from NASA).



Artistic rendering of the Ocean Color Instrument (OCI) (image from NASA).

Sensor Information

	OCI
GSD (m)	1,000, 4,000
Swath (km)	2,000
Data portal	—

JACIE

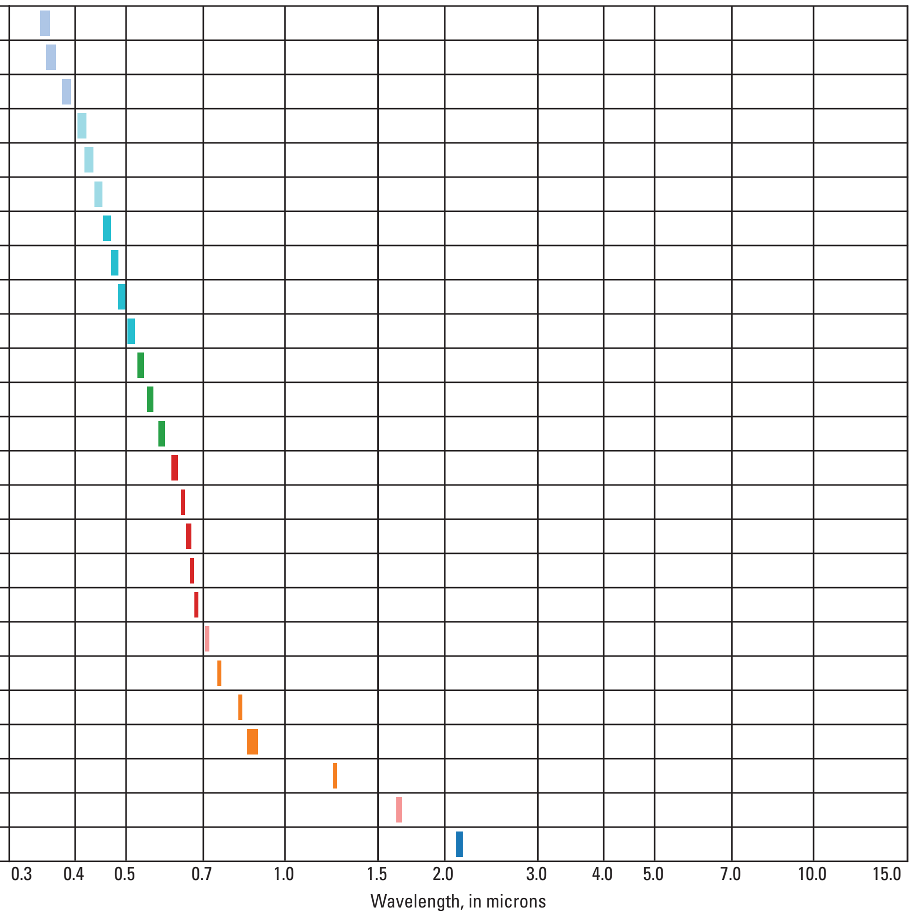
PACE—Continued

United States
Civil/Government
Future

OCI

The OCI aboard PACE was built by Goddard Space Flight center based on a long heritage of NASA technology development and flight programs. The OCI takes advantage of advancements made developing previous instruments such as ORCA, CZCS, SeaWiFS, VIIRS, and MODIS. The satellite also uses a polarimeter for calibration. OCI data will be freely available.

Band	Lower	Center	Upper	GSD (m)
UV	0.343	0.350	0.358	1,000
UV	0.353	0.360	0.368	1,000
UV	0.378	0.385	0.393	1,000
CA	0.405	0.412	0.420	1,000
CA	0.418	0.425	0.433	1,000
CA	0.436	0.443	0.451	1,000
Blue	0.453	0.460	0.468	1,000
Blue	0.468	0.475	0.483	1,000
Blue	0.483	0.490	0.498	1,000
Blue	0.503	0.510	0.518	1,000
Green	0.525	0.532	0.540	1,000
Green	0.548	0.555	0.563	1,000
Green	0.576	0.583	0.591	1,000
Red	0.610	0.617	0.625	1,000
Red	0.635	0.640	0.645	1,000
Red	0.648	0.655	0.663	1,000
Red	0.660	0.665	0.670	1,000
Red	0.673	0.678	0.683	4000
Red Edge	0.703	0.710	0.718	1,000
NIR	0.743	0.748	0.753	1,000
NIR	0.813	0.820	0.828	1,000
NIR	0.845	0.865	0.885	1,000
NIR	1.230	1.240	1.250	1,000
SWIR 1	1.620	1.640	1.660	1,000
SWIR 2	2.105	2.130	2.155	1,000



PeruSat-1

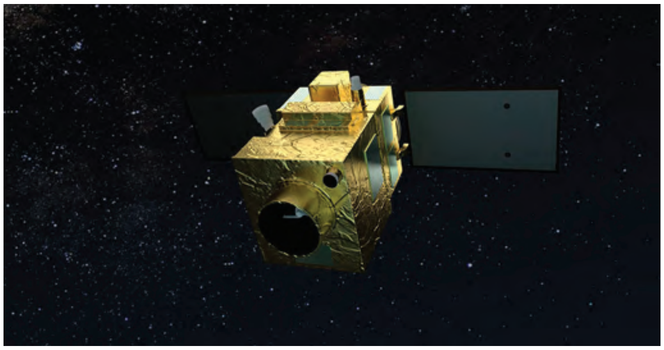
Peru
Civil/Government
Operational

Platform Overview

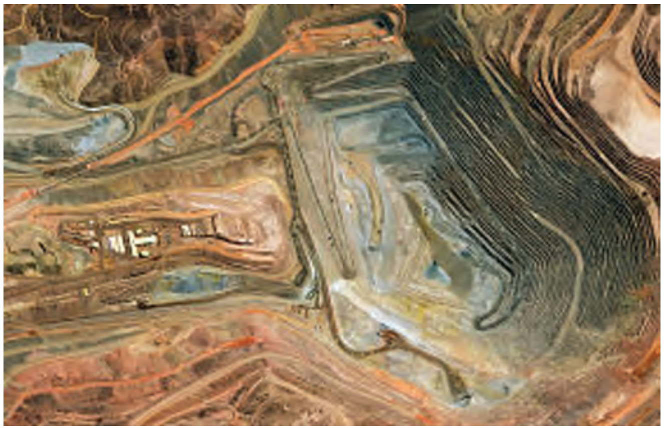
PeruSat-1 is a high-resolution multispectral satellite launched in 2016 by the Peruvian Space Agency (CONIDA) on a Vega launcher from Kourou, French Guiana, for Earth resources monitoring. The PeruSat-1 satellite was designed and built by Airbus Defence and Space and uses the Astro-Bus-S satellite bus, a smaller version of the Astrobus-5000. PeruSat-1 carries the New AstroSat Optical Modular Instrument (NAOMI) sensor for civil and military applications.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	09/16/2016
Design lifetime	10 years
Platform owner	CONIDA
Altitude	695 km
Orbit period	98.64 min
Inclination	98.3°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	https://www.airbus.com/space/earth-observation/perusat.html



Artistic rendering of PeruSat-1 (image from Airbus DS, used with permission).



PeruSat-1 image of Cuajone, a large copper mine in Peru (image from Airbus DS, used with permission).

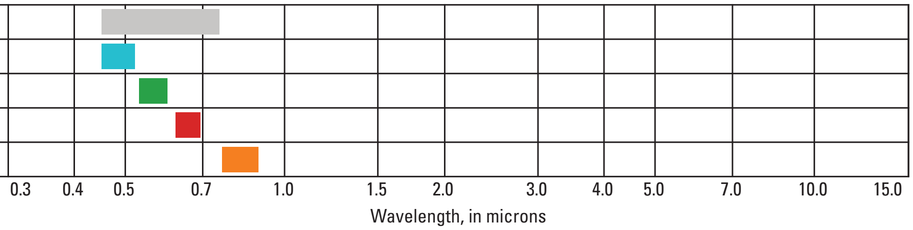
Sensor Information

	NAOMI
GSD (m)	0.7, 2
Swath (km)	60
Data portal	—

NAOMI

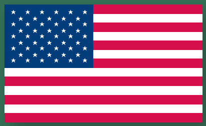
The NAOMI sensor is a proven design from Airbus used on the Alsat-2, SPOT-6, SPOT-7, and VNREDSat-1A satellites. This sensor provides an improved resolution of 0.7 meter in panchromatic and 2 m in visible and near-infrared bands. The swath width and operational capability remain the same as the previous versions of the sensor.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.600	0.750	0.7
Blue	0.450	0.485	0.520	2
Green	0.530	0.565	0.600	2
Red	0.620	0.655	0.690	2
NIR	0.760	0.825	0.890	2



Planet's Mission-1

United States
Commercial
Operational



Platform Overview

Mission-1 is a high-resolution multisatellite constellation built, launched, and operated by Planet for Earth observation. Dove-1 and -2 were launched in 2013 as technology demonstration satellites followed by the Flocks. Flocks 1a, 1b, 1c, 1d, 1d', 2e, and 2e' (about 115 satellites) were launched into an orbit similar to ISS (nonoperational currently), whereas Flocks 2p, 3p, 3m, 2k, and Dove Pioneer (about 180 satellites) were launched into an SSO orbit. The operational Flock satellites carry multispectral imagers that together can image the Earth daily in the visable and near-infrared parts of the spectrum.

Flock satellite (image from Planet Labs Inc., used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

Constellation	Flock-2p	Flock-3p	Flock-3m	Flock-2k	Flock-3p′	Dove Pioneer	Flock-3r	Flock-3s	Flock-3k
Number	12	88	4	48	4	1	16	3	12
Launch date	06/22/2016	02/15/2017	10/31/2017	07/14/2017	01/12/2018	01/21/2018	11/29/2018	12/03/2018	12/27/2018
Design lifetime	3 year	3 year	3 years	3 years	3 years	3 years	3 years	3 years	3 years
Platform owner	Planet								
Altitude	475 km								
Orbit period	94.1 min								
Inclination	97.3°								
Crossing time	10:30 DN								
Nadir repeat	—								
Status	Operational								
System website	https://www.planet.com								

Sensor Information

	PS-1	PS-2
GSD (m)	2.7	4
Swath (km)	20	24
Data portal	https://www.planet.com/products/planet-imagery/	

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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eccoe@usgs.gov

Planet's Mission-1—Continued

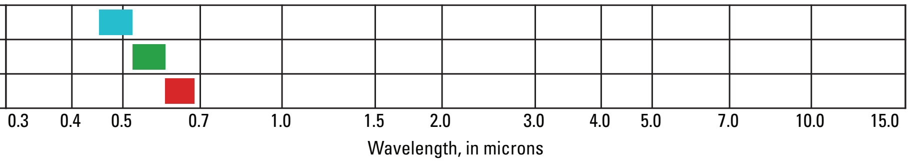
United States
Commercial
Operational

Planet Scope-1

The Planet Scope-1 (PS-1) is a three-band multispectral imager used on early Flock satellites (1a–1e). PS-1 images the Earth in the visible spectrum, providing imagery daily at a ground sample distance (GSD) of 2.7 meters (m). Data are available to customers by way of Planet's commercial portal.

Image of Pamplona, Spain, by Dove satellite. (image from Planet Labs Inc., used with permission).

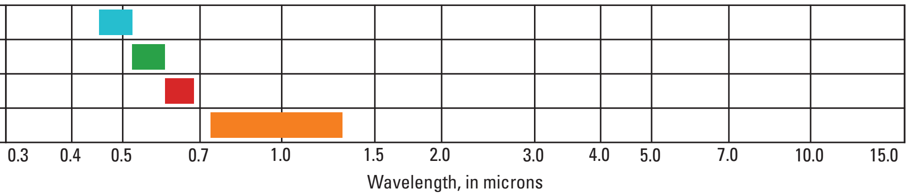
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	2.7
Green	0.520	0.560	0.600	2.7
Red	0.600	0.640	0.680	2.7



Planet Scope-2

The Planet Scope-2 (PS-2) is an improved version of the PS-1 carried by second generation flock satellites (2e–2k). PS-2 images the Earth in four bands (3 visible, 1 near infrared) providing imagery daily at a GSD of 4 m. Data are available to customers by way of Planet's commercial portal.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	4
Green	0.520	0.560	0.600	4
Red	0.600	0.640	0.680	4
NIR	0.730	1.015	1.300	4



Pleiades-HR (1A and 1B)

France
Civil/Government
Operational

JACIE

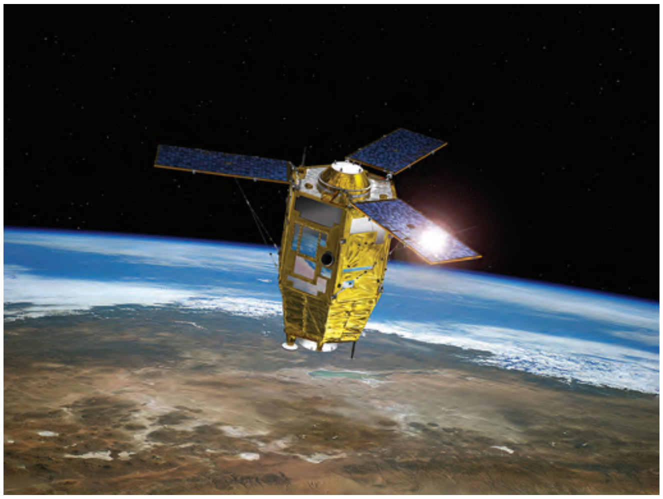
Platform Overview

The Pleiades-HR constellation of high-resolution multispectral satellites consists of Pleiades-1A and Pleiades-1B launched in 2011 and 2012, respectively, by the French National Centre for Space Studies (CNES) on Soyuz ST launchers from Kourou, French Guiana, for intelligence and Earth resources monitoring. This mission is completely funded by CNES and has been in continual operation since 2011.

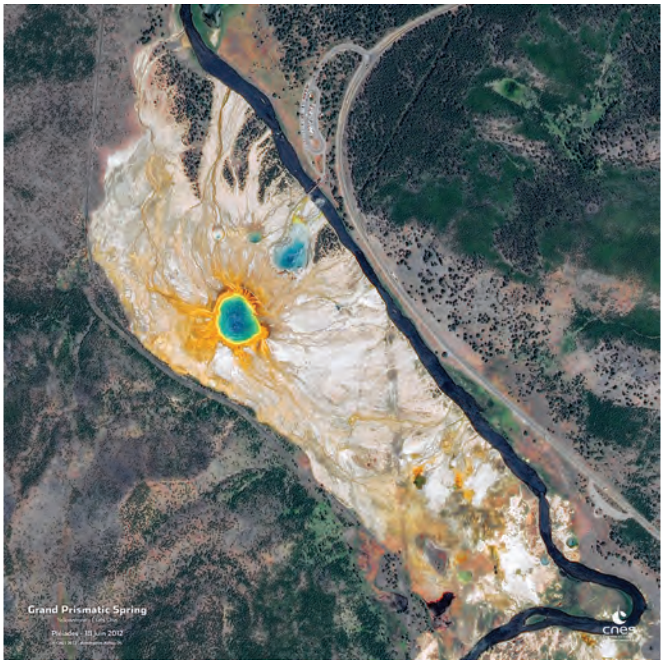
The Pleiades-HR series of satellites were designed and built by Airbus for CNES and use the Astrosat-1000 bus and a High-Resolution Imager (HiRI). Imagery in visible and near infrared is gathered for civil and military applications.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

	Pleiades-1A	Pleiades-1B
Launch date	12/17/2011	12/01/2012
Design lifetime	5 years	
Platform owner	CNES	
Altitude	694 km	
Orbit period	98.6 min	
Inclination	98.2°	
Crossing time	10:30 DN	
Nadir repeat	26 days	
Status	Operational	
System website	https://pleiades.cnes.fr/en/PLEIADES/index.htm	



Artistic rendering of Pleiades-1A in orbit (image from CNES/ill/DUCROS David, 2018, used with permission).



Grand Prismatic Spring in Yellowstone National Park (image from CNES/Distribution Airbus DS, 2012, used with permission).

Sensor Information

	HiRI
GSD (m)	0.7,2.8
Swath (km)	20
Data portal	https://www.intelligence-airbusds.com/pleiades/

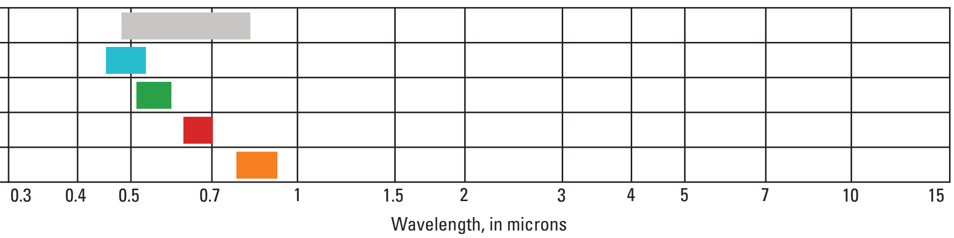
Pleiades-HR (1A and 1B)—Continued

France
Civil/Government
Operational

HiRI

The HiRI sensor aboard the Pleiades-HR (1A and 1B) satellites is a design from Thales Alenia Space-France (TAS-F). The GSD of 2.8 meters (m) in visible and near infrared and 0.7 m in Pan with a swath width of 20 kilometers is provided on a global and targeted basis. Data are available to customers through Airbus's commercial portal.

Band	Lower	Center	Upper	GSD (m)
Pan	0.480	0.650	0.820	0.7
Blue	0.450	0.490	0.530	2.8
Green	0.510	0.550	0.590	2.8
Red	0.620	0.660	0.700	2.8
NIR	0.775	0.845	0.915	2.8



JACIE

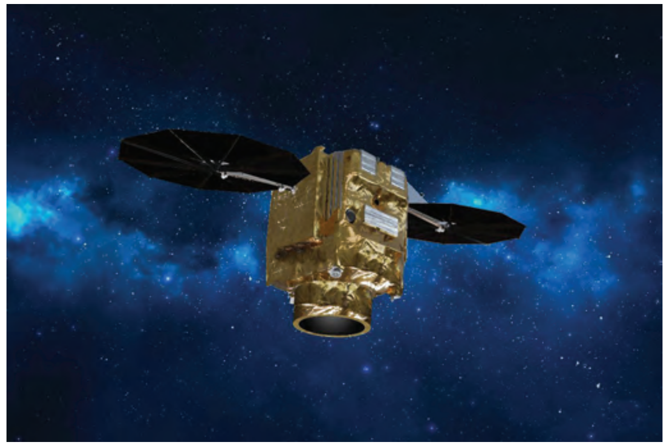
Pleiades-NEO

France
Commercial
Future

Platform Overview

Pleiades-Neo is a high-resolution four-satellite constellation being developed by Airbus Defence and Space (Airbus DS) as a follow-on to the currently operational Pleiades-HR satellites. The satellites are planned to launch in pairs of two in 2020 and 2021 on Vega-C rockets.

The Pleiades-Neo satellites will operate in two orbital planes at an altitude of 620 kilometers to allow intraday revisit times. They will carry a high-resolution multispectral imager for Earth imaging.



Artistic rendering of the Pleiades-Neo satellite (image from Airbus DS, used with permission).

[Abbreviations in tables: km, kilometer; —, no data; DN, descending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared]

	Pleiades-Neo 1 and 2	Pleiades-Neo 3 and 4
Launch date	2020	2021
Design lifetime	10 years	
Platform owner	Airbus DS	
Altitude	620 km	
Orbit period	—	
Inclination	—	
Crossing time	10:30 DN	
Nadir repeat	30 days	
Status	Development	
System website	https://www.intelligence-airbusds.com/en/8671-pleiades-neo-trusted-intelligence	

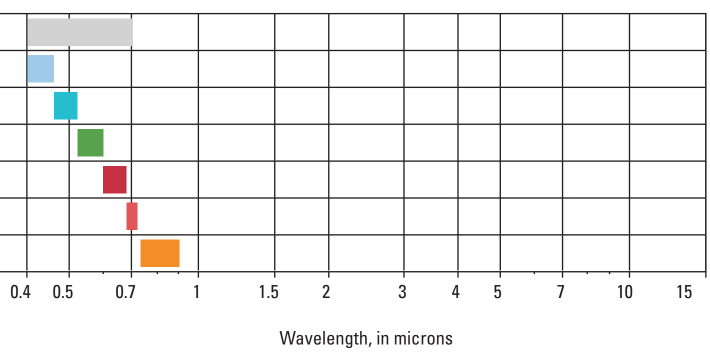
Sensor Information

	HR sensor
GSD (m)	0.3
Swath (km)	14
Revisit (days)	1
Data portal	—

HR sensor

The high-resolution (HR) sensor on Pleiades-Neo satellites collects Earth data in the visible and near-infrared region with six bands and a panchromatic band. The satellites can operate off nadir to achieve a revisit of less than 1 day.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.400	0.550	0.700	0.3
CA	0.400	0.430	0.460	0.3
Blue	0.460	0.490	0.520	0.3
Green	0.520	0.560	0.600	0.3
Red	0.600	0.640	0.680	0.3
Red Edge	0.680	0.700	0.720	0.3
NIR	0.730	0.815	0.900	0.3



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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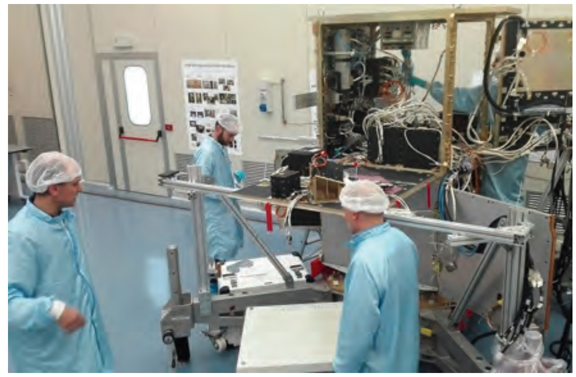
PRISMA

Italy
Civil/Government
Operational

Platform Overview

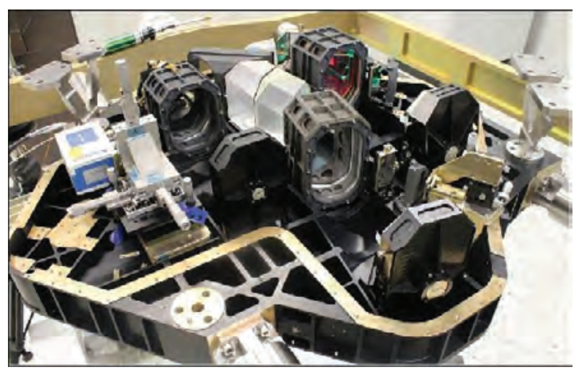
The Hyperspectral Precursor of the Application Mission (PRISMA) is a medium-resolution hyperspectral satellite launched March 2019 by the Italian Space Agency (ASI) on a Vega launcher for environmental monitoring. PRISMA was developed at Carlo Gavazzi Space of Milan, Italy. The satellite is based on a minisatellite bus of MITA heritage. PRISMA carries a hyperspectral sensor for medium-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic; Hyper, hyperspectral]



PRISMA satellite in development (image from ASI, used with permission).

Launch date	03/21/2019
Design lifetime	5 years
Platform owner	ASI
Altitude	615 km
Orbit period	97 min
Inclination	97.84°
Crossing time	10:30 DN
Nadir repeat	29 days
Status	Operational
System website	http://prisma-i.it/



Prototype model of the PRISMA sensor (image from ASI, used with permission).

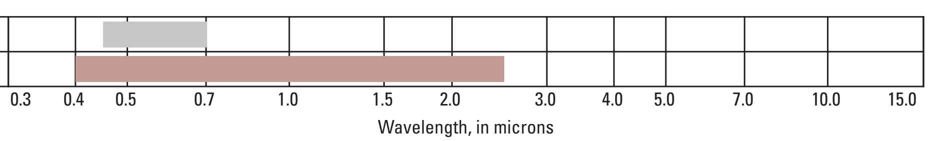
Sensor Information

	PRISMA
GSD (m)	5, 30
Swath (km)	30
Data portal	https://prismauserregistration.asi.it/

PRISMA

The hyperspectral sensor is primarily being developed by Selex ES of Campi Bisenzio, Italy. The imager has approximately 250 bands. The instrument is based on the prism spectrometer concept.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.575	0.700	5
Hyper	0.400	1.450	2.500	30

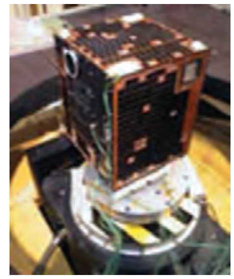


PROBA-1

European Space Agency
Civil/Government
Operational

Platform Overview

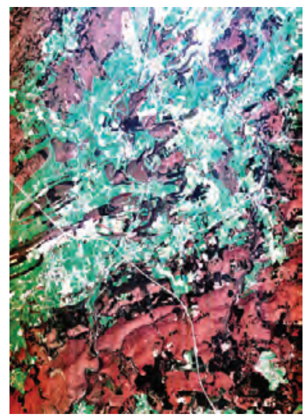
Project for On-Board Autonomy-1 (PROBA-1) is a medium-resolution hyperspectral satellite launched by the European Space Agency (ESA) in 2001 on a Polar Satellite Launch Vehicle (PSLV) for technology demonstration and Earth observation. This is the first satellite in the PROBA series manufactured by Verhaert Space NV along with 18 other contractors. Proba-1 was followed by Proba-2 and Proba-V, currently in operation. Proba-3 is under development. Proba-1 carries the Compact High-Resolution Imaging Spectrometer (CHRIS) for medium-resolution hyperspectral imaging. According to ESA, Proba-1 is currently drifting from its 10:30 a.m. orbit.



Proba-1 during vibration tests (image from ESA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Hyper, hyperspectral]

Launch date	10/22/2001
Design lifetime	1 year
Platform owner	ESA
Altitude	621 km
Orbit period	96.97 min
Inclination	97.9°
Crossing time	7:30 DN
Nadir repeat	7 days
Status	Operational
System website	http://www.esa.int/Our_Activities/Observing_the_Earth/Proba-1/Overview



CHRIS's image of Ardennes, Belgium (image from ESA).

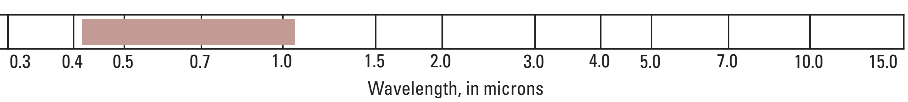
Sensor Information

	CHRIS
GSD (m)	18
Swath (km)	14
Data portal	https://earth.esa.int/web/guest/-/proba-chris-level-1a-1488

CHRIS

The CHRIS instrument is a hyperspectral sensor designed to image the Earth in 19 visible and near-infrared bands at a ground sample distance (GSD) of 18 meters (m). CHRIS can be reconfigured to provide 63 bands at a GSD of 34 m and 150 bands at a lower GSD. Data are available for free at https://earth.esa.int/web/guest/-/proba-chris-level-1a-1488.

Band	Lower	Center	Upper	GSD (m)
Hyper	0.415	0.733	1.050	18



JACIE

PROBA-V

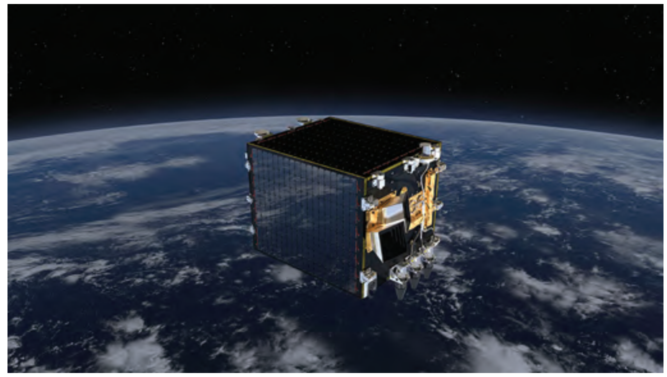
European Space Agency
Civil/Government
Operational

Platform Overview

Project for On-Board Autonomy-V (PROBA-V) is a medium-resolution multispectral satellite launched by the European Space Agency (ESA) in 2013 on a Vega launcher for Earth observation. This is the third satellite in the PROBA series manufactured by QinetiQ Space Belgium. Proba-V will be followed by Proba-3. Proba-V carries a Vegetation Instrument (VI) for low-resolution vegetation monitoring.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared]

Launch date	05/07/2013
Design lifetime	2.5 years
Platform owner	ESA
Altitude	820 km
Orbit period	101 min
Inclination	98.73°
Crossing time	11:00 DN
Nadir repeat	—
Status	Operational
System website	https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/proba-v



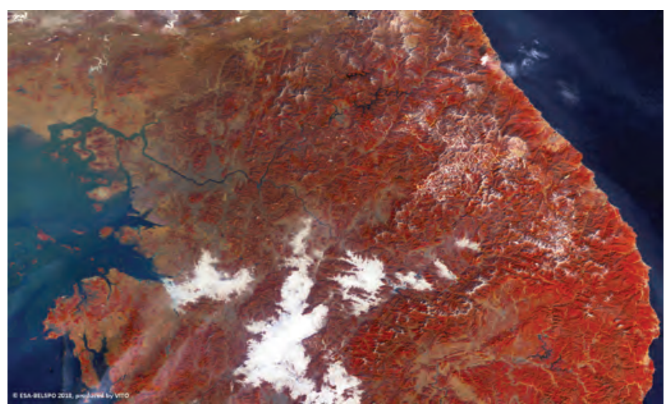
Artistic rendering of Proba-V satellite in orbit (image from ESA).

Sensor Information

	VI
GSD (m)	100
Swath (km)	2,250
Data portal	http://proba-v.vgt.vito.be/en/product-access

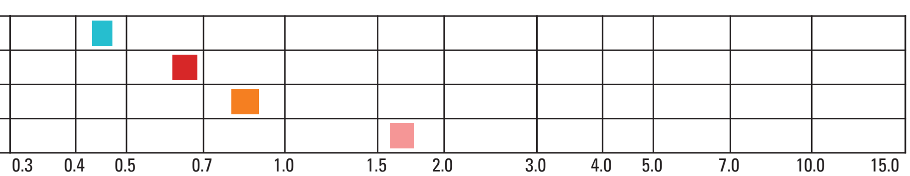
VI

The VI sensor on PROBA-V is intended to extend the dataset of the SPOT-4 and -5 instruments. With a swath width of 2,250 kilometers, VI images the Earth in visible, near-infrared, and shortwave infrared wavelengths providing a ground sample distance of 100 meters. Data are available for free.



Proba-V image of South Korea (ESA; image from ESA).

Band	Lower	Center	Upper	GSD (m)
Blue	0.430	0.450	0.470	100
Red	0.610	0.645	0.680	100
NIR	0.790	0.840	0.890	100
SWIR 1	1.580	1.665	1.750	300



QPS-SAR

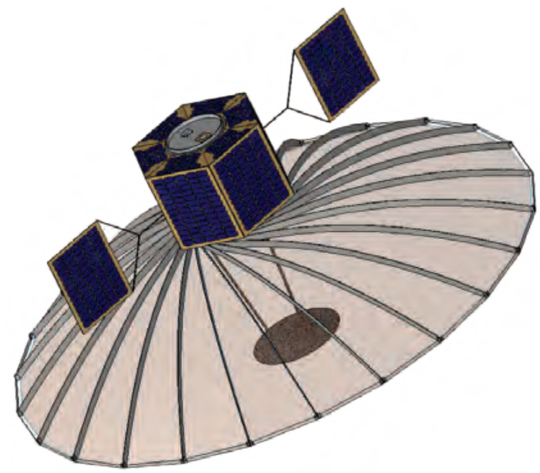
Japan
Commercial
Operational/Future

Platform Overview

QPS Synthetic Aperture Radar (QPS-SAR) is a high-resolution radar constellation developed by QPS Laboratory, Inc., (iQPS) of Japan. The first satellite in the constellation, Izanagi (QPS-SAR 1), was launched on India's Polar Satellite Launch Vehicle in 2019. The QPS-SAR constellation is planned to have 36 satellites to provide high revisits of any region on Earth. Izanami (QPS-SAR 2) is planned for launch in 2020. The satellites carry a SAR.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

Launch date	12/11/2019
Design lifetime	—
Platform owner	iQPS
Altitude	578 km
Orbit period	96.1 min
Inclination	37°
Crossing time	—
Nadir repeat	—
Status	Operational
System website	https://i-qps.net/



A model of the QPS-SAR satellite (image from iQPS).

SAR

Detailed information not yet available.

RADARSAT Constellation Mission

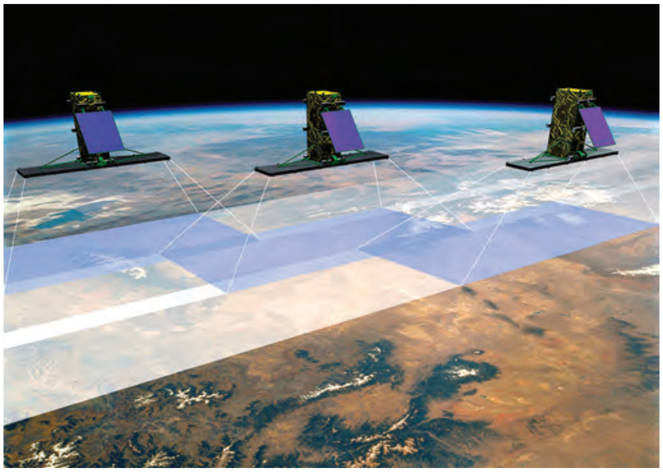
Canada
Civil/Government
Operational

Platform Overview

The RADARSAT Constellation Mission (RCM) consists of three small high-resolution synthetic aperture radar (SAR) satellites launched in 2019 by the Canadian Space Agency (CSA) and MDA for Earth observation. The RCM satellites operate in tandem with RADARSAT-2, significantly improving revisit. The RCM satellite bus is based on the Magellan MAC-200 bus designed by Bristol Aerospace. The bus is also referred to as the Canadian Smallsat Bus. The RCM satellites carry the SAR sensor for high-resolution SAR data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; m, meter; —, no data; H, horizontal; V, vertical]

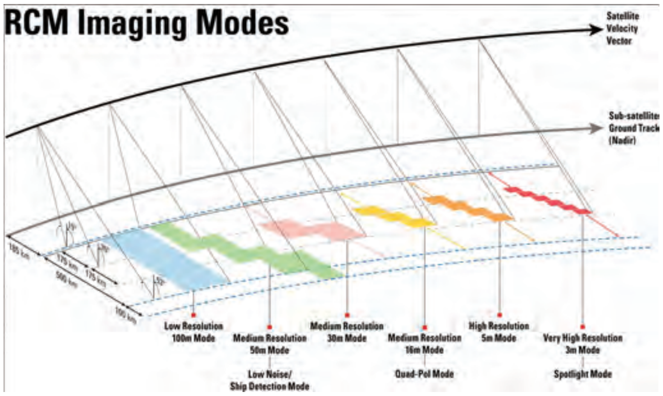
Launch date	06/12/2019
Design lifetime	7 years
Platform owner	CSA/MDA
Altitude	600 km
Orbit period	96.4 min
Inclination	97.74°
Crossing time	6:00 DN
Nadir repeat	12 days
Status	Operational
System website	http://www.asc-csa.gc.ca/eng/satellites/radarsat/default.asp



Artistic rendering of RADARSAT Constellation Mission satellites in orbit (image from MDA/NASA, used with permission).

Sensor Information

	SAR
Resolution (m)	1–100 (selectable)
Swath (km)	14–500 (selectable)
Data portal	—



RADARSAT Constellation imaging modes (image from CSA).

JACIE

RADARSAT Constellation Mission—Continued

Canada
Civil/Government
Operational

SAR

The SAR instrument aboard the RCM satellites is derived from RADARSAT-2's SAR instrument. The ground sample distance will be the same, and the size of the antenna will be decreased. The SAR instrument operates in the C-band at 5.405 gigahertz (λ = 5.5 centimeters). The angle of incidence is 19–53 degrees. SAR data are available through MDA.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Low Resolution	Single Dual	HH, VV, HV, VH	500	100 x 100
		HH/HV, VV/VH, HH/VV, Compact		
Medium Resolution 50 m	Single	HH, VV, HV, VH	350	50 x 50
	Dual	HH/HV, VV/VH, HH/VV, Compact		
Medium Resolution 30 m	Single	HH, VV, HV, VH	125	30 x 30
	Dual	HH/HV, VV/VH, HH/VV, Compact		
Medium Resolution 16 m	Single	HH, VV, HV, VH	30	16 x 16
	Dual	HH/HV, VV/VH, HH/VV, Compact		
High Resolution	Single	HH, VV, HV, VH	30	5 x 5
	Dual	HH/HV, VV/VH, HH/VV, Compact		
Very High Resolution 3 m	Single	HH, VV, HV, VH	20	3 x 3
	Dual	HH/HV, VV/VH, HH/VV, Compact		
Low Noise	Single	HH, VV, HV, VH	350	100 x 100
	Dual	HH/HV, VV/VH, Compact		
Ship Detection	Single	HH, VV, HV, VH	350	Variable
	Dual	HH/HV, VV/VH, Compact		
Spotlight	Single	HH, VV, HV, VH	14 [5 km in azimuth]	1 x 3
	Dual	HH/HV, VV/VH, Compact		
Quad-Polarization	Quad	HH/HV/VH/VV	20	9 x 9

RADARSAT-2

Canada
Civil/Government
Operational

Platform Overview

RADARSAT-2 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2007 on a Soyuz launch vehicle by the Canadian Space Agency (CSA) for Earth observation. RADARSAT-2 operated in tandem with RADARSAT-1 (before RADARSAT-1's retirement). RADARSAT-2 was designed and built by MDA. Alenia Spazio was subcontracted to build the bus, which was designed on PRIMA, a bus originally designed for the Italian Space Agency. RADARSAT-2 carries the SAR instrument for high-resolution SAR data.

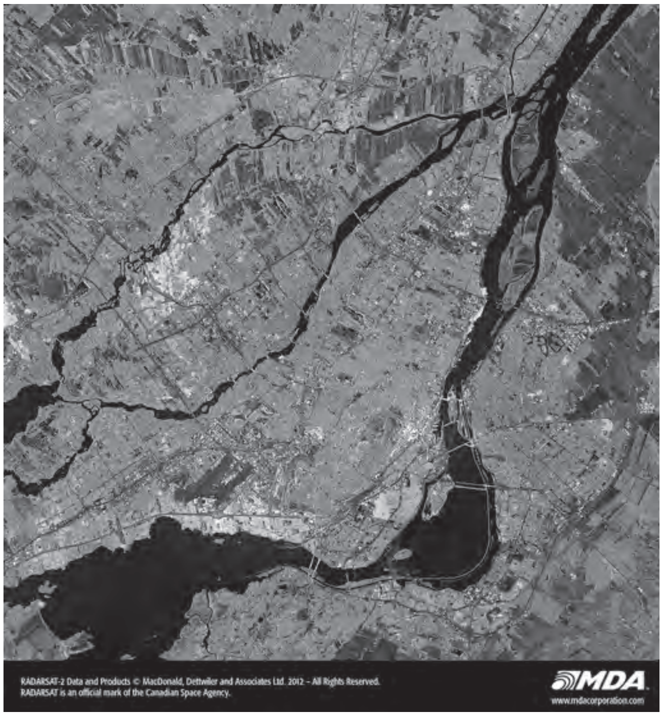
[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

Launch date	12/14/2007
Design lifetime	7 years
Platform owner	CSA/MDA
Altitude	798 km
Orbit period	100.7 min
Inclination	98.6°
Crossing time	6:00 DN
Nadir repeat	24 days
Status	Operational
System website	http://www.asc-csa.gc.ca/eng/satellites/radarsat2/default.asp

Artistic rendering of RADARSAT-2 in orbit (image from MDA/NASA, used with permission).

Sensor Information

	SAR
GSD (m)	1–100 (selectable)
Swath (km)	18–530 (selectable)
Data portal	http://www.asc-csa.gc.ca/eng/satellites/radarsat2/order-contact.asp



Montreal, Quebec, captured by RADARSAT-2 (image from MDA, used with permission).

JACIE

RADARSAT-2—Continued

Canada
Civil/Government
Operational

JACIE

SAR

The SAR instrument aboard RADARSAT-2 is very similar in design to the SAR instrument aboard RADARSAT-1. The new SAR instrument has improved resolution. The SAR instrument operates in the C-band at 5.405 gigahertz (λ = 5.5 centimeters). The angle of incidence is 10–60 degrees. SAR data are available through MDA.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Fine	Single	HH, HV, VH, VV	50	8
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
Wide Fine	Single	HH, HV, VH, VV	150	8
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
Standard	Single	HH, HV, VH, VV	100	25
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
Wide	Single	HH, HV, VH, VV	150	25
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
ScanSAR Narrow	Single	HH, HV, VH, VV	300	50
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
ScanSAR Wide	Single	HH, HV, VH, VV	500	100
	Dual	HH/HH, HH/HV, HV/HH, HV/HV		
Ocean Surveillance	Single Dual	HH, HV, VH, VV	530	Variable
		HH/HH, HH/HV, HV/HH, HV/HV		
Fine Quad-Pol	Polarimetric	HH, HV, VH, VV	25	12
Wide Fine Quad-Pol	Polarimetric	HH, HV, VH, VV	50	12
Standard Quad-Pol	Polarimetric	HH, HV, VH, VV	25	25
Wide Standard Quad-Pol	Polarimetric	HH, HV, VH, VV	50	25
Extended High	Single	HH	75	25
Extended Low	Single	HH	170	60
Spotlight	Single	HH, HV, VH, VV	18	1
Ultra-Fine	Single	HH, HV, VH, VV	20	3
Wide Ultra-Fine	Single	HH, HV, VH, VV	50	3
Extra-Fine	Single	HH, HV, VH, VV	125	5
Multi-Look Fine	Single	HH, HV, VH, VV	50	8
Wide Multi-Look Fine	Single	HH, HV, VH, VV	90	8
Ship Detection	Single	HH, HV, VH, VV	450	Variable

RASAT

Turkey
Civil/Government
Operational

Platform Overview

RASAT is a medium-resolution, panchromatic, and multispectral satellite launched in 2011 by TUBITAK-UZAY on a Dnepr-1 launch vehicle from the Yasny/Dombarovsky launch site for Earth observation. RASAT was designed and built in Turkey by Space Technologies Research Institute-Tubitak and is of BILSAT heritage (Turkey's previous satellite). RASAT carries the Optical Imaging System (OIS) sensor for medium-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic]

Launch date	08/17/2011
Design lifetime	3 years
Platform owner	TUBITAK-UZAY
Altitude	700 km
Orbit period	98 min
Inclination	98.25°
Crossing time	10:30 AN
Nadir repeat	—
Status	Operational
System website	http://uzay.tubitak.gov.tr/en/uydu-uzay/rasat

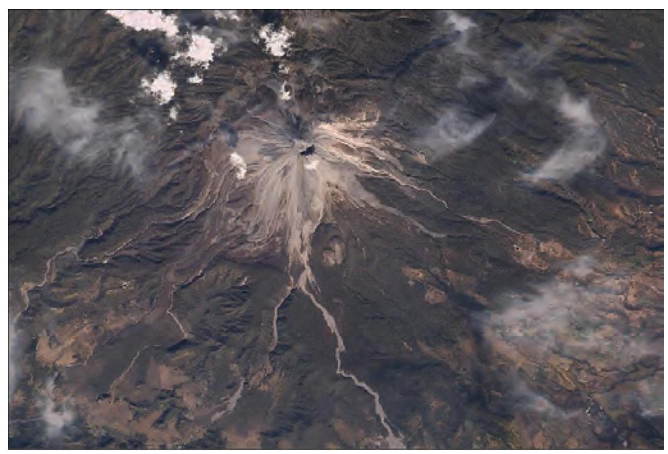
Artistic rendering of RASAT in orbit (image from TUBITAK-UZAY, used with permission).

Sensor Information

	OIS
GSD (m)	7.5, 15
Swath (km)	30
Data portal	gezgin.gov.tr
	blog.gezgin.gov.tr

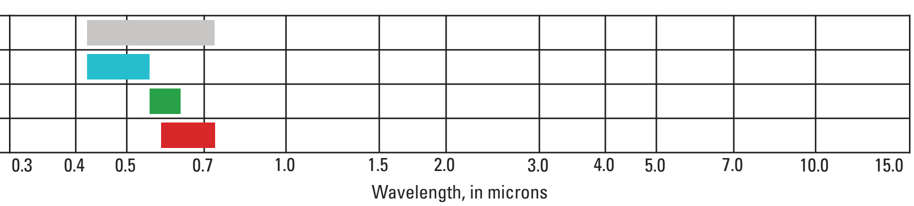
OIS

The OIS aboard RASAT is a pushbroom-style imager. OIS was designed and developed by Satrec Initiative in Korea and is a variant of their Earth Observing System-A.



RASAT image of the Colima volcano in Mexico (image from TUBITAK-UZAY, used with permission).

Band	Lower	Center	Upper	GSD (m)
Pan	0.420	0.575	0.730	7.5
Blue	0.420	0.485	0.550	15
Green	0.550	0.590	0.630	15
Red	0.580	0.655	0.730	15



JACIE

ResourceSat-2 and -2A

India
Civil/Government
Operational

Platform Overview

ResourceSat-2 is a medium- and high-resolution satellite launched in 2011 on the Polar Satellite Launch Vehicle (PSLV)-C16 launch vehicle. ResourceSat-2 carries the same sensing elements as ResourceSat-1 (launched in October 2003) and provides continuity for the mission. The objectives of the ResourceSat mission are to provide remote sensing data services to global users, focusing on data for integrated land and water resources management.

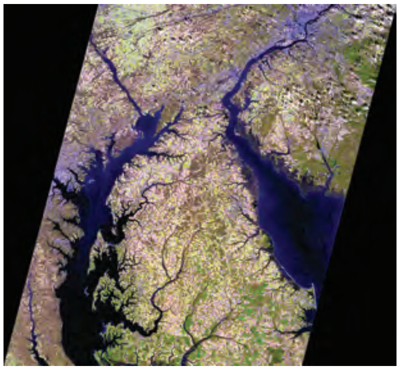
ResourceSat-2A is identical to ResourceSat-2 and was launched in 2016 on the PSLV-C36 launch vehicle for continuity of data and improved temporal resolution. The two satellites (ResourceSat-2 and ResourceSat-2A) operating in tandem improved the revisit capability from 5 days to 2–3 days.

The ResourceSat-2 platform is of IRS-1C/1D-P3 heritage and was built by the Indian Space Research Organization (ISRO). ResourceSat-2 and 2A carry the Advanced Wide Field Sensor (AWiFS), the Linear Imaging Self Scanning Sensor–III (LISS-3), and the Linear Imaging Self Scanning Sensor–IV (LISS-4) for medium-resolution imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared]

	RS-2	RS-2A
Launch date	04/20/2011	12/07/2016
Design lifetime	5 years	
Platform owner	ISRO	
Altitude	817 km	
Orbit period	101.35 min	
Inclination	98.78°	
Crossing time	10:30 DN	
Nadir repeat	24 days	
Status	Operational	
System website	https://www.isac.gov.in/earth-observation/html/resourcesat-2.jsp	

ResourceSat-2 satellite in clean room (image from ISRO, used with permission).



ResourceSat-2 LISS-3 imagery over Chesapeake Bay and Delaware Bay, United States (image from USGS).

Sensor Information

	AWiFS	LISS-3	LISS-4
GSD (m)	56	23.5	5.8
Swath (km)	740	141	70
Data Portal	https://nrsc.gov.in/		

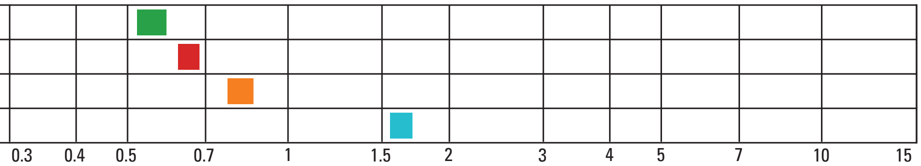
ResourceSat-2 and -2A—Continued

India
Civil/Government
Operational

AWiFS

The AWiFS aboard ResourceSat-2 and 2A is identical to the AWiFS sensor on ResourceSat-1. The data quantization for all sensors is now 10 bits. AWiFS data are available for purchase.

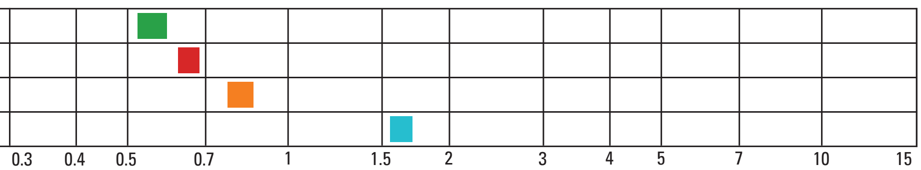
Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.555	0.590	56
Red	0.620	0.650	0.680	56
NIR	0.770	0.815	0.860	56
SWIR 1	1.550	1.625	1.700	56



LISS-3

The LISS-3 aboard ResourceSat-2 and 2A is identical to the LISS-3 sensor on ResourceSat-1. The data quantization for all sensors is now 10 bits. LISS-3 data are available for purchase.

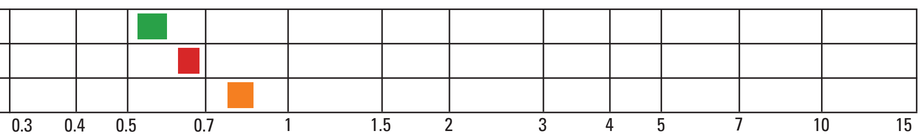
Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.555	0.590	23.5
Red	0.620	0.650	0.680	23.5
NIR	0.770	0.815	0.860	23.5
SWIR 1	1.550	1.625	1.700	23.5



LISS-4

The LISS-4 aboard ResourceSat-2 and 2A is based on the LISS-4 sensor on ResourceSat-1 and has an increased swath of 70 kilometers. The data quantization for all sensors is now 10 bits. LISS-4 data are available for purchase.

Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.555	0.590	5.8
Red	0.620	0.650	0.680	5.8
NIR	0.770	0.815	0.860	5.8



ResourceSat-3 and -3A

India
Civil/Government
Future

Platform Overview

ResourceSat-3 and -3A are medium-resolution wide swath satellites to be launched in 2020 and 2021, respectively, for advanced land and water resources management by the Indian Space Research Organization (ISRO). ResourceSat-3 and -3A will provide continuity of the ResourceSat program and enhanced capabilities. ResourceSat-3 and -3A will carry the Advanced Linear Imaging Self Scanning Sensor-III (ALISS) and Atmospheric Correction (ATCOR) sensor for medium- and high-resolution land imaging, respectively.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared; SWIR, shortwave infrared; Hyper, hyperspectral]

	RS-3	RS-3A
Launch date	2020	2021
Design lifetime	5 years	
Platform owner	ISRO	
Altitude	795 km	
Orbit period	101 min	
Inclination	97.91°	
Crossing time	10:30 DN	
Nadir repeat	11 days	
Status	Development	
System website	—	

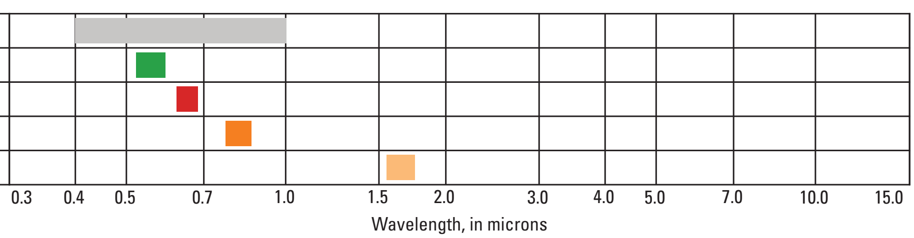
Sensor Information

	ALISS	ATCOR
GSD (m)	10, 20	240
Swath (km)	925	
Data portal	—	

ALISS

The ALISS-3 sensor is an improvement upon the LISS-3 sensor flown on previous ResourceSat missions. ALISS-3 has visible and near-infrared (VNIR) and shortwave infrared bands with improved 20-meter ground sample distance and a 925-kilometer swath. ALISS data will be commercially available.

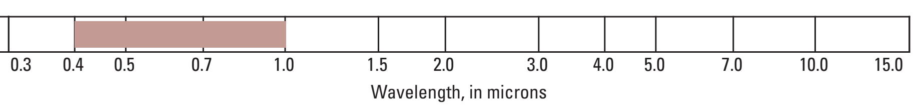
Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.700	1.000	20
Green	0.520	0.555	0.590	20
Red	0.620	0.650	0.680	20
NIR	0.770	0.815	0.860	20
SWIR1	1.550	1.650	1.750	20



ATCOR

The ATCOR sensor is a new hyperspectral sensing element that will operate in VNIR bands. ATCOR is intended to improve the quality of the data products. ATCOR data will be commercially available.

Band	Lower	Center	Upper	GSD (m)
Hyper	0.400	0.700	1.000	240



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ResourceSat-3S and -3SA

India
Civil/Government
Future

Platform Overview

ResourceSat-3S and -3SA are high-resolution, multispectral, and panchromatic Earth imaging satellites to be launched in 2020 and 2021 by the Indian Space Research Organization (ISRO) for generating improved digital elevation models (DEMs). ResourceSat-3S and -3SA will be used for stenographic mapping with improved resolution. ResourceSat-3S and -3SA will carry the Advanced Panchromatic (APAN) and Linear Self-Scanner (LISS-V) sensors for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; NIR, near infrared; Pan, panchromatic]

	RS-3S	RS-3SA
Launch date	2020	2021
Design lifetime	5 years	
Platform owner	ISRO	
Altitude	633 km	
Orbit period	97.5 min	
Inclination	98.89°	
Crossing time	10:30 DN	
Nadir repeat	48 days	
Status	Development	
System website	—	

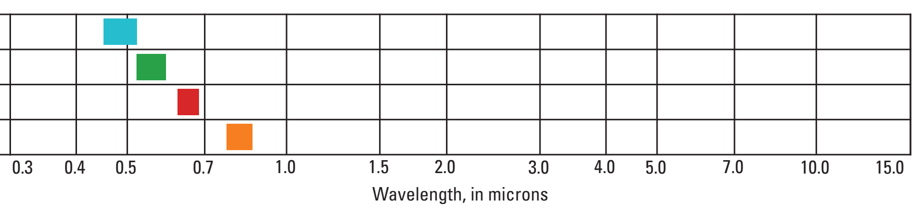
Sensor Information

	LISS-V	APAN
GSD (m)	2.5	1.5
Swath (km)	60	
Data portal	—	

LISS-V

The LISS-V sensor is an improvement on the LISS-4 sensor flown on previous ResourceSat missions. LISS-V has visible and near-infrared (VNIR) bands with improved 2.5-meter ground sample distance.

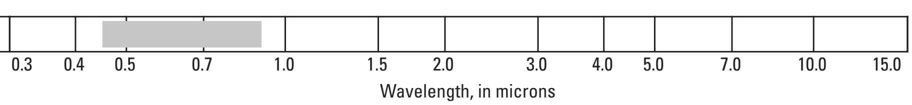
Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	2.5
Green	0.520	0.555	0.590	2.5
Red	0.620	0.650	0.680	2.5
NIR	0.770	0.815	0.860	2.5



APAN

The APAN sensor is a new high-resolution, panchromatic imager for sharpening. Both sensors have a narrowed swath of 60 kilometers.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	1.5



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Resurs-P

Russia
Civil/Government
Operational/Future

Platform Overview

Resource-Prospective (Resurs-P) satellites are a series of hyperspectral satellites developed and launched by the Joint Stock Company Space Rocket Centre Progress (JSC “SRC” Progress) for the Roscosmos State Corporation. The three operational spacecrafts are operated by the Scientific Center for Operational Earth Monitoring of the JSC Russian Space Systems.

Resurs-P satellites are based on the Resurs-DK satellites operated by Roscosmos State Corporation. The Resurs-PM series of next generation satellites are planned for launch after 2023. Resurs-P satellites carry multispectral and hyperspectral imagers for high-resolution Earth resources monitoring.

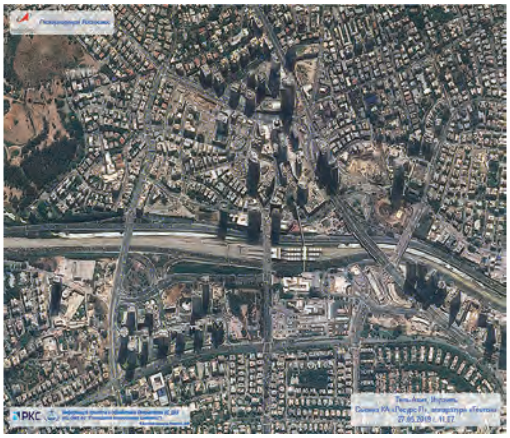
A model of the Resurs-P3 satellite (image from JSC “SRC” Progress).

[Abbreviations in tables: km, kilometer; —, no data; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared]

	Resurs-P satellites				
	No. 1	**No. 2**	**No. 3**	**No. 4**	**No. 5**
Launch date	06/25/2013	12/26/2014	03/13/2016	2022	2023
Design lifetime	5 years			—	—
Platform owner	Roscosmos State Corporation				
Altitude	475 km			—	—
Orbit period	94.1 min			—	—
Inclination	97.3°			—	—
Crossing time	10:30 DN			—	—
Nadir repeat	3 days			—	—
Status	Operational			Development	Development
System website	https://www.samspace.ru/products/earth_remote_sensing_satellites/ka_resurs_p/				

Sensor Information

	Geoton-L1	GSA hyperspectral imager	ShMSA-medium resolution	ShMSA-high resolution
GSD (m)	1/3	25	12/24	60/120
Swath (km)	38	25	97	441
Data portal	https://pod.gptl.ru/			



Resurs-P No. 1 image of Tel Aviv, Israel, acquired on May 27, 2019 (image from JSC “SRC” Progress).

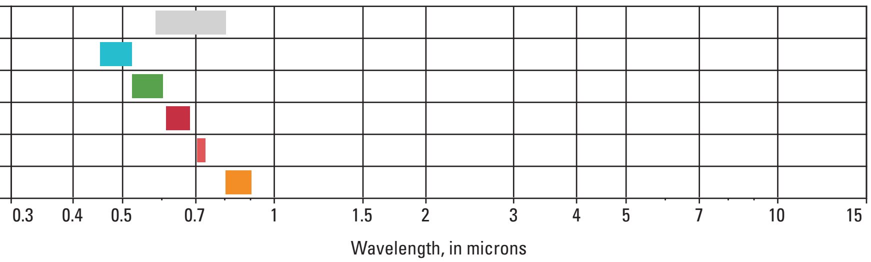
Resurs-P—Continued

Russia
Civil/Government
Operational/Future

Geoton-1

Geoton-1 (also referred to as “Geoton-L1”) is an optoelectronic pushbroom imaging instrument. The overall objective is to obtain high-resolution imagery of the Earth’s surface for commercial and research applications. The instrument provides panchromatic and multispectral imagery in a total of eight bands in the visible and near-infrared (VNIR) spectral range. The instrument can be tilted in the cross-track direction for an improved field of regard, which is done by spacecraft body pointing (plus or minus 30 degrees).

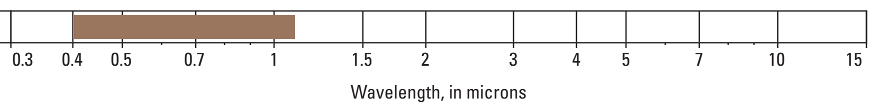
Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.580	0.690	0.800	1
Blue	0.450	0.485	0.520	3
Green	0.520	0.560	0.600	3
Red	0.610	0.645	0.680	3
Red Edge	0.700	0.715	0.730	3
NIR	0.800	0.850	0.900	3



GSA Hyperspectral Imager

The GSA hyperspectral imager can observe 216 spectral channels covering 400–1,100 nanometers (nm) at a ground resolution of 25 meters. Imagery delivered by the instrument has a spectral resolution of 5–10 nm, and the instrument covers a ground swath of 30 kilometers (km).

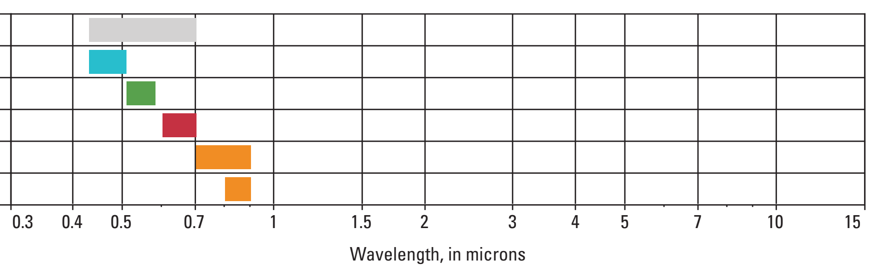
Band	Lower	Center	Upper	GSD (m)
Hyperspectral	0.400	0.750	1.100	25



ShMSA Medium-Resolution Multispectral Spectrometer

ShMSA is a complex of two multispectral cameras in medium and high resolution. The medium-resolution camera operates with a wide swath of 441 km in panchromatic and VNIR regions. The two ShMSA cameras can operate separately and simultaneously.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.430	0.565	0.700	60
Blue	0.430	0.470	0.510	120
Green	0.510	0.545	0.580	120
Red	0.600	0.650	0.700	120
NIR-1	0.700	0.800	0.900	120
NIR-2	0.800	0.850	0.900	23.8



JACIE

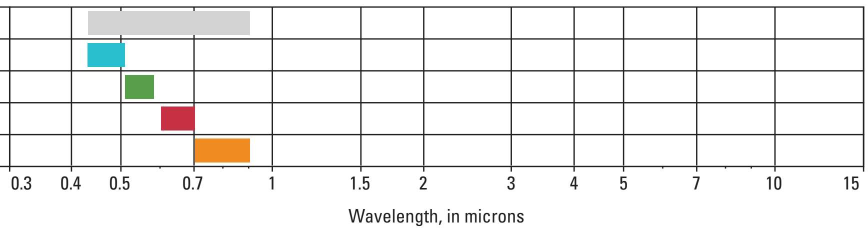
Resurs-P—Continued

Russia
Civil/Government
Operational/Future

ShMSA High-Resolution Multispectral Spectrometer

ShMSA is a complex of two multispectral cameras in medium and high resolution. The high-resolution camera operates with a swath of 97 km in panchromatic and VNIR regions. The two ShMSA cameras can operate separately and simultaneously.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.430	0.665	0.900	12
Blue	0.430	0.470	0.510	23.8
Green	0.510	0.545	0.580	23.8
Red	0.600	0.650	0.700	23.8
NIR	0.700	0.800	0.900	23.8



RISAT-1, -1A, and -1B

India
Civil/Government
Operational/Future

Platform Overview

The Radar Imaging Satellite (RISAT)-1 is a multiresolution Synthetic Aperture Radar (SAR) satellite launched in 2012 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center for Earth resources monitoring. RISAT-1A and RISAT-1B are copies of RISAT-1 and are planned for launch in 2020 and 2021, respectively. The RISAT-1 satellites carry the RISAT-SAR instrument for measuring radar data.

RISAT-1 main structure (image from ISRO, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	RISAT-1	RISAT-1A	RISAT-1B
Launch date	04/26/2012	2020 (Planned)	March 2021 (Planned)
Design lifetime	5 years		
Platform owner	ISRO		
Altitude	536 km		
Orbit period	95.49 min		
Inclination	97.55°		
Crossing time	6:00 AN		
Nadir repeat	25 days		
Status	Operational	Development	
System website	https://www.isro.gov.in/Spacecraft/risat-1		

Sensor Information

	RISAT-SAR
GSD (m)	0.67–55 (selectable)
Swath (km)	10–223 (selectable)
Data portal	http://uops.nrsc.gov.in:33333/ImgeosUops/FinalImgeosUops/FinalImgeosUops.html

RISAT-1 image of the Chambal river, Madhya Pradesh (image from ISRO, used with permission).

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RISAT-1, -1A, and -1B—Continued

India
Civil/Government
Operational/Future

RISAT-SAR

The RISAT-SAR instrument was built by ISRO's Space Applications Center and uses dual receivers. RISAT-SAR operates in the C-band at 5.35 gigahertz (λ = 5.60 centimeters). The angle of incidence is 12–55 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
High Resolution Spotlight (HRS)	Single	HH, HV, VH, VV	10 x 10	1 x 0.67
	Dual	HH/HV, VV/VH		
	Circular	CP/VH		
Fine Resolution Stripmap-1 (FRS-1)	Single	HH, HV, VH, VV	25	3 x 2
	Dual	HH/HV, VV/VH		
	Circular	CP/VH		
Fine Resolution Stripmap-2 (FRS-2)	Circular	CP/VH	25	3 x 4
	Quad	HH/HV/VV/VH		9 x 4
Medium Resolution ScanSAR (MRS)	Single	HH, HV, VH, VV	115	21–23 x 8
	Dual	HH/HV, VV/VH		
	Circular	CP/VH		
Coarse Resolution ScanSAR (CRS)	Single	HH, HV, VH, VV	223	41–55 x 8
	Dual	HH/HV, VV/VH		
	Circular	CP/VH		

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RISAT-2, 2B, and 2BR1

India
Civil/Government
Operational/Future

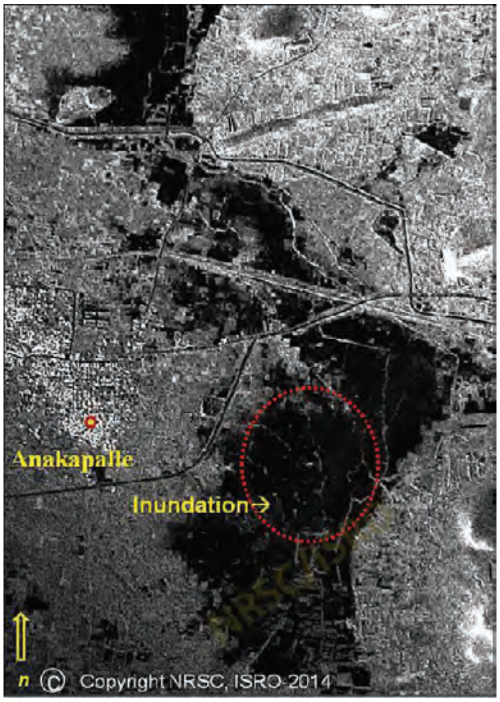
Platform Overview

RISAT-2, 2B, and 2BR1 are multiresolution synthetic aperture radar (SAR) satellites launched in 2009 and 2019 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle (PSLV) from Satish Dhawan Space Center (SDSC) for Earth resources monitoring. RISAT-2 was designed and built by Israel Aerospace Industries, Ltd., (IAI/MBT) and uses the OptSat-2000 platform of TecSAR bus heritage. ISRO purchased RISAT-2 when RISAT-1 was delayed. A larger, more capable model of the satellite, RISAT-2A, is planned to be launched in 2020–21. RISAT-2B. RISAT-2, 2B and 2BR1 satellites carry the X-SAR instrument for measuring SAR data.

Artistic rendering of RISAT-2 (image from ISRO, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	RISAT-2	RISAT-2B	RISAT-2BR1
Launch date	04/20/2009	05/22/2019	12/11/2019
Design lifetime	5 years		
Platform owner	ISRO		
Altitude	548 km	557 km	576
Orbit period	95.61 min	95.7 min	96.1 min
Inclination	41.21°	37°	37°
Crossing time	—		
Nadir repeat	—		
Status	Operational		
System website	https://nrsc.gov.in/RISAT-2		



RISAT-2 image of Anakapalle, Vishakapatnam district, Andhra Pradesh (image from ISRO, used with permission).

Sensor Information

	X-SAR
GSD (m)	1–8 (selectable)
Swath (km)	10–120 (selectable)
Data portal	—

JACIE

RISAT-2, 2B, and 2BR1—Continued

India
Civil/Government
Operational/Future

X-SAR

The X-band SAR (X-SAR) instrument was built by Elta Systems, Ltd., of Ashdod, Israel, and has heritage of the X-SAR instrument flown on TecSAR. X-SAR operates in the X-band at 9.59 GHz (λ = 3.13 cm). The angle of incidence is 20–45 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Spotlight mode	Single	HH, HV, VH, VV	10	<1
Super Stripmap (mosaic) mode	Single	HH, HV, VH, VV	10	1.8
Stripmap mode	Single	HH, HV, VH, VV	10	3
Wide coverage ScanSAR mode	Single	HH, HV, VH, VV	50	8

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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ROSE-L

European Space Agency
Civil/Government
Future

Platform Overview

The Radar Observing System for Europe—L-band (ROSE-L) mission is a synthetic aperture radar (SAR) mission planned by the European Space Agency (ESA) for launch after 2028 for Earth resources monitoring. It is a part of the Copernicus High Priority Candidates missions being developed by the ESA.

[Abbreviations in tables: —, no data; GSD, ground sample distance; m, meter; km, kilometer]

Launch date	2028
Design lifetime	5 years
Platform owner	ESA
Altitude	—
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Planned
System website	https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates

Sensor Information

	L-band SAR
GSD (m)	5
Swath (km)	—
Revisit (days)	6
Data portal	—

L-Band SAR

The L-band SAR will have a revisit of 6 days globally and acquires radar imagery at a 5-meter resolution.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—

JACIE

SABIA-Mar 1 and 2

Argentina, Brazil
Civil/Government
Future

JACIE

Platform Overview

SABIA-Mar 1 is a low-resolution multispectral satellite to be launched in 2022 to study the sea and coasts. The Argentinian National Space Activities Commission (CONAE) partnered with the Brazilian space agency (AEB) to form a constellation of two ocean satellites. CONAE is fully responsible for SABIA-Mar 1 and AEB is responsible for SABIA-Mar 2. Investigación Aplicada is the primary contractor for the development of SABIA-Mar 1. SABIA-Mar 1 will carry two primary sensors, visible-near infrared (VIS-NIR) and near infrared-shortwave infrared (NIR-SWIR), for ocean color monitoring. The mission also includes a high-sensitivity panchromatic camera (H-PAN) and a thermal infrared (TIR) sensor for measuring ocean temperature as a secondary payload.

[Abbreviations in tables: —, no data; km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter]

	SABIA-Mar 1	SABIA-Mar 2
Launch date	2022 (Planned)	—
Design lifetime	5 years	
Platform owner	CONAE, AEB	
Altitude	702 km	
Orbit period	98.81 min	
Inclination	98.19°	
Crossing time	22:20 AN	
Nadir repeat	4 days	
Status	Development	Planned
System website	http://www.conae.gov.ar/index.php/espanol/introduccion-sace	

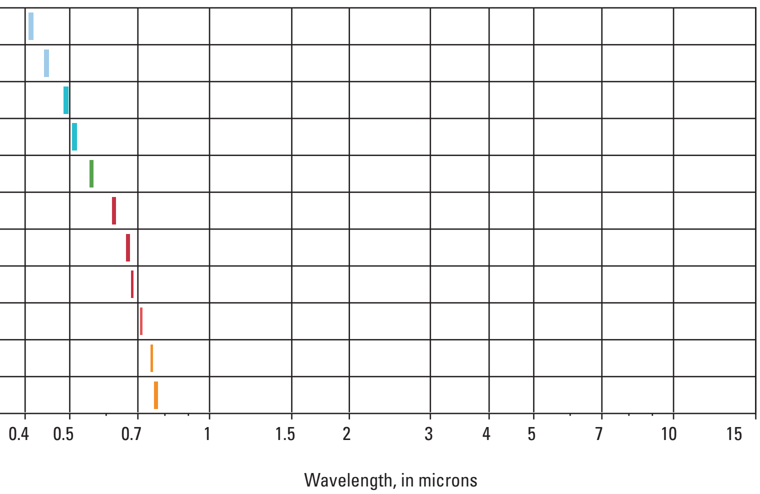
Sensor Information

	VIS-NIR	NIR-SWIR	TIR
GSD (m)	200, 400	200, 400	400
Swath (km)	—	—	—
Data portal	—		

VIS-NIR

The VIS-NIR sensor will have 11 bands between 412 and 865 nanometers (nm) (visible to near infrared) to study ocean color and coasts. The sensor will provide 800-meter (m) ground sample distance (GSD) data over oceans and 200-m GSD data over coasts.

Band	Lower	Center	Upper	GSD (m)
CA-1	0.407	0.412	0.417	200
CA-2	0.438	0.443	0.448	200
Blue-1	0.485	0.490	0.495	200
Blue-2	0.505	0.510	0.515	200
Green	0.550	0.555	0.560	200
Yellow	0.615	0.620	0.625	200
Red	0.660	0.665	0.670	200
Red Edge	0.676	0.680	0.684	200
NIR-1	0.705	0.710	0.715	200
NIR-2	0.745	0.750	0.755	200
NIR-3	0.760	0.765	0.770	400



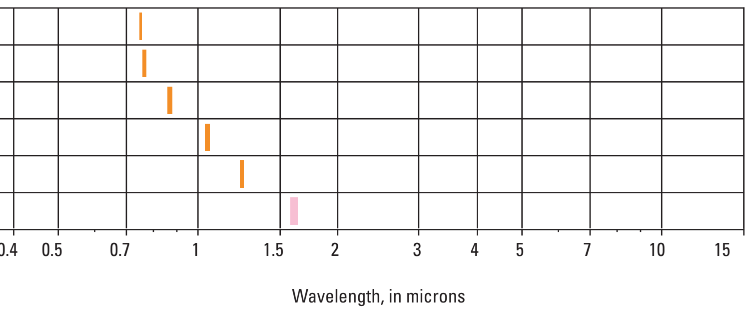
SABIA-Mar 1 and 2—Continued

Argentina, Brazil
Civil/Government
Future

NIR-SWIR

The NIR-SWIR sensor will have six bands between 750 and 1,600 nm (near infrared to shortwave infrared) to study ocean color and coasts. The sensor will provide 800-m GSD data over oceans and 400-m GSD data over coasts. The spectral information shown below is for South American coastal imaging only. For the global mission, only two bands centered at 750 and 865 nm are available at an 800-m resolution.

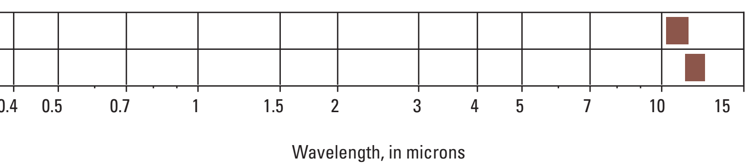
Band	Lower	Center	Upper	GSD (m)
NIR-1	0.745	0.750	0.755	200
NIR-2	0.760	0.765	0.770	400
NIR-3	0.855	0.865	0.875	200
NIR-4	1.034	1.044	1.054	400
NIR-5	1.230	1.240	1.250	400
SWIR1	1.580	1.610	1.640	400



TIR

The TIR sensor will have two bands centered at 11 and 12 micrometers (thermal infrared) for measuring sea surface temperature. The sensor is not available for global measurements.

Band	Lower	Center	Upper	GSD (m)
TIR-1	10.200	10.800	11.400	400
TIR-2	11.200	11.800	12.400	400



H-PAN

No information is available currently.

JACIE

SARAL

India, France
Civil/Government
Operational

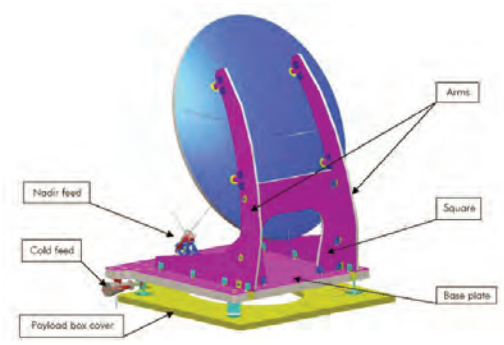
Platform Overview

SARAL is a radar altimeter satellite launched in 2013 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle—C20 launch vehicle from Satish Dhawan Space Center, Sriharikota, India, for oceanographic studies. SARAL is complementary to Jason-2 and will improve sea surface height mapping. The SARAL mission is a collaboration with the French National Centre for Space Studies (CNES). ISRO developed a new bus for SARAL, referred to as Indian MiniSatellite-2, and a Payload Instrument Module. SARAL carries the Altimeter in Ka band (AltiKa) instrument, which measures radar data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; —, no data]

Launch date	02/25/2013
Design lifetime	5 years
Platform owner	ISRO/CNES
Altitude	800 km
Orbit period	100.6 min
Inclination	98.54°
Crossing time	6:00 AN
Nadir repeat	35 days
Status	Operational
System website	https://www.isro.gov.in/Spacecraft/saral https://altika-saral.cnes.fr/en/

Artistic rendering of SARAL in orbit (image from CNES/ill/SATTLER Oliver, 2010, used with permission).



3-Dimensional model of the AltiKa instrument aboard SARAL (image from CNES, 2016, used with permission).

Sensor Information

	AltiKa
GSD (m)	—
Swath (km)	—
Data portal	—

AltiKa

The AltiKa was designed and built by CNES and is of Poseidon (flown on the Jason missions) heritage. The altimeter operates in the Ka-band at 35.75 gigahertz (GHz) (λ = 0.84 centimeter [cm]). The AltiKa instrument also includes a bifrequency radiometer that operates at 23.8 GHz (λ = 1.26 cm) and 37 GHz (λ = 0.81 cm).

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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Sentinel-1

European Commission/European Space Agency
Civil/Government
Operational/Future

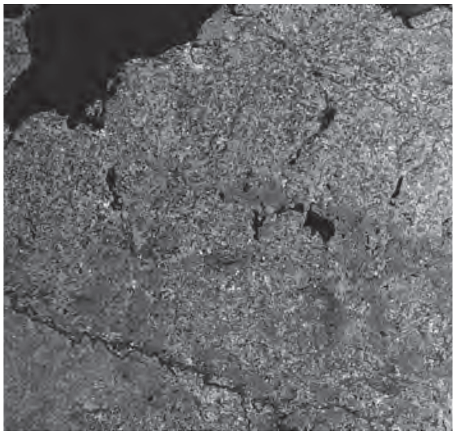
Platform Overview

Copernicus Sentinel-1 is Europe's all-weather, day-and-night radar imaging mission for land and ocean services. Sentinel-1A was launched in 2014, followed by Sentinel-1B in 2016. Two more Sentinel-1 satellites (C and D) are planned to be launched in 2021 and 2023, respectively, to extend the Sentinel-1 mission at least until the end of 2030. The Sentinel-1 satellites are built by Thales Alenia Space Italia (TAS-I) and are based on the Piattaforma Italiana Multi Applicativa (PRIMA) bus of TAS-I, of COSMO-SkyMed and RADARSAT-2 heritage, with a mission-specific payload module. The satellites carry the C-band synthetic aperture radar (C-SAR) sensor for medium-resolution SAR data.

Artistic rendering of Sentinel-1 in orbit (image from ESA).

[Abbreviations in tables: ESA, European Space Agency; km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	Sentinel-1A	Sentinel-1B	Sentinel-1C	Sentinel-1D
Launch date	04/03/2014	04/25/2016	2021 (Planned)	2023 (Planned)
Design lifetime	7.25 years			
Platform owner	ESA			
Altitude	693 km			
Orbit period	98.6 min			
Inclination	98.18			
Crossing time	18:00 DN			
Nadir repeat	12 days			
Status	Operational		Development	
System website	https://scihub.copernicus.eu/			



The Alps between Munich and Bozen captured by Sentinel-1A (image from DLR).

Sensor Information

Mode	C-SAR
GSD (m)	5–40
Swath (km)	80–400
Data portal	https://scihub.copernicus.eu/

C-SAR

The C-SAR is designed and developed by EADS Astrium GmbH of Germany. The center frequency of the C-band is 5.405 gigahertz (λ = 5.5 centimeters). The angle of incidence is 20–46 degrees. C-SAR data are freely available.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Stripmap Mode (SM)	Dual	HH/HV, VV/VH	80	5 x 5
Interferometric Wide Swath Mode (IW)	Dual	HH/HV, VV/VH	250	5 x 20
Extra Wide Swath Mode (EW)	Dual	HH/HV, VV/VH	400	20 x 40
Wave Mode (WV)	Single	HH, VV	20 x 20	5 x 5

JACIE

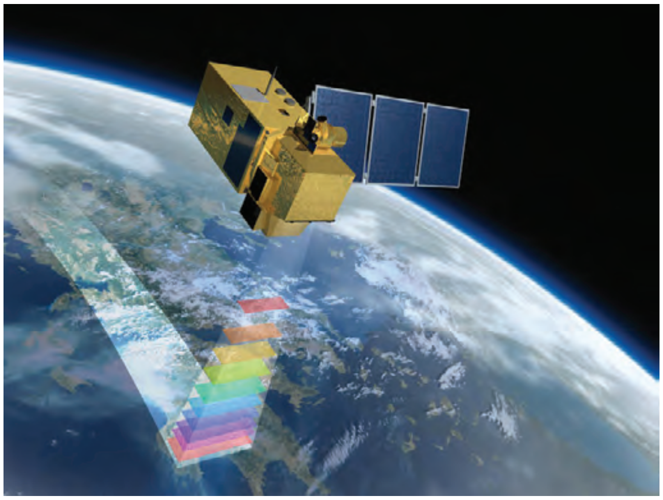
Sentinel-2

European Commission/European Space Agency
Civil/Government
Operational/Future

Platform Overview

Copernicus Sentinel-2 is Europe's high-resolution, multispectral Earth imaging mission with high revisit capability. Sentinel-2A was launched in 2015 and followed by Sentinel-2B in 2017. Sentinel-2C and Sentinel-2D are under construction and will be ready for launch in 2021.

The Sentinel-2 satellites are built by Airbus Defence and Space and use the AstroBus-L bus, a standard modular European Cooperation for Space Standards compatible satellite platform. The Sentinel-2 satellites carry the Multispectral Imager (MSI) for medium-resolution land imaging.



Artistic rendering of Sentinel-2A satellite in orbit (image from ESA).

[Abbreviations in tables: ESA, European Space Agency; km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared]

	Sentinel-2A	Sentinel-2B	Sentinel-2C	Sentinel-2D
Launch date	06/23/2015	03/07/2017	2023 (Planned)	
Design lifetime	7.25 years			
Platform owner	ESA			
Altitude	786 km			
Orbit period	100.7 min			
Inclination	98.5°			
Crossing time	10:30 DN			
Nadir repeat	10 days			
Design lifetime	7.25 years			
Status	Operational		Development	
System website	https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2			

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Sentinel-2—Continued

European Commission/European Space Agency
Civil/Government
Operational/Future

Sensor Information

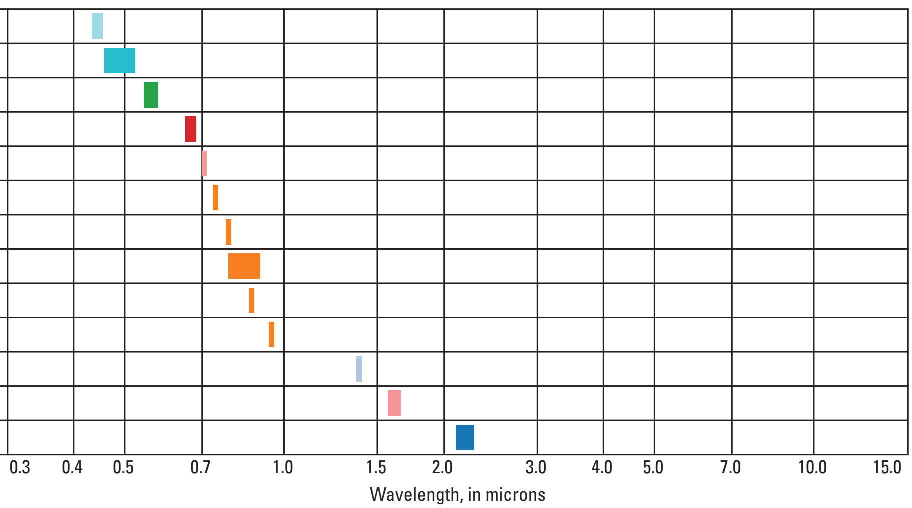
	MSI
GSD (m)	10, 20, 60
Swath (km)	290
Data portal	https://scihub.copernicus.eu/

Satellite image of Amsterdam, Netherlands, captured by Sentinel-2B (image from ESA).

MSI

The MSI aboard Sentinel-2 is a new pushbroom sensor with visible and near-infrared and shortwave infrared bands. Onboard calibration bands in combination with ground targets ensure high-quality radiometric performance.

Band	Lower	Center	Upper	GSD (m)
CA	0.433	0.443	0.453	60
Blue	0.458	0.490	0.523	10
Green	0.542	0.560	0.578	10
Red	0.650	0.665	0.681	10
Red Edge	0.698	0.705	0.713	20
NIR	0.733	0.740	0.748	20
NIR	0.773	0.783	0.793	20
NIR	0.785	0.842	0.900	10
NIR	0.855	0.865	0.875	20
NIR	0.935	0.945	0.955	60
Cirrus	1.365	1.380	1.395	60
SWIR 1	1.565	1.610	1.655	20
SWIR 2	2.100	2.190	2.280	20



JACIE

Sentinel-3

European Commission/European Space Agency
Civil/Government
Operational/Future

Platform Overview

Copernicus Sentinel-3 is a multi-instrument mission to measure sea-surface topography, sea- and land-surface temperature, ocean color, and land color with high accuracy and reliability. Sentinel-3A was launched in 2016 followed by Sentinel-3B in 2018. Sentinel-3C and Sentinel-3D are planned to follow, extending the mission at least until 2030.

The Sentinel-3 satellites are built by Thales Alenia Space-France (TAS-F) and are based on a new generation of avionics for the TAS-F low earth orbit platform. Sentinel-3 carries the Ocean and Land Color Instrument (OLCI), Sea and Land Surface Temperature Radiometer (SLSTR), and SAR Radar Altimeter (SRAL) sensing elements. Data are available to the public for free.

Artistic rendering of Sentinel-3 in orbit (image from ESA).

[Abbreviations in tables: ESA, European Space Agency; km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared; MWIR, midwave infrared; TIR, thermal infrared]

	Sentinel-3A	Sentinel-3B	Sentinel-3C	Sentinel-3D
Launch date	02/16/2016	04/25/2018	2021 (Planned)	2023 (Planned)
Design lifetime	7.5 years			
Platform owner	ESA			
Altitude	814 km			
Orbit period	100 min			
Inclination	98.65°			
Crossing time	10:00 DN			
Nadir repeat	27 days			
Status	Operational		Development	
System website	https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3			

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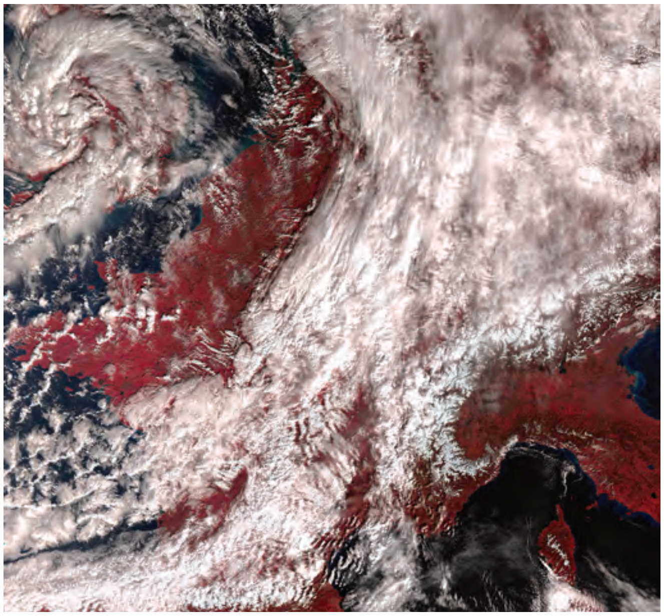
Sentinel-3—Continued

European Commission/European Space Agency
Civil/Government
Operational/Future

Sensor Information

	OLCI	SLSTR	SRAL
GSD (m)	300	500/1,000	300
Swath (km)	1,270	1,420	1,270
Data portal	https://scihub.copernicus.eu/		

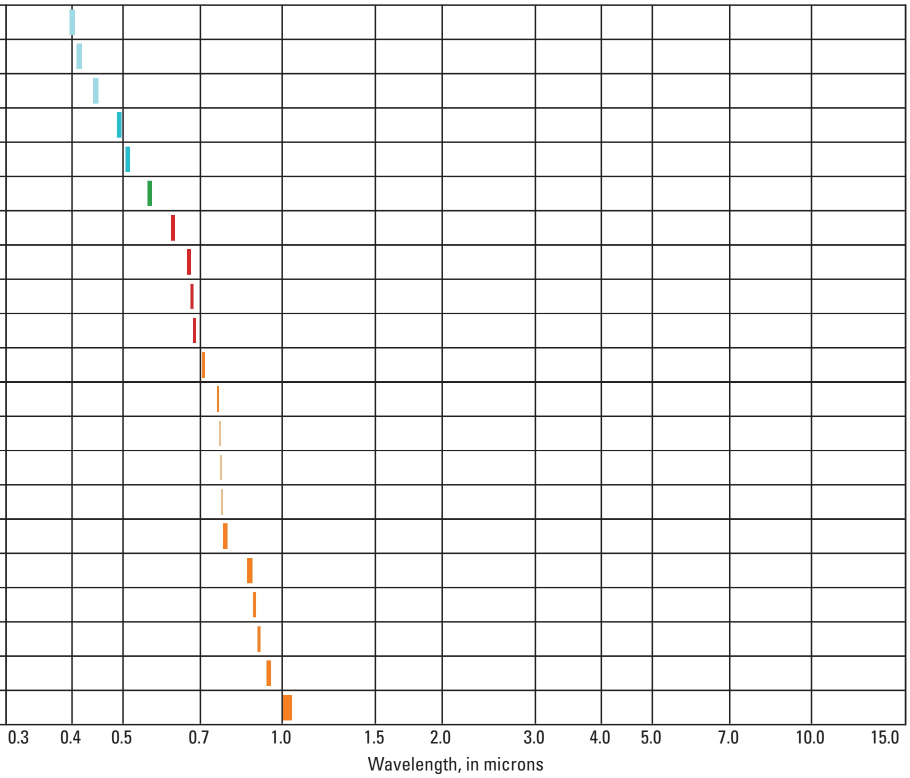


Europe captured by Sentinel-3B (image from ESA).

OLCI

The OLCI is of the European Space Agency's medium-spectral resolution, imaging spectrometer of MERIS heritage (flown on Envisat). The field of view is tilted toward the west 12 degrees from the sun to minimize the sunglint effect over the ocean and increase the effective swath.

Band	Lower	Center	Upper	GSD (m)
CA	0.395	0.400	0.405	300
CA	0.408	0.413	0.418	300
CA	0.438	0.443	0.448	300
Blue	0.485	0.490	0.495	300
Blue	0.505	0.510	0.515	300
Green	0.555	0.560	0.565	300
Red	0.615	0.620	0.625	300
Red	0.660	0.665	0.670	300
Red	0.670	0.674	0.678	300
Red	0.678	0.681	0.685	300
NIR	0.703	0.708	0.713	300
NIR	0.750	0.754	0.758	300
NIR	0.760	0.761	0.763	300
NIR	0.763	0.764	0.766	300
NIR	0.766	0.768	0.769	300
NIR	0.771	0.779	0.786	300
NIR	0.855	0.865	0.875	300
NIR	0.880	0.885	0.890	300
NIR	0.895	0.900	0.905	300
NIR	0.930	0.940	0.950	300
NIR	1.000	1.020	1.040	300



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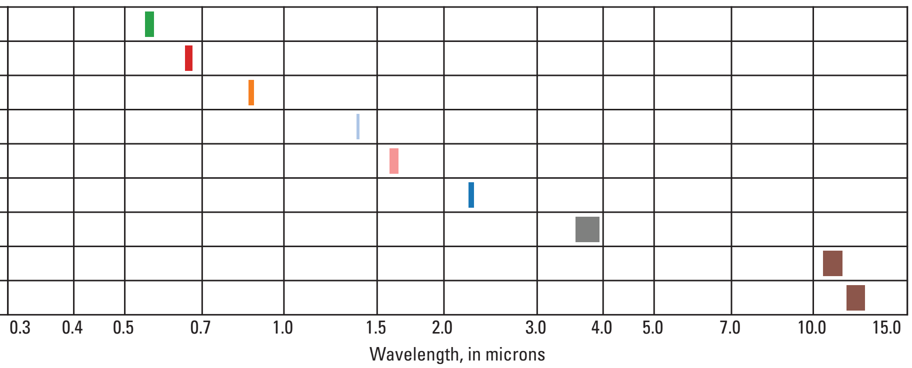
Sentinel-3—Continued

European Commission/European Space Agency
Civil/Government
Operational/Future

SLSTR

The SLSTR is an upgraded and advanced version of the Advanced Along-Track Scanning Radiometer (AATSR) instrument flown on Envisat, offering a wider swath, more bands, and greater resolution. The wider swath allows for shorter revisit time. Two dedicated channels were added for fire and high temperature events monitoring at a 1-kilometer resolution, and two SWIR bands were added to improve cloud and aerosol detection.

Band	Lower	Center	Upper	GSD (m)
Green	0.545	0.555	0.565	500
Red	0.649	0.659	0.669	500
NIR	0.855	0.865	0.875	500
Cirrus	1.368	1.375	1.383	500
SWIR 1	1.580	1.610	1.640	500
SWIR 2	2.225	2.250	2.275	500
MWIR	3.550	3.740	3.930	1,000
TIR	10.400	10.850	11.300	1,000
TIR	11.500	12.000	12.500	1,000



SRAL

The SAR Radar Altimeter (SRAL) instrument has strong heritage of the instrument techniques implemented on the Poseidon-3 altimeter on Jason-2, SAR Interferometer Radar Altimeter on CryoSat-2, and Altimeter in Ka-band on the SRAL mission of ISRO and CNES. SRAL is the core instrument of the topographic payload.

JACIE

Sentinel-6 Michael Freilich

EUMETSAT/France/United States
European Commission/European Space Agency
Civil/Government
Future

Platform Overview

Copernicus Sentinel-6 Michael Freilich, also known as Jason Continuity of Service (Jason-CS), is Europe's radar altimeter satellite, intended to ensure continuity with Jason-3. Sentinel-6 Michael Freilich is a partnership between the European Space Agency (ESA), European Organization for the Exploitation of Meteorological Satellites, French National Centre for Space Studies, European Commission, National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration. Sentinel-6A is planned to be launched in 2020 with Sentinel-6B to be launched before the end of life of Sentinel-6A to ensure continuity of data. The two Sentinel-6 Michael Freilich satellites are based on the CryoSat-2 heritage platform and are being built by Airbus Defence and Space in Germany. Sentinel-6 Michael Freilich will carry the Poseidon-4 Synthetic Aperture Radar Altimeter (POS4) sensor for SAR data.

Artistic rendering of Sentinel-6 Michael Freilich in orbit (image from ESA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter]

	Sentinel-6A	Sentinel-6B
Launch date	2020 (Planned)	2023 (Planned)
Design lifetime	7.5 years	
Platform owner	ESA	
Altitude	1,366 km	
Orbit period	112 min	
Inclination	66.03°	
Crossing time	—	
Nadir repeat	9.9 days	
Status	Development	Planned
System website	https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-6	

Sensor Information

	POS4
GSD (m)	—
Swath (km)	—
Data portal	—

POS4

POS4 is the principal payload instrument aboard Sentinel-6 Michael Freilich. The new instrument is a collaboration between agencies, each contributing different elements. The instrument measures surface height and wind speed. The system can operate in conventional pulse-width limited and synthetic aperture radar processing simultaneously. POS4 operates in the Ku-band at 13.575 gigahertz (GHz) (λ = 2.2 centimeters [cm]) and the C-band at 5.3 GHz (λ = 5.7 cm). The angle of incidence and the beam modes are unavailable. The data will be freely available.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
—	—	—	—	—

SEOSat

Spain
Civil/Government
Future

Platform Overview

The Spanish System for Earth Observation Satellite (SEOSat), also known as Ingenio (Spanish for “ingenuity”), is a high-resolution multispectral satellite to be launched in 2020 by the National Institute of Aerospace Technology (INTA) for Earth observation. This is a flagship mission of the Spanish Space Strategic Plan 2007–11. The spacecraft development has been led by Airbus Defence and Space. SEOSat uses the proven AstroSat-250 bus. SEOSat carries the Primary Payload (PP) instrument for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	2020 (Planned)
Design lifetime	7 years
Platform owner	INTA
Altitude	670 km
Orbit period	98.15 min
Inclination	98°
Crossing time	10:30 DN
Nadir repeat	38 days
Status	Development
System website	—

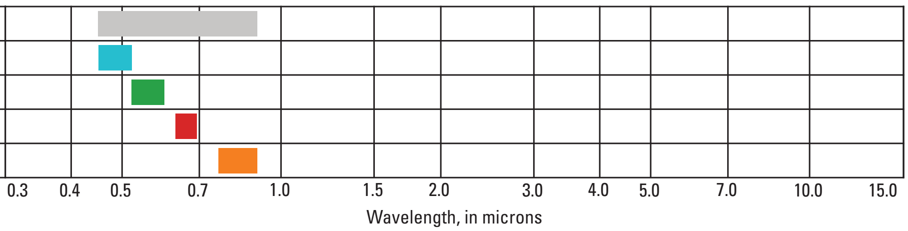
Sensor Information

	PP
GSD (m)	2.5, 10
Swath (km)	55
Data portal	—

PP

The PP instrument is a new design being developed by Sener Ingeniería y Sistemas S.A. of Spain.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	2.5
Blue	0.450	0.485	0.520	10
Green	0.520	0.560	0.600	10
Red	0.630	0.660	0.690	10
NIR	0.760	0.830	0.900	10



SHALOM

Italy/Israel
Civil/Government
Future

Platform Overview

The Space-borne Hyperspectral Applicative Land and Ocean Satellite (SHALOM) is a high-resolution hyperspectral mission planned for launch in 2022 on a Vega rocket from French Guinea. The satellite is a joint mission between the Italian Space Agency (ASI) and Israel Space Agency. SHALOM will use the OPTSAT-3000 satellite platform built by Israel Aerospace Industries (IAI). It will carry a panchromatic and an infrared camera in addition to a visible to shortwave infrared hyperspectral sensor.

[Abbreviations in tables: km, kilometer; —, no data; CHIS, Commercial Hyperspectral Imaging Spectrometer; Pan, panchromatic; GSD, ground sample distance; m, meter; VNIR, visible and near infrared; SWIR, shortwave infrared]

Launch date	2022
Design lifetime	5 years
Platform owner	IAI/ASI
Altitude	600 km
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Development
System website	—

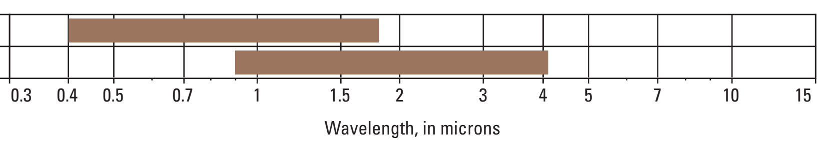
Sensor Information

	CHIS	Pan
GSD (m)	10	2.5
Swath (km)	—	—
Revisit (days)	2	
Data portal	—	

CHIS

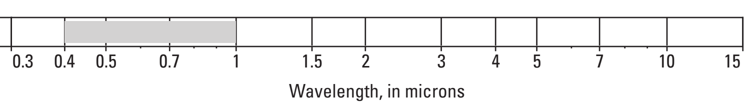
The Commercial Hyperspectral Imaging Spectrometer (CHIS) is a hyperspectral imager operating in visible and near infrared and shortwave infrared parts of the spectrum. It is being built by ASI.

Band	Lower	Center	Upper	GSD (m)
Hyperspectral-VNIR	0.400	0.750	1.100	10
Hyperspectral-SWIR	0.900	1.700	2.500	10



Panchromatic Camera

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.400	0.550	0.700	2.5



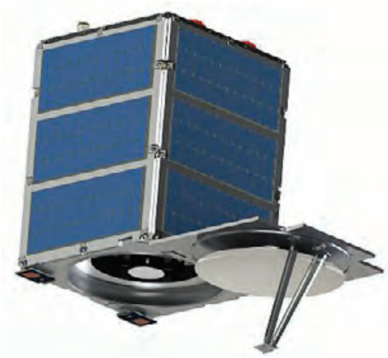
SkySat-1 to -13

United States
Commercial
Operational

Platform Overview

SkySat-1 through -13 are high-resolution, multispectral microsatellites for high revisit, high-resolution imaging. SkySat-1 and -2 were built by Skybox Imaging. Skybox Imaging (Skybox), acquired by Google, was changed to "Terra Bella" in 2016 before being acquired by Planet in 2017. Sinclair Interplanetary (SI) was contracted to develop the ST-16-star trackers for the satellites. SkySat-3 through -13 were built by Space Systems/Loral (SS/L) and were very similar in design to SkySat-1 and -2. The new SkySats feature better reaction wheels and a propulsion system, increasing agility, as well as smaller pixels. Each SkySat is equipped with a Ritchey-Chretien Cassegrain telescope. The camera provides a ground sample distance of 2 meters (m) in visible and near infrared and 0.9 m in panchromatic bands. Data can be ordered from Planet.

SkySat-14 and -15 launched in 2018 and SkySat-16 to -18 launched in 2020.



SkySat-1 and -2 deployed configurations (image from Planet Labs Inc., used with permission).

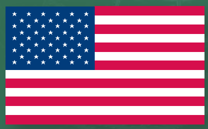
SkySat-3 through -13 deployed configurations (image from Planet Labs Inc., used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; AN, ascending node; GSD, ground sample distance; m, meter; Pan, panchromatic, NIR, near infrared]

	SS-1	SS-2	SS-3	SS-4 to -7	SS-8 to -13	SS-14 to -15	SS-16 to -18
Launch date	11/21/2013	07/08/2014	06/22/2016	09/16/2016	10/31/2017	12/03/2018	06/13/2020
Design lifetime	6 years						
Launch vehicle	Dnepr	Soyuz-2.1b/Fregat	PSLV-C34	Vega	Minotaur-C	Falcon-9	Falcon-9
Platform owner	Planet						
Altitude	587 km		500 km	695 km	500 km		350 km
Orbit period	96.41 min		94.6 min	98.6 min	94.6 min		91.1 min
Inclination	97.98°		95.3°	98.3°	95.3°		53°
Crossing time	10:30 DN				13:30 AN		—
Status	Operational						
System website	https://www.planet.com/products/hi-res-monitoring/						

SkySat-1 to -13—Continued

United States
Commercial
Operational



Sensor Information

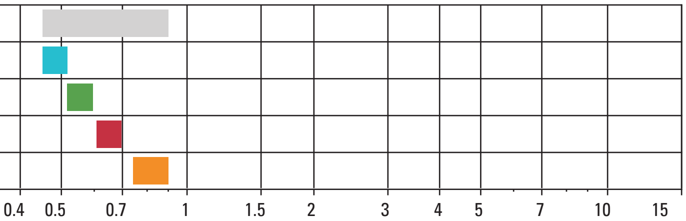
	SS-MSI
GSD (m)	0.5/0.72/0.86/1
Swath (km)	8
Data portal	https://www.planet.com/products/planet-imagery/

Skysat imagery of Rome, Italy (image from Planet Labs Inc., used with permission).

SS-MSI

The SkySat-Multispectral Imager is an optical payload of the SkySat satellites based on a Ritchey-Chretien Cassegrain telescope design with a focal length of 3.6 m. The camera can deliver full motion video with frame rates as high as 50 hertz. SkySat data are available from Planet. The SkySats launched into lower inclined orbits provide higher resolution data than the previous SkySats.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.675	0.900	0.72/0.86
Blue	0.450	0.483	0.515	1
Green	0.515	0.555	0.595	1
Red	0.605	0.650	0.695	1
NIR	0.740	0.820	0.900	1



JACIE

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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SMAP

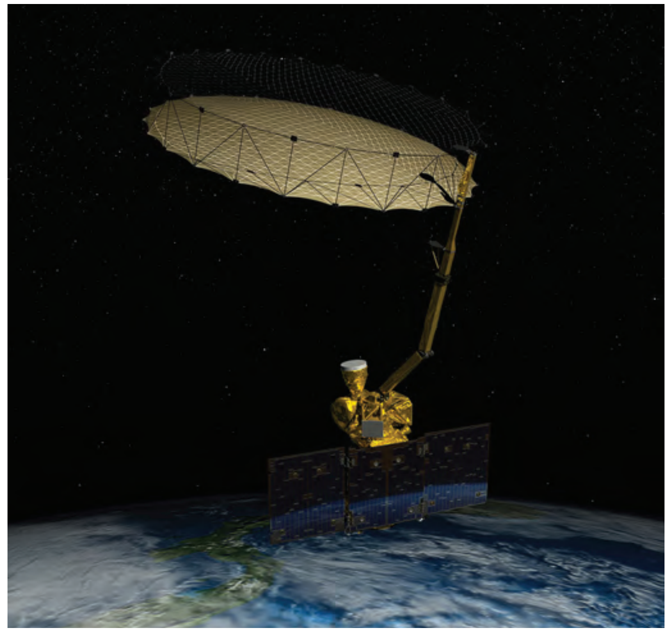
United States
Civil/Government
Operational

Platform Overview

The Soil Moisture Active/Passive (SMAP) satellite is a low-resolution synthetic aperture radar (SAR) satellite launched in 2015 by the National Aeronautics and Space Administration (NASA) on a Delta-II launch vehicle from Vandenberg Air Force Base in California for global soil moisture mapping. SMAP was designed by NASA's Jet Propulsion Laboratory (JPL) and has heritage of previous radar missions developed at JPL. SMAP carries a SAR sensor for measuring low-resolution radar data.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter]

Launch date	01/31/2015
Design lifetime	3 years
Platform owner	NASA
Altitude	685 km
Orbit period	98.5 min
Inclination	98°
Crossing time	18:00 AN
Nadir repeat	8 days
Status	Operational
System website	https://smap.jpl.nasa.gov/



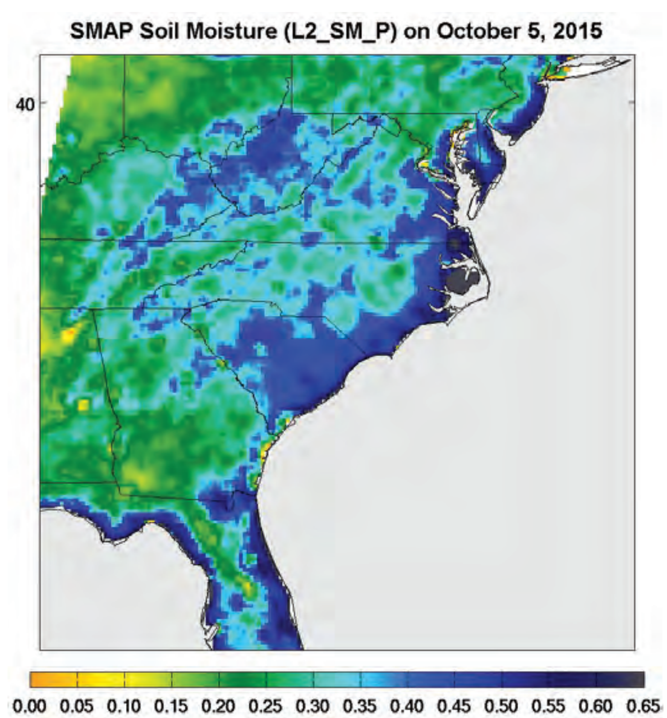
Artistic rendering of SMAP in orbit (image from NASA).

Sensor Information

	SMAP
GSD (m)	3,000
Swath (km)	1,000
Data portal	https://www.asf.alaska.edu/smap/data-imagery/

SMAP

The SMAP instrument is a SAR developed at JPL. Astro Aerospace (a business unit of Northrop Grumman) was contracted to design the reflector boom assembly (RBA). The RBA rotates and scans the Earth conically. SMAP's SAR instrument operates in the L-band at 1,217–1,298 megahertz (MHz) (λ = 24.6—23.1 centimeters [cm]). The radiometer on board operates in the L-band at 1,400–1,427 MHz (λ = 21.4–21.0 cm). The angle of incidence is 40 degrees.



SMAP soil moisture map of southeastern United States (image from NASA).

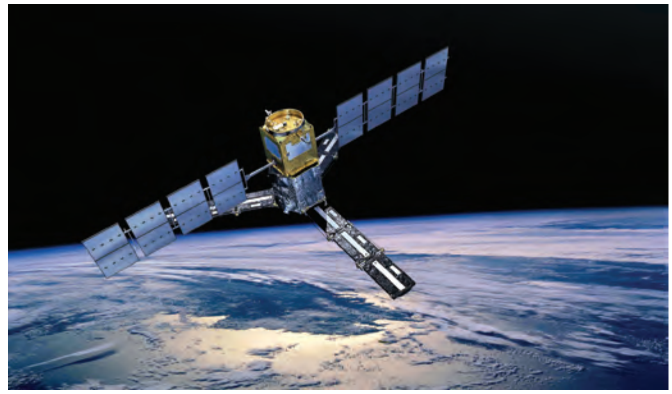
SMOS

European Space Agency
Civil/Government
Operational

Platform Overview

The Soil Moisture and Ocean Salinity (SMOS) satellite is a low-resolution satellite launched in 2009 on a Rockot launch vehicle for making global observations of soil moisture over land and salinity over oceans. SMOS is an Earth Explorer Opportunity mission.

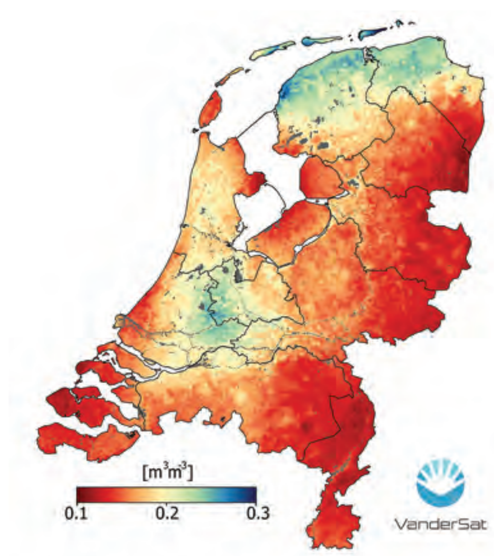
SMOS utilizes the Proteus bus developed by the French National Centre for Space Studies and Alcatel Alenia Space and carries the Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) sensor, which captures 30-kilometer ground sample distance imagery freely available to the public.



Artistic rendering of SMOS in orbit (image from ESA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter]

Launch date	11/02/2009
Design lifetime	3 years
Platform owner	ESA
Altitude	755 km
Orbit period	100 min
Inclination	98.44°
Crossing time	6:00 AN
Nadir repeat	23 days
Status	Operational
System website	https://www.esa.int/Our_Activities/Observing_the_Earth/SMOS



Soil moisture in the Netherlands measured by SMOS (image from ESA).

Sensor Information

	MIRAS
GSD (m)	30,000
Swath (km)	900
Data portal	https://smos-ds-02.eo.esa.int/oads/access/

MIRAS

The MIRAS instrument was developed by European Aeronautics Defense and Space. MIRAS operates at frequencies around 1.4 gigahertz (L-band) to capture images of emitted microwave radiation from Earth.

MIRAS works by collecting the data via an 8-meter antenna-receiver unit with 69 antenna elements called LICEFs. Each LICEF antenna weighs 190 grams and is 165 millimeters (mm) in diameter and 19 mm high.

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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SPOT-6 and -7

France, Azerbaijan
Commercial
Operational

Platform Overview

SPOT-6 and -7 are high-resolution multispectral satellites launched in 2012 and 2014, respectively, by the EADS Astrium on a Polar Satellite Launch Vehicle from the Satish Dhawan Space Center SHAR for Earth resources monitoring. These missions continue the SPOT series that has been in continual operation since the launch of SPOT-1 in 1986. These satellites are privately owned by EADS Astrium. Azerbaijan acquired SPOT-7 and renamed it Azersky. The SPOT-6 and -7 satellites were designed and built by Airbus Defence and Space and use the AstroSat-250 bus. With a highly agile system, the satellites can provide visible and near-infrared imagery at global scale and on a targeted basis. SPOT-6 and SPOT-7 are placed 180 degrees apart and operate with the high-resolution Pleaides-HR satellites in orbit. SPOT-6 and -7 carry the New AstroSat Optical Modular Instrument (NAOMI) sensor for high-resolution land imaging.

SPOT-7 in orbit (image from Airbus DS, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

	SPOT-6	SPOT-7
Launch date	09/09/2012	06/30/2014
Design lifetime	10 years	
Platform owner	EADS Astrium/Azercosmos	
Altitude	694 km	
Orbit period	98.6 min	
Inclination	98.2°	
Crossing time	10:00 DN	
Nadir repeat	26 days	
Status	Operational	
System website	https://www.intelligence-airbusds.com/en/191-spot-technical-information	

SPOT-7 satellite image of Sydney, Australia (image from Airbus DS, used with permission).

Sensor Information

	NAOMI
GSD (m)	1.5, 6
Swath (km)	60
Data portal	https://www.intelligence-airbusds.com/en/147-spot-6-7-satellite-imagery

JACIE

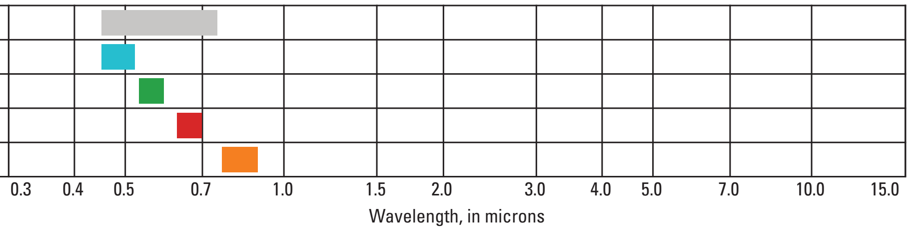
SPOT-6 and -7—Continued

France, Azerbaijan
Commercial
Operational

NAOMI

The NAOMI sensor is a proven design from Airbus used on Disaster Monitoring Constellation satellites. The sensor aboard SPOT-6 operates with two cameras to provide greater swath width. Data are available to customers through the Airbus's commercial portal.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.598	0.745	1.5
Blue	0.450	0.485	0.520	6
Green	0.530	0.560	0.590	6
Red	0.625	0.660	0.695	6
NIR	0.760	0.825	0.890	6



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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SSTL-S1 (1-4)/DMC-3

United Kingdom, China
Commercial
Operational

Platform Overview

TripleSat-1, -2, and -3 are three identical high-resolution, multispectral satellites launched in 2015 on the Polar Satellite Launch Vehicle for disaster monitoring. The TripleSat satellites form the third generation of the Disaster Monitoring Constellation (DMC). The Twenty First Century Aerospace Technology Co. (21AT) has leased 100 percent of the imaging capacity of the TripleSat constellation.

The TripleSats were designed and built by Surrey Satellite Technology (SSTL) and were based on the SSTL-300 S1 bus, building on the heritage of the SSTL-300 platform and avionics of NigeriaSat-2. The Very High-Resolution Imager-100 aboard TripleSat captures 3.2-meter (m) ground sample distance (GSD) visible and near-infrared imagery and 0.8 m GSD panchromatic imagery available for purchase from DMCii.

TripleSat is also known as DMC-3 or Beijing-2. A fourth identical satellite, SSTL-S1, launched in 2018. The imaging capacity of SSTL-S1 is also being leased to 21AT.

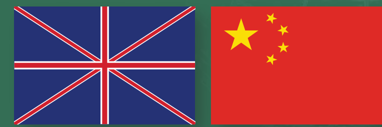
Sir Martin Sweeting with DMC3/TripleSat Satellites, 2015 (image from SSTL, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

	TripleSat-1 to 3	SSTL-S1-4
Launch date	07/10/2015	09/16/2018
Design lifetime	7 years	
Platform owner	DMCii	
Altitude	651 km	
Orbit period	97.7 min	
Inclination	98.1°	
Crossing time	10:30 DN	
Nadir repeat	1 day	
Status	Operational	
System website	https://www.intelligence-airbusds.com/en/8079-triplesat	

SSTL-S1 (1-4)/DMC-3—Continued

United Kingdom, China
Commercial
Operational



Sensor Information

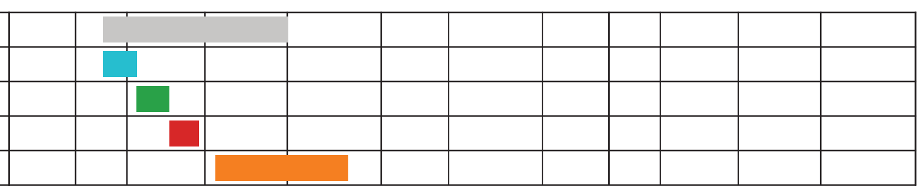
	VHRI-100
GSD (m)	0.8/3.2
Swath (km)	23.8
Data portal	http://www.21at.com.cn/en/Imagery/OnlinePortal/

A 1-meter resolution pan-sharpened image is an extract showing Sydney Airport acquired by DMC3/TripleSat satellite, 2015 (image from SSTL, used with permission).

VHRI-100

The VHRI is a modified Newtonian telescope. VHRI-100 is the next generation of the VHRI imager flown on NigeriaSat-2. Data are available commercially through 21AT.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.725	1.000	0.8
Blue	0.450	0.485	0.520	3.2
Green	0.520	0.560	0.600	3.2
Red	0.600	0.640	0.680	3.2
NIR	0.730	1.015	1.300	3.2



StriX SAR Constellation

Japan
Commercial
Future

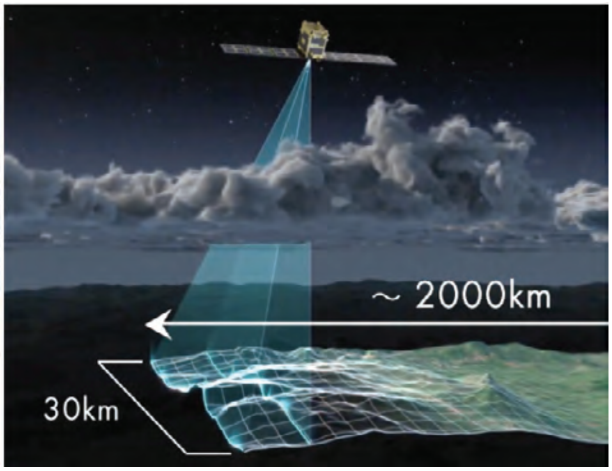
Platform Overview

StriX-α is a synthetic aperture radar (SAR) technology demonstration satellite developed by Synspective, Inc., of Japan to be launched on Rocket Lab's Electron rocket in 2020–21 for day/night Earth monitoring. The planned constellation is to consist of 25 satellites with 6 satellites to be launched by 2022 to achieve daily coverage. The StriX satellites carry an X-band SAR (X-SAR) for high-resolution radar imaging from a sun-synchronous orbit.

StriX satellite model (image from Synspective, Inc.).

[Abbreviations in tables: —, no data; GSD, ground sample distance; m, meter; km, kilometer; V, vertical]

Launch date	2020
Design lifetime	5 years
Platform owner	Synspective, Inc.
Altitude	—
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Planned
System website	https://synspective.com/satellite



Coverage of the X-SAR on a StriX satellite (image from Synspective, Inc.).

Sensor Information

	X-SAR
GSD (m)	1
Swath (km)	30
Data portal	—

X-SAR

The X-SAR was built by Synspective, Inc.

Beam mode	Polarization	Nominal swath width (km)	Approximate resolution (m)
Strip map	VV	30	3
Sliding spotlight		10	1

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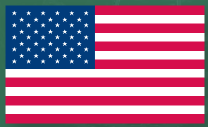
Suomi NPP, NOAA-20, JPSS-2 to -4

United States
Civil/Government
Operational/Future



Platform Overview

The Suomi National Polar-orbiting Partnership (NPP) is a low-resolution satellite launched in 2011 on a Delta-II rocket to serve as a gap filler between the National Oceanic and Atmospheric Administration (NOAA) Polar Operational Environmental Satellites and the new NOAA Joint Polar Satellite System (JPSS) satellites and to provide continuity to the National Aeronautics and Space Administration's (NASA's) Earth Observing System mission observations.

Nearly identical to Suomi NPP, NOAA-20 is the second satellite in the JPSS mission series. NOAA-20, designated JPSS-1 prior to launch, was launched in 2017 by NOAA on a Delta-II rocket for Earth resources monitoring. Suomi NPP and NOAA-20 were built by Ball Aerospace and Technologies Corp. for NOAA and use the BCP-2000 bus like the KEPLER and Quickbird satellites. JPSS-2, -3, and -4 will feature similar instruments and are scheduled to launch in 2021, 2026, and 2031, respectively. These satellites carry the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument for land imaging as well as several atmospheric measurement instruments.

Artistic rendering of NOAA-20 satellite in orbit (image from NOAA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; AN, ascending node; GSD, ground sample distance; m, meter; Pan DNB, panchromatic day night band; CA, coastal aerosol; NIR, near infrared, SWIR, shortwave infrared, MWIR, midwave infrared, TIR, thermal infrared]

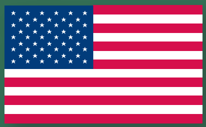
	Suomi NPP	NOAA-20	JPSS-2	JPSS-3	JPSS-4
Launch date	10/28/2011	11/18/2017	2021 (Planned)	2026 (Planned)	2031 (Planned)
Design lifetime	7 years				
Platform owner	NOAA, NASA				
Altitude	824 km				
Orbit period	101 min				
Inclination	98.74°				
Crossing time	10:30 DN	13:30 AN			
Nadir repeat	16 days	20 days			
Status	Operational	Development			
System website	http://www.jpss.noaa.gov/				

Sensor Information

	VIIRS
GSD (m)	375, 750
Swath (km)	3,000
Data Portal	https://www.nnvl.noaa.gov/view/globaldata.html

Suomi NPP, NOAA-20, JPSS-2 to -4—Continued

United States
Civil/Government
Operational/Future

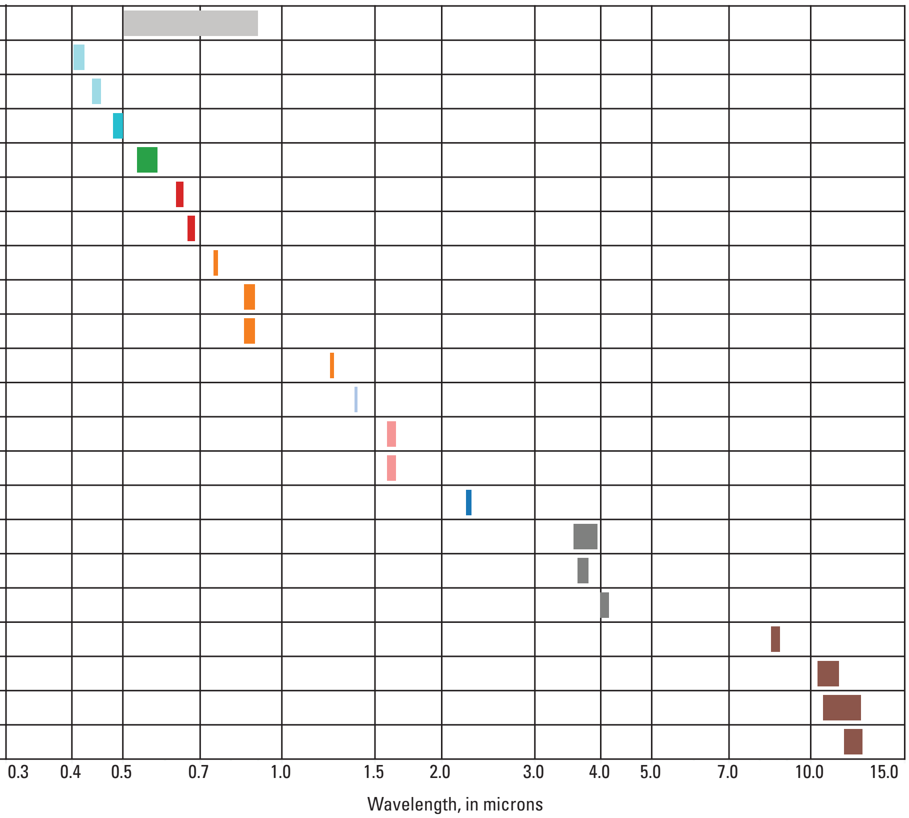


VIIRS

The VIIRS is a proven design from Raytheon. It combines technology developed in the Moderate-Resolution Imaging Spectroradiometer and SeaWiFS sensors. The ground sample distance, swath width, and operating model remain the same as the previous version of this sensor. Data are available in two sets of records called environmental data records produced by NOAA, and Earth System Data Records produced by NASA. VIIRS also includes a panchromatic Day/Night Band (DNB) that is capable of detailed night imaging. This DNB improves upon the heritage of similar bands aboard the Defense Meteorological Support Program satellites. VIIRS data are freely available.

NOAA-20 VIIRS image showing one of the largest wildfires in California history (image from NOAA).

Band	Lower	Center	Upper	GSD (m)
Pan DNB	0.500	0.700	0.900	750
CA	0.402	0.412	0.422	750
CA	0.436	0.445	0.454	750
Blue	0.478	0.488	0.498	750
Green	0.530	0.555	0.580	750
Red	0.630	0.640	0.650	375
Red	0.662	0.672	0.682	750
NIR	0.739	0.746	0.754	750
NIR	0.846	0.865	0.885	375
NIR	0.846	0.865	0.885	750
NIR	1.230	1.240	1.250	750
Cirrus	1.371	1.378	1.386	750
SWIR 1	1.580	1.610	1.640	375
SWIR 1	1.580	1.610	1.640	750
SWIR 2	2.225	2.250	2.275	750
MWIR	3.550	3.740	3.930	750
MWIR	3.610	3.700	3.790	375
MWIR	3.973	4.050	4.128	750
TIR	8.400	8.550	8.700	750
TIR	10.263	10.763	11.263	750
TIR	10.500	11.450	12.400	375
TIR	11.538	12.013	12.488	750



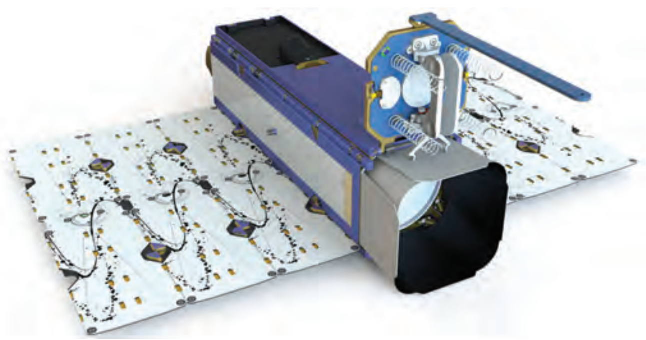
SuperDove

United States
Commercial
Operational/Future

Platform Overview

SuperDoves are next-generation satellites developed by Planet, Inc., for Earth resources monitoring. The first flock of SuperDoves was launched in early 2019. The SuperDoves carry modified PlanetScope imagers with eight spectral bands. Flock-4a (20 satellites) is the first batch of SuperDove satellites launched by Planet, Inc., in April 2019 on Indian Space Research Organization's Polar Satellite Launch Vehicle (PSLV) from the Satish Dhawan Space Center.

Flock-4p (12) is the second batch of SuperDove satellites launched by Planet, Inc., in November 2019 on Indian Space Research Organization's PSLV from the Satish Dhawan Space Center. A fleet of Flock-4v satellites is planned for launch in March 2020.



A model of the SuperDove satellite (image from Planet, Inc.).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; SD PS, SuperDove Planet Scope; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared]

	Flock-4a	Flock-4p
Launch date	04/01/2019	11/27/2019
Design lifetime	3 years	
Platform owner	Planet, Inc.	
Altitude	515 km	
Orbit period	94.8 min	
Inclination	97.5°	
Crossing time	10: 30 DN	
Nadir repeat	—	
Status	Operational	
System website	https://www.planet.com	

Sensor Information

	SD PS
GSD (m)	03/06/2012
Swath (km)	36
Data portal	https://www.planet.com/products/planet-imagery/

JACIE

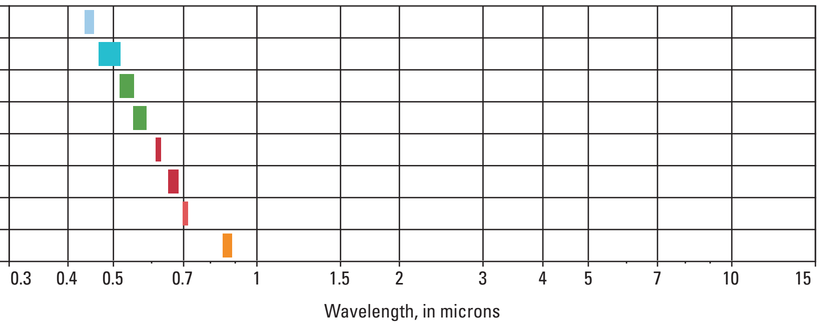
SuperDove—Continued

United States
Commercial
Operational/Future

SuperDove Planet Scope

Planet Scope imagers on SuperDove satellites have improvements in spectral, spatial, and temporal capabilities. The SuperDove constellation can provide daily revisits of any location on the Earth.

Band	Lower	Center	Upper	GSD (m)
CA	0.433	0.443	0.453	12
Blue	0.465	0.490	0.515	3
Green-1	0.513	0.531	0.549	3
Green-2	0.547	0.565	0.583	3
Yellow	0.613	0.620	0.628	6
Red	0.650	0.665	0.681	3
Red Edge	0.698	0.705	0.713	6
NIR	0.845	0.865	0.885	6



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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SuperView-1 (GaoJing-1)

China
Commercial
Operational

Platform Overview

SuperView-1 is a high-resolution commercial satellite constellation planned by Beijing Space View Technology Company, Ltd. (Space View), of China for Earth resources monitoring. A total of four satellites, SuperView-1 01 and 02 and SuperView-1 03 and 04, were launched in 2016 and 2017, respectively, on Long March rockets from the Taiyuan Satellite Launch Center. The satellites are phased 90 degrees in relation to each other in a sun-synchronous orbit, providing a revisit of 2 days for imaging any point on the Earth. They each carry a panchromatic camera and multispectral camera for Earth imaging.

The planned SuperView-1 constellation network of 24 satellites is expected to be built by 2022. SuperView-1 satellites are operated by Siwei Star Company, Ltd., of China, and data are distributed by Space View.

A model of the SuperView-1 satellite (image from Beijing Space View Technology Company, Ltd.).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

	SuperView-1 01 and 02	SuperView-1 03 and 04
Launch date	12/28/2016	01/09/2018
Design lifetime	8 years	
Platform owner	Space View	
Altitude	530 km	
Orbit period	95.2 min	
Inclination	97.5°	
Crossing time	10:30 DN	
Nadir repeat	—	
Status	Operational	
System website	http://www.spaceview.com/SuperView-1English/index.html	

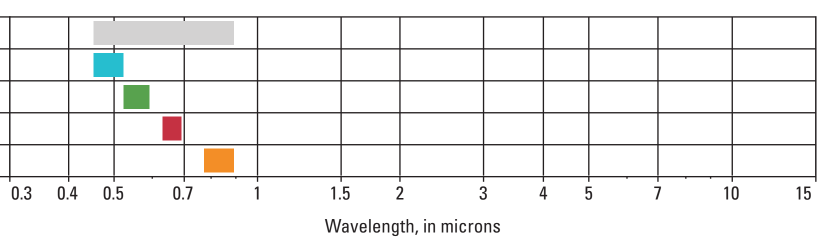
Sensor Information

	SuperView Imager
GSD (m)	0.5/2
Swath (km)	12
Data portal	https://spaceview.com

SuperView Imager

The imager on SuperView-1 satellites is a pushbroom imager in panchromatic, visible, and near-infrared regions.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.670	0.890	0.5
Blue	0.450	0.485	0.520	2
Green	0.520	0.555	0.590	2
Red	0.630	0.660	0.690	2
NIR	0.770	0.830	0.890	2



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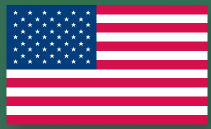
Surface Biology and Geology Mission

United States
Civil/Government
Future



Platform Overview

The Surface Biology and Geology (SBG) mission concept is for a medium-resolution hyperspectral and multispectral satellite estimated to be launched in 2027 by the National Aeronautics and Space Administration (NASA) for the study of Earth surface biology, geology, and natural disaster monitoring. SBG currently (2020) is in conceptual development. SBG is expected to carry the visible shortwave infrared (VSWIR) and thermal infrared (TIR) sensors for medium resolution land imaging, roughly 30-60 meter spatial resolution, band dependent.

[Abbreviations in tables: km, kilometer; —, no data; °, degree; DN, descending node; GSD, ground sample distance; m, meter; Hyper, hyperspectral; MWIR, midwave infrared; TIR, thermal infrared]

Launch date	2027 (Planned)
Design lifetime	3 years
Platform owner	NASA
Altitude	626 km
Orbit period	—
Inclination	98°
Crossing time	11:00 DN
Nadir repeat	19 days
Status	Concept
System website	https://hyspiri.jpl.nasa.gov/

Artistic rendering of HyspIRI, an early development, conceptual sensor precursor to the SBG mission (image from NASA).

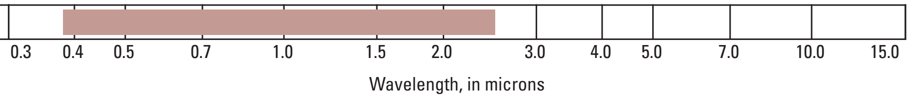
Sensor Information

	VSWIR	TIR
GSD (m)	30-45, 40-60m	
Swath (km)	185	
Data portal	—	

VSWIR

The VSWIR Imaging Spectrometer is a hyperspectral imager with a wide spectral range.

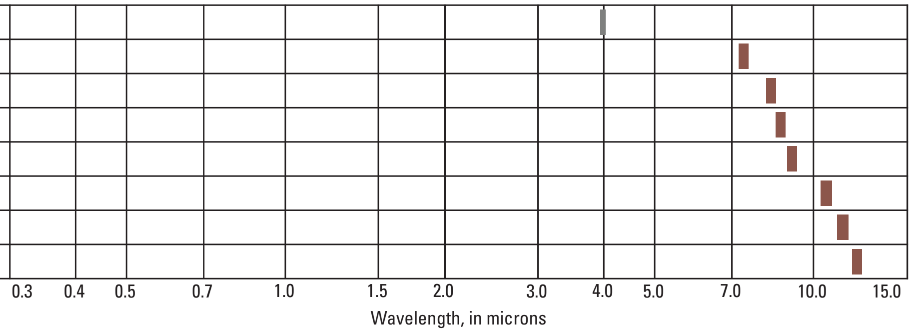
Band	Lower	Center	Upper	GSD (m)
Hyper	0.380	1.445	2.510	60



TIR

The TIR is a multispectral infrared imager with a wide swath operating in the thermal part of the spectrum.

Band	Lower	Center	Upper	GSD (m)
MWIR	3.940	3.982	4.024	60
TIR	7.190	7.350	7.509	60
TIR	8.107	8.279	8.450	60
TIR	8.455	8.628	8.801	60
TIR	8.894	9.074	9.254	60
TIR	10.258	10.528	10.798	60
TIR	11.060	11.330	11.600	60
TIR	11.790	12.050	12.310	60



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SWOT

United States, France
Civil/Government
Future

Platform Overview

The Surface Water Ocean Topography (SWOT) mission is a wide-swath altimeter satellite to be launched in 2021 by the National Aeronautics and Space Administration (NASA) and French National Centre for Space Studies (CNES) on a Falcon 9 launch vehicle from Vandenberg Air Force Base in California for monitoring local sea level changes along coasts. The SWOT mission is also supported by the Canadian Space Agency and United Kingdom Space Agency. The spacecraft bus for SWOT was provided by CNES and has heritage of technologies developed through the CNES Incitation à l'utilisation Scientifique des Images Spot program. SWOT carries the Ka-band Radar Interferometer (KaRIn), Jason-class Altimeter, and a Microwave Radiometer for medium-resolution imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; —, no data; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

Launch date	September 2021 (Planned)
Design lifetime	3 years
Platform owner	NASA/CNES
Altitude	890 km
Orbit period	102.78 min
Inclination	77.6°
Crossing time	—
Nadir repeat	21 days
Status	Development
System website	https://swot.jpl.nasa.gov/

Artistic rendering of SWOT in orbit (image from CNES/DUCROS David, 2015, used with permission).

Sensor Information

	KaRIn
GSD (m)	5–1,000 (selectable)
Swath (km)	120 (combined)
Data portal	—

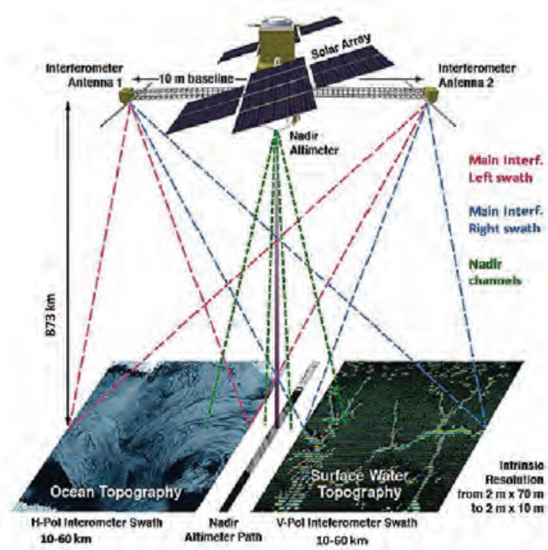


Illustration of the KaRIn instrument operation (image from NASA).

KaRIn

KaRIn was developed at NASA's Jet Propulsion Laboratory and was based on heritage of ERS-1, TOPEX/Poseidon, ERS-2, Jason-1, Envisat, and Jason-2. KaRIn operates in the Ka-band at 35.75 gigahertz (λ = 0.84 centimeter).

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Left swath	Single	HH	50	5 x 10–70
Right swath	Single	VV	50	5 x 10–70

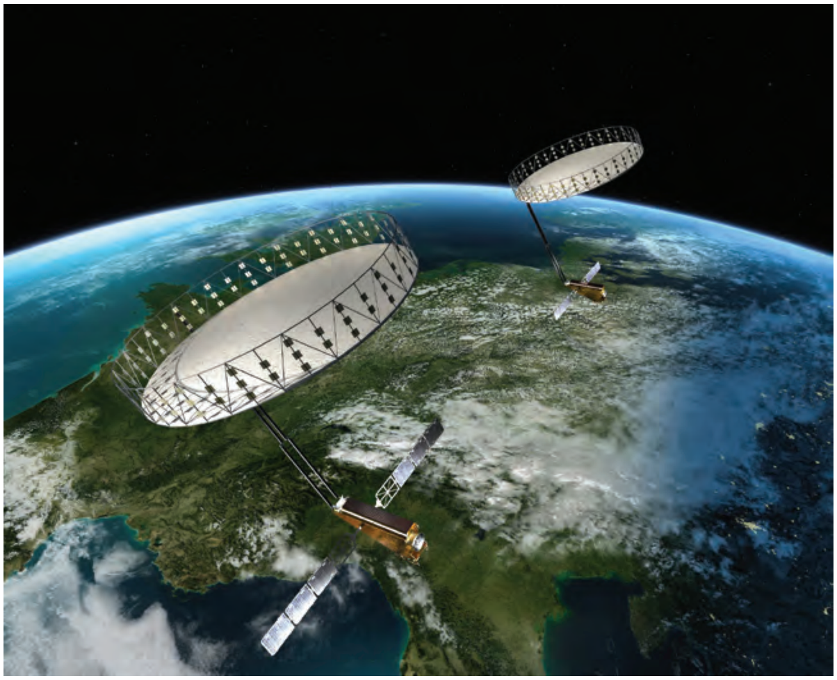
JACIE

TanDEM-L

Germany
Civil/Government
Future

Platform Overview

TanDEM-L is a multiresolution synthetic aperture radar (SAR) satellite to be launched by German Aerospace Center (DLR) for creating detailed digital elevation models. TanDEM-L is a follow-on mission to the TanDEM-X mission launched in 2010. TanDEM-L will carry an L-band synthetic aperture radar (L-SAR) instrument for collecting SAR data.



Artistic rendering of TanDEM-L in orbit (image from DLR).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter; —, no data]

Launch date	2022 (Planned)
Design lifetime	10 years
Platform owner	DLR
Altitude	745 km
Orbit period	99.72 min
Inclination	98.4°
Crossing time	18:00
Nadir repeat	16 days
Status	Planned
System website	https://www.dlr.de/hr/en/desktopdefault.aspx/tabid-8113/

Sensor Information

	L-SAR
GSD (m)	1
Swath (km)	350
Data portal	—

L-SAR

The L-SAR instrument in the L-band has a center frequency of 1.5 gigahertz ($\lambda = 20.0$ centimeter). The angle of incidence is 26.3–47.0 degrees. Details of beam modes currently (2020) are not available.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
—	—	—	—	—

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TeLEOS

Singapore
Commercial
Operational/Future

Platform Overview

TeLEOS is a commercial Earth observation mission of Singapore developed by ST Electronics, the electronics arm of Singapore Technologies Engineering, Ltd. (STEE). The system currently has an optical satellite (TeLEOS-1) in operations and a synthetic aperture radar (SAR) satellite (TeLEOS-2) under development.

TeLEOS-1 is a high-resolution panchromatic (Pan) satellite launched in 2015 on the Indian Space Research Organization's Polar Satellite Launch Vehicle-C29 mission for STEE for Earth resources monitoring. The minisatellite was developed by ST Electronics. STEE is the owner and operator of the satellite. TeLEOS-1 carries a high-resolution Pan imager.

TeLEOS-2 is a high-resolution SAR satellite being developed by STEE of Singapore in partnership with Defence Science and Technology. The satellite is the second in the TeLEOS constellation intended to provide day/night imaging capability.

[Abbreviations in tables: km, kilometer; —, no data; min, minute; °, degree; GSD, ground sample distance; m, meter]

	TeLEOS-1	TeLEOS-2
Launch date	12/16/2015	2021
Design lifetime	5 years	
Platform owner	STEE	
Altitude	550 km	—
Orbit period	96 min	—
Inclination	15°	—
Crossing time	—	—
Nadir repeat	—	—
Status	Operational	Planned
System website	—	—

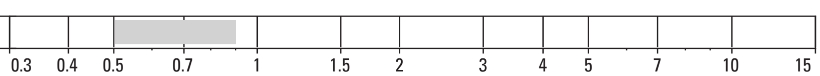
Sensor Information

	Pan	SAR
GSD (m)	1	1
Swath (km)	12	—
Data portal	—	

Pan Camera

The Pan camera on TeLEOS-1 has a swath of 12 kilometers with a dynamic range of 10 bits. It has a ground resolution of 1 meter at nadir.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.500	0.700	0.900	1



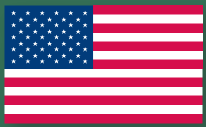
SAR

TeLEOS-2 SAR is under development. Details are not available at this point.

JACIE

Terra

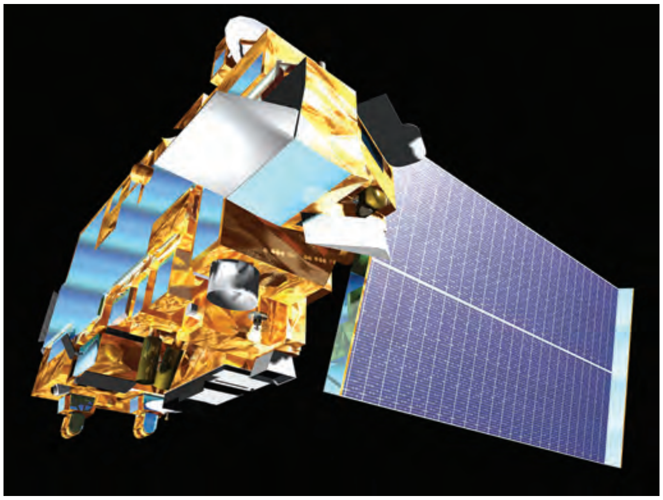
United States
Civil/Government
Operational



Platform Overview

Terra is an Earth observation mission with five sensors that monitor Earth's air, ocean, land, and overall energy exchange. It was launched in 1999 by National Aeronautics and Space Administration (NASA) on an Atlas Centaur II expendable launch vehicle from Vandenberg Air Force Base in California. Formerly named Earth Observing System (EOS) AM-1 signifying its morning crossing time, Terra is the flagship mission of the EOS.

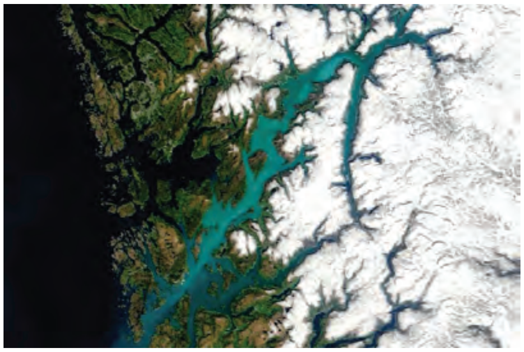
The Terra satellite was built by NASA on the spacecraft bus designed by Lockheed Martin Missiles and Space with five instruments on board: Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Clouds and Earth's Radiant Energy System (CERES), Multi-angle Imaging Spectroradiometer (MISR), Measurements of Pollution in the Troposphere (MOPITT), and Moderate Resolution Imaging Spectroradiometer (MODIS). ASTER and MODIS are the land imaging instruments included here.



Artistic rendering of Terra in orbit (image from NASA).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared; CA, coastal aerosol; MWIR, midwave infrared; WV, water vapor]

Launch date	12/18/1999
Design lifetime	6 years
Platform owner	NASA
Altitude	705 km
Orbit period	98.8 min
Inclination	98.3°
Crossing time	10:30 DN
Nadir repeat	16 days
Status	Operational
System website	https://terra.nasa.gov/



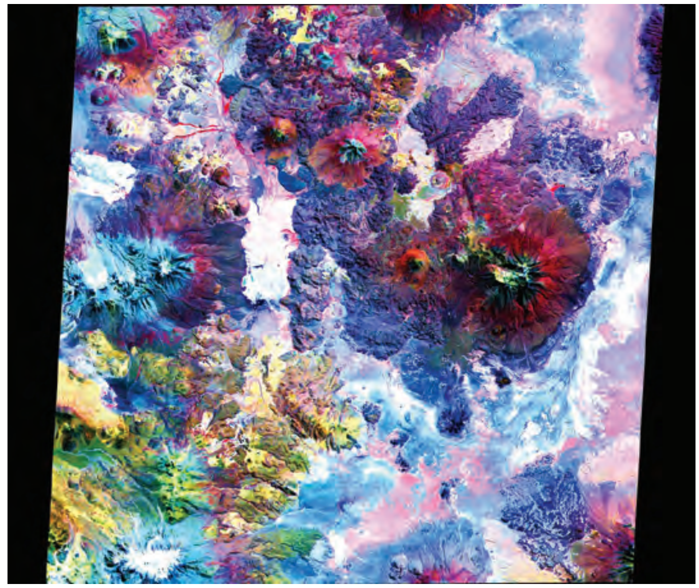
A vivid phytoplankton bloom colored the surface waters of the country's second-longest fjord. Terra MODIS image taken May 30, 2020, in southern Norway (image from NASA).

Terra—Continued

United States
Civil/Government
Operational

Sensor Information

	ASTER	MODIS
GSD (m)	15/30/90	250/500/1,000
Swath (km)	60	2,230
Data portal	https://earthexplorer.usgs.gov/ https://glovis.usgs.gov/app	

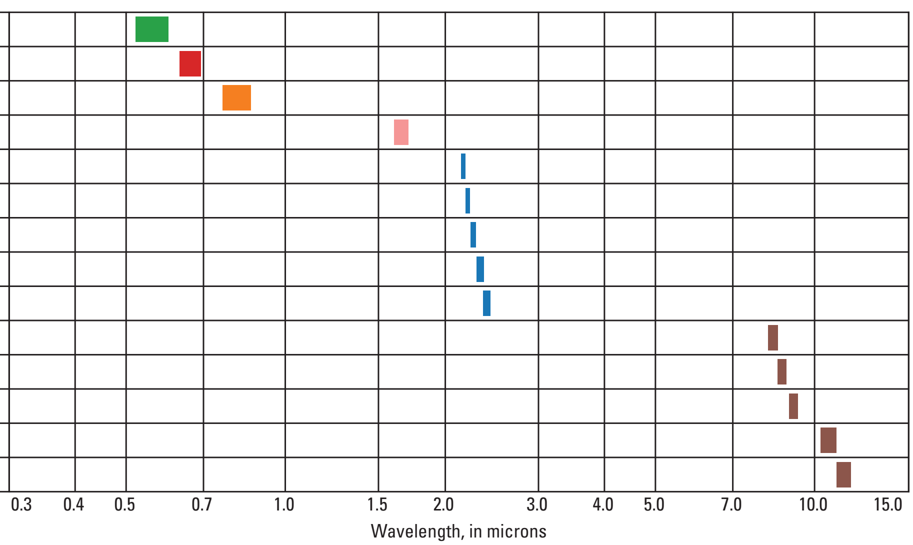


ASTER image of the Andes Mountains (image from NASA).

ASTER

The ASTER sensor is a cooperative effort between NASA and Japan's Ministry of Economy Trade and Industry. ASTER on Terra captures images in 14 spectral bands from visible to thermal infrared and provides stereo capability for digital elevation modeling. The swath width is 60 kilometers (km) with a ground sample distance of 15 meters (m) in visible and near infrared (VNIR), 30 m in shortwave infrared (SWIR), and 90 m in thermal infrared (TIR). Beginning in 2008, ASTER SWIR imagery began to degrade and in January of 2009 the mission managers declared that the SWIR detectors were no longer functioning and no further actions were being taken. Data are available for free download to all the customers.

Band	Lower	Center	Upper	GSD (m)
Green	0.520	0.560	0.600	15
Red	0.630	0.660	0.690	15
NIR	0.760	0.810	0.860	15
SWIR 1	1.600	1.650	1.700	30
SWIR 2	2.145	2.165	2.185	30
SWIR 2	2.185	2.205	2.225	30
SWIR 2	2.235	2.260	2.285	30
SWIR 2	2.295	2.330	2.365	30
SWIR 2	2.360	2.395	2.430	30
TIR	8.125	8.300	8.475	90
TIR	8.475	8.650	8.825	90
TIR	8.925	9.100	9.275	90
TIR	10.250	10.600	10.950	90
TIR	10.950	11.300	11.650	90



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Terra—Continued

United States
Civil/Government
Operational

MODIS

MODIS is a proven design built by NASA's Goddard Space Flight Center heritage of High Resolution Infrared Radiation Sounder, Landsat Thematic Mapper and Nimbus-7 Coastal Zone Color Scanner. MODIS, onboard both the Terra and Aqua satellites, is a 36-band spectroradiometer measuring visible, shortwave, and thermal infrared radiation. This sensor provides a swath width of 2,300 km with a ground sample distance of 250 m (2 bands), 500 m (5 bands), and 1,000 m (29 bands). Imagery is collected in VNIR through TIR and data are available with no cost or restrictions.

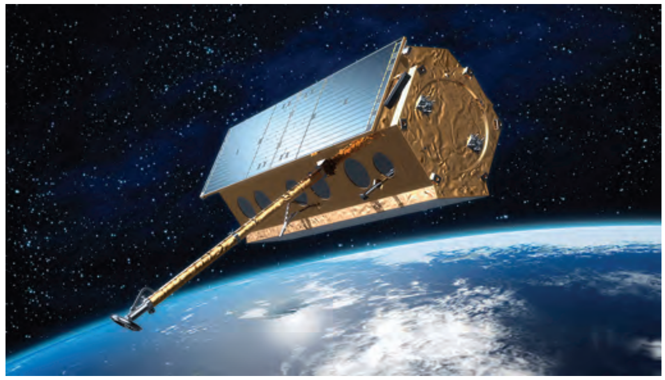
Band	Lower	Center	Upper	GSD (m)
CA	0.405	0.413	0.420	1,000
CA	0.438	0.443	0.448	1,000
Blue	0.459	0.469	0.479	500
Blue	0.483	0.488	0.493	1,000
Blue	0.526	0.531	0.536	1,000
Green	0.545	0.555	0.565	500
Green	0.546	0.551	0.556	1,000
Red	0.620	0.645	0.670	250
Red	0.662	0.667	0.672	1,000
Red	0.673	0.678	0.683	1,000
NIR	0.743	0.748	0.753	1,000
NIR	0.841	0.859	0.876	250
NIR	0.862	0.870	0.877	1,000
NIR	0.890	0.905	0.920	1,000
NIR	0.915	0.940	0.965	1,000
NIR	0.931	0.936	0.941	1,000
NIR	1.230	1.240	1.250	500
Cirrus	1.360	1.375	1.390	1,000
SWIR 1	1.628	1.640	1.652	500
SWIR 2	2.105	2.130	2.155	500
MWIR	3.660	3.750	3.840	1,000
MWIR	3.929	3.959	3.989	1,000
MWIR	4.020	4.050	4.080	1,000
MWIR	4.433	4.466	4.498	1,000
MWIR	4.482	4.516	4.549	1,000
WV-1	6.535	6.715	6.895	1,000
WV-2	7.175	7.325	7.475	1,000
TIR	8.400	8.550	8.700	1,000
TIR	9.580	9.730	9.880	1,000
TIR	10.780	11.030	11.280	1,000
TIR	13.185	13.335	13.485	1,000
TIR	13.485	13.635	13.785	1,000
TIR	13.785	13.935	14.085	1,000
TIR	14.085	14.235	14.385	1,000

TerraSAR-X and TanDEM-X

Germany
Civil/Government
Operational

Platform Overview

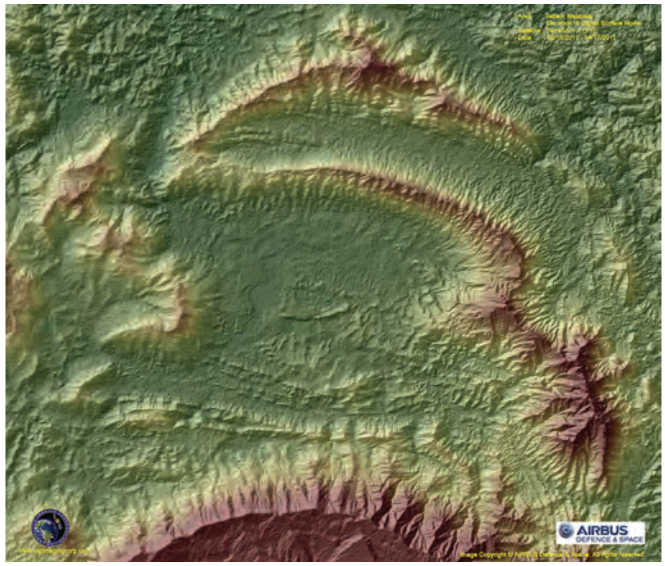
TerraSAR-X (TSX) is a multiresolution synthetic aperture radar (SAR) satellite launched in 2007 by the German Aerospace Centre (DLR) on a Dnepr-1 launch vehicle from the Russian Cosmodrome, Baikonur, Kazakhstan, for Earth resources monitoring. TSX was built by Airbus Defence and Space GmbH and uses the proven AstroSat-1000 bus. TanDEM-X (TDX) is a follow-on mission to TerraSAR-X launched in 2010 to improve digital elevation models (DEMs). The two satellites carry identical instruments. TSX and TDX carry the TSX-SAR and TDX-SAR instruments, respectively, for collecting SAR data. Tandem-X DEM 90-m data are available free of charge for scientific purposes.



Artistic rendering of TerraSAR-X in orbit (image from DLR).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; AN, ascending node; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	TerraSAR-X	TanDEM-X
Launch date	06/15/2007	06/21/2010
Design lifetime	5 years	
Platform owner	DLR	
Altitude	514 km	
Orbit period	94.85 min	
Inclination	97.44°	
Crossing time	18:00 AN	
Nadir repeat	11 days	
Status	Operational	
System website	https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10377/	



TerraSAR-X elevation data of Sabah, Malaysia (image from Airbus DS, used with permission).

Sensor Information

	TSX-SAR
GSD (m)	1–16 (selectable)
Swath (km)	5–1500 (selectable)
Data portal	https://terrasar-x-archive.terrasar.com/

TerraSAR-X and TanDEM-X—Continued

Germany
Civil/Government
Operational

TSX-SAR

The TSX-SAR and TDX-SAR instruments are active phased array X-band antenna systems operating at 9.65 gigahertz (λ = 3.11 centimeters). The angle of incidence is 15–60 degrees.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
Experimental Spotlight	Single	HH, HV, VH, VV	5 x 10	2 x 1
	Dual	—		
Spotlight HS	Single	HH, HV, VH, VV	10 x 10	2 x 1
	Dual	—		
Spotlight SL	Single	HH, HV, VH, VV	5 x 10	1 x 1
	Dual	—		
Stripmap	Single	HH, HV, VH, VV	1,500 x 30	3 x 3
	Dual	—		
ScanSAR	Single	HH, HV, VH, VV	1,500 x 100	16 x 16
	Dual	—		

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THEOS

Thailand
Civil/Government
Operational

Platform Overview

Thailand Earth Observing System (THEOS) is a medium-resolution, panchromatic, and multispectral satellite launched in 2008 on a Dnepr launch vehicle from Yasny/Dombarovsky launch center by Geo-Informatics and Space Technology Development Agency (GISTDA) for Earth observation. THEOS was designed and built by European Aeronautics Defense and Space Astrium SAS of France and utilizes the AstroSat-500 platform. The satellite is of FormoSat-2 heritage and carries the panchromatic (Pan) and multispectral (MS) sensors for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

Launch date	10/01/2008
Design lifetime	5 years
Platform owner	GISTDA
Altitude	822 km
Orbit period	101.4 min
Inclination	98.7°
Crossing time	10:00 DN
Nadir repeat	26 days
Status	Operational
System website	https://www.gistda.or.th/main/en/node/569

Artistic rendering of THEOS in orbit (image from GISTDA, used with permission).

Sensor Information

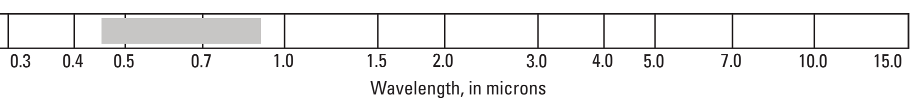
	Pan	MS
GSD (m)	2	15
Swath (km)	22	90
Data portal	—	

Sample THEOS images (image from GISTDA, used with permission).

Pan

The Pan aboard THEOS is a pushbroom-style charge coupled device (CCD) imager.

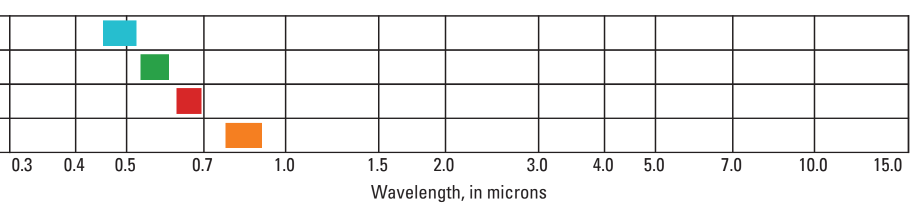
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	2



MS

The MS aboard THEOS is a pushbroom-style CCD imager with four visible and near-infrared bands.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	15
Green	0.530	0.565	0.600	15
Red	0.620	0.655	0.690	15
NIR	0.770	0.835	0.900	15



VENµS

France, Israel
Civil/Government
Operational

Platform Overview

The Vegetation and Environment monitoring on a New MicroSatellite mission (VENµS) is a medium-resolution superspectral satellite launched in 2017 on a Vega launch vehicle from the Guiana Space Center in Kourou, French Guiana, for Earth resources monitoring. The spacecraft was designed and developed by the French National Centre for Space Studies (CNES) and Israel Aerospace Industries, Ltd., (IAI). The satellite will first operate as a science mission (VM1, VENµS Mission 1) aimed at understanding vegetation and water dynamics. The science mission is designed to operate for 2.5 years at an altitude of 720 kilometers (km), and then the satellite will be lowered for 1 year to 410 km and operate as a technology mission (VM2, VENµS Mission 2). The technology mission aims to improve understanding of orbital dynamics and related goals and after an expected time of 6 months will continue imagery acquisition related to science mission goals (VM3, VENµS Mission 3). VENµS carries the VENµS Superspectral Camera (VSSC) for medium-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; CA, coastal aerosol; NIR, near infrared]

Launch date	08/02/2017
Design lifetime	3.5 years
Platform owner	CNES, IAI
Altitude	720/410 km
Orbit period	99.19 min
Inclination	98.28°
Crossing time	10:30 DN
Nadir repeat	2 days
Status	Operational
System website	https://venus.cnes.fr/en/home-41

Sensor Information

	VSSC
GSD (m)	5.3/ 3.0
Swath (km)	27.56
Data portal	—

Artistic rendering of VENµS in orbit (image from IDÉ/SARIAN Robin, 2015, used with permission).

Archipelago of Jardines de la Reina in the Caribbean Sea in Cuba seen by the satellite Venµs (image from CNES, used with permission).

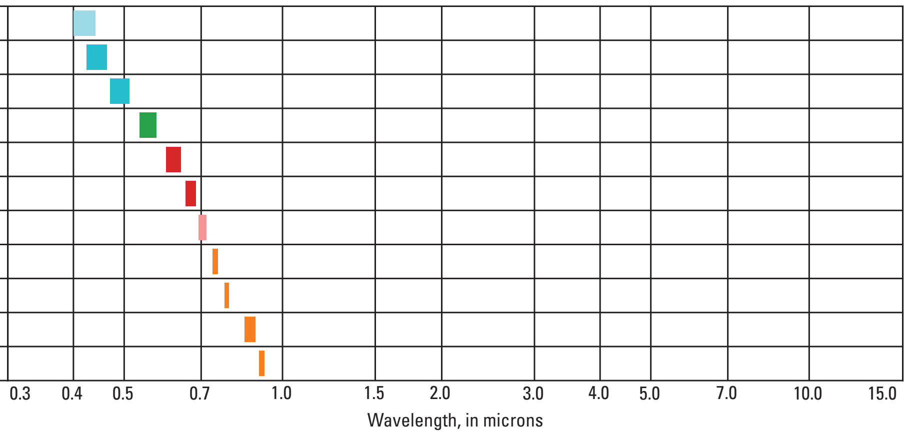
VENμS—Continued

France, Israel
Civil/Government
Operational

VSSC

The VSSC was built by Elbit Systems Electro-Optics of Rehovot, Israel, under contract with CNES.

Band	Lower	Center	Upper	GSD (m)
CA	0.400	0.420	0.440	5.3
Blue	0.423	0.443	0.463	5.3
Blue	0.470	0.490	0.510	5.3
Green	0.535	0.555	0.575	5.3
Red	0.600	0.620	0.640	5.3
Red	0.652	0.667	0.682	5.3
Red Edge	0.690	0.702	0.714	5.3
NIR	0.734	0.742	0.750	5.3
NIR	0.774	0.782	0.790	5.3
NIR	0.845	0.865	0.885	5.3
NIR	0.900	0.910	0.920	5.3



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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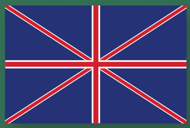
JACIE

Vivid-i 1 to 5

United Kingdom
Commercial
Future



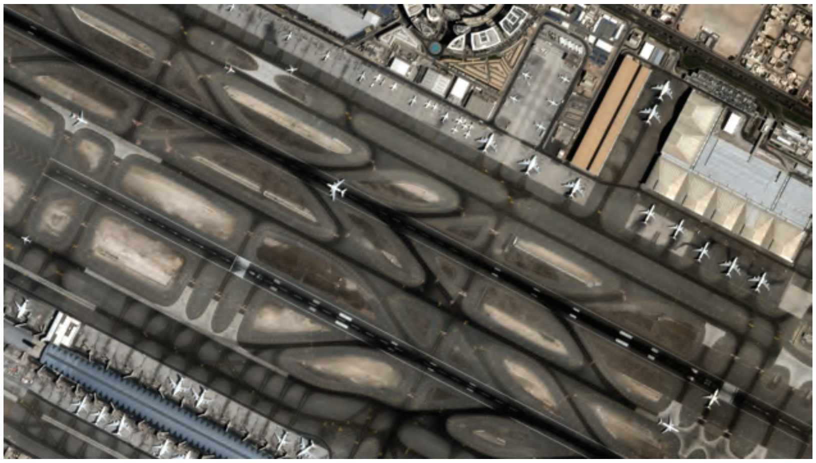
Platform Overview

Vivid-i 1 to 5 are high-resolution multispectral satellites planned to be launched in 2022 by Earth-i for commercial Earth observation. A prototype technology demonstration satellite, VividX2 (also known as Carbonite-2) was launched in January 2018. The Vivid-i satellites are being built by SSTL and are based on the SSTL-X50 platform. The Vivid-i satellites will carry the High-Resolution Imager (HRI) for high-resolution land imaging.

Artistic rendering of a Vivid-i satellite (image from Earth-i, Ltd., used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter]

Launch date	01/12/2018
Design lifetime	5 years
Platform owner	Earth-i
Altitude	500 km
Orbit period	94.36 min
Inclination	97.33°
Crossing time	10:30 DN
Nadir repeat	1 day
Status	Operational
System website	http://earthi.space/



A 1-meter resolution image of Dubai Airport acquired by CARBONITE-2 satellite, 2018 (image from SSTL, used with permission).

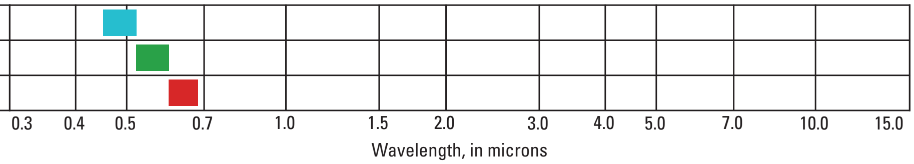
Sensor Information

	HRI
GSD (m)	0.6
Swath (km)	5
Data portal	https://earthi.space/image-data/

HRI

The HRI aboard the Vivid-i satellites is expected to be similar to the imager aboard the VividX2 prototype satellites. HRI data will be commercially available.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	0.6
Green	0.520	0.560	0.600	0.6
Red	0.600	0.640	0.680	0.6



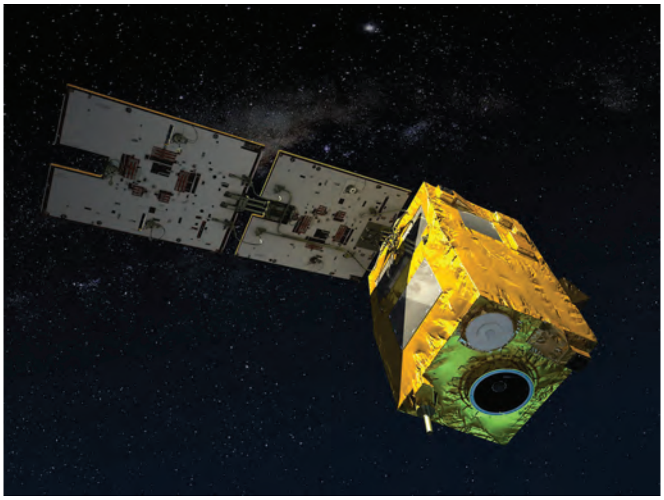
VNREDSat-1A

Vietnam
Civil/Government
Operational

Platform Overview

The Vietnamese Natural Resources, Environment and Disaster Monitoring Satellite-1A (VNREDSat-1A) is a high-resolution, multispectral satellite designed for natural resource, environment, and disaster monitoring. It was launched on a Vega launch vehicle in 2013.

VNREDSat-1A was developed and built by European Aeronautic Defence and Space Company Astrium and is based on the AstroSat-100 bus. It is operated by the Vietnam Academy of Science and Technology (VAST) and is the first Earth Observation satellite for Vietnam. The satellite carries the New AstroSat Optical Modular Instrument (NAOMI), which provides 2.5-meter (m) ground sample distance (GSD) panchromatic and 10-m GSD multispectral imagery available freely to the public.



Artistic rendering of VNREDSat-1A (image from Airbus DS, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared]

Launch date	05/07/2013
Design lifetime	5 years
Platform owner	STI-VAST
Altitude	704 km
Orbit period	98.85 min
Inclination	98.7°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	http://www.sti.vast.ac.vn/en/

Sensor Information

	NAOMI
GSD (m)	2.5/10
Swath (km)	17.5
Data portal	http://datacube.vn/

VNREDSat-1 imagery (image from Airbus DS, used with permission).

JACIE

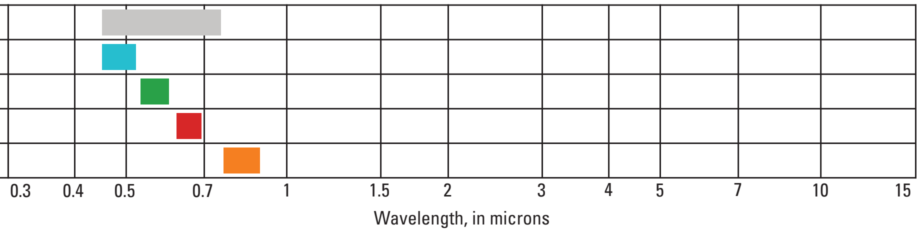
VNREDSat-1A—Continued

Vietnam
Civil/Government
Operational

NAOMI

The NAOMI sensor aboard VNREDSat-1A is based on the instruments of the same name aboard AlSat-2, SSOT, and SPOT-6.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.600	0.750	2.5
Blue	0.450	0.485	0.520	10
Green	0.530	0.565	0.600	10
Red	0.620	0.655	0.690	10
NIR	0.760	0.825	0.890	10



VRSS-1

Venezuela
Civil/Government
Operational

Platform Overview

The Venezuelan Remote Sensing Satellite-1 (VRSS-1) is a medium-resolution multispectral satellite launched on a Long March-2D rocket from Jiuquan Satellite Launch Center. This is the first Earth observing mission for Venezuela, mainly used for resource investigation and urban planning. VRSS-1 was designed and manufactured by China Academy of Space (CAST) for Bolivarian Agency for Space Activities (ABAE) based on the CAST 2000 platform. VRSS-1 carries the Panchromatic and Multispectral Camera (PMC) and Wide-swath Multispectral Camera (WMC) for high- and medium-resolution land imaging, respectively.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

Launch date	09/29/2012
Design lifetime	5 years
Platform owner	ABAE
Altitude	640 km
Orbit period	97.5 min
Inclination	98°
Crossing time	10:30 DN
Nadir repeat	4 days
Status	Operational
System website	http://www.abae.gob.ve/web/VRSS-1.php

Sensor Information

	PMC	WMC
GSD (m)	2.5, 10	16
Swath (km)	57	370
Data portal	—	

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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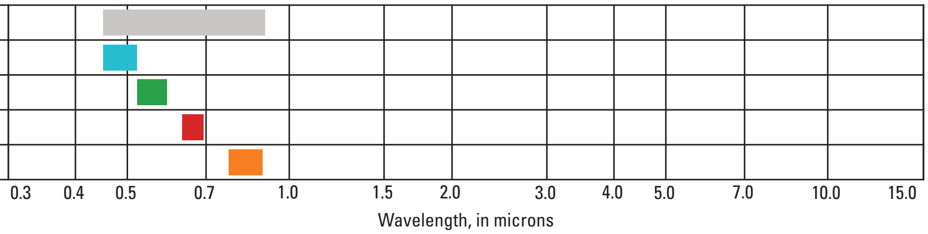
VRSS-1—Continued

Venezuela
Civil/Government
Operational

PMC

The PMC is a set of two imagers with time-delay integration capability (TDI). The combined swath width of both imagers is 57 kilometers.

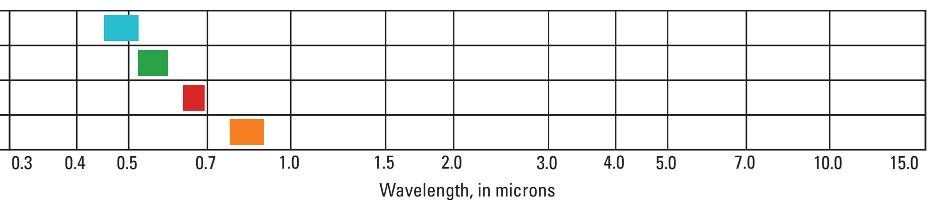
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	2.5
Blue	0.450	0.485	0.520	10
Green	0.520	0.555	0.590	10
Red	0.630	0.660	0.690	10
NIR	0.770	0.830	0.890	10



WMC

The WMC is like PMC with two imagers operating with TDI capability.

Band	Lower	Center	Upper	GSD (m)
Blue	0.450	0.485	0.520	16
Green	0.520	0.555	0.590	16
Red	0.630	0.660	0.690	16
NIR	0.770	0.830	0.890	16



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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VRSS-2

Venezuela
Civil/Government
Operational

Platform Overview

The Venezuelan Remote Sensing Satellite-2 (VRSS-2) is a high-resolution multispectral satellite launched in 2017 on a Long March-2D rocket from Jiuquan Satellite Launch Center. This is the second Earth observing mission for Venezuela, mainly used for resource investigation and urban planning. VRSS-2 was designed and manufactured by China Great Wall Industry Corporation for Bolivarian Agency for Space Activities (ABAE) based on the CAST 2000 platform. VRSS-2 carries the Panchromatic and Multispectral Camera (PMC)-2 and Infrared Camera (IRC) sensors for high- and medium-resolution land imaging, respectively.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared]

Launch date	10/09/2017
Design lifetime	5 years
Platform owner	ABAE
Altitude	645 km
Orbit period	97.62 min
Inclination	98°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	http://www.abae.gob.ve/web/VRSS-2.php

Sensor Information

	PMC-2	IRC
GSD (m)	1, 4	30, 60
Swath (km)	30	30
Data portal	—	

JACIE

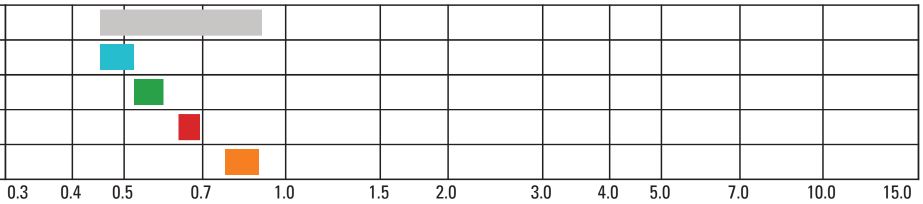
VRSS-2—Continued

Venezuela
Civil/Government
Operational

PMC-2

The PMC-2 is a proven design based on PMC from VRSS-1. PMC-2 has an improved GSD of 4 meters (m) for visible and near infrared and 1 m for panchromatic bands.

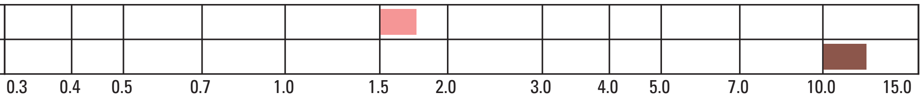
Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.675	0.900	1
Blue	0.450	0.485	0.520	4
Green	0.520	0.555	0.590	4
Red	0.630	0.660	0.690	4
NIR	0.770	0.830	0.890	4



IRC

The IRC is a new design with a capability of observing in the SWIR and TIR parts of the spectrum.

Band	Lower	Center	Upper	GSD (m)
SWIR 1	1.500	1.625	1.750	30
TIR	10.000	11.000	12.000	60



Whitney Constellation

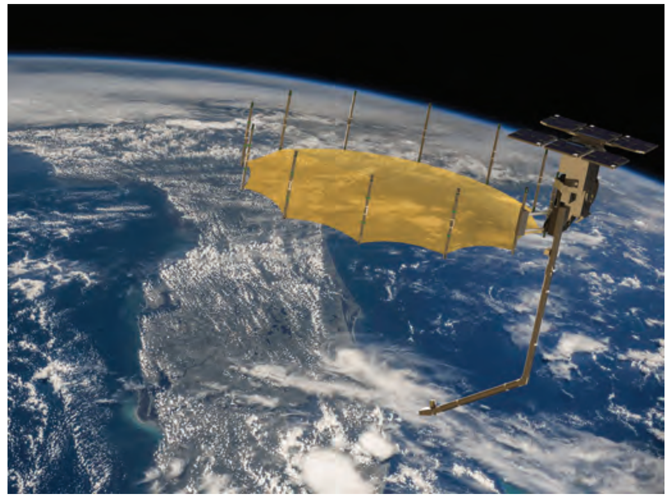
United States
Commercial
Operational/Future

Platform Overview

Denali is a synthetic aperture radar (SAR) technology demonstration satellite launched in 2018 by Capella Space for radar Earth monitoring. Capella Space unveiled a new design for the next batch of operational satellites called the "Whitney Constellation." Sequoia was launched as the first satellite of this constellation and was followed by five more satellites in 2020.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; H, horizontal; V, vertical]

	Denali	Sequoia
Launch date	12/03/2018	2020 (Planned)
Design lifetime	—	
Platform owner	Capella Space	
Altitude	575 km	
Orbit period	96.16 min	
Inclination	97.68°	
Crossing time	10:30 DN	
Nadir repeat	—	
Status	Operations	Planned
System website	https://www.capellaspace.com/	



Capella 1 SAR satellite. (image from Capella Space, used with permission).

Sensor Information

	SAR
GSD (m)	0.5
Swath (km)	7
Data portal	—

SAR

The X-band (9.4–9.9 gigahertz) SAR sensor will provide cloud-free data, which will be commercially available. Beam mode details are shown in the table.

Beam mode	Polarization		Nominal swath width (km)	Approximate resolution (m)
SPOT	Single	HH, VV	5 km	0.3 × 0.5
SITE	Single	HH, VV	5 km	0.5 × 0.5
STRIP	Single	HH, VV	5 km	1.0 × 7.0
SCAN	Single	HH, VV	7 km	2.5 × 1.7

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-EO) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: https://www.usgs.gov/land-resources/eros/calval/jacie

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: https://www.usgs.gov/land-resources/eros/calval/jacie

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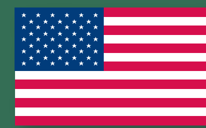
WorldView-1

United States
Commercial
Operational



JACIE

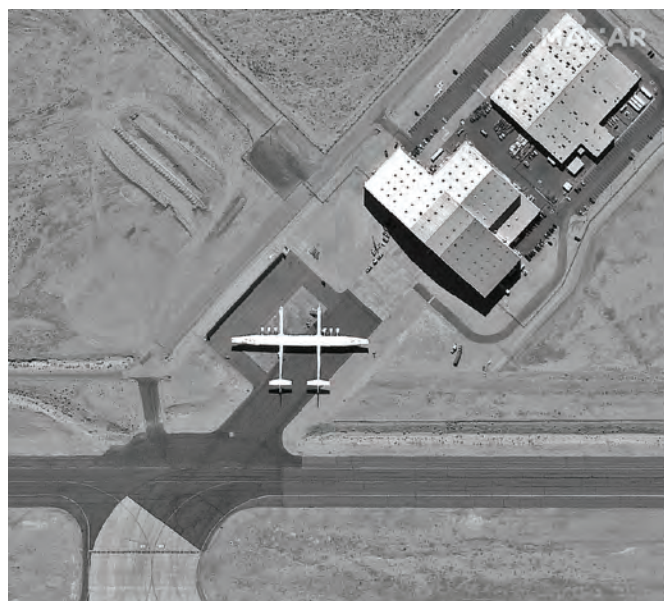
Platform Overview

WorldView-1 (WV-1) is a high-resolution panchromatic satellite launched in 2007 by DigitalGlobe on a Delta-II launch vehicle from Vandenberg Air Force Base for commercial Earth resources monitoring. The WV-1 satellite was designed and built by Ball Aerospace and Technologies Corporation (BATC) in the United States and utilizes the BCP-5000 bus. WV-1 carries the WorldView-60 (WV-60) camera for high-resolution land imaging.

Artistic rendering of WorldView-1 (image from Maxar Technologies, 2019, used with permission).

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic]

Launch date	09/18/2007
Design lifetime	7.5 years
Platform owner	Maxar Technologies, Ltd.
Altitude	496 km
Orbit period	94.6 min
Inclination	97.2°
Crossing time	13:30 DN
Nadir repeat	—
Status	Operational
System website	https://www.digitalglobe.com/about/our-constellation



WorldView-1 image of Stratolaunch in Mojave, California (image from Maxar Technologies, 2019, used with permission).

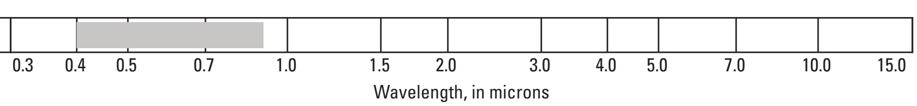
Sensor Information

	WV-60
GSD (m)	0.5
Swath (km)	18
Data portal	—

WV-60

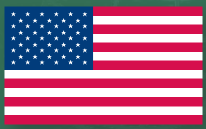
The WV-60 aboard WV-1 was designed and developed by BATC and is of QuickBird heritage. The camera captures high-resolution panchromatic imagery.

Band	Lower	Center	Upper	GSD (m)
Pan	0.400	0.650	0.900	0.5



WorldView-2

United States
Commercial
Operational



Platform Overview

WorldView-2(WV-2) is a high-resolution multi-spectral satellite launched in 2009 by DigitalGlobe on a Delta 7920 from Vandenberg Air Force Base for Earth resources monitoring. This mission continues the WV series that has been in continual operation since the launch of WorldView-1 in 2007. The WorldView-2 satellite was designed and built by Ball Aerospace for DigitalGlobe and uses the BCP-5000 bus. WorldView-2 carries the WorldView-110 camera for high-resolution land imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; Pan, panchromatic; CA, coastal aerosol; NIR, near infrared]

Launch date	10/08/2009
Design lifetime	10–12 years
Platform owner	Maxar Technologies, Ltd.
Altitude	770 km
Orbit period	100.2 min
Inclination	97.8°
Crossing time	10:30 DN
Nadir repeat	—
Status	Operational
System website	https://www.digitalglobe.com/about/our-constellation

At right: Artistic rendering of WorldView-2 (image from Maxar Technologies, 2019, used with permission).

Below: WorldView-2 image of Indian Wells Tennis Garden in Indian Wells, California (image from Maxar Technologies, 2019, used with permission).

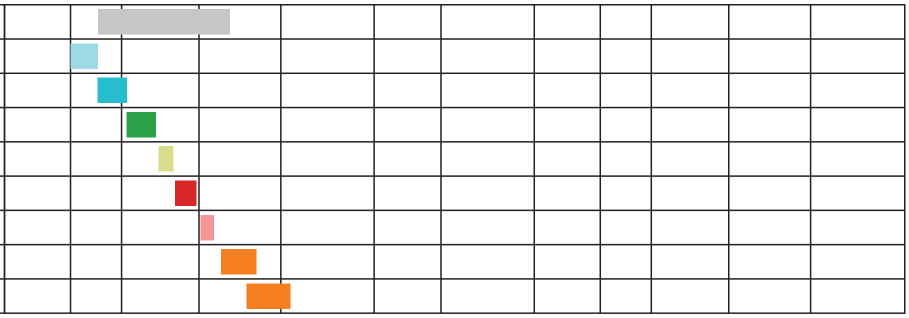
Sensor Information

	WorldView-110
GSD (m)	0.46, 1.85
Swath (km)	16
Data portal	https://discover.digitalglobe.com/

WorldView-110

The WV-110 camera was newly designed and built by ITT Exelis. The new design adds a yellow and red-edge band that previous WV satellites did not have. Data are available to customers through DigitalGlobe's commercial portal.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.625	0.800	0.46
CA	0.400	0.425	0.450	1.85
Blue	0.450	0.480	0.510	1.85
Green	0.510	0.545	0.580	1.85
Yellow	0.585	0.605	0.625	1.85
Red	0.630	0.660	0.690	1.85
Red Edge	0.705	0.725	0.745	1.85
NIR	0.770	0.833	0.895	1.85
NIR	0.860	0.950	1.040	1.85



WorldView-3

United States
Commercial
Operational

Platform Overview

WorldView-3 (WV-3) is a high-resolution multispectral satellite launched in 2014 by the DigitalGlobe on an Atlas V from Vandenberg Air Force Base in California for Earth resource monitoring. WV-3 provides significant technical improvements to previous WorldView satellites, including spectral bands, ground sample distance (GSD), and swath.

The WV-3 satellite was designed and built by Lockheed Martin for the DigitalGlobe Corporation using the BCP-5000 bus with the WorldView-3 Imager and the Clouds, Aerosols, Vapors, Ice and Snow (CAVIS) sensor. The high-resolution WV-3 Imager is the main instrument, with the CAVIS providing additional data on obscurants and other atmospheric effects used in data production.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared; Pan, panchromatic]

Launch date	08/13/2014
Design lifetime	7.25 years
Platform owner	Maxar Technologies, Ltd.
Altitude	620 km
Orbit period	97 min
Inclination	97.9°
Crossing time	10:30 DN
Nadir repeat	5 days
Status	Operational
System website	http://worldview3.digitalglobe.com/

Sensor Information

	CAVIS	WV-3 Imager
GSD (m)	30	0.31/1.24/3.7
Swath (km)	13.1	
Data portal	https://www.digitalglobe.com/products/collection-request	

Artistic rendering of WorldView-3 in orbit (image from Maxar Technologies, 2019, used with permission).

WorldView-3 image of Beijing Daxing International Airport, Beijing, China (image from Maxar Technologies, 2019, used with permission).

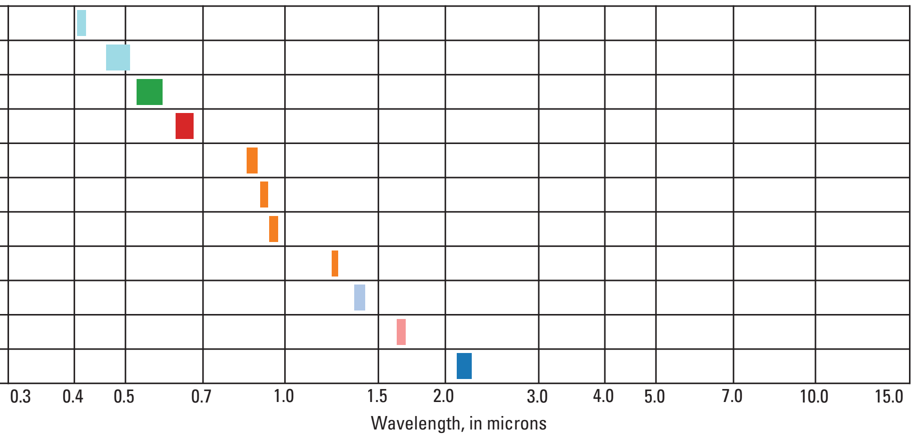
WorldView-3—Continued

United States
Commercial
Operational

CAVIS

The CAVIS instrument on WV-3 provides 12 spectral bands at 30-meter (m) GSD to improve atmospheric corrections and image production. Data from this sensor are not generally available outside of Digital Globe.

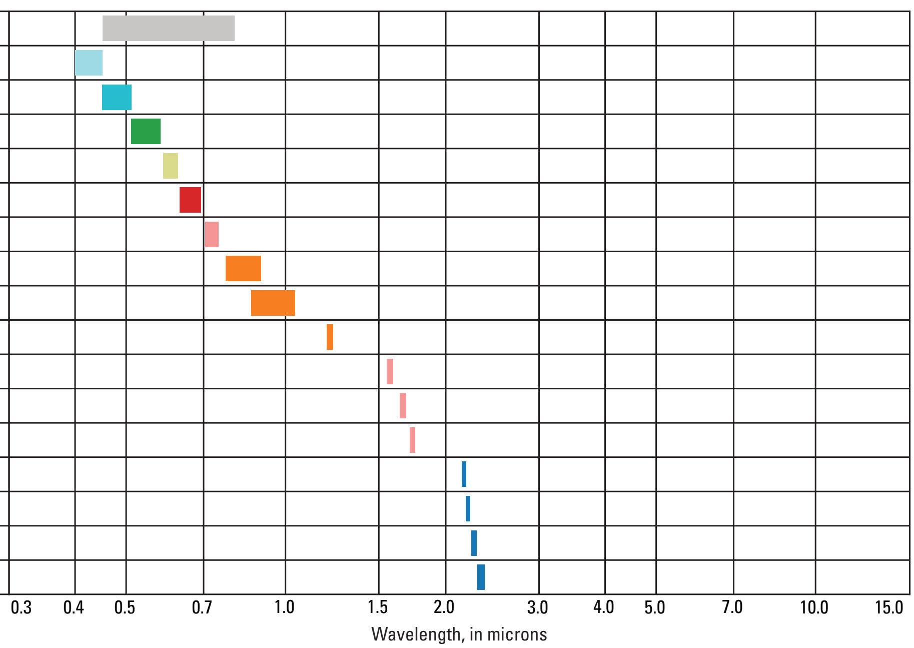
Band	Lower	Center	Upper	GSD (m)
CA	0.405	0.413	0.420	30
CA	0.459	0.484	0.509	30
Green	0.525	0.555	0.585	30
Red	0.620	0.645	0.670	30
NIR	0.845	0.865	0.885	30
NIR	0.897	0.912	0.927	30
NIR	0.930	0.948	0.965	30
NIR	1.220	1.236	1.252	30
Cirrus	1.350	1.380	1.410	30
SWIR 1	1.620	1.650	1.680	30
SWIR 2	2.105	2.175	2.245	30



WV-3 Imager

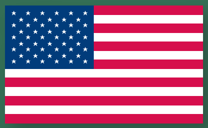
The Imaging sensor aboard WV-3 was built by ITT Exelis. The WV-3 Imager provides the same eight visible and near-infrared (VNIR) bands as WV-2 and adds eight shortwave infrared (SWIR) bands. The GSD is improved to 31 centimeters for panchromatic data, 1.2 m in VNIR, and images at a GSD of 3.7 m in SWIR; however, terms of its licensing as of 2018 require Digital Globe to resample the SWIR data to 7.5-m effective GSD. DigitalGlobe is working with the U.S. Government to revise this restriction so that SWIR data can be distributed at its 3.7-m native resolution.

Band	Lower	Center	Upper	GSD (m)
Pan	0.450	0.625	0.800	0.31
CA	0.400	0.425	0.450	1.24
Blue	0.450	0.480	0.510	1.24
Green	0.510	0.545	0.580	1.24
Yellow	0.585	0.605	0.625	1.24
Red	0.630	0.660	0.690	1.24
Red Edge	0.705	0.725	0.745	1.24
NIR	0.770	0.833	0.895	1.24
NIR	0.860	0.950	1.040	1.24
NIR	1.195	1.210	1.225	3.7
SWIR 1	1.550	1.570	1.590	3.7
SWIR 1	1.640	1.660	1.680	3.7
SWIR 1	1.710	1.730	1.750	3.7
SWIR 2	2.145	2.165	2.185	3.7
SWIR 2	2.185	2.205	2.225	3.7
SWIR 2	2.235	2.260	2.285	3.7
SWIR 2	2.295	2.330	2.365	3.7



WorldView Legion

United States
Commercial
Future

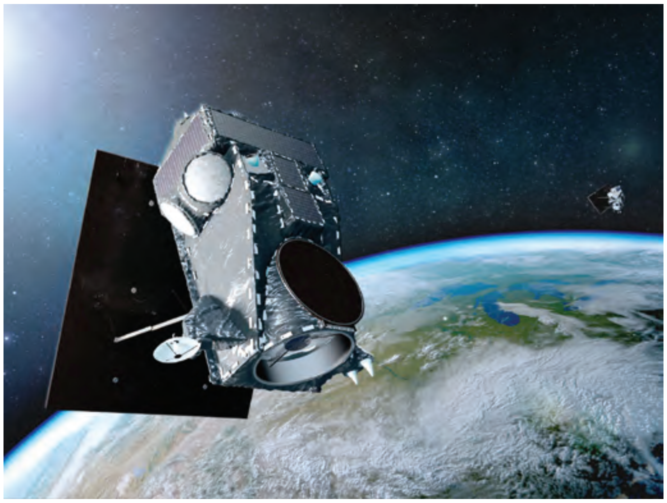


Platform Overview

The WorldView Legion constellation of high-resolution, panchromatic, and multispectral satellites are planned to be launched in 2021 by DigitalGlobe for commercial Earth observation. The satellites will have a mix of mid-latitude and sun-synchronous orbits. In conjunction with the World-View Scout satellites, DigitalGlobe will have the ability to image regions of Earth as many as 40 times daily. Digital-Globe announced the new six-satellite constellation shortly after being acquired by MDA in 2017.

[Abbreviations in tables: km, kilometer; min, minute; —, no data; DN, descending node; m, meter; CA, coastal aerosol; NIR, near infrared]

Launch date	2021 (Planned)
Design lifetime	7.5 years
Platform owner	Maxar Technologies, Ltd.
Altitude	450 km
Orbit period	94 min
Inclination	—
Crossing time	10:30 DN
Nadir repeat	—
Status	Planned
System website	https://www.digitalglobe.com/



Artistic rendering of a WorldView Legion satellite in orbit (image from Maxar Technologies, 2019, used with permission).

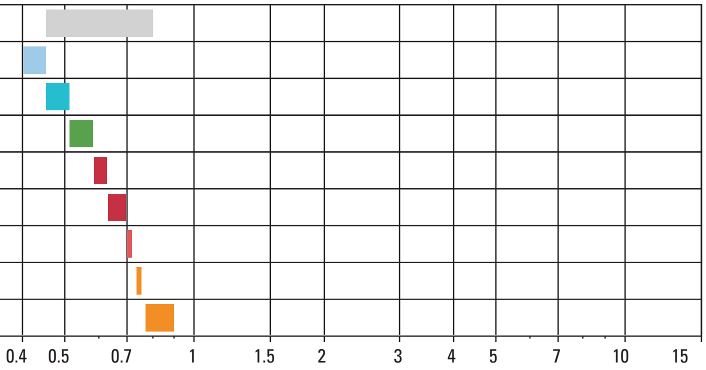
Sensor Information

	WVLI
GSD (m)	0.29/1.16
Swath (km)	9
Data portal	—

WorldView Legion Imager (WVLI)

The imager aboard the WorldView Legion satellites will have a ground sample distance of 0.29 meter. Data will be commercially available.

Band	Lower	Center	Upper	GSD (m)
Panchromatic	0.450	0.625	0.800	0.29
CA	0.400	0.425	0.450	1.16
Blue	0.450	0.480	0.510	1.16
Green	0.510	0.545	0.580	1.16
Yellow	0.585	0.605	0.625	1.16
Red	0.630	0.660	0.690	1.16
Red Edge-1	0.695	0.705	0.715	1.16
Red Edge-2	0.730	0.740	0.750	1.16
NIR	0.770	0.833	0.895	1.16



WorldView Scout

United States
Commercial
Future

Platform Overview

The WorldView Scout constellation of high-resolution panchromatic and multispectral satellites are planned to be launched in 2021 for commercial Earth observation. The satellites will have mid-latitude orbits. In conjunction with the WorldView Legion satellites, DigitalGlobe will have the ability to image regions of Earth as many as 40 times daily. DigitalGlobe and Saudi Arabia's King Abdul Aziz City for Science and Technology Space Research Institute (KACST SRI) have announced a partnership for building and operating the WorldView Scout constellation.

[Abbreviations in tables: —, no data; WVSI, WorldView Scout Imager; GSD, ground sample distance; m, meter; ~, approximately; km, kilometer]

Launch date	2021 (Planned)
Design lifetime	—
Platform owner	DigitalGlobe/KACST SRI
Altitude	—
Orbit period	—
Inclination	—
Crossing time	—
Nadir repeat	—
Status	Development
System website	https://www.digitalglobe.com/

WorldView Scout Imager

The imager aboard the WorldView Scout satellites will have a ground sample distance of approximately 0.8 meter. Spectral information details are unavailable at this time.

Sensor Information

	WVSI
GSD (m)	~0.8
Swath (km)	—
Data portal	—

JACIE

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