

2022 Joint Agency Commercial Imagery Evaluation— Remote Sensing Satellite Compendium



Circular 1500
Supersedes USGS Circular 1468

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

Cover. Images showing (clockwise from top left) the Schooner Cays shoal complex near Eleuthera Island in the Bahamas, the jagged scars of extensive valleys carved by water flowing from the Andes Mountains in northern Chile, Alaska's Columbia Glacier, and false-color Landsat images showing the forests in Mexico where monarch butterflies spend the winter. Images by the U.S. Geological Survey.

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 the National Aeronautics and Space Administration, acquired by Landsat 7's Enhanced Thematic Mapper Plus sensor on February 28, 2000).



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By Shankar N. Ramaseri Chandra, Jon B. Christopherson, Kimberly A. Casey,
Jane Lawson, and Aparajithan Sampath



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Preface

The U.S. Geological Survey (USGS) National Land Imaging Program (NLIP) is responsible 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 50-year data record of our changing planet.

The Requirements, Capabilities, and Analysis for Earth Observation (RCA–EO) Project was established to understand and quantify Earth observation scientific and operational user needs. 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 mission and has developed this compendium as one of the USGS contributions to the Joint Agency Commercial Imagery Evaluation 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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Compendium Coverage, Conventions, and Caveats

- This edition of the compendium provides data sheets for the numerous land remote sensing systems.
- Many sources were mined for the data and information in this compendium. Those sources, and how we harvested information from them, are listed in appendixes 1 and 2.
- 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. Many of the data sheets in appendix 4 were originally published by Christopher-son and others (2019) and Ramaseri Chandra and others (2020). If applicable, these have been updated for this compendium and a few sheets have been added.
- Where data are not available or unknown, this lack of information is indicated with a dash (—).
- The compendium focuses heavily, but not exclusively, on land imaging satellites and measuring sensors. For satellites carrying multiple instruments (for example, Terra or Aqua), only the instruments aboard with substantial land imaging or measuring capabilities are described.

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.

Acknowledgments

Remote sensing involves many technical and scientific accomplishments, but at the heart of them are dedicated people who have applied their curiosity, expertise, and ingenuity to make these accomplishments possible. In this issue, we remember three people without whom Earth observation, and specifically the Landsat Program, would not be the same.

Aeronautical engineer William Stoney assembled a lengthy list of accomplishments at the National Aeronautics and Space Administration, including directing of Earth observation programs, where he worked with Landsat. He also compiled information about civilian and commercial satellites, affectionately called the “Bill Stoney list,” that later would serve as a template for the U.S. Geological Survey Earth Resources Observation and Science (EROS) Center-produced compendium. Mr. Stoney passed away May 28, 2022, at the age of 96.



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

Land change scientist Thomas Loveland spent decades at EROS as a passionate advocate for using Landsat to study the Earth and its natural resources. In addition to producing prolific and respected research, which has been referenced more than 30,000 times, Dr. Loveland also mentored other scientists, served on the Landsat Science Team, and earned a Pecora Award for his contributions. Dr. Loveland passed away May 13, 2022, at the age of 69.



Photograph of Thomas Loveland, January 2016 (photograph by the U.S. Geological Survey).

Scientist John Dwyer held a variety of titles during his decades of accomplishments at EROS, which included development work for Landsat 8 and Landsat 9, establishment of the Landsat Satellites Data System Science Research and Development project team, and much more. Mr. Dwyer considered his Distinguished Service Award from the Department of the Interior the capstone of his career. Mr. Dwyer passed away July 4, 2021, at the age of 65. In addition, we would like to recognize the Landsat Program itself as it celebrates an unprecedented 50 years of Earth observation from space. We benefit every day from the data collected by Landsat and other satellites that have launched around the world in the program’s footsteps. Our future relies on remote sensing and its continued revelations.



Photograph of John Dwyer, August 2017 (photograph by the U.S. Geological Survey).

Celebrating



YEARS

LandSat

1972–2022

The Landsat Program, which began in 1972, has been providing Earth observation from space for 50 years (image by the U.S. Geological Survey).

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Conversion Factors

U.S. customary units to International System of Units

| Multiply | By | To obtain |
|-----------|--------|----------------|
| | Length | |
| mile (mi) | 1.609 | kilometer (km) |

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) |

Abbreviations

| | |
|-----------|----------------------------------------------------------------|
| Airbus DS | Airbus Defence and Space |
| EO | Earth observation |
| EROS | Earth Resources Observation and Science |
| ERTS | Earth Resources Technology Satellite |
| ESG | environmental, social, and governance |
| ET | evapotranspiration |
| GHG | greenhouse gas |
| JACIE | Joint Agency Commercial Imagery Evaluation |
| MSS | Multispectral Scanner |
| NASA | National Aeronautics and Space Administration |
| NLIP | National Land Imaging Program |
| RCA–EO | Requirements, Capabilities, and Analysis for Earth Observation |
| SAR | synthetic aperture radar |
| USGS | U.S. Geological Survey |

An artist's illustration of Landsat 9 in space. Image by the National Aeronautics and Space Administration.



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By Shankar N. Ramasari Chandra,¹ Jon B. Christopherson,¹ Kimberly A. Casey,² Jane Lawson,¹ and Aparajithan Sampath¹

Introduction

The Joint Agency Commercial Imagery Evaluation (JACIE) is a collaborative multiagency group that began in 2000 among the National Aeronautics and Space Administration (NASA), the National Geospatial-Intelligence Agency, 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 was interested in the use of these commercial datasets in fulfilling their missions and 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, three more agencies have joined JACIE: the U.S. Department of Agriculture, the National Oceanic and Atmospheric Administration, and the National Reconnaissance Office. 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 the JACIE annual workshop.

¹KBR, Inc., under contract to the U.S. Geological Survey.

²U.S. Geological Survey.

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 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 third assembly of such a compendium. Previous compendiums were published in 2019 and 2020 (Christopherson and others, 2019; Ramasari Chandra and others, 2020). The JACIE compendium is planned to be updated annually, and the Earth Observation Requirements Evaluation System database is planned to be updated and enhanced continuously, as resources allow. An online version of the compendium can be accessed at <https://calval.cr.usgs.gov/apps/compendium>.

This report consists of two primary 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 Landsat and land remote sensing. The appendixes contain a list of acronyms, a table of recent and future satellite launches, 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 (EROS) Cal/Val Center of Excellence website (<https://www.usgs.gov/land-resources/eros/calval>), which is linked to on each data sheet.

Exploring Earth from Space for 50 Years

The Earth Resources Technology Satellite (ERTS), an experimental satellite, launched into orbit in 1972 carrying the hopes of geologists, cartographers, agronomists, and governments around the world to regularly view Earth from space. This single satellite, the first explicitly designed to observe the Earth's surface, also launched a global science and technology revolution of remote sensing that continues today.

Hundreds of miles above Earth, ERTS, which was later renamed as the first Landsat, peered down upon land on which few, if any, people had set foot, such as vast ice sheets and oceans, and temperate lands that had been occupied for thousands of years. The imagery revealed much about both kinds of places. Now, the ninth Landsat has launched, and scientists and researchers use Landsat's unparalleled archive of 10 million scenes to explore changes over time in ecosystems around the world, from forests to coasts to urban areas. With Landsat as a role model, many other EO satellite programs—government and commercial—have arisen to meet the needs of users who have more capability of using satellite data than ever before (fig. 1).

The Launch of Land Observation from Space

The Soviet Union launched the first satellite, Sputnik 1, which transmitted radio signals, into space in 1957. The United States followed in 1958 with its first satellite, Explorer 1, which carried a cosmic ray detector. Many other satellites followed with various mission objectives, especially measurement capabilities aimed at reconnaissance and meteorology.

USGS Director William Pecora saw satellites as a potential solution to the challenge of viewing the Earth's surface from above, in a manner more thorough and inexpensive than aerial photography. In 1966, Interior Secretary Stewart Udall (fig. 2) announced Project Earth Resources Observation Satellites. "The time is now right and urgent to apply space technology towards the solution of many pressing natural resources problems being compounded by population and industrial growth," Udall said (Department of the Interior, 1966, p. 1).

The USGS and NASA worked together to develop a program that would launch Landsat 1, capture and process the data sent back to Earth, and distribute the imagery. On July 23, 1972, ERTS carried the first EO satellite sensor, the Multispectral Scanner (MSS), 570 miles into space (fig. 3). The MSS was designed by Virginia Norwood, the "mother of Landsat." MSS images had 60-meter (m) spatial resolution

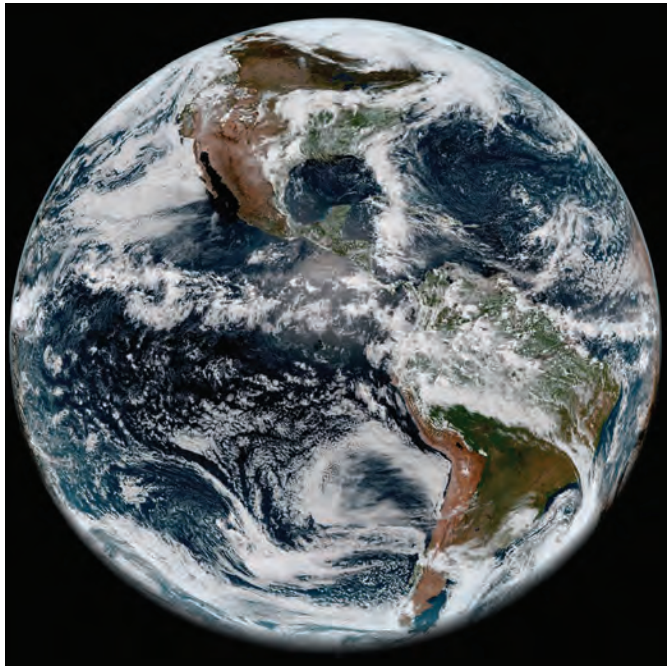


Figure 1. One of the first images, collected May 20, 2018, by the Geostationary Operational Environmental Satellite GOES-17 upon its arrival in orbit. Image courtesy of the National Oceanic and Atmospheric Administration and National Aeronautics and Space Administration.



Figure 2. Stewart Udall, U.S. Secretary of the Interior from 1961 to 1969. Photograph by U.S. Geological Survey.



Figure 3. Delta rocket containing Landsat 1, then called Earth Resources Technology Satellite, or ERTS, sits on the launch pad at Vandenberg Air Force Base in California in July 1972. Photograph courtesy of the National Aeronautics and Space Administration.

and four spectral bands: one visible green, one visible red, and two near-infrared bands.

The initial ERTS data were received by ground stations in California and Alaska, which sent tapes to the NASA Goddard Space Flight Center in Maryland. The Goddard Space Flight Center converted the digital data into film negatives, which were flown to the USGS EROS Center in Sioux Falls, South Dakota, to be processed into photographs and distributed upon request to users around the world. ERTS launched on a Sunday; negatives of the first images arrived at EROS late the following Tuesday. Imagery from the first Landsat delighted scientists and researchers who pored over the photographs for unknown mineral deposits, islands, remote fires, and many other geographic surprises. The imagery teased them with potential revelations of so much more.

After 50 years, the Landsat Program reveals more than just what the Earth's surface looks like with each satellite overpass. Today, with decades of continuous and consistently calibrated data offered for free, anyone with an internet connection can discover changes over time in ecosystems—from



Figure 4. A true color composite image of Chesapeake Bay (showing southeastern states New Jersey, Maryland, Delaware, District of Columbia, and Virginia) created using Provisional Surface Reflectance data from five Landsat 8 scenes, acquired in October and November 2014. Image by the U.S. Geological Survey.

forests to coasts (fig. 4), urban areas to glaciers—and even predict how the ecosystems might keep changing. Now, Landsat has plenty of company watching Earth. Technological advancements, affordability, access to launch vehicles, and user demand have sent hundreds of EO satellites into orbit and spawned enterprises to interpret and analyze the data and advise natural resource managers.

Landsat and Its Followers

The Landsat Program was intended to produce a continuous record of data, preferably with two optical polar-orbiting satellites placed opposite to each other. Producing a continuous record of data for 50 years was no small feat, especially when considering that Landsat has relied on most of the eight satellites to transmit data well beyond their life expectancies. One satellite, Landsat 5, delivered data for a quarter of a century longer than its 3-year design, earning it the Guinness World Record for the longest operating EO satellite. For more than 5 years, after Landsat 4 ended its transmissions in 1993 and before Landsat 7 started in 1999, Landsat 5 worked alone.

Having 50 years of Landsat data is an achievement in satellite function and data archiving, but trusting the data enough to reliably compare scenes of the same location 20 or

30 years apart is an achievement in calibration. The EROS Cal/Val Center of Excellence characterizes and calibrates the radiometric and geometric performance of Landsat satellite instruments and makes adjustments to present and past data. Missions are cross-calibrated to maintain the same quality reference. Civil and commercial satellite operators, meanwhile, trust Landsat's standards of excellence to cross-calibrate Landsat data with their own data.

Although the United States started Landsat, other countries also have launched their own land remote sensing satellites; for example, France launched its 10-m resolution commercial SPOT-1 satellite, which had an unusually high resolution for its time, in 1986 and launched the second-longest land observation archive, following Landsat, at the same time. Currently, SPOT-6 and SPOT-7 deliver data as commercial satellites owned by Airbus Defence and Space (Airbus DS).

Some of the other international space Earth-observing achievements include those by India, which launched its first satellite in the Indian Remote Sensing multispectral satellite series in 1988. The intergovernmental, multicountry European Space Agency launched its first European Remote Sensing satellite in 1991, which included an imaging synthetic aperture radar (SAR) instrument to penetrate clouds. The Japanese Earth Resources Satellite (known as JERS-1) launched in 1992 with SAR and an optical sensor. Canada sent RADARSAT-1 with SAR into space in 1995. The Korea Aerospace Research Institute launched its first KOMPSAT mission in 1999. In the early 2000s, Surrey Satellite Technology Ltd. launched the Disaster Monitoring Constellation, operated by DMC International Imaging, to provide daily high-resolution imaging

for Algeria, Turkey, the United Kingdom, Nigeria, and China. Germany has been an integral land remote sensing data provider, from key participation in the Shuttle Radar Topography Mission (2000), EnviSat (2002), and GRACE (2002) and leading TerraSAR-X (2007) and TanDEM-X (2010). Recently, Italy and Germany launched the hyperspectral satellites PRISMA (2019) and EnMAP (2022), respectively. Many other countries have joined as well, including Argentina, Brazil, Finland, Israel, Peru, Poland, Singapore, Spain, Thailand, United Arab Emirates, Venezuela, and Vietnam. The USGS Land Remote Sensing Satellites Online Compendium tool (<https://calval.cr.usgs.gov/apps/compendium>) can be used to sort and track the numerous land remote sensing satellites and their history, present status, and forthcoming planned missions.

Earth Observation Satellites Today

The extreme technical challenges involved with launching a satellite have been reduced in recent years. Dozens of countries have satellites in orbit that are dedicated to various aspects of EO, such as disasters, oceans, natural resources, polar ice, and vegetation.

One of the more robust programs today is Copernicus, the European Union's EO program. Two Sentinel-1 satellites complete SAR imaging. The twin optical Sentinel-2 satellites function similarly to Landsat and have 13 spectral bands, 10-m resolution data, and a 10-day revisit for each satellite. Sentinel-3 OLCI and SLSTR sensors focus on high-resolution marine and land data, such as aquatic color and temperature. Sentinel-4, Sentinel-5, and Sentinel-5P monitor the atmosphere. Sentinel-6 Michael Freilich (fig. 5) studies sea levels



Figure 5. The front of the Sentinel-6 Michael Freilich satellite with its deployable solar panels extended. The satellite was launched as a partnership between the European Union and the United States. Image courtesy of the National Aeronautics and Space Administration.

in a partnership with the United States; a twin to this satellite is planned for launch in the mid-2020s.

China's deep interest in space and EO lacks some transparency. However, it is known that China has launched its own disaster monitoring satellite constellation, Huanjing; ocean monitoring constellation, Haiyang; high spatial resolution constellation, Gaofen; and a resources detection and monitoring series, Ziyuan, part of which is a collaboration with Brazil.

India has continued to have considerable interest in EO after the launch of IRS-1A. Its Resourcesat, RISAT, EOS-01, and Cartosat series of satellites take land and water measurements, and the Oceansat and SARAL series focus on oceanographic applications.

Russia's EO satellites include the Resurs series for monitoring the environment, disasters, and infrastructure development and the Kanopus-Vulcan series for ecological monitoring, natural resources monitoring, mineral exploration, and topographic mapping.

In addition to Landsat, among satellites the United States has orbiting are Terra and Aqua, the NASA complete Earth Observing System satellites; SMAP, a soil-focused satellite; GRACE Follow-On, a water movement satellite; and ICESat-2, a satellite for cryosphere and topographic analysis applications.

The United States also has launched or participated in several International Space Station instrument deployments over recent years, many of which explore new EO strategies. A few of the most notable International Space Station missions include the Hyperspectral Imager for the Coastal Ocean (known as HICO), an early imaging spectroscopy mission that operated from 2009 to 2014. Currently deployed are ECO-system Spaceborne Thermal Radiometer Experiment (known as ECOSTRESS), a high thermal resolution land imager; the Global Ecosystem Dynamics Investigation (known as GEDI), a three-dimensional vegetation measurement campaign that uses the light detection and ranging laser method of remote sensing; and Earth Surface Mineral Dust Source Investigation (known as EMIT), an imaging spectroscopy sensor aimed at measuring mineral composition of Earth's deserts.

Meanwhile, geostationary satellites, which orbit 36,000 kilometers above Earth and thus appear fixed relative to the Earth's rotation, have branched out from meteorological applications. Advanced imagers with more spectral bands and higher resolutions now allow these satellites to monitor land and ocean resources for environmental characteristics like forest fires, disaster risks, and food security. Examples include the United States' Geostationary Operational Environmental Satellite (known as GOES) series; Japan's geostationary meteorological Himawari-8 and Himawari-9 satellites; Korea's Communication, Oceanography, and Meteorology Satellite (known as COMS) series; China's Fengyun-4 satellites; and the European Space Agency's Meteosat series.

The U.S. Land Remote Sensing Policy Act of 1992 encouraged the commercial land observation satellite industry by authorizing businesses to apply for licenses for privately operated land remote sensing systems (NASA, 1992). In 1995,

in partnership with Lockheed Martin and Raytheon, Space Imaging, LLC, received a license to build, launch, and operate a commercial satellite system. Its IKONOS satellite launched in 1999 as the first commercially developed and launched EO satellite, selling 1-m resolution panchromatic imagery beginning in 2000. DigitalGlobe (now MAXAR Technologies) followed in 2001 with the launch of the high-resolution satellite QuickBird, and ORBIMAGE's competing high-resolution satellite OrbView-3 launched 2 years later. These early commercial efforts marked the first time the public could acquire imagery resolutions previously associated only with reconnaissance satellites. Imagery from commercial satellites is used by governments and private customers for a wide variety of purposes, including defense, land-use and infrastructure management, resource and disaster monitoring and risk assessment, mining, and research. The location and timing of the imagery are often by request of the government agency or private customer.

Since its start, the commercial high-resolution EO industry has continued to grow exponentially, encouraged by the 2003 U.S. Commercial Remote Sensing Space Policy (White House, 2003) and the 2015 U.S. Commercial Space Launch Competitiveness Act (Public Law 114-90). The advent of SmallSats, weighing 600 kilograms or less; lower launch costs through companies like SpaceX; and the launch of multiple satellites together have helped lead to satellite launches by dozens of companies. Airbus DS, Maxar Technologies, and Planet are the key contributors to commercial satellite missions. The Airbus DS Pléiades Neo constellation offers 30-centimeter (cm) resolution imagery from two—soon to be four—satellites. Maxar Technologies will build on its WorldView legacy of high-resolution satellites with its six-satellite, 30-cm resolution WorldView Legion constellation, and the first two satellites are planned for launch in 2022. Planet, meanwhile, has 21 SkySats in orbit with 50-cm resolution imagery, video clips, and as many as 7 revisits in a day.

Early Experiment Results

Landsat started out as an experiment. Before ERTS soared into orbit and began sending back its views of Earth, scientists did not know quite what to expect from its resolution. The satellite's first images, including images of the

"Some of those experimenters are like kids with new toys. They're so excited about the resolution, saying, 'Look at this,' and, 'Hey, look at that,'" Jack Hays of the Goddard Space Flight Center said several days after the launch of ERTS from nearby Vandenberg Air Force Base (La Rue, 1972, p. 3A).

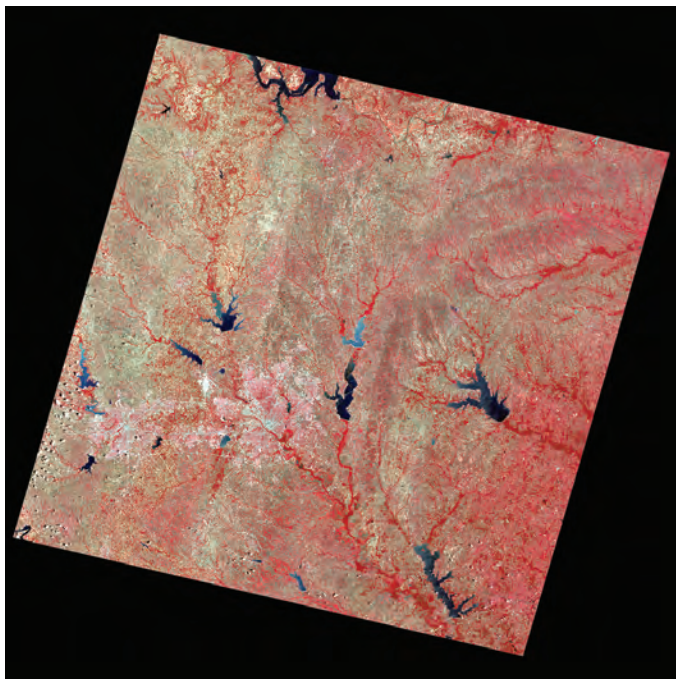


Figure 6. Landsat 1 first captured the Dallas-Fort Worth, Texas, area. The resolution is 60 meters per pixel in this false-color image, where shades of red indicate vegetated land and grays and whites are urban or rocky surfaces. Image by U.S. Geological Survey.

Dallas, Texas, area, encouraged them—they could make out details like roads, an airport, and farm fields (fig. 6).

Soon, scientists and government agencies were using Landsat for measuring the global food supply; locating mineral deposits; estimating timber volume; and monitoring flooding, snowmelt runoff, and glacier footprints around the world. An island off the coast of Labrador in Canada bears Landsat's name because satellite imagery helped researchers discover it in 1976. A diving expedition between NASA and Jacques Cousteau in 1975 tested Landsat's ability to measure ocean water depth and gave birth to satellite-derived bathymetry.

As Landsat's archive grew, it revealed changes over time: urban growth, deforestation, shrinking ice caps and lakes, fluctuating rivers and reservoirs, burned area and volcanic flow recovery, and any other circumstances people could think of to study. Landsat offered samples of what satellites could reveal about their planet. The satellites that have since been developed also seek to deliver answers about the Earth's resources, their effect on humanity and ecosystems, and humanity's effect on them.

Path to Data Use

The path from launching a satellite to seeing its data resound throughout the world was not always smooth. In 1972, for example, computers for processing and analyzing

digital data and mapping with geographic information system software tools were rare; so were the people who knew how to use that technology. However, anyone could order photographic prints or transparencies of Landsat scenes from the large photographic laboratory at EROS, then use a magnifying glass to scrutinize all four corners and everything in between (fig. 7).

Tom Loveland was a longtime USGS scientist at EROS. During an interview before his recent death, Loveland recalled that his first job with the South Dakota State Planning Bureau in 1976 involved bridging the gap between photographic and digital data. Before he started, South Dakota had made one of the first State land cover maps in the world with Landsat photographs, but officials wanted more detail. So Loveland and Jeff Eidenshink, a longtime EROS employee and past EROS deputy director, remade the map digitally using Landsat MSS data, which at that time, were stored on computer-compatible tapes.

Training was clearly needed to help the government agencies and scientists responsible for managing resources benefit from applying Landsat data to their work, so EROS, home of the archive and also of scientists developing applications for data, invited people from U.S. agencies and other countries to attend monthlong training sessions at the facility through the late 1970s and early 1980s and take their new skills home (fig. 8). "It really had sort of a foreign policy, humanitarian aid flavor to it that brought people in from all over," Loveland said. EROS helped other countries develop Landsat applications as well.



Figure 7. In-house data processing systems at the U.S. Geological Survey Earth Resources Observation and Science Center, shown here in 1976, supported research based on aerial photography and satellite data. Photograph by the U.S. Geological Survey.



Figure 8. The U.S. Geological Survey Earth Resources Observation and Science Center, home of the archive for Landsat and other remote sensing data, held training sessions like this one in 1977 for domestic and international scientists. Photograph by the U.S. Geological Survey.

Universities with remote sensing programs later took over the role of training. For example, AmericaView is an educational program established in the early 2000s that links many U.S. States and universities with the goal of improving EO educational skills. Many online EO training platforms are now sponsored by universities, space agencies, and other intergovernmental programs across the globe.

As working with digital data became more common, people found plenty of uses for satellite data. For Landsat users, however, making maximum use of the data still had some challenges. Landsat 4 and Landsat 5 both had Thematic Mapper sensors in addition to MSS. The Thematic Mapper had seven spectral bands, which added to the size of data and made the data less compatible with earlier image processing software. In addition, the 1980s efforts to privatize Landsat, turning it over to Earth Observation Satellite Company, a commercial vendor, resulted in the scene price increasing from \$650 to \$4,400. Projects using more than one or a few scenes were unaffordable for most users; thus, scientific or operational EO analysis was often limited to single-scene conclusions. Data from the French SPOT-1 satellite had become an alternative option during that decade as well and also were often scene limited. The Landsat Program would have perished if not for congressional and global objections. Landsat returned to government operations with a cheaper image price and a new satellite on the horizon with plans for Landsat 7, which launched in 1999.

Data use picked up again, even as other government and commercial satellite operations found interest in their own data. In the early 1990s, for example, Russia offered commercial sales of the highest resolution imagery available to the public—surveillance photographs taken from uncrewed space

capsules and processed to 2-m resolution digital data. “Suddenly, we were in a time when the amount of imagery around the world was growing more rapidly, and the access to data improved significantly as well,” Loveland said.

Revolutionary Decision

In 2008, the USGS made a move that proved revolutionary to Landsat data usage. A new, novel open data policy was announced by Brazil at the Group of Earth Observations Cape Town Ministerial Summit regarding its commitment to providing free and open data from the newly launched CBERS land remote sensing instrument. The open data ideology sparked the interest of then-Department of the Interior Secretary Dirk Kempthorne, who made an announcement at the following Esri User Conference in August 2008 that the 35 years of Landsat data would also be made available freely and openly. The new “Landsat Data Distribution Policy” opened up the entire Landsat archive to the world (Ryan and Freilich, 2008). University researchers, geographers in developing countries, and anyone yearning to look at decades of change in tens or even hundreds of Landsat scenes could download the data without worrying about a price tag. The examination of regional and even global patterns of change became possible. A study on the economic benefit of Landsat imagery determined that it yields \$2.06 billion in annual benefits to U.S. users alone, and \$3.45 billion worldwide (fig. 9; Straub and others, 2019).

“That started the era of people using the data they needed, not the data they could afford. Single scenes aren’t enough to capture the diversity on the landscape,” Loveland said. “To me, from 2008 forward is when Landsat really started achieving the expectations, the potential, that was envisioned by Pecora and Udall in the 1960s.”

The concept of free and open data inspired other countries to offer the same, including the European Union’s Copernicus program, Italy’s PRISMA mission, and many others. Commercial data, meanwhile, are often purchased by government agencies and industries and made available through resellers, analysts, and consultants.

Most recently, cloud computing has been revolutionizing remote sensing by allowing people to access and analyze massive amounts of data in the cloud rather than their local computer. “You no longer have to bring all the data into a collection of your own and deal with it. Now you just send your question to the cloud, and the answer is sent back from the collection in the cloud,” said principal systems engineer Jon Christopherson, a contractor at EROS. Based on decades of historical patterns, data users can model ecosystem change

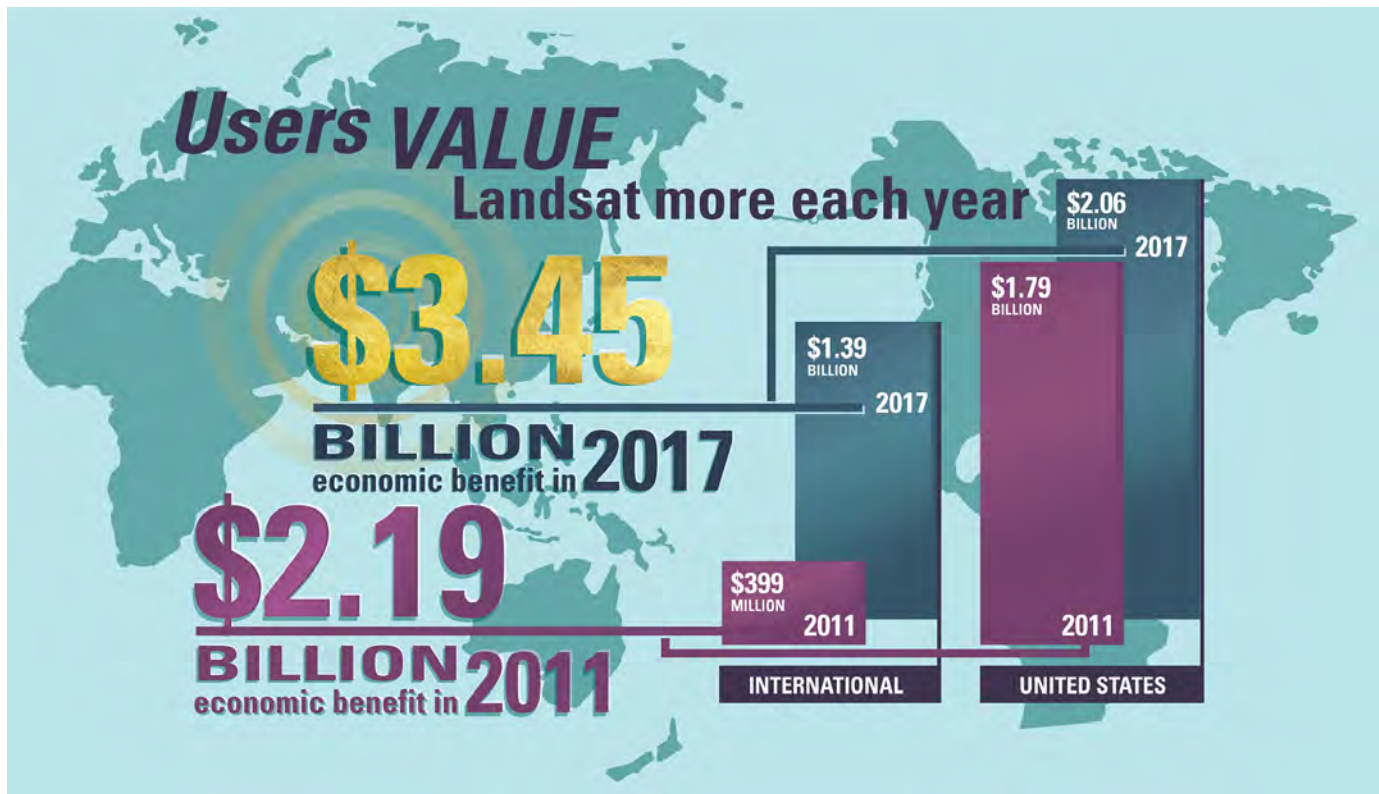


Figure 9. Landsat imagery provides an economic benefit to users in the United States and worldwide. Graphic by the U.S. Geological Survey.

decades into the future. The applications for civil and commercial satellite data are now almost endless. “A lot of studies... have really proven that a community-based cloud approach is just brilliant. I think it’s not an overstatement to say that when Google made all free Landsat data available to the world on a free computing platform, we accelerated the pace of global learning of environmental conditions,” Loveland said. “Landsat is just one data stream with many more joining it,” Christopherson added.

International Coordination

Ground stations (fig. 10) are one vital example of international cooperation. The internationally located ground station network is essential to having a vast, deep global archive of land remote sensing data. Before the Landsat 7 era, no means were available to record data on the satellite. As technology has improved, onboard recorders and enhanced ground station networks have greatly improved data records that are collected. At present, cloud computing and ample agreements now allow for satellite data to transmit directly into the cloud from the ground station that receives the data. Traditionally, as with the Landsat network, ground stations downlink real-time and recorded science data from the satellite and then transmit the data to the processing location.

The primary ground stations for Landsat 8 and Landsat 9 outside the United States are in Norway, Germany, and Australia. Historically, additional international cooperators have received Landsat data directly for themselves in locations such as Russia, Pakistan, Kenya, and Brazil. Some ground stations, including China, South Africa, and Argentina, still do.

Another example of international collaboration includes satellites developed and launched by partnering countries, such as the China/France Oceanography Satellite (known as CFO-SAT) and the upcoming United States/India Synthetic Aperture Radar (known as NISAR) mission. In addition, the European Union and the United States have combined measurements from Landsat 8 and Landsat 9 and the twin Sentinel-2 satellites into one data product, Harmonized Landsat Sentinel-2, which offers global observations every 2 to 3 days.

International remote sensing policy spent years in discussion before the “Principles Relating to Remote Sensing of the Earth from Outer Space,” also known as the United Nations Remote Sensing Principles, were adopted in 1986 (United Nations Office for Outer Space Affairs, 1986). The United States and most developed countries had advocated for an open skies policy, allowing for the freedom to observe foreign territories from space, whereas the Soviet Union and developing countries were opposed. Lengthy negotiations eventually resulted in an open skies policy with some compromises. The principles dictate the use of remote sensing activities for the benefit of all

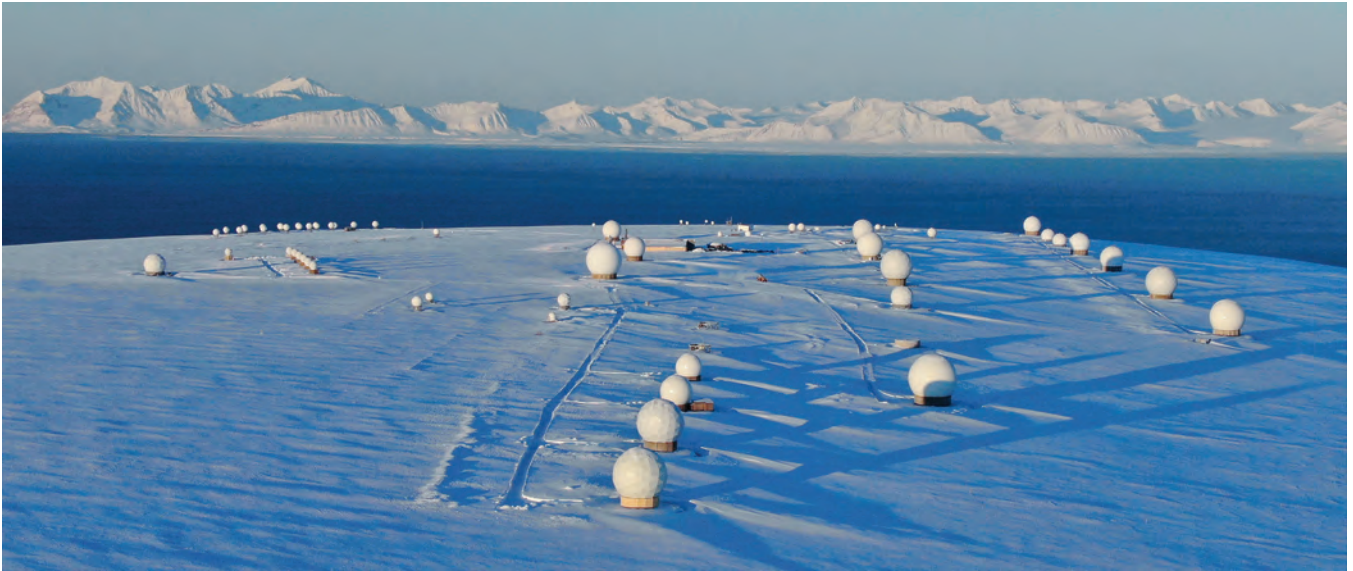


Figure 10. The Svalbard ground station at the Svalsat facility in Svalbard, Norway. Photograph by the U.S. Geological Survey.

countries while improving natural resources management, land use, and the protection of the environment. Many countries have crafted their own national remote sensing policies as well.

The Committee on Earth Observation Satellites works toward international coordination of EO programs and the exchange of data. The Committee on Earth Observation Satellites has working groups for specific topics and provides information about space agency activities and upcoming remote sensing events and publications.

Looking Beyond 50 Years

Loveland pointed to three themes where Landsat has especially helped in achieving comprehensive monitoring. The first is agriculture, in which the world has benefited from continual monitoring of the global food supply and early warning alerts for famine in vulnerable areas (fig. 11). The second is forestry, which is monitored through early warning systems for losses and gains, disturbances, and deforestation and longer term trends (figs. 12 and 13).

“Now, I think the hot area for applications has to deal with water,” Loveland said. Efforts have included a global inventory of surface water, the monitoring of water quality, and studies of energy balance in the hydrologic cycle to determine how much water is consumed in irrigation (through evapotranspiration [ET]). These efforts rely on Landsat’s thermal data, which were among the first available.

Dr. Gabriel Senay, a USGS research physical scientist who models ET, calls it “the biggest component of the water budget. Really, ET maps tell you how much water [is available] and where and when it’s being used.” The implications stretch from water management decisions to water rights

determinations and are likely to become even more important in a changing climate, especially in drier regions of the world.

Landsat Next is the proposed successor to Landsat 9, with a potential launch later this decade. Dr. Zhuoting Wu, a USGS physical scientist, was involved in collecting stakeholders’ land imaging needs to help define Landsat Next’s science objectives and requirements. “The user community has expressed great interest in maintaining Landsat continuity, supporting synergy with the Copernicus Sentinel-2 mission, and enabling new emerging applications that are critical to tackle the challenges in today’s global environment,” Wu said.

“Landsat is truly a system of systems. It has very unique capabilities addressing user needs. It also nicely complements some of the other available missions and systems out there,” said Paul Haugen, USGS chief engineer and acting project manager for Landsat Next. “Landsat Next is continuing to evolve the Landsat continuity mission, and harmonization and interoperability are really key elements. But we see—at least in the commercial sector—that these missions really depend on Landsat as a reference calibrated measurement to adjust or align their measurements to Landsat,” added Chris Crawford, a USGS research physical scientist who serves as the USGS Landsat project scientist and the project manager and principal scientist for the EROS-Imaging Spectroscopy Project that informs the USGS’s Sustainable Land Imaging program for development of future Landsat missions.

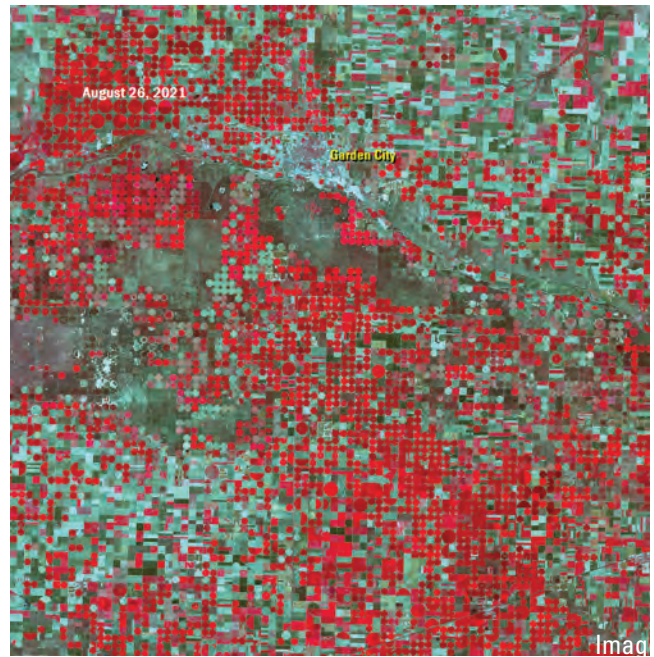


Figure 11. Landsat false-color images showing the growth of center-pivot irrigation (shown as red circles) in fields around Garden City in southwestern Kansas between August 16, 1972 (left), and August 26, 2021 (right). The irrigation water is drawn from the High Plains aquifer. Images by the U.S. Geological Survey.

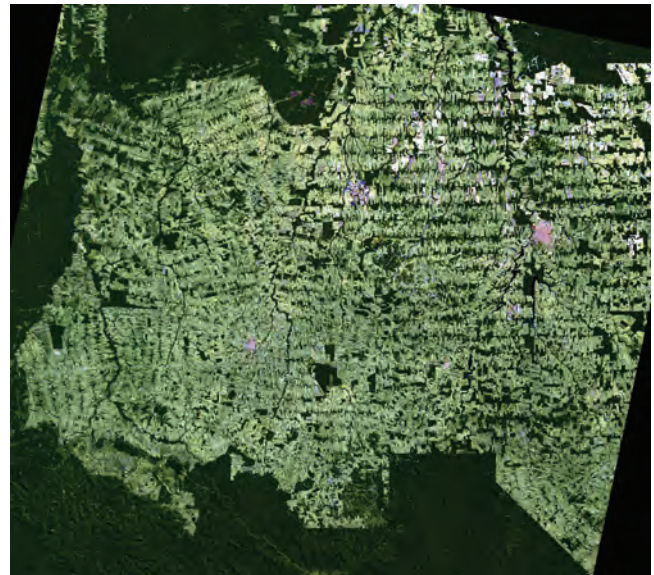
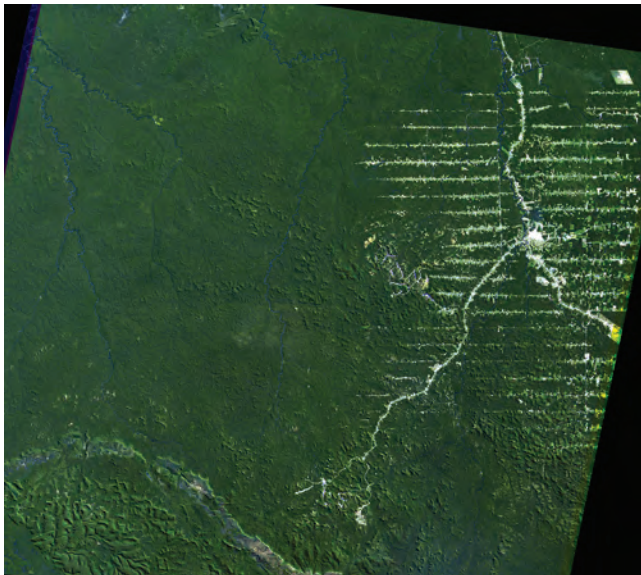


Figure 12. The Landsat image of the State of Rondônia, Brazil, from June 24, 1984 (left), shows tropical rainforest cutting along roads had begun. The Landsat image of the same area on July 26, 2021 (right), shows how extensive forest clearing had become. Images by the U.S. Geological Survey.

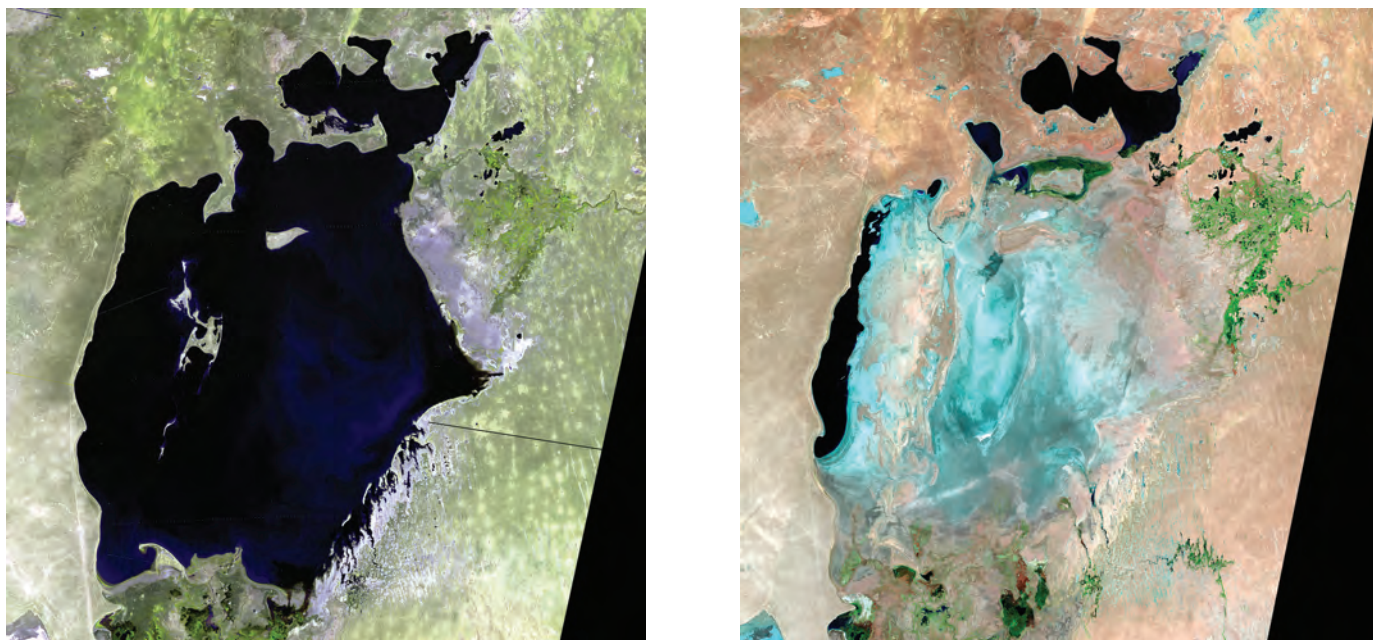


Figure 13. A comparison of Landsat images from September 1977 (left) and May/June 2021 (right) shows how drastically the Aral Sea, on the border of Kazakhstan and Uzbekistan, has shrunk. The Aral Sea relies on the inflow of river water and once was the fourth-largest lake in the world. Images by the U.S. Geological Survey.

Improved spatial resolution, an increased temporal revisit, and an increase to 26 spectral bands would provide enhanced detail for applications. In agriculture, these improvements would translate to a better understanding of the effects of cover crop and rotational crop planting. In freshwater, these improvements would further define algal blooms and other water quality issues. Measurements would reveal more about snowpack and polar ice changes (fig. 14). New emissivity measurements would increase the accuracy of surface temperatures.

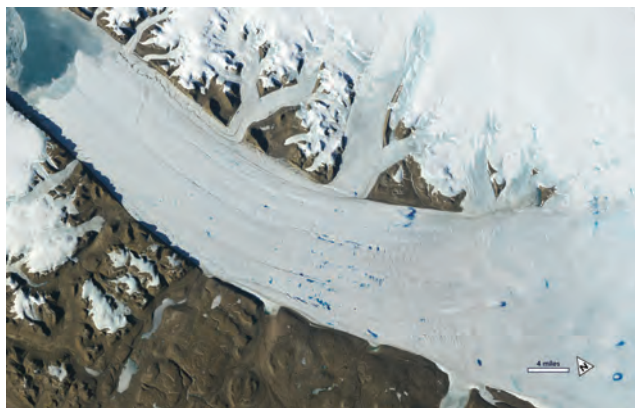


Figure 14. Meltwater lakes form on the surface of Greenland's Petermann Glacier, shown here in a June 2019 Landsat image. Image by the U.S. Geological Survey.

The United States has several other upcoming satellites planned, such as the imaging spectroscopy Surface Biology and Geology (known as SBG) and Plankton, Aerosol, Cloud, ocean Ecosystem (known as PACE) missions. The Surface Water and Ocean Topography (known as SWOT) satellite mission, which is a joint effort by the United States, France, and Canada, is planned for launch in 2022. Other satellite ventures designed to extract more detailed data about the Earth's land and water include Canada's WildFireSat, which is being planned to launch this decade and will focus on monitoring active wildfires and air quality, and Texas-based commercial start-up Albedo's satellite, which is being planned with the hopes of offering the highest-resolution satellite imagery commercially available—10 cm—while also collecting 2-m thermal imagery.

An upcoming International Space Station mission to further explore remote sensing capabilities is Climate Absolute Radiance and Refractivity Observatory Pathfinder (known as CLARREO-PF), a climate radiometry-focused instrument that will take precise measurements of sunlight reflected by Earth and the Moon.

"There's growth ahead for companies to turn data into usable and easily accessible information, too," Christopherson predicted, and for those who use data to help address resource issues—especially in the face of climate change and growing populations.

Climate change affects different parts of the Earth in different ways, from rising seas, extreme droughts, and

sweltering cities to intensified storms, dwindling rivers, and worsening wildfires. Satellites shift our perspective and let us look down on one spot, look across a broad area, look back in time, and even look forward. They help us learn from the past and present and give us a chance to change the future.

Between the launches of Landsat 1 in 1972 and Landsat 2 in 1975 (fig. 15), then-NASA administrator James C. Fletcher said, “If I had to pick one spacecraft, one Space Age

development to save the world, I would pick ERTS and the satellites which I believe will be evolved from it later in this decade” (NASA, 1975, p. 1). Decades later, hundreds of satellites have launched from all over the globe, but the prophecy still stands. EO satellites hold a vital key to understanding our planet and preserving it for the future—and ultimately preserving humankind.

Landsat Missions: Imaging the Earth Since 1972

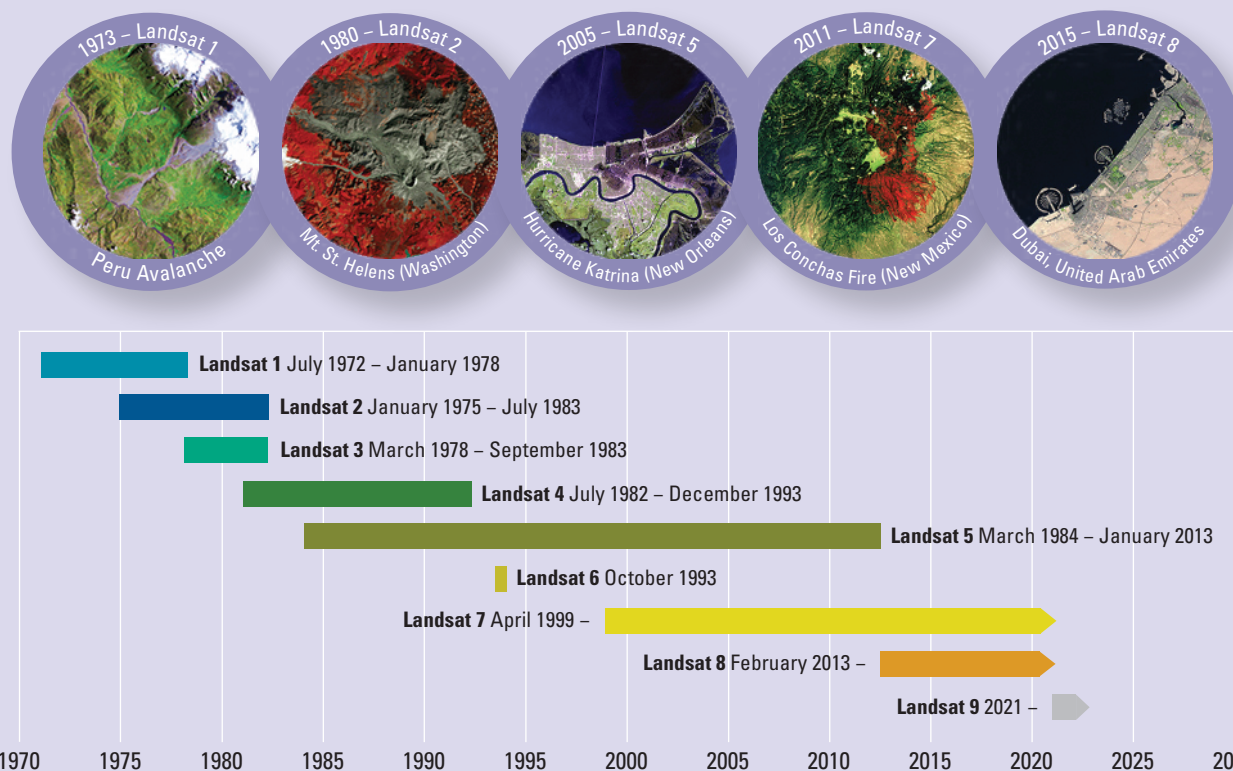


Figure 15. Since 1972, Landsat satellites have continuously acquired space-based images of the Earth’s land surface. Image by the U.S. Geological Survey.

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An artist's illustration of Landsat 4 in space. Image by the U.S. Geological Survey.



Finance—A New Player in Remote Sensing?

Satellite remote sensing provides an expansive and unique view of the world. The satellite platform is valued because of its ability to monitor the Earth on a continual basis. Continuous improvements in sensor technology have made it possible to monitor the Earth at high spectral and spatial resolutions. The traditional customers of these remote sensing data have been the defense and intelligence communities and governmental science. Governmental science supports functions performed at all levels of the government and includes applications such as weather forecasting, agricultural support, ecosystem monitoring, resource mapping, and so on. Traditionally, access to satellite-based remote sensing data has been limited because of many reasons including the high cost of acquisition, which necessitated government investment into acquisition and distribution of data, data governance rules, internet and computational power, algorithms, and so on. However, digital transformation and the commoditization of various components of the space ecosystem (fig. 16) are disrupting the current value drivers and providing opportunities for more users to access multiple data sources and create more opportunities for value. Current value drivers include the availability of well calibrated remote sensing data and analytic software that is driven by experienced remote sensing scientists to generate reports of value to governmental and scientific organizations. The digital transformation (that is, the development of connectivity, proliferation of sensors and devices, application programming interfaces, computing power, and open-sourced algorithms) has given businesses and scientific organizations the ability to deliver value to users directly from satellites and other sensors with low latencies and minimal manual processing.

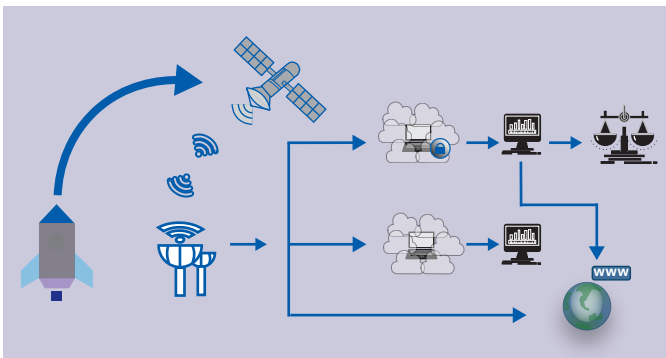


Figure 16. The space remote sensing ecosystem, which includes launch vehicles, satellite platforms, ground stations (cloud and high performance), computing platforms, data processing software, data distribution channels (internet), and decision makers.

The availability of Landsat data in Cloud Optimized GeoTIFF format, and the provisioning of representational state transfer application programming interfaces (by the USGS EROS Center via the Amazon Web Services cloud) to access these datasets is an example of digital transformation. This digital provisioning of data allows users to develop pipelines for continuous, on-demand access (in a manner reminiscent of the just-in-time manufacturing philosophy), along with other datasets. Light detection and ranging data from the USGS's 3D Elevation Program also are available on the Amazon Web Services cloud, accessible via cloud optimized data formats that allow selection of data for the specific area of interest at full resolution and at continental scale at lower resolution.

Inexpensive data processing software (open source and proprietary) and higher computational power (cloud computing and high-performance computing) make it possible to use these multiple data sources, identify causal forces for multiple applications including carbon stock monitoring, and better inform decisions and actions. The commoditization seen in recent years of satellite launch services, sensors, communications (including ground stations), data processing, and computational infrastructure has encouraged a wide array of for-profit, nonprofit, and nongovernmental entrepreneurs to offer services (Navarro and others, 2020). For example, MethaneSAT is a satellite being launched by a nonprofit organization to map methane emissions. Carbon Mapper is a program that brings together for-profit companies such as Planet and nonprofit groups such as the Jet Propulsion Laboratory at NASA to solve societal problems.

Together, all these developments have increased access to data and information in terms of availability and timeliness, which has allowed new uses for geospatial data to be imagined as solutions to societal problems. Climate change poses some of the most important long-term challenges to society in terms of risk to lives, livelihood, and assets over the coming decades and beyond (Climate-Related Market Risk Subcommittee, 2020). The financial community is particularly concerned about this risk. The financial industry also has deep resources (regulatory, organizational, and capital) available to make full use of the new availability of data and algorithms for developing a climate risk assessment framework.

These climate-related risk assessments within the financial system also are often grouped within sustainability indices or environmental, social, and governance (ESG) indices. These indices are used by institutional investors and private equity firms (a total of 7,000 in the United States alone) to inform their investment decisions. It is estimated that the market for supporting the ESG indices and risk assessments using satellite remote sensing is \$100 billion (Space & Satellite Professionals International and New York Space Alliance, 2021). Included in this article are a brief description of the ESG market and the remote sensing activities necessary to service the market. This article also describes the current trends and governmental activities that can complement the current remote sensing trends.

Satellite Remote Sensing Value Proposition to Financial Systems

The financial system's risks and indices associated with climate change are complex and hard to quantify (fig. 17). Any complex system also is subject to cascading risks. An example of such risks because of climate events was seen during the 2011 earthquake in Japan (Danninger and Kang, 2011), which resulted in shortages of electronics needed to build cars around the world, including the United States. As with any system, the financial system is composed of entities (in this case, companies, their supply chain, financial institutions that lend, and so on). For simplicity, the risks to these entities are divided into two types: physical and transitional. Physical risk is defined as risk that can destroy or impair the value of assets from the shocks and stresses attributable to climate change. Transitional risk, on the other hand, is defined as risk associated with a system transitioning from one paradigm to another as a reaction to regulatory and other changes.

These risks could arise, for example, from changes in policy, technological breakthroughs, and shifts in consumer preferences and social norms (Bolton and others, 2020). For example, oil companies can be subject to regulatory risk if they are required to monitor leaks more closely, and many companies are under reputational risk if they are determined to be polluting, which could lead to product boycotts.

These risks are not just notional. Many large asset owners and investors are beginning to act on these risks. The size of pension funds in the United States alone is \$9 trillion as of 2016. The California State Teachers' Retirement System divested from U.S. thermal coal companies in 2016 and from non-U.S. thermal coal companies in 2017 (Department of Finance, 2020). The Norwegian Government pension fund, valued at \$1 trillion in 2019, has set forth climate risk assessments as requirements for all the portfolios it owns (Norges

Bank, 2019). The pension fund also has divested its holdings in industries determined to be contributing to negative climate effects. These funds seek low returns but long-term stability and reliability, and climate-related risks are some of the most substantial risks for such goals.

Securities laws in the United States are designed to minimize the asymmetry of information that naturally exists between the investors and asset owners as much as possible; therefore, the Securities and Exchange Commission has issued guidance that all listed companies must declare risks to their assets because of climate (Maidenberg, 2021; Sorkin and others, 2022). Another requirement for monitoring and mitigating effects of climate change is to quantify emissions by not just the primary assets but also secondary and tertiary assets (primary assets are owned directly by listed companies, whereas secondary and tertiary assets are owned further down their supply chains). Therefore, emissions quantification and monitoring, as well as carbon credits as a means of emissions exchange, are seen as increasingly important parts of the financial system-climate change risk ecosystem.

Additionally, subsystemic effects of climate change on agricultural banks, or local insurance markets, are expected to leave small businesses, farmers, and households without access to critical financial services. For example, in 2020, 980 climate events incurred \$82 billion in insurance payouts (from a total of \$210 billion losses); in 2019, 860 climate events incurred \$57 billion in insurance payouts (from \$166 billion total losses); and in 2018, 850 events incurred \$80 billion in insurance payouts (from \$160 billion total losses). In comparison, for the previous 30 years (1988–2017), the average number of climate events was 500, which incurred \$41 billion in insured losses from \$140 billion in total loss (Swiss Re, 2021). The ongoing trend of 5–6-percent growth in insured losses per year is shown in figure 18.

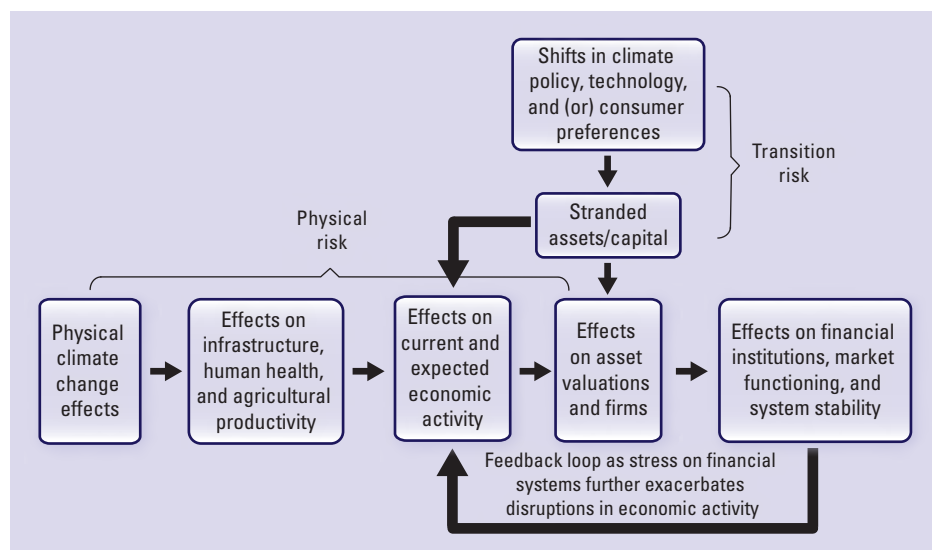


Figure 17. Risk to the financial system from climate change (modified from Climate-Related Market Risk Subcommittee [2020]).

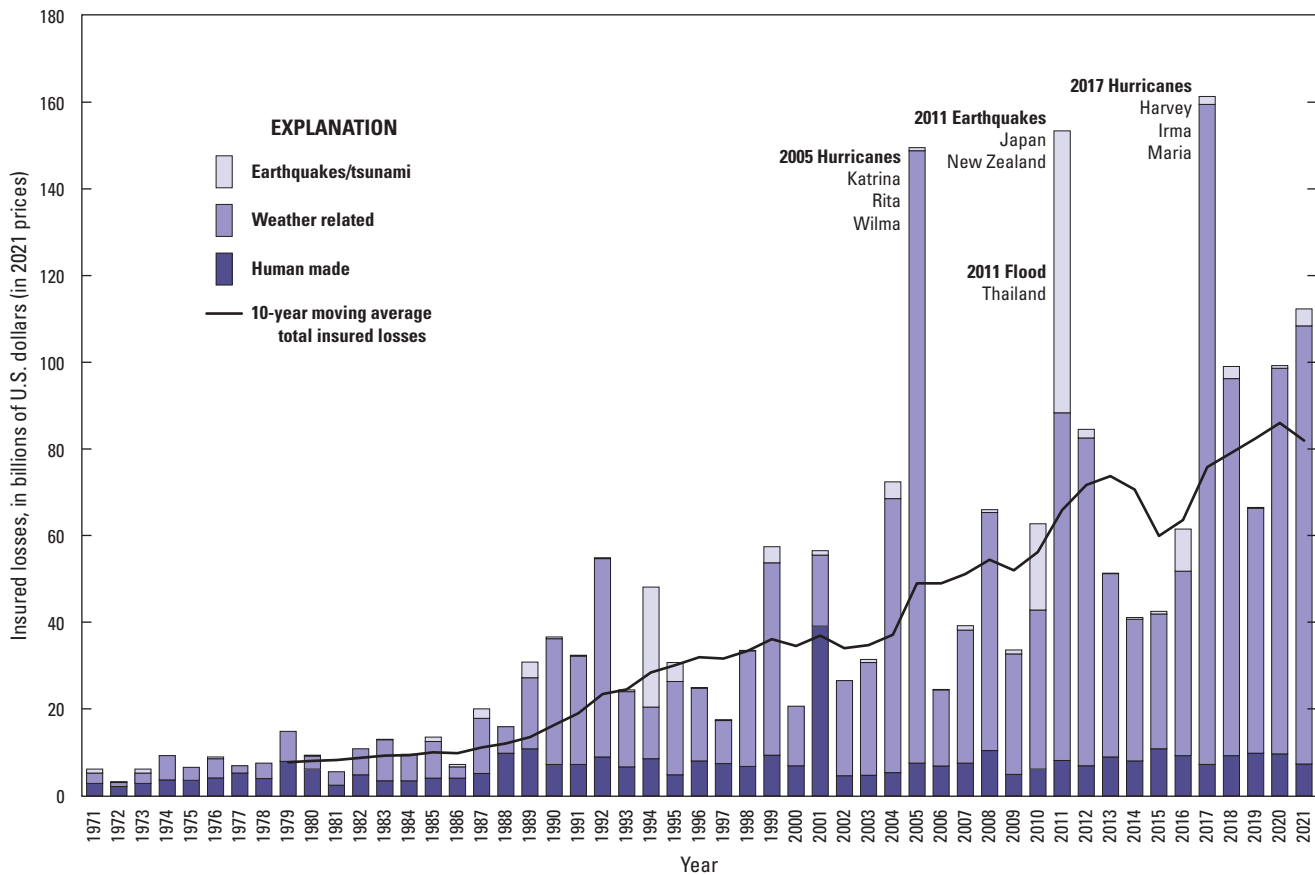


Figure 18. Ongoing trend of 5–6-percent growth in insured losses per year (modified from Swiss Re [2021]).

Remote Sensing Tasks

Remote sensing is increasingly considered a critical input into the quantification of risk to assets arising from climate change. Remote sensing also is critical in informing investment risk to regulatory bodies such as the Securities and Exchange Commission (fig. 19).

Satellite remote sensing is used to continually collect asset-level location data at higher temporal rates. These data refer to imagery, SAR, and other three-dimensional geospatial data sources (for example, light detection and ranging). Once assets are located and identified, a list of applicable climate hazards and climate stressors can be made, followed by a comprehensive (qualitative and then quantitative) sensitivity analysis for assets against climate hazards. Comprehensive effect analysis of hazards on assets is modeled based on estimates of probabilities of climate events (based on past events), local climate data, and estimates of loss. The asset level estimates can then be merged into financial portfolios and reported to regulatory agencies.

Additionally, the ability of satellite remote sensing to monitor greenhouse gas (GHG) emissions, carbon sequestration efforts for carbon credits monitoring, and so on is possibly unique. The ability to directly measure GHG emissions has

excited the industry, and even nonprofit industry is gearing for new remote sensing satellite launches. MethaneSAT is an example of a nonprofit organization (Environmental Defense Fund) launching a satellite to monitor methane emissions. GHGSat is an example of an existing for-profit company that monitors point sources of emissions, whereas the TROPospheric Monitoring Instrument can monitor large areas for emissions.

Monitoring emissions directly is possible, as of 2022, if the assets (such as oil pipelines) have been identified (for example, Orbital Sidekick, MethaneSAT). The planned launch of the Carbon Mapper program (Rasmussen, 2021) is expected to further boost the ability to track and monitor carbon emissions. Carbon Mapper is an example of commercial industry (for example, Planet) coming together with a nonprofit organization (Jet Propulsion Laboratory) to execute space remote sensing programs for precise estimation of GHG.

Investments in Remote Sensing Value Chain

Several investments have been made in the last decade in companies supporting the new remote sensing value drivers. A notional and generic remote sensing value chain, where value is delivered to nontraditional customers of remote sensing data, is shown in figure 20. At each stage, newer players (and

in some cases, traditional incumbents, mostly government) are competing. The value created (for example, risk assessments, carbon estimates, and asset tracking) for the (often nontraditional) final customers is being captured in part by all the constituents of the value chain. More information on the

investments into the remote sensing value chain, particularly in the financial system (ESG) applications, is listed in table 1.

The remote sensing requirements to generate value to these nontraditional customers are different from requirements for traditional customers of satellite remote sensing data.

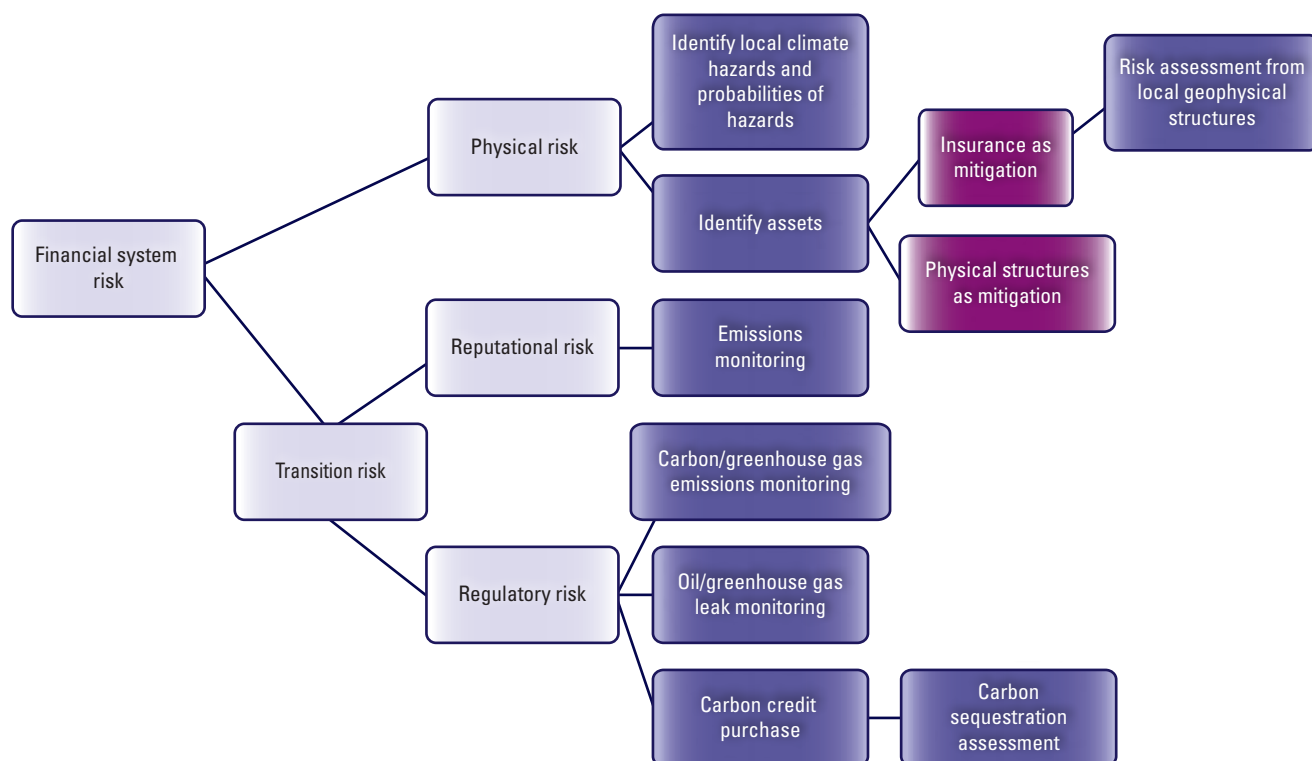


Figure 19. Decision tree from financial system risk to actionable items informed using remote sensing.

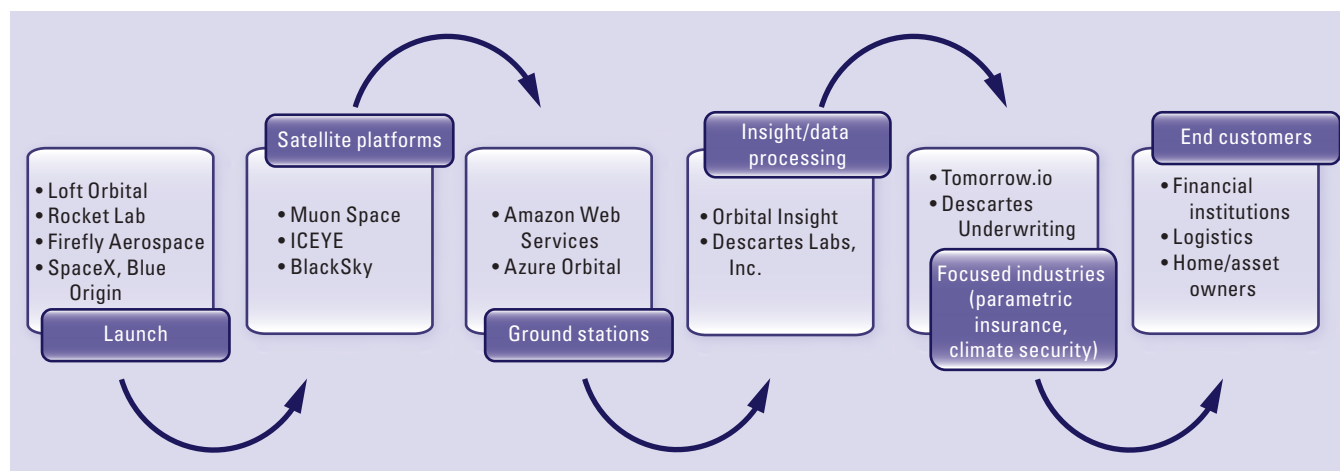


Figure 20. Notional remote sensing value chain. The companies mentioned are a mix of established companies and startups.

Table 1. Investments in the remote sensing industry from venture capital in recent years (2017 and later).

[Data from PitchBook (2022). --, no data or not applicable; ESG, environmental, social, and governance; GHG, greenhouse gas; IOT, Internet of Things; SAR, synthetic aperture radar]

| Company | Money raised | Total valuation | Initial end use/vertical | Eventual end use/vertical |
|-----------------------------|-----------------|-----------------|--------------------------|---------------------------|
| Orbital Insight | -- | \$325,000,000 | Analytics | ESG |
| Descartes Labs, Inc. | -- | \$250,000,000 | Analytics | ESG |
| RS Metrics | -- | -- | Analytics | ESG |
| Indigo Agriculture | \$1,160,000,000 | \$2,760,000,000 | Carbon sequestration | ESG |
| Pachama | -- | \$80,000,000 | Carbon sequestration | ESG |
| Sustainalytics | \$136,000,000 | \$227,000,000 | ESG | -- |
| FTSE Russell/Beyond Ratings | -- | \$17,000,000 | ESG | -- |
| Measurabl | \$82,000,000 | \$195,000,000 | ESG | -- |
| Gresb | -- | -- | ESG | -- |
| Persefoni | \$116,000,000 | -- | ESG | -- |
| Sylvera | \$40,000,000 | \$123,000,000 | ESG | -- |
| Kayrros | \$79,000,000 | \$82,000,000 | ESG/climate | -- |
| Orbital Sidekick | \$20,000,000 | \$56,000,000 | GHG/oil leak monitoring | ESG |
| Cape Analytics | \$88,000,000 | \$268,000,000 | Insurance | -- |
| Arbol | \$9,200,000 | \$37,000,000 | Insurance | ESG |
| Jupiter Intelligence | \$97,000,000 | \$244,000,000 | Insurance | ESG |
| Descartes Underwriting | -- | \$536,000,000 | Insurance/IOT | -- |
| Rocket Lab | -- | \$3,640,000,000 | Launch | -- |
| Loft Orbital | -- | \$550,000,000 | Launch | -- |
| Astro Digital, Inc. | \$16,650,000 | -- | Launch/full lifecycle | -- |
| ICEYE | \$285,000,000 | \$727,000,000 | Satellite | Analytics |
| PredaSAR | \$25,000,000 | \$90,000,000 | Satellite | Analytics |
| Pixxel | \$25,000,000 | \$95,000,000 | Satellite sensor | -- |
| BlackSky | -- | \$225,000,000 | Satellite sensor | Analytics |
| Capella Space | \$126,000,000 | \$185,000,000 | Satellite sensor/SAR | -- |
| Axelspace | \$67,000,000 | -- | Satellite/sensor | -- |
| Tomorrow.io | \$185,000,000 | \$1,200,000,000 | Climate intelligence | ESG |

These differences are as follows:

- *Persistent coverage of Earth.*—The current design is to move away from single expensive sensor platforms to constellations of similar sensors that can provide persistent coverage of Earth.
- *Spectral bands.*—The NASA Hyperion hyperspectral sensor was a precursor to the current revolution in hyperspectral imaging, inspiring newer players such as Satelloptic (Vrabel and others, 2022), MethaneSAT (Wofsy and Hamburg, 2019), and Orbital Sidekick (Weaver and others, 2020).
- *Spatial resolution.*—Although the ability to see smaller objects has always been important, the financial industry does not need hyperspatial (for example, submeter) resolution. Medium-resolution (5–30-m ground sample distance) satellites are often sufficient to localize geospatial risks.
- *Actionable information.*—The requirement to deliver actionable information from imaging data has been perhaps the most prominent driver of value of the current interest in remote sensing satellites. A traditional satellite image is a store of unstructured information, but this latent information is impossible to merge with other databases without processing. The increase in availability of computing power has allowed companies to scale up the processing and convert image data into information that can be queried using traditional

database languages (for example, Structured Query Language [or SQL]). This ability has allowed remote sensing data to be combined with other information. For example, remote sensing data collected during flood events are combined with traditional water and streamgage information to inform insurance payouts that reach affected people far more quickly than traditional insurance schemes.

- *Nimble design.*—Small satellites are being built with components that can be sourced using existing dominant designs, which allows the owners of the satellites to be nimble and change their design and requirements to meet the current trends and removes the shock of single failure during launch or suboptimal performance of sensors.
- *Future enabling technologies.*—Internet and Internet of Things for local and hyperdata collection, trustless transactions based on open-source algorithms, and using blockchain technology to create a transparent means of algorithmic implementation of risk assessments and secure records can further drive the adoption of remote sensing data into our daily lives and create a new set of customers (fig. 21).

Potential Roles of Governmental/Remote Sensing Community Stakeholders

The remote sensing community and traditional governmental remote sensing stakeholders have a large role to play in these newer applications of remote sensing. All aspects

of remote sensing data governance benefit from careful consideration. The curation, understanding, and most importantly, access to data can still be managed and affected by the traditional stakeholders (governmental science). The “access” could mean acquiring (through contracts and other means) and distributing data to end users and providing the ability to users to process and manage these large remote sensing datasets using technologies such as cloud computing.

It should be noted that the use cases of remote sensing (that is, driven by the financial system) mentioned in the previous sections are narrow and focused on estimating the investment risk emanating from climate change. These use cases, and hence the entire value chain, are not designed for preventing climate change or large-scale mitigation of the negative effects of climate change. The remote sensing satellites are solely seen as part of the risk mitigation strategy (Jones and Milstead, 2022) that informs investors of the climate-related risks in investing in assets and may perhaps be used to explore (financial) options that lower these risks.

Governmental organizations, of course, can take advantage of the data from these satellites to explore a larger and more holistic response to climate change. Governmental scientists, academics, and nonprofits can evaluate and characterize the newer constellations of satellites for their usefulness towards their respective mission. New algorithms that take advantage of multiple constellations and ground-based sensors simultaneously also are expected to be developed. Many of these data, algorithms, and systems will be open source and may be adapted by other stakeholders in the remote sensing community, evaluated for correctness, and validated. The traditional stakeholders also can be at the forefront of

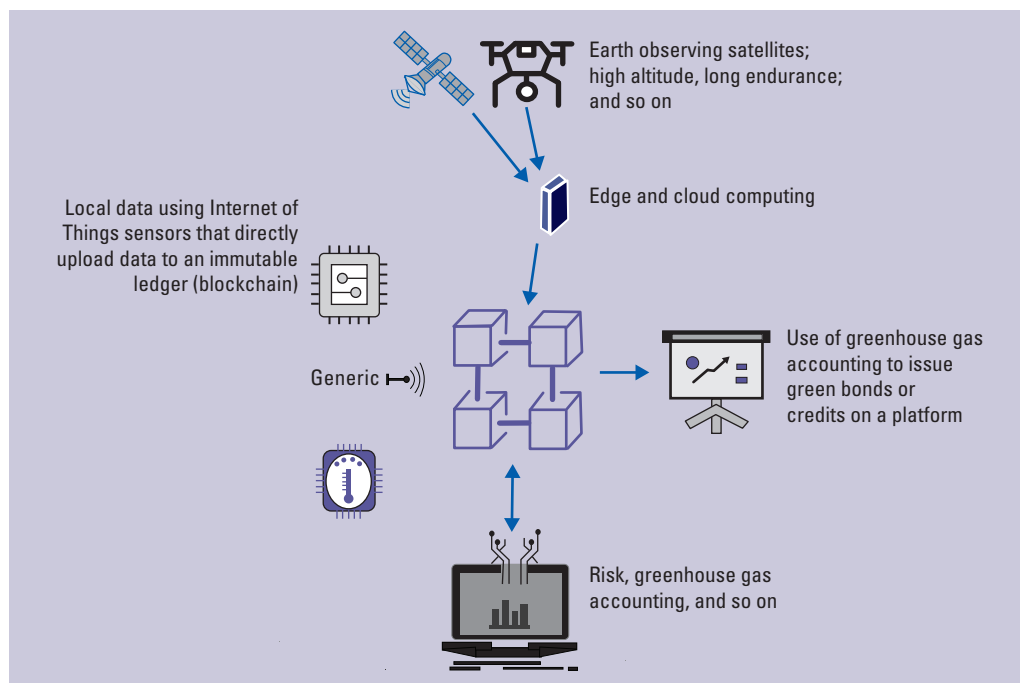


Figure 21. Technological convergence for new drivers of remote sensing.

innovations in terms of developing data processing algorithms that are transparent and open sourced.

All the new sensors also are expected to be, by design, less stable than the sensors traditionally used in satellite remote sensing (for example, Landsat and the Moderate Resolution Imaging Spectrometer). However, many of the applications will continue to be driven by regulatory requirements (for example, as imposed by the Securities and Exchange Commission). Therefore, governmental sensors will continue to play an important role in provisioning the “gold standard” sensors for data provenance and traceability to standards. Enhanced calibration, validation, and verification of the data will help ensure reliability of the data, and interoperability using improved automation, common definitions, and processes will be key.

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An artist's illustration of Landsat 2 in space. Image by the U.S. Geological Survey.







Appendix 1. Selected References

An artist's illustration of Landsat 3 in space. Image by the U.S. Geological Survey.



Appendix 1. Selected References

Many data sources were used in the process of assembling this compendium. The authors made every attempt to provide the best data available at the time of publication. These data sources at times provided conflicting information; in such circumstances, the authors 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.

Satellite Resources

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Appendix 2. Additional Resources

Landsat 8 launched February 11, 2013. Photograph by the U.S. Geological Survey.



Appendix 2. Additional Resources

The following resources provide useful information related to the usage of satellite and 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 2022.

Satellite Resources

Land Remote Sensing Satellites Online Compendium—Details about past, present and future Earth observing satellites and sensors. [Available at <https://calval.cr.usgs.gov/apps/compendium/>.]

New Space Index—Information on satellite constellations. [Available at <https://www.newspace.im/>.]

Remote Sensing 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/>.]

Belgian Earth Observation—This web page provides details on the missions supported by Belgium, either as European Space Agency core missions or third party missions. [Available at <https://eo.belspo.be/en/satellites-and-sensors/>.]

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/>.]

Earth Observing Dashboard—A triagency maintained dashboard, consisting of the National Aeronautics and Space Administration, Japan Aerospace Exploration Agency, and European Space Agency, to explore environmental and economic indicators on remote sensing. [Available at <https://eodashboard.org/>.]

EO College—A free online educational resource for Earth observation courses, topics include introductions to hyperspectral and radar remote sensing. [Available at <https://eo-college.org/>.]

ESA Tools—A website that provides analysis, processing, and visualization tools developed by the European Space Agency. [Available at <https://earth.esa.int/eogateway/tools/>.]

Group on Earth Observations 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/>.]

Index Database—A database that provides a quick overview of which remote sensing indices are usable for a specific sensor and a specific topic. [Available at <https://www.indexdatabase.de/info/idb.php>.]

Land Product Characterization System Explorer—A U.S. Geological Survey digital database that facilitates the application of multisatellite and in situ data for characterization and validation of satellite-derived land-related products. [Available at <https://lpcsexplorer.cr.usgs.gov/>.]

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 Applied Remote Sensing Training—This resource offers education and training programs to familiarize users with various remote sensing data capabilities. [Available at <https://arset.gsfc.nasa.gov/webinars/fundamentals-remotesensing/>.]

National Aeronautics and Space Administration 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/>.]

National Oceanic and Atmospheric Administration Comprehensive Large Array-Data Stewardship System—The National Oceanic and Atmospheric Administration's library system that offers environmental data from polar orbiting satellites, geostationary satellites, and other derived data. [Available at <https://www.avl.class.noaa.gov/saa/products/welcome>.]

PRISMA mission hyperspectral products—This website provides data that are freely available for all users [Available at <https://www.asi.it/en/earth-science/prisma/>.]

Stuff in Space—A real-time three-dimensional map of objects in Earth’s orbit. [Available at <https://sky.rogue.space/>.]

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://unbiodiversitylab.org/>.]

World Metrological Organization Coordination Group for Meteorological Satellites Virtual Laboratory—The World Metrological Organization Coordination Group for Meteorological Satellites 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/>.]



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

Landsat 5 launched March 1, 1984. Photograph by the National Aeronautics and Space Administration/Raytheon.



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

Included in this appendix are tables listing recent launches (table 3.1) and planned future launches (table 3.2) of government and commercial satellites. A map (fig. 3.1) of countries with Earth observing satellites, and the number of satellites launched by each country, also is included.

Table 3.1. Earth observation satellite launches from 2020 to 2022.

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-------------------|--------------------------|------------------|--------------------------------------|
| 01/15/2020 | Jilin-1 Kuanfu-01 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 01/15/2020 | NewSat-7 | Optical imager | Commercial | Argentina/Satellogic |
| 01/15/2020 | NewSat-8 | Optical imager | Commercial | Argentina/Satellogic |
| 02/18/2020 | Geo-KOMPSAT 2B | Optical imager | Government/civil | Japan |
| 05/31/2020 | Gaofen-9 02 | Optical imager | Government/civil | China |
| 06/10/2020 | Haiyang-1D | Optical imager | Government/civil | China |
| 06/13/2020 | SkySat-16 | Optical imager | Commercial | U.S./Planet |
| 06/13/2020 | SkySat-17 | Optical imager | Commercial | U.S./Planet |
| 06/13/2020 | SkySat-18 | Optical imager | Commercial | U.S./Planet |
| 06/17/2020 | Gaofen-9 03 | Optical imager | Government/civil | China |
| 07/03/2020 | Gaofen Duomo | Optical imager | Government/civil | China |
| 07/10/2020 | Jilin-1 GF-02E | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 07/25/2020 | Zi Yuan-3-03 | Optical imager | Government/civil | China |
| 08/06/2020 | Gaofen-9 04 | Optical imager | Government/civil | China |
| 08/07/2020 | BlackSky Global-7 | Optical imager | Commercial | U.S./BlackSky |
| 08/07/2020 | BlackSky Global-8 | Optical imager | Commercial | U.S./BlackSky |
| 08/18/2020 | Skysat-19 | Optical imager | Commercial | U.S./Planet |
| 08/18/2020 | Skysat-20 | Optical imager | Commercial | U.S./Planet |
| 08/18/2020 | Skysat-21 | Optical imager | Commercial | U.S./Planet |
| 08/23/2020 | Gaofen-9 05 | Optical imager | Government/civil | China |
| 08/30/2020 | SAOCOM-1B | Synthetic aperture radar | Government/civil | Argentina |
| 08/31/2020 | Sequoia | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 09/03/2020 | NewSat-6 | Optical imager | Commercial | Argentina/Satellogic |
| 09/03/2020 | Flock-4v 01 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 02 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 03 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 04 | Optical imager | Commercial | U.S./Planet |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-----------------------|-----------------|------------------|--------------------------------------|
| 09/03/2020 | Flock-4v 05 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 06 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 07 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 08 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 09 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 10 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 11 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 12 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 13 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 14 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 15 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 16 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 17 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 18 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 19 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 20 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 21 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 22 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 23 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 24 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 25 | Optical imager | Commercial | U.S./Planet |
| 09/03/2020 | Flock-4v 26 | Optical imager | Commercial | U.S./Planet |
| 09/07/2020 | Gaofen-11 02 | Optical imager | Government/civil | China |
| 09/15/2020 | Jilin-1 Gaofen-03B 01 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03B 02 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03B 03 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03B 04 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03B 05 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03B 06 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03C 01 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03C 02 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/15/2020 | Jilin-1 Gaofen-03C 03 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/21/2020 | HaiYang-2C | Optical imager | Government/civil | China |
| 09/27/2020 | Huanjing 2A | Optical imager | Government/civil | China |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|---------------------|--------------------------|------------------|-------------------------|
| 09/27/2020 | Huanjing 2B | Optical imager | Government/civil | China |
| 09/27/2020 | ICEYE-X6 | Synthetic aperture radar | Commercial | U.S./ICEYE |
| 09/27/2020 | ICEYE-X7 | Synthetic aperture radar | Commercial | U.S./ICEYE |
| 10/11/2020 | Gaofen-13 | Synthetic aperture radar | Government/civil | China |
| 10/28/2020 | Flock-4e 01 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 02 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 03 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 04 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 05 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 06 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 07 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 08 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | Flock-4e 09 | Optical imager | Commercial | U.S./Planet |
| 10/28/2020 | CE-SAT-IIB | Optical imager | Commercial | Japan/Canon Electronics |
| 11/06/2020 | NewSat-9 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-10 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-11 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-12 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-13 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-14 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-15 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-16 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-17 | Optical imager | Commercial | Argentina/Satellogic |
| 11/06/2020 | NewSat-18 | Optical imager | Commercial | Argentina/Satellogic |
| 11/07/2020 | EOS-01 (RISAT-2BR2) | Synthetic aperture radar | Government/civil | India |
| 11/20/2020 | Landmapper-BC 5 | Optical imager | Commercial | U.S./Astro Digital Inc. |
| 11/21/2020 | Sentinel-6 | Synthetic aperture radar | Government/civil | ESA |
| 12/06/2020 | Gaofen-14 | Optical imager | Government/civil | China |
| 12/15/2020 | StriX-Alpha | Synthetic aperture radar | Commercial | Japan/Synspective Inc. |
| 12/22/2020 | Haisi-1 | Synthetic aperture radar | Commercial | China/Spacety |
| 12/22/2020 | ET-SMART-RSS | Optical imager | Government/civil | Ethiopia |
| 12/22/2020 | ET-SMART-RSS | Optical imager | Government/civil | China |
| 01/19/2021 | Tianhui | Optical imager | Government/civil | China |
| 01/24/2021 | Whitney-1 | Synthetic aperture radar | Commercial | U.S./Capella Space |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|---------------------|--------------------------|------------|------------------------|
| 01/24/2021 | Whitney-2 | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 01/24/2021 | Umbra-SAR 2001 | Synthetic aperture radar | Commercial | U.S./Umbra Labs |
| 01/24/2021 | Izanami (QPS-SAR 2) | Synthetic aperture radar | Commercial | Japan/Synspective Inc. |
| 01/24/2021 | Flock-4s 01 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 02 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 03 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 04 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 05 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 06 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 07 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 08 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 09 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 10 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 11 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 12 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 13 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 14 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 15 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 16 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 17 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 18 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 19 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 20 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 21 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 22 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 23 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 24 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 25 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 26 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 27 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 28 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 29 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 30 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 31 | Optical imager | Commercial | U.S./Planet |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|----------------|--------------------------|------------------|--------------------------------------|
| 01/24/2021 | Flock-4s 32 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 33 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 34 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 35 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 36 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 37 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 38 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 39 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 40 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 41 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 42 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 43 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 44 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 45 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 46 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 47 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | Flock-4s 48 | Optical imager | Commercial | U.S./Planet |
| 01/24/2021 | ICEYE X8 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 01/24/2021 | ICEYE X9 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 01/24/2021 | ICEYE X10 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 01/24/2021 | GHGSAT | Optical imager | Government/civil | Canada |
| 02/28/2021 | Amazonia-1 | Optical imager | Government/civil | Brazil |
| 02/28/2021 | Jilin-1 GF-2D | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 03/14/2021 | CAS500-1 | Optical imager | Government/civil | Republic of Korea |
| 03/14/2021 | DMSAT-1 | Optical imager | Government/civil | UAE |
| 03/14/2021 | FPS | Optical imager | Commercial | Japan/Axelspace |
| 03/14/2021 | GRUS-1 | Optical imager | Commercial | Japan/Axelspace |
| 03/14/2021 | GRUS-2 | Optical imager | Commercial | Japan/Axelspace |
| 03/14/2021 | GRUS-3 | Optical imager | Commercial | Japan/Axelspace |
| 03/22/2021 | Global-9 | Optical imager | Commercial | U.S./BlackSky |
| 03/23/2021 | Gaofen-12 02 | Optical imager | Government/civil | China |
| 05/15/2021 | Capella-6 | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 04/05/2021 | PredaSAR 1 | Synthetic aperture radar | Commercial | U.S./PredaSAR |
| 04/29/2021 | Pléiades-NEO 3 | Optical imager | Commercial | France/Airbus Defence and Space |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-----------------------------|--------------------------|------------------|--------------------------------------|
| 04/27/2021 | Golden Bauhinia-1 01 | Optical imager | Commercial | China/Zero G Lab |
| 04/27/2021 | Golden Bauhinia-1 02 | Optical imager | Commercial | China/Zero G Lab |
| 05/19/2021 | Haiyang-2D | Optical imager | Government/civil | China |
| 06/02/2021 | Fengyun 4B | Optical imager | Government/civil | China |
| 06/30/2021 | STORK-4 | Optical imager | Commercial | Poland/SatRevolution |
| 06/30/2021 | STORK-5 (MARTA) | Optical imager | Commercial | Poland/SatRevolution |
| 06/30/2021 | Aurora (Shasta) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 06/30/2021 | Capella-5 | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 06/30/2021 | ICEYE-11 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 06/30/2021 | ICEYE-12 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 06/30/2021 | ICEYE-13 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 06/30/2021 | ICEYE-14 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 06/30/2021 | NewSat-19 | Optical imager | Commercial | Argentina/Satellogic |
| 06/30/2021 | NewSat-20 | Optical imager | Commercial | Argentina/Satellogic |
| 06/30/2021 | NewSat-21 | Optical imager | Commercial | Argentina/Satellogic |
| 06/30/2021 | NewSat-22 | Optical imager | Commercial | Argentina/Satellogic |
| 07/03/2021 | Jilin-1 Kuanfu-01B | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 07/03/2021 | Jilin-1 Gaofen-03D 01 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 07/03/2021 | Jilin-1 Gaofen-03D 02 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 07/03/2021 | Jilin-1 Gaofen-03D 03 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 07/04/2021 | Fengyun 3E | Optical imager | Government/civil | China |
| 07/29/2021 | Tianhui-1D | Optical imager | Government/civil | China |
| 08/17/2021 | Pléiades-NEO 4 | Optical imager | Commercial | France/Airbus Defence and Space |
| 08/18/2021 | Tianhui-2 02A | Optical imager | Government/civil | China |
| 08/18/2021 | Tianhui-2 02A | Optical imager | Government/civil | China |
| 09/07/2021 | Gaofen-5 02 | Optical imager | Government/civil | China |
| 09/27/2021 | Jilin-1 GF-02D | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 09/27/2021 | Landsat-9 | Optical imager | Government/civil | U.S. |
| 10/14/2021 | Guidao Daqi Midu TSW (MD-1) | Optical imager | Government/civil | China |
| 10/14/2021 | HEAD-2E | Optical imager | Commercial | China/HEAD Aerospace |
| 10/14/2021 | HEAD-2F | Optical imager | Commercial | China/HEAD Aerospace |
| 10/14/2021 | Golden Bauhinia-2 | Optical imager | Commercial | China/Zero G Lab |
| 10/27/2021 | Jilin-1 GF-02F | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-----------------------------|--------------------------|------------------|----------------------|
| 11/05/2021 | SDGSAT-1 (Guangmu/CASEarth) | Optical imager | Government/civil | China |
| 11/18/2021 | BlackSky 10 | Optical imager | Commercial | U.S./BlackSky |
| 11/18/2021 | BlackSky 11 | Optical imager | Commercial | U.S./BlackSky |
| 11/22/2021 | Gaofen 3-02 | Synthetic aperture radar | Government/civil | China |
| 12/02/2021 | BlackSky 12 | Optical imager | Commercial | U.S./BlackSky |
| 12/02/2021 | BlackSky 13 | Optical imager | Commercial | U.S./BlackSky |
| 12/07/2021 | Baoyun | Optical imager | Commercial | China |
| 12/07/2021 | Golden Bauhinia-1 03 | Optical imager | Commercial | China/Zero G Lab |
| 12/07/2021 | Golden Bauhinia-5 | Optical imager | Commercial | China/Zero G Lab |
| 12/08/2021 | BlackSky 14 | Optical imager | Commercial | U.S./BlackSky |
| 12/08/2021 | BlackSky 15 | Optical imager | Commercial | U.S./BlackSky |
| 12/26/2021 | Zi Yuan-I-02E | Optical imager | Government/civil | China |
| 12/29/2021 | Tianhui-4 | Optical imager | Government/civil | China |
| 01/13/2022 | Capella-7 | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 01/13/2022 | Capella-8 | Synthetic aperture radar | Commercial | U.S./Capella Space |
| 01/13/2022 | ICEYE-14 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 01/13/2022 | ICEYE-15 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 01/13/2022 | UMBRA-02 | Synthetic aperture radar | Commercial | U.S./Umbra Labs |
| 01/13/2022 | Sich-2-30-1 | Optical imager | Government/civil | Ukraine |
| 01/13/2022 | Sich-2-30-2 | Optical imager | Government/civil | Ukraine |
| 01/13/2022 | ETV-A1 | Optical imager | Commercial | UK/Sen |
| 01/13/2022 | STORK-1 | Optical imager | Commercial | Poland/SatRevolution |
| 01/13/2022 | STORK-2 | Optical imager | Commercial | Poland/SatRevolution |
| 01/13/2022 | Flock-4x-01 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-02 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-03 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-04 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-05 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-06 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-07 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-08 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-09 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-10 | Optical imager | Commercial | U.S./Planet |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-------------|-----------------|------------|---------------|
| 01/13/2022 | Flock-4x-11 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-12 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-13 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-14 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-15 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-16 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-17 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-18 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-19 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-20 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-21 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-22 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-23 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-24 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-25 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-26 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-27 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-28 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-29 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-30 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-31 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-32 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-33 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-34 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-35 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-36 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-37 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-38 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-39 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-40 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-41 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-42 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-43 | Optical imager | Commercial | U.S./Planet |
| 01/13/2022 | Flock-4x-44 | Optical imager | Commercial | U.S./Planet |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|-----------------------|--------------------------|------------------|-----------------------------------------|
| 01/13/2022 | SW1FT | Optical imager | Commercial | Poland/SatRevolution |
| 01/13/2022 | Challenger | Synthetic aperture radar | Commercial | U.S./Quub |
| 01/13/2022 | Unicorn-2A | Optical imager | Commercial | Scotland/Alba Orbital |
| 01/13/2022 | Unicorn-2D | Optical imager | Commercial | Scotland/Alba Orbital |
| 01/13/2022 | Unicorn-2E | Optical imager | Commercial | Scotland/Alba Orbital |
| 01/13/2022 | HYPISO-1 | Optical imager | Commercial | Norway/NTNU SmallSat Lab |
| 01/13/2022 | STORK-3 | Optical imager | Commercial | Poland/SatRevolution |
| 01/25/2022 | L-SAR 01A | Synthetic aperture radar | Government/civil | China |
| 01/31/2022 | CSG-2 | Synthetic aperture radar | Government/civil | Italy |
| 02/14/2022 | RISAT-1A | Synthetic aperture radar | Government/civil | India |
| 02/26/2022 | L-SAR 01B | Synthetic aperture radar | Government/civil | China |
| 02/27/2022 | Hainan-1 01 | Optical imager | Commercial | China/Hainan Westar |
| 02/27/2022 | Hainan-1 02 | Optical imager | Commercial | China/Hainan Westar |
| 02/27/2022 | Jilin-1 GF-03D 10 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 11 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 12 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 13 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 14 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 15 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 16 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 17 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 GF-03D 18 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Jilin-1 Mofang-02A 01 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 02/27/2022 | Taijing-3 01 | Optical imager | Commercial | China/MinoSpace |
| 02/27/2022 | Taijing-4 01 | Optical imager | Commercial | China/MinoSpace |
| 02/27/2022 | Tianxian-1 | Optical imager | Commercial | China/Spacety |
| 02/27/2022 | Chuangxing Leishen | Optical imager | Commercial | China/Spacety |
| 02/27/2022 | Wenchang-1 01 | Optical imager | Commercial | China/Sanya Institute of Remote Sensing |
| 02/27/2022 | Wenchang-1 02 | Optical imager | Commercial | China/Sanya Institute of Remote Sensing |
| 02/27/2022 | Xidian-1 | Optical imager | Commercial | China/MinoSpace |
| 02/27/2022 | Qimingxing-1 | Optical imager | Commercial | China |
| 02/28/2022 | StriX-Beta | Synthetic aperture radar | Commercial | Japan/Synspective Inc. |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|------------------------|--------------------------|------------------|--------------------------------------|
| 03/01/2022 | GOES-T | Optical imager | Government/civil | U.S. |
| 03/05/2022 | Xuanming Xingyuan | Optical imager | Commercial | China/SpaceWish |
| 03/29/2022 | Pujiang-2 | Optical imager | Government/civil | China |
| 04/01/2022 | NewSat-23 | Optical imager | Commercial | Argentina/Satellogic |
| 04/01/2022 | NewSat-24 | Optical imager | Commercial | Argentina/Satellogic |
| 04/01/2022 | NewSat-25 | Optical imager | Commercial | Argentina/Satellogic |
| 04/01/2022 | NewSat-26 | Optical imager | Commercial | Argentina/Satellogic |
| 04/01/2022 | NewSat-27 | Optical imager | Commercial | Argentina/Satellogic |
| 04/01/2022 | EnMAP | Optical imager | Government/civil | Germany |
| 04/01/2022 | Pixxel TD-2 Shakuntala | Optical imager | Commercial | India/Pixxel |
| 04/02/2022 | BlackSky-16 | Optical imager | Commercial | U.S./BlackSky |
| 04/02/2022 | BlackSky-17 | Optical imager | Commercial | U.S./BlackSky |
| 04/06/2022 | Gaofen 3-03 | Optical imager | Government/civil | China |
| 04/30/2022 | Jilin-1 Gaofen-03D 04 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 04/30/2022 | Jilin-1 Gaofen-03D 05 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 04/30/2022 | Jilin-1 Gaofen-03D 06 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 04/30/2022 | Jilin-1 Gaofen-03D 07 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/02/2022 | Unicorn-2 | Optical imager | Commercial | Scotland/Alba Orbital |
| 05/05/2022 | Jilin-1 Kuanfu-01 C | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 27 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 28 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 29 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 30 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 31 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 32 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/05/2022 | Jilin-1 Gaofen-03D 33 | Optical imager | Commercial | China/Chang Guang Satellite Co. Ltd. |
| 05/25/2022 | GHGSat C3 | Optical imager | Commercial | Canada/GHGSat |
| 05/25/2022 | GHGSat C4 | Optical imager | Commercial | Canada/GHGSat |
| 05/25/2022 | GHGSat C5 | Optical imager | Commercial | Canada/GHGSat |
| 05/25/2022 | ICEYE-17 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 05/25/2022 | ICEYE-18 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 05/25/2022 | ICEYE-19 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 05/25/2022 | ICEYE-20 | Synthetic aperture radar | Commercial | Finland/ICEYE |
| 05/25/2022 | ICEYE-21 | Synthetic aperture radar | Commercial | Finland/ICEYE |

Table 3.1. Earth observation satellite launches from 2020 to 2022.—Continued

[Launch date is given in month/day/year format. Co., Company; Ltd., Limited; U.S., United States; GF, Gaofen; SAOCOM, Satélite Argentino de Observación Con Microondas; RISAT, Radar Imaging Satellite; ESA, European Space Agency; SAR, synthetic aperture radar; UAE, United Arab Emirates; UK, United Kingdom; NTNU, Norwegian University of Science and Technology; CSG, COSMO-SkyMed second generation; GOES, Geostationary Operational Environmental Satellite; EnMAP, Environmental Mapping and Analysis Program; EMIT, Earth Surface Mineral Dust Source Investigation]

| Launch date | Spacecraft | Instrument type | User | Country/owner |
|-------------|--------------------|--------------------------|------------------|------------------------|
| 05/25/2022 | NewSat-28 | Optical imager | Commercial | Argentina/Satellologic |
| 05/25/2022 | NewSat-29 | Optical imager | Commercial | Argentina/Satellologic |
| 05/25/2022 | NewSat-30 | Optical imager | Commercial | Argentina/Satellologic |
| 05/25/2022 | NewSat-31 | Optical imager | Commercial | Argentina/Satellologic |
| 05/25/2022 | Umbra 03 | Synthetic aperture radar | Commercial | U.S./Umbra Labs |
| 05/25/2022 | Umbra 04 | Synthetic aperture radar | Commercial | U.S./Umbra Labs |
| 05/25/2022 | Umbra 05 | Synthetic aperture radar | Commercial | U.S./Umbra Labs |
| 05/25/2022 | Guardian-1 | Optical imager | Commercial | Spain/Aistech |
| 06/30/2022 | DS EO | Optical imager | Commercial | Singapore |
| 06/30/2022 | NeuSAR | Synthetic aperture radar | Commercial | Singapore |
| 07/14/2022 | EMIT | Optical imager | Government/civil | U.S. |
| 07/15/2022 | SuperView Neo 2-01 | Optical imager | Commercial | China |
| 07/15/2022 | SuperView Neo 2-02 | Optical imager | Commercial | China |

Table 3.2. Earth observation satellite launches planned for 2022 and beyond.

[U.S., United States; ESA, European Space Agency; EUMETSAT, European Organisation for the Exploitation of Meteorological Satellites; SAR, synthetic aperture radar; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; JPL, Jet Propulsion Laboratory; NASA, National Aeronautics and Space Administration; ISRO, Indian Space Research Organisation; No., Number]

| Launch year | Spacecraft | Instrument type | User | Country/owner |
|-------------|--------------------------------------------------------|--------------------------|------------------|---------------------------------|
| 2022 | WorldView Legion | Optical imager | Commercial | U.S./Maxar Technologies |
| 2022 | Advanced Land Observing Satellite-3 (ALOS-3) | Optical imager | Government/civil | Japan |
| 2022 | Compact Advanced Satellite 500-2 (CAS500-2) | Optical imager | Government/civil | South Korea |
| 2022 | ConstellIR-1 | Optical imager | Commercial | Germany/ConstellIR |
| 2022 | Earth Cloud Aerosol and Radiation Explorer (EarthCARE) | Optical imager | Government/civil | Japan, ESA |
| 2022 | Global Hyperspectral Observation Satellite-1 (GHOS-1) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Global Hyperspectral Observation Satellite-2 (GHOS-2) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Global Hyperspectral Observation Satellite-3 (GHOS-3) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Global Hyperspectral Observation Satellite-4 (GHOS-4) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Global Hyperspectral Observation Satellite-5 (GHOS-5) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Global Hyperspectral Observation Satellite-6 (GHOS-6) | Optical imager | Commercial | U.S./Orbital Sidekick |
| 2022 | Hydra 1 | Optical imager | Commercial | Spain/Aistech Space |
| 2022 | Joint Polar Satellite System-2 (JPSS-2) | Optical imager | Government/civil | U.S. |
| 2022 | Korean Multi-Purpose Satellite-6 (Komsat-6) | Synthetic aperture radar | Government/civil | South Korea |
| 2022 | Korean Multi-Purpose Satellite-7 (Komsat-7) | Optical imager | Government/civil | South Korea |
| 2022 | Meteosat Third Generation-Imaging 1 (MTG I1) | Optical imager | Government/civil | EUMETSAT |
| 2022 | OceanSat-3 | Optical imager | Government/civil | India |
| 2022 | OceanSat-3A | Optical imager | Government/civil | India |
| 2022 | Pléiades Neo-5 | Optical imager | Commercial | France/Airbus Defence and Space |
| 2022 | Pléiades Neo-6 | Optical imager | Commercial | France/Airbus Defence and Space |
| 2022 | PredaSAR-1 | Synthetic aperture radar | Commercial | U.S./PredaSAR |
| 2022 | Radar Imaging Satellite-1B (RISAT-1B) | Synthetic aperture radar | Government/civil | India |
| 2022 | ResourceSat-3S | Optical imager | Government/civil | India |
| 2022 | SABIA-Mar 1 | Optical imager | Government/civil | Argentina, Brazil |

Table 3.2. Earth observation satellite launches planned for 2022 and beyond.—Continued

[U.S., United States; ESA, European Space Agency; EUMETSAT, European Organisation for the Exploitation of Meteorological Satellites; SAR, synthetic aperture radar; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; JPL, Jet Propulsion Laboratory; NASA, National Aeronautics and Space Administration; ISRO, Indian Space Research Organisation; No., Number]

| Launch year | Spacecraft | Instrument type | User | Country/owner |
|-------------|------------------------------------------------------------------------------|--------------------------|------------------|---------------------------------|
| 2022 | Spaceborne Hyperspectral Applicative Land and Ocean Satellite (SHALOM) | Optical imager | Government/civil | Italy, Israel |
| 2022 | Surface Water Ocean Topography Satellite (SWOT) | Radar interferometer | Government/civil | U.S. |
| 2022 | Vivid-i 1-5 | Optical imager | Commercial | Earth-i |
| 2023 | Advanced Land Observing Satellite-4 (ALOS-4) | Synthetic aperture radar | Government/civil | Japan |
| 2023 | High Resolution Satellite-1A (HRSAT-1A) | Optical imager | Government/civil | India |
| 2023 | High Resolution Satellite-1B (HRSAT-1B) | Optical imager | Government/civil | India |
| 2023 | High Resolution Satellite-1C (HRSAT-1C) | Optical imager | Government/civil | India |
| 2023 | Advanced Satellite with New system Architecture for Observation-3 (ASNARO-3) | Optical imager | Government/civil | Japan |
| 2023 | Biomass Satellite | Synthetic aperture radar | Government/civil | ESA |
| 2023 | Tanager-1 | Optical imager | Commercial | U.S./Planet/JPL |
| 2023 | Tanager-2 | Optical imager | Commercial | U.S./Planet/JPL |
| 2023 | Constellation Optique 3D-1 (CO3D-1) | Optical imager | Commercial | France/Airbus Defence and Space |
| 2023 | Constellation Optique 3D-2 (CO3D-2) | Optical imager | Commercial | France/Airbus Defence and Space |
| 2023 | Constellation Optique 3D-3 (CO3D-3) | Optical imager | Commercial | France/Airbus Defence and Space |
| 2023 | Constellation Optique 3D-4 (CO3D-4) | Optical imager | Commercial | France/Airbus Defence and Space |
| 2023 | EarthDaily-1 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | EarthDaily-2 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | EarthDaily-3 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | EarthDaily-4 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | EarthDaily-5 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | EarthDaily-6 | Optical imager | Commercial | Canada/EarthDaily Analytics |
| 2023 | Hypersat-1 | Optical imager | Commercial | U.S./QinetiQ |
| 2023 | HySpecIQ-1 | Optical imager | Commercial | U.S./HyspecIQ |

Table 3.2. Earth observation satellite launches planned for 2022 and beyond.—Continued

[U.S., United States; ESA, European Space Agency; EUMETSAT, European Organisation for the Exploitation of Meteorological Satellites; SAR, synthetic aperture radar; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; JPL, Jet Propulsion Laboratory; NASA, National Aeronautics and Space Administration; ISRO, Indian Space Research Organisation; No., Number]

| Launch year | Spacecraft | Instrument type | User | Country/owner |
|-------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------|------------------|-------------------|
| 2023 | NASA-ISRO Synthetic Aperture Radar Satellite (NISAR) | Synthetic aperture radar | Government/civil | U.S., India |
| 2023 | Pelican-1 | Optical imager | Commercial | U.S./Pelican |
| 2023 | ResourceSat-3 | Optical imager | Government/civil | India |
| 2023 | ResourceSat-3SA | Optical imager | Government/civil | India |
| 2023 | Sentinel-3C (S-3C) | Optical imager | Government/civil | ESA |
| 2024 | Albedo-1 Satellite | Optical imager | Commercial | U.S./Albedo Space |
| 2024 | Formosat-8A | Optical imager | Government/civil | Taiwan |
| 2024 | Geostationary Operational Environmental Satellite-U (GOES-U) | Optical imager | Government/civil | U.S. |
| 2024 | Plankton, Aerosol, Cloud, ocean Ecosystem Satellite (PACE) | Optical imager | Government/civil | U.S. |
| 2024 | ResourceSat-3A | Optical imager | Government/civil | India |
| 2024 | Sentinel-1C (S-1C) | Synthetic aperture radar | Government/civil | ESA |
| 2024 | Sentinel-2C (S-2C) | Optical imager | Government/civil | ESA |
| 2024 | Thermal infrared Imaging Satellite for High Resolution Natural resource Assessment Satellite (TRISHNA) | Optical imager | Government/civil | France, India |
| 2025 | Canopus-Vulcan No. 7 (Canopus-V No. 7) | Optical imager | Government/civil | Russia |
| 2025 | Canopus-Vulcan No. 8 (Canopus-V No. 8) | Optical imager | Government/civil | Russia |
| 2025 | Fluorescence Explorer Satellite (FLEX) | Optical imager | Government/civil | ESA |
| 2025 | Formosat-8B | Optical imager | Government/civil | Taiwan |
| 2025 | Land Surface Temperature Monitoring Satellite-1 (LSTM-1) | Optical imager | Government/civil | ESA |
| 2025 | Land Surface Temperature Monitoring Satellite-2 (LSTM-2) | Optical imager | Government/civil | ESA |
| 2025 | Meteosat Third Generation-Imaging 2 (MTG I2) | Optical imager | Government/civil | EUMETSAT |
| 2025 | Sentinel-1D (S-1D) | Synthetic aperture radar | Government/civil | ESA |
| 2025 | Sentinel-2D (S-2D) | Optical imager | Government/civil | ESA |
| 2025 | Sentinel-3D (S-3D) | Optical imager | Government/civil | ESA |
| 2026 | Copernicus Imaging Radiometer Satellite (CIMR) | Optical imager | Government/civil | ESA |
| 2026 | Formosat-8C | Optical imager | Government/civil | Taiwan |
| 2026 | Sentinel-6B (S-6B) | Radar altimeter/ synthetic aperture radar | Government/civil | ESA |
| 2027 | Formosat-8D | Optical imager | Government/civil | Taiwan |

Table 3.2. Earth observation satellite launches planned for 2022 and beyond.—Continued

[U.S., United States; ESA, European Space Agency; EUMETSAT, European Organisation for the Exploitation of Meteorological Satellites; SAR, synthetic aperture radar; SABIA-Mar, Satélites Argentino-Brasileño para Información Ambiental del Mar; JPL, Jet Propulsion Laboratory; NASA, National Aeronautics and Space Administration; ISRO, Indian Space Research Organisation; No., Number]

| Launch year | Spacecraft | Instrument type | User | Country/owner |
|-------------|--------------------------------------------------------------------------------|--------------------------|------------------|---------------|
| 2027 | Surface Biology and Geology Light (SBG Light) | Optical imager | Government/civil | U.S. |
| 2027 | Surface Biology and Geology Satellite Heat (SBG Heat) | Optical imager | Government/civil | U.S. |
| 2028 | Formosat-8E | Optical imager | Government/civil | Taiwan |
| 2028 | Meteosat Third Generation-Imaging 3 (MTG I3) | Optical imager | Government/civil | EUMETSAT |
| 2028 | Radar Observing System for Europe - L-band Satellite (ROSE-L) | Synthetic aperture radar | Government/civil | ESA |
| 2028 | WildFireSat-1 (WFS-1) | Optical imager | Government/civil | Canada |
| 2028 | WildFireSat-2 (WFS-2) | Optical imager | Government/civil | Canada |
| 2028 | WildFireSat-3 (WFS-3) | Optical imager | Government/civil | Canada |
| 2029 | Copernicus Hyperspectral Imaging Mission for the Environment Satellite (CHIME) | Optical imager | Government/civil | ESA |
| 2029 | Formosat-8F | Optical imager | Government/civil | Taiwan |
| 2029 | Landsat NeXt (LNeXt) | Optical imager | Government/civil | U.S. |
| 2032 | Meteosat Third Generation-Imaging 4 (MTG I4) | Optical imager | Government/civil | EUMETSAT |

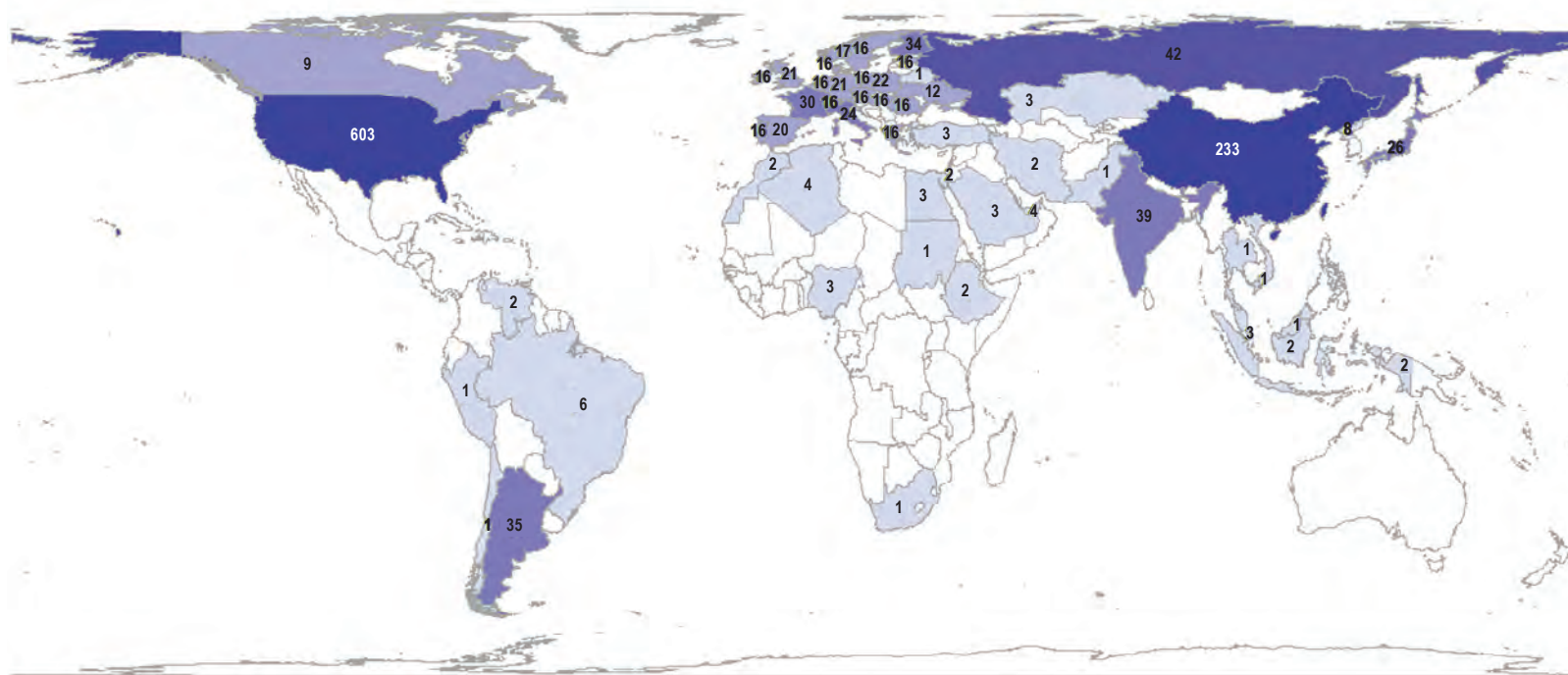


Figure 3.1. Map of countries with Earth observing satellites and the number of satellites launched.





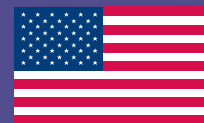
Appendix 4. Remote Sensing Satellite Data Sheets

An artist's illustration of Landsat 8 in space. Image by the U.S. Geological Survey.



Albedo Constellation

United States
Commercial
Future



Platform Overview

Albedo Space Corporation is planning to launch a constellation of 24 high-resolution multispectral satellites for Earth resources monitoring. The first satellite is planned for launch in 2024, and the remaining satellites are planned to be launched by 2027. The satellites will carry a panchromatic, multispectral, and thermal imager for high-resolution Earth imaging.

[Abbreviations in tables: —, no data; km, kilometer; PanMux, panchromatic and multispectral imager; GSD, ground sample distance; m, meter; NIR, near infrared; TIR, thermal infrared]

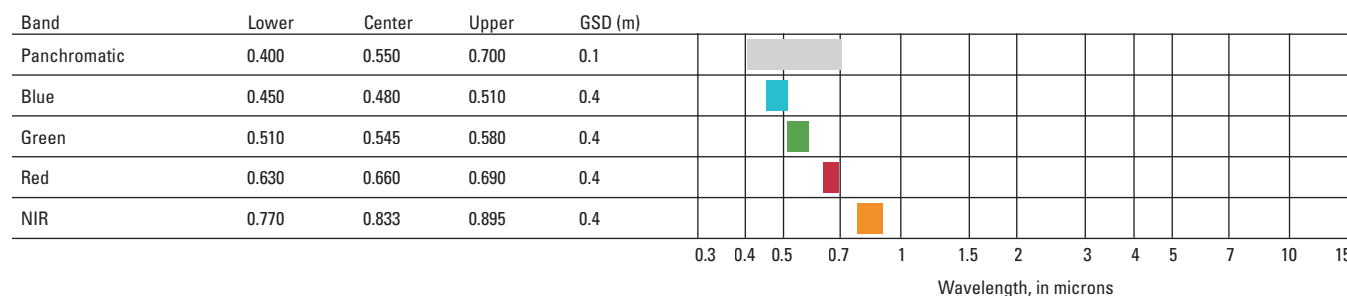
| | |
|-----------------|---------------------------------------------------------------------------------|
| Launch date | 2024 (Planned) |
| Design lifetime | 5 years |
| Platform owner | — |
| Altitude | 150–450 km |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Planned |
| System website | https://albedo.com/product-specs |

Sensor Information

| | PanMux | Thermal |
|----------------|---------|---------|
| GSD (m) | 0.1/0.4 | 4 |
| Swath (km) | — | — |
| Revisit (days) | 0.2 | 0.2 |
| Data portal | — | — |

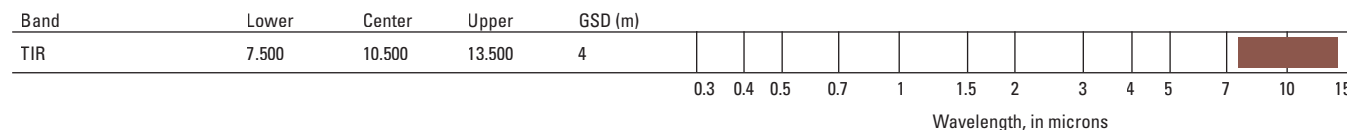
Panchromatic and Multispectral Imager

The sensor has a panchromatic band and four multispectral bands collecting Earth imagery at a high resolution with 5-day revisits at an angle of 30 degrees off nadir.



Thermal Imager

The thermal sensor has an off-nadir capability of as much as 30 degrees.



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]

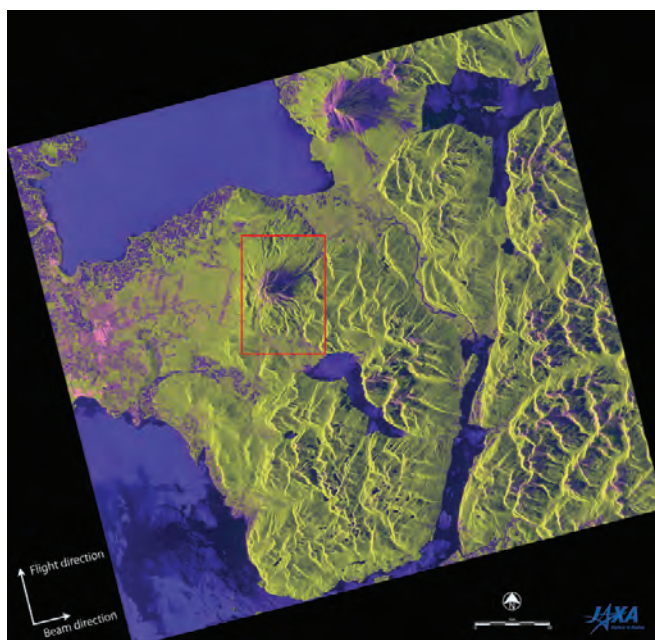
| | |
|------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Launch date | 05/24/2014 |
| Design lifetime | 5 years |
| Platform owner | JAXA |
| Altitude | 628 km |
| Orbit period | 97.26 min |
| Inclination | 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 |

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/ | |



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).

ALOS-2—Continued

Japan
Civil/Government
Operational



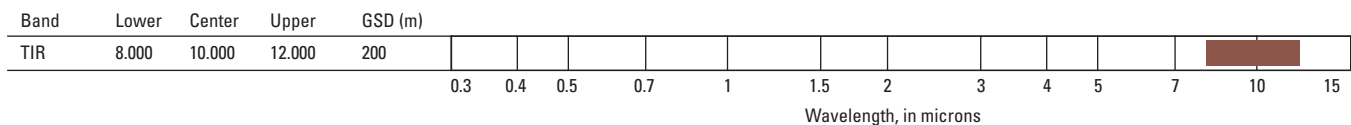
PALSAR

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) ($\lambda = 24.2$ centimeters [cm]), 1,257.5 MHz ($\lambda = 23.8$ cm), or 1,278.5 MHz ($\lambda = 23.4$ 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 | 25×25 | 3×1 |
| 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 | | |
| | Compact | Circular, 45° linear | | |
| | Quad | HH/HV/VV/VH | 30 | |
| Stripmap (fine) | Single | HH, HV, VV | 70 | 10 |
| | Dual | HH/HV, VV/VH | | |
| | Compact | 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 commercial off-the-shelf product by MELCO. CIRC provides infrared imagery for wildfire detection. The resolution of CIRC is less than 200 meters at nadir.



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 2022. 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.

[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 | 2022 (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/ |



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

Sensor Information

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

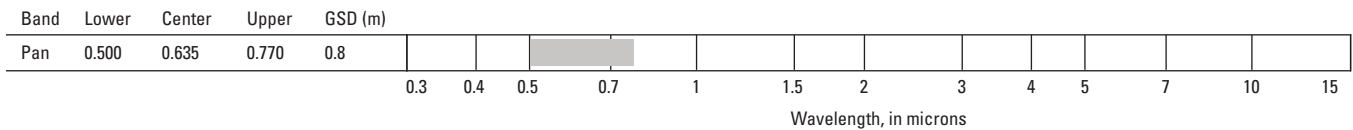
ALOS-3—Continued

Japan
Civil/Government
Future



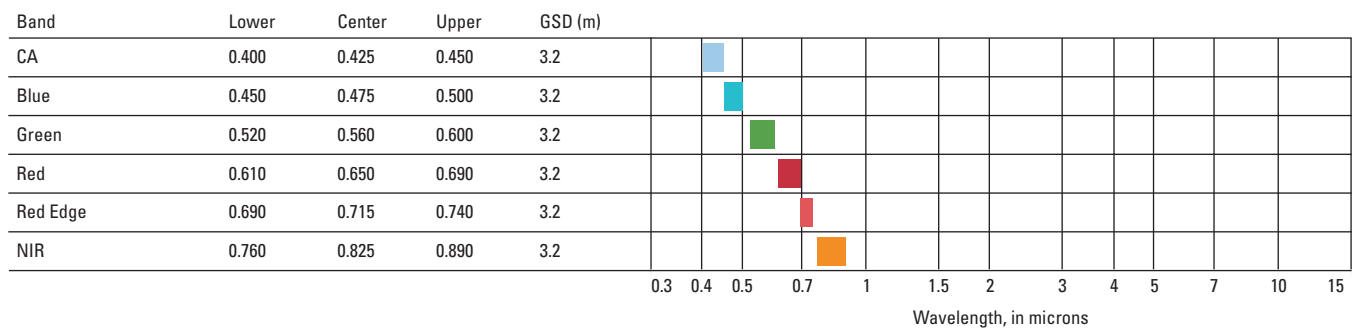
PRISM-2

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.



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.



ALOS-4

Japan
Civil/Government
Future

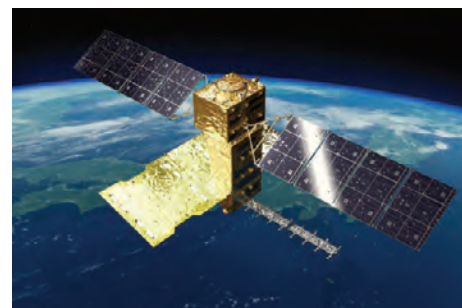


Platform Overview

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.

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

| | |
|------------------------|---------------------------------------------------------------------------------------------------|
| Launch date | 2023 (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/ |



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

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 ($\lambda = 20.0$ 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 | — | — | 35×35 | 1×3 |

AlSat-1B

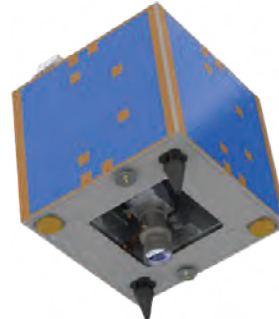
Algeria
Civil/Government
Operational



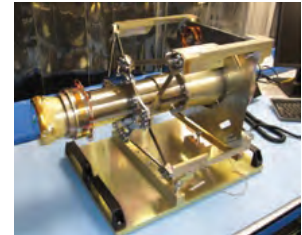
Platform Overview

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 Ltd. (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. Visible and near infrared imagery is captured at 24-meter (m) resolution by the Algerian Imager Telescope (ALITE) and is used by the Algerian Government. At the end of its design life, Alsat-1B's orbit was reduced by 25 kilometers to slow down the drift of its local time by a few minutes to maintain acceptable lighting conditions for image acquisition.



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; DN, descending node; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

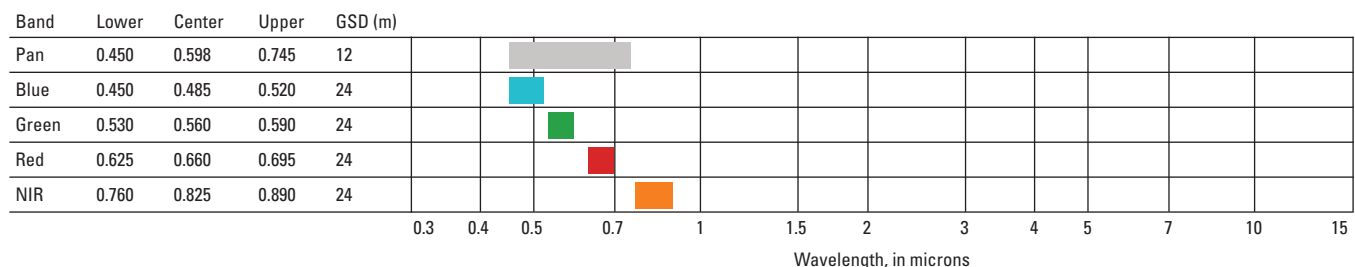
| | |
|------------------------|-------------------------------------------------------------------------------|
| Launch date | 09/26/2016 |
| Design lifetime | 5 years |
| Platform owner | ASAL |
| Altitude | 670 km |
| Orbit period | 98 min |
| Inclination | 98.1° |
| Crossing time | 10:00 DN |
| Nadir repeat | 7 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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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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.

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

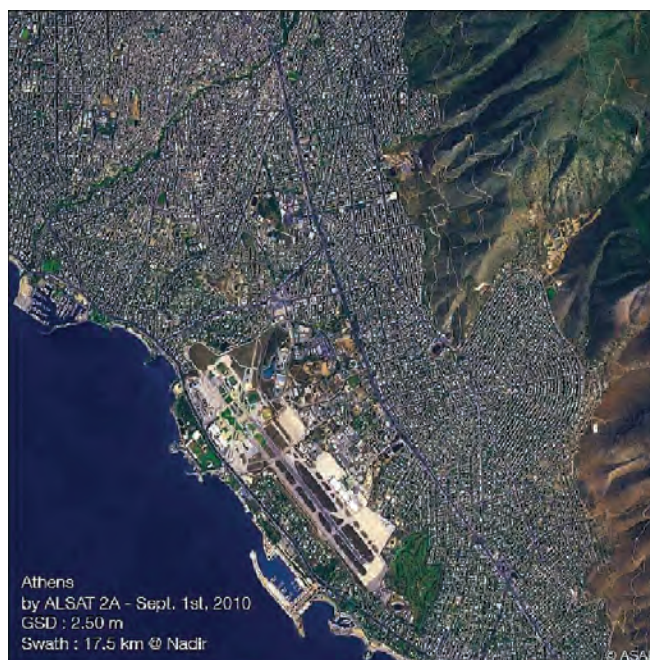
| | AlSat-2A | AlSat-2B |
|------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Launch date | 07/12/2010 | 09/26/2016 |
| Design lifetime | 5 years | |
| Platform owner | ASAL | |
| Altitude | 670 km | |
| Orbit period | 98 min | |
| Inclination | 98.1° | |
| Crossing time | 9:55 DN | 9:30 DN |
| Nadir repeat | 14 days | |
| Status | Operational | |
| System website | http://www.asal.dz/Alsat-2A.php | http://www.asal.dz/Alsat-2B.php |

Sensor Information

| | NAOMI |
|--------------------|---------|
| GSD (m) | 2.5, 10 |
| Swath (km) | 17.5 |
| Data portal | — |



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



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

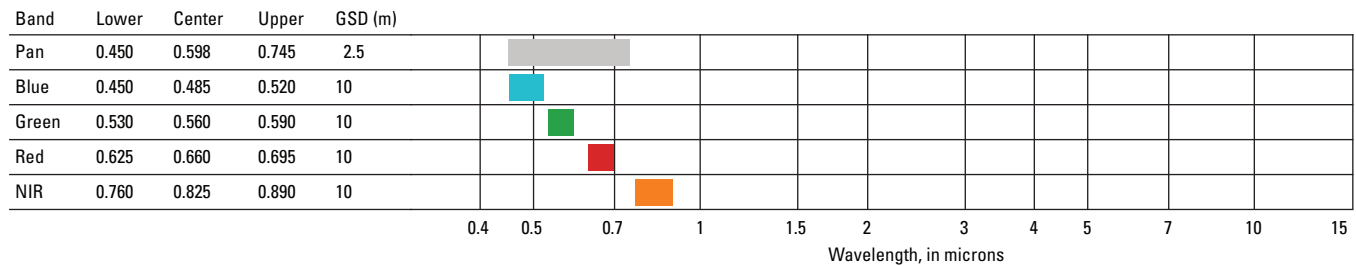
AlSat-2A and 2B—Continued

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.



Amazônia-1

Brazil
Civil/Government
Operational



Platform Overview

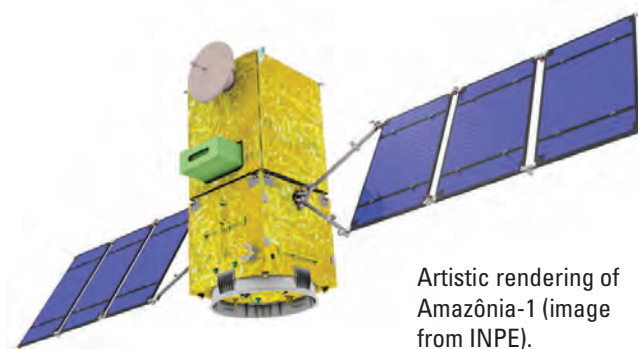
Amazônia-1 is a medium-resolution multispectral satellite launched in 2021 by National Institute of Space Research (INPE) on a Polar Satellite Launch Vehicle for monitoring deforestation, especially in the Amazon region. Amazônia-1 is the first satellite completely designed, integrated, and tested in Brazil. The satellite utilizes the Multi-Mission Platform designed by the Brazilian Space Agency. Amazônia-1 carries the Wide Field Imager (WFI)-2 sensor for medium-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]

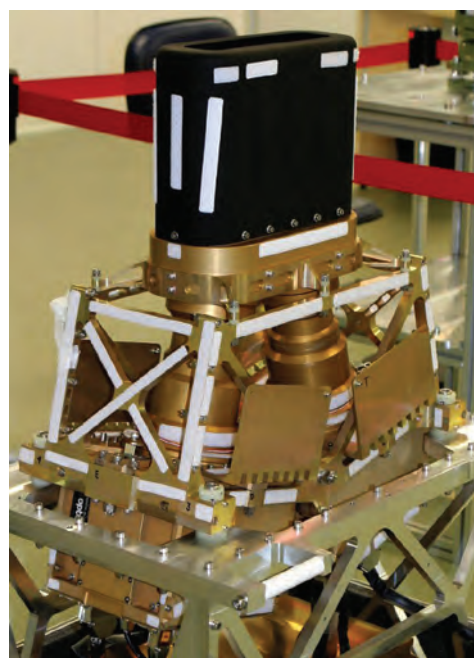
| | |
|------------------------|-------------------------------------------------------------------------------|
| Launch date | 02/28/2021 |
| Design lifetime | 2 years |
| Platform owner | INPE |
| Altitude | 752 km |
| Orbit period | 99.9 min |
| Inclination | 98.4° |
| Crossing time | 10:30 DN |
| Nadir repeat | 26 days |
| Status | Operational |
| System website | http://www3.inpe.br/amazonia-1/ |

Sensor Information

| | WFI-2 |
|--------------------|--------------|
| GSD (m) | 64 |
| Swath (km) | 850 |
| Data portal | — |



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



WFI-2 sensor model (image from INPE).

WFI-2

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

| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | |
|-------|-------|--------|-------|---------|------------------------|-----|-----|-----|---|-----|---|---|---|---|---|
| Blue | 0.450 | 0.475 | 0.500 | 64 | | | | | | | | | | | |
| Green | 0.520 | 0.545 | 0.570 | 64 | | | | | | | | | | | |
| Red | 0.630 | 0.660 | 0.690 | 64 | | | | | | | | | | | |
| NIR | 0.760 | 0.830 | 0.900 | 64 | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 |
| | | | | | Wavelength, in microns | | | | | | | | | | |

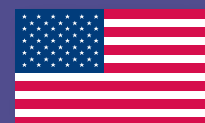
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Aqua

United States
Civil/Government
Operational



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 in California 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.

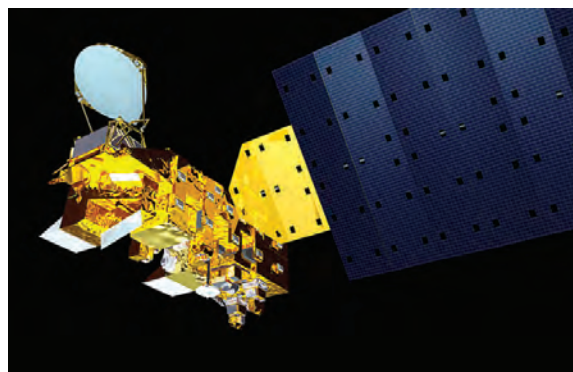
The Aqua satellite was built by Northrop Grumman Corp. based on their modular, standardized T330 bus for NASA. Aqua carries six instruments: Atmospheric Infrared Sounder (AIRS), Advanced Microwave Sounding Unit (AMSU-A), Clouds and the Earth's Radiant Energy System (CERES), Moderate-Resolution Imaging 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]

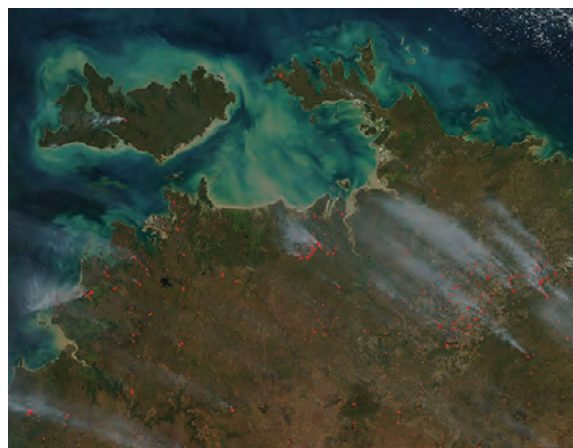
| | |
|------------------------|-------------------------------------------------------------|
| Launch date | 05/04/2002 |
| Design lifetime | 6 years |
| Platform owner | NASA |
| Altitude | 705 km |
| Orbit period | 98.8 min |
| Inclination | 98.2° |
| Crossing time | 13:30 AN |
| Nadir repeat | 16 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 |



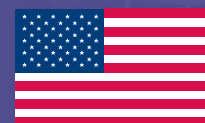
Artistic rendering of Aqua in orbit (image from NASA).



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

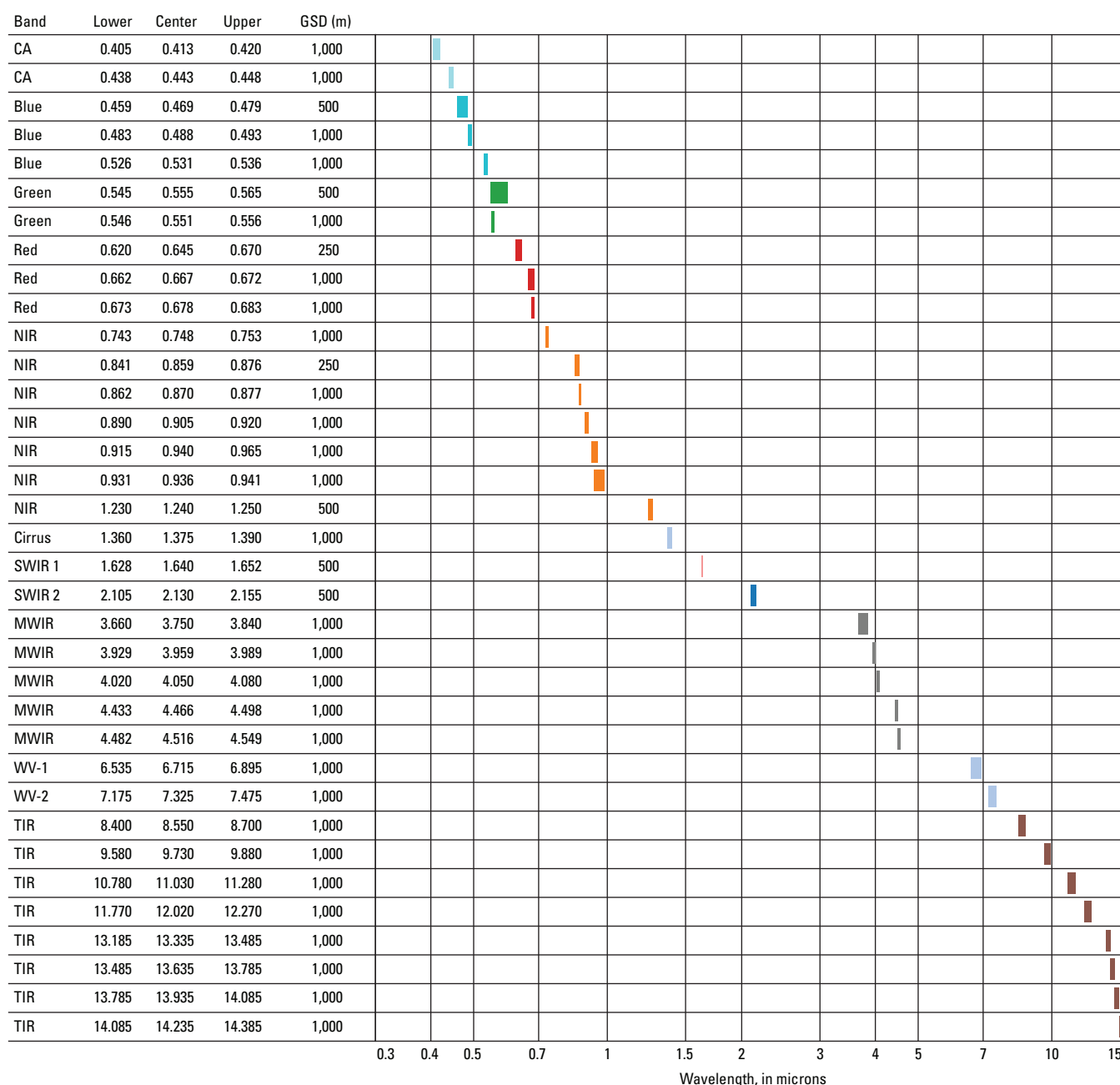
Aqua—Continued

United States
Civil/Government
Operational



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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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ASNARO

Japan
Civil/Government
Operational/Future

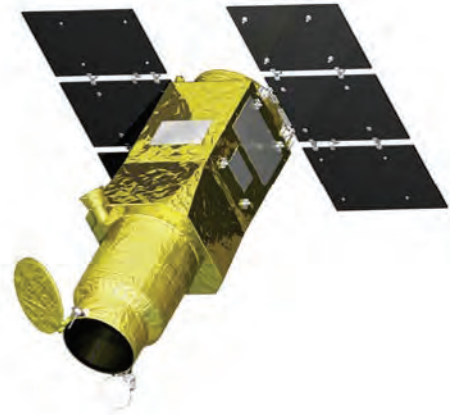


Platform Overview

ASNARO is a Japanese optical high-resolution Earth observation mission by the NEC Corporation and the Institute for Unmanned Space Experiment Free Flyer. The mission is funded by New Energy and Industrial Technology Development and the Ministry of Economy, Trade and Industry. ASNARO-1 and ASNARO-2 were launched in 2014 and 2018, respectively. ASNARO-3 is under development and planned for launch in the future.

[Abbreviations in tables: METI, Ministry of Economy, Trade and Industry; km, kilometer; —, no data; min, minute; °, degree; DN, descending node; OPS, optical sensor; X-SAR, X-band synthetic aperture radar; GSD, ground sample distance; m, meter; NIR, near infrared; H, horizontal; V, vertical]

| | ASNARO-1 | ASNARO-2 | ASNARO-3 |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------|
| Launch date | 11/06/2014 | 01/17/2018 | 2023 (Planned) |
| Design lifetime | 3+ years | | |
| Platform owner | METI | | |
| Altitude | 504 km | | — |
| Orbit period | 94.8 min | | — |
| Inclination | 97.5° | | — |
| Crossing time | 11:00 DN | 11:30 DN | — |
| Nadir repeat | — | | |
| Status | Operational | | Development |
| System website | https://www.jspacesystems.or.jp/en/project/observation/en_asnaro_r/ | | |



Model of the ASNARO-1 satellite (image from the Ministry of Economy, Trade and Industry of Japan).

Sensor Information

| | ASNARO-1 OPS | ASNARO-2 X-SAR |
|-----------------------|--------------|----------------|
| GSD (m) | 1/2 | 1 |
| Swath (km) | 10 | 50 |
| Revisit (days) | — | |
| Data portal | — | |

Optical Sensor

The optical sensor on ASNARO-1 is a compact pushbroom imager developed by the NEC Corporation and NEC Toshiba Space Systems, Ltd., that collects data in visible and near-infrared bands.

| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | | | | | |
|--------------|-------|--------|-------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Panchromatic | 0.400 | 0.550 | 0.700 | 1 | | | | | | | | | | | | | | | |
| Blue | 0.450 | 0.485 | 0.520 | 2 | | | | | | | | | | | | | | | |
| Green | 0.520 | 0.550 | 0.580 | 2 | | | | | | | | | | | | | | | |
| Yellow | 0.580 | 0.610 | 0.640 | 2 | | | | | | | | | | | | | | | |
| Red | 0.620 | 0.650 | 0.680 | 2 | | | | | | | | | | | | | | | |
| Red Edge | 0.680 | 0.705 | 0.730 | 2 | | | | | | | | | | | | | | | |
| NIR | 0.730 | 0.815 | 0.900 | 2 | | | | | | | | | | | | | | | |

0.4 0.5 0.7 1 1.5 2 3 4 5 7 10 15
Wavelength, in microns

ASNARO—Continued

Japan
Civil/Government
Operational/Future



X-Band Synthetic Aperture Radar

The X-band synthetic aperture radar on ASNARO-2 operates in X-band frequency with three modes. The sensor was developed by the Mitsubishi Electric Corporation.

| Beam mode | Polarization | Swath (km) | Azimuth resolution (m) |
|----------------|--------------|------------|------------------------|
| ScanSAR mode | HH, VV | 50 | 16 |
| Spotlight mode | HH, VV | 10 | 1 |
| Stripmap mode | HH, VV | 12 | 2 |

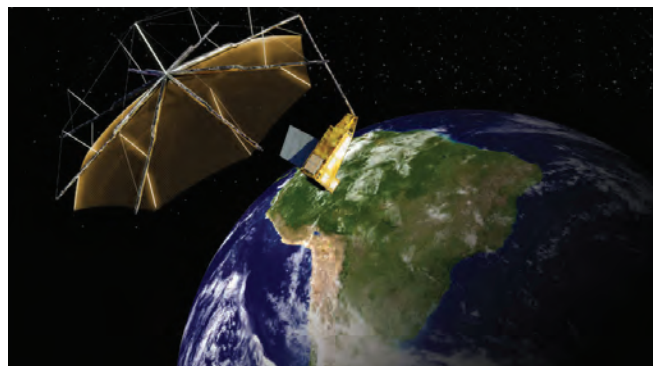
Biomass

European Space Agency
Civil/Government
Future



Platform Overview

Biomass is a low-resolution Synthetic Aperture Radar (SAR) satellite planned to be launched in 2023 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 Defence and Space, used with permission).

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

| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 5.5 years |
| Platform owner | ESA |
| Altitude | 666 km |
| Orbit period | 97.93 min |
| Inclination | 97.97° |
| Crossing time | 6:00 DN |
| Nadir repeat | 228 days |
| Status | Development |
| System website | https://www.esa.int/Applications/Observing_the_Earth/FutureEO/Biomass |

Sensor Information

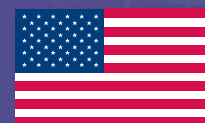
| | P-SAR |
|--------------------|-------|
| GSD (m) | 200 |
| Swath (km) | 50 |
| Data portal | — |

P-SAR

The P-SAR instrument will be built by Airbus Defence and Space. 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 ($\lambda = 68.9$ centimeters). The angle of incidence will be 23–35 degrees. Details of the beam modes are not currently (2022) available.

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. As of September 2022, 15 Global (Block-2) satellites of the BlackSky constellation were launched. These satellites carry a SpaceView-24 imaging system built by Harris Corporation's Exelis for high-resolution imaging. The Global satellites are developed and built by Spaceflight Services based on their SCOUT bus.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; 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 | 680 km | 484 km | 580 km | 445 km | 530 km |
| Orbit period | 98.4 min | 94.1 min | 96.30 min | 93.30 min | 95.10 min |
| Inclination | 97.9° | 97.4° | 97.6° | 45° | 45° |
| Crossing time | 10:30 DN | 10:30 DN | 10:30 DN | — | — |
| Nadir repeat | — | | | | |
| Status | Retired | Operational | | | |
| System website | https://www.blacksky.com/ | | | | |

| | Global-7, 8 | Global-9 | Global-12, 13 | Global-14, 15 | Global-16, 17 | Global-18, 20 |
|------------------------|-----------------------------------------------------------------|------------|---------------|---------------|---------------|---------------|
| Launch date | 08/07/2020 | 03/22/2021 | 12/02/2021 | 11/18/2021 | 12/09/2021 | 04/02/2022 |
| Design lifetime | 3 years | | | | | |
| Platform owner | BlackSky | | | | | |
| Altitude | 400 km | 450 km | 430 km | 437 km | 437 km | 437 km |
| Orbit period | 92.5 min | 93.5 min | 93.2 min | 93.2 min | 93.2 min | 93.2 min |
| Inclination | 53° | 45° | 53° | 42° | 42° | 42° |
| Crossing time | — | | | | | |
| Nadir repeat | — | | | | | |
| Status | Operational | | | | | |
| System website | https://www.blacksky.com | | | | | |



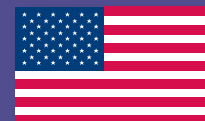
A model of the BlackSky Satellite (image from BlackSky).

Sensor Information

| | SV-24 |
|--------------------|-----------------------------------------------------------------|
| GSD (m) | 0.8–1.3 |
| Swath (km) | 6 |
| Data portal | https://www.blacksky.com |

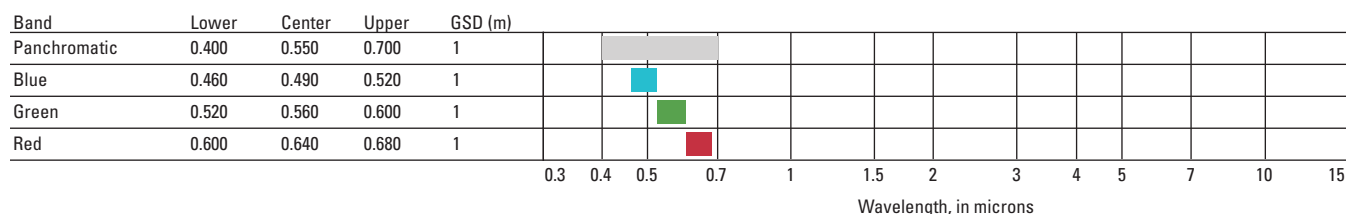
BlackSky Constellation—Continued

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 can capture still images, whereas the Block-2 also can capture video at 1 foot per second.



Cartosat-2A and -2B

India
Civil/Government
Operational



Platform Overview

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

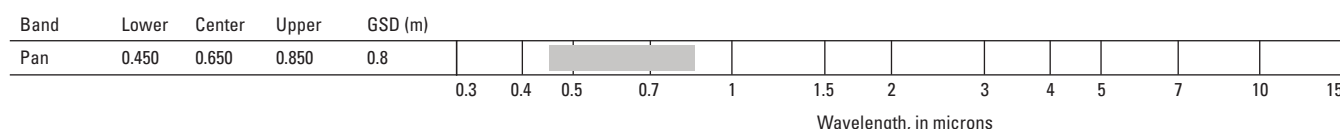
The Cartosat-2A and -2B satellites were designed and built by ISRO and use the Indian Remote Sensing Satellite (IRS)-1 bus and two panchromatic cameras. Panchromatic imagery is gathered on a global scale to provide stereo pairs required for generating digital elevation models, Ortho Image products, and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

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

| | Cartosat-2A | Cartosat-2B |
|------------------------|---------------------------------------------------------------------------------------------------------------|-------------|
| Launch date | 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/CARTOSAT_2_PSLVC38.html | |

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.



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).

Sensor Information

| | Pan |
|--------------------|-------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.8 |
| Swath (km) | 9.6 |
| Data portal | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html |

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

India
Civil/Government
Operational/Future

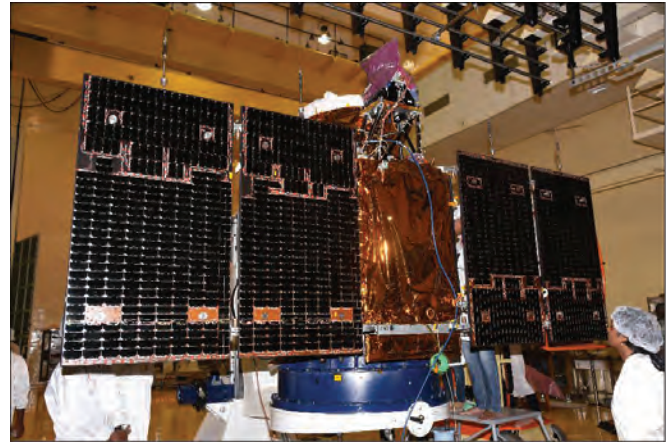


Platform Overview

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 in Sriharikota, India, 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.

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



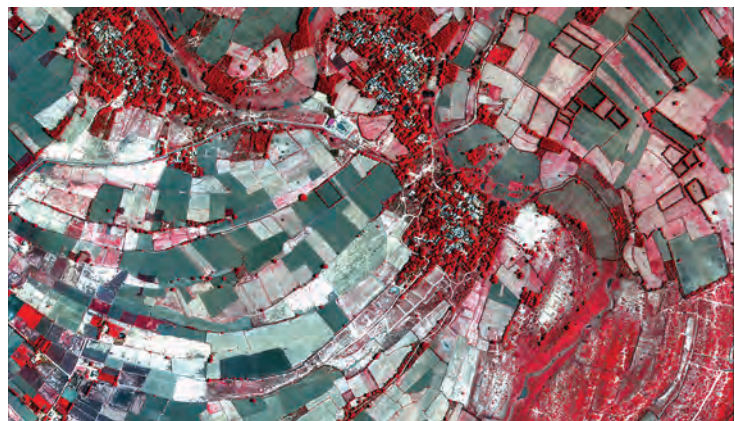
Cartosat-2E undergoing solar panel deployment test (image from ISRO, used with permission).

| | 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/CARTOSAT_2_PSLVC40.html | | | |

Sensor Information

| | HRMX | Pan |
|--------------------|-------------------------------------------------------------------------------------------------------------------|------|
| GSD (m) | 2 | 0.65 |
| Swath (km) | 10 | 9.6 |
| Data portal | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html | |

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



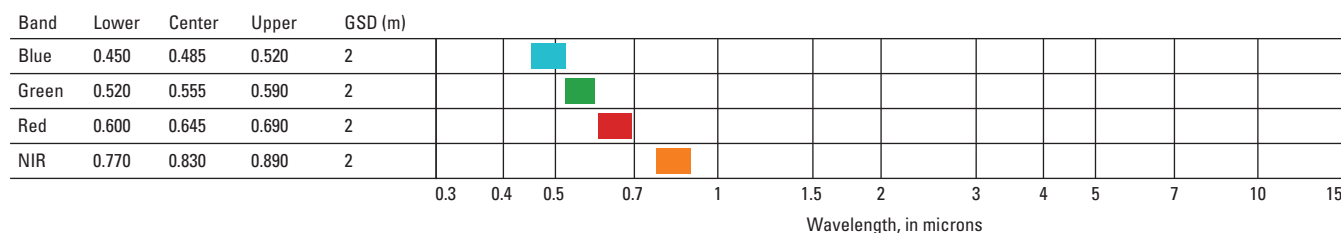
Cartosat-2C, -2D, -2E, and -2F— Continued

India
Civil/Government
Operational/Future



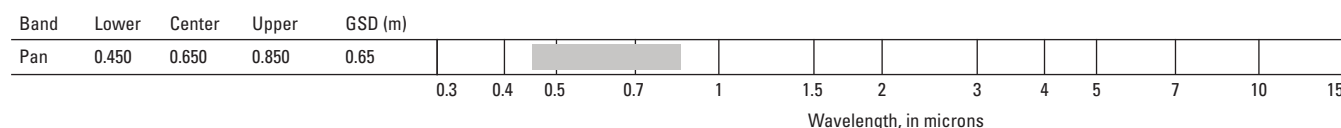
HRMX

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



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.



Cartosat-3

India
Civil/Government
Operational



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]

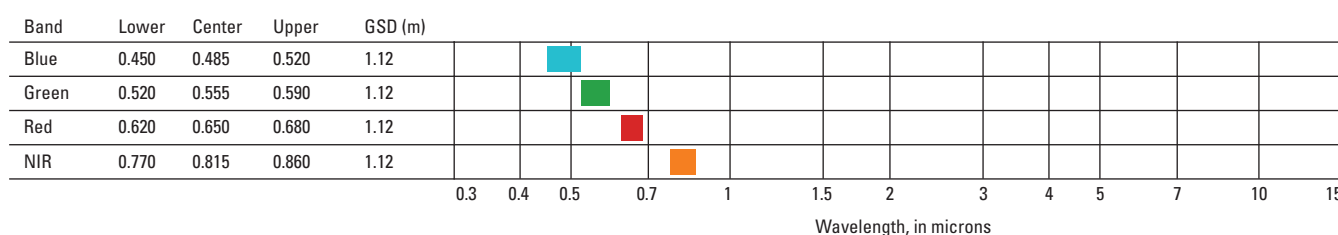
| | |
|------------------------|-----------------------------------------------------------------------------------------------|
| Launch date | 11/27/2019 |
| Design lifetime | 5 years |
| Platform owner | ISRO |
| Altitude | 509 km |
| Orbit period | 94.8 min |
| Inclination | 97.5° |
| Crossing time | 09:30 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | https://www.isro.gov.in/Cartosat_3.html |

Sensor Information

| | MSI | Pan |
|--------------------|-------------------------------------------------------------------------------------------------------------------|------|
| GSD (m) | 1.12 | 0.28 |
| Swath (km) | 17 | 17 |
| Data portal | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html | |

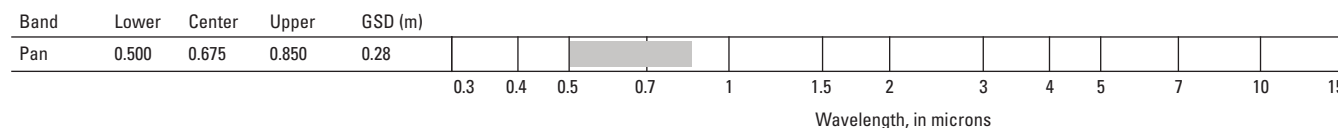
MSI

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



Pan

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



CAS500-1 and -2

South Korea
Civil/Government/Commercial
Operational/Future

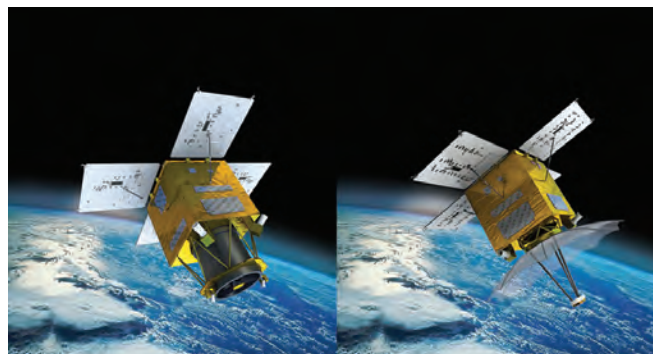


Platform Overview

Compact Advanced Satellite (CAS) 500-1 and -2 are high-resolution panchromatic and multispectral satellites for Earth observation. The first satellite, CAS500-1, was developed and launched by the Korean Aerospace Research Institute (KARI) in 2021. 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 carry the Advanced Earth Imaging Sensor System (AEISS-C) sensor for high-resolution land imaging. CAS500-3, -4, and -5 represent the second stage of the CAS500 program and are planned to have optical and C-band synthetic aperture radar sensors.

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

| | CAS500-1 | CAS500-2 |
|------------------------|---------------------------------------------------------------------------------------------------|----------------|
| Launch date | 03/22/2021 | 2022 (Planned) |
| Design lifetime | 4 years | |
| Platform owner | KARI | |
| Altitude | 498 km | |
| Orbit period | 94.62 min | |
| Inclination | 97.4° | |
| Crossing time | 10:50 AN | |
| Nadir repeat | 28 days | |
| Status | Operational | Development |
| System website | https://www.kari.re.kr/eng/sub03_02_03.do | |



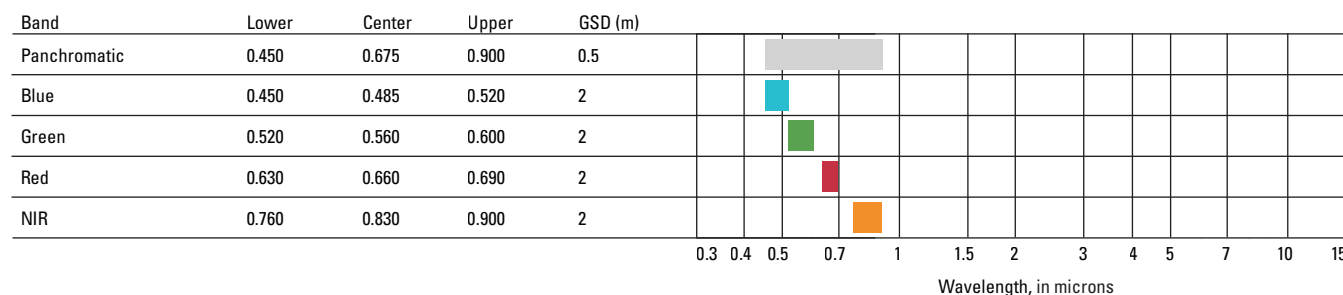
Artistic renderings of CAS500-1 and -2 in orbit (image from KARI, used with permission).

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.



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 in Shanxi, China, 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 (MUXCam), Panchromatic and Multispectral Camera (PANMUX), and Wide Field Imager (WFI) for medium-resolution land imaging.

[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; Pan, panchromatic]

| | |
|-----------------|---------------------------------------------------------------------|
| 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.cbbers.inpe.br/ |

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/ | | | |



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



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

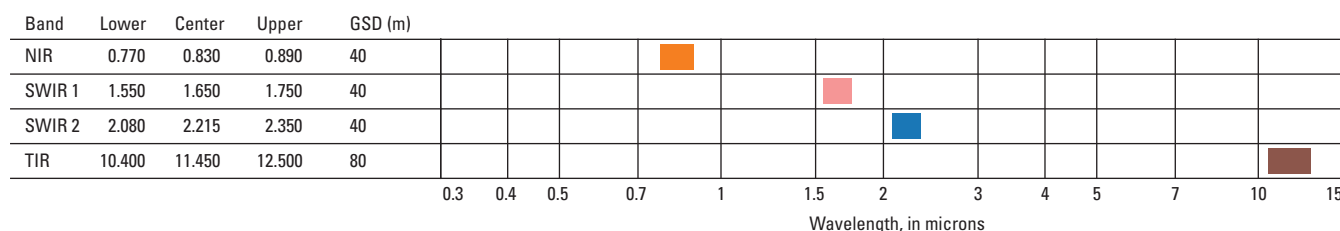
CBERS-4—Continued

China, Brazil
Civil/Government
Operational



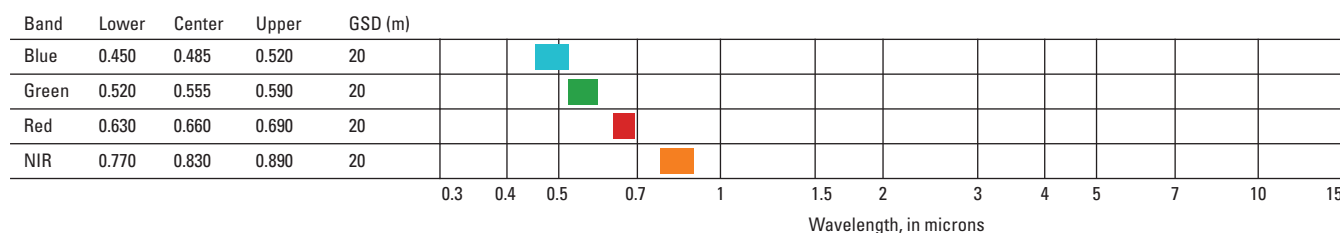
IRMSS

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.



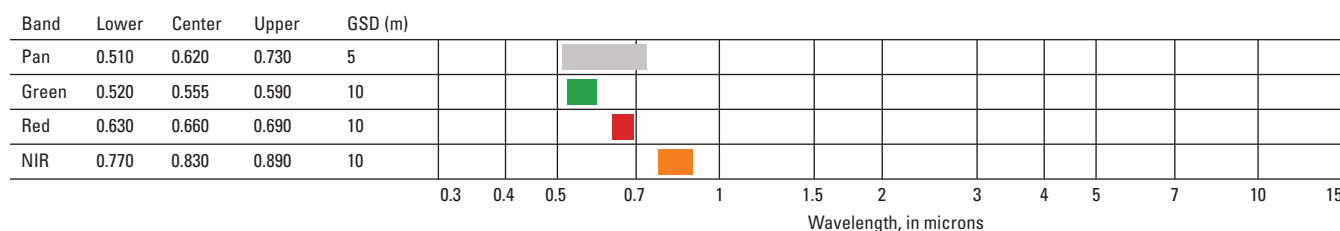
MUX

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.



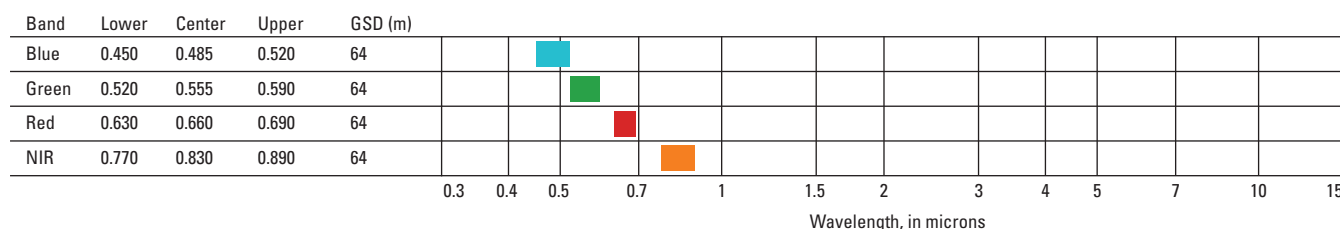
PANMUX

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



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.



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 in Shanxi, China, 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.

[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.cbbers.inpe.br/lancamentos/cbbers04a.php |



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

Sensor Information

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

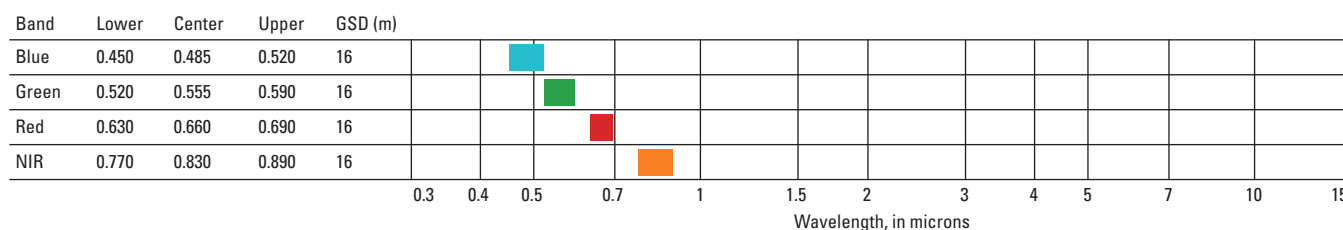
CBERS-4A—Continued

China, Brazil
Civil/Government
Operational



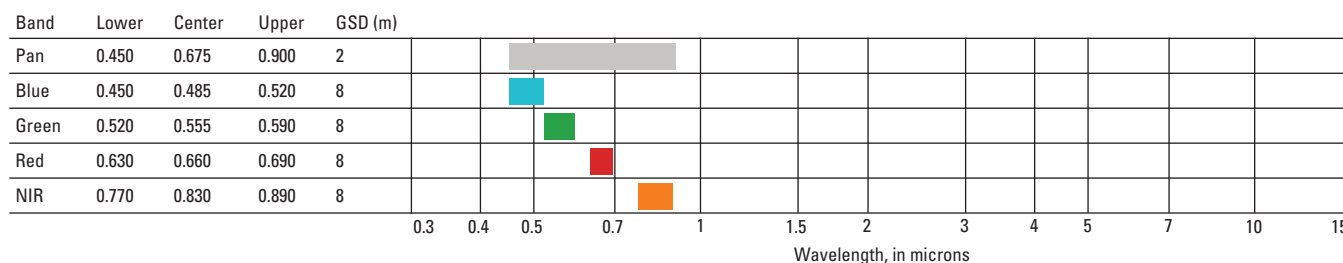
MUXCam

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.



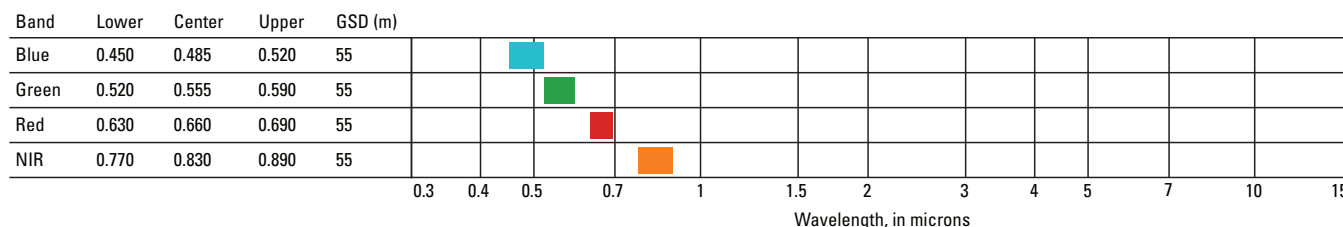
WPM

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



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.



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

| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2029 |
| Design lifetime | 5 years |
| Platform owner | ESA |
| Altitude | 632 km |
| Orbit period | 97.3 min |
| Inclination | 97.9° |
| Crossing time | 10:45 DN |
| Nadir repeat | 22 days |
| Status | Planned |
| System website | https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates |



Artistic rendering of CHIME satellite (image from Thales Alenia Space).

Sensor Information

| | Hyperspectral imager |
|--------------------|----------------------|
| GSD (m) | 20 |
| Swath (km) | 130 |
| 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 |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

CHORUS

Canada
Commercial
Development



Platform Overview

CHORUS-C and CHORUS-X are medium and high-resolution synthetic aperture radar (SAR) satellites, respectively, planned by MDA Ltd. as data continuity missions to Radarsat-2. CHORUS-C is planned to carry a C-band SAR that provides a 700-kilometer (km) swath with a 50-meter (m) resolution capable of looking in left- and right-looking modes. CHORUS-X is planned to carry an X-band SAR that provides a 700-km swath with a 0.5-m resolution. The CHORUS-X satellite is planned to trail the CHORUS-C satellite by 1 hour to capture high-resolution SAR images of the regions identified by the CHORUS-C satellite.

[Abbreviations in table: —, no data]

| | CHORUS-C | CHORUS-X |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Launch date | 2025 (Planned) | |
| Design lifetime | 5 years | |
| Platform owner | MDA | |
| Altitude | — | |
| Orbit period | — | |
| Inclination | — | |
| Crossing time | — | |
| Nadir repeat | — | |
| Status | Development | |
| System website | https://mda.space/en/article/mda-announces-chorus-name-of-its-commercial-earth-observation-mission/ | |

C-Band SAR

The C-band SAR will provide a 700-km swath with a 50-m resolution.

X-Band SAR

The X-band SAR will provide a 700-km swath with a 0.5-m resolution.

CIMR

European Space Agency
Civil/Government
Future

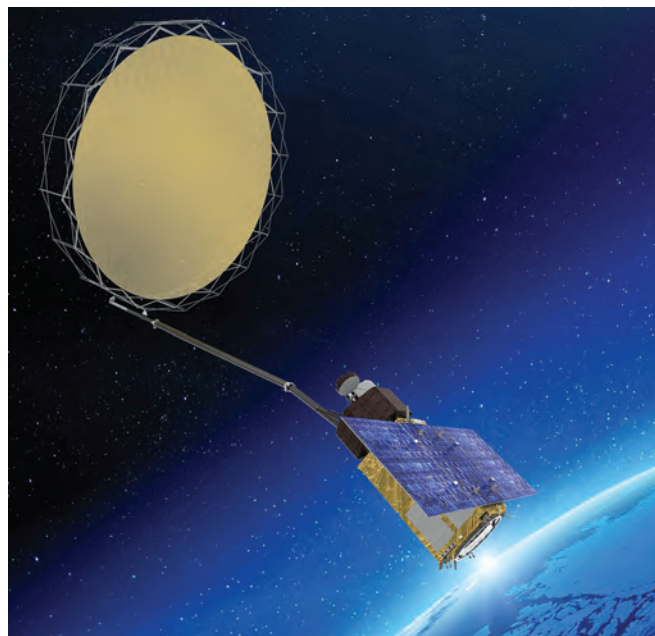


Platform Overview

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 |



Artistic rendering of the CIMR satellite in orbit (image from Thales Alenia Space).

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.

COMS

South Korea
Civil/Government
Operational

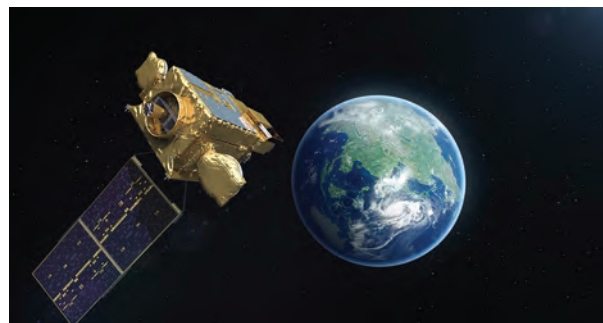


Platform Overview

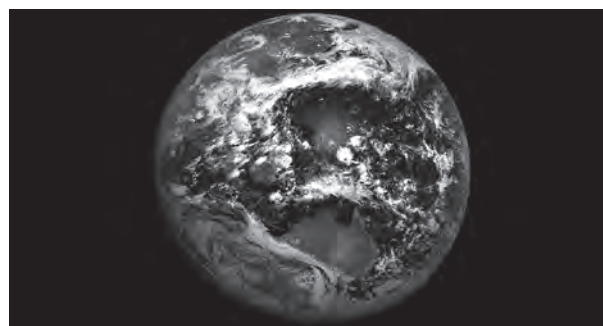
The Communication, Ocean and Meteorological Satellite (COMS), also known as GEO-KOMPSAT-1, is a low-resolution, multispectral, geostationary satellite launched in 2010 by the Korean Aerospace Research Institute (KARI) on an Ariane-5ECA launch vehicle for meteorology, ocean observation, and communications. COMS was South Korea's first geostationary satellite, was designed and built by Airbus Defence and Space 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.

[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 |



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



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 | https://nmisc.kma.go.kr/ | |

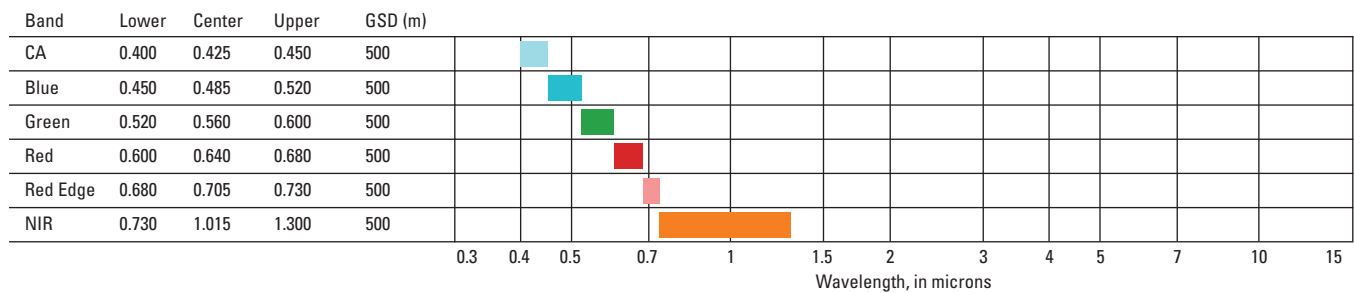
COMS—Continued

South Korea
Civil/Government
Operational



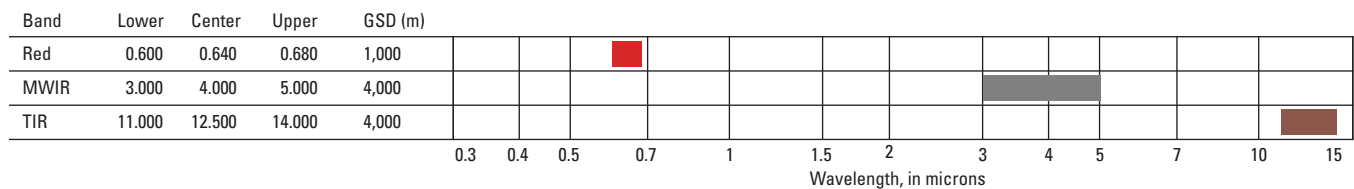
GOCI

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



MI

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



ConstellIR-HiVE

Germany
Commercial
Future



Platform Overview

ConstellIR's High-resolution VEgetation (HiVE) monitoring mission is a thermal infrared satellite constellation being developed and planned for launch in 2022 for Earth resources monitoring. The company ConstellIR, headquartered in Germany, aims to provide global coverage with daily revisits at a high spatial resolution. The satellites carry a thermal infrared sensor for land-surface temperature monitoring.

[Abbreviations in table: —, no data]

| | |
|------------------------|-----------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | — |
| Platform owner | ConstellIR |
| Altitude | — |
| Orbit period | — |
| Longitude | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Development |
| System website | https://constellr.space/ |

Infrared Imager

Detailed information on the sensor is not currently (2022) available.

Constellation Optique 3D (CO3D)

France
Civil/Government
Future



Platform Overview

Constellation Optique 3D (CO3D) are high-resolution satellites planned for launch by French National Centre for Space Research (CNES) in 2023 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.

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

| | |
|------------------------|--------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 10 years |
| Platform owner | CNES, Airbus Defence and Space |
| Altitude | 502 km |
| Orbit period | 94.65 min |
| Inclination | 97.4° |
| Crossing time | — |
| Nadir repeat | — |
| Status | Planned |
| System website | — |



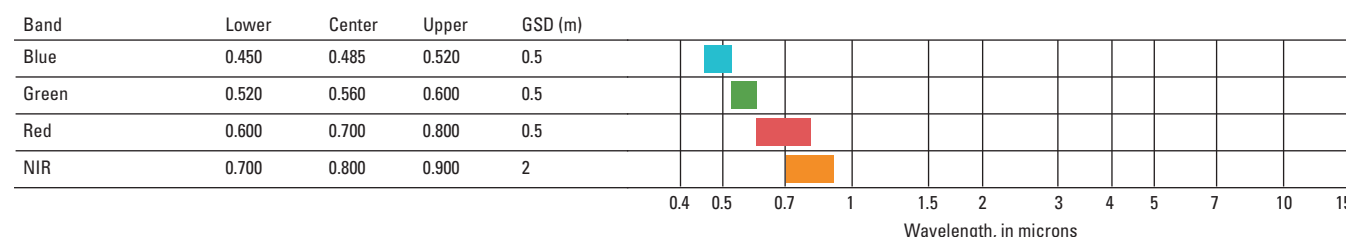
Stereo pair of CO3D satellites (image from Airbus Defence and Space, used with permission).

Sensor Information

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

CO3D Stereo Imager

The four CO3D satellites carry four band (red, green, blue, and near infrared) multispectral imagers capable of imaging at a resolution of 50 centimeters in red, green, and blue and 2 meters in near infrared.



COSMO-SkyMed-1 to -4

Italy
Civil/Government
Operational



Platform Overview

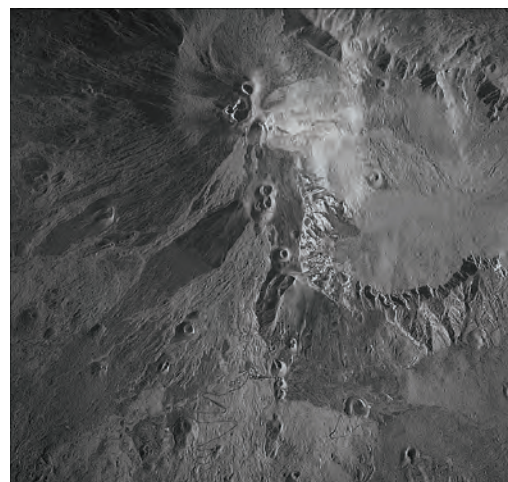
The Constellation of small Satellites for Mediterranean basin Observation (COSMO-SkyMed) satellites are multiresolution synthetic aperture radar (SAR) satellites for Earth observation. The four satellites were launched on Delta-7420-10C launch vehicles. The COSMO-SkyMed (CSK) satellites are based on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

[Abbreviations in tables: ASI, Italian Space Agency; 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 | | | |



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



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 ($\lambda = 3.1$ 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 |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

CryoSat-2

European Space Agency
Civil/Government
Operational



Platform Overview

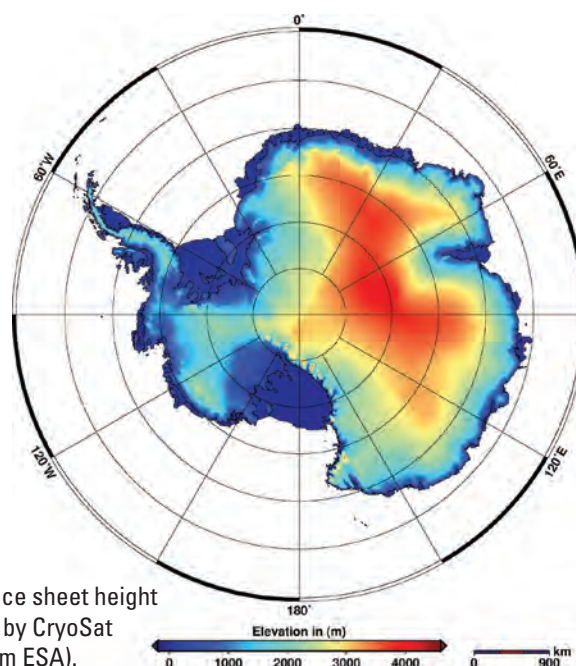
CryoSat-2 is a low-resolution radar altimeter satellite launched in 2010 on a Dnepr launch vehicle for monitoring ice thickness. CryoSat-2 replaces CryoSat, which was lost because of a launch failure in 2005. CryoSat-2 was built and integrated by European Aeronautics Defense and Space Astrium. CryoSat-2 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) | — | — | — |

CSG-1 and -2

Italy
Civil/Government
Operational



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 were built by Thales Alenia Space, use the PRIMA bus, and carry the CSG-SAR sensor for high-resolution radar data.

CSG-1 was launched in 2019 on a Soyuz rocket; CSG-2 was launched in 2022 on the Falcon 9 launch vehicle.

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

| | CSG-1 | CSG-2 |
|------------------------|-------------------------------------------------------------------------------------------------------------------|------------|
| Launch date | 12/18/2019 | 01/31/2022 |
| 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 | |
| System website | https://www.asi.it/en/earth-science/cosmo-skymed/ | |

Sensor Information

| | CSG-SAR |
|--------------------|---------------------------------------------------------------------------------------------------|
| GSD (m) | 0.8–6 (selectable) |
| Swath (km) | 10–200 (selectable) |
| Data portal | https://portal.cosmo-skymed.it/CDMFE/home |

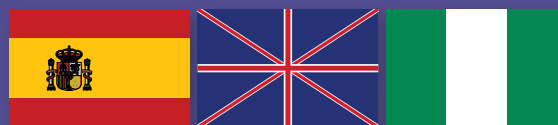
CSG-SAR

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 ($\lambda = 3.12$ 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 | 10×10 | 0.8×0.8 |
| Spotlight-2B | Dual | HH/HV, VV/VH | 10×10 | 1×1 |
| Stripmap | Single | HH, HV, VV, VH | 40×2,500 | 3×3 |
| | Dual | HH/HV, VV/VH | | |
| Pingpong | Burst dual | HH/HV, VV/VH | 30×2,500 | 5×20 |
| Quadpol | Quad | HH/HV/VV/VH | 15×2,500 | 3×3 |
| ScanSAR-1 | Dual | HH/HV, VV/VH | 100×2,500 | 4×20 |
| ScanSAR-2 | Dual | HH/HV, VV/VH | 200×2,500 | 6×20 |

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.



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

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

| | 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 | Elecnor Deimos | SSTL | Nigerian National Space Research and Development Agency |
| Altitude | 650 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://elecnor-deimos.com/project/deimos-1/ | https://www.sstl.co.uk/space-portfolio/launched-missions/2000-2009/uk-dmc2-launched-2009 | http://nasrda.gov.ng/en/ |

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

Spain, United
Kingdom, Nigeria
Civil/Government
Operational

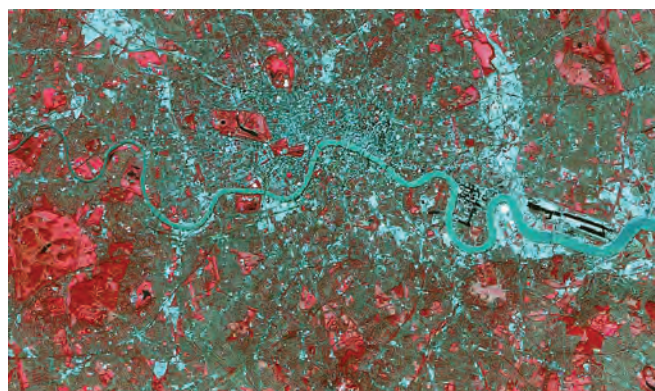


Sensor Information

| | |
|-------------|-----|
| GSD (m) | 22 |
| Swath (km) | 650 |
| Data portal | — |

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.



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

| 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 | | | | | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | | |
| | | | | | Wavelength, in microns | | | | | | | | | | | | | | |

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 South 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.

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

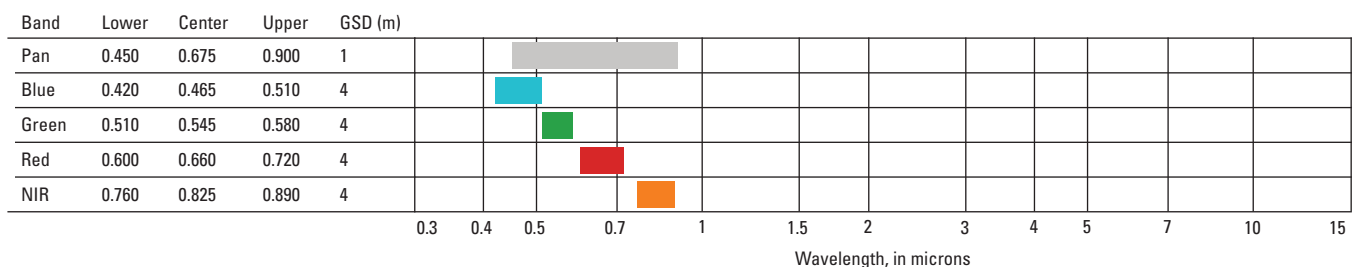
| | |
|------------------------|----------------|
| Launch date | 06/19/2014 |
| Design lifetime | 10 years |
| Platform owner | Deimos Imaging |
| Altitude | 620 km |
| Orbit period | 97.3 min |
| Inclination | 98° |
| Crossing time | 10:30 AN |
| Nadir repeat | 4 days |
| Status | Operational |
| System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

Sensor Information

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

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 South Korea. HiRAIS data are commercially available.



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



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

United Arab Emirates
Civil/Government
Operational

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

EarthDaily Constellation

Canada
Commercial
Future

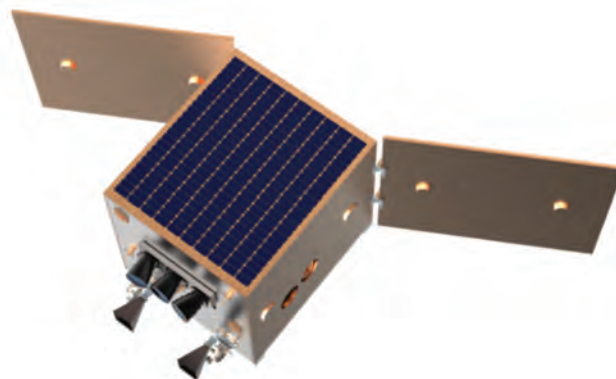


Platform Overview

EarthDaily-1 is a superspectral medium-resolution satellite planned for launch in July–September 2023 as part of a nine (plus one orbit spare) satellite constellation by EarthDaily Analytics for Earth resources monitoring. The orbit of EarthDaily satellites is similar to the Sentinel-2 orbit to cross-calibrate all bands and to maintain high radiometric and geometric accuracy. The satellites will carry a super-spectral camera with 21 bands for medium-resolution Earth imaging.

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

| | EarthDaily |
|------------------------|-------------------------------------------------------------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 10 years |
| Platform owner | EarthDaily Analytics |
| Altitude | 786 km |
| Orbit period | 100.7 min |
| Inclination | 98.5° |
| Crossing time | 10:30 DN |
| Nadir repeat | — |
| Status | Development |
| System website | https://earthdailystg.wpengine.com/earthdaily/ |



A model of the EarthDaily satellite (image from EarthDaily Analytics).

Sensor Information

| | Superspectral camera |
|-----------------------|----------------------|
| GSD (m) | 5 |
| Swath (km) | — |
| Revisit (days) | — |
| Data portal | — |

Superspectral Camera

The sensors on EarthDaily satellites will have 21 spectral bands that are matched to scientific missions, including Sentinel-2. The ground sample distance is 5 meters at nadir.

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, Russia. Electro-L No. 4 and No. 5 are planned for launch in 2023 and 2024, 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.

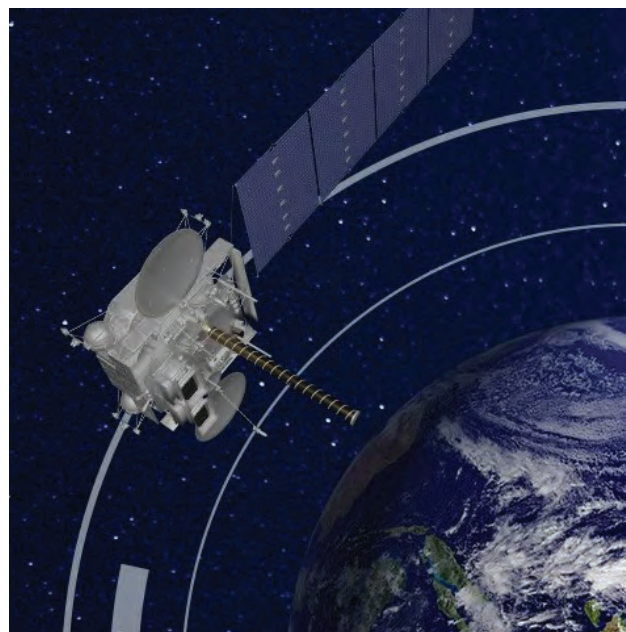
Electro-L satellites carry a multizone scanning hydro-meteorological support device (MSD) to obtain multispectral images of clouds and Earth's surface, a heliogeophysical instrument to detect solar flares, and an airborne radio complex for the International COSPAS-SARSAT emergency call system.

[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]

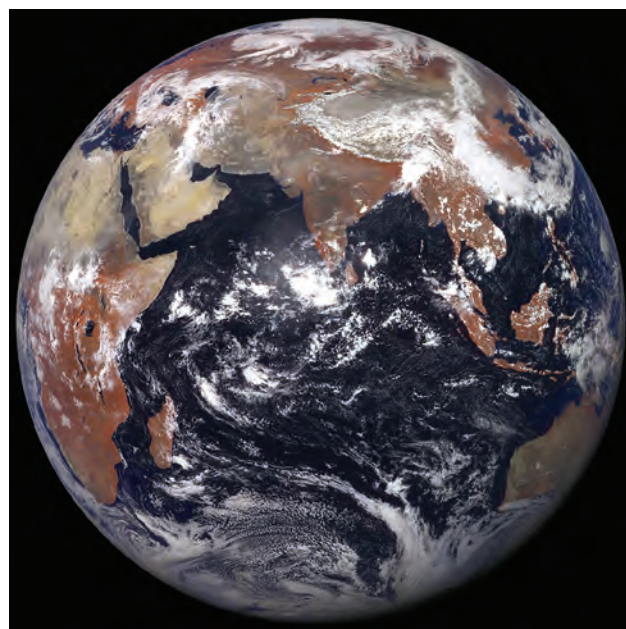
| | Electro-L No. 1 | Electro-L No. 2 | Electro-L No. 3 |
|-----------------|-------------------------------------------------------------------------------|-----------------|-----------------|
| Launch date | 01/20/2011 | 12/11/2015 | 12/24/2019 |
| Design lifetime | 10 years | | |
| Platform owner | 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/ | | |

Sensor Information

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



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



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

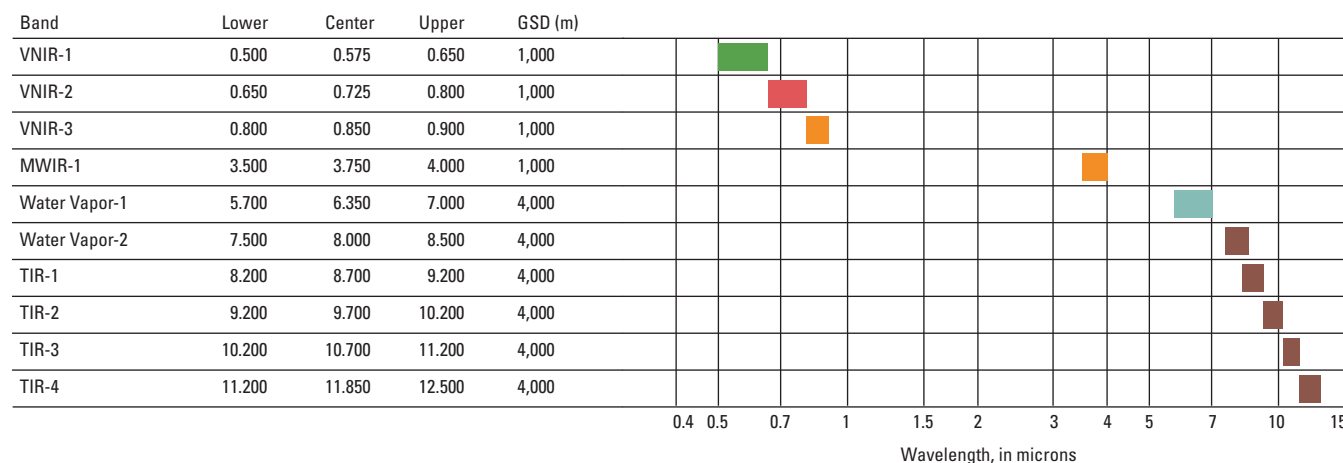
Electro-L—Continued

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.



EnMAP

Germany
Civil/Government
Operational

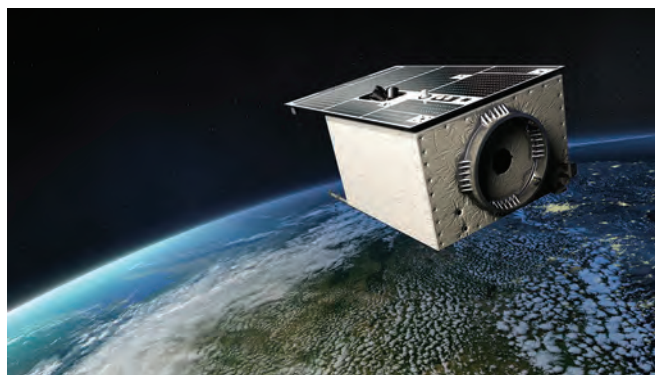


Platform Overview

Environmental Mapping and Analysis Program (EnMAP) is medium-resolution hyperspectral minisatellite launched in 2022 on the Falcon 9 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 carries the Hyperspectral Imager (HSI) sensor for medium-resolution hyperspectral land imaging.

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

| | |
|------------------------|-----------------------------------------------------------|
| Launch date | 04/01/2022 |
| Design lifetime | 5 years |
| Platform owner | German Aerospace Center (DLR) |
| Altitude | 643 km |
| Orbit period | 97.56 min |
| Inclination | 98° |
| Crossing time | 11:00 AN |
| Nadir repeat | 27 days |
| Status | Operational |
| System website | http://www.enmap.org/ |



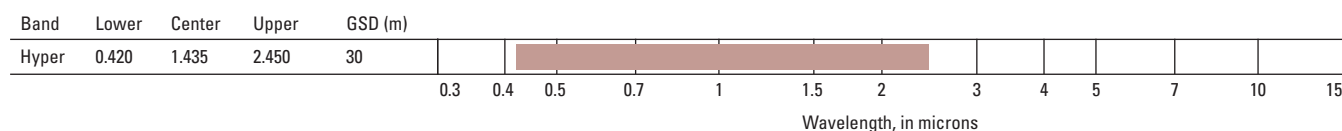
Artistic rendering of EnMAP in orbit (image from DLR).

Sensor Information

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

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.



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.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; E, east; GSD, ground sample distance; m, meter; —, no data; VNIR, visible and near infrared; MWIR, midwave infrared; TIR, thermal 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 | 99.5° 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 |

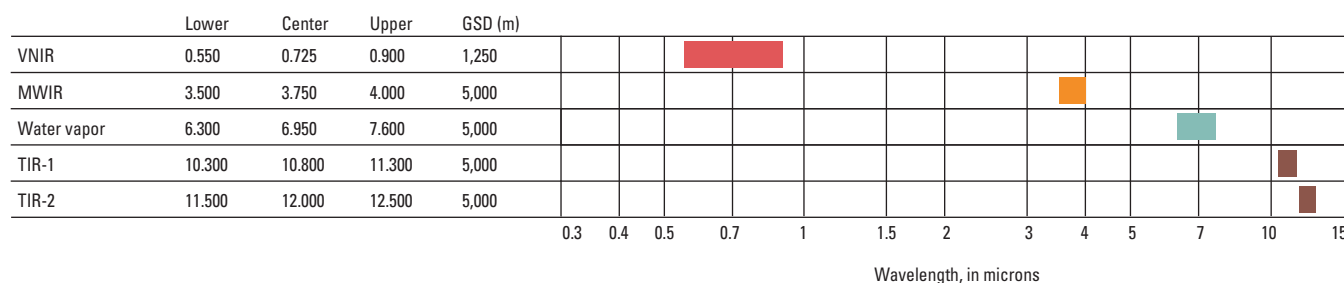
Fengyun-2—Continued

China
Civil/Government
Operational



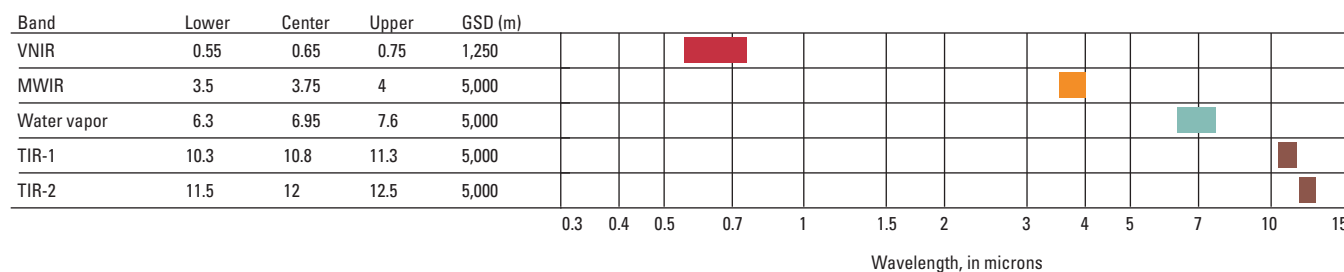
FY-2A and 2B VISSR

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.



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.



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 was launched on a Long March-3B rocket from Xichang Satellite Launch Center in China in 2021.

[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 | FY-4B |
|------------------------|-------------------------------------------------------------------------------------------------------------|------------|
| Launch date | 12/10/2016 | 06/02/2021 |
| Design lifetime | 10 years | |
| Platform owner | CMA/NSMC | |
| Altitude | 36,000 km | |
| Orbit period | 1,440 min | |
| Longitude | 104.7° E | 123.5° E |
| Crossing time | NA | |
| Nadir report | NA | |
| Status | Operational | |
| System website | http://fy4.nsmc.org.cn/nsmc/en/theme/FY4A.html | |

Sensor Information

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

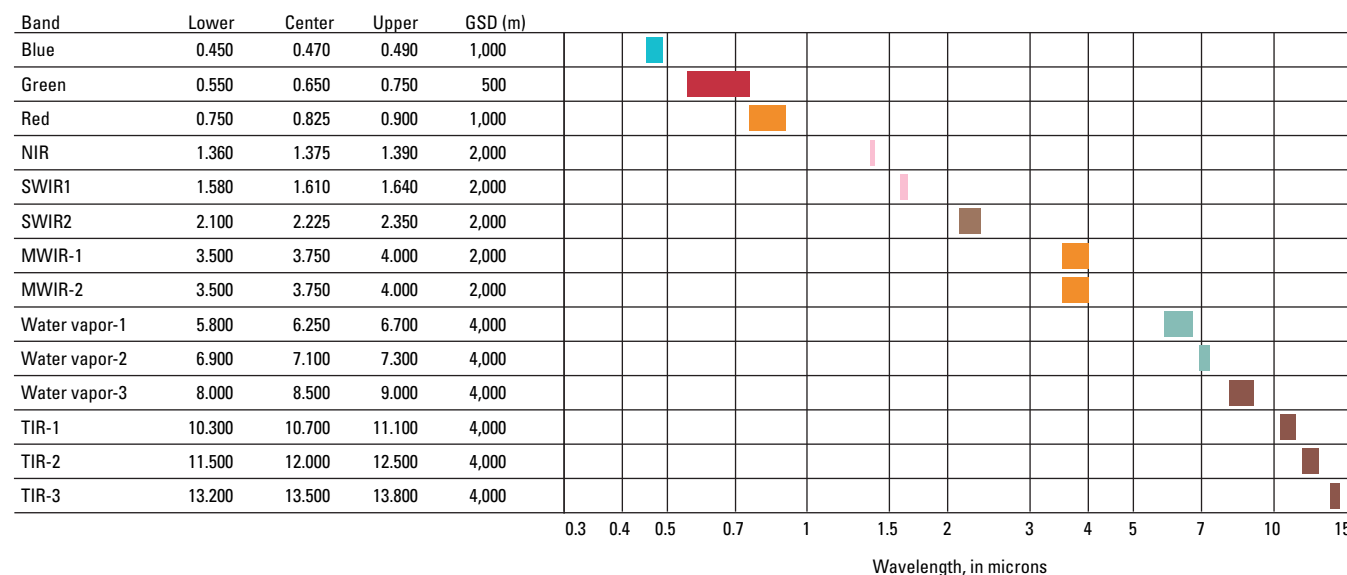
Fengyun-4—Continued

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.



FLEX

European Space Agency
Civil/Government
Future



Platform Overview

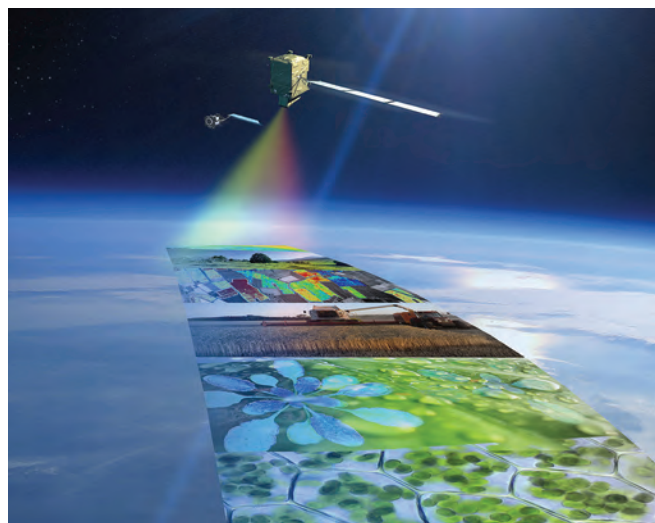
The Fluorescence Explorer (FLEX) is a European Space Agency (ESA) high-resolution imaging spectrometer satellite to be launched in 2025 for mapping vegetation fluorescence. FLEX was selected as the eighth Earth Explorer mission in 2015 and carries the FLuOREscence Imaging Spectrometer (FLORIS) sensor for low-resolution land imaging, with an expected 500–800-nanometer (nm) spectral range.

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

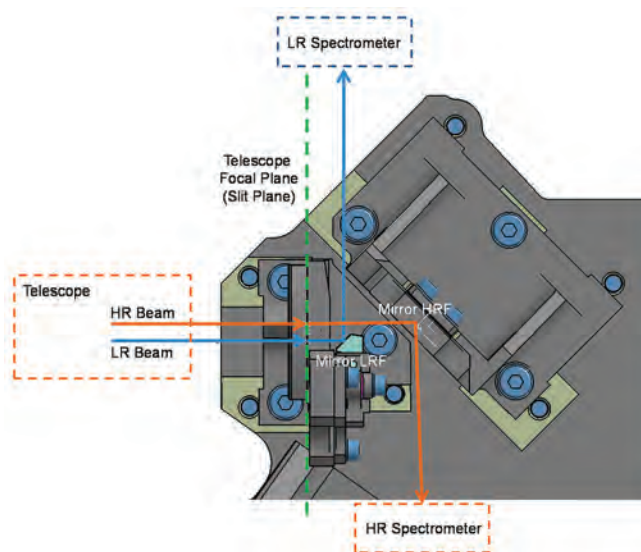
| | |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2025 (Planned) |
| Design lifetime | 5 years |
| Platform owner | ESA |
| Altitude | 815 km |
| Orbit period | 101.2 min |
| Inclination | 98.64° |
| Crossing time | 10:00 DN |
| Nadir repeat | 27 days |
| Status | Planned |
| System website | https://earth.esa.int/web/guest/missions/esa-future-missions/flex |

Sensor Information

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



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



FLORIS sensor illustration (image from ESA).

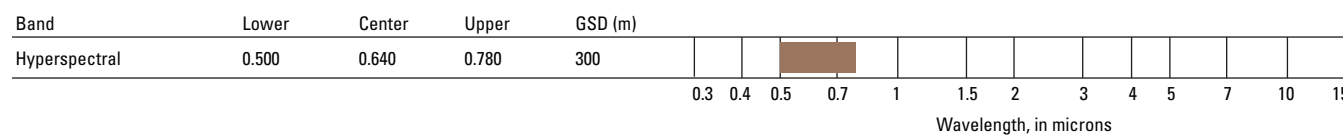
FLEX—Continued

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 (759–769 nm and 686–697 nm) and the other has lower spectral resolution (3 nm) for atmospheric and vegetation parameters.



FORMOSAT-5

Taiwan
Civil/Government
Operational



Platform Overview

Formosat-5 is a high-resolution multispectral satellite launched on a Falcon 9 rocket in 2017 by Taiwan's National Space Organization (NSPO). The satellite mission was built and operated entirely by NSPO. The satellite carries a multispectral imager that images in the visible and near-infrared parts of the spectrum for high-resolution Earth imaging.

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

| | Formosat-5 |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 08/24/2017 |
| Design lifetime | 5 years |
| Platform owner | NSPO |
| Altitude | 720 km |
| Orbit period | 99 min |
| Inclination | 98.28° |
| Crossing time | 10:30 DN |
| Nadir report | — |
| Status | Operational |
| System website | https://www.nspo.narl.org.tw/inprogress.php?c=20030301&ln=en |



Satellite model of Formosat-5 before launch (image from National Space Organization).

Sensor Information

| | Hyperspectral imager |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 2/4 |
| Swath (km) | 24 |
| Revisit (days) | 2 |
| Data portal | https://www.nspo.narl.org.tw/activity/formosatimagery/en/index.html |

Optical Remote Sensing Instrument

The remote sensing instrument on Formosat-5 is a multispectral imager, similar to the one flown on Formosat-2, that provides panchromatic and multispectral imagery.

| Band | Lower | Center | Upper | GSD (m) | |
|--------------|-------|--------|-------|---------|--|
| Panchromatic | 0.400 | 0.575 | 0.750 | 2 | |
| Blue | 0.450 | 0.495 | 0.540 | 4 | |
| Green | 0.520 | 0.570 | 0.620 | 4 | |
| Red | 0.620 | 0.675 | 0.730 | 4 | |
| NIR | 0.720 | 0.825 | 0.930 | 4 | |

Wavelength, in microns

FORMOSAT-8

Taiwan
Civil/Government
Development



Platform Overview

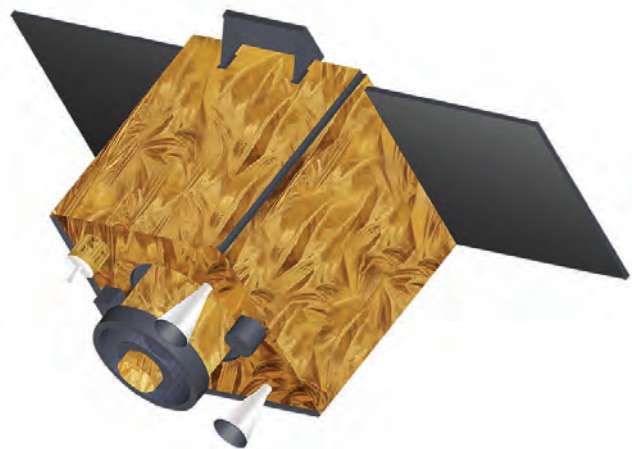
Formosat-8 is a high-resolution multispectral satellite constellation planned to be launched by Taiwan's National Space Organization in 2024 for Earth-resources monitoring. The Formosat-8 mission consists of six satellites, each of which will carry a multispectral imager that provides panchromatic and multispectral imagery at 1 meter and 2 meters, respectively.

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

| | Formosat-8A | Formosat-8B | Formosat-8C | Formosat-8D | Formosat-8E | Formosat-8F |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|----------------|----------------|
| Launch date | 2024 (Planned) | 2025 (Planned) | 2026 (Planned) | 2027 (Planned) | 2028 (Planned) | 2029 (Planned) |
| Design lifetime | 3 years | | | | | |
| Platform owner | NSPO | | | | | |
| Altitude | 561 km | | | | | |
| Orbit period | 95.8 min | | | | | |
| Inclination | 97.63° | | | | | |
| Crossing time | 10:30 DN or 13:30 DN | | | | | |
| Nadir report | — | | | | | |
| Status | Development | | | | | |
| System website | https://www.nspo.narl.org.tw/inprogress.php?c=20022501&ln=en | | | | | |

Sensor Information

| | Hyperspectral imager |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 1/2 |
| Swath (km) | 10 |
| Revisit (days) | 1 |
| Data portal | https://www.nspo.narl.org.tw/activity/formosatimagery/en/index.html |



Artistic rendering of Formosat-8 satellite (image from National Space Organization).

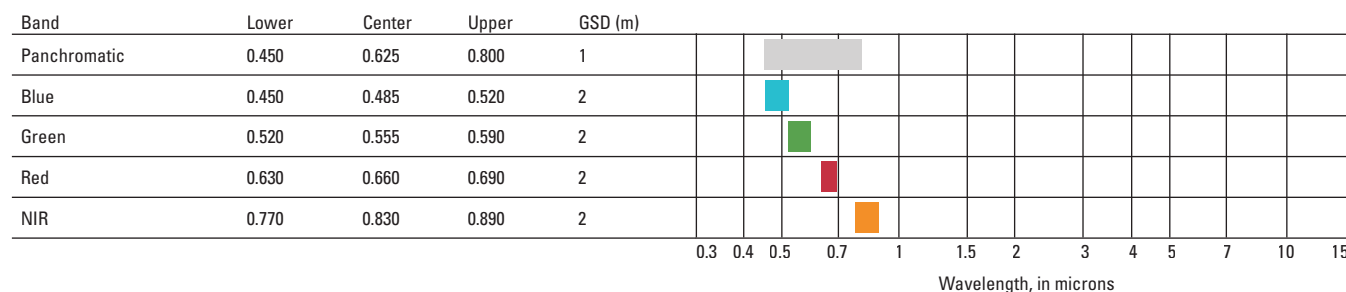
FORMOSAT-8—Continued

Taiwan
Civil/Government
Development



Remote Sensing Instrument

The remote sensing instrument on Formosat-8 is a multispectral imager similar to the one flown on Formosat-5, providing panchromatic and multispectral imagery, and has improved swath and ground sample distance.



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 in China. 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 | 1 |
| 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 | | | | | | | | | | | | | | | |

Wavelength, in microns

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 | | | | | | | | | | | | | | | |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NSA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

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 in China. 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.

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

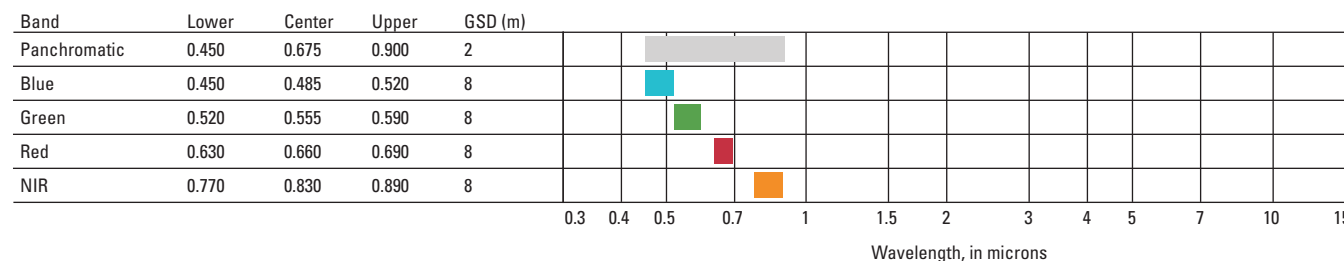
| | |
|------------------------|-----------------------------------------------------------------------------------------------------------|
| Launch date | 03/30/2018 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 645 km |
| Orbit period | 97.62 min |
| Inclination | 98.05° |
| 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.



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 in China. 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]

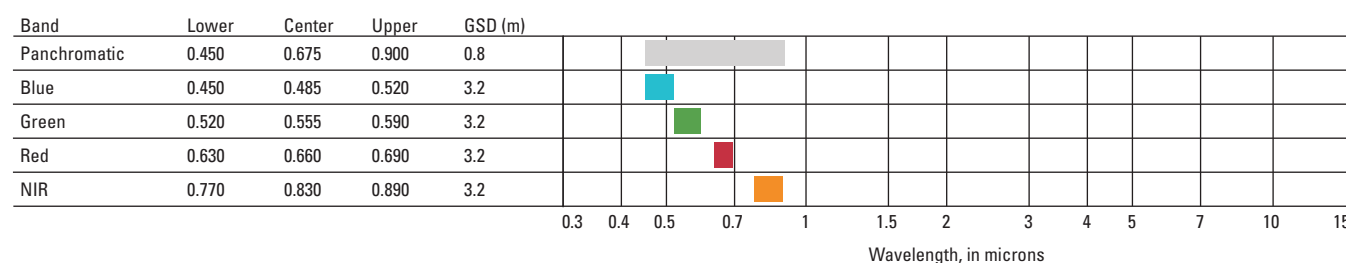
| | |
|------------------------|-----------------------------------------------------------------------------------------------------------|
| Launch date | 08/19/2014 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 645 km |
| Orbit period | 97.62 min |
| Inclination | 98.05° |
| 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.



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 | — |

Sensor Information

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

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 in China 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; °, degree; E, east; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; MWIR, midwave infrared]

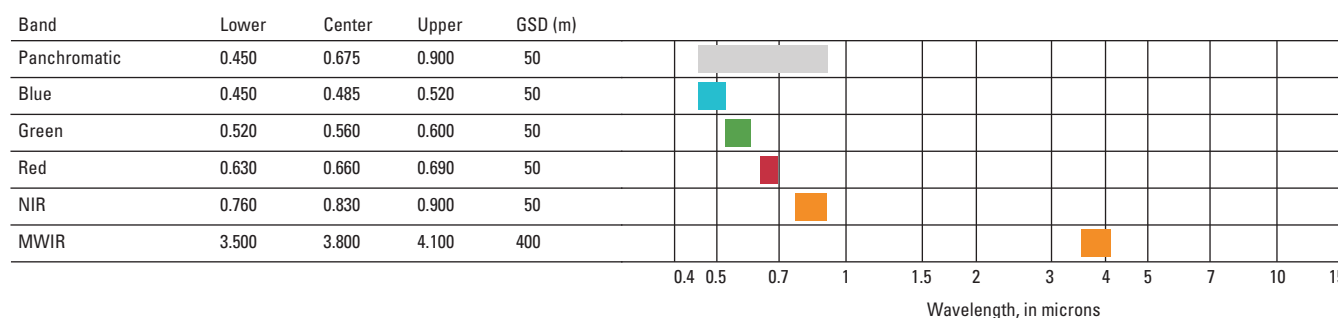
| | |
|------------------------|-------------|
| Launch date | 12/29/2015 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 36,000 km |
| Orbit period | 1,440 min |
| Longitude | 105.6° E |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Operational |
|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



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]

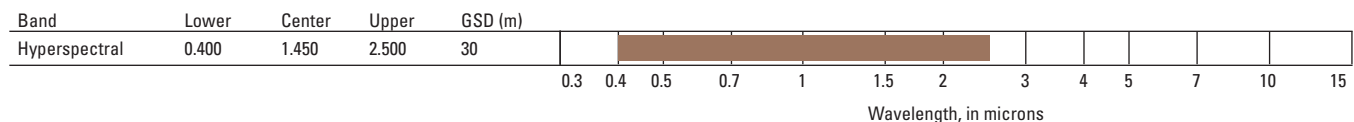
| | |
|------------------------|-------------|
| Launch date | 05/08/2018 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 708 km |
| Orbit period | 98.8 min |
| Inclination | 98.2° |
| Crossing time | 13:30 AN |
| Nadir repeat | — |
| Status | Operational |
| System website | —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

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.



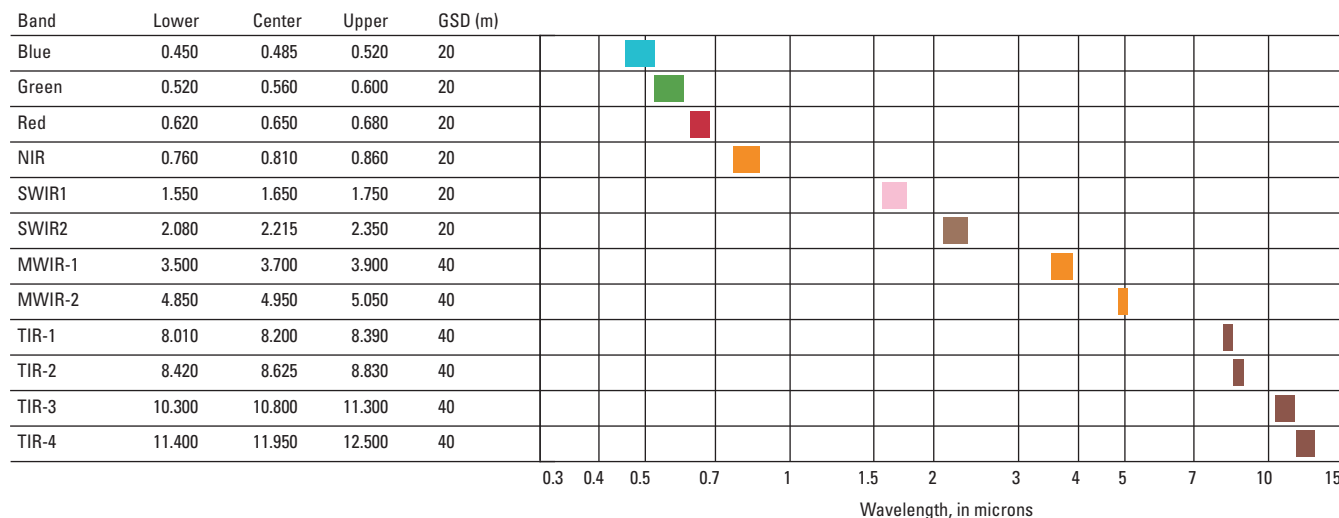
Gaofen-5—Continued

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.



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 in China 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]

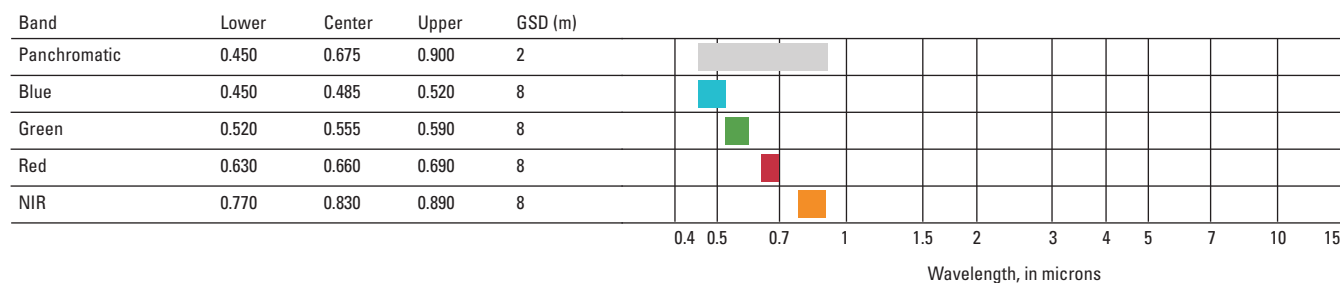
| | |
|------------------------|-------------|
| Launch date | 06/02/2018 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 645 km |
| Orbit period | 97.62 min |
| Inclination | 98.05° |
| Crossing time | 10:30 DN |
| Nadir repeat | 41 days |
| Status | Operational |
| System website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

Sensor Information

| | PMC-1 | WFC |
|-----------------------|------------------------------------------------------------|-----|
| GSD (m) | 2/8 | 16 |
| Swath (km) | 95 | 860 |
| Revisit (days) | 4 | 1 |
| Data portal | www.cnsageo.com/#/ | |

PMC-1

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



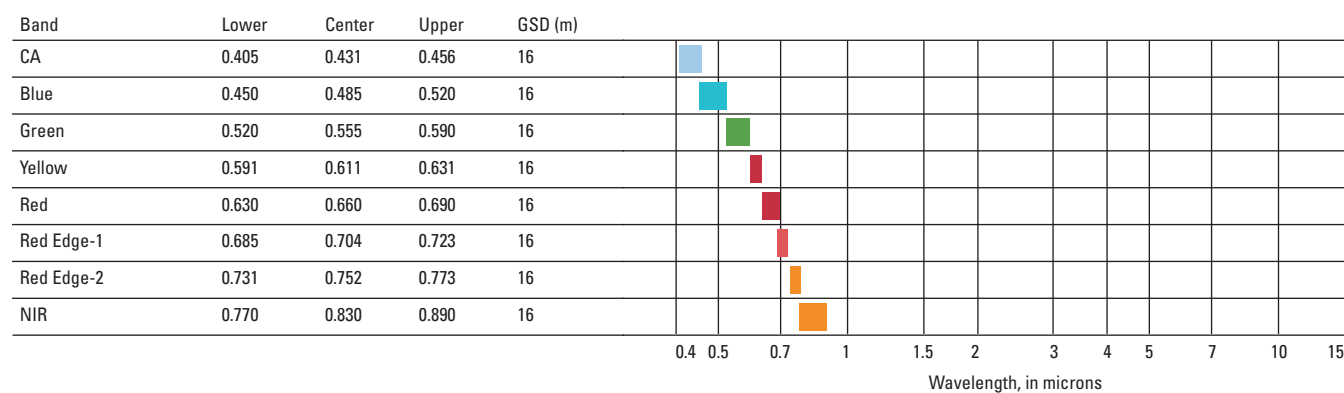
Gaofen-6—Continued

China
Civil/Government
Future



WFC

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



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 in China. 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]

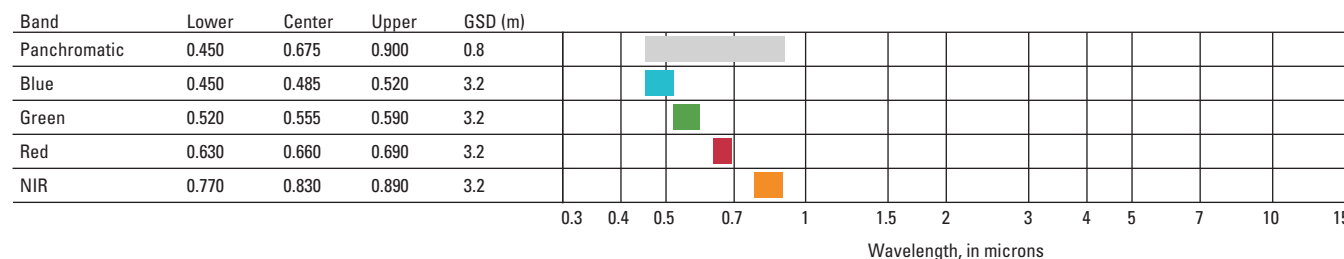
| | |
|------------------------|-------------|
| Launch date | 06/26/2015 |
| Design lifetime | 8 years |
| Platform owner | CNSA |
| Altitude | 485 km |
| Orbit period | 94.3 min |
| Inclination | 97.3° |
| Crossing time | 10:30 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | —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

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.



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 in China 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 to 5 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]

| | GR-9 01 | GF-9 02 | GF-9 03 | GF-9 04 | GF-9 05 |
|------------------------|-------------|------------|------------|------------|------------|
| Launch date | 09/14/2015 | 05/31/2020 | 06/17/2020 | 08/06/2020 | 08/23/2020 |
| 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 | | | | | | | | | | | | | | | |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Gaofen-11

China
Civil/Government
Operational



Platform Overview

Gaofen-11 (GF-11) is a series of high-resolution multispectral satellites launched in 2018, 2020, and 2021 by the China National Space Administration (CNSA) on a Long March rocket from the Taiyuan Satellite Launch Center in China for Earth resources monitoring. The GF-11 satellites were developed by the China Academy of Space Technology as a part of the China High-resolution Earth Observation System. The satellites carry 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]

| | Gaofen-11 01 | Gaofen-11 02 | Gaofen-11 03 |
|------------------------|--------------|--------------|--------------|
| Launch date | 07/31/2018 | 09/07/2020 | 11/20/2021 |
| Design lifetime | 8 years | | |
| Platform owner | CNSA | | |
| Altitude | 485 km | | |
| Orbit period | 94.3 min | | |
| Inclination | 97.4° | | |
| Crossing time | 10:30 DN | | |
| Nadir report | — | | |
| 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 | | | | | | | | | | | | | | | |

0.3 0.4 0.5 0.7 1 1.5 2 3 4 5 7 10 15

Wavelength, in microns

Gaofen-12

China
Civil/Government
Operational



Platform Overview

Gaofen-12, 12 02, and 12 03 are high-resolution synthetic aperture radar (SAR) satellites launched in 2019, 2021, and 2022, respectively, by China National Space Agency (CNSA) on a Long March rocket from Taiyuan Satellite Launch Center for Earth resources monitoring. GF-12 satellites were designed and built by Shanghai Academy of Spaceflight Technology. These radar satellites are a part of the China High Resolution Earth Observing System. The satellites carry 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]

| | Gaofen-12 | Gaofen-12 02 | Gaofen-12 03 |
|------------------------|-------------|--------------|--------------|
| Launch date | 11/27/2019 | 03/30/2021 | 06/27/2022 |
| Design lifetime | 8 years | | |
| Platform owner | CNSA | | |
| Altitude | 635 km | | |
| Orbit period | 97.3 min | | |
| Inclination | 97.8° | | |
| Crossing time | 06:00 DN | | |
| Nadir report | — | | |
| Status | Operational | | |
| System website | — | | |

Sensor Information

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

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 |

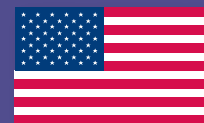
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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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 in California for commercial Earth resources monitoring. Maxar Technologies 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.

[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 | Maxar Technologies |
| Altitude | 681 km |
| Orbit period | 98 min |
| Inclination | 98.12° |
| Crossing time | 10:30 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | https://www.maxar.com/ |

Artistic rendering of GeoEye-1 (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.maxar.com/ |



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

GIS

The GIS sensor is a pushbroom-style charge coupled device imager. The sensor was designed and developed by ITT Corporation 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 | | | | | | | | | | | | | | | |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/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.

[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 |



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

Sensor Information

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

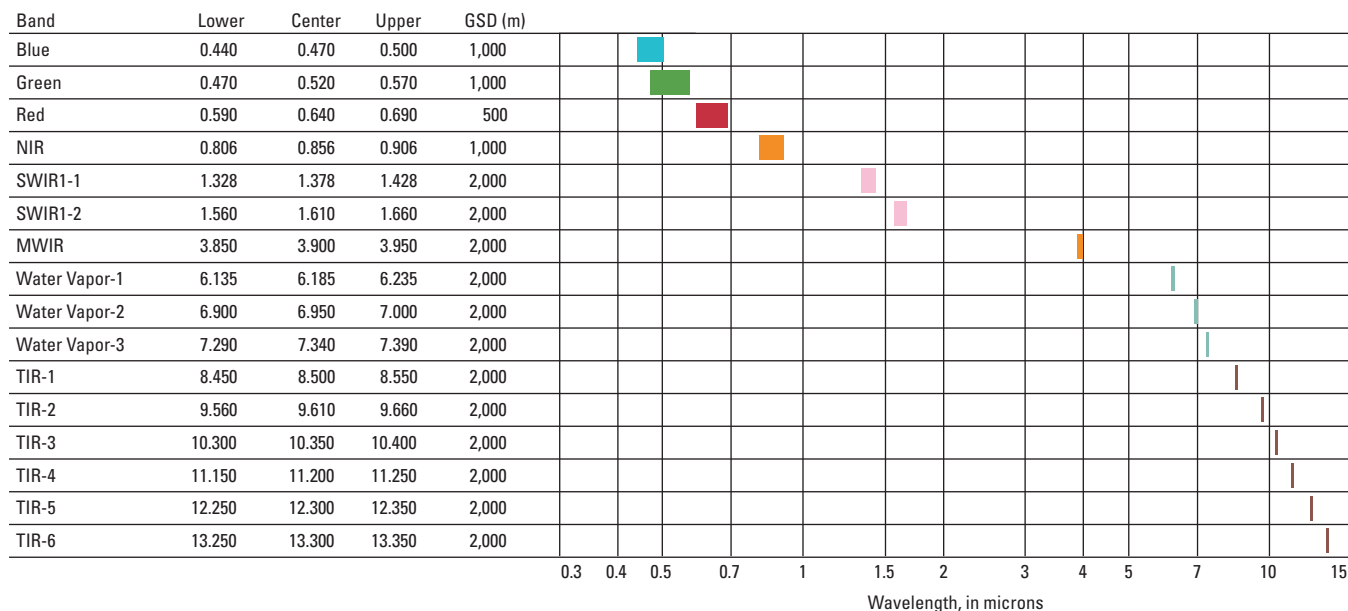
GEO-KOMPSAT-2A—Continued

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.



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.

[Abbreviations in tables: km, kilometer; °, degree; E, east; NA, not applicable; GSD, ground sample distance; m, meter; —, no data; UV, ultraviolet; CA, coastal aerosol; 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 |



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

Sensor Information

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

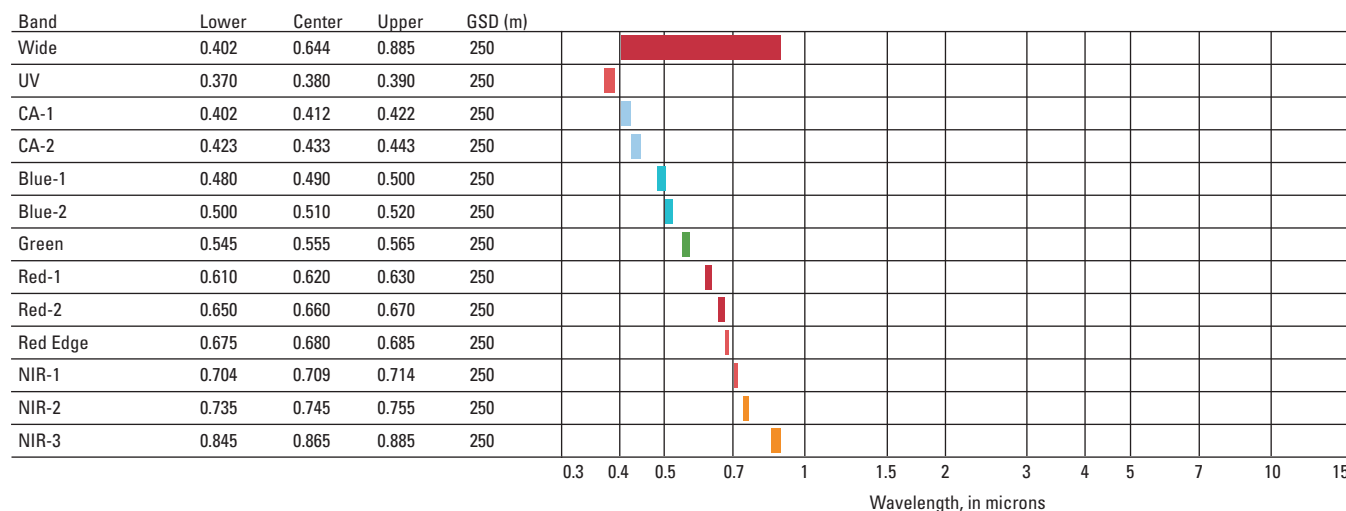
GEO-KOMPSAT-2B—Continued

South Korea
Civil/Government
Operational



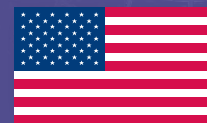
GOCI-II

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



GHOSt

United States
Commercial
Future



Platform Overview

The Global Hyperspectral Observation Satellite (GHOSt) is a medium-resolution hyperspectral satellite constellation planned to be launched by Orbital Sidekick starting in 2022 for Earth resources monitoring. The satellite is manufactured by the Astro Digital, Inc., Corvus-XL bus and uses a Ka-band downlink capability. Orbital Sidekick launched their precursor satellite, Aurora, in 2021, but the satellite suffered a failure soon after its first contact.

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

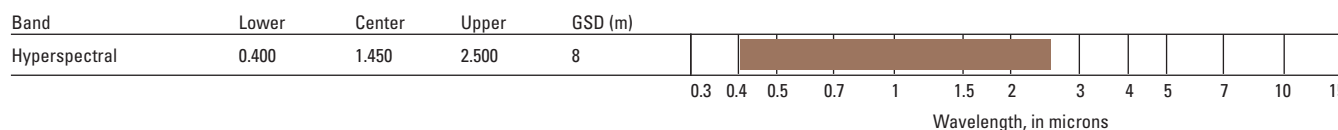
| | GHOSt 1–6 |
|-----------------|-----------------------------------------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | 5 years |
| Platform owner | Orbital Sidekick |
| Altitude | — |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Development |
| System website | https://orbitalsidekick.com/technology/ |

Sensor Information

| | Hyperspectral Imager |
|----------------|----------------------|
| GSD (m) | 8 |
| Swath (km) | — |
| Revisit (days) | 2–3 |
| Data portal | — |

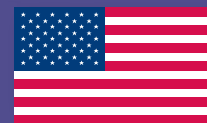
Hyperspectral Imager

The GHOSt hyperspectral imager will capture imagery in more than 400 spectral bands in the visible to shortwave infrared range of 400–2,500 nanometers.



GOES-16, -17, -18, and -U

United States
Civil/Government
Operational/Future



Platform Overview

The third-generation Geostationary Operational Environmental Satellites (GOES-16, -17, -18, and -U), commonly referred to as the GOES-R series, are low-resolution multispectral satellites for environmental monitoring. GOES-16, -17, and -18 were launched in 2016, 2018, and 2022, respectively. GOES-U is planned to be launched in 2024. 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.



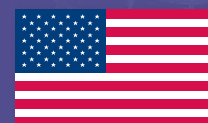
Artistic rendering of a GOES-R satellite in orbit (image from Lockheed Martin, used with permission).

[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-18 | GOES-U |
|------------------------|---------------------------------------------------------------|------------|-------------|----------------|
| Launch date | 11/19/2016 | 03/01/2018 | 03/01/2022 | 2024 (Planned) |
| Design lifetime | 10 years | | | |
| Platform owner | NOAA | | | |
| Altitude | 35,786 km | | | |
| Orbit period | 24 hours | | | |
| Longitude | 75.2° W | 137.2° W | 89.5° W | — |
| Inclination | 0° | | | |
| Crossing time | NA | | | |
| Nadir repeat | NA | | | |
| Status | Operational | | Operational | Development |
| System website | https://www.goes-r.gov/ | | | |

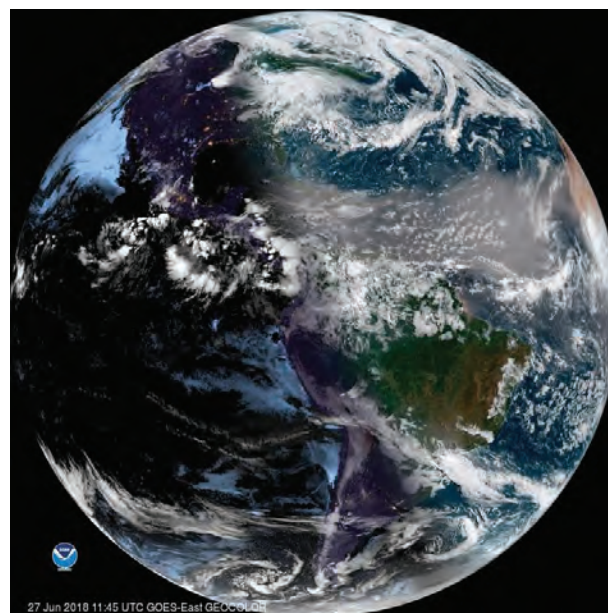
GOES-16, -17, -18, and -U—Continued

United States
Civil/Government
Operational/Future



Sensor Information

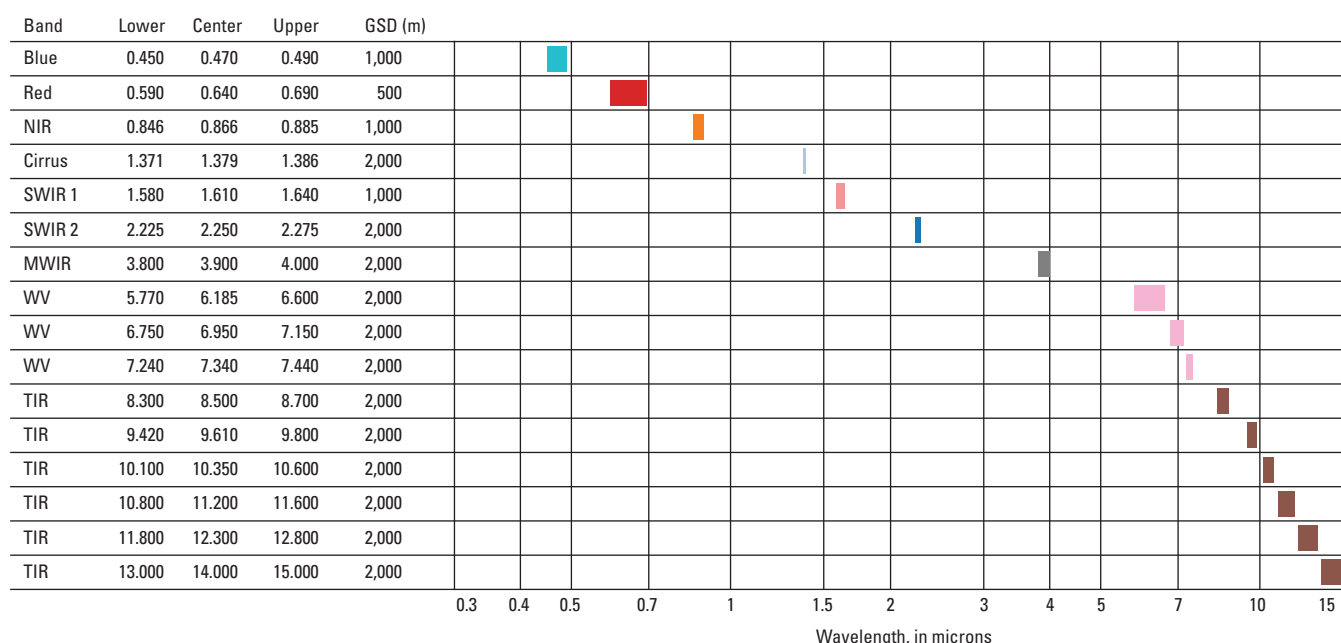
| | ABI |
|-------------|-----------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 500; 1,000; 2,000 |
| Swath (km) | — |
| Data portal | https://www.ngdc.noaa.gov/stp/satellite/goes-r.html |



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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/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.

[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/ |



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



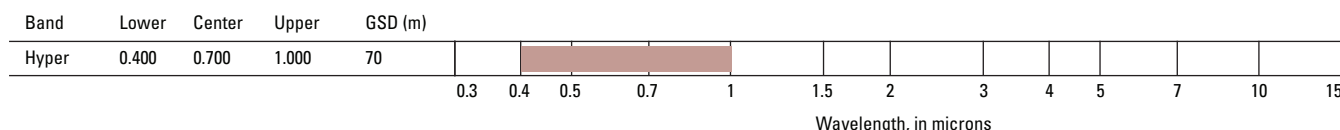
HyperScout sensor (image from COSINE Measurement Systems (<https://cosine.nl>), used with permission).

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 commercial off-the-shelf component from COSINE.



GRUS Constellation

Japan
Commercial
Operational



GRUS

GRUS is a high-resolution multispectral satellite constellation launched starting in 2018 by Japan's Axelspace. GRUS satellites carry 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; AN, ascending node; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared]

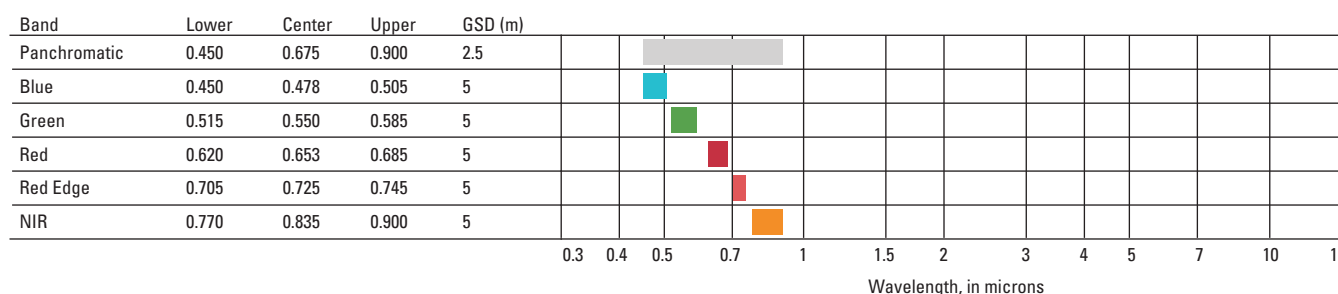
| | GRUS-1A | GRUS-1B | GRUS-1C | GRUS-1D | GRUS-1E |
|-----------------|---------------------------------------------------------------------|------------|---------|---------|---------|
| Launch date | 12/27/2018 | 03/22/2021 | | | |
| Design lifetime | 5 years | | | | |
| Platform owner | Axelspace | | | | |
| Altitude | 600 km | | | | |
| Orbit period | 96.5 min | | | | |
| Inclination | 97.7° | | | | |
| Crossing time | 10:30 AN | | | | |
| Nadir repeat | — | | | | |
| Status | Operational | | | | |
| System website | https://www.axelspace.com/ | | | | |

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.



Haiyang-1

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, HY-1C in 2018, and HY-1D in 2020. 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 the 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.

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

| | HY-1B | HY-1C | HY-1D |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------|------------|------------|
| Launch date | 04/11/2007 | 09/07/2018 | 06/10/2020 |
| Design lifetime | 3 years | 5 years | |
| Platform owner | National Satellite Ocean Application Service | | |
| Altitude | 798 km | 782 km | |
| Orbit period | 100.8 min | 100.8 min | |
| Inclination | 98.8° | 98.8° | |
| Crossing time | 10:30 DN | 10:30 DN | 13:30 AN |
| Nadir repeat | 7 days | | |
| Status | Operational | | |
| System website | http://www1.nsoas.org.cn/NSOAS_En/Satellites/index.html | | |

Sensor Information

| | COCTS | CZI | UVI |
|-----------------------|-------|-----|-------|
| GSD (m) | 1,100 | 50 | 550 |
| Swath (km) | 3,000 | 950 | 3,000 |
| Revisit (days) | 1 | 3 | 1 |
| Data portal | — | | |

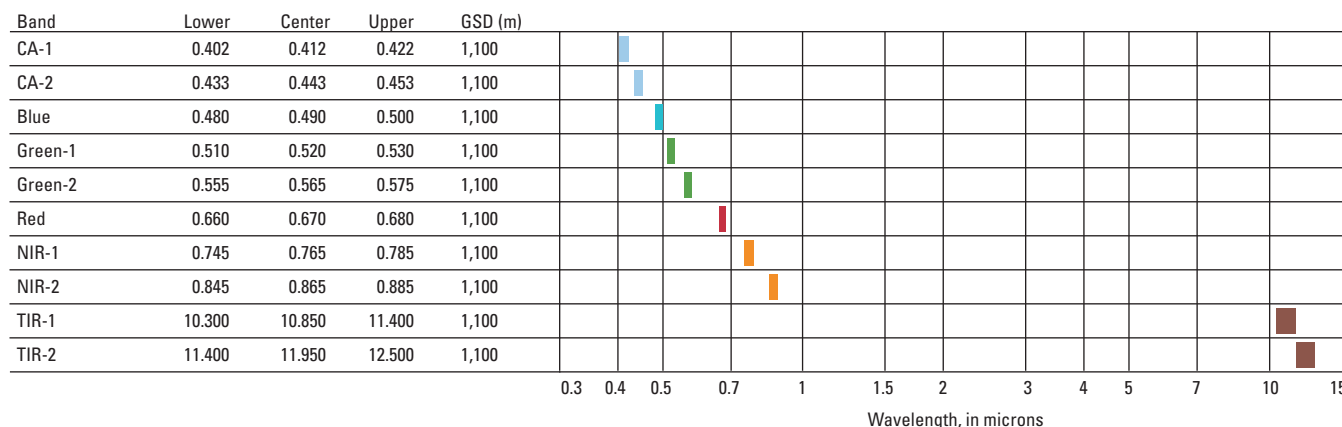
Haiyang-1—Continued

China
Civil/Government
Operational



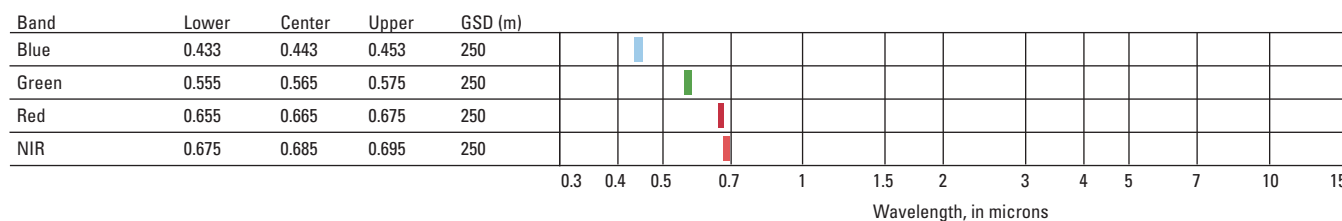
COCTS

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 for detection of ocean color parameters and sea surface temperature.



CZI

CZI is a four-band VNIR imager on HY-1C/1D satellites providing images at a GSD of 50 meters. It is primarily used for obtaining real-time imagery of the ocean-land interaction zone to monitor coastal area and suspended sediment distribution of key estuaries and harbors. CZI also provides real-time monitoring of ice, red tide, green tide, pollutant, and other ocean environmental disasters.



UVI

The UVI is primarily used to improve COCTS's atmospheric correction accuracy of nearshore turbid water.

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 operational with HY-2C and HY-2D, launched in 2020 and 2021, respectively. HY-2C/2D carry an altimeter, a scatterometer, a correction microwave radiometer and an automatic identification system.

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

| | HY-2A | | HY-2C/2D | |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------|-----------|------------|------------|
| Launch date | 08/16/2011 | | 09/21/2020 | 05/19/2021 |
| Design lifetime | 3 years | | | |
| Platform owner | NSOAS | | | |
| Altitude | 973 km | 950 km | | |
| Orbit period | 104.50 min | 104.1 min | | |
| Inclination | 99.34° | 66° | | |
| 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 |

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 2023 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 table: NSOAS, National Satellite Ocean Application Service; —, no data]

| | HY-3A | HY-3B |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------|
| Launch date | 2023 | 2025 |
| 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 currently (2022) 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 in Japan for meteorology and weather monitoring.

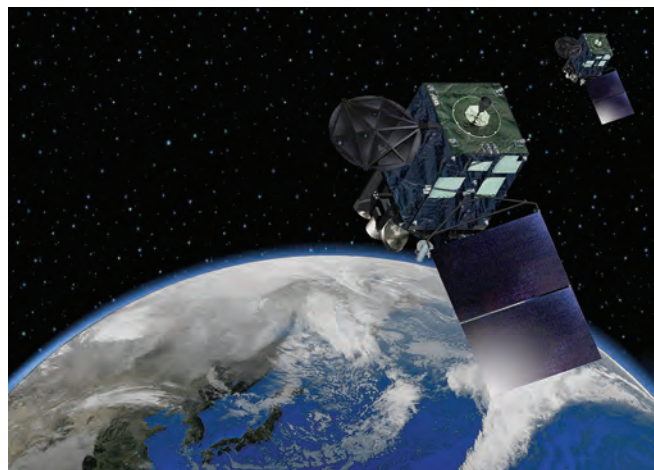
The satellites were built by Mitsubishi Electric (ME) with assistance from Boeing based on ME's DS-2000 satellite bus. The satellites are owned and operated by the Japan Meteorological Agency (JMA). Himawari-8 and -9 carry an Advanced Himawari Imager (AHI) with similar spectral and spatial capabilities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

[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 |



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



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

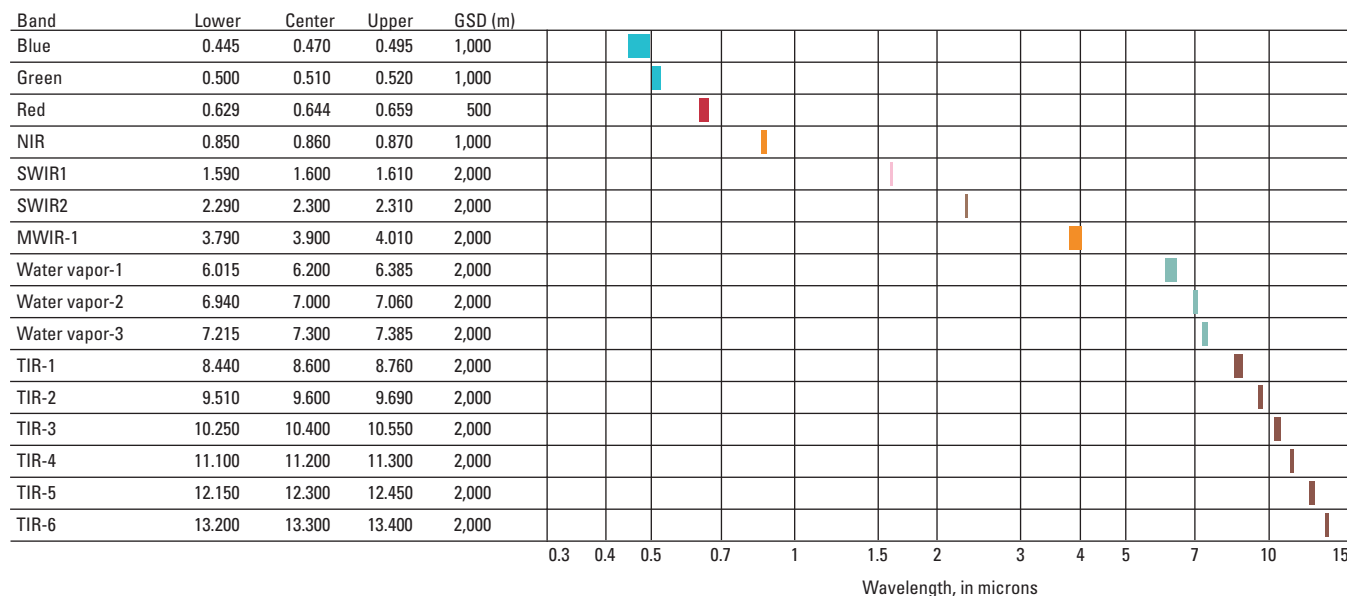
Himawari—Continued

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.



HRSAT 1A, 1B, 1C

India
Civil/Government
Future



Platform Overview

HRSAT 1A, 1B, and 1C are high-resolution multispectral satellites to be launched in 2023 by the Indian Space Research Organization (ISRO) for Earth observation. Limited information currently (2022) is available. The HRSAT satellites will carry a panchromatic (Pan), a multispectral (MX), and an infrared sensor (IR) for high-resolution land imaging.

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

| | HRSAT 1A | HRSAT 1B | HRSAT 1C |
|-----------------|----------------|----------|----------|
| Launch date | 2023 (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 | — | | |

Sensor Information

| | MX | Pan | IR |
|-------------|------|-----|----|
| GSD (m) | 2, 4 | 1 | 20 |
| Swath (km) | 15 | 20 | 6 |
| Data portal | — | | |

Pan and MX

The HRSAT will carry a Pan, an MX, and an IR sensor capable of imaging at a resolution of about 1 meter, 2/4 meters, and 20 meters, respectively.

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 in China 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.

[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

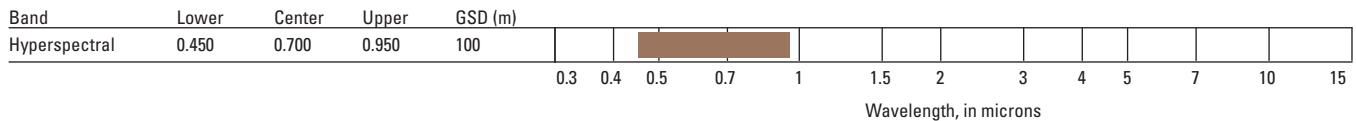
| | HJ-1A hyperspectral imager | HJ-1A/1B CCD camera | HJ-1B infrared scanner |
|--------------------|----------------------------------|------------------------|---------------------------|
| GSD (m) | 100 | 30 | 150/300 |
| Swath (km) | 50 | 700 | 720 |
| Data portal | — | | |

Huanjing-1A/1B—Continued

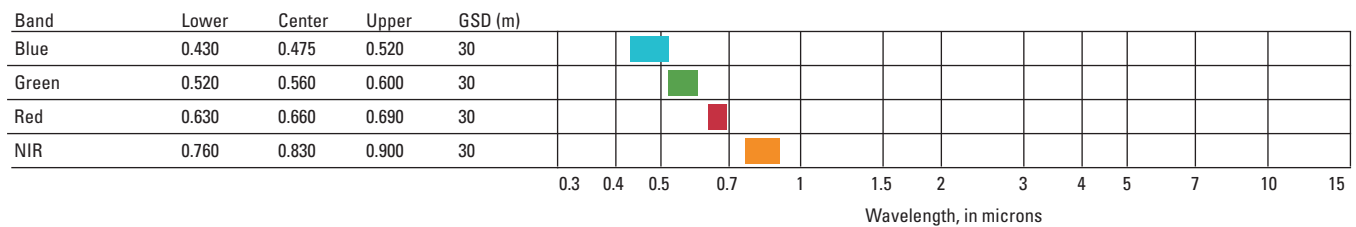
China
Civil/Government
Operational



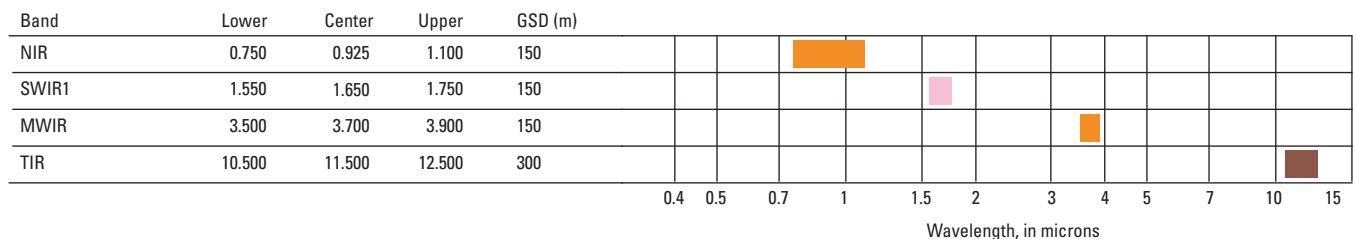
HJ-1A Hyperspectral Imager



CCD Camera



Infrared Scanner



Huanjing-1C

China
Civil/Government
Operational



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 |

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 |

Hyperfield Constellation

Finland
Commercial
Operational/Future



Platform Overview

Kuva Space is planning to launch Hyperfield, a constellation of hyperspectral satellites for Earth resources monitoring starting in 2023. A technology demonstration satellite (2U) named Reaktor Hello World was launched in 2018 to demonstrate a miniature infrared hyperspectral payload. The planned constellation will carry a hyperspectral imager in visible and near infrared regions of the spectrum.

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

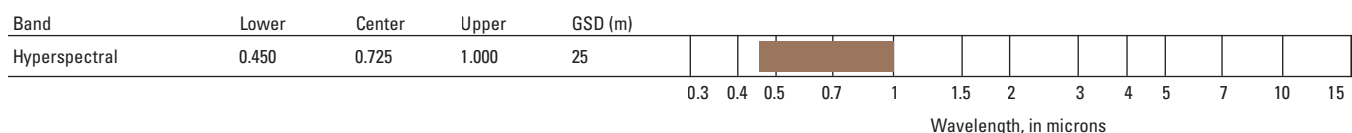
| | Reaktor Hello World | Hyperfield-1 |
|------------------------|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Launch date | 11/29/2018 | 2023 (Planned) |
| Design lifetime | — | — |
| Platform owner | Kuva Space | |
| Altitude | 492 km | — |
| Orbit period | 94.5 min | — |
| Inclination | 97.37° | — |
| Crossing time | — | — |
| Nadir repeat | — | — |
| Status | Operational | Planned |
| System website | https://kuvaspace.com/reaktor-hello-world/ | https://kuvaspace.com/ |

Sensor Information

| | Hyperspectral Imager |
|-----------------------|----------------------|
| GSD (m) | 25 |
| Swath (km) | — |
| Revisit (days) | — |
| Data portal | — |

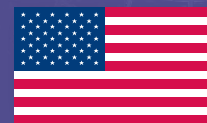
Hyperspectral Imager

The hyperspectral sensor on Hyperfield-1 satellite is a novel tunable imager, which covers visible and near infrared (450–1,000 nanometer) wavelengths with a ground sample distance of 25 meters.



Hypersat Constellation

United States
Commercial
Future



Platform Overview

Hypersat has planned a six-satellite hyperspectral constellation to be launched in early 2023. The constellation consists of six satellites is being developed by QinetiQ and will be launched by Virgin Orbit on their LauncherOne launch vehicle. The initial satellites will have a visible to shortwave infrared capability with about 500 spectral bands at a resolution of 6 meters. The subsequent satellites are planned with a thermal infrared capability.

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

| | |
|------------------------|----------------|
| Launch date | 2023 (Planned) |
| Design lifetime | — |
| Platform owner | — |
| Altitude | — |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Planned |
| System website | — |

Sensor Information

| | |
|-----------------------|-----------------------------|
| | Hyperspectral Imager |
| GSD (m) | 6 |
| Swath (km) | — |
| Revisit (days) | — |
| Data portal | — |

Hyperspectral Imaging System

The hyperspectral imaging system is a pushbroom imager in visible and near infrared and shortwave infrared bands.

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; GSD, ground sample distance; m, meter; VNIR, visible and near infrared; SWIR, shortwave infrared]

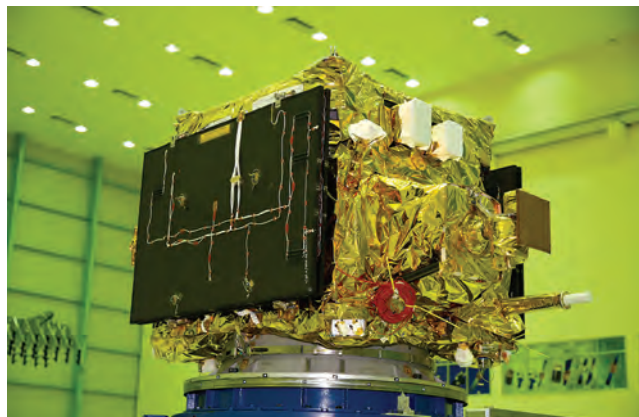
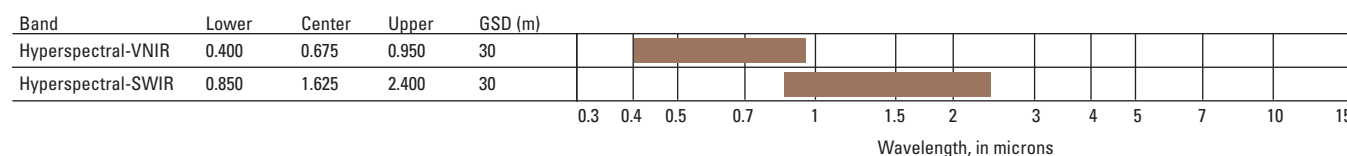
| | |
|-----------------|-------------------------------------------------------------------------------------|
| Launch date | 11/29/2018 |
| Design lifetime | 5 years |
| Platform owner | ISRO |
| Altitude | 636 km |
| Orbit period | 97.43 min |
| Inclination | 97.92° |
| Crossing time | — |
| Nadir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

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.



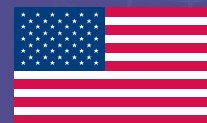
HySIS in the clean room before launch (image from Indian Space Research Organization, used with permission).



First day image of HySIS, Lakhpat, Gujarat (image from Indian Space Research Organization, used with permission).

HySpecIQ Constellation

United States
Commercial
Future



Platform Overview

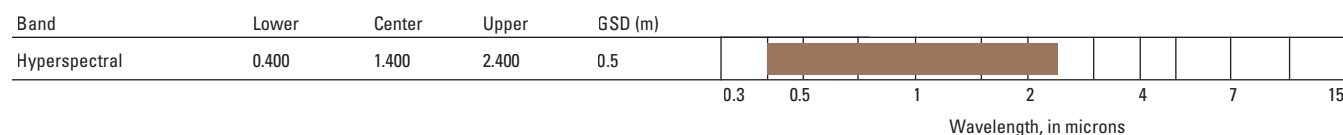
HySpecIQ is planning a 12-satellite hyperspectral constellation to be launched starting in 2023. The company was awarded an imaging contract by the National Reconnaissance Office in 2021.

[Abbreviations in table: km, kilometer; min, minute; °, degree; —, no data]

| | |
|------------------------|-----------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 5 years |
| Platform owner | HySpecIQ |
| Altitude | 480 km |
| Orbit period | 94.2 min |
| Inclination | 97.3° |
| Crossing time | — |
| Nadir repeat | 7 days |
| Status | Planned |
| System website | https://hyspeciq.com/ |

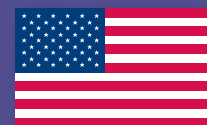
Hyperspectral Imager

The hyperspectral imager will operate in visible and shortwave infrared regions with 100 bands and a spectral resolution of 20 nanometers.



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).

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

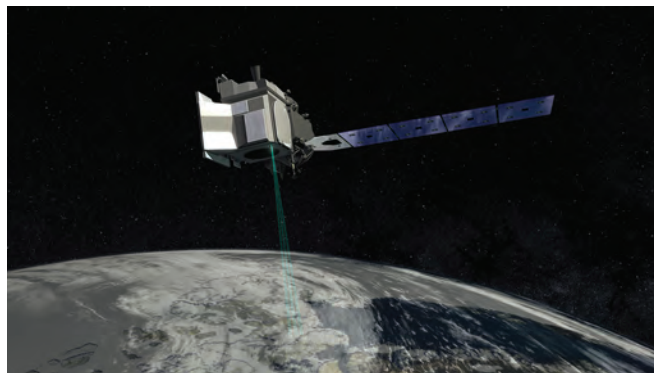
| | |
|------------------------|-------------------------------------------------------------------------------|
| Launch date | 09/15/2018 |
| Design lifetime | 3 years |
| Platform owner | NASA |
| Altitude | 500 km |
| Orbit period | 94.6 min |
| Inclination | 92° |
| Crossing time | — |
| Nadir repeat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

Sensor Information

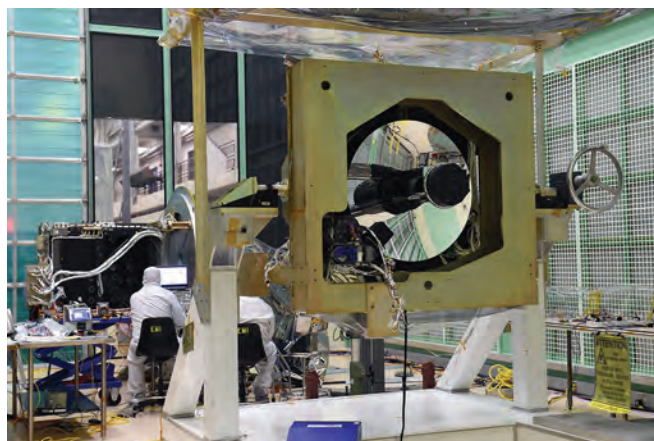
| | ATLAS |
|--------------------|-------------------------------------------------------------------------------|
| GSD (m) | 0.7 (along track) |
| Swath (km) | 0.013 |
| Data portal | https://nsidc.org/data/icesat-2 |

ATLAS

The ATLAS is a new design from NASA's Goddard Space Flight Center. 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).



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



ATLAS instrument model (image from NASA).

INSAT-3D and -3DR

India
Civil/Government
Operational

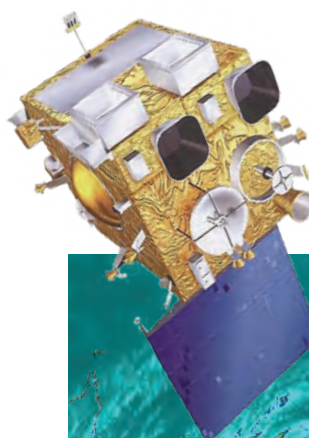


Platform Overview

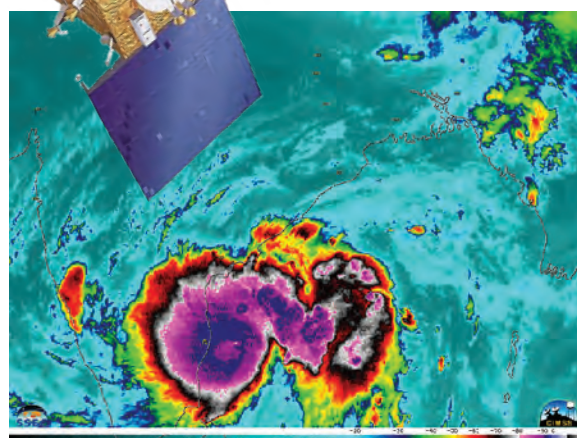
The Indian National Satellite-3D (INSAT-3D) is a low-resolution multispectral satellite launched in 2013 by the Indian Space Research Organization (ISRO) on an Ariane-5 launch vehicle from Kourou, French Guiana, for meteorological monitoring. This mission continues the INSAT-3 series of satellites with 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 Multi-spectral Imager (MSI) for meteorological monitoring.

[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/INSAT_3D.html | https://www.isro.gov.in/INSAT_3DR.html |



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



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

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 | | | | | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | | |
| | | | | | Wavelength, in microns | | | | | | | | | | | | | | |

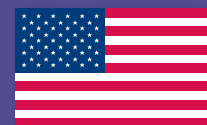
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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ISS DESIS ON MUSES

United States
Civil/Government
Operational



Platform Overview

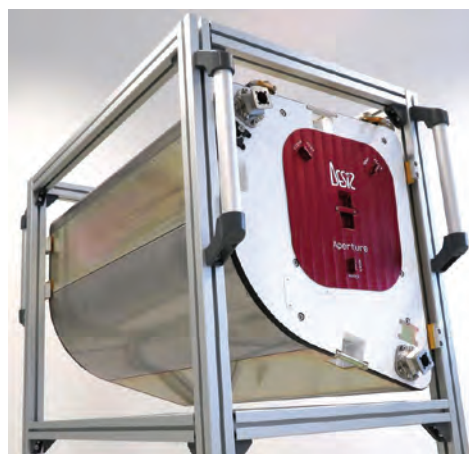
The Multiple User System for Earth Sensing (MUSES) is a commercially operated multiuser facility aboard the International Space Station (ISS) launched in June 2017 on a SpaceX Falcon 9 launch vehicle. MUSES was developed by Teledyne Brown Engineering. The facility is mounted on the starboard side of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

[Abbreviations in tables: —, no data; NASA, National Aeronautics and Space Administration; 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/explorer/Investigation.html?id=1147 |



MUSES pointing platform (image from NASA).



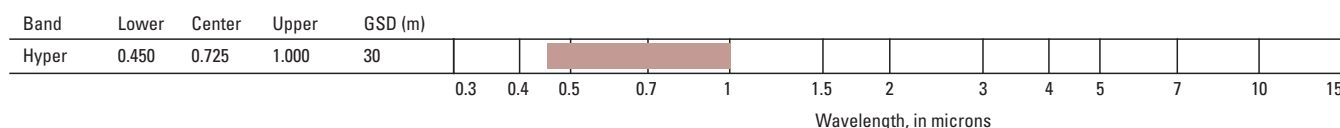
DESI sensor model (image from DLR).

Sensor Information

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

DESI

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.



ISS JEM-EF/Kibo

Japan
Civil/Government
Operational/Future



Platform Overview

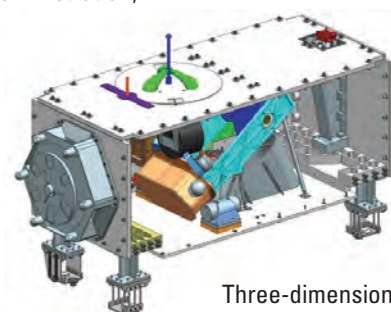
The Japanese Experiment Module Exposed Facility (JEM-EF) is a part of JEM (referred to as Kibo in Japan), launched in 2009 by the Japan Aerospace Exploration Agency (JAXA) on STS-127 with an emphasis on Earth observation instruments. JEM-EF hosts the ECOsystem Spaceborne Thermal Radiometer Experiment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

[Abbreviations in tables: —, no data; JAXA, Japan Aerospace Exploration Agency; km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter; SWIR, shortwave infrared; TIR, thermal infrared; NIR, near 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 National Aeronautics and Space Administration).



Three-dimensional model of ECOSTRESS (image from National Aeronautics and Space Administration).

Sensor Information

| | ECOSTRESS | GEDI | HISUI | EMIT | iSIM |
|--------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------|-------------|
| GSD (m) | 38 | — | 20 | 30 | 2 |
| Swath (km) | 384 | — | 20 | 80 | 13 |
| Status | Operational | Operational | Operational | Operational | Operational |
| Data portal | https://ecostress.jpl.nasa.gov/data | https://gedi.umd.edu/data/download/ | — | https://science.jpl.nasa.gov/projects/EMIT/ | — |

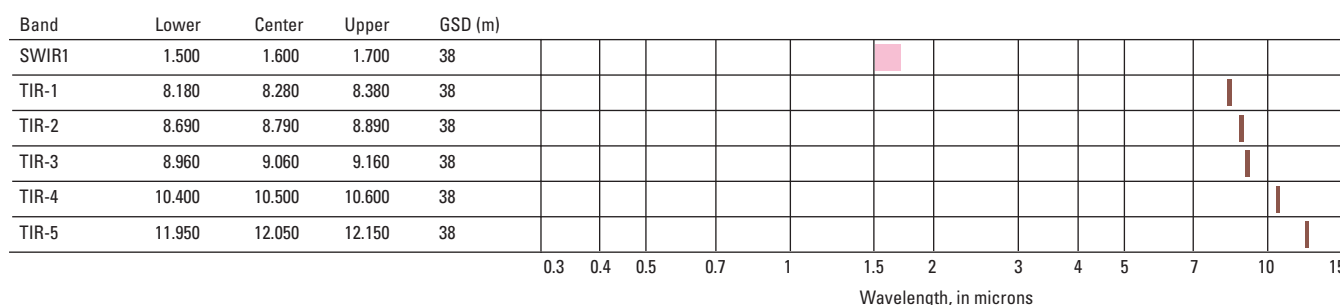
ISS JEM-EF/Kibo—Continued

Japan
Civil/Government
Operational/Future



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 HypSPiRI Thermal Infrared Radiometer developed by National Aeronautics and Space Administration (NASA). ECOSTRESS data are freely available.

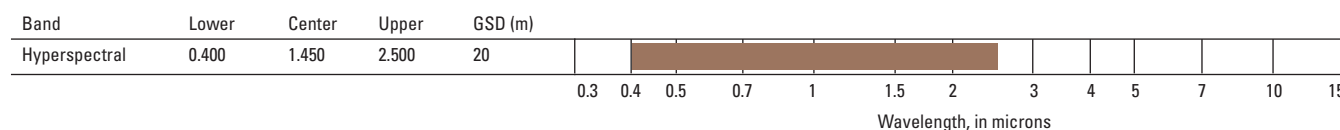


GEDI

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.

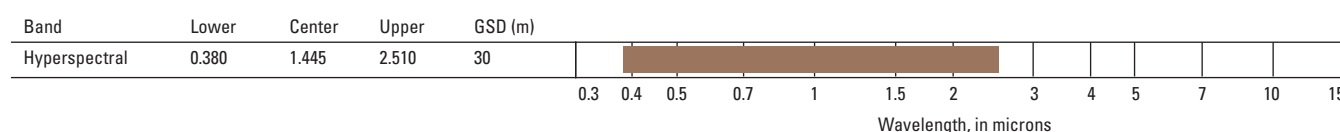
HISUI

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



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.



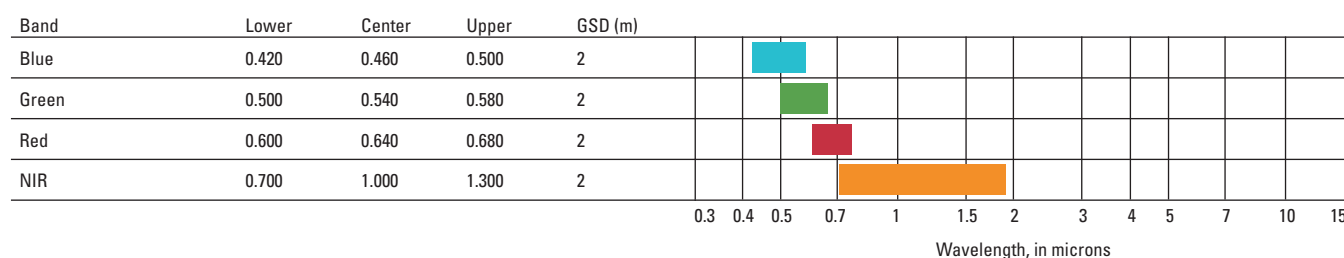
ISS JEM-EF/Kibo—Continued

Japan
Civil/Government
Operational/Future



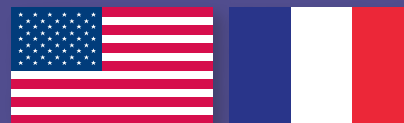
iSIM-90

The integrated Standard Imager for Microsatellites (iSIM), developed by SATLANTIS, is a new generation high-resolution optical binocular telescope for Earth observation. The sensor operated in visible and near infrared parts of the spectrum, providing a swath of 13 kilometers and a GSD of around 2 meters at a 500-kilometer altitude.



Jason-3

United States, France
Civil/Government
Operational



Platform Overview

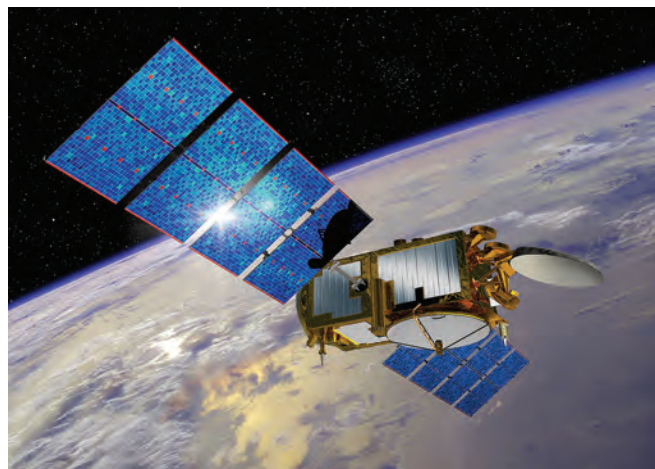
Jason-3 is a radar altimeter satellite launched in January 2016 on a Falcon 9 launch vehicle from Vandenberg Air Force Base in California for oceanic observation. This mission is a follow-on to Jason-2 with a collaboration between the National Aeronautics and Space Administration (NASA) and French National 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 table: km, kilometer; min, minute; °, degree; —, no data]

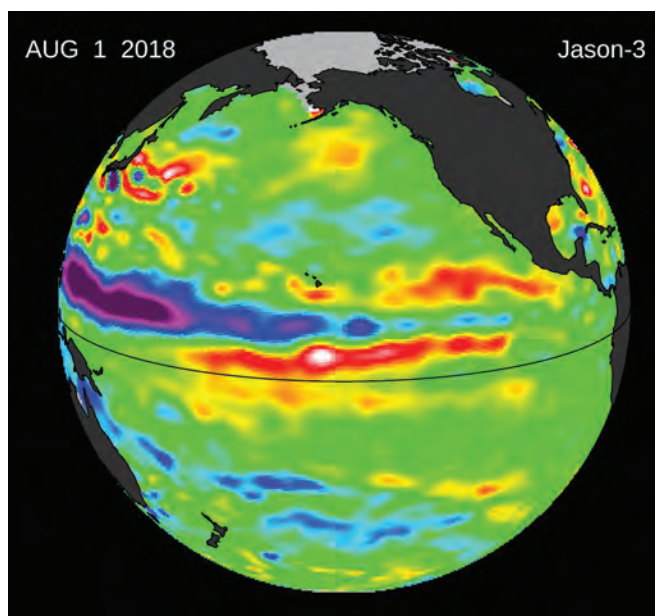
| | |
|------------------------|-------------------------------------------------------------------------------------------------------------|
| Launch date | 01/17/2016 |
| Design lifetime | 5 years |
| Platform owner | NASA, CNES |
| Altitude | 1,336 km |
| Orbit period | 112.38 min |
| Inclination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

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) ($\lambda = 5.66$ centimeters [cm]) and Ku-band at 13.575 GHz ($\lambda = 2.21$ cm).



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



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

Jilin-1 Gaofen-02 Satellites

China
Commercial
Operational



Platform Overview

Jilin-1 Gaofen- (GF-) 02 are high-resolution multispectral satellites launched starting in 2019 on Kuaizhou-1A rocket by China for Earth resources monitoring. They are the new generation optical satellites developed by Chang Guang Satellite Technology Company, Ltd. 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-02D | Jilin-1 GF-02F |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|
| Launch date | 11/13/2019 | 12/07/2019 | 09/27/2021 | 10/27/2021 |
| Design lifetime | 3+ years | | | |
| Platform owner | Chang Guang Satellite Technology Company, Ltd. | | | |
| Altitude | 572 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 | | | |

Sensor Information

| | Jilin-1 GF-02 imager |
|-----------------------|-------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.75/3 |
| Swath (km) | 40 |
| 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 | 0.75 | | | | | | | | | | | | | | | |
| Blue | 0.450 | 0.480 | 0.510 | 3 | | | | | | | | | | | | | | | |
| Green | 0.510 | 0.545 | 0.580 | 3 | | | | | | | | | | | | | | | |
| Red | 0.630 | 0.660 | 0.690 | 3 | | | | | | | | | | | | | | | |
| NIR | 0.770 | 0.833 | 0.895 | 3 | | | | | | | | | | | | | | | |

Wavelength, in microns

Jilin-1 Gaofen-03 Satellites

China
Commercial
Operational



Platform Overview

Jilin-1 Gaofen- (GF-) 03 are high-resolution multispectral satellites launched starting in 2019 on Long March rockets by China for Earth resources monitoring. They are the new generation of 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.

As of September 2022, 34 satellites were launched in the Jilin-1 GF-03D series.

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

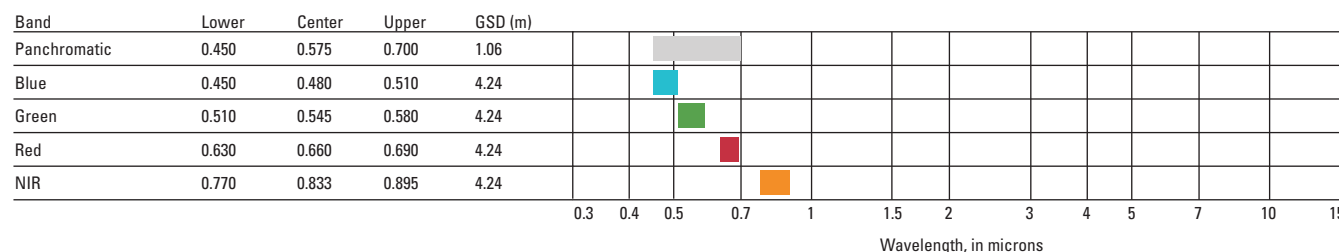
| | Jilin-1 GF-03A | Jilin-1 GF-03B-01 to 06 | Jilin-1 GF-03C-01 to 03 | Jilin-1 GF-03D-01 to 03 |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|
| Launch date | 11/13/2019 | 09/16/2020 | 09/16/2020 | 07/03/2021 |
| Design lifetime | 3+ years | | | |
| Platform owner | Chang Guang Satellite Technology Company, Ltd. | | | |
| Altitude | 572 km | 535 km | | |
| Orbit period | 96.1 min | 95.3 min | | |
| Inclination | 45° | 97.5° | | |
| Crossing time | — | 09:00 DN | | |
| Nadir repeat | — | — | | |
| Status | Operational | | | |
| System website | http://www.charmingglobe.com/EWeb/product_view.aspx?id=677 | | | |

Sensor Information

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

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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Jilin-1 Guangpu Satellites

China
Commercial
Operational/Future



Platform Overview

Jilin-1 Guangpu, or Spectrum 01 and 02, are high-resolution optical satellites launched in 2019 on a CZ-11 rocket from the Jiuquan Satellite Launch Center in China 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 |

Sensor Information

| | Shiyun-1 |
|--------------------|-------------------------------------------------------------------------------------------------------|
| GSD (m) | 5/100 |
| Swath (km) | 110 |
| Revisit | 2–3 |
| Data portal | http://mall.charmingglobe.com/dataShow.html |

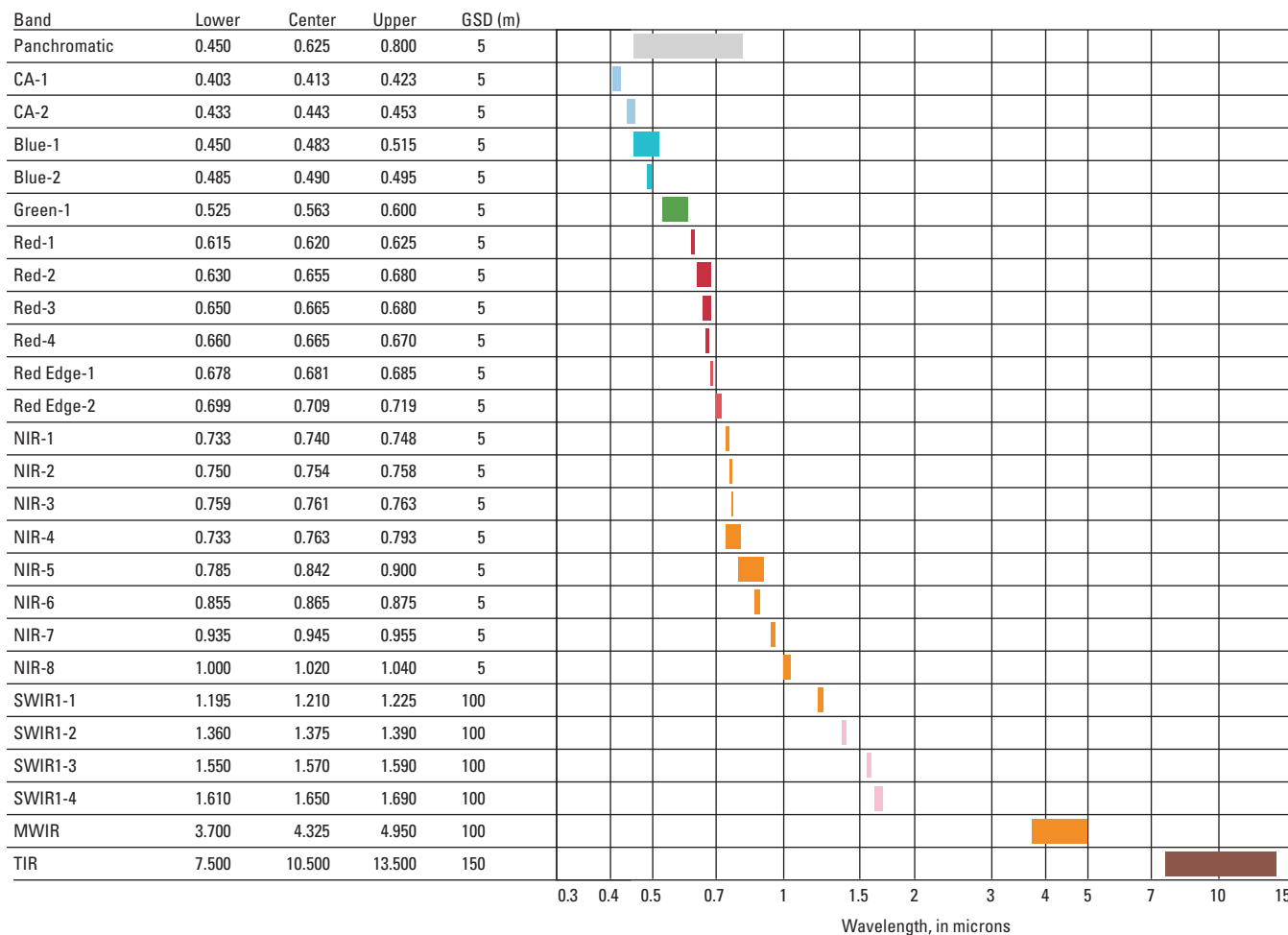
Jilin-1 Guangpu Satellites— Continued

China
Commercial
Operational/Future



Shiyun 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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Jilin-1 Guangxe-A Satellite

China
Commercial
Operational/Future



Platform Overview

Jilin-1 Guangxe-A (GX-A), or Optical A, is the first high-resolution multispectral satellite in the Jilin-1 GX series launched by China in 2015 aboard the CZ-2D rocket from the Jiuquan Satellite Launch Center in China 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]

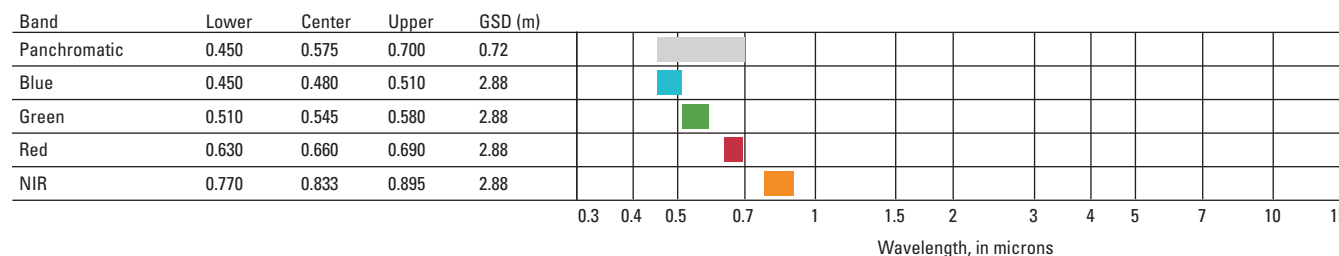
| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 10/07/2015 |
| Design lifetime | 3 years |
| Platform owner | Chang Guang Satellite Technology Company, Ltd. |
| Altitude | 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 |

Sensor Information

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

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.



Jilin-1 Kuanfu Satellites

China
Commercial
Operational/Future



Platform Overview

Jilin-1 Kuanfu (KF) 01 satellites are high-resolution optical satellites launched in 2020 and 2021 on a Long March-2D rocket from the Taiyuan Satellite Launch Center in China for Earth resources monitoring. The satellites were built by Chang Guang Satellite Technology Company, Ltd., and carry a multispectral imager in the visible and near infrared spectral regions.

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

| | Jilin-1 KF 01A | Jilin-1 KF 01B (Nei Mongol-1) |
|------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------|
| Launch date | 01/15/2020 | 07/03/2021 |
| Design lifetime | 3+ years | |
| Platform owner | Chang Guang Satellite Technology Company, Ltd. | |
| Altitude | 545 km | |
| Orbit period | 95.4 min | |
| Inclination | 97.7° | |
| Crossing time | 09:30 DN | |
| Nadir repeat | — | |
| Status | Operational | |
| System website | http://www.jl1.cn/EWeb/chanpin_view.aspx?id=758 | |

Sensor Information

| | Jilin-1 KF 01 |
|-----------------------|-------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.5/2 |
| Swath (km) | 150 |
| Revisit (days) | 2–3 |
| Data portal | http://mall.charmingglobe.com/dataShow.html |

Jilin-1 KF 01A Imager

The imager on the Jilin-1 KF 01 satellites images the Earth in panchromatic, visible, and near infrared parts of the spectrum at a resolution of 0.5 meter and 2 meters, respectively, with a swath of 150 kilometers.

| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | | | | | |
|--------------|-------|--------|-------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Panchromatic | 0.450 | 0.625 | 0.800 | 0.5 | | | | | | | | | | | | | | | |
| Blue | 0.450 | 0.480 | 0.510 | 2 | | | | | | | | | | | | | | | |
| Green | 0.510 | 0.545 | 0.580 | 2 | | | | | | | | | | | | | | | |
| Red | 0.630 | 0.660 | 0.690 | 2 | | | | | | | | | | | | | | | |
| NIR | 0.770 | 0.833 | 0.895 | 2 | | | | | | | | | | | | | | | |

0.3 0.4 0.5 0.7 1 1.5 2 3 4 5 7 10 15

Wavelength, in microns

Jilin-1 LQ Satellite

China
Commercial
Operational/Future



Platform Overview

The Jilin-1 LQ or Smart Verification Satellite (SVS) is a high-resolution technology demonstration satellite launched by China 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: —, no data; km, kilometer; min, minute; °, degree; GSD, ground sample distance; m, meter]

| | |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 10/07/2015 |
| Design lifetime | — |
| 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 |

Sensor Information

| | SVS imager |
|-----------------------|-------------------------------------------------------------------------------------------------------|
| GSD (m) | 4.7 |
| Swath (km) | 9.6 |
| Revisit (days) | 3.3 |
| Data portal | http://mall.charmingglobe.com/dataShow.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 |

Wavelength, in microns

Jilin-1 Shipin Satellites

China
Commercial
Operational



Platform Overview

Jilin-1 Shipin, or Video 01/02 and Video 03, satellites are high-resolution video satellites launched in 2015 and 2017, respectively, aboard a Long March rocket from the Jiuquan Satellite Launch Center in China 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 in China 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.

[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 | 11/01/2017 | 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 | | |

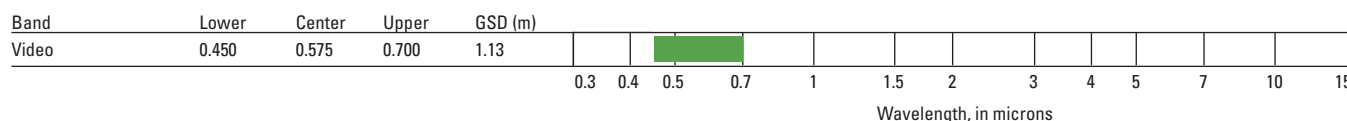
Jilin-1 Shipin Satellites— Continued

China
Commercial
Operational



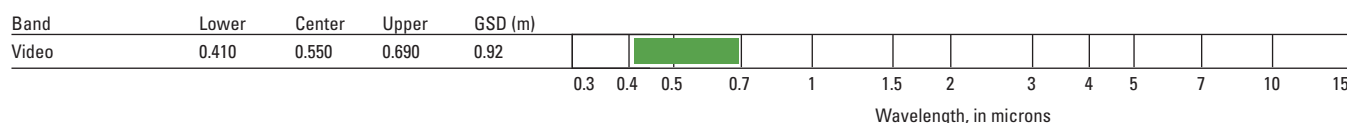
Video 01/02 Camera

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.



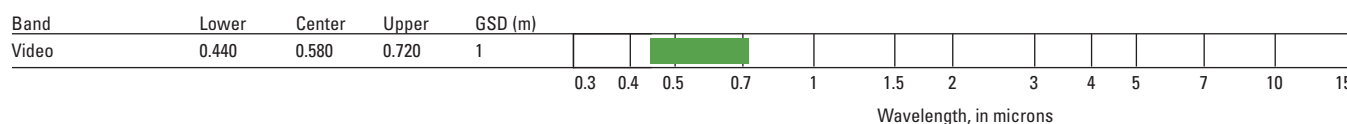
Video 03 Camera

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



Video 04–08 Camera

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



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 infrared; 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 | | | | | | Planned | |
| 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).



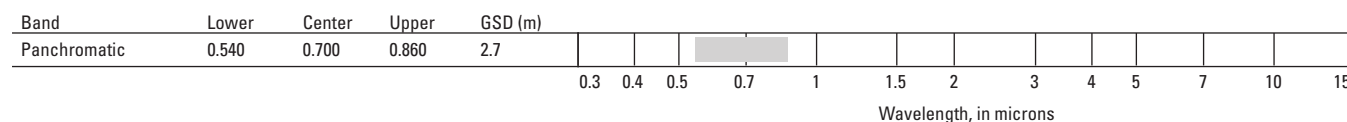
Kanopus-V—Continued

Russia
Civil/Government
Operational/Future



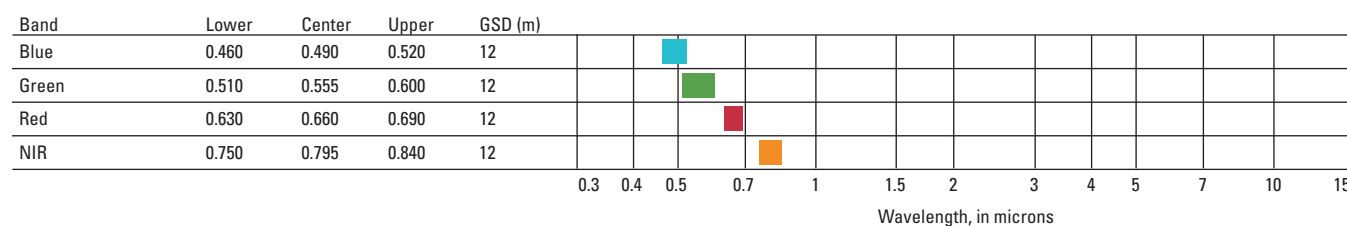
Pan Imager

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.



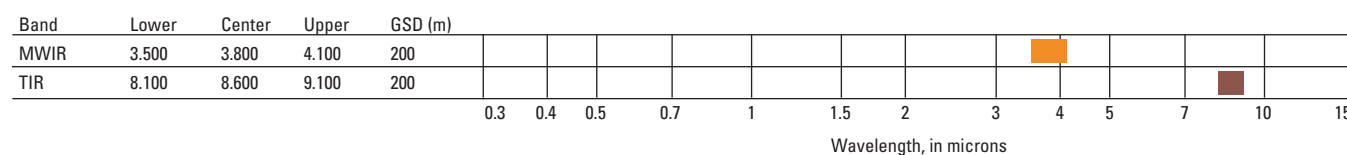
MSS

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



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.



KazEOSat-1

Kazakhstan
Civil/Government
Operational



Platform Overview

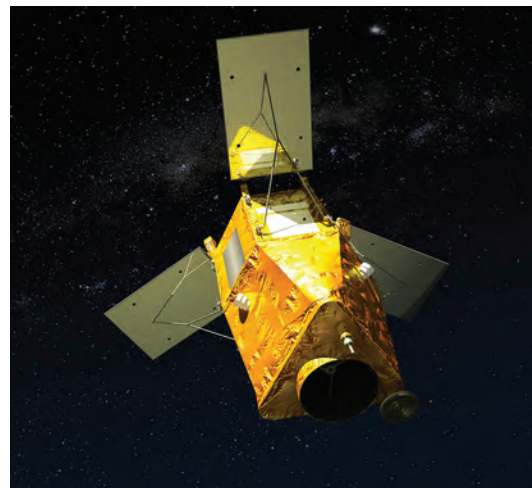
The Kazakhstan Earth Observation Satellite-1 (KazEOSat-1) is a high-resolution multispectral satellite launched in 2014 on a Vega launch vehicle from the Guiana Space Center, French Guiana, for Earth observation. KazEOSat-1 is part of a two-satellite Earth observation system. The Kazakhstan National 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 Defence and Space 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 | — |

Sensor Information

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



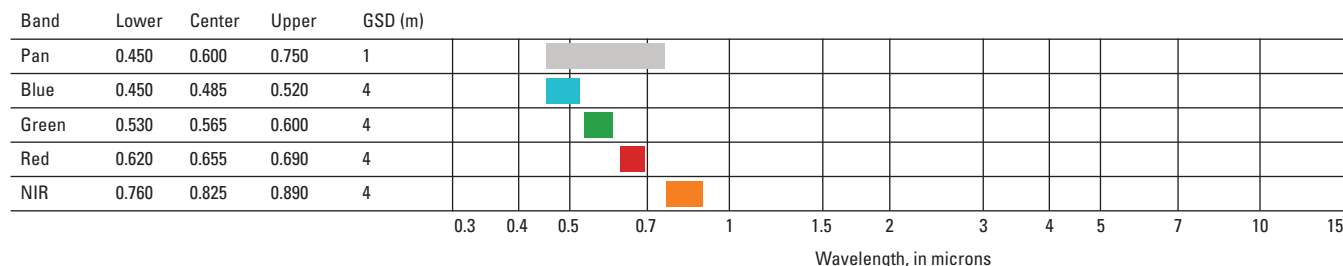
Artistic rendering of KazEOSat-1 (image from Airbus Defence and Space, used with permission).



KazEOSat-1 image of Singapore (image from Airbus Defence and Space, used with permission).

NAOMI

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



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 Yasný 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 Beijing-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]

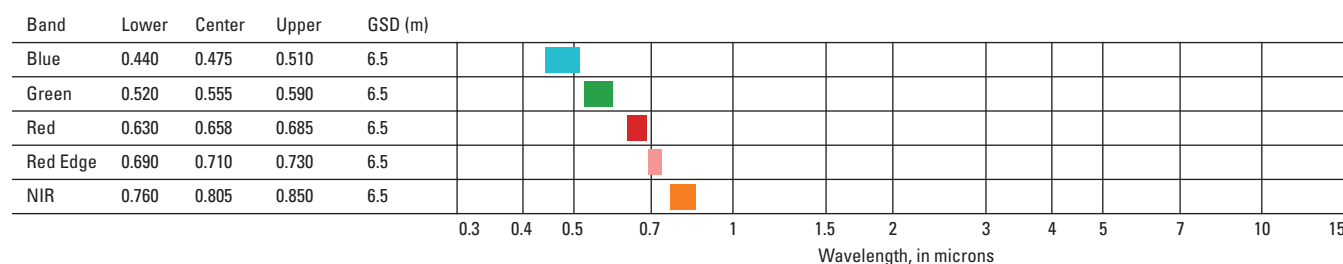
| | |
|------------------------|-------------|
| Launch date | 06/19/2014 |
| Design lifetime | 7 years |
| Platform owner | Kazcosmos |
| Altitude | 630 km |
| Orbit period | 97.31 min |
| Inclination | 98° |
| Crossing time | 10:30 AN |
| Nadir repeat | — |
| Status | Operational |
| System website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

Sensor Information

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

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.



KhalifaSat

United Arab Emirates
Civil/Government
Operational

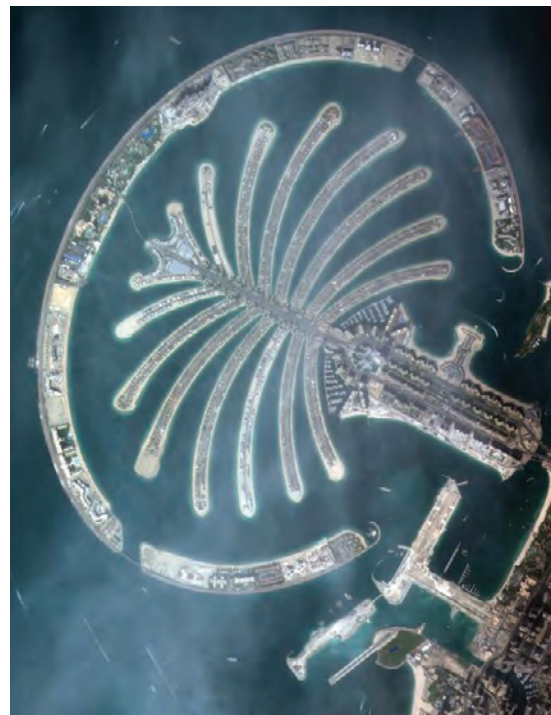


Platform Overview

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 Rashid 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/ |



Sensor Information

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

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

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 | | | | | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | |
| | | | | | Wavelength, in microns | | | | | | | | | | | | | | |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

Kompsat-3

South Korea
Civil/Government
Operational



Platform Overview

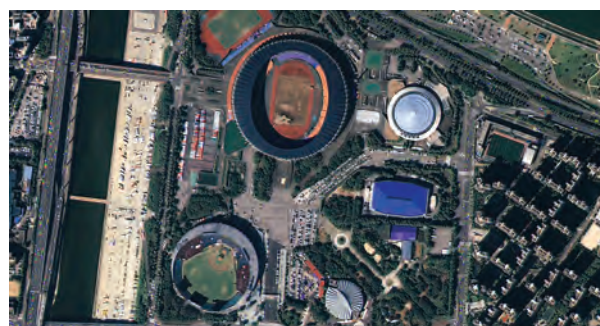
Kompsat-3 is a high-resolution multispectral satellite launched in 2012 by the Republic of Korea on the H-IIA launch vehicle from Tanegashima Space Center of the Japan Aerospace Exploration Agency for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since 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 South Korea with submeter resolution. Kompsat-3 carries the Advanced Earth Imaging Sensor System (AEISS) 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]

| | |
|------------------------|---------------------------------------------------------------------------------------------------|
| Launch date | 05/18/2012 |
| 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 |



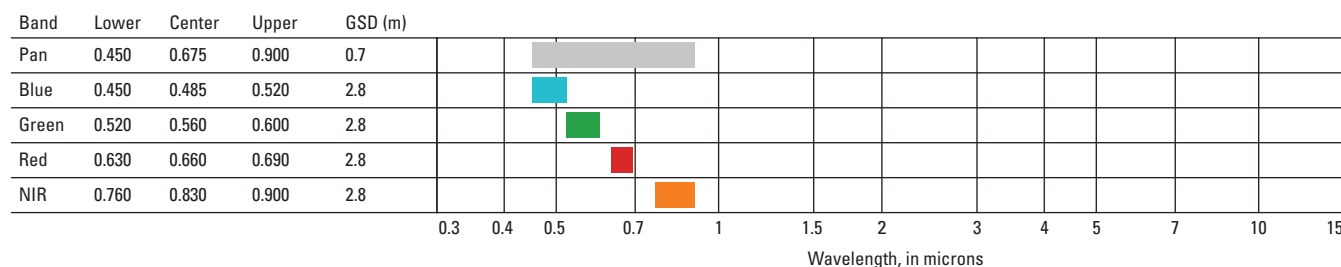
Artistic rendering of Kompsat-3 in orbit (image from KARI, used with permission).



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

AEISS

The AEISS is a pushbroom-style imager designed by KARI with support from European Aeronautics Defense and Space Astrium.



Sensor Information

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

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]

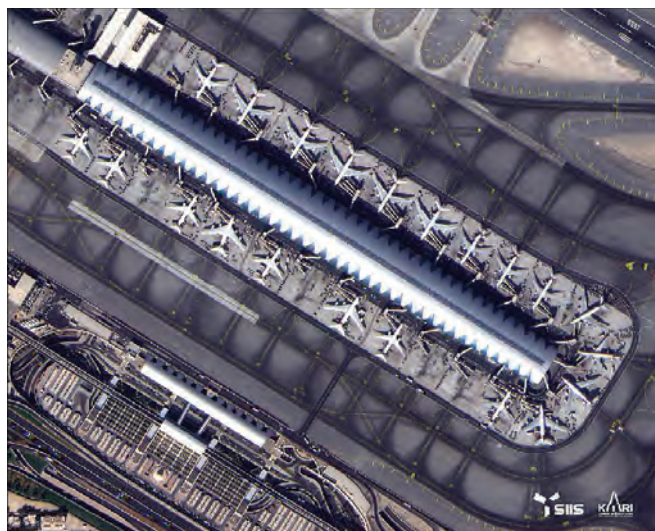
| | |
|-----------------|---------------------------------------------------------------------------------------------------|
| Launch date | 03/25/2015 |
| Design lifetime | 4 years |
| Platform owner | KARI |
| Altitude | 528 km |
| Orbit period | 95.21 min |
| Inclination | 97.51° |
| Crossing time | 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).

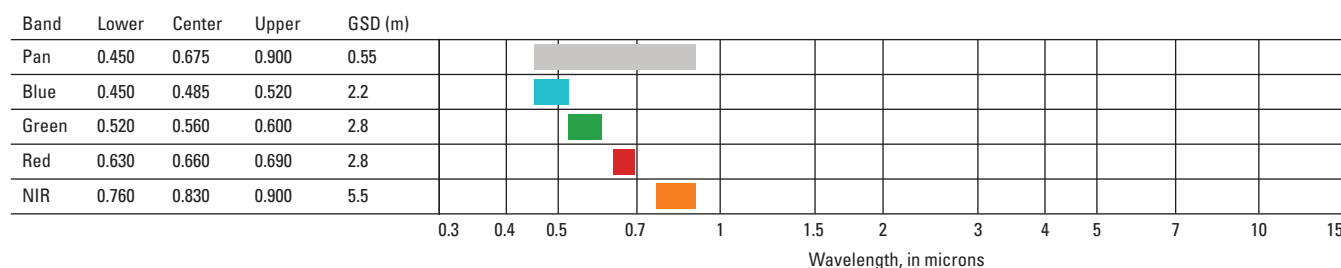
Kompsat-3A—Continued

South Korea
Civil/Government
Operational



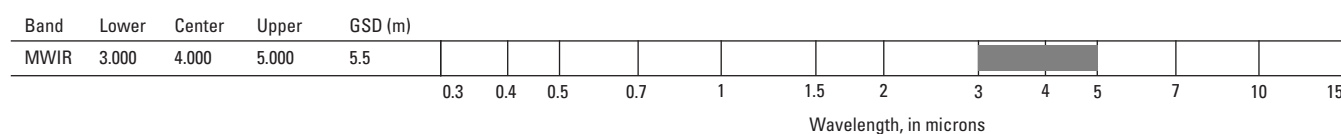
AEISS-A

The AEISS-A is a design from KARI built with support from European Aeronautics Defense and Space Astrium on the heritage of AEISS.



IIS

The Infrared Imaging System (IIS) on Kompsat-3A was built by AIM Infrarot-Module GmbH (AIM) in Heilbronn, Germany.



Kompsat-5

South Korea
Civil/Government
Operational



Platform Overview

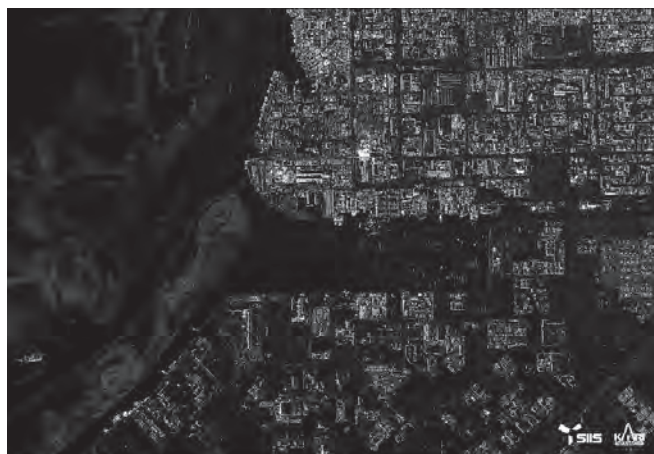
Kompsat-5 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2013 by the Republic of Korea on a Dnepr-1 vehicle from the Dombrovsky launch site in Russia for Earth resources monitoring. This mission continues the Kompsat series that has been in operation since the launch of Kompsat-1 in 1999. Kompsat-5 is also called a Geographic information system, 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 South Korea. Kompsat-5 carries the Core 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).

COSI

The COSI is a design by Thales Alenia Space for KARI. It provides high-resolution imagery in X-band at 9.66 gigahertz ($\lambda = 3.1$ centimeters). The angle of incidence is 20–55 degrees.

Sensor Information

| | COSI |
|--------------------|--------------------|
| GSD (m) | 1–20 (selectable) |
| Swath (km) | 5–100 (selectable) |
| Data portal | — |

| 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

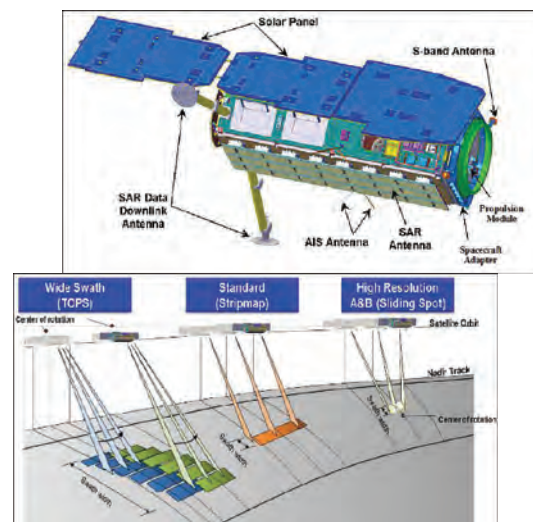


Platform Overview

Kompsat-6 is an all-weather, high-resolution synthetic aperture radar (SAR) satellite scheduled for launch in 2022 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 South 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 | 2022 (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 | Planned |
| 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 Defence and Space 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 | | |

Kompsat-7

South Korea
Civil/Government
Future



Platform Overview

Kompsat-7 is a high-resolution multispectral satellite scheduled for launch in 2022 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 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]

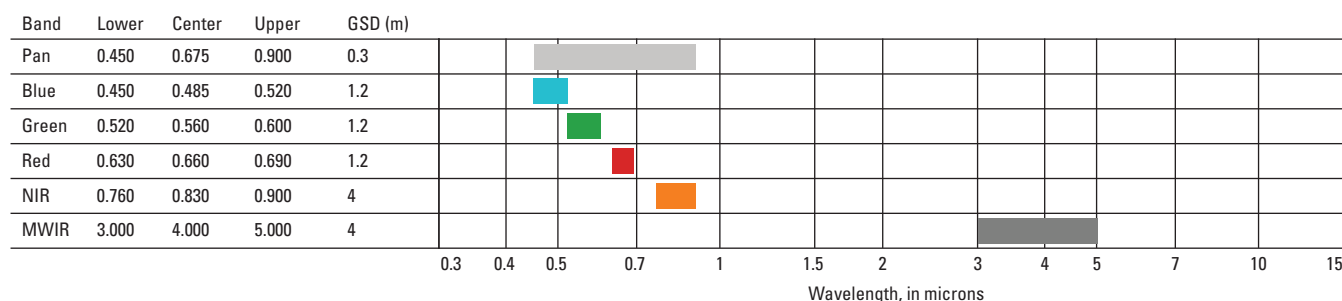
| | |
|------------------------|---------------------------------------------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | 5 years |
| Platform owner | KARI |
| Altitude | 685 km |
| Orbit period | 98.5 min |
| Inclination | 98.1° |
| Crossing 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 | — |

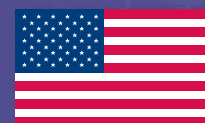
AEISS-HR

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.



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. Landmapper-BC 5 was launched in 2020. 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.

[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 | Landmapper-BC 5 |
|-----------------|---------------------------------------------------------------------------|-----------------|-----------------|
| Launch date | 01/12/2018 | 12/03/2018 | 11/20/2020 |
| Design lifetime | 5 years | | |
| Platform owner | Astro Digital, Inc. | | |
| Altitude | 500 km | 590 km | 500 km |
| Orbit period | 94.8 min | 96.3 min | 94.8 min |
| Inclination | 97.4° | 97.7° | 97.4° |
| Crossing time | 10:00 DN | 10:00 DN | 10:00 DN |
| Nadir repeat | — | — | — |
| Status | Operational | | |
| System website | https://www.astrodigital.com/ | | |



Artistic rendering of Landmapper-BC satellite (image from Astro Digital, used with permission).

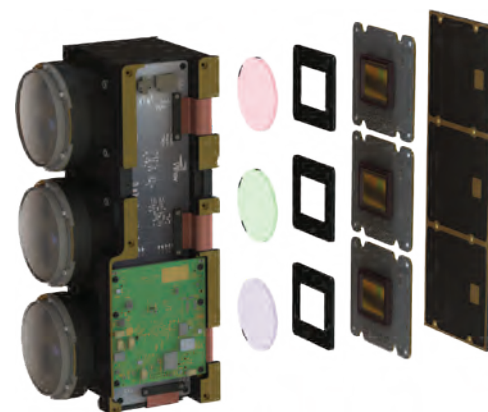


Image of Landmapper-BC imager (image from Astro Digital, used with permission).

Sensor Information

| | Landmapper-BC Imager |
|-------------|-----------------------------------------------------------------------------------|
| GSD (m) | 22 |
| Swath (km) | 220 |
| Data portal | https://www.astrodigital.com/api/ |

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 | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 |
| | | | | | Wavelength, in microns | | | | | | | | | |

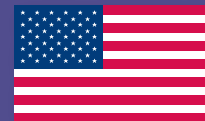
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Landsat 7

United States
Civil/Government
Standby



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 in California 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. On April 6, 2022, Landsat 7's ETM+ was placed in a standby mode to lower the satellite's altitude by 8 kilometers. The data acquired by Landsat 7 in the lower orbit will be accessed for quality and usability. In the lower orbit, Landsat 7 will be available for servicing by NASA's On-Orbit Servicing, Assembly, and Manufacturing-1 (OSAM-1) mission.

[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 | 697 km |
| Orbit period | 98.6 min |
| Inclination | 97.9° |
| Crossing time | 08:50 DN |
| Nadir repeat | 16 days |
| Status | Standby |
| System website | https://www.usgs.gov/landsat-missions/landsat-7 |

Sensor Information

| | ETM+ |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 15, 30, 60 |
| Swath (km) | 185 |
| Data portal | https://earthexplorer.usgs.gov/ ; https://glovis.usgs.gov/app |



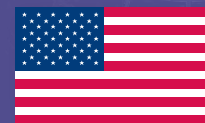
Artistic rendering of Landsat 7 in orbit (image from NASA).



Landsat 7 imagery of Seattle, Washington (image from NASA).

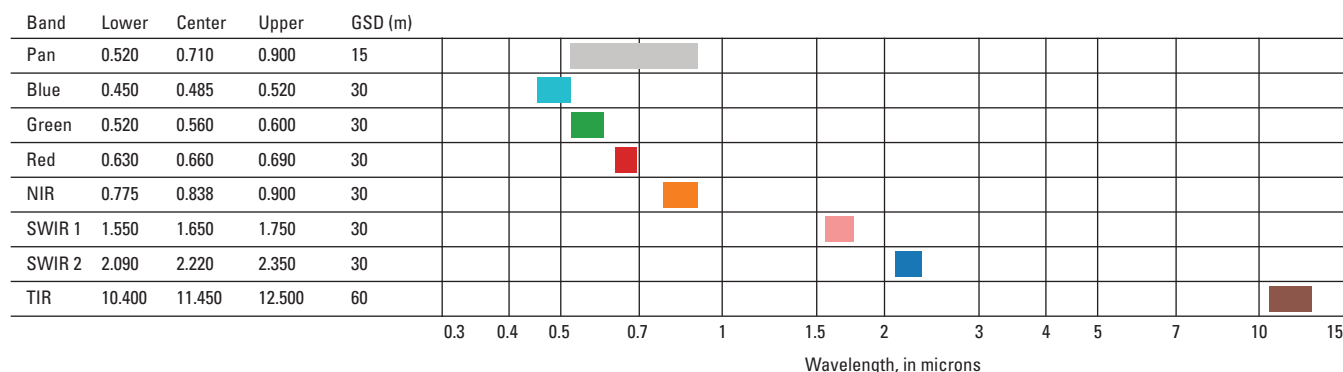
Landsat 7—Continued

United States
Civil/Government
Operational



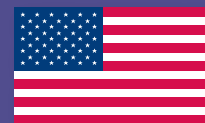
ETM+

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.



Landsat 8 and 9

United States
Civil/Government
Operational



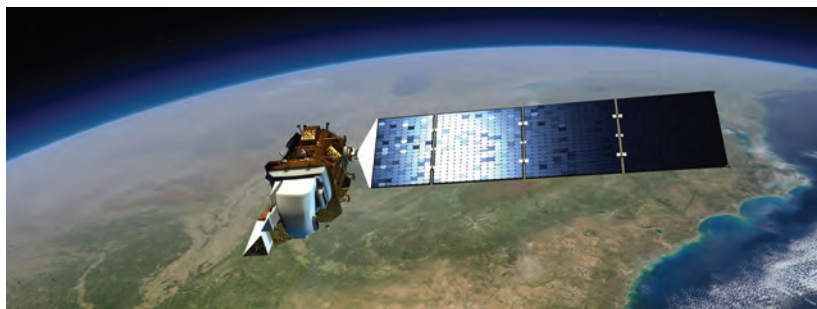
Platform Overview

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, was joined by Landsat 9 with its launch in September 2021. Together they 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 U.S. 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 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, shortwave infrared; TIR, thermal infrared]



Artistic rendering of Landsat 8 in orbit (image from NASA).

| | Landsat 8 | Landsat 9 |
|-----------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Launch date | 02/11/2013 | 09/27/2021 |
| 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 | |
| System website | https://www.usgs.gov/landsat-missions/landsat-8 | https://www.usgs.gov/landsat-missions/landsat-9 |



Landsat 8 OLI image of Netherlands 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 |

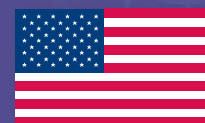
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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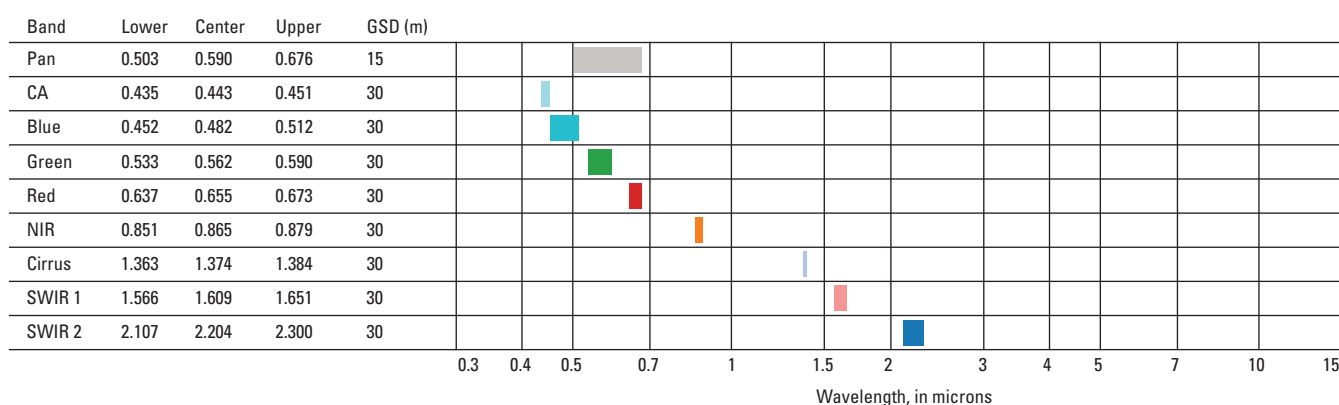
Landsat 8 and 9—Continued

United States
Civil/Government
Operational



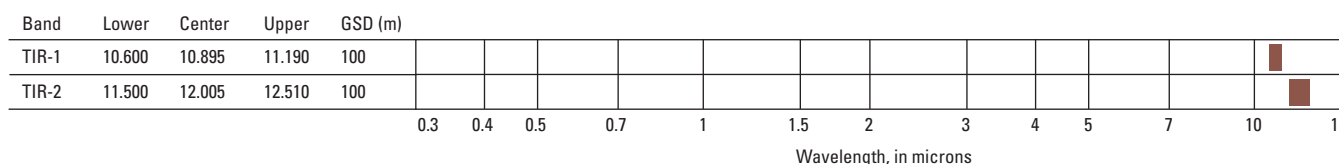
OLI

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 Enhanced Thematic Mapper Plus sensor on Landsat 7. The 185-kilometer swath width is maintained from previous Landsat Thematic Mapper and Enhanced Thematic Mapper Plus 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 increased to 14 bits with Landsat 9. OLI data are freely available.



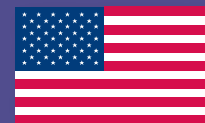
TIRS

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 carries a second-generation TIRS instrument of similar specifications and enhanced reliability. The 12-bit radiometric resolution of Landsat 8 is increased to 14 bits with Landsat 9. TIRS data are freely available.



Landsat Next

United States
Civil/Government
Future



Platform Overview

Landsat Next (LNext) is a medium-resolution multi-spectral satellite mission, currently in its early phase and planned to continue the legacy of Landsat satellites. The goal for LNext is to measure as many as 25 spectral bands to unlock new applications. The mission is planned for launch in 2029.

[Abbreviations in table: NASA, National Aeronautics and Space Administration; USGS, U.S. Geological Survey; —, no data]

| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2029 (Planned) |
| Design lifetime | 5 years |
| Platform owner | NASA, USGS |
| Altitude | — |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Planned |
| System website | https://landsat.gsfc.nasa.gov/satellites/landsat-next/ |

Multispectral Imager

Detailed information on the sensor is not currently (2022) available.

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 2023, 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 thought to be similar to Planet Scope 1, flown on Planet's Dove satellites.

[Abbreviations in table: —, no data; km, kilometer; min, minute; °, degree]

| | |
|------------------------|---------------------------------------------------------------------------|
| 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/ |

LSTM

European Space Agency
Civil/Government
Future

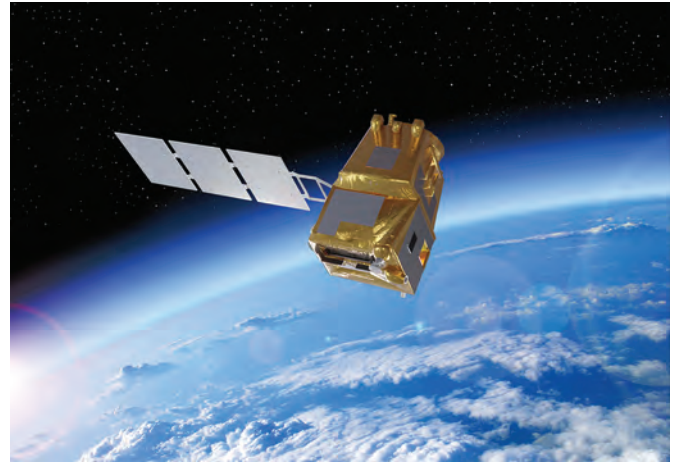


Platform Overview

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; MSS, multispectral imager; GSD, ground sample distance; m, meter; —, no data]

| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 | 4 days |
| Status | Development |
| System website | https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates |



Artistic rendering of LSTM satellite in orbit (image from Airbus Defence and Space, used with permission).

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 in Russia. 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 | 2023 |
| 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/ | | |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

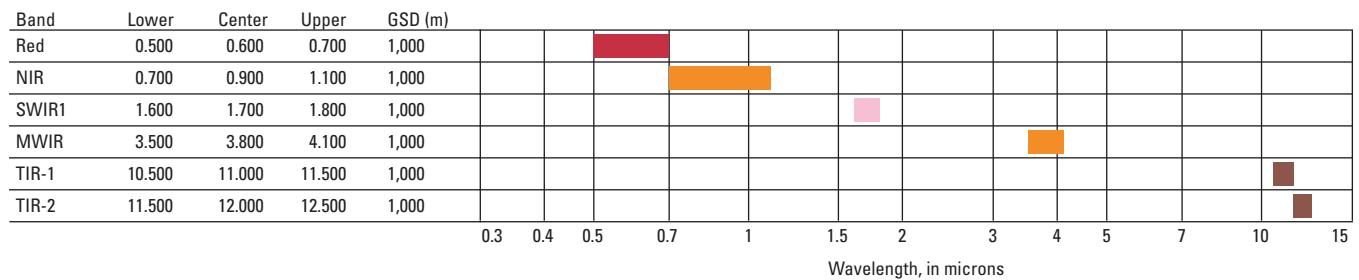
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Meteor-M—Continued

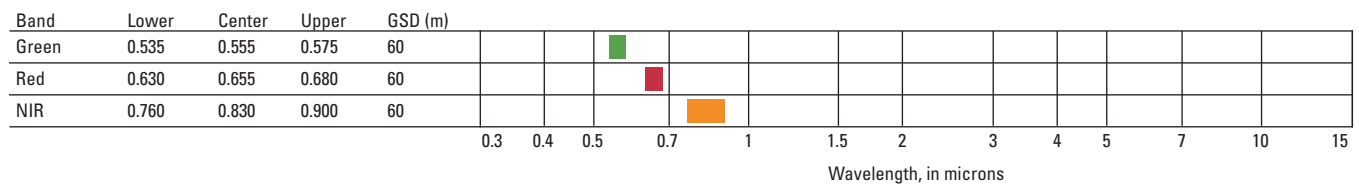
Russia
Civil/Government
Operational/Future



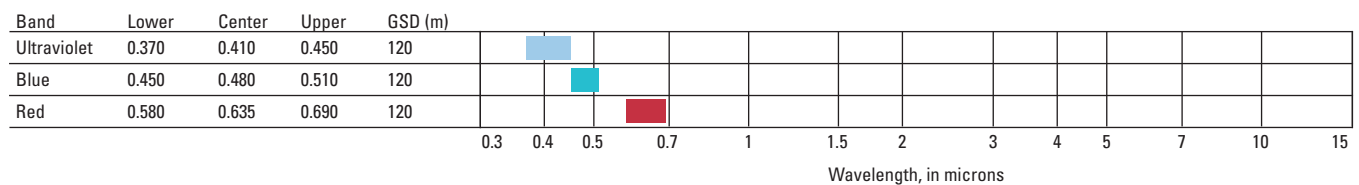
Low-Resolution Multispectral Sensor



Medium-Resolution Multispectral Sensor-50



Medium-Resolution Multispectral Sensor-101/102



Mohammed VI-A and -B

Morocco
Civil/Government
Operational



Platform Overview

Mohammed VI-A and -B are high-resolution, multi-spectral, 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 Defence and Space and use the Astro-Sat-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 | — | |



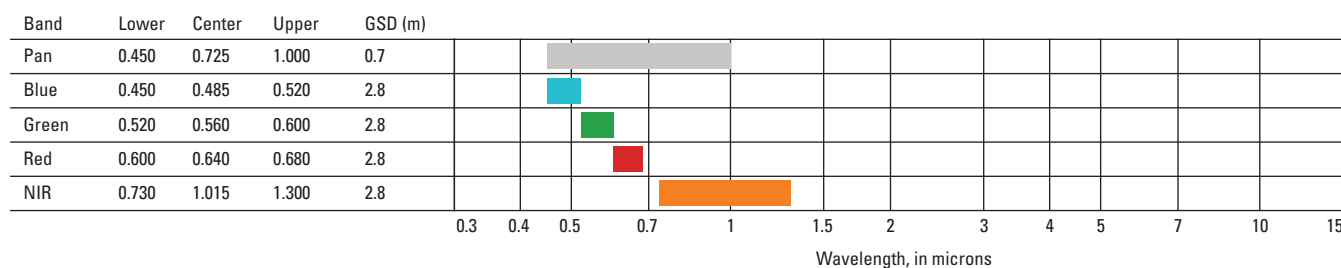
Artistic rendering of Pléiades satellite (identical to Mohammed-VIA satellite) in orbit (image from CNES, used with permission).

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 Pléiades HiRI heritage.



NewSat-1 to -31

Argentina
Commercial
Operational/Future



Platform Overview

The Aleph-1 constellation of NewSat satellites consists of multiresolution multispectral satellites for commercial Earth imaging. As of May 2022, 31 satellites were launched.

The NewSat satellites are developed, built, and operated by Satellogic, headquartered in Buenos Aires, Argentina. The satellites carry the Multispectral Imager (MSI) for high-resolution land imaging and the Hyperspectral Imager (HSI) 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; Hyper, hyperspectral]

| | N-1 | N-2 | N-3 | N-4 | N-5 | N-6 | N-7 | N-8 | N-9-18 | N-19-22 | N-23-27 | N-28-31 |
|------------------------|-----------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|---------|---------|---------|
| Launch date | 05/30/2016 | 06/15/2017 | 02/02/2018 | 09/03/2020 | 01/15/2020 | 11/06/2020 | 06/30/2021 | 04/01/2022 | 05/24/2022 | | | |
| 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

| | MSI | HSI |
|--------------------|-----------------------------------------------------------------------|-----|
| GSD (m) | 1 | 30 |
| Swath (km) | 5 | 150 |
| Data portal | https://www.satellogic.com/ | |



Artistic rendering of a NewSat in orbit (image from Satellogic, used with permission).

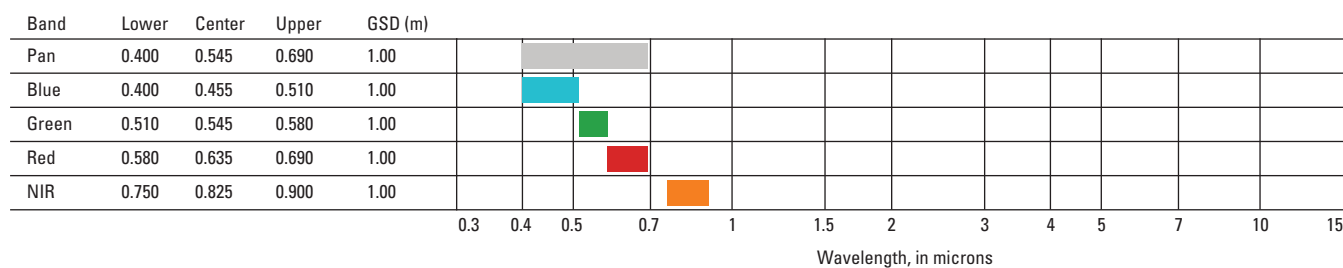
NewSat-1 to -31—Continued

Argentina
Commercial
Operational/Future



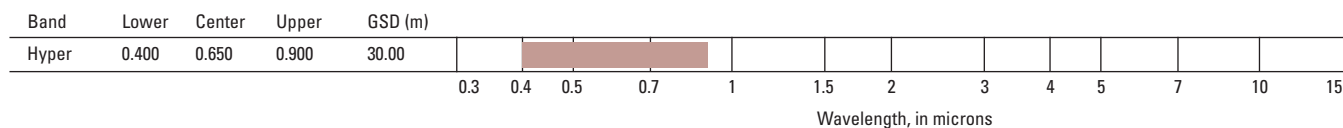
MSI

MSI data are commercially available from Satellogic.



HSI

HSI data are commercially available from Satellogic.



NigeriaSat-2

Nigeria
Civil/Government
Operational



Platform Overview

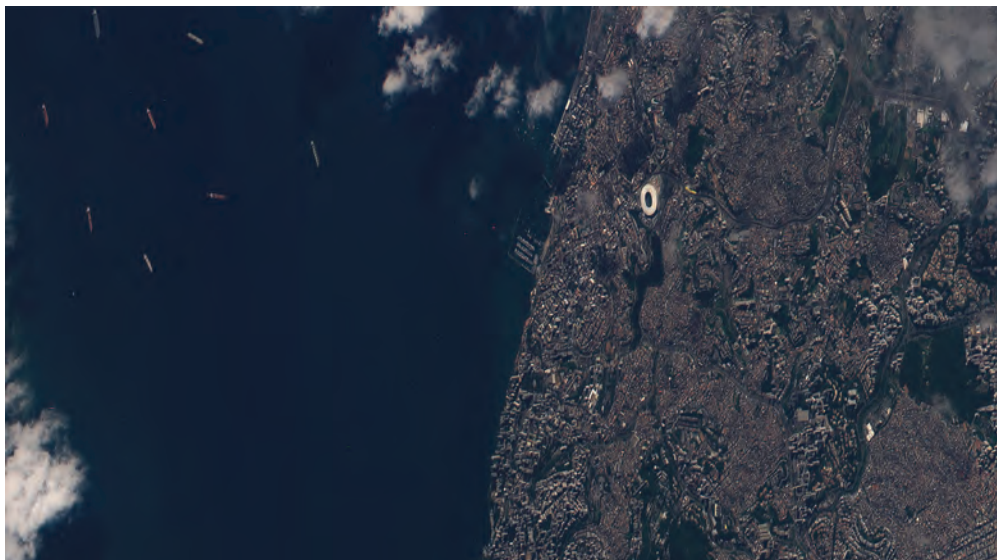
NigeriaSat-2 is a high-resolution, multispectral, and panchromatic imaging minisatellite launched alongside NigeriaSat-X in 2011 on a Dnepr-1 launch vehicle for Earth observation and disaster monitoring. NigeriaSat-2 is based on the newly developed SSTL-300 bus. The Nigerian National Space Research and 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;
—, no data; 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 | — | |



Salvador, State of Bahia, Brazil—NigeriaSat-2 satellite (image from NASRDA, 2014, all rights reserved, supplied by DMCii, used with permission).

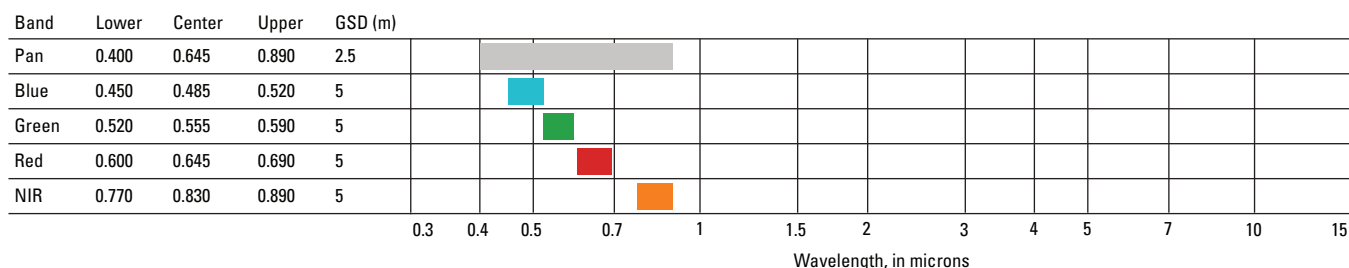
NigeriaSat-2—Continued

Nigeria
Civil/Government
Operational



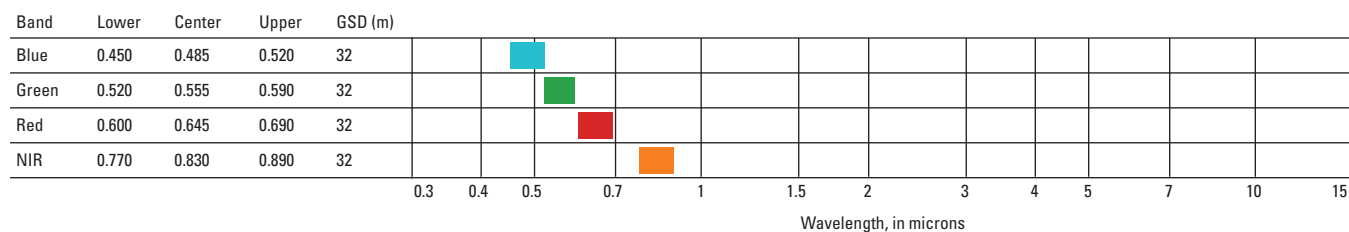
VHRI

The VHRI was built by SSTL and is of CMT (China Mapping Telescope flown on Beijing-1) heritage. The VHRI is essentially a scaled-up version of CMT, giving it a wider aperture. The VHRI data are commercially available.



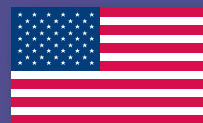
MRI

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.



NISAR

United States, India
Civil/Government
Future

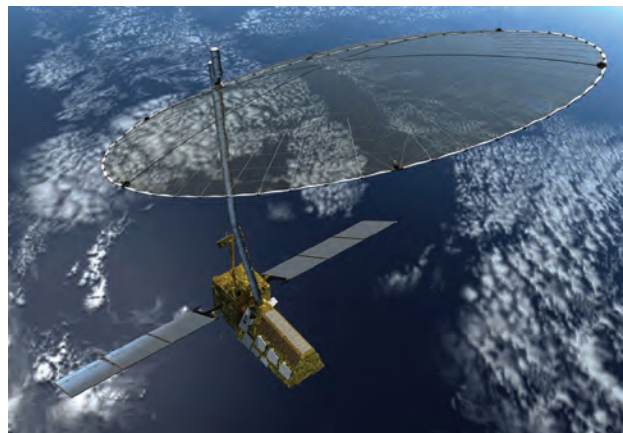


Platform Overview

The National Aeronautics and Space Administration/ Indian Space Research Organization (NASA/ISRO) Synthetic Aperture Radar satellite (NISAR) is planned to be launched in 2023 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; —, no data; H, horizontal; V, vertical]

| | |
|------------------------|-----------------------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 3 years |
| Platform owner | NASA/ISRO |
| 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 use 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) ($\lambda = 23.85$ centimeters [cm]). The S-band instrument operates at 3.2 GHz ($\lambda = 9.37$ cm). The angle of incidence for both instruments is 33–47 degrees. Data will be freely available.

| Beam mode | Polarization | | Nominal swath width (km) | Approximate resolution (m) |
|-----------|--------------|--------------|--------------------------|---------------------------------|
| S-band | Single | HH, VV | 240 | Azimuth: 7 Slant range: 3–24 |
| | Dual | HH/HV, VV/VH | | |
| | Compact | RH/RV | | |
| | Quasi-Quad | HH/HV, VH/VV | | |
| L-band | Single | HH, VV | 240 | Azimuth: 7 Slant range: 3–48 |
| | Dual | HH/HV, VV/VH | | |
| | Compact | RH/RV | | |
| | Quad | HH/HV/VH/VV | | |

NovaSAR-1

United Kingdom
Commercial
Operational



Platform Overview

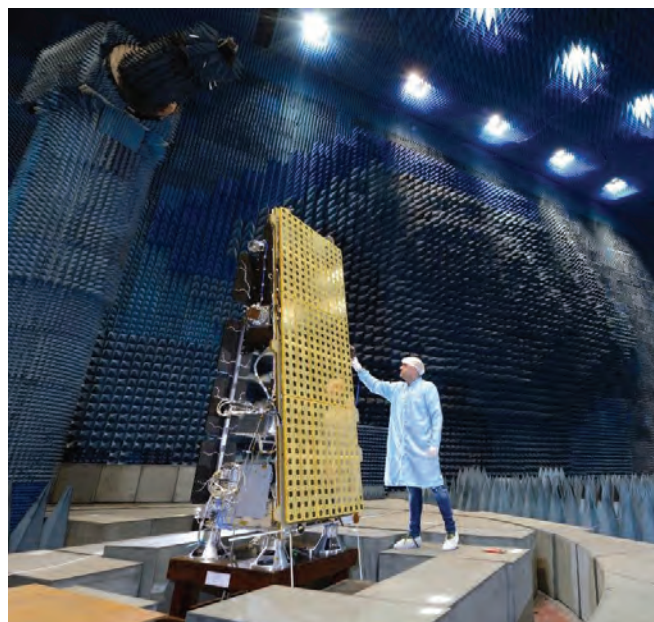
NovaSAR-1 is a medium-resolution synthetic aperture radar (SAR) satellite launched in 2018 on the Indian Space Research Organization's Polar Satellite Launch Vehicle by the United Kingdom. It operates with the Vision-1 (SSTL-S4) satellite for Opti-SAR applications. The satellite was developed through a partnership by the United Kingdom Space Agency, Australia's Commonwealth Scientific and Industrial Research Organisation, the Indian Space Research Organization, the Republic of the Philippines Department of Science and Technology-Advanced Science and Technology Institute, and Space-Eyes, LLC. It carries an S-band SAR and operates in four imaging modes.



A SAR mosaic image of the United Kingdom, acquired by NovaSAR-1, December 2021 (image from Surrey Satellite Technology Ltd./Airbus Defence and Space/United Kingdom Space Agency).

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

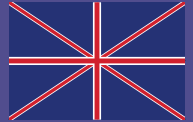
| | NovaSAR-1 |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 09/16/2018 |
| Design lifetime | 7 years |
| Platform owner | United Kingdom Space Agency |
| Altitude | 583 km |
| Orbit period | 96.2 min |
| Inclination | 97.5° |
| Crossing time | 10:30 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | https://www.sstl.co.uk/space-portfolio/launched-missions/2010-2019/novasat-1-launched-2018 |



A model of the NovaSAR-1 satellite (image from Surrey Satellite Technology Ltd./Airbus Defence and Space/United Kingdom Space Agency).

NovaSAR-1—Continued

United Kingdom
Commercial
Operational



Sensor Information

| Beam mode | Polarization | | Swath | Azimuth resolution (m) |
|---------------------|--------------|----------------|-------|------------------------|
| Maritime | Single | HH, VV, VH, HV | 400 | 6 |
| ScanSAR | Single | HH, VV, VH, HV | 100 | 20 |
| ScanSAR wide | Single | HH, VV, VH, HV | 140 | 30 |
| Stripmap | Single | HH, VV, VH, HV | 20 | 6 |

S-Band SAR

The S-band SAR payload was developed collaboratively by Airbus Defence and Space, the United Kingdom Space Agency, and Surrey Satellite Technology Ltd. It operates in four imaging modes, ScanSAR, Maritime, Stripmap, and ScanSAR wide modes.

OceanSat-2

India
Civil/Government
Operational

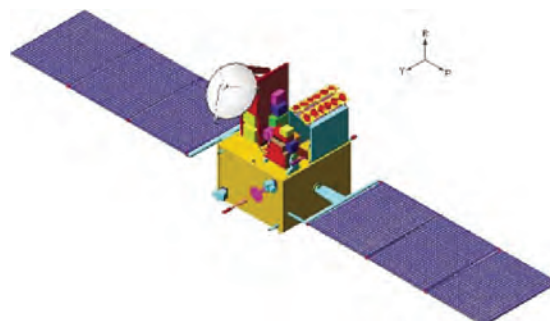


Platform Overview

OceanSat-2 is a low-resolution multispectral satellite launched in 2009 on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center in India 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.

[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/Oceansat_2.html |



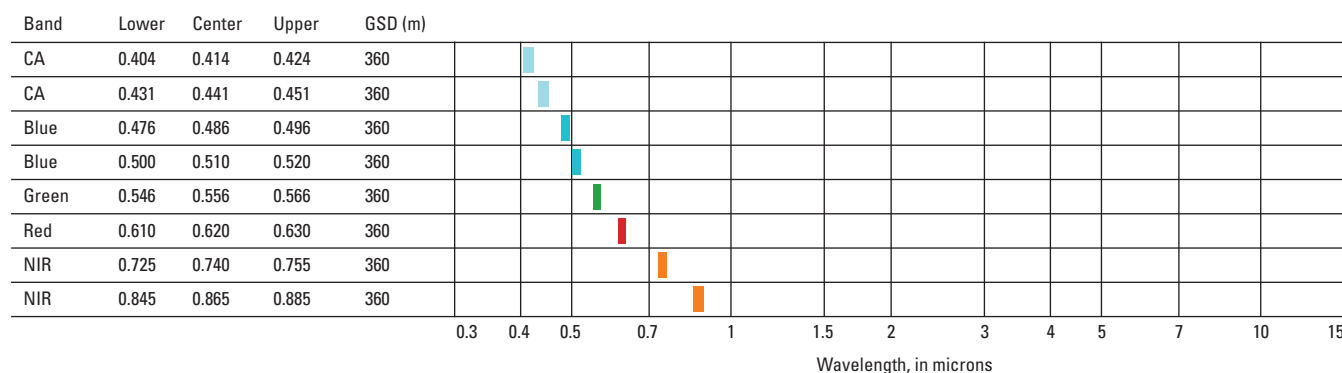
Three-dimensional model of OceanSat-2 (image from ISRO, used with permission).



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 | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

OceanSat-3 and -3A

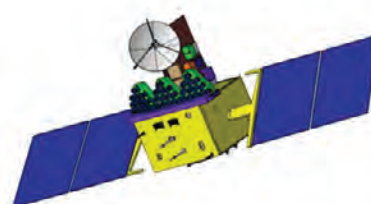
India
Civil/Government
Future



Platform Overview

OceanSat-3 and -3A are low-resolution multispectral satellites planned to be launched in 2022 and 2023, respectively, on Polar Satellite Launch Vehicles from the Satish Dhawan Space Center in India 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.

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



Three-dimensional model of OceanSat-3 (image from ISRO, used with permission).

| | OceanSat-3 | OceanSat-3A |
|------------------------|----------------|----------------|
| Launch date | 2022 (Planned) | 2023 (Planned) |
| Design lifetime | — | — |
| Platform owner | ISRO | |
| Altitude | — | — |
| Orbit period | — | — |
| Inclination | — | — |
| Crossing time | — | — |
| Nadir repeat | — | — |
| Status | Planned | |
| 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 | |

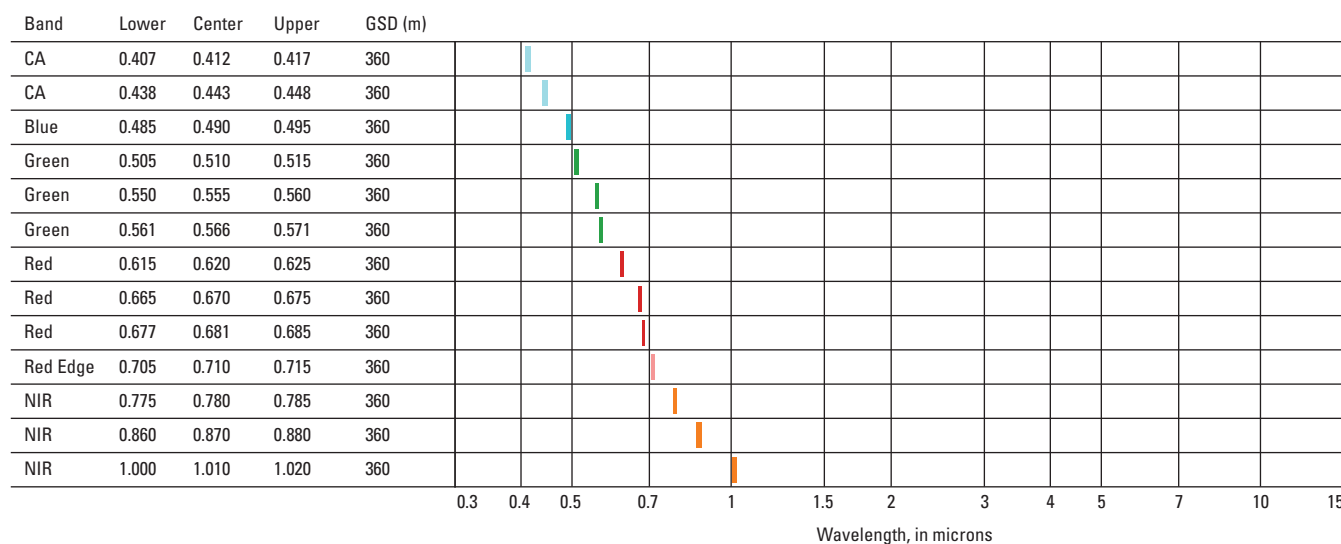
OceanSat-3 and -3A—Continued

India
Civil/Government
Future



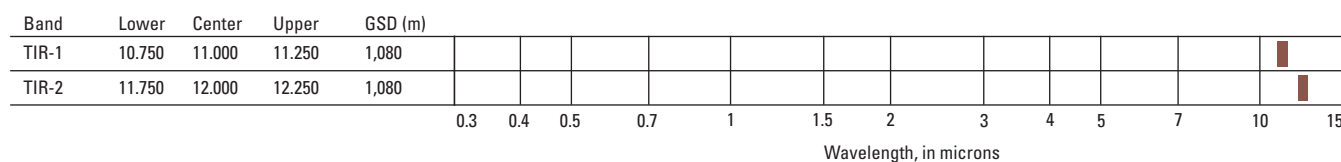
OCM-3

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.



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.



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 in China. 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.

[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 | 5 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 |

China
Commercial
Operational

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

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 in China. 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.

[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 | |

OroraTech Constellation

Germany
Commercial
Operational/Future



Platform Overview

OroraTech-1 is an infrared 3U CubeSat launched as a precursor to the OroraTech constellation on a Falcon 9 rocket in 2022. It is owned and operated by Orbital Oracle Technologies (OroraTech), a German-based startup planning to launch a constellation of 100 satellites for early detection and monitoring of wildfires. The satellites carry an infrared imager for early detection and monitoring of wildfires. The satellites are built on the Spire CubeSat platform and OroraTech's own bus.

[Abbreviations in table: km, kilometer; min, minute; °, degree; DN, descending node]

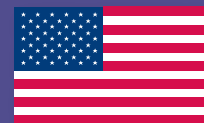
| | OroraTech-1 |
|------------------------|-----------------------------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | 01/13/2022 |
| Platform owner | 2 years |
| Altitude | OroraTech |
| Orbit period | 530 km |
| Inclination | 95.2 min |
| Crossing time | 97.5° |
| Nadir repeat | 10:30 DN |
| Status | Planned |
| System website | https://ororatech.com/technology/ |

Thermal Infrared Imager

Details are currently (2022) not available.

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 2024 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; NIR, near infrared; SWIR, shortwave infrared]

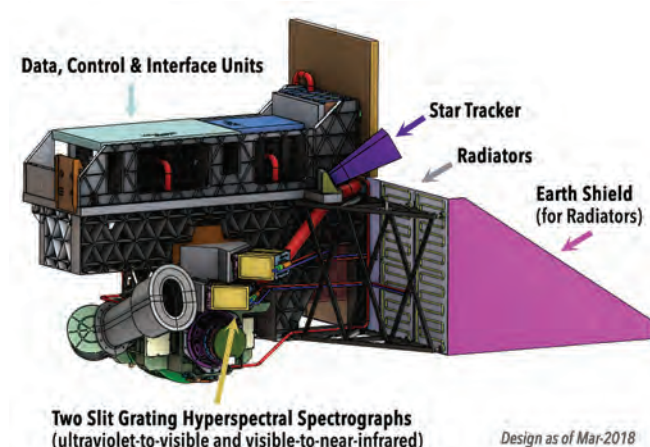
| | |
|------------------------|-------------------------------------------------------------------------------|
| Launch date | 2024 (Planned) |
| Design lifetime | 3 years |
| Platform owner | NASA |
| Altitude | 676.5 km |
| Orbit period | 98 min |
| Inclination | 98° |
| Crossing time | 13:00 AN |
| Nadir repeat | 11 days |
| Status | Development |
| System website | https://pace.oceansciences.org/ |

Sensor Information

| | OCI |
|--------------------|--------------|
| GSD (m) | 1,000, 4,000 |
| Swath (km) | 2,000 |
| Data portal | — |



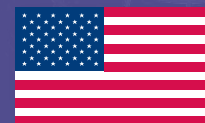
Artistic rendering of The Plankton, Aerosol, Cloud, ocean Ecosystem satellite (PACE) in orbit (image from NASA).



Artistic rendering of the Ocean Color Instrument (image from NASA).

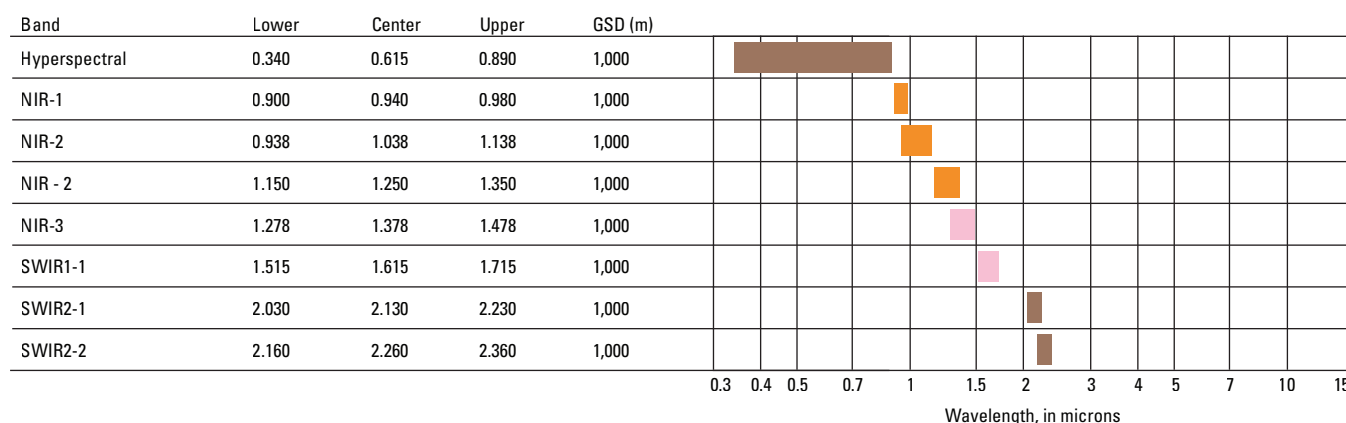
PACE—Continued

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.



PAZ

Spain
Civil/Commercial
Operational

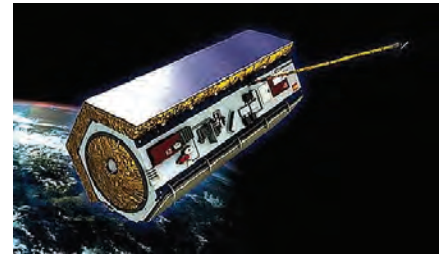


Platform Overview

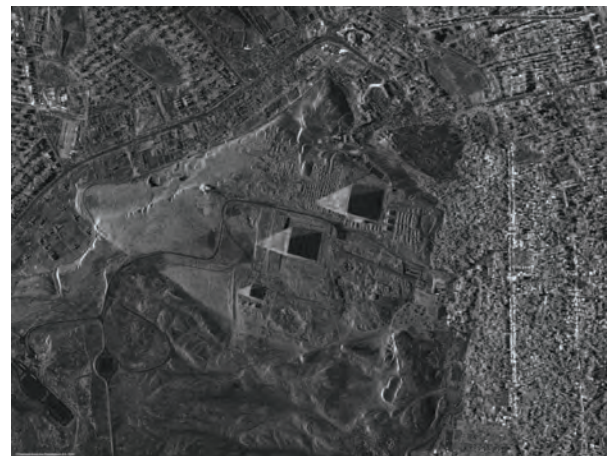
The PAZ (Spanish for “peace”) satellite, launched on February 22, 2018, is owned and operated by Hisdesat. PAZ operates in the same orbit of the twin satellites TerraSAR-X and TanDEM-X, and the three satellites work together as a constellation. PAZ flies in a polar dawn-dusk Sun-synchronous orbit, which allows it to cover all of Earth with a mean revisit time of 24 hours. The satellite carries an X-band synthetic aperture radar (SAR) for Earth imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; H, horizontal; V, vertical]

| | PAZ |
|------------------------|---------------------------------------------------------------------------------------------------------|
| Launch date | 02/22/2018 |
| Design lifetime | 7 years |
| Platform owner | Hisdesat/Airbus Defence and Space |
| Altitude | 514 km |
| Orbit period | 95 min |
| Inclination | 97.4° |
| Crossing time | 06:00 DN |
| Nadir repeat | 11 days |
| Status | Operational |
| System website | https://earth.esa.int/eogateway/missions/paz |



A model of the PAZ satellite in orbit (image from Airbus Defence and Space, used with permission).



PAZ satellite image of the great pyramids complex, Egypt (image from Airbus Defence and Space, used with permission).

Sensor Information

| Beam mode | Polarization | | Scene size (range × azimuth) (km) | Azimuth resolution (m) |
|----------------------------------------------|--------------|---------------------|-----------------------------------|------------------------|
| High Resolution Spotlight mode (HS-S) | Single | HH, VV, HV, VH | [10–6]×5 | 1 |
| High Resolution Spotlight mode (HS-D) | Dual | HH/VV, HH/HV, VV/VH | 10×5 | 2 |
| Staring Spotlight mode (ST) | Single | HH, VV, HV, VH | [9–4.6]×[2.7–3.6] | 0.25 |
| SpotLight mode (SL-S) | Single | HH, VV, HV, VH | 10×10 | 2 |
| SpotLight mode (SL-D) | Dual | HH/VV, HH/HV, VV/VH | 10×10 | 3 |
| StripMap mode (SM-S) | Single | HH, VV, HV, VH | 30×50 | 3 |
| StripMap mode (SM-D) | Dual | HH/VV, HH/HV, VV/VH | 15×50 | 6 |
| ScanSAR mode (SC) | Single | HH, VV, HV, VH | 100×150 | 18 |
| Wide ScanSAR mode (WS) | Single | HH, VV, HV, VH | [273–196]×208 | 38 |

PAZ—Continued

Spain
Civil/Commercial
Operational



PAZ X-Band SAR

PAZ is equipped with a side-looking X-band SAR using the active phased-array antenna technology, with an operational instantaneous bandwidth of as much as 300 megahertz. The sensor has been designed to be very flexible and is able to operate in a wide array of configurations.

PeruSat-1

Peru
Civil/Government
Operational



Platform Overview

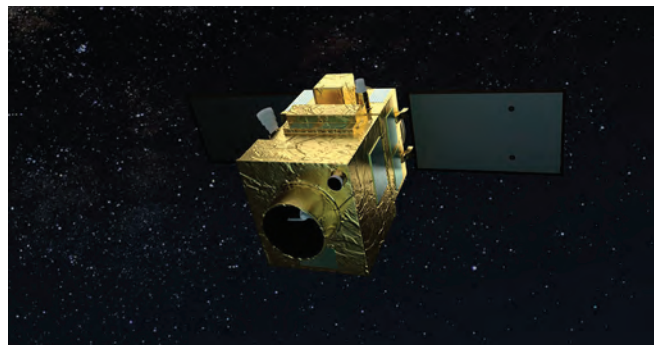
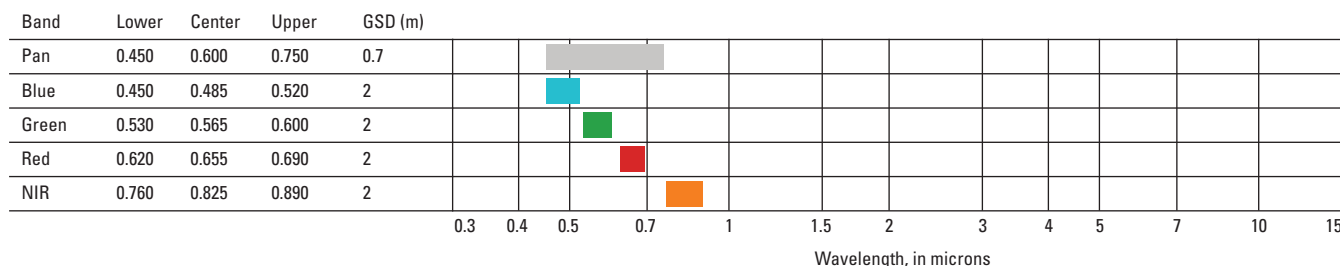
PeruSat-1 is a high-resolution multispectral satellite launched in 2016 by the Peruvian Space Agency (CONIDA) on a Vega launcher from Kourou, French Guiana, for Earth resources monitoring. The PeruSat-1 satellite was designed and built by Airbus Defence and Space and uses the Astro-Bus-S satellite bus, 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; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

| | |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 09/16/2016 |
| Design lifetime | 10 years |
| Platform owner | CONIDA |
| Altitude | 695 km |
| Orbit period | 98.80 min |
| Inclination | 98.19° |
| Crossing time | 10:30 DN |
| Nadir repeat | 26 days |
| Status | Operational |
| System website | https://www.airbus.com/en/products-services/space/earth-observation/earth-observation-portfolio/perusat |

NAOMI

The NAOMI sensor is a proven design from Airbus Defence and Space used on the Alsat-2, SPOT-6, SPOT-7, and VNREDSat-1A satellites. This sensor provides an improved resolution of 0.7 meter (m) 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.



Artistic rendering of PeruSat-1 (image from Airbus Defence and Space, used with permission).



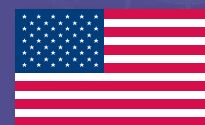
PeruSat-1 image of Cuajone, a large copper mine in Peru (image from Airbus Defence and Space, used with permission).

Sensor Information

| | NAOMI |
|--------------------|--------|
| GSD (m) | 0.7, 2 |
| Swath (km) | 14.5 |
| Data portal | — |

Planet Pelican

United States
Commercial
Future



Platform Overview

Planet's Pelican series of high-resolution multispectral satellites are planned to be launched in 2023 for Earth resources monitoring. The constellation of 32 satellites will replace the existing SkySat series and will provide higher frequency revisits and better spatial resolution. The Pelican satellites are being built by Planet and carry a multispectral imager.

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

| | |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 5 years |
| Platform owner | — |
| Altitude | — |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Development |
| System website | https://www.planet.com/pulse/planet-introduces-new-high-resolution-pelican-satellites-and-fusion-with-sar/ |

Sensor Information

| | |
|-----------------------|-----|
| GSD (m) | 0.3 |
| Swath (km) | — |
| Revisit (days) | — |
| Data portal | — |

Multispectral Imager

The multispectral imager on Pelican satellites is planned to operate with seven spectral bands at a ground resolution of 30 centimeters.

Pléiades-HR (1A and 1B)

France
Civil/Government
Operational



Platform Overview

The Pléiades-HR constellation of high-resolution multispectral satellites consists of Pléiades-1A and Pléiades-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 Pléiades-HR series of satellites were designed and built by Airbus Defence and Space 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]

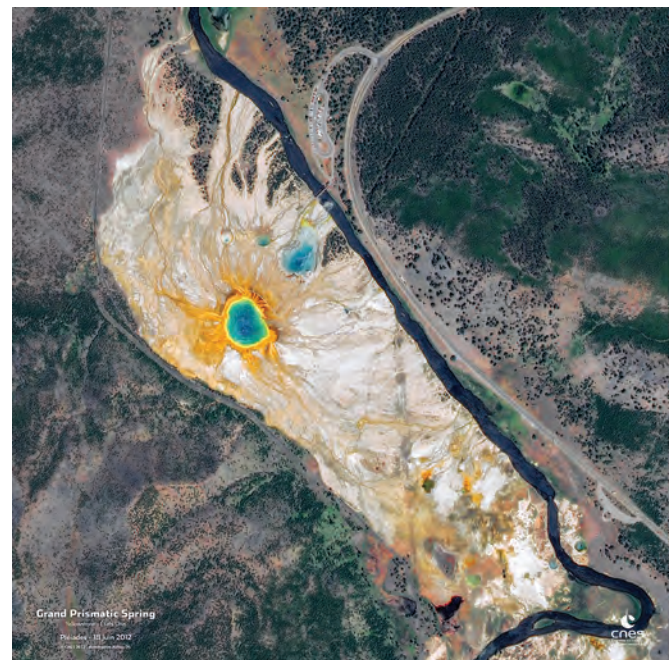
| | Pléiades-1A | Pléiades-1B |
|------------------------|-------------------------------------------------------------------------------------------------------------|-------------|
| Launch date | 12/17/2011 | 12/01/2012 |
| Design lifetime | 5 years | |
| Platform owner | CNES | |
| Altitude | 694 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 | |

Sensor Information

| | HiRI |
|--------------------|---------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.7, 2.8 |
| Swath (km) | 20 |
| Data portal | https://www.intelligence-airbusds.com/pleiades/ |



Artistic rendering of Pléiades-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 Defence and Space, 2012, used with permission).

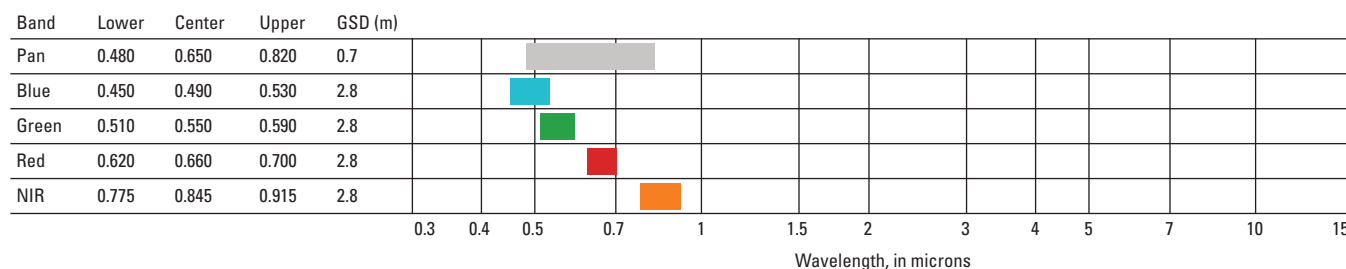
Pléiades-HR (1A and 1B)—Continued

France
Civil/Government
Operational



HiRI

The HiRI sensor aboard the Pléiades-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.



Pléiades-NEO

France
Commercial
Operational

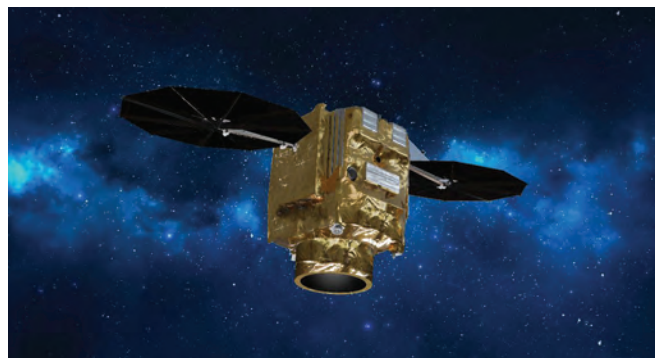


Platform Overview

Pléiades-Neo is a high-resolution four-satellite constellation being developed by Airbus Defence and Space as a follow-on to the currently operational Pléiades-HR satellites. Pléiades-Neo 3 and 4 were launched in 2021 and 5 and 6 are planned for launch in 2022.

The Pléiades-Neo satellites operate in two orbital planes at an altitude of 620 kilometers to allow intraday revisit times. They carry a high-resolution multispectral imager for Earth 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]



Artistic rendering of the Pléiades-Neo satellite (image from Airbus Defence and Space, used with permission).

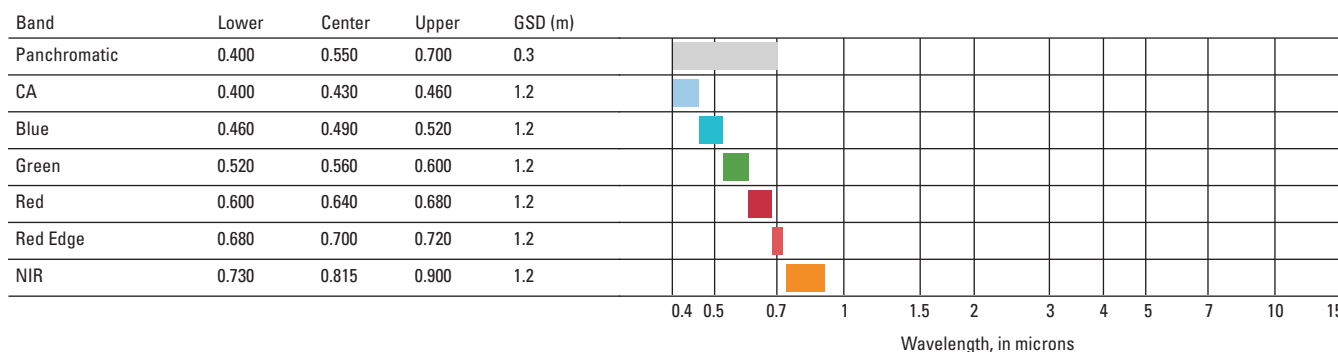
| | Pléiades-Neo 3 | Pléiades-Neo 4 | Pléiades-Neo 5 | Pléiades-Neo 6 |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|
| Launch date | 04/28/2021 | 08/17/2021 | 2022 (Planned) | 2022 (Planned) |
| Design lifetime | 10 years | | | |
| Platform owner | Airbus Defence and Space | | | |
| Altitude | 620 km | | | |
| Orbit period | 97.1 min | | | |
| Inclination | 97.8° | | | |
| Crossing time | 10:30 DN | 10:30 DN | 10:30 DN | 10:30 DN |
| Nadir repeat | 30 days | | | |
| Status | Operational | | | |
| 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 | — |

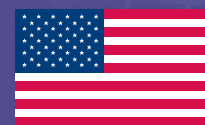
HR sensor

The high-resolution (HR) sensor on Pléiades-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.



PredaSAR

United States
Civil/Commercial
Future



Platform Overview

PredaSAR-1 is a synthetic aperture radar (SAR) satellite planned to be launched in 2022 for Earth resources monitoring. It is part of the PredaSAR constellation planned for launch starting in 2022 by PredaSAR, a subsidiary of Terran Orbital. The company plans to build the largest SAR constellation of 96 satellites on 24 orbital planes. The satellites carry C-band and X-band radar for high-resolution SAR imaging.

[Abbreviations in table: —, no data]

| | PredaSAR-1 |
|-----------------|---------------------------------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | — |
| Platform owner | PredaSAR |
| Altitude | — |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Planned |
| System website | https://www.predasar.com/technology |

X-Band SAR

PredaSAR-1 satellites will carry an X-band SAR. Details on the operation modes are not currently (2022) available.

PRISMA

Italy
Civil/Government
Operational



Platform Overview

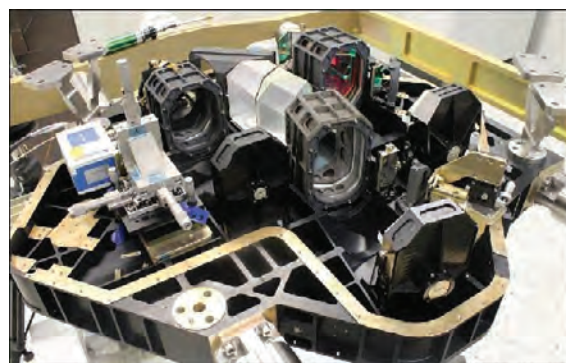
The Hyperspectral Precursor of the Application Mission (PRISMA) is a medium-resolution hyperspectral satellite launched March 2019 by the Italian Space Agency (ASI) on a Vega launcher for environmental monitoring. PRISMA was developed at Carlo Gavazzi Space of Milan, Italy. The satellite is based on 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]

| | |
|------------------------|-------------------------------------------------------------------------------------------------------|
| 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 | https://www.asi.it/en/earth-science/prisma/ |



PRISMA satellite in development (image from ASI, used with permission).



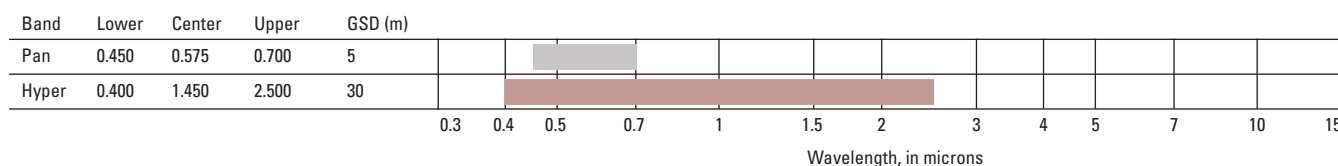
Prototype model of the PRISMA sensor (image from ASI, used with permission).

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.



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. Izanami (QPS-SAR 2) was launched in 2021 on a Falcon 9 rocket. The QPS-SAR constellation is planned to have 36 satellites to provide high revisits of any region on Earth. The satellites carry an X-band SAR for radar Earth imaging.

[Abbreviations in table: —, no data; km, kilometer; min, minute; °, degree]

| | QPS-SAR1 (Izanagi) | QPS-SAR2 (Izanami) |
|-----------------|-----------------------------------------------------|-----------------------|
| Launch date | 12/11/2019 | 01/24/2021 |
| Design lifetime | — | |
| Platform owner | iQPS | |
| Altitude | 578 km | 530 km |
| Orbit period | 96.1 min | 95.1 min |
| Inclination | 37° | 97.5° |
| Crossing time | — | |
| Nadir repeat | — | |
| Status | Operational | |
| System website | https://i-qps.net/ | |

SAR

Detailed information not currently (2022) available.

RADARSAT Constellation Mission

Canada
Civil/Government
Operational



Platform Overview

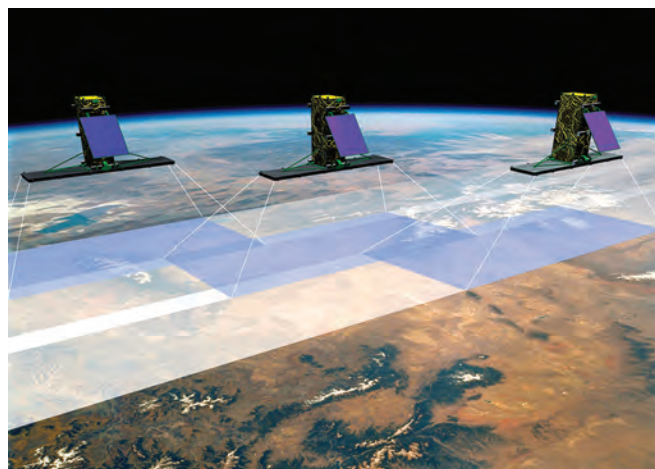
The RADARSAT Constellation Mission (RCM) consists of three small high-resolution synthetic aperture radar (SAR) satellites launched in 2019 by the Canadian Space Agency (CSA) and MDA for Earth observation. The RCM satellites operate in tandem with RADARSAT-2, significantly improving revisit. The RCM 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]

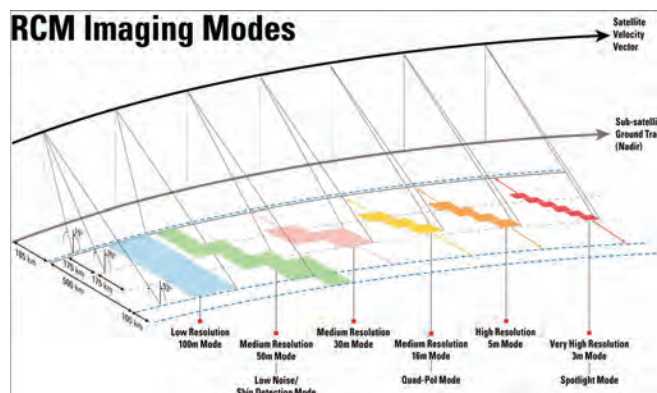
| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 06/12/2019 |
| Design lifetime | 7 years |
| Platform owner | CSA/MDA |
| Altitude | 600 km |
| Orbit period | 96.4 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 |

Sensor Information

| | SAR |
|-----------------------|---------------------|
| Resolution (m) | 1–100 (selectable) |
| Swath (km) | 14–500 (selectable) |
| Data portal | — |



Artistic rendering of RADARSAT Constellation Mission satellites in orbit (image from MDA/NASA, used with permission).



RADARSAT Constellation imaging modes (image from CSA).

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 was the same, and the size of the antenna was decreased. The SAR instrument operates in the C-band at 5.405 gigahertz ($\lambda = 5.5$ 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 | HH, VV, HV, VH | 500 | 100×100 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| Medium Resolution 50 m | Single | HH, VV, HV, VH | 350 | 50×50 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| Medium Resolution 30 m | Single | HH, VV, HV, VH | 125 | 30×30 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| Medium Resolution 16 m | Single | HH, VV, HV, VH | 30 | 16×16 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| High Resolution | Single | HH, VV, HV, VH | 30 | 5×5 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| Very High Resolution 3 m | Single | HH, VV, HV, VH | 20 | 3×3 |
| | Dual | HH/HV, VV/VH, HH/VV, Compact | | |
| Low Noise | Single | HH, VV, HV, VH | 350 | 100×100 |
| | 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] | 1×3 |
| | Dual | HH/HV, VV/VH, Compact | | |
| Quad-Polarization | Quad | HH/HV/VH/VV | 20 | 9×9 |

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 |

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 |



Artistic rendering of RADARSAT-2 in orbit (image from MDA/ NASA, used with permission).



Montreal, Quebec, captured by RADARSAT-2 (image from MDA, used with permission).

RADARSAT-2—Continued

Canada
Civil/Government
Operational



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 ($\lambda = 5.5$ 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 | HH, HV, VH, VV | 530 | Variable |
| | Dual | 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/Dombrovsky launch site in Turkey 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 |

OIS

The OIS aboard RASAT is a pushbroom-style imager. OIS was designed and developed by Satrec Initiative in South Korea and is a variant of their Earth Observing System-A.



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 |



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 | | | | | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | | |
| | | | | | Wavelength, in microns | | | | | | | | | | | | | | |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NSA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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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.isro.gov.in/RESOURCESAT_2A.html | |



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 U.S. Geological Survey).

Sensor Information

| | AWiFS | LISS-3 | LISS-4 |
|--------------------|-------------------------------------------------------------------------------------------------------------------|--------|--------|
| GSD (m) | 56 | 23.5 | 5.8 |
| Swath (km) | 740 | 141 | 70 |
| Data Portal | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html | | |

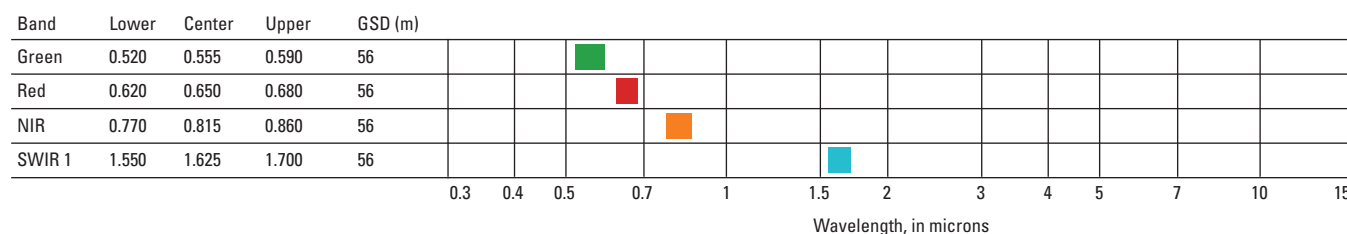
ResourceSat-2 and -2A—Continued

India
Civil/Government
Operational



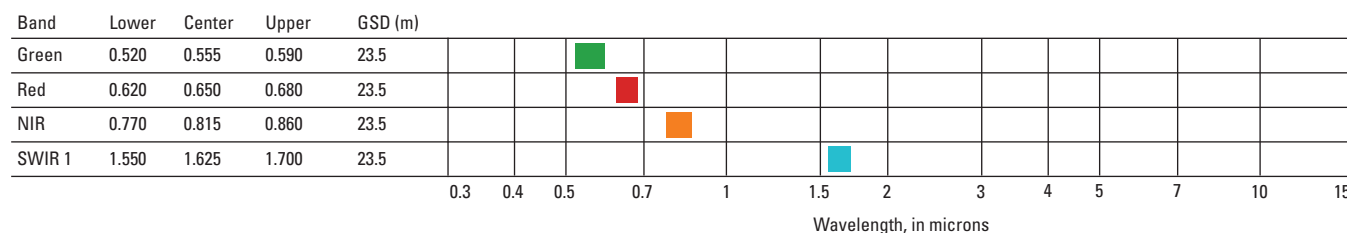
AWiFS

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.



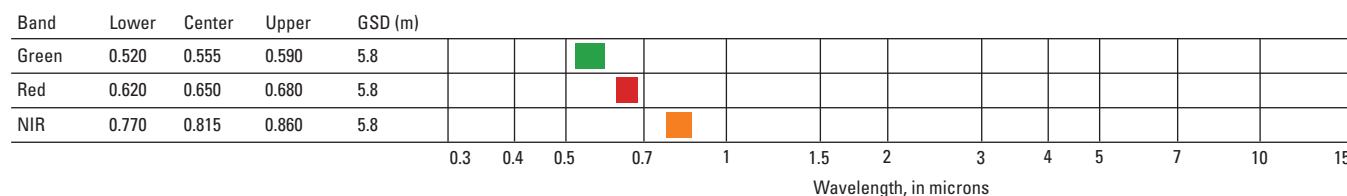
LISS-3

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.



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.



ResourceSat-3 and -3A

India
Civil/Government
Future



Platform Overview

ResourceSat-3 and -3A are medium-resolution wide swath satellites planned to be launched in 2023 and 2024, 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]

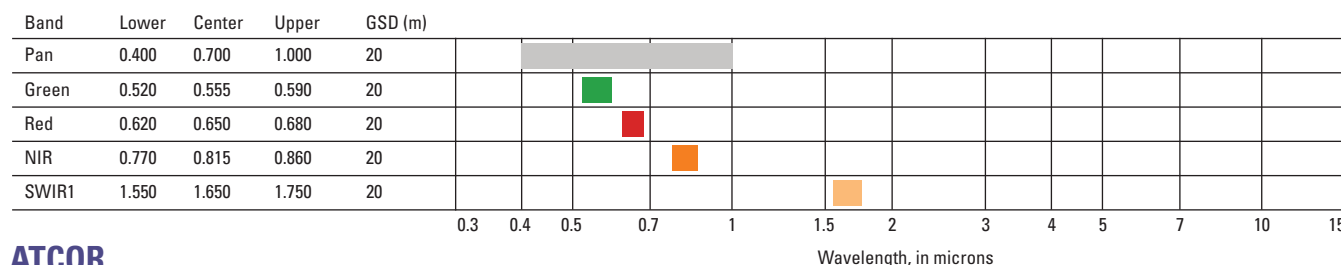
| | RS-3 | RS-3A |
|-----------------|-------------|-------|
| Launch date | 2023 | 2024 |
| Design lifetime | 5 years | |
| Platform owner | ISRO | |
| Altitude | 795 km | |
| Orbit period | 101 min | |
| Inclination | 97.91° | |
| Crossing time | 10:30 DN | |
| Nadir repeat | 11 days | |
| Status | Development | |
| System website | — | |

Sensor Information

| | ALISS | ATCOR |
|-------------|--------|-------|
| GSD (m) | 10, 20 | 240 |
| Swath (km) | 925 | |
| Data portal | — | |

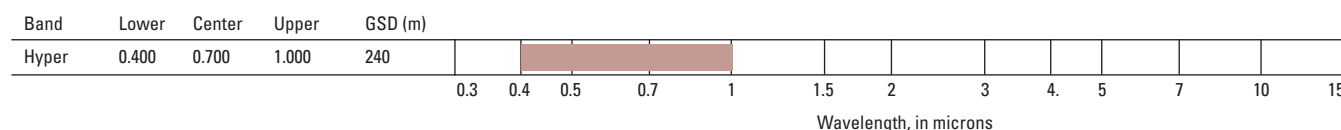
ALISS

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.



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.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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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 2022 and 2023 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; —, no data; GSD, ground sample distance; m, meter; NIR, near infrared; Pan, panchromatic]

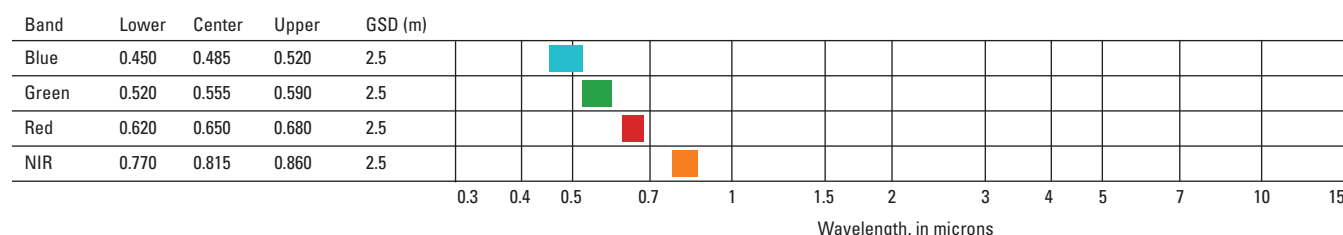
| | RS-3S | RS-3SA |
|-----------------|-------------|--------|
| Launch date | 2022 | 2023 |
| Design lifetime | 5 years | |
| Platform owner | ISRO | |
| Altitude | 633 km | |
| Orbit period | 97.5 min | |
| Inclination | 98.89° | |
| Crossing time | 10:30 DN | |
| Nadir repeat | 48 days | |
| Status | Development | |
| System website | — | |

Sensor Information

| | LISS-V | APAN |
|-------------|--------|------|
| GSD (m) | 2.5 | 1.5 |
| Swath (km) | 60 | |
| Data portal | — | |

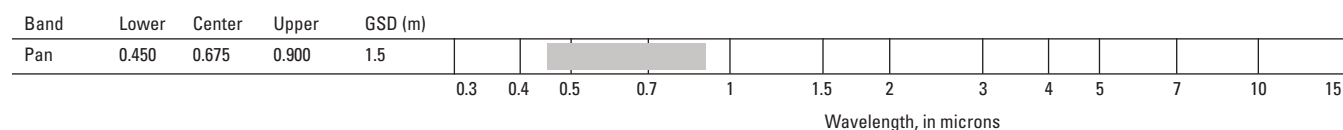
LISS-V

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.



APAN

The APAN sensor is a new high-resolution, panchromatic imager for sharpening. Both sensors have a narrowed swath of 60 kilometers.



Resurs-P

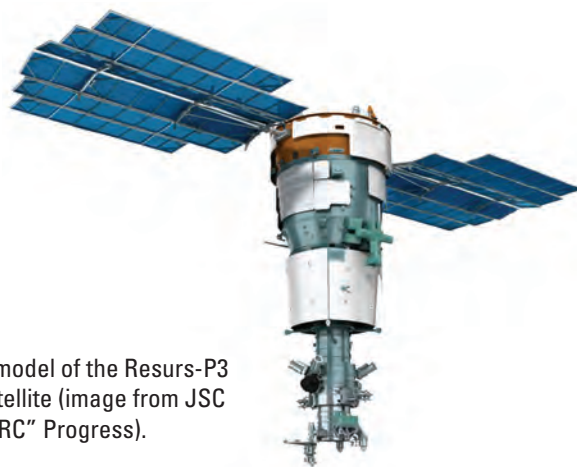
Russia
Civil/Government
Operational/Future



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).

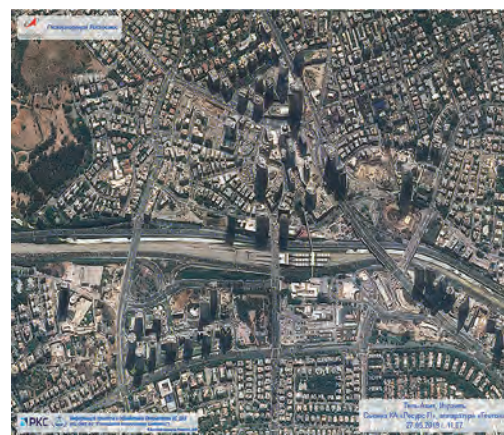
[Abbreviations in tables: —, no data; km, kilometer; min, minute; °, degree; DN, descending node; GSD, ground sample distance; m, meter; NIR, near infrared]

| | 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).



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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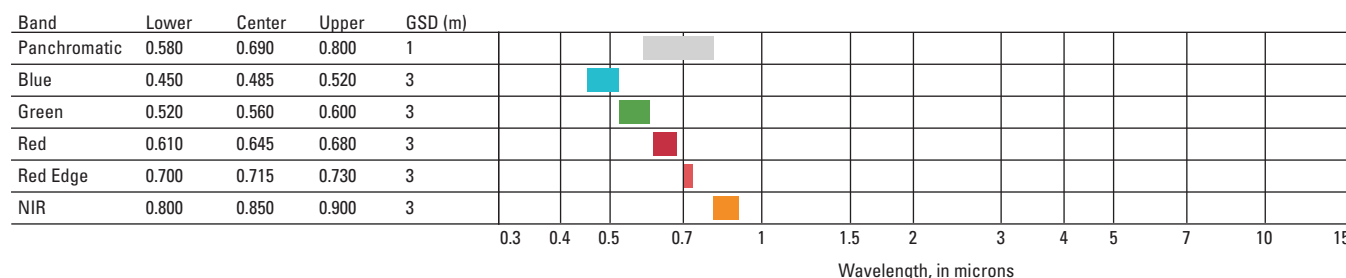
Resurs-P—Continued

Russia
Civil/Government
Operational/Future



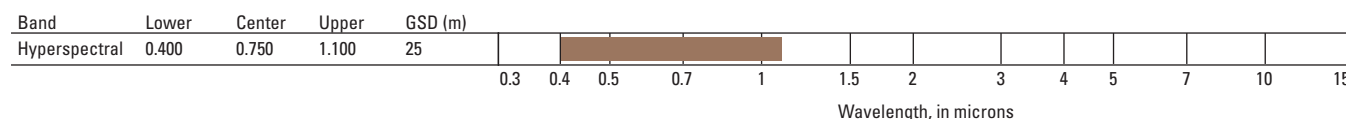
Geoton-1

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).



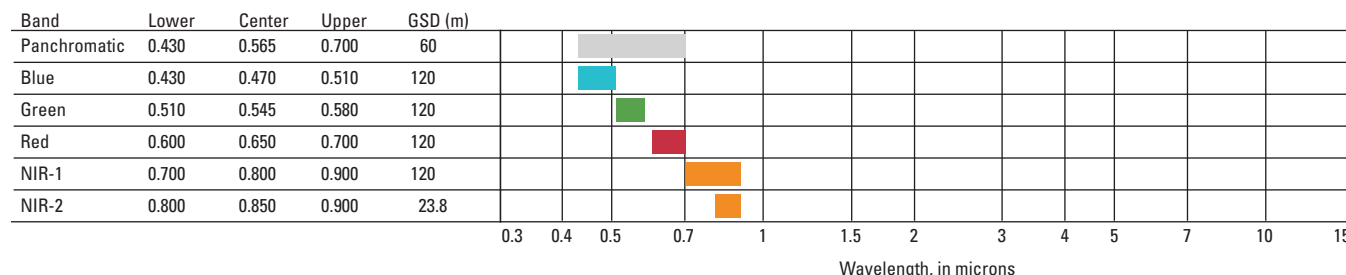
GSA Hyperspectral Imager

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).



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.



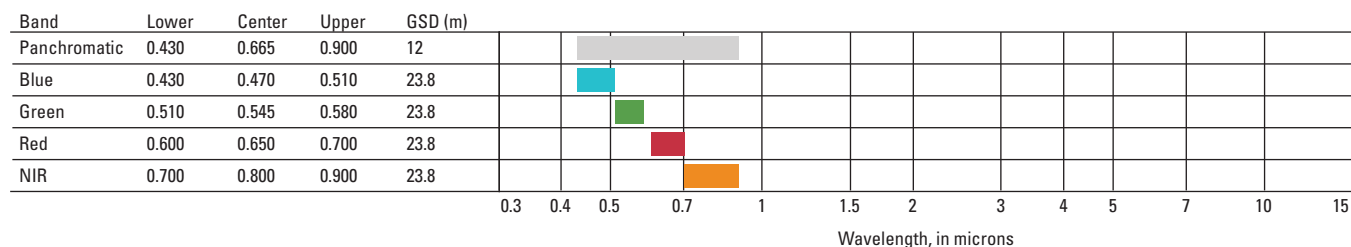
Resurs-P—Continued

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.



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 in India for Earth resources monitoring. RISAT-1A and RISAT-1B are copies of RISAT-1, launched in 2022 and planned for launch in 2022, respectively. The RISAT-1 satellites carry the RISAT-SAR instrument for measuring radar data.

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

| | RISAT-1 | RISAT-1A | RISAT-1B |
|------------------------|-----------------------------------------------------------------------------------------|------------|----------------|
| Launch date | 04/26/2012 | 02/14/2022 | 2022 (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/RISAT_1.html | | |



RISAT-1 main structure (image from ISRO, used with permission).

Sensor Information

| | RISAT-SAR |
|--------------------|-------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.67–55 (Selectable) |
| Swath (km) | 10–223 (Selectable) |
| Data portal | https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html |



RISAT-1 image of the Chambal river, Madhya Pradesh (image from ISRO, used with permission).

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 ($\lambda = 5.60$ 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 | 10×10 | 1×0.67 |
| | Dual | HH/HV, VV/VH | | |
| | Circular | CP/VH | | |
| Fine Resolution Stripmap-1 (FRS-1) | Single | HH, HV, VH, VV | 25 | 3×2 |
| | Dual | HH/HV, VV/VH | | |
| | Circular | CP/VH | | |
| Fine Resolution Stripmap-2 (FRS-2) | Circular | CP/VH | 25 | 3×4 |
| | Quad | HH/HV/VV/VH | | 9×4 |
| Medium Resolution ScanSAR (MRS) | Single | HH, HV, VH, VV | 115 | 21–23×8 |
| | Dual | HH/HV, VV/VH | | |
| | Circular | CP/VH | | |
| Coarse Resolution ScanSAR (CRS) | Single | HH, HV, VH, VV | 223 | 41–55×8 |
| | Dual | HH/HV, VV/VH | | |
| | Circular | CP/VH | | |

RISAT-2, 2B, and 2BR1

India
Civil/Government
Operational/Future

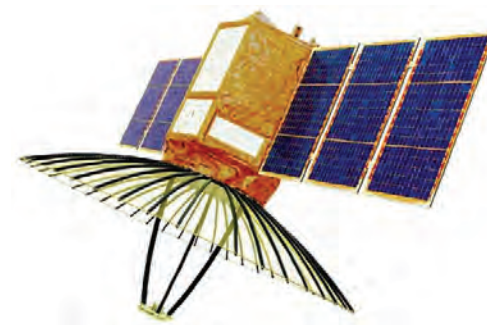


Platform Overview

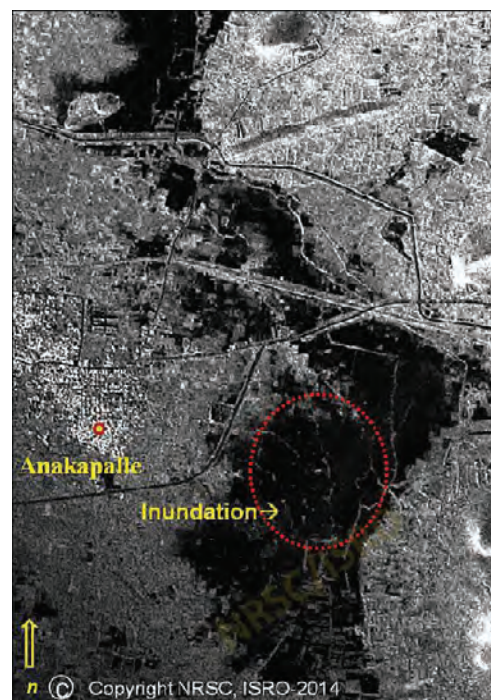
RISAT-2, 2B, and 2BR1 are multiresolution synthetic aperture radar (SAR) satellites launched in 2009 and 2019 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle from Satish Dhawan Space Center in India for Earth resources monitoring. RISAT-2 was designed and built by 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 2023. RISAT-2, 2B, and 2BR1 satellites carry the X-SAR instrument for measuring SAR data.

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

| | 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://www.isro.gov.in/RISAT_2.html | | |



Artistic rendering of RISAT-2 (image from ISRO, used with permission).



RISAT-2 image of Anakapalle, Vishakapatnam district, Andhra Pradesh, India (image from ISRO, used with permission).

Sensor Information

| | X-SAR |
|--------------------|---------------------|
| GSD (m) | 1–8 (selectable) |
| Swath (km) | 10–120 (selectable) |
| Data portal | — |

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 ($\lambda = 3.13$ 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 |

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: km, kilometer; —, no data; GSD, ground sample distance; m, meter]

| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2028 |
| Design lifetime | 5 years |
| Platform owner | ESA |
| Altitude | 690 km |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Development |
| System website | https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_High_Priority_Candidates |



Artistic rendering of ROSE-L satellite in orbit (image from Thales Alenia Space).

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.

SABIA-Mar 1 and 2

Argentina, Brazil
Civil/Government
Future



Platform Overview

SABIA-Mar 1 is a low-resolution multispectral satellite planned 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; AN, ascending node; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared]

| | SABIA-Mar 1 | SABIA-Mar 2 |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Launch date | 2023 (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) | 1,500 | 1,500 | 1,500 |
| 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 | | | | | | | | | | | | | | | |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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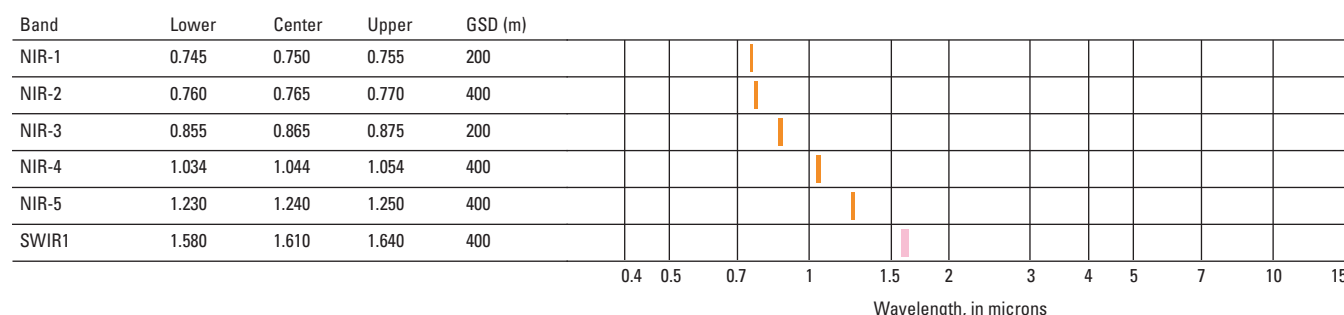
SABIA-Mar 1 and 2— Continued

Argentina, Brazil
Civil/Government
Future



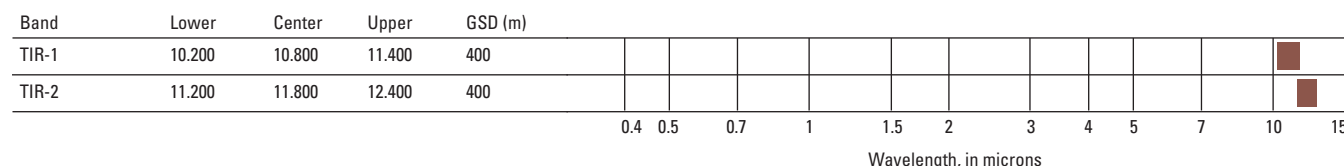
NIR-SWIR

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.



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.



H-PAN

No information is currently (2022) available.

SARAL

India, France
Civil/Government
Operational

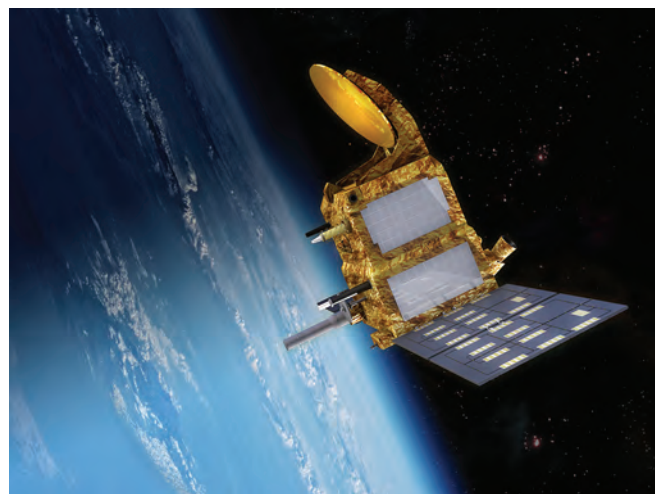


Platform Overview

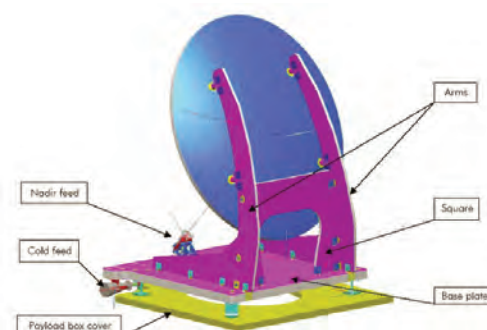
SARAL is a radar altimeter satellite launched in 2013 by the Indian Space Research Organization (ISRO) on a Polar Satellite Launch Vehicle—C20 launch vehicle from Satish Dhawan Space Center, Sriharikota, India, for oceanographic studies. SARAL is complementary to Jason-2 and will improve sea surface 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 table: km, kilometer; min, minute; °, degree; AN, ascending node]

| | |
|------------------------|---------------------------------------------------------------------------------|
| 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://altika-saral.cnes.fr/en/ |



Artistic rendering of SARAL in orbit (image from CNES/ill/SAT-TLER Oliver, 2010, used with permission).



Three-dimensional model of the AltiKa instrument aboard SARAL (image from CNES, 2016, used with permission).

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) ($\lambda = 0.84$ centimeter [cm]). The AltiKa instrument also includes a bifrequency radiometer that operates at 23.8 GHz ($\lambda = 1.26$ cm) and 37 GHz ($\lambda = 0.81$ cm).

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. Sentinel-1B likely malfunctioned because of a power system failure on December 23, 2021, and all the efforts to reactivate the power were not successful.

[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]

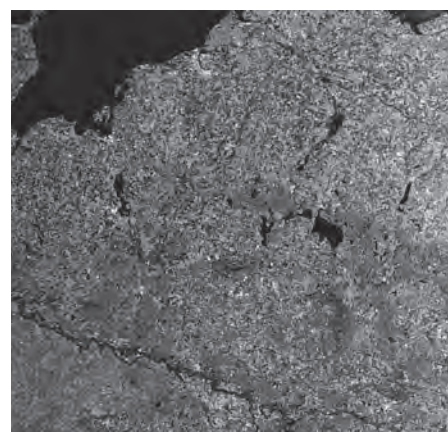
| | Sentinel-1A | Sentinel-1B | Sentinel-1C | Sentinel-1D |
|-----------------|---------------------------------------------------------------------------|-------------|----------------|----------------|
| Launch date | 04/03/2014 | 04/25/2016 | 2024 (Planned) | 2025 (Planned) |
| Design lifetime | 7.25 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 | Failed | Development | |
| System website | https://scihub.copernicus.eu/ | | | |



Artistic rendering of Sentinel-1 in orbit (image from ESA).

Sensor Information

| Mode | C-SAR |
|--------------------|---------------------------------------------------------------------------|
| GSD (m) | 5–40 |
| Swath (km) | 80–400 |
| Data portal | https://scihub.copernicus.eu/ |



The Alps between Munich, Germany, and Bozen, Italy, captured by Sentinel-1A (image from DLR).

Sentinel-1— Continued

European Commission/European Space Agency
Civil/Government
Operational/Future



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 ($\lambda = 5.5$ 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 | 5×5 |
| Interferometric Wide Swath Mode (IW) | Dual | HH/HV, VV/VH | 250 | 5×20 |
| Extra Wide Swath Mode (EW) | Dual | HH/HV, VV/VH | 400 | 20×40 |
| Wave Mode (WV) | Single | HH, VV | 20×20 | 5×5 |

Sentinel-2

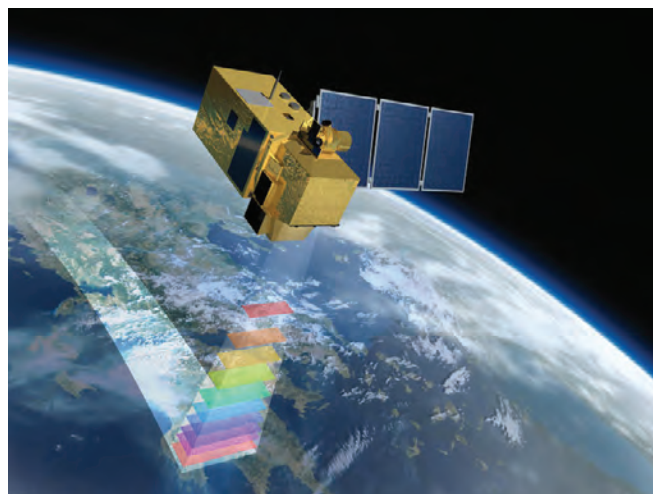
European Commission/European Space Agency
Civil/Government
Operational/Future



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 2024 and 2025, respectively.

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 | 2024 (Planned) | 2025 (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 | | | |
| Status | Operational | | Development | |
| System website | https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2 | | | |

Sentinel-2— Continued

European Commission/European Space Agency
Civil/Government
Operational/Future



Sensor Information

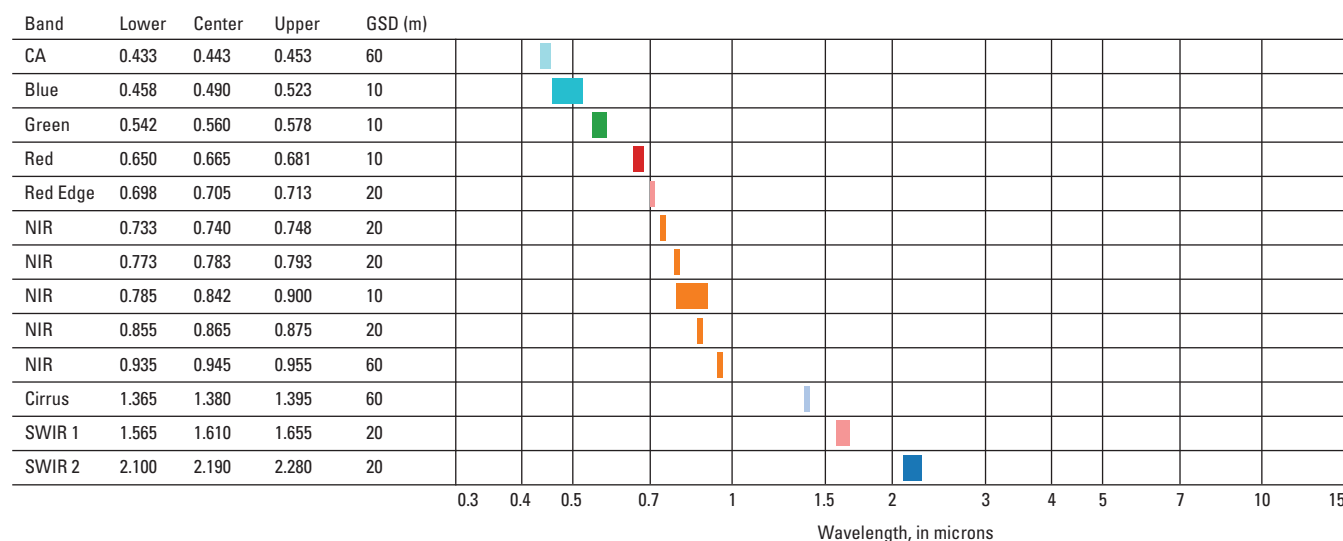
| | MSI |
|-------------|---------------------------------------------------------------------------|
| GSD (m) | 10, 20, 60 |
| Swath (km) | 290 |
| Data portal | https://scihub.copernicus.eu/ |



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.



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 Synthetic Aperture 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 | 2023 (Planned) | 2025 (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://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-3 | | | |

Sentinel-3— Continued

European Commission/European Space Agency
Civil/Government
Operational/Future

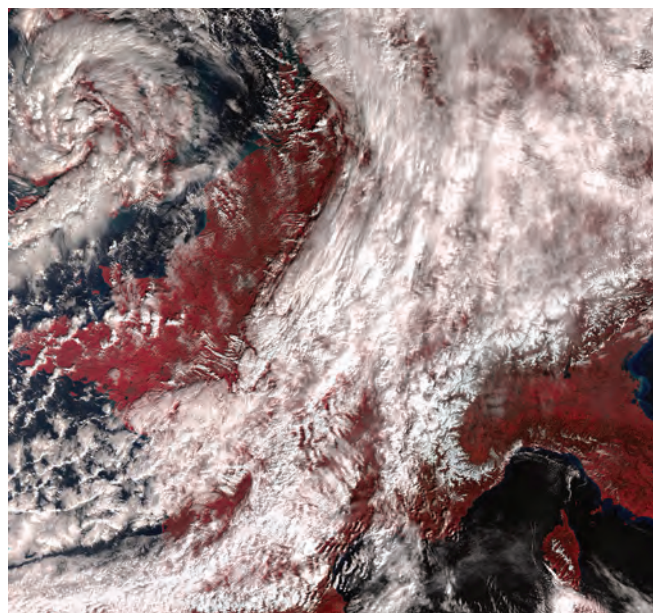


Sensor Information

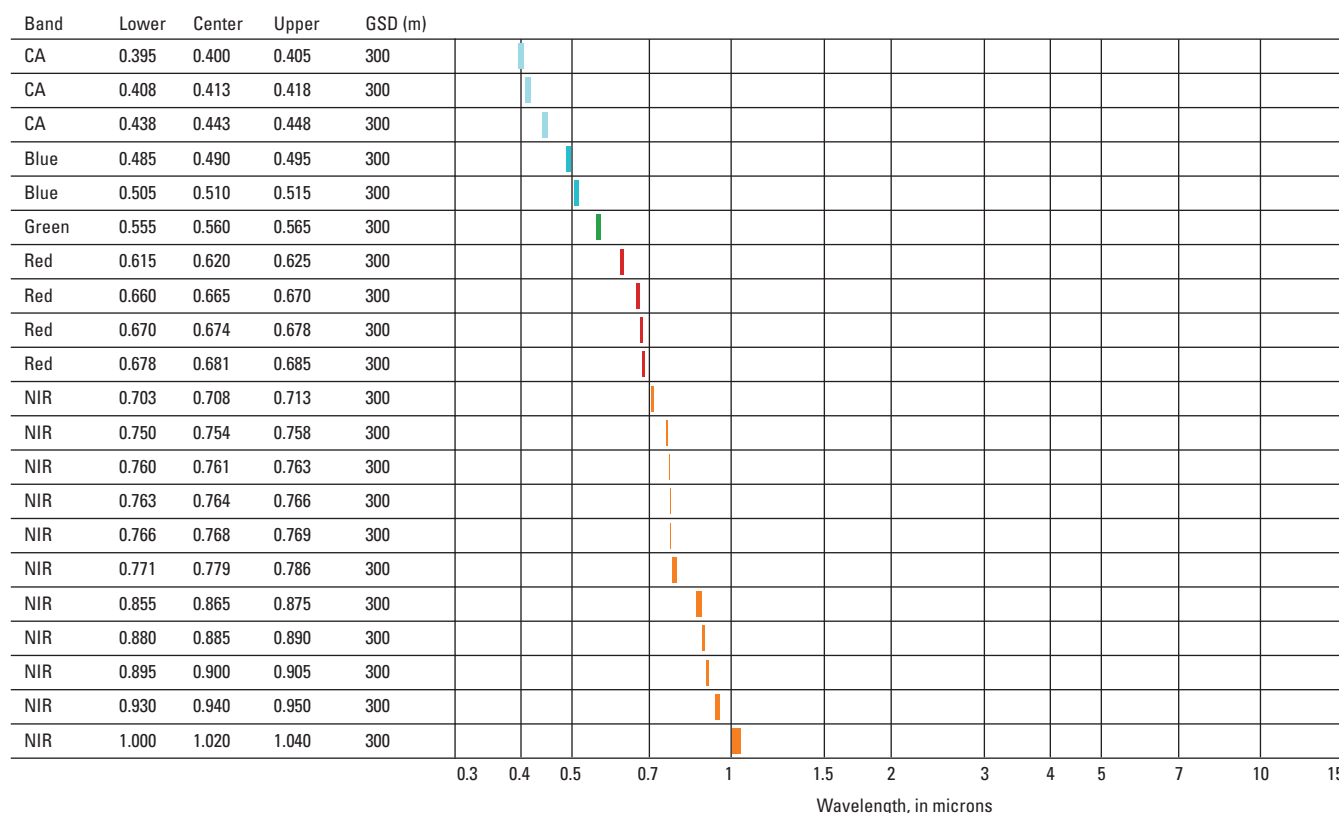
| | OLCI | SLSTR | SRAL |
|--------------------|---------------------------------------------------------------------------|-----------|-------|
| GSD (m) | 300 | 500/1,000 | 300 |
| Swath (km) | 1,270 | 1,420 | 1,270 |
| Data portal | https://scihub.copernicus.eu/ | | |

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.



Europe captured by Sentinel-3B (image from ESA).



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

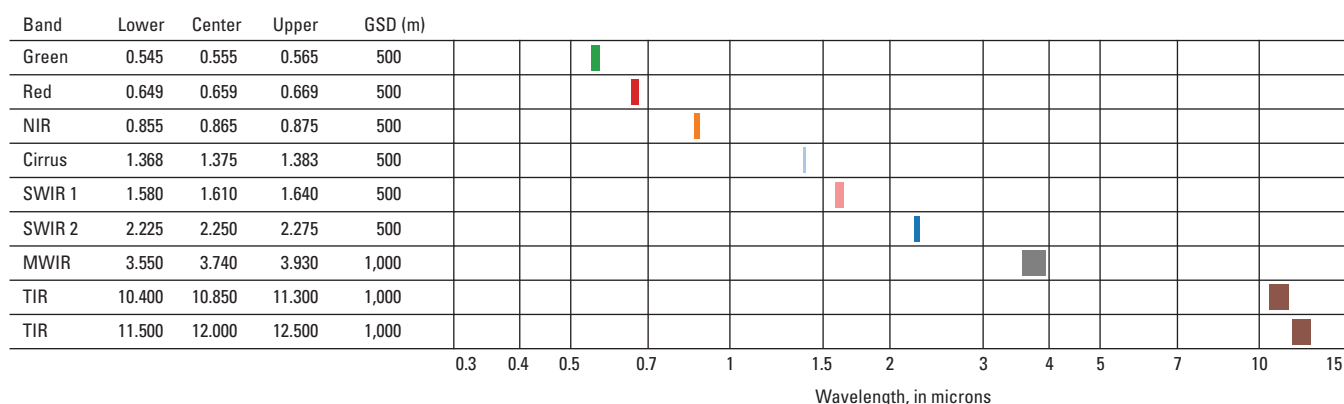
Sentinel-3— Continued

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.



SRAL

The SRAL instrument has strong heritage of the instrument techniques implemented on the Poseidon-3 altimeter on Jason-2, Synthetic Aperture Radar 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. SRAL operates in two modes: Low Resolution Mode, as a conventional altimeter pulse-limited mode based on a 3 Ku/ 1C/ 3 Ku pulse pattern, and Synthetic Aperture Radar mode, with high along-track resolution composed of bursts of 64 Ku-band pulses surrounded by two C-band pulses. Ku-band (13.575 gigahertz, bandwidth of 350 megahertz) is used for range measurements, and the C-band (5.41 gigahertz, bandwidth of 320 megahertz) is used for ionospheric correction.

Sentinel-6 Michael Freilich

EUMETSAT/France/United States
European Commission/European Space Agency
Civil/Government
Operational/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 was 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 carries the Poseidon-4 Synthetic Aperture Radar Altimeter (POS4) sensor for synthetic aperture radar data.

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



Artistic rendering of Sentinel-6 Michael Freilich in orbit (image from ESA).

| | Sentinel-6A | Sentinel-6B |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Launch date | 11/21/2020 | 2026 (Planned) |
| Design lifetime | 8 years | |
| Platform owner | ESA | |
| Altitude | 1,366 km | |
| Orbit period | 112 min | |
| Inclination | 66.03° | |
| Crossing time | — | |
| Nadir repeat | 9.9 days | |
| Status | Operational | Planned |
| System website | https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-6 | |

Sensor Information

| | POS4 |
|--------------------|-----------------------------------------------------------------------------------------------------------|
| GSD (m) | — |
| Swath (km) | — |
| Data portal | https://www.eumetsat.int/eumetsat-data-centre |

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) ($\lambda = 2.2$ centimeters [cm]) and the C-band at 5.3 GHz ($\lambda = 5.7$ cm). The angle of incidence and the beam modes are unavailable. The data are freely available.

SEOSat

Spain
Civil/Government
Operational



Platform Overview

The Spanish System for Earth Observation Satellite (SEOSat), also known as Ingenio (Spanish for “ingenuity”), is a high-resolution multispectral satellite 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 was 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; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared]

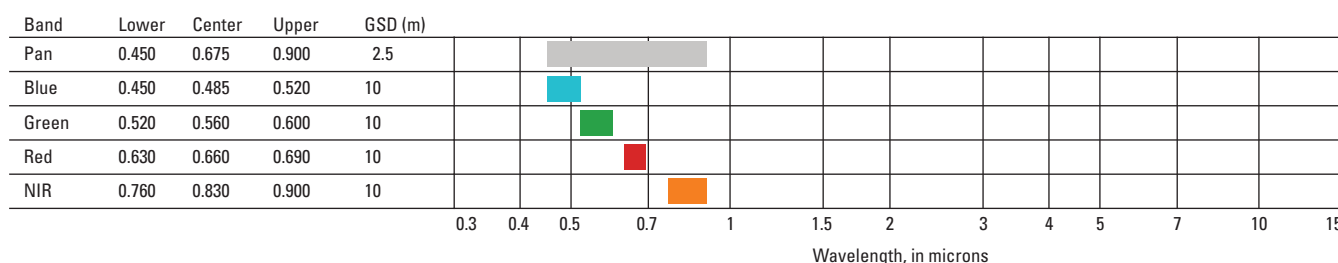
| | |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 11/16/2020 |
| Design lifetime | 7 years |
| Platform owner | INTA |
| Altitude | 670 km |
| Orbit period | 98.15 min |
| Inclination | 98° |
| Crossing time | 10:30 DN |
| Nadir repeat | 38 days |
| Status | Operational |
| System website | https://www.aeroespacial.sener/en/products/seosat-ingenio-spanish-earth-observation-satellite |

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.



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 2025 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]

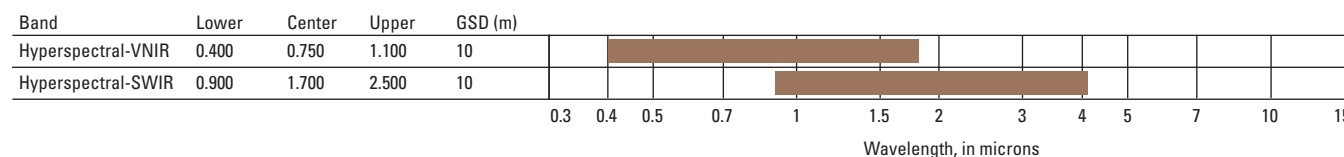
| | |
|------------------------|----------------|
| Launch date | 2025 (Planned) |
| Design lifetime | 5 years |
| Platform owner | IAI/ASI |
| Altitude | 600 km |
| Orbit period | — |
| Inclination | — |
| Crossing time | — |
| Nadir repeat | — |
| Status | Development |
| System website | — |

Sensor Information

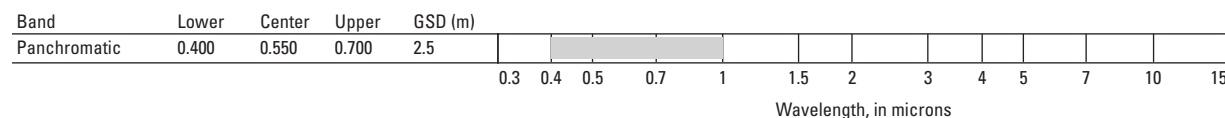
| | CHIS | Pan |
|-----------------------|------|-----|
| GSD (m) | 10 | 2.5 |
| Swath (km) | — | — |
| Revisit (days) | 2 | — |
| Data portal | — | — |

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.



Panchromatic Camera



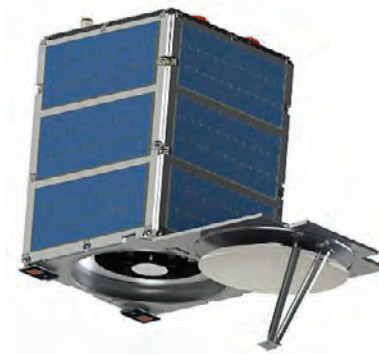
SkySats

United States
Commercial
Operational



Platform Overview

SkySats 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, increased 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-1 and -2 deployed configurations (image from Planet Labs Inc., used with permission).



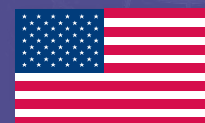
SkySat-3 through -13 deployed configurations (image from Planet Labs Inc., used with permission).

[Abbreviations in tables: SS, SkySat; km, kilometer; min, minute; °, degree; DN, descending node; AN, ascending node; —, no data; MSI, Multispectral Imager; GSD, ground sample distance; m, meter; 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 | SS-19 to 21 |
|-----------------|---------------------------------------------------------------------------------------------------------------------|-----------------------|------------|------------|-------------|--------------|--------------|-------------|
| Launch date | 11/21/2013 | 07/08/2014 | 06/22/2016 | 09/16/2016 | 10/31/2017 | 12/03/2018 | 06/13/2020 | 08/18/2020 |
| Design lifetime | 6 years | | | | | | | 5 years |
| Launch vehicle | Dnepr | Soyuz-2.1b/ Fregat | PSLV-C34 | Vega | Minotaur-C | Falcon 9 | Falcon 9 | Falcon 9 |
| Platform owner | Planet | | | | | | | |
| Altitude | 587 km | | 500 km | 695 km | 500 km | | 400 km | 400 km |
| Orbit period | 96.41 min | | 94.6 min | 98.6 min | 94.6 min | | 92.4 min | 92.4 min |
| Inclination | 97.98° | | 95.3° | 98.3° | 95.3° | | 53° | 53° |
| Crossing time | 10:30 DN | | | | 13:30 AN | | — | — |
| Status | Operational | | | | | | | |
| System website | https://www.planet.com/products/hi-res-monitoring/ | | | | | | | |

SkySats—Continued

United States
Commercial
Operational



Sensor Information

| | SS-MSI |
|-------------|---------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.5/0.72/0.86/1 |
| Swath (km) | 5.5/8 |
| 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 | 0.57/0.72/0.86 | |
| Blue | 0.450 | 0.483 | 0.515 | 0.75/1 | |
| Green | 0.515 | 0.555 | 0.595 | 0.75/1 | |
| Red | 0.605 | 0.650 | 0.695 | 0.75/1 | |
| NIR | 0.740 | 0.820 | 0.900 | 0.75/1 | |

Wavelength, in microns

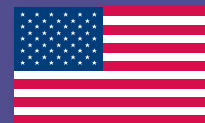
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/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]

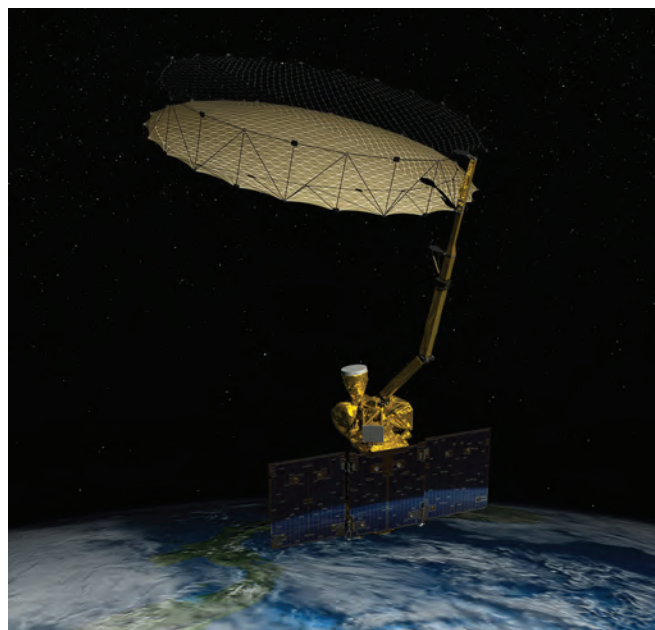
| | |
|------------------------|---------------------------------------------------------------------|
| Launch date | 01/31/2015 |
| Design lifetime | 3 years |
| Platform owner | NASA |
| Altitude | 685 km |
| Orbit period | 98.5 min |
| Inclination | 98° |
| Crossing time | 18:00 AN |
| Nadir repeat | 8 days |
| Status | Operational |
| System website | https://smap.jpl.nasa.gov/ |

Sensor Information

| | SMAP |
|--------------------|-----------------------------------------------------------------------------------------------------------|
| GSD (m) | 3,000 |
| Swath (km) | 1,000 |
| Data portal | https://www.asf.alaska.edu/smap/data-imagery/ |

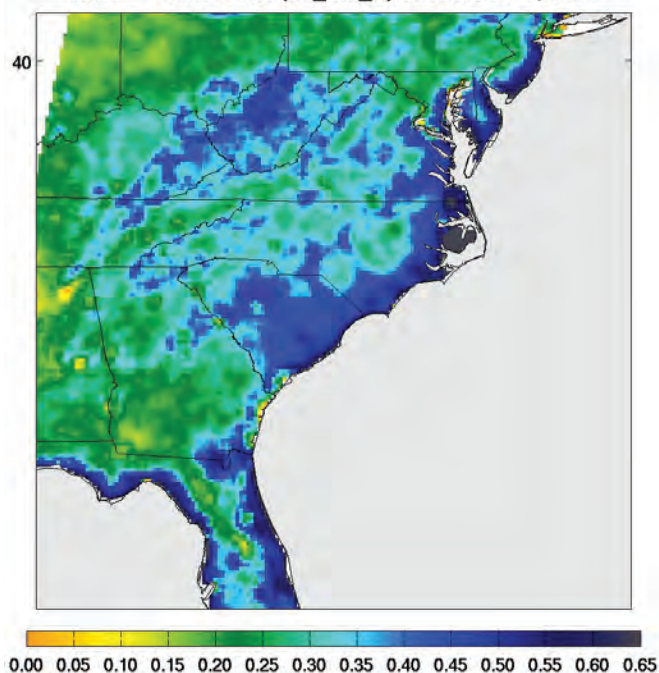
SMAP

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 failed in July 2015, after which Sentinel-1C-band radar data have been used as a substitute. The radiometer on board operates in the L-band at 1,400–1,427 MHz ($\lambda = 21.4\text{--}21.0$ cm). The angle of incidence is 40 degrees.



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

SMAP Soil Moisture (L2_SM_P) on October 5, 2015



SMAP soil moisture map (unitless) 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.

[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 |

Sensor Information

| | MIRAS |
|--------------------|-----------------------------------------------------------------------------------------------------|
| GSD (m) | 30,000 |
| Swath (km) | 900 |
| Data portal | https://smos-ds-02.eo.esa.int/oads/access/ |

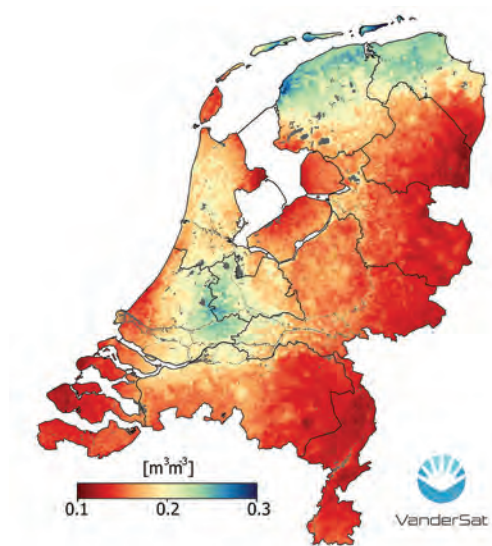
MIRAS

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.



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



Soil moisture in the Netherlands measured by SMOS (image from ESA).

Spacety-SAR Constellation

China
Commercial
Operational



Platform Overview

Hisea-1 is a high-resolution synthetic aperture radar (SAR) satellite launched by Spacety in 2020 on a Long March rocket from China for Earth resources monitoring. The satellite is the first in the TY-SAR constellation planned by Spacety. The satellite carries a C-band SAR for ocean remote sensing.

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

| | Hisea-1 |
|-----------------|-----------------------------------------------------------------------------------------------------------------------|
| Launch date | 12/22/2020 |
| Design lifetime | 5 years |
| Platform owner | Spacety |
| Altitude | 512 km |
| Orbit period | 94.8 min |
| Inclination | 97.4° |
| Crossing time | 12:00 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | https://en.spacety.com/index.php/sar-constellation/ |

Sensor Information

| Beam mode | Polarization | | Width (km) | Azimuth resolution (m) |
|-----------------|--------------|----|------------|------------------------|
| Striping | Single | VV | 20 | 3 |
| Spotlight | Single | VV | 5×5 | 1 |
| Scanning | Single | VV | 50 | 10 |
| Scanning (wide) | Single | VV | 100 | 20 |

C-Band and X-Band SAR

The C-band SAR on Hisea-1, centered at 5.4 gigahertz, operates in three modes with an incidence angle of 20–35 degrees.

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 in India 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 Pleiades-HR satellites in orbit. SPOT-6 and -7 carry the New AstroSat Optical Modular Instrument (NAOMI) sensor for high-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]

| | 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/8693-spot-67 | |

Sensor Information

| | NAOMI |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 1.5, 6 |
| Swath (km) | 60 |
| Data portal | https://www.intelligence-airbusds.com/en/4871-ordering |



SPOT-7 in orbit (image from Airbus Defence and Space, used with permission).



SPOT-7 satellite image of Sydney, Australia (image from Airbus Defence and Space, used with permission).

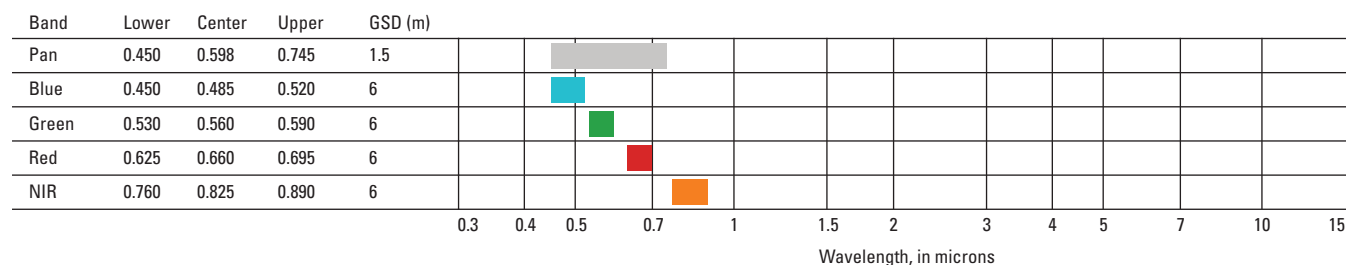
SPOT-6 and -7—Continued

France, Azerbaijan
Commercial
Operational



NAOMI

The NAOMI sensor is a proven design from Airbus Defence and Space 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 Defence and Space commercial portal.



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 Ltd. (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 (VHRI)-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, was launched in 2018. The imaging capacity of SSTL-S1 is also being leased to 21AT.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; —, no data; GSD, ground sample distance; m, meter; 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 | — | |
| Status | Operational | |
| System website | https://www.satimagingcorp.com/satellite-sensors/triplesat-satellite/ | |



Sir Martin Sweeting with DMC3/TripleSat Satellites, 2015 (image from SSTL, used with permission).

Sensor Information

| | VHRI-100 |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.8/3.2 |
| Swath (km) | 23.8 |
| Data portal | http://www.21at.sg/productsservices/triplesat-constellation/ |

SSTL-S1 (1-4)/DMC-3— Continued

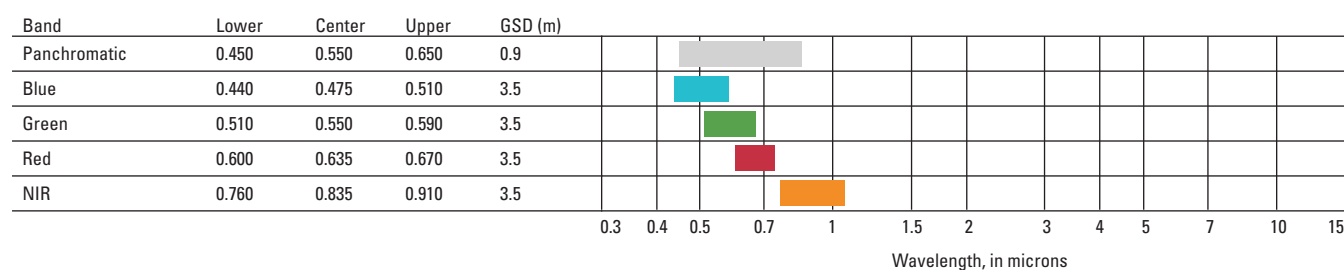
United Kingdom, China
Commercial
Operational



A 1-meter resolution pan-sharpened image is an extract showing Sydney Airport in Australia 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.



STORK

Poland
Commercial
Operational/Future



Platform Overview

STORK is a constellation of 3U CubeSats launched by Poland's SatRevolution for Earth resources monitoring. Out of 14 satellites in the constellation, 5 are currently operational. The STORK satellites are based on a 3U UniBus platform developed by SatRevolution and carry a Vision 300 sensor for medium-resolution Earth imaging.

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

| | STORK-1 | STORK-2 | STORK-3 | STORK-4 | STORK-5 |
|-----------------|-----------------------------------------------------------------------------|---------|---------|-------------|---------|
| Launch date | 01/13/2022 | | | 06/30/2021 | |
| Design lifetime | 3 years | | | | |
| Platform owner | SatRevolution | | | | |
| Altitude | 530 km | | | 500 km | |
| Orbit period | 95.2 min | | | 94.7 min | |
| Inclination | 97.5° | | | 61° | |
| Crossing time | 10:00 DN | | | — | |
| Nadir repeat | — | | | — | |
| Status | Operational | | | Operational | |
| System website | https://www.satrevolution.com/ | | | | |

Sensor Information

| | Vision 300 |
|-----------------------|------------|
| GSD (m) | 5 |
| Swath (km) | — |
| Revisit (days) | — |
| Data portal | — |

Vision 300

Vision 300 is an optical payload designed for nanosatellite and microsatellite applications. It is a medium-resolution imager with visible and near infrared spectral bands.

| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | | | | | |
|-------|-------|--------|-------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Blue | 0.400 | 0.455 | 0.510 | 5 | | | | | | | | | | | | | | | |
| Green | 0.520 | 0.560 | 0.600 | 5 | | | | | | | | | | | | | | | |
| Red | 0.600 | 0.640 | 0.680 | 5 | | | | | | | | | | | | | | | |
| NIR | 0.760 | 0.810 | 0.860 | 5 | | | | | | | | | | | | | | | |

Wavelength, in microns

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

RCA-E0; USGS EROS Center
47914 252nd St.
Sioux Falls, SD 57198
eccoe@usgs.gov

StriX SAR Constellation

Japan
Commercial
Operational



Platform Overview

StriX-Alpha is a synthetic aperture radar (SAR) technology demonstration satellite developed by Synspective, Inc., of Japan and launched on Rocket Lab's Electron rocket for day/night Earth monitoring. The planned constellation is to consist of 30 satellites with 6 satellites to be launched by 2023 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-1 is planned for launch on September 15 on a Rocket Lab Electron rocket from New Zealand into a 561-kilometer Sun-synchronous orbit.

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

| | StriX-Alpha | StriX-Beta | StriX-1 |
|-----------------|-----------------------------------------------------------------------------------|------------|------------|
| Launch date | 12/15/2020 | 02/28/2022 | 09/15/2022 |
| Design lifetime | 5 years | | |
| Platform owner | Synspective, Inc. | | |
| Altitude | 500 km | | 561 km |
| Orbit period | 94.5 min | | — |
| Inclination | 97.3° | | — |
| Crossing time | 10:30 AN | | — |
| Nadir repeat | — | | |
| Status | Operational | | Planned |
| System website | https://synspective.com/satellite | | |

Sensor Information

| Beam mode | Polarization | | Scene size (range × azimuth) [km] | Azimuth resolution (m) |
|-------------------|--------------|----|-----------------------------------------|---------------------------|
| StripMap | Single | VV | 30 | 3 |
| Sliding Spotlight | Single | VV | 10 | 1 |

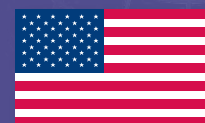
X-SAR

The X-SAR on StriX satellites operates in Spotlight and StripMap modes.

| Beam mode | Polarization | Nominal swath width (km) | Approximate resolution (m) |
|-------------------|--------------|-----------------------------|-------------------------------|
| StripMap | VV | 30 | 3 |
| Sliding Spotlight | VV | 10 | 1 |

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 2022, 2028, and 2032, 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 | 2022 (Planned) | 2028 (Planned) | 2032 (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 |

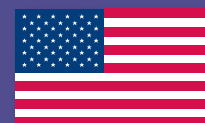
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Suomi NPP, NOAA-20, JPSS-2 to -4—Continued

United States
Civil/Government
Operational/Future

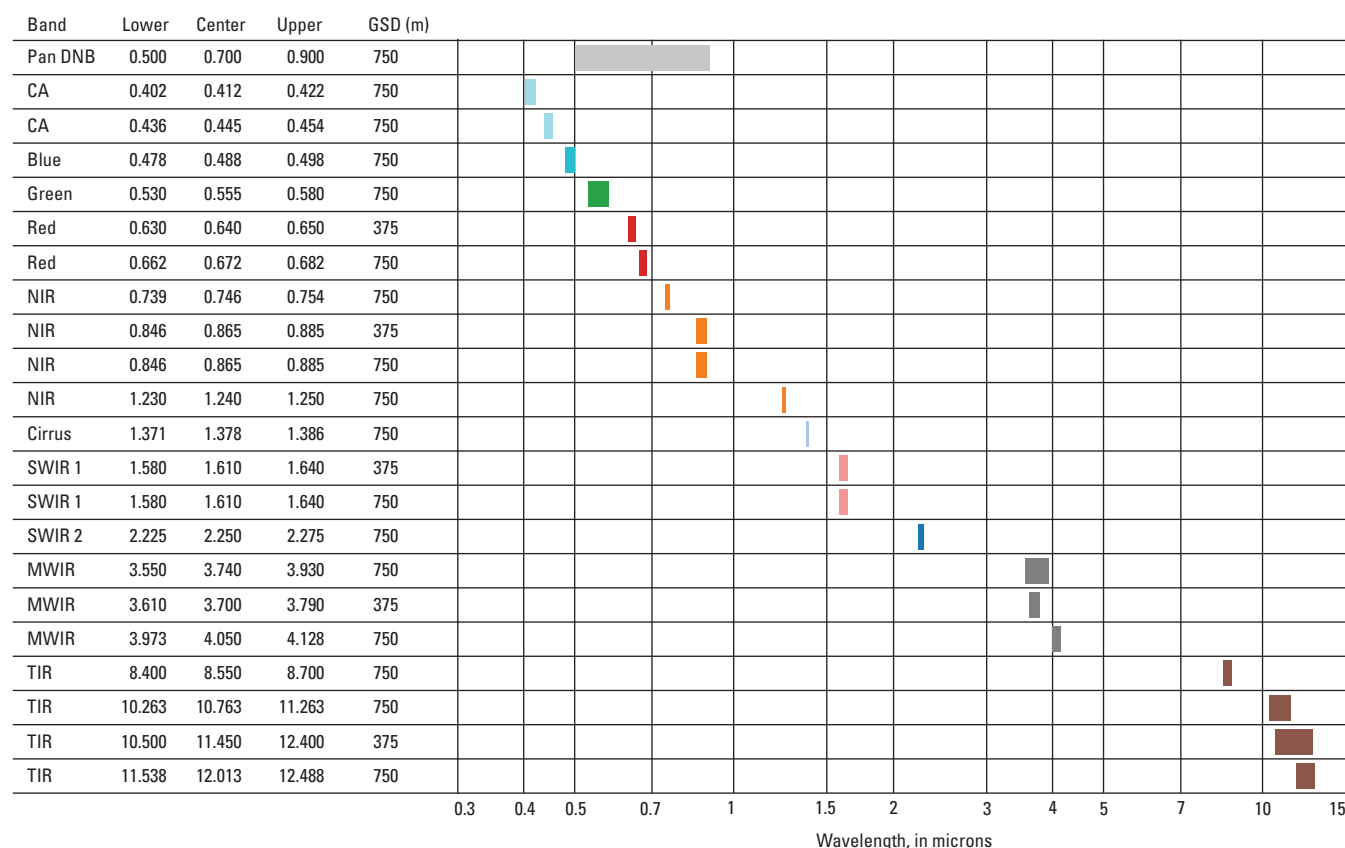


VIIRS

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.

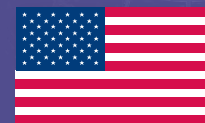


NOAA-20 VIIRS image showing one of the largest wildfires in California history (image from NOAA).



SuperDove

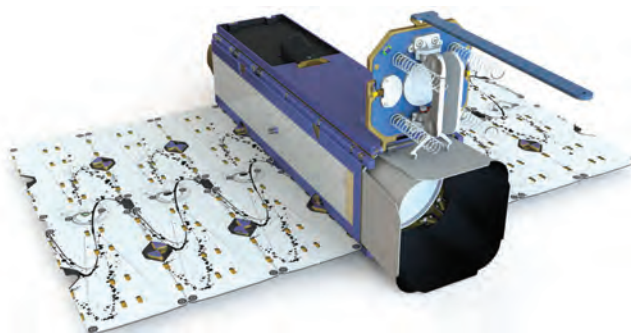
United States
Commercial
Operational/Future



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 in India.

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. Flock-4v and Flock-4s were launched in 2020 and 2021, respectively.



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]

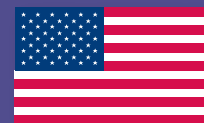
| | Flock-4a | Flock-4p | Flock-4s | Flock-4v | Flock-4x |
|------------------------|-------------------------------------------------------------|------------|------------|------------|------------|
| Launch date | 04/01/2019 | 11/27/2019 | 01/24/2021 | 09/03/2020 | 01/13/2020 |
| Design lifetime | 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) | 3/6/12 |
| Swath (km) | 36 |
| Data portal | https://www.planet.com/products/planet-imagery/ |

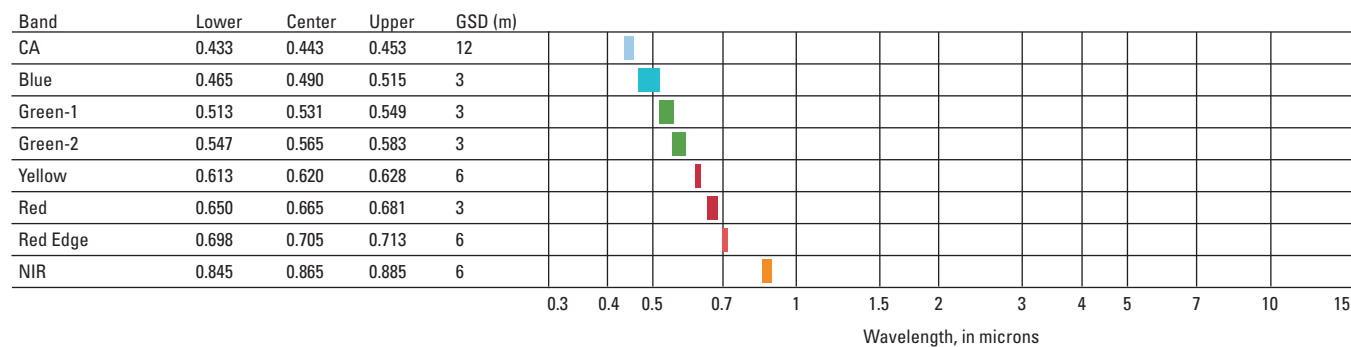
SuperDove—Continued

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.



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 in China. 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.

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

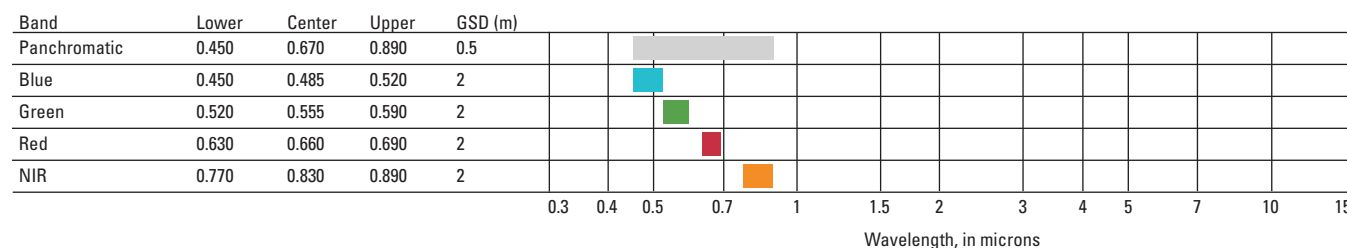
| | SuperView-1 01 and 02 | SuperView-1 03 and 04 |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Launch date | 12/28/2016 | 01/09/2018 |
| Design lifetime | 8 years | |
| 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 | http://www.spacewillinfo.com/SuperView-1English/index.html |

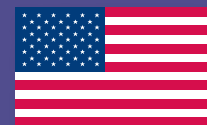
SuperView Imager

The imager on SuperView-1 satellites is a pushbroom imager in panchromatic, visible, and near-infrared regions.



Surface Biology and Geology Mission

United States
Civil/Government
Future



Platform Overview

Surface Biology and Geology (SBG) mission consists of two medium-resolution satellites, SBG Light and SBG Heat, 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 Light will carry a hyperspectral imager in visible shortwave infrared (VSWIR) at a 30-meter (m) ground sample distance (GSD), and SBG Heat will carry an infrared sensor at a 60-m GSD for medium-resolution land imaging.

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

| | SBG Light | SBG Heat |
|-----------------|-------------------------------------------------------------------|-----------|
| Launch date | 2027 | |
| Design lifetime | 3 years | |
| Platform owner | NASA | |
| Altitude | 619 km | 666 km |
| Orbit period | 97.08 min | 98.06 min |
| Inclination | 97.86° | 98.04° |
| Crossing time | 11:00 DN | 13:30 DN |
| Nadir repeat | 16 days | 3 day |
| Status | Development | |
| System website | https://sbg.jpl.nasa.gov/ | |



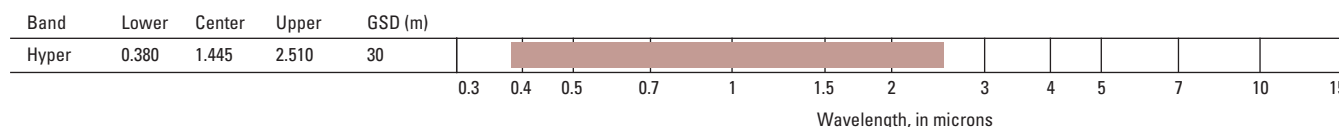
Artistic rendering of HypSIIRI, an early development, conceptual sensor precursor to the SBG mission (image from NASA).

Sensor Information

| | VSWIR | TIR |
|-------------|-------|-------|
| GSD (m) | 30–45 | 40–60 |
| Swath (km) | 185 | |
| Data portal | — | |

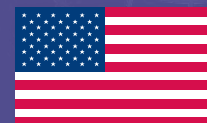
VSWIR

The VSWIR Imaging Spectrometer on SBG Light is a hyperspectral imager with a wide spectral range.



Surface Biology and Geology Mission—Continued

United States
Civil/Government
Future



TIR

The TIR sensor on SBG Heat is a multispectral infrared imager with a wide swath, operating in the thermal part of the spectrum.

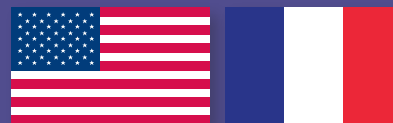
| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | | | | | |
|------|--------|--------|--------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| MWIR | 3.940 | 3.982 | 4.024 | 60 | | | | | | | | | | | | | | | |
| TIR | 7.190 | 7.350 | 7.509 | 60 | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | |

0.3 0.4 0.5 0.7 1 1.5 2 3 4 5 7 10 15

Wavelength, in microns

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 2022 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 | 2022 (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/ |

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 ($\lambda = 0.84$ centimeter).



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 | — |

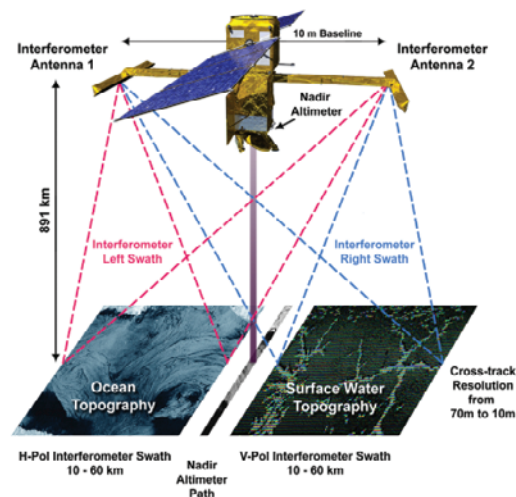


Illustration of the KaRIn instrument operation (image from NASA).

| Beam mode | Polarization | | Nominal swath width (km) | Approximate resolution (m) |
|--------------------|---------------------|----|---------------------------------|-----------------------------------|
| Left swath | Single | HH | 50 | 5×10–70 |
| Right swath | Single | VV | 50 | 5×10–70 |

TanDEM-L

Germany
Civil/Government
Future

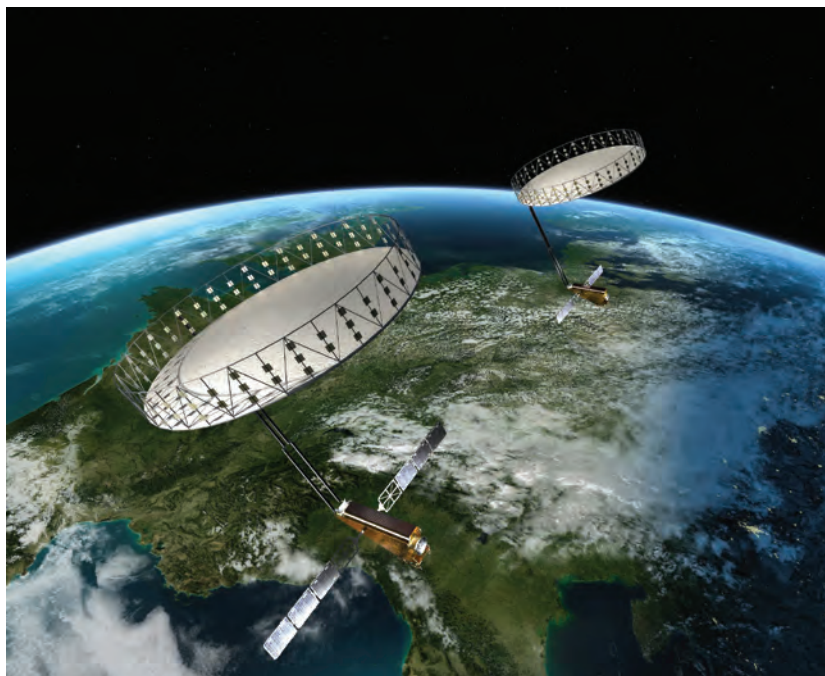


Platform Overview

TanDEM-L is a medium-resolution, multisatellite synthetic aperture radar (SAR) satellite mission 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. The TanDEM-L mission will have 2 satellites and will carry an L-band synthetic aperture radar (L-SAR) instrument for collecting SAR data.

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

| | |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Launch date | 2024 (Planned) |
| Design lifetime | 10 years |
| Platform owner | DLR |
| Altitude | 741 km |
| Orbit period | 99.72 min |
| Inclination | 98.37° |
| Crossing time | 18:00 AN |
| Nadir repeat | 16 days |
| Status | Development |
| System website | https://www.dlr.de/hr/en/desktopdefault.aspx/tabid-8113/ |



Artistic rendering of TanDEM-L in orbit (image from DLR).

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 (2022) are not available.

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]

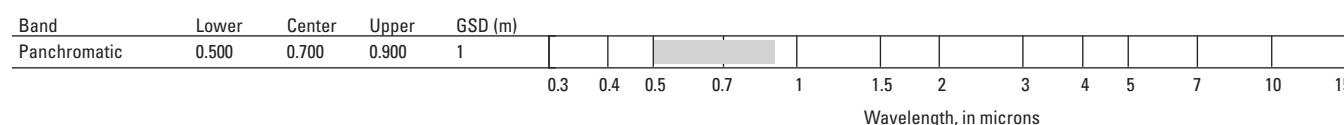
| | TeLEOS-1 | TeLEOS-2 |
|------------------------|-------------|----------------|
| Launch date | 12/16/2015 | 2022 (Planned) |
| Design lifetime | 5 years | |
| Platform owner | STEE | |
| Altitude | 550 km | — |
| Orbit period | 96 min | — |
| Inclination | 15° | — |
| Crossing time | — | — |
| Nadir 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.

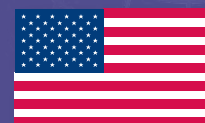


SAR

TeLEOS-2 SAR is under development. Details are not currently (2022) available.

Terra

United States
Civil/Government
Operational



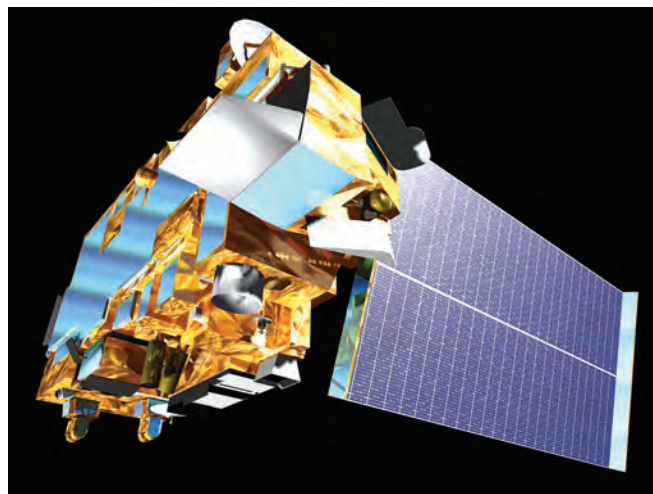
Platform Overview

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.

[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]

| | |
|------------------------|---------------------------------------------------------------|
| 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/ |



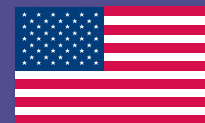
Artistic rendering of Terra in orbit (image from NASA).



A vivid phytoplankton bloom colored the surface waters of Norway'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 | | | | | | | | | | | | | | | |

Wavelength, in microns

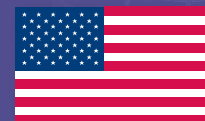
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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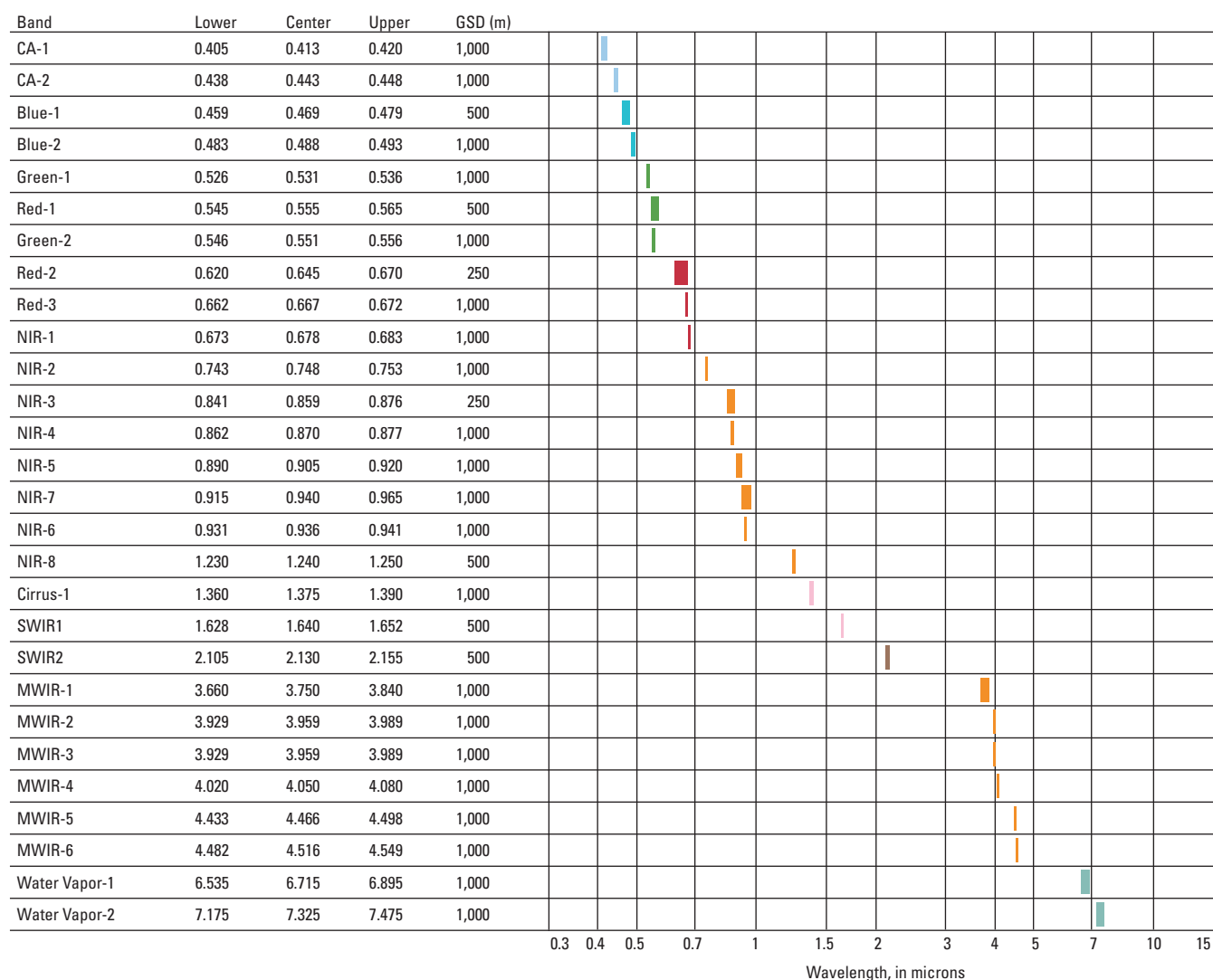
Terra—Continued

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.



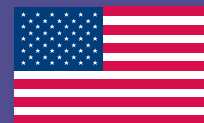
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

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Terra—Continued

United States
Civil/Government
Operational



MODIS—Continued

| Band | Lower | Center | Upper | GSD (m) | | | | | | | | | | | | | | | |
|-------|--------|--------|--------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| TIR-1 | 8.400 | 8.550 | 8.700 | 1,000 | | | | | | | | | | | | | | | |
| TIR-2 | 9.580 | 9.730 | 9.880 | 1,000 | | | | | | | | | | | | | | | |
| TIR-3 | 10.780 | 11.030 | 11.280 | 1,000 | | | | | | | | | | | | | | | |
| TIR-4 | 11.770 | 12.020 | 12.270 | 1,000 | | | | | | | | | | | | | | | |
| TIR-5 | 13.185 | 13.335 | 13.485 | 1,000 | | | | | | | | | | | | | | | |
| TIR-6 | 13.485 | 13.635 | 13.785 | 1,000 | | | | | | | | | | | | | | | |
| TIR-7 | 13.785 | 13.935 | 14.085 | 1,000 | | | | | | | | | | | | | | | |
| TIR-8 | 14.085 | 14.235 | 14.385 | 1,000 | | | | | | | | | | | | | | | |

0.3 0.4 0.5 0.7 1 1.5 2 3 4 5 7 10 15
Wavelength, in microns

TerraSAR-X and TanDEM-X

Germany
Civil/Government
Operational



Platform Overview

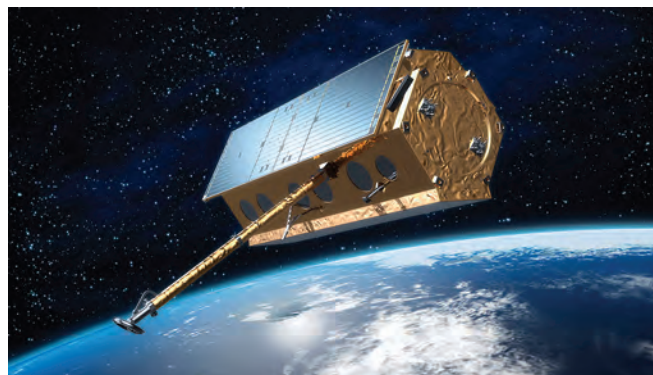
TerraSAR-X (TSX) is a multiresolution synthetic aperture radar (SAR) satellite launched in 2007 by the German Aerospace Centre (DLR) on a Dnepr-1 launch vehicle from the Russian Cosmodrome, Baikonur, Kazakhstan, for Earth resources monitoring. TSX was built by Airbus Defence and Space GmbH and uses the 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.

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

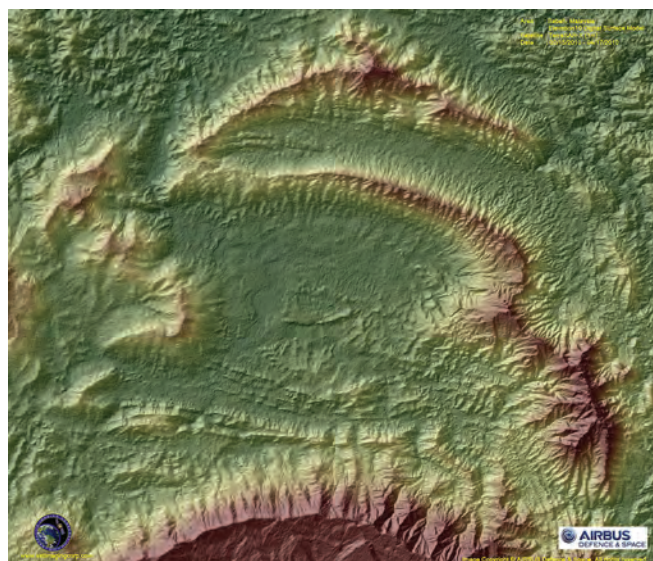
| | TerraSAR-X | TanDEM-X |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------|------------|
| Launch date | 06/15/2007 | 06/21/2010 |
| Design lifetime | 5 years | |
| Platform owner | DLR | |
| Altitude | 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/content/en/missions/terrasar-x.html | |

Sensor Information

| | TSX-SAR |
|--------------------|-------------------------------------------------------------------------------------------------|
| GSD (m) | 1–16 (selectable) |
| Swath (km) | 5–1,500 (selectable) |
| Data portal | https://terrasar-x-archive.terrasar.com/ |



Artistic rendering of TerraSAR-X in orbit (image from DLR).



TerraSAR-X elevation data of Sabah, Malaysia (image from Airbus Defence and Space, used with permission).

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 ($\lambda = 3.11$ 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 | 5×10 | 2×1 |
| | Dual | — | | |
| Spotlight HS | Single | HH, HV, VH, VV | 10×10 | 2×1 |
| | Dual | — | | |
| Spotlight SL | Single | HH, HV, VH, VV | 5×10 | 1×1 |
| | Dual | — | | |
| Stripmap | Single | HH, HV, VH, VV | 1,500×30 | 3×3 |
| | Dual | — | | |
| ScanSAR | Single | HH, HV, VH, VV | 1,500×100 | 16×16 |
| | Dual | — | | |

THEOS

Thailand
Civil/Government
Operational



Platform Overview

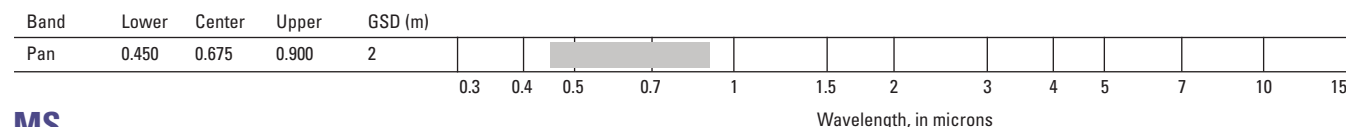
Thailand Earth Observing System (THEOS) is a medium-resolution, panchromatic, and multispectral satellite launched in 2008 on a Dnepr launch vehicle from Yasny/Dombrovsky launch center in Thailand by Geo-Informatics and Space Technology Development Agency (GISTDA) for Earth observation. THEOS was designed 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; —, no data; GSD, ground sample distance; m, meter; 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 | — |

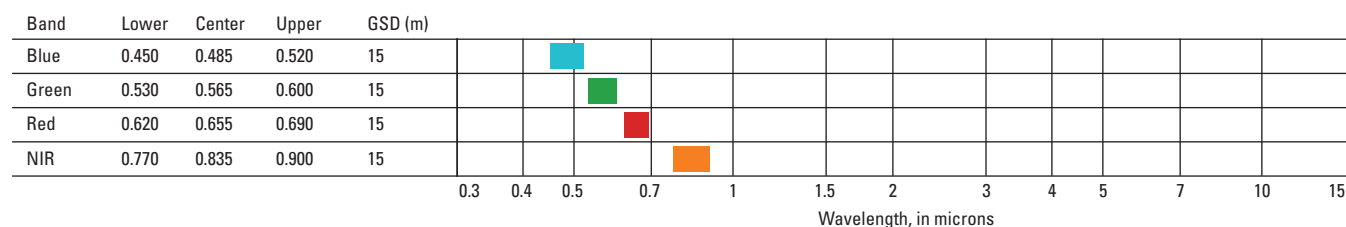
Pan

The Pan aboard THEOS is a pushbroom-style charge coupled device (CCD) imager.



MS

The MS aboard THEOS is a pushbroom-style CCD imager with four visible and near-infrared bands.



Artistic rendering of THEOS in orbit (image from GISTDA, used with permission).

Sensor Information

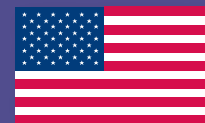
| | Pan | MS |
|--------------------|-----|----|
| GSD (m) | 2 | 15 |
| Swath (km) | 22 | 90 |
| Data portal | — | |



Sample THEOS images (image from GISTDA, used with permission).

Umbra SAR Constellation

United States
Commercial
Operational



Platform Overview

Umbra SAR 01 is a high-resolution synthetic aperture radar (SAR) satellite launched in 2021 on a Falcon 9 rocket by Umbra Lab for Earth resources monitoring. The satellite is part of a 24-satellite constellation planned by Umbra Lab to provide X-band SAR data at a high revisit rate. The Umbra satellites carry an X-band SAR for radar imaging.

[Abbreviations in tables: km, kilometer; min, minute; °, degree; DN, descending node; m, meter; H, horizontal; V, vertical]

| | Umbra SAR 01 |
|-----------------|---------------------------------------------------------------------------|
| Launch date | 06/30/2021 |
| Design lifetime | 5 years |
| Platform owner | Umbra Lab |
| Altitude | 560 km |
| Orbit period | 95.5 min |
| Inclination | 97.4° |
| Crossing time | 13:30 DN |
| Nadir repeat | 14 |
| Status | Operational |
| System website | https://umbra.space/sar-specs |



Image of the Umbra satellite model (image from Umbra Lab).

Sensor Information

| Beam mode | Polarization | | Swath | Azimuth resolution (m) |
|----------------|--------------|--------|-------|------------------------|
| Extended swell | Single | HH, VV | 4 | 0.3 |
| Scanning | Single | HH, VV | 100 | 10 |
| Spotlight | Single | HH, VV | 4 | 0.3 |
| Stripmap | Single | HH, VV | 20 | 3 |

StriX X-Band SAR

The X-band SAR on Umbra satellites operates in four modes. The data from the Umbra satellite are planned to be available commercially.

VEN μ S

France, Israel
Civil/Government
Operational



Platform Overview

The Vegetation and Environment monitoring on a New MicroSatellite mission (VEN μ S) 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, VEN μ S 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, VEN μ S 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, VEN μ S Mission 3). VEN μ S carries the VEN μ S Superspectral Camera (VSSC) for medium-resolution land imaging. The VEN μ S mission began a new phase, VM5, in March 2022 and now operates in a 560-km orbit providing a 1-day revisit with a 4-meter spatial resolution.

[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 | 4 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 VEN μ S 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 Ven μ s (image from CNES, used with permission).

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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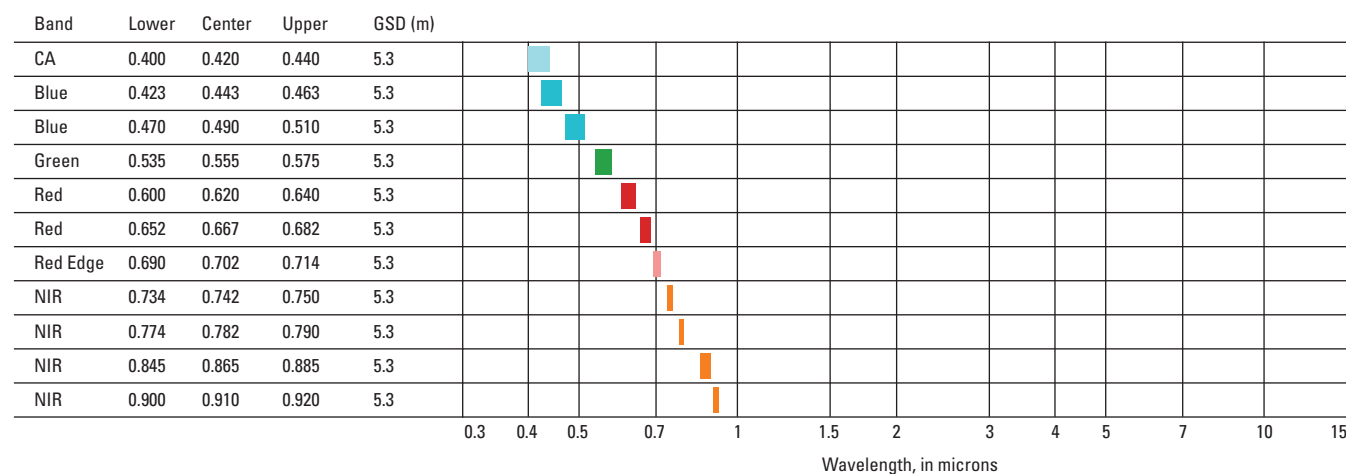
VEN_μS—Continued

France, Israel
Civil/Government
Operational



VSSC

The VSSC was built by Elbit Systems Electro-Optics of Rehovot, Israel, under contract with CNES.



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 2023 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 Surrey Satellite Technology Ltd. (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.

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

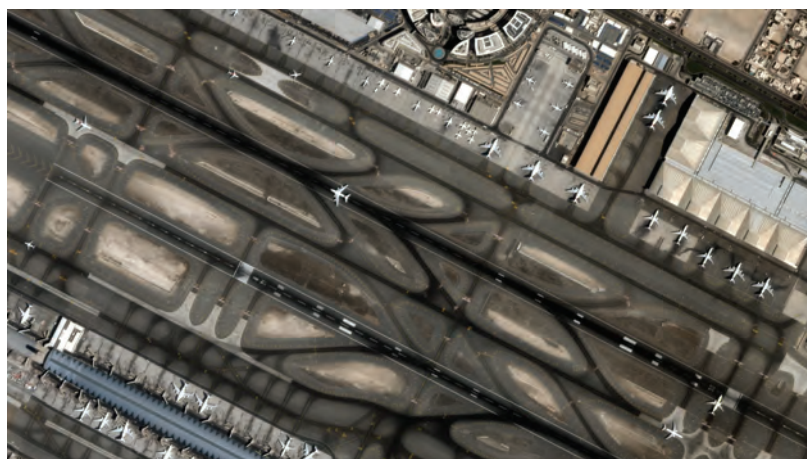
| | |
|------------------------|-----------------------------------------------------------|
| Launch date | 2023 (Planned) |
| Design lifetime | 5 years |
| Platform owner | Earth-i |
| Altitude | 500 km |
| Orbit period | 94.36 min |
| Inclination | 97.33° |
| Crossing time | 10:30 DN |
| Nadir repeat | 1 day |
| Status | Development |
| System website | http://earth-i.space/ |

Sensor Information

| | HRI |
|--------------------|-----------------------------------------------------------------------------------|
| GSD (m) | 0.6 |
| Swath (km) | 5 |
| Data portal | https://earth-i.space/image-data/ |



Artistic rendering of a Vivid-i satellite (image from Earth-i, Ltd., used with permission).



A 1-meter resolution image of Dubai Airport in Dubai, United Arab Emirates, acquired by CARBONITE-2 satellite, 2018 (image from SSTL, used with permission).

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 | | | | | | | | | | | | | | | |
| | | | | | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 1 | 1.5 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | |
| | | | | | Wavelength, in microns | | | | | | | | | | | | | | |

Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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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.

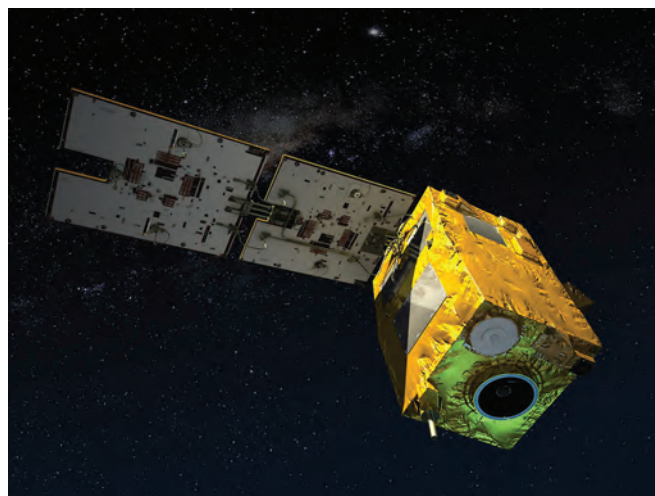
VNREDSat-1A was developed and built by European Aeronautic Defence and Space Company Astrium and is based on the AstroSat-100 bus. It is operated by the Vietnam Academy of Science and Technology (VAST) and is the first Earth Observation satellite for Vietnam. The satellite carries the New AstroSat Optical 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.

[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/ |

Sensor Information

| | NAOMI |
|--------------------|--------|
| GSD (m) | 2.5/10 |
| Swath (km) | 17.5 |
| Data portal | — |



Artistic rendering of VNREDSat-1A (image from Airbus Defence and Space, used with permission).



VNREDSat-1 imagery (image from Airbus Defence and Space, used with permission).

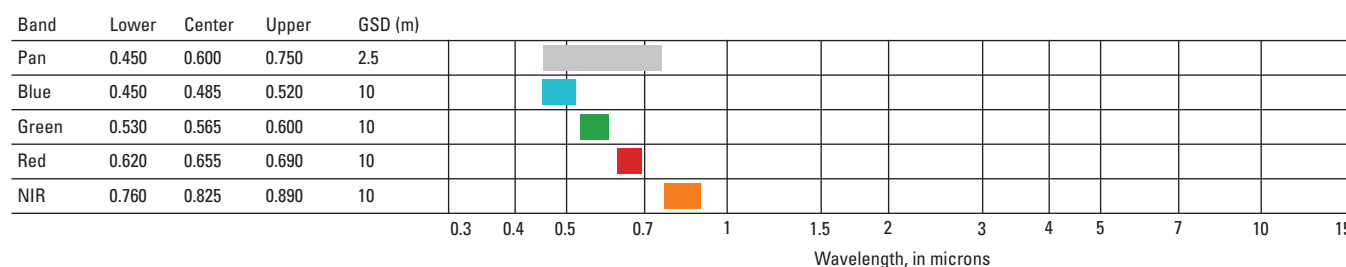
VNREDSat-1A—Continued

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.



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 in China. 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]

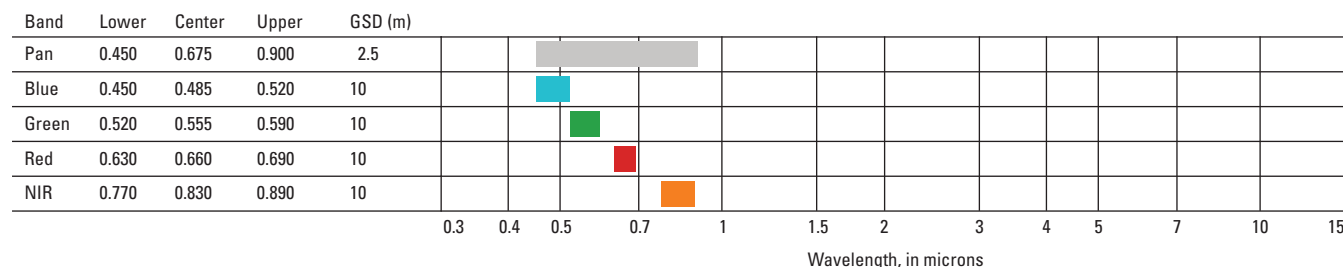
| | |
|------------------------|-----------------------------------------------------------------------------------------|
| Launch date | 09/29/2012 |
| Design lifetime | 5 years |
| Platform owner | ABAE |
| Altitude | 640 km |
| Orbit period | 97.5 min |
| Inclination | 98° |
| Crossing time | 10:30 DN |
| Nadir repeat | 4 days |
| Status | Operational |
| System website | http://www.abae.gob.ve/?page_id=1092 |

Sensor Information

| | PMC | WMC |
|--------------------|---------|-----|
| GSD (m) | 2.5, 10 | 16 |
| Swath (km) | 57 | 370 |
| Data portal | — | |

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.



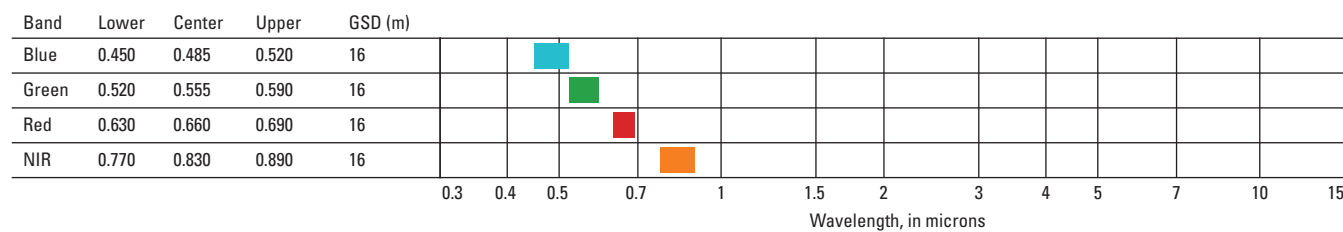
VRSS-1—Continued

Venezuela
Civil/Government
Operational



WMC

The WMC is like PMC with two imagers operating with TDI capability.



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 in China. 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; GSD, ground sample distance; m, meter; —, no data; Pan, panchromatic; NIR, near infrared; SWIR, shortwave infrared; TIR, thermal infrared]

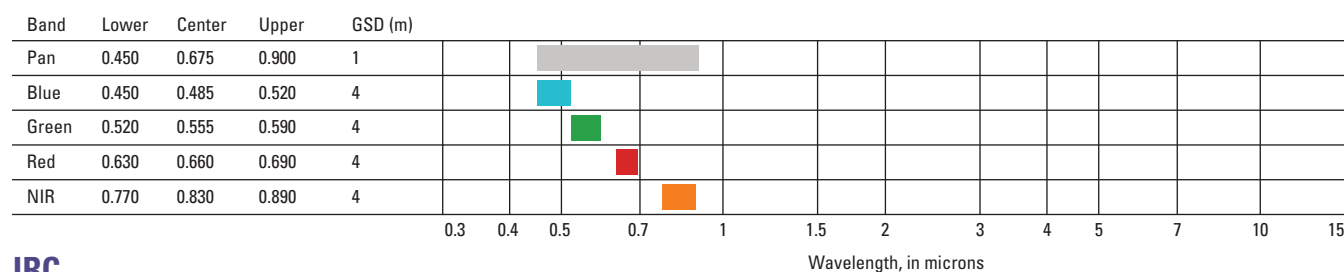
| | |
|-----------------|-----------------------------------------------------------------------------------------|
| Launch date | 10/09/2017 |
| Design lifetime | 5 years |
| Platform owner | ABAE |
| Altitude | 650 km |
| Orbit period | 97.62 min |
| Inclination | 98° |
| Crossing time | 11:30 DN |
| Nadir repeat | 4 days |
| Status | Operational |
| System website | http://www.abae.gob.ve/?page_id=1094 |

Sensor Information

| | PMC-2 | IRC |
|-------------|-------|--------|
| GSD (m) | 1, 4 | 30, 60 |
| Swath (km) | 30 | 30 |
| Data portal | — | |

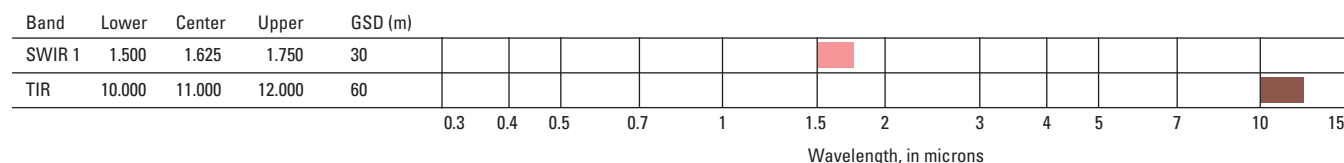
PMC-2

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.



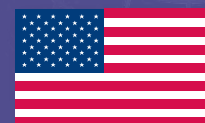
IRC

The IRC is a new design with a capability of observing in the SWIR and TIR parts of the spectrum.



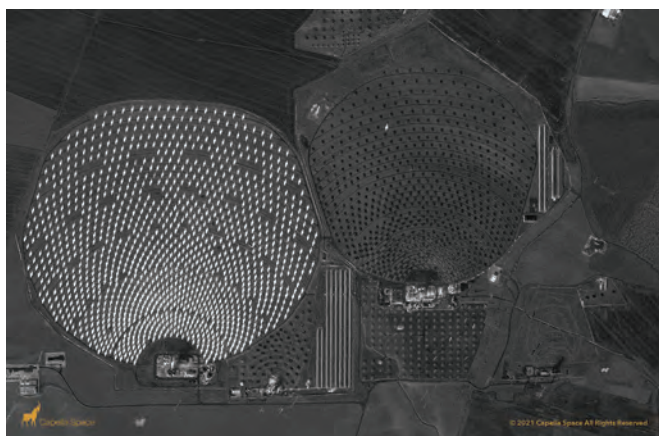
Whitney Constellation

United States
Commercial
Operational/Future

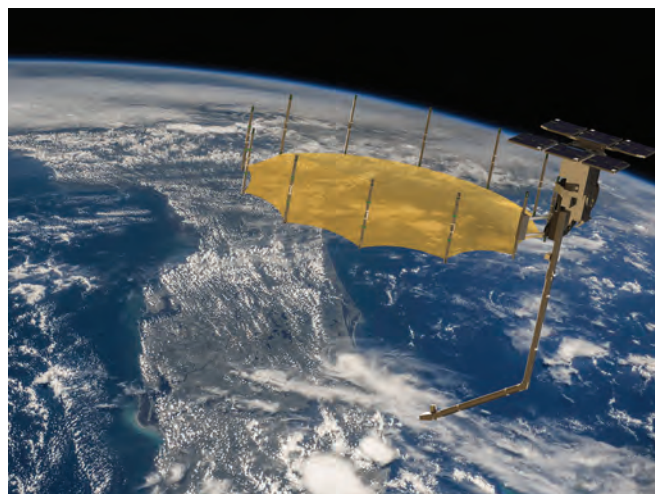


Platform Overview

Denali is a synthetic aperture radar (SAR) technology demonstration satellite launched in 2018 by Capella Space for radar Earth monitoring. Capella Space is launching a constellation of SAR satellites called the “Whitney constellation” and consisting of 36 12U CubeSats. They carry an X-band SAR for radar Earth observation.



The PS10 Solar Power Plant in Seville, Spain, imaged by the Whitney satellite in Spotlight mode (image from Capella Space, used with permission).



Artistic rendering of Sequoia satellite in orbit (image from Capella Space, used with permission).

Sensor Information

| | SAR |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| GSD (m) | 0.5 |
| Swath (km) | 7 |
| Data portal | https://www.capellaspace.com/community/capella-open-data/ |

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

| | Denali | Sequoia | Whitney-1, 2 | Whitney-3 | Whitney-4 | Whitney-5, 6 |
|------------------------|---------------------------------------------------------------------------|------------|--------------|------------|------------|--------------|
| Launch date | 12/03/2018 | 03/30/2020 | 01/24/2021 | 06/30/2021 | 05/15/2021 | 01/13/2022 |
| Design lifetime | — | | | | | |
| Platform owner | Capella Space | | | | | |
| Altitude | 575 km | 525 km | 525 km | 575 km | 530 km | |
| Orbit period | 96.16 min | 95 min | 95 min | 96.1 min | 95.1 min | |
| Inclination | 97.7° | 45° | 97.5° | 53.0° | 97.5° | |
| Crossing time | 10:30 DN | — | 10:30 DN | — | 10:30 DN | |
| Nadir repeat | — | | | | | |
| Status | Operational | | | | | |
| System website | https://www.capellaspace.com/ | | | | | |

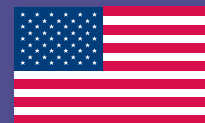
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

For Joint Agency Commercial Imagery Evaluation (JACIE) sensor performance information see: <https://www.usgs.gov/calval/jacie>

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Whitney Constellation—Continued

United States
Commercial
Operational/Future



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 | 0.3×0.5 |
| SITE | Single | HH, VV | 5 | 0.5×0.5 |
| STRIP | Single | HH, VV | 5 | 1.0×7.0 |
| SCAN | Single | HH, VV | 7 | 2.5×1.7 |

WildFireSat

Canada
Civil/Government
Future



Platform Overview

WildFireSat (WFS) is a medium-resolution Earth observation satellite constellation planned for launch in 2028 by the Canadian Space Agency to monitor wildfires. The constellation is planned to consist of three satellites phased at 90 degrees with each other in a Sun-synchronous orbit. The satellites will carry a multispectral imager covering visible and infrared regions for wildfire management.

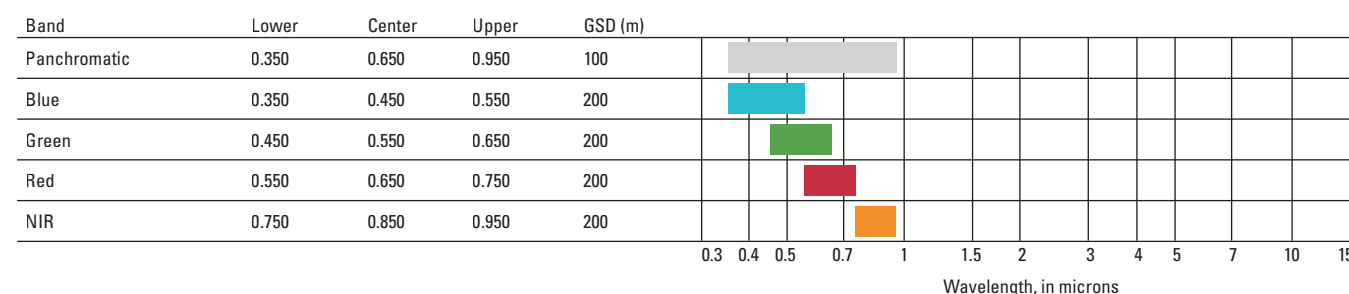
[Abbreviations in tables: km, kilometer; —, no data; AN, ascending node; VNIR, visible and near infrared; GSD, ground sample distance; m, meter; NIR, near infrared; MWIR, midwave infrared; TIR, thermal infrared]

| | WFS-1 | WFS-1 | WFS-1 |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| Launch date | 2028 (Planned) | | |
| Design lifetime | 5 years | | |
| Platform owner | Canadian Space Agency | | |
| Altitude | 650 km | | |
| Orbit period | — | | |
| Inclination | — | | |
| Crossing time | 18:00 AN | | |
| Nadir repeat | — | | |
| Status | Development | | |
| System website | https://www.asc-csa.gc.ca/eng/satellites/wildfiresat/default.asp | | |

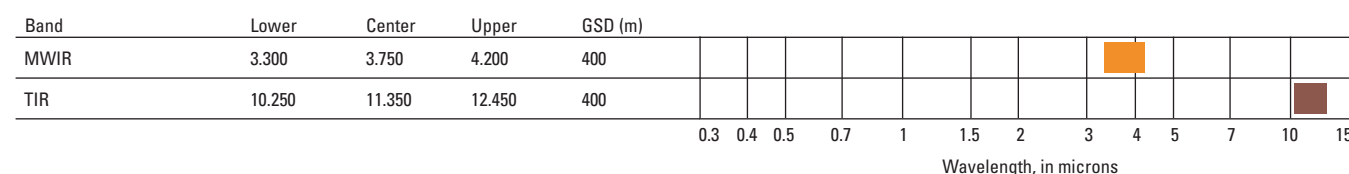
Sensor Information

| | VNIR camera | Thermal camera |
|-----------------------|-------------|----------------|
| GSD (m) | 100/200 | 400 |
| Swath (km) | 400 | 400 |
| Revisit (days) | 0.5 | |
| Data portal | — | |

WFS Visible and Near-Infrared Camera



WFS Thermal Camera



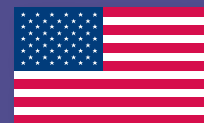
Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

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WorldView-1

United States
Commercial
Operational



Platform Overview

WorldView-1 (WV-1) is a high-resolution panchromatic satellite launched in 2007 by Maxar Technologies on a Delta-II launch vehicle from Vandenberg Air Force Base in California 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.

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

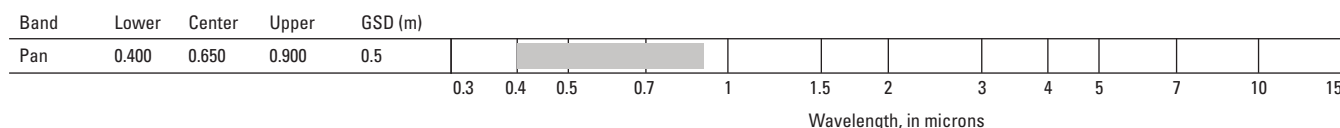
| | |
|------------------------|-------------------------------------------------------------|
| Launch date | 09/18/2007 |
| Design lifetime | 7.5 years |
| Platform owner | Maxar Technologies |
| Altitude | 496 km |
| Orbit period | 94.6 min |
| Inclination | 97.2° |
| Crossing time | 13:30 DN |
| Nadir repeat | — |
| Status | Operational |
| System website | https://www.maxar.com/ |

Sensor Information

| | WV-60 |
|--------------------|-------------------------------------------------------------|
| GSD (m) | 0.5 |
| Swath (km) | 18 |
| Data portal | https://www.maxar.com/ |

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.



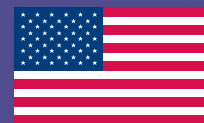
Artistic rendering of WorldView-1 (image from Maxar Technologies, 2019, used with permission).



WorldView-1 image of Stratolaunch in Mojave, California (image from Maxar Technologies, 2019, used with permission).

WorldView-3

United States
Commercial
Operational



Platform Overview

WorldView-3 (WV-3) is a high-resolution multispectral satellite launched in 2014 by the Maxar Technologies on an Atlas V from Vandenberg Air Force Base in California for Earth resource monitoring. WV-3 provides substantial 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 Maxar Technologies 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. |
| Altitude | 620 km |
| Orbit period | 97 min |
| Inclination | 97.9° |
| Crossing time | 10:30 DN |
| Nadir repeat | 5 days |
| Status | Operational |
| System website | https://www.maxar.com/ |

Sensor Information

| | CAVIS | WV-3 Imager |
|--------------------|-------------------------------------------------------------|---------------|
| GSD (m) | 30 | 0.31/1.24/3.7 |
| Swath (km) | 13.1 | |
| Data portal | https://www.maxar.com/ | |



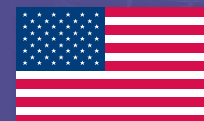
Artistic rendering of WorldView-3 in orbit (image from Maxar Technologies, 2019, used with permission).



WorldView-3 image of Beijing Daxing International Airport, Beijing, China (image from Maxar Technologies, 2019, used with permission).

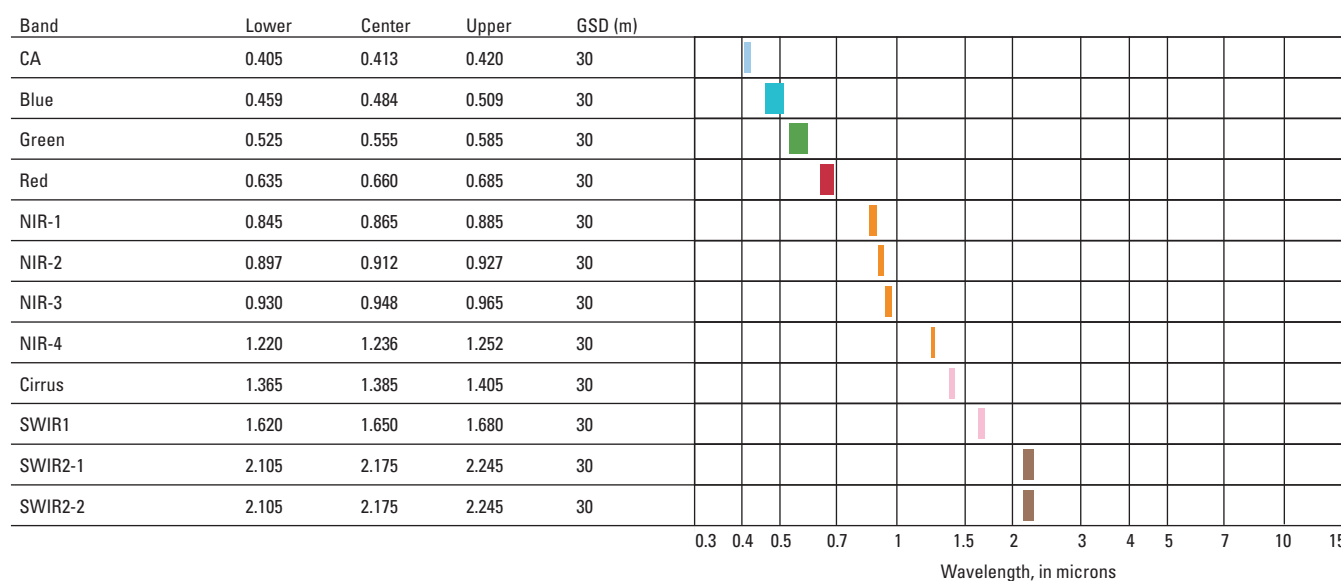
WorldView-3—Continued

United States
Commercial
Operational



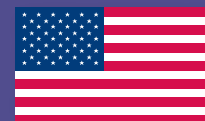
CAVIS

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 Maxar Technologies.



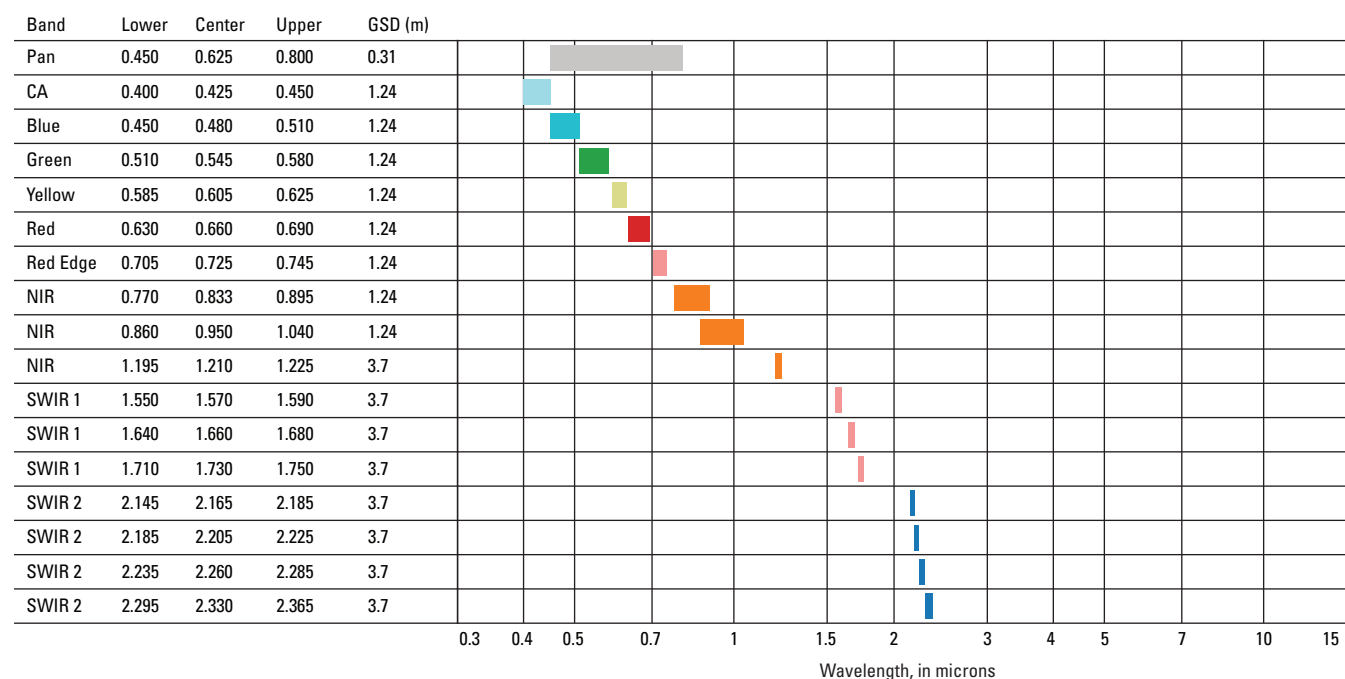
WorldView-3—Continued

United States
Commercial
Operational



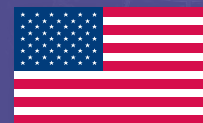
WV-3 Imager

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 Maxar Technologies to resample the SWIR data to 7.5-m effective GSD.



WorldView Legion

United States
Commercial
Future

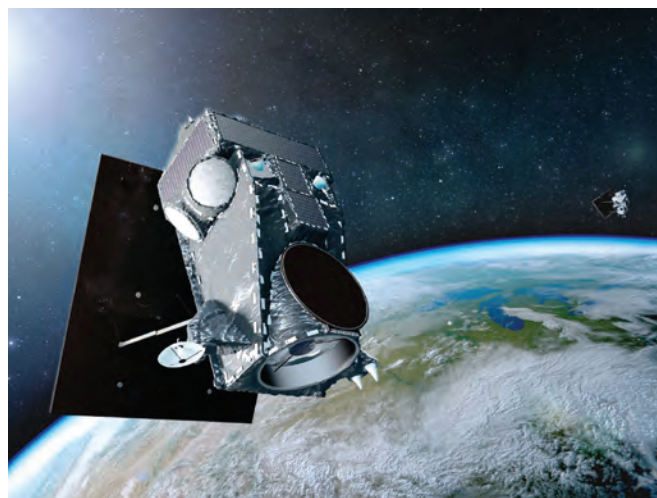


Platform Overview

The WorldView Legion constellation of high-resolution, panchromatic, and multispectral satellites are planned to be launched in 2022 by Maxar Technologies for commercial Earth observation. The satellites will have a mix of mid-latitude and Sun-synchronous orbits. In conjunction with the WorldView Scout satellites, Maxar Technologies will have the ability to image regions of Earth as many as 40 times daily. Maxar Technologies 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; WVLI, WorldView Legion Imager; GSD, ground sample distance; m, meter; CA, coastal aerosol; NIR, near infrared]

| | |
|------------------------|-------------------------------------------------------------|
| Launch date | 2022 (Planned) |
| Design lifetime | 7.5 years |
| Platform owner | Maxar Technologies |
| Altitude | 450 km |
| Orbit period | 94 min |
| Inclination | — |
| Crossing time | 10:30 DN |
| Nadir repeat | — |
| Status | Development |
| System website | https://www.maxar.com/ |



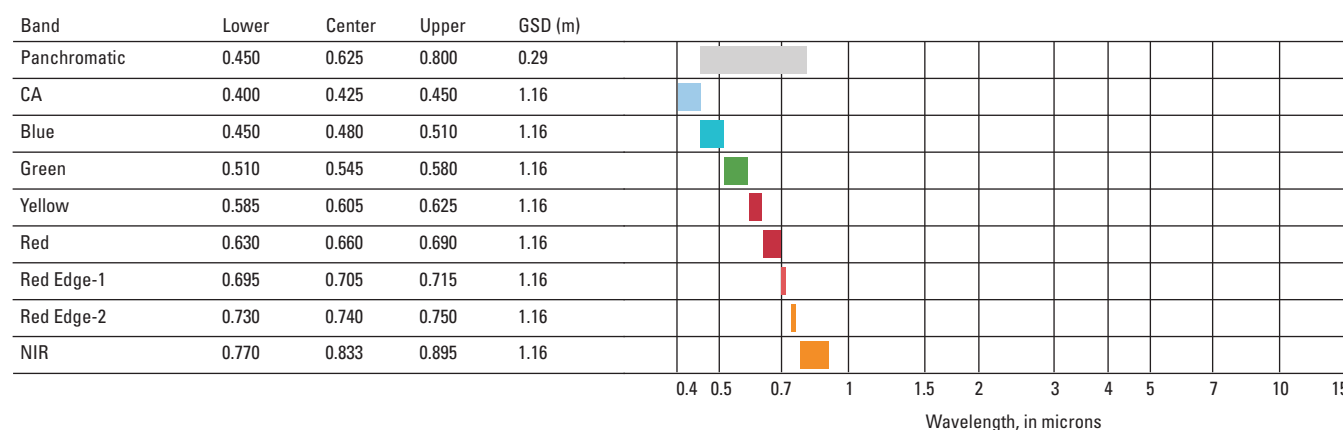
Artistic rendering of a WorldView Legion satellite in orbit (image from Maxar Technologies, 2019, used with permission).

Sensor Information

| | WVLI |
|--------------------|-------------------------------------------------------------|
| GSD (m) | 0.29/1.16 |
| Swath (km) | 9 |
| Data portal | https://www.maxar.com/ |

WorldView Legion Imager

The imager aboard the WorldView Legion satellites will have a ground sample distance of 0.29 meter. Data will be commercially available.



Data compiled by the USGS National Land Imaging Program's Requirements Capabilities and Analysis for Earth Observation (RCA-E0) project. JACIE is a collaboration between U.S. Federal agencies NASA, NGA, NOAA, USDA, and USGS. For more information see: <https://www.usgs.gov/calval/jacie>

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