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IAC-26,B1,1,2,x117403

# Transforming the Speed of Science with a new model for Earth Observation Cooperation: International and Commercial Fleets with More Rapid Mission Development

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**Abstract**

As commercial capabilities in satellite bus development and launch capabilities to low Earth orbit have expanded, the approach to Earth observation cooperation can evolve into a more cost effective and rapid partnering approach. By coordinating launches of disaggregated missions to fly in formation, each partner can shorten time to development and simplify mission integration. Three examples of this approach will be discussed in the context of mission changes announced by NASA in late March 2026, with the latest updates on how international and commercial missions gain synergistic advantages through the approach.

Missions addressing atmosphere, clouds, convection and precipitation are being re-visioned as a new fleet, titled FALCON (Fleet for the Atmosphere Linking Commercial Observations with NASA). This revisioning is flexible to accommodate the JAXA Precipitation Measuring Mission, HAWC Mission from the Canadian Space Agency, Radar and Lidar mission contributions from NASA, and a fully commercial radiometry mission, with a recently released RFI. Additional international agency contributions are welcome and under discussion. The missions that join the fleet will benefit from also being part of FALCON integrated science teams that work across the mission data to optimize the combination of observations for rapid advances in scientific and applications.

In the area of Gravimetry, the NASA- DLR mission Grace-Continuity is progressing through final integration and test, while ESA's Next Generation Gravity Mission (NGGM) is advancing through the preliminary design phase. The two missions together will form the Mass Change and Geosciences International Constellation (MAGIC).

Observations in advanced hyperspectral and thermal imaging are planned in new missions by NASA, titled EAGLE. Explorer for Artemis Geology Lunar and Earth (EAGLE) provides the fleet concept for advancing surface biology and geology measurements, but also has opportunities for multi-mission observations in Sustainable Land Imaging including Landsat and Sentinel-2 products, and plans for future incorporation of commercial satellite data into harmonized products.

This keynote paper, including international EO leaders as co-authors, will provide an overview of this rapidly changing approach and the latest status of international and commercial cooperation in ensuring rapid implementation of observations that will be new to science.

**Keywords:** NASA Earth Science; Earth observation; international cooperation; commercial Earth observation; rapid mission development

**Acronyms/Abbreviations**

Aerosol Limb Imager (ALI); Canadian Space Agency (CSA); Clouds, Convection, and Precipitation (CCP); Data, Applications, Research, and Technology (DART); Earth Dynamics Geodetic Explorer (EDGE); Earth System Observatory (ESO); European Space Agency (ESA); Explorer for Artemis Geology, Lunar, and Earth (EAGLE); fiscal year (FY); Fleet for the Atmosphere Linking Commercial Observations with NASA (FALCON); German Aerospace Center (DLR);

Global Ecosystem Dynamics Investigation (GEDI); GRACE-Continuity (GRACE-C); Gravity Recovery and Climate Experiment (GRACE); Harmonized Landsat Sentinel-2 (HLS); High-altitude Aerosols, Water vapour and Clouds (HAWC); Ice, Cloud, and land Elevation Satellite-2 (ICESat-2); Indian Space Research Organisation (ISRO); INvestigation of Convective UpdraftS (INCUS); Japan Aerospace Exploration Agency (JAXA); Jet Propulsion Laboratory (JPL); Mass Change and Geosciences International Constellation (MAGIC); Microwave Limb Sounder (MLS); Multisource Integrated Observatory (MIO); NASA-ISRO Synthetic Aperture Radar (NISAR); Next Generation Gravity Mission (NGGM); Polarized Submillimeter Ice-cloud Radiometer (PolSIR); Precipitation Measuring Mission (PMM); Request for Information (RFI); Spatial Heterodyne Observations of Water (SHOW); Stratosphere Troposphere Response using Infrared Vertically-Resolved Light Explorer (STRIVE); Surface Biology and Geology (SBG); thermal infrared (TIR); Thin Ice Clouds and Far InfraRed Emissions (TICFIRE); U.S. Geological Survey (USGS); visible to shortwave infrared (VSWIR).

## 1. Introduction

Earth observations from space provide a unique vantage point for understanding our planet as an interconnected system and for informing decisions that affect people and communities around the world. NASA's Earth Science Division is working to increase the value of these observations by making missions more cost-efficient and capable, while accelerating the delivery of new scientific knowledge and its application to challenges ranging from food and water security and resilience to extreme weather to the identification and mapping of critical minerals.

This effort is part of a broader focus across NASA's Science Mission Directorate on increasing the speed of science and the scale of its impact [1]. For Earth science, speed encompasses several related objectives: reducing the time required to develop and place new observing capabilities in orbit, accelerating the transformation of observations into scientific discovery, and increasing the speed and scale at which that knowledge can contribute to research, applications, and decision making.

Achieving these objectives requires more than accelerating individual mission development. It also requires reconsidering how observing systems are designed and implemented and how NASA works with international and commercial partners. Advances in spacecraft, instruments, launch services, data systems, and commercial Earth observation capabilities provide new opportunities to distribute complementary measurements across multiple platforms, incorporate capabilities from different partners, and allow observing systems to evolve as new technologies and capabilities become available.

These changes also create opportunities to strengthen interdisciplinary Earth system science. Coordinating observations across missions and data sources can increase their collective scientific value and enable a broader understanding of the Earth system than individual measurements can provide alone. The objective is therefore not simply to increase speed to orbit, but to shorten the path from observation to scientific discovery and from discovery to applications and impact.

## 2. Evolution of the Earth System Observatory

NASA's current approach builds on the science priorities established by the 2017 Earth Science and Applications from Space Decadal Survey [2] and the subsequent formulation of the Earth System Observatory (ESO). The decadal survey identified the core priorities for ESO formulation as five “Designated Observables”: surface biology and geology; surface deformation and change; mass change; clouds convection and precipitation; and atmosphere. Those science objectives remain priorities, but NASA is evolving how they are implemented.

The ESO framework addressed these observation goals in initial formulation of missions, but as the architectures were evaluated, the large and complex missions had grown in cost and had further programmatic risks of future cost growth [3]. A first step of reframing the approach was announced in 2024 as “decouple, partner and compete,” seeking to engage with partners to fly multiple smaller missions as novel instruments were ready. Since that time, NASA has further focused on the accumulating cost of long mission development times, using the previous formulation and technology maturation activities to implement the decoupled missions more rapidly and cost effectively. The approach emphasizes focused science objectives, defined cost constraints, use of proven capabilities and common heritage where appropriate, and streamlined development. New missions announced in 2026 [1] included development timelines that target delivery to orbit within approximately 36 months. Shorter development cycles can reduce the time between identification of a scientific need and availability of new observations, accelerate the demonstration and maturation of new technologies in space, and provide greater flexibility to respond to emerging priorities and future Decadal Survey recommendations.

More rapid technology development also creates opportunities to strengthen connections between Earth science and NASA's broader exploration objectives. Many of the measurement technologies needed to understand Earth's surface and atmosphere have

potential applications at the Moon and Mars, including characterization of surface composition and resources and atmospheric conditions relevant to future exploration. Developing and demonstrating these capabilities first through Earth science missions can mature instruments, calibration approaches, algorithms, and operational experience that may subsequently be adapted for other destinations. At the same time, advances developed for exploration can create new opportunities for Earth observation. This exchange can increase the value of NASA's technology investments while accelerating scientific capability across the Agency.

The result is a more flexible Earth observing portfolio in which NASA-led, competitively selected, internationally partnered, and commercial capabilities can collectively advance priority Earth system science. NASA can apply different implementation approaches based on the scientific need, maturity of the technology, and capabilities available within and external to the Agency as opposed to requiring all complementary measurements to follow a single development or integration pathway. The science objectives remain the foundation, while the architecture used to achieve them can evolve.

## 3. Mission Portfolio: Evolving Approaches to Implementation

This evolving approach is reflected across NASA's Earth Science mission portfolio. The examples that follow illustrate different models for advancing Decadal Survey priorities, including directed and competitively selected missions, coordinated fleets and constellations, international partnerships, and commercial capabilities. They also demonstrate opportunities for Earth Science investments to advance technologies with broader applications across NASA's science and exploration missions. Together, these approaches can accelerate new observations while maintaining a common focus on the scientific objectives they are intended to achieve.

### *3.1 Surface Biology and Geology: EAGLE and Complementary Surface Observations*

The Surface Biology and Geology (SBG) designated observable identified a need for global measurements to improve understanding of changes occurring across Earth's surface. NASA is continuing to pursue the science objectives associated with SBG through an evolved implementation approach centered on two directed, cost-capped, Explorer-class missions: Explorer for Artemis Geology Lunar and Earth – Visible to Shortwave Infrared (EAGLE-VSWIR) and EAGLE – Thermal Infrared (EAGLE-TIR). Together with complementary capabilities elsewhere in the Earth science portfolio, these missions will provide observations needed to characterize Earth's changing surface while taking advantage of focused mission designs, existing technology investments, and more rapid development approaches.

EAGLE-VSWIR will provide visible to shortwave infrared imaging spectroscopy using a best-in-class imaging spectrometer. The mission is being developed at NASA's Jet Propulsion Laboratory (JPL) with a target of delivery to orbit within approximately 36 months and launch in 2029. The instrument has reached Critical Design Review-level maturity and is in development at JPL, and a commercial spacecraft is under contract. EAGLE-VSWIR observations will support science and applications spanning changing ecosystems, agriculture, wildfires, water quality, disaster response, and the identification and mapping of critical minerals.

EAGLE-VSWIR also provides a direct connection between Earth science and NASA's broader exploration objectives. The imaging spectroscopy needed to characterize Earth's surface can also provide information about surface composition and resources at the Moon and Mars. Developing the first implementation for Earth provides an opportunity to demonstrate the instrument, calibration approach, algorithms, and operations in space before related capabilities are considered for other destinations. Copies or adaptations of the instrument architecture could subsequently support observations in cislunar space or at Mars, including characterization of resources and surface conditions relevant to future science and exploration. In this way, a focused Earth science investment can both address Decadal Survey priorities and mature capabilities with potential value elsewhere across NASA.

EAGLE-TIR will extend this observing capability through high-sensitivity thermal infrared measurements. The mission is being formulated to provide a three-day refresh, an early afternoon overpass, and mid-infrared bands that enable measurement of high-temperature phenomena without saturation. These capabilities will support observations of fires and volcanic activity as well as applications in agriculture, fire risk, urban heat, and human health. EAGLE-TIR is planned to follow EAGLE-VSWIR, with a target launch in 2031. Instrument component designs are being finalized and engineering units are being developed, with the mission leveraging the earlier EAGLE-VSWIR investment through reuse of elements of its instrument architecture.

The broader portfolio also includes competitively selected missions that provide complementary observations relevant to the science originally envisioned through SBG. In February 2026, NASA selected the Earth Dynamics Geodetic Explorer (EDGE) as one of two missions from the 2023 Earth System Explorers Announcement of Opportunity, for further formulation. EDGE will use space-based laser altimetry to observe the three-dimensional structure of terrestrial

ecosystems and the surface topography of glaciers, ice sheets, and sea ice. Building on expertise and technology heritage from NASA's Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) and Global Ecosystem Dynamics Investigation (GEDI), EDGE will improve measurement of dynamic surface processes while providing a next-generation global baseline elevation data set.

EDGE's 40-beam lidar design combines proven GEDI technology with an agile commercial production spacecraft, enabling greater global coverage and rapid targeting. Its measurements will provide the canopy penetration and vertical accuracy needed to characterize three-dimensional changes in terrestrial ecosystems and critical ice regions, with applications including agriculture, water resources, forestry, wildfire risk, land use, and infrastructure. The mission also represents a potential step toward future commercial swath-imaging lidar altimeter constellations.

Together, EAGLE and complementary missions such as EDGE preserve traceability to SBG science objectives while allowing individual capabilities to proceed on development paths appropriate to their technology and maturity. This approach takes advantage of existing investments, commercial spacecraft, and opportunities for technology reuse while maintaining flexibility as the observing portfolio evolves.

### *3.2 Clouds, Convection, Precipitation, and Aerosols: The FALCON Fleet*

The science objectives associated with the Clouds, Convection, and Precipitation (CCP) and Aerosols designated observables are being advanced through a new implementation model. The Fleet for the Atmosphere Linking Commercial Observations with NASA (FALCON) brings together complementary atmospheric measurements as a coordinated observing fleet, with flexibility in how individual elements are developed, contributed, and brought into the observing system.

Rather than requiring all measurements to be developed and integrated within a single mission architecture, FALCON distributes capabilities across multiple spacecraft. The fleet brings together directed, cost-capped NASA missions, competitively selected missions, international partner contributions, and commercial observations. Individual elements can proceed on development paths appropriate to their capabilities and partners, reducing schedule and integration dependencies while allowing their observations to be coordinated for greater scientific value. Where appropriate, formation flying can further increase the value of complementary measurements without requiring the missions themselves to share a common spacecraft or development pathway.

The initial fleet includes the directed FALCON-Radar and FALCON-Lidar Next Generation missions; the Japan Aerospace Exploration Agency (JAXA) Precipitation Measuring Mission (PMM); commercially provided radiometry under evaluation through FALCON-Radiometry; and the competitively selected Investigation of Convective Updrafts (INCUS), Polarized Submillimeter Ice-cloud Radiometer (PolSIR), and Stratosphere Troposphere Response using Infrared Vertically-Resolved Light Explorer (STRIVE). INCUS and PolSIR are nearing completion for launch in 2027. STRIVE is one of two Earth System Explorer missions competitively selected for further formulation. Additional international capabilities can be incorporated as opportunities develop. Together, these elements provide complementary observations of clouds, convection, precipitation, aerosols, water vapor, and atmospheric structure that can be integrated to address urgent atmospheric science questions, including the origin and energy transfer in convective processes driving phenomena such as atmospheric rivers and torrential rain events.

#### *3.2.1 FALCON-Radar*

FALCON-Radar is a directed, Explorer-class mission being developed at JPL to provide detailed measurements of critical cloud and precipitation processes. Its observations will provide cloud profiles and Doppler motion measurements that improve understanding of atmospheric dynamics and processes associated with severe weather. These measurements also address national needs for improved weather intelligence, including observations at high latitudes in the Arctic and Antarctic, and can provide information relevant to aviation hazards such as icing conditions and turbulence.

The mission is being implemented in accordance with NASA's Faster to Science objectives, pairing focused investment in an advanced millimeter-wave (W-band) radar instrument with commercial spacecraft capabilities and a streamlined development approach. The instrument has reached Preliminary Design Review-level maturity and spacecraft acquisition, targeting launch in 2029.

The millimeter-wave radar technology advanced through FALCON-Radar also has potential applications beyond Earth. Developing and demonstrating the capability through an Earth Science mission can mature technologies and measurement approaches that advance exploration observation approaches, including for plume surface interactions at the Moon or Mars, water vapor on Mars, and even the ability to measure dynamic environments of Titan or Enceladus.

*3.2.2 FALCON-Radiometry*

Microwave radiometry provides an important component of the FALCON observing strategy by measuring background temperature and water vapor fields that place the Fleet's other atmospheric observations in context. These measurements complement the more specialized observations provided by radar, lidar, and other FALCON elements and contribute to an integrated understanding of atmospheric processes.

For this capability, NASA is exploring a commercial approach. A Request for Information (RFI) in 2026 sought concepts for commercially owned and operated microwave radiometry observations that could fly in formation with other FALCON missions. A range of concepts with varying capabilities is now under evaluation, providing an opportunity to assess where commercial observations can meet NASA's measurement needs without requiring NASA to develop and operate every element of the observing system.

*3.2.3 FALCON-Lidar Next Generation*

FALCON-Lidar Next Generation will provide vertically resolved atmospheric observations at multiple wavelengths to characterize clouds, aerosols, water vapor, and the interactions among them. A central advance is the planned measurement of vertical water vapor profiles using lidar wavelengths not previously observed from space. This first spaceborne implementation is intended to provide vertical detail and coverage unavailable from current observing systems while providing parallel observations of clouds and aerosols needed to investigate their coupled behavior, including the role of aerosols as condensation nuclei in cloud formation.

New high-speed detector technologies will substantially improve the vertical resolution of cloud and aerosol observations, enabling the mission to resolve transitions between clear sky and cloud or aerosol layers at much finer scales. These measurements will improve characterization of processes at cloud and aerosol boundaries and of near-surface aerosol layers relevant to air quality and human health. More detailed measurements of the vertical distributions of water vapor, clouds, and aerosols can also improve representation of atmospheric processes in numerical weather prediction and provide training and evaluation data for the application of artificial intelligence and machine learning methods to priority Decadal Survey science questions.

FALCON-Lidar also advances technologies with potential relevance to future Mars science and exploration. Demonstrating aerosol, cloud, and water vapor profiling from space could establish an observing capability adaptable to characterization of the Martian atmosphere. Vertical information on these elements could improve understanding of atmospheric conditions relevant to future science and exploration, including conditions affecting entry, descent, and landing. As with EAGLE and FALCON-Radar, the initial Earth mission provides an opportunity to mature a capability that could subsequently be adapted for use elsewhere in the solar system.

*3.2.4 Precipitation Measuring Mission*

NASA is continuing its longstanding partnership with JAXA through PMM, which will provide an important precipitation-observing component of the FALCON fleet. PMM will reveal the three-dimensional structure of precipitation systems across a wide range of weather regimes, from intense convection to light snowfall, and characterize the motions that drive their development and evolution using its Ku-band Doppler radar. These observations will advance understanding of the physical processes governing precipitation systems and storm evolution and improve the ability to identify storms with the potential to develop into high-impact weather events.

The global coverage of PMM is critical for understanding precipitation over the oceans and its role in atmospheric dynamics, as the Global Precipitation Mission (GPM) nears the end of its mission lifetime in the early 2030s. As part of the FALCON fleet, PMM observations will enable substantially greater scientific impact through integration with the broader FALCON observing system.

PMM also provides an example of how an established bilateral partnership can contribute to a broader, flexible observing architecture. The joint mission can proceed through its own development pathway while its measurements are coordinated with complementary observations from other FALCON elements. NASA and JAXA are currently refining mission interfaces and developing launch vehicle solicitation documentation. PMM is currently planned for launch in Japan FY 2028.

*3.2.5 Potential Complementary Observations: Canada's HAWC Mission*

NASA and the Canadian Space Agency (CSA) are discussing potential scientific harmonization between FALCON and Canada's High-altitude Aerosols, Water vapour and Clouds (HAWC) mission concept. HAWC is being formulated to provide observations of clouds, water vapor, aerosols, and Earth's atmospheric energy balance, with particular relevance to processes in the rapidly changing Arctic. The concept includes the Aerosol Limb Imager (ALI), which would characterize aerosols in the middle and upper atmosphere, and Spatial Heterodyne Observations of Water (SHOW), which would measure water vapor in the upper troposphere and lower stratosphere. Thin Ice Clouds and

Far InfraRed Emissions (TICFIRE) would provide complementary measurements of water vapor, ice-cloud properties, and far-infrared radiation emitted by the atmosphere. Together, these capabilities are designed to provide a more complete view of interactions among aerosols, water vapor, and clouds.

NASA, CSA and other potential partners are exploring how these measurements could complement FALCON observations and support future science activities and data products. These discussions are ongoing, including the exploration of collaboration on commercial access to space, with the Canadian capabilities currently targeting the 2032 timeframe. Their potential incorporation illustrates the flexibility of the Fleet approach to accommodate additional international observations as partner capabilities develop.

#### *3.2.6 Competitively Selected Missions: INCUS, PolSIR, and STRIVE*

The FALCON fleet also incorporates missions selected through NASA's competed Earth science programs. INCUS and PolSIR, both Venture-class missions approaching launch, and the recently selected Explorer-class STRIVE mission provide complementary measurements that advance FALCON's atmospheric science objectives. Importantly, these missions did not need to originate as part of FALCON to contribute to its integrated science. Capabilities already in development can become part of a broader observing strategy when their measurements address complementary aspects of the Earth system.

INCUS, led by Colorado State University in partnership with JPL, will address fundamental questions about why, when, and where tropical convective storms form and why only some develop into severe weather. Three small satellites flying in formation will provide the first space-based measurements designed to quantify convective mass flux, the amount of air and water transported upward within storms. These observations will provide new information about the processes governing storm development and improve understanding and prediction of severe weather. The three integrated spacecraft are expected to be delivered to storage by the end of FY 2026 in preparation for a targeted 2027 launch.

PolSIR, led by Vanderbilt University in partnership with NASA's Goddard Space Flight Center, will characterize the evolution of high-altitude ice clouds, which remain a significant source of uncertainty and are directly related to the Decadal Survey priority of reducing uncertainty in cloud feedbacks. High-frequency observations sensitive to small ice particles will characterize ice clouds in tropical and subtropical regions and determine how their properties change over the daily cycle. These measurements will provide constraints on ice-cloud properties and the processes through which deep convection redistributes energy through the Earth system, supporting improvements across Earth system models. PolSIR consists of two CubeSats with both spacecraft complete and in storage. The instruments are undergoing environmental testing, with launch targeted for 2027.

STRIVE, led by the University of Washington in partnership with Goddard, was recently selected through NASA's Earth System Explorers program for further formulation. Using infrared limb sounding, STRIVE will provide high-density vertical profiles of the atmosphere and a new view of interactions between the stratosphere and troposphere, contributing to understanding and prediction of weather patterns, extreme events, air quality, and changes in the ozone layer. The mission is expected to produce in approximately two months a number of atmospheric profiles comparable to that obtained by the Microwave Limb Sounder (MLS) aboard Aura over approximately two decades of operation, making STRIVE an important replacement for the ageing MLS component of the AURA mission [4]. This substantial increase in observing density provides a direct example of how new measurement capabilities can accelerate the collection of information needed to advance atmospheric science. The Fleet architecture further increases the value of these observations. STRIVE will primarily characterize aerosols and water vapor in the stratosphere, while FALCON-Lidar will provide complementary observations the troposphere. These integrated measurements will provide a more complete view of the vertical structure of Earth's atmosphere and interactions across atmospheric layers. STRIVE completed its System Requirements Review in July 2026, with launch planned for no earlier than 2030.

Together, these missions extend FALCON across key atmospheric processes while allowing the fleet to build on investments already underway. Combining competed missions with directed NASA missions, international contributions, and commercial observations expands the observing system without requiring every capability to originate as a new element of a single mission architecture.

### *3.3 Mass Change: GRACE-Continuity and the MAGIC Constellation*

NASA is continuing the long-term record of global mass change observations through the GRACE-Continuity (GRACE-C) mission, a directed, Explorer-class mission developed in partnership with the German Space Agency at the German Aerospace Center (DLR). GRACE-C builds on more than two decades of observations from the Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On missions, measuring changes in Earth's gravitational

field to determine how mass moves within and among components of the Earth system.

These measurements provide information used to estimate changes in groundwater availability, assess and forecast drought, support water resource management, characterize changes in glaciers and ice sheets, and improve understanding of Earth's energy balance. GRACE-C will advance the measurement capability through laser ranging between its two spacecraft, providing greater ranging accuracy than the microwave approach used on earlier GRACE missions. The mission is currently in observatory integration and test and is targeting launch no later than 2029.

GRACE-C will also form the first component of a broader international observing strategy for mass change [5]. NASA, DLR, and the European Space Agency (ESA) are collaborating toward the Mass Change and Geosciences International Constellation (MAGIC), which will combine the NASA-DLR GRACE-C satellite pair with a second pair provided through ESA's Next Generation Gravity Mission (NGGM). With the full constellation planned for deployment by 2032, the two pairs will provide complementary observations intended to increase the scientific and applications value of the individual missions.

NASA and ESA have established a MAGIC Working Group to coordinate science and applications planning and to exchange studies, results, simulated data, and data products in preparation for the combined constellation. Although the agencies plan to generate and provide MAGIC products independently, early coordination can support consistent products, improve understanding of the characteristics and systematic errors associated with each satellite pair, and determine how their observations can be optimally combined. This model allows independently developed missions to operate as components of a larger observing system while partners retain responsibility for their respective missions and products, increasing the scientific and applications value of each partner's investment.

### *3.4 Surface Deformation and Change: NISAR*

The NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission addresses the Surface Deformation and Change designated observable identified in the Decadal Survey for this decadal period. Measurements of surface deformation and change contribute to understanding dynamic Earth processes ranging from earthquakes and landslides to changes in permafrost and ice sheets, with applications in hazard assessment, agriculture, water management, and understanding processes contributing to sea-level change.

NISAR is a partnership between NASA and ISRO that combines complementary L-band and S-band synthetic aperture radar capabilities on a single observatory. The mission launched in August 2025 and transitioned to science operations on December 29, 2025. NISAR is implementing open science principles intended to make its observations broadly accessible to the global science and applications communities and has acquired more than 1.6 million images since launch.

Both radar systems are healthy, and processing of L-band observations in the cloud is proceeding nominally. Approximately 107,000 pre-calibrated data products were released to the science community in February 2026, with known issues documented for users. Release of forward-processed data began in July 2026, with earlier observations planned for reprocessing [6]. Joint L-band and S-band observations have been acquired over India, Antarctica, Greenland, and selected sites around the world.

NISAR represents culmination of the older a more tightly integrated model of international cooperation compared to the distributed architectures described elsewhere in this paper. The initial Implementing Arrangement was signed in 2014, and NASA and ISRO combined their respective capabilities on a single observatory to implement a complex Earth observing mission and are now providing broad access to its observations. Given the delay from initial targeted launch dates, the NISAR mission will provide the Surface Deformation and Change observable for this decadal. The importance of the mission's centimeter-scale precision is demonstrated by the extremely high global demand for observations of ice, earthquakes, volcanic eruptions, landslides, and land subsidence, among other products.

Across these reformulated missions and observing systems, NASA is maintaining clear traceability to the science priorities established by the Decadal Survey. Although implementation approaches are evolving, the fundamental scientific questions remain the foundation. NASA continues to engage scientific leaders and subject matter experts who helped establish and mature the original observing concepts to identify the measurements and capabilities of greatest scientific value. This continuity helps ensure that streamlined mission designs and new implementation approaches remain focused on advancing the highest-priority science.

## 4. Sustainable Land Imaging: A Product-Based Approach to Commercialization

For more than five decades, the Landsat program has provided the longest continuous space-based record of Earth's land surface and a global standard for land imaging. The value of that record rests on its scientific quality, calibration, consistency, continuity, and open availability. As NASA and the U.S. Geological Survey (USGS) look toward the needs of the 2030s, users

increasingly require more frequent observations and higher spatial resolution while continuing to depend on the science-quality measurements and long-term record that Landsat provides.

Landsat 10 will continue the government observing capability, and under interagency agreements is built by NASA for transfer to USGS for operations, and is on track for launch in 2031. Its superspectral Landsat instrument suite [7], LandIS, has completed Preliminary Design Review, and spacecraft procurement is underway. At the same time, increasingly capable commercial Earth observation constellations create opportunities to augment the government system and expand the observations available to users.

NASA's current land imaging capabilities already demonstrate the value of harmonizing observations across independently operated systems. Harmonized Landsat Sentinel-2 (HLS) combines Landsat and Sentinel-2 observations to support products with greater observation frequency than either system can provide alone. Building on this approach, NASA and USGS are evaluating how commercial observations can augment established land imaging products while meeting the spectral, spatial, calibration, and other technical requirements needed for consistent science-quality products. The Agencies engaged with dozens of interested companies at an Industry Week held August 31-September 4, 2026.

NASA and USGS are pursuing a phased, product-based approach to Sustainable Land Imaging commercialization [8]. Rather than asking industry to reproduce a government-designed Landsat satellite, the strategy defines the characteristics of the data products users require and creates opportunities for commercially provided observations to contribute to those products. The approach begins with augmentation, where commercial data can provide additional spatial, temporal, or spectral information. As commercial capabilities and government processing workflows mature, products that demonstrate sufficient accuracy, stability, archive compatibility, and operational viability can progress toward greater reliance on commercial observations and, where appropriate, replacement of government-generated inputs. Demonstrations in FY 2027 and FY 2028 will begin testing this approach, followed by initial capability activities from FY 2029 through FY 2031 and an assessment in 2031 to inform broader operational capability beginning in FY 2032.

Preserving the scientific integrity and continuity of the Landsat record remains a central requirement. NASA is leading development of processing and harmonization approaches that account for differences among sensors and observing geometries, while USGS is leading product definition and evaluation, engagement with user communities, and assessment of compatibility with the historical archive. NASA and USGS are also working with industry to explore sustainable business and cost models. The long-term objective is that, as soon as feasible and no later than 2035, all or a majority of USGS Landsat products can be produced using commercially provided data that are harmonizable with the historical archive and supported by a robust and competitive marketplace.

This approach provides a different model for incorporating commercial capabilities into Earth observation. The Government maintains responsibility for the scientific requirements, quality, continuity, and accessibility that underpin the Landsat record while creating pathways for commercial observations to contribute as their capabilities mature. The objective is not commercialization for its own sake, but an observing model that can take advantage of innovation and investment outside government while expanding the frequency, resolution, and scale of observations available to users.

## 5. Multisource Integrated Observatory: Integrating Science Across the Portfolio

As NASA moves toward more flexible observing architectures, scientific integration becomes increasingly important. Missions developed independently, through different acquisition approaches, or by different partners can proceed with fewer integration dependencies, while their observations can be brought together to address common Earth system questions. NASA's Multisource Integrated Observatory (MIO) provides a framework for integrating observations and expertise across the Earth science portfolio.

MIO brings together observations from NASA missions, international partners, and commercial providers with scientific, applications, data, and technology expertise. A central element is the establishment of Data, Applications, Research, and Technology (DART) teams. Mission DART teams will bring these disciplines together during a mission's prime operational phase, while Multisource DART teams will integrate observations and expertise across missions around rotating Earth system challenge themes. The initial implementation will establish two Multisource DART teams focused on complex, high-impact Earth system science questions. The Earth observation community will be given the opportunity to provide inputs on the topics for subsequent Grand Challenges.

MIO will also provide common capabilities to support multisource science, including a unified computing environment for collaboration and data harmonization and shared capabilities in areas such as algorithm development, modeling, and calibration and validation. These investments are intended to reduce technical barriers to working across disparate

observations and make it easier for scientific teams to use combined information to address priority questions.

MIO therefore complements the evolution occurring in NASA's mission architecture, and addresses key recommendations of the ESO Independent Review board [3]. A fleet such as FALCON can distribute complementary measurements across NASA, international, competed, and commercial missions, while MIO provides a framework for integrating observations and expertise across those sources. The FALCON DART also provides the mechanism for including international partner missions in the broader scientific collaboration, increasing the scientific value to all contributing partners. This allows NASA to separate the integration of the mission architecture from the integration of the science. Missions can be developed through approaches appropriate to their individual capabilities and partners, while their observations can be brought together around common Earth system questions. This model is central to increasing not only speed to orbit, but speed to discovery and the scale of impact from NASA's Earth observations.

## 6. Conclusion

The evolution of NASA's Earth observation portfolio reflects a broader evolution in how NASA approaches mission implementation and cooperation. The science priorities established by the Decadal Survey remain the foundation, while the architectures used to pursue them are becoming more flexible. There is no single implementation model appropriate for every measurement. NASA can combine directed and competitively selected missions with international and commercial capabilities, matching the approach to the scientific need, technology maturity, and capabilities of partners. FALCON and MAGIC show how independently developed missions can contribute to coordinated observing systems without requiring every element to share a common development schedule or integration pathway.

The expanding commercial Earth observation sector provides additional opportunities, from commercially owned and operated observations being explored for FALCON to the product-based approach being pursued for Sustainable Land Imaging. Across these models, NASA can preserve the benefits of integrated Earth system science while allowing greater flexibility in how individual observing capabilities are developed and implemented. MIO extends this approach by providing a framework for integrating science and applications across diverse observations and data sources. Together, more rapid mission development, international and commercial cooperation, and stronger integration of observations around shared scientific objectives can increase the speed of science by shortening the path from mission concept to observation, from observation to discovery, and from discovery to impact.

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