Call for Sponsors: OGC Space Pilot

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The concept of *New Space*—referring to the emerging private space industry and the democratization of space exploration—is important for several reasons. These include economic growth and innovation, strategic and security interests, scientific and technological progress, environmental monitoring and solutions, and several others, as outlined in Annex C: Benefits of Space Exploration.

The Open Geospatial Consortium (OGC), supported by GeoHuntsville, is calling on sponsors for the ***OGC Space Pilot***. The pilot will center around three key topics, though this list is open for discussion and can easily be adapted based on sponsor interests. With a focus on the Moon, or, more precisely, the cislunar space, this pilot will address:

- Lunar navigation and Positioning, Navigation, and Timing (PNT)
- Exposing lunar data through standards
- Digital Twins (visualization, simulation, training, remote control, etc.)

Lunar navigation and Positioning, Navigation, and Timing (PNT)

Positioning and navigation are essential for precisely determining an object's location on the lunar surface or in lunar orbit and guiding that object from one location to another. Accurate time synchronization is critical for communication, navigation, and coordination among lunar missions or systems. PNT is essential for surface exploration, orbital operations, communication systems, resource utilization, and safety. Various solutions for Lunar PNT are currently being discussed, including satellite networks, ground beacons, optical and celestial navigation, and Earth-based support. As lunar exploration grows, robust PNT systems will ensure mission success and enable sustained human and robotic activities on and around the Moon. *From a PNT perspective, the OGC Space Pilot will investigate the fundamental questions "Where am I? What is around me?" and "How do I best get from here to there?"*

Exposing lunar data through standards

This pilot will leverage the mature ecosystem of standards and practices for Earth PNT and investigate the data models and required interfaces for reliable and interoperable data exchange among the various components related to lunar PNT. The initiative will

develop the necessary language for robust, standards-based PNT data exchange and processing between all participating systems, such as landers, rovers, astronauts, and PNT support systems and base data. This includes previously collected data, such as the lunar reference and coordinate systems, and real-time data from sensors and platforms.

Digital Twin(s) of the Moon and lunar objects

Once the fundamentals for positioning are defined, digital twins will help illustrate objects in the cislunar space and on the lunar (sub-) surface. Creating Digital Twin(s) of the Moon and lunar objects involves developing a high-fidelity, dynamic virtual representation of the lunar environment, including astronauts, rovers, landers, and other elements of lunar missions. The OGC Space Pilot will explore the various components required for such a digital twin(s), including:

- High-resolution lunar surface and subsurface data (topography, mineral and resource mapping, subsurface models)
- Precise spatial and temporal models
- 3D models of real objects to be placed/built/operated on the lunar surface
- Physics-based simulation aspects such as gravity models, environmental conditions, and lunar dust
- Communication and networking infrastructure
- Dynamic models of human activities
- Activities and behavior of robotic systems

The digital twin work will consider the fact that the Moon is significantly smaller than the Earth and thus that digital twin data models built for Earth coordinates may need modification to work in significantly different physical spatial characteristics.

Additional Sponsors, additional areas to investigate

The OGC will leverage its Collaborative Solutions and Innovation Program (COSI) for the OGC Space Pilot. The COSI Program is the Open Geospatial Consortium's (OGC) research and development arm, dedicated to advancing geospatial interoperability through collaborative initiatives. By uniting expertise and funding, COSI addresses pressing environmental and societal challenges, strategically important exploration efforts, and the development of digital twins. COSI aims to progressively increase geospatial IT solutions' Technology Readiness Level (TRL), facilitating their transition from concept to operational use. The program offers a neutral space for research and development, focusing on joint solution development without commercial biases.

This Call For Sponsors aims to attract additional sponsors for the OGC Space Pilot. By combining sponsorship funds, it will be possible to effectively utilize synergies between the individual sponsors and—together with OGC members—develop robust solutions

for the various challenges based on a collaborative approach and standards. Each sponsor has the opportunity to influence the exact areas of work.

OGC takes the sponsors' individual requirements, creates a common list of tasks, incorporates them into a standards-based architecture, and publicly announces the overall initiative. After that, OGC recruits the best experts for this initiative worldwide and hires them as subcontractors. OGC then leads the initiative and, together with the participants, develops solutions for the various fields of activity in close cooperation with the sponsors.

If you are interested in sponsoring this initiative, or have any questions, please email space-pilot-responses@ogc.org by March 15, 2025.

1 Annex A: OGC's previous work in the Space context

OGC's previous work marks a significant advancement in extending geospatial standards beyond Earth-centric applications, enabling the precise representation and tracking of objects in non-terrestrial environments.

By leveraging ISO 19111, OGC GeoPose, and NASA SPICE frameworks, the team has developed an innovative solution for spatial referencing and coordinate transformations applicable to celestial bodies, spacecraft, and interplanetary trajectories. This includes a robust hierarchical system of coordinate reference systems (CRS) such as inertial, terrestrial, and engineering CRS, addressing challenges posed by astronomical scales, relativistic effects, and the complexities of deep space navigation.

Practical demonstrations, including the NASA Double Asteroid Redirection Test (DART) and the International Space Station trajectory tracking, illustrate the successful implementation of 3D+ spatial visualizations and transformations between inertial and local reference systems. Furthermore, the OGC GeoTIFF standard was enhanced to support extraterrestrial imaging by introducing spherical coordinate systems and celestial body referencing, enabling precise localization and mapping of planetary surfaces and space objects. Complementing these innovations, enhancements to the OGC GeoPose standard now allow seamless integration of moving features such as spacecraft motion and dynamic sensor data, paving the way for accurate visualization, synchronization, and analysis of both terrestrial and interplanetary scenarios.

Collectively, this work establishes a transformative foundation for interoperable geospatial standards, enabling reliable and dynamic space-based data management across the solar system and beyond.

The following documents provide an overview of current OGC work in the context of Space.

- **Advanced Standards Framework for 3D+ Space**: The work successfully extends geospatial standards beyond Earth-centric applications, introducing solutions for non-terrestrial spatial data using ISO 19111, OGC GeoPose, and NASA SPICE frameworks. This supports spatial referencing and transformations for objects in orbit or deep space.
- **Innovative Coordinate Systems and Data Streaming**: New hierarchical coordinate systems, including inertial, terrestrial, and engineering CRS, are proposed to precisely track and represent spacecraft, planetary bodies, and trajectories across 4D spacetime, addressing challenges posed by relativity and astronomical scales.
- **Practical Demonstrations with DART and Solar System Data**: Experiments involving NASA's Double Asteroid Redirection Test (DART) scenario and International Space Station tracking showcase accurate 3D+ visualizations and transformations between inertial and local reference systems, proving feasibility for real-world applications.
- **Extending GeoTIFF for Extraterrestrial Imaging**: The GeoTIFF standard was expanded to support celestial objects and spherical coordinate systems, enabling precise localization and image-based referencing in non-terrestrial settings like asteroids and planetary surfaces.
- **Groundbreaking Applications for GeoPose and Moving Features**: By integrating dynamic features like spacecraft motion and sensor data synchronization, GeoPose enhancements allow for seamless tracking, visualization, and analysis of both terrestrial and interplanetary moving objects.

This work sets a transformative foundation for interoperable standards in space-based geospatial technology, paving the way for accurate, reliable, and dynamic data handling across the solar system and beyond.

2 Annex B: Tentative Design of the OGC Lunar Pilot – Phase 1

The current document is deliberately kept open to give other sponsors the opportunity to contribute their ideas and participate in the project design. In the following, we present initial ideas for a possible project that builds on OGC's previous work as documented in Annex C: Benefits of Space Exploration.

The project currently in the pipeline will be part of a series. The individual phases will build incrementally on each other, ultimately leading to a complete simulated lunar environment.

As documented above, this first phase will focus on positioning, navigation, and timing. It is titled "**Simulating Lunar Navigation for Future Moon Missions**." Digital Twin elements can be added to this first phase or addressed in one of the following phases.

This project aims to develop and test a realistic Lunar navigation framework to address the unique challenges of operating on the Moon. The exercise will simulate conditions on the Lunar surface using the NASA New Mexico test site, establishing a digital twin of this location relocated to a Lunar setting. All data will be tied to a Lunar Spatial Reference System, degraded to the precision currently available from Lunar surveys. Unlike Earth-based navigation, the Moon lacks a magnetic field, GPS, and atmospheric conditions to reflect radio waves, making conventional tools like compasses and Internet-dependent services (e.g., DNS and ARP) unusable. To reflect these realities, the simulation will be conducted entirely under Lunar conditions, with no access to compasses, GPS, or Solar cues. The exercise will take place at night, and portions of the course will extend beyond line-of-sight from the base—a frequent operational challenge on the Moon.

The project builds on prior achievements, including OGC Testbeds 18 and 19, which demonstrated that OGC Feature and Geometry models function on rigid planetary bodies, and existing Lunar spatial reference systems published by the International Astronomical Union (IAU) and the OGC Planetary Domain Working Group. Additionally, the effort will leverage the ongoing work by NGA Geomatics to create a WGS84 equivalent for the Moon, establishing a consistent reference framework for Lunar exploration.

One key challenge addressed will be communication constraints. The Moon lacks an Internet infrastructure and a reflective ionized atmosphere, limiting communication to line-of-sight transmissions or relay satellites, which are currently unavailable. This exercise will test the feasibility and adaptability of OGC Web Services and Web APIs under such conditions, exploring innovative solutions to achieve robust data exchange in a communications-limited environment.

Deliverables will include a comprehensive technical report detailing the exercise, technologies used, required modifications, open issues, and future work. The report will serve as a foundation for advancing Lunar mission simulations and addressing gaps in current standards and tools. All data and software developed during this phase will be preserved to enable iterative improvements in future phases, allowing us to progressively enhance the realism and scope of Lunar mission simulations.

By simulating Lunar conditions with precision, and leveraging cutting-edge geospatial technologies, this project will provide critical insights and tools for future Moon missions, supporting navigation, communication, and operational readiness on Earth's nearest celestial neighbor.

3 Annex C: Benefits of Space Exploration

1. Economic Growth and Innovation

- **Commercial Opportunities**: New space companies, such as SpaceX, Blue Origin, and Rocket Lab, are opening up new markets like satellite internet, space tourism, asteroid mining, and on-orbit manufacturing.
- **Innovation Catalyst**: Competition among private players drives rapid technological advancements, reducing costs and improving efficiency.
- **Job Creation**: The new space economy generates jobs across engineering, manufacturing, and services, contributing to global economic development.

2. Lower Costs and Accessibility

- **Reusable Technology**: Innovations like reusable rockets have dramatically reduced the cost of launching payloads into space.
- **Widened Access**: Lower costs make space accessible to smaller nations, universities, startups, and individuals, fostering global collaboration.

3. Scientific and Technological Progress

- **Exploration and Research**: Expanding space exploration enables humanity to study planets, asteroids, and other celestial bodies, advancing our understanding of the universe.
- **Spin-Off Technologies**: Technologies developed for space applications often benefit other industries (e.g., satellite imaging improving agriculture, GPS for navigation).

4. Environmental Monitoring and Solutions

- **Earth Observation**: Satellites help monitor climate change, track deforestation, predict natural disasters, and improve agricultural efficiency.
- **Space-Based Energy**: Concepts like solar power satellites could offer solutions to the global energy crisis.

5. Ensuring Humanity's Future

- **Planetary Defense**: Monitoring and mitigating threats from asteroids and comets are vital for Earth's long-term safety.
- **Space Colonization**: Establishing a human presence on the Moon, Mars, and beyond could ensure humanity's survival in case of catastrophic events on Earth.
- **Resource Utilization**: Extracting resources from asteroids and other celestial bodies could supplement Earth's finite supplies.

6. Cultural and Inspirational Impact

- **Global Collaboration**: Space exploration fosters international partnerships and cooperation, transcending political and cultural boundaries.
- **Inspiration**: Pursuing space exploration inspires innovation, creativity, and a sense of global unity, motivating future generations to dream and achieve.

7. Strategic and Security Interests

- **National Security**: Control over space-based assets (e.g., communication, navigation, and surveillance satellites) is critical for national defense.
- **Leadership**: Countries leading in space technology gain strategic advantages and influence in global affairs.

8. New Frontiers for Humanity

- **Space Tourism**: Companies like Virgin Galactic and Blue Origin are opening space travel to civilians, making it a tangible dream.
- **Cultural Expansion**: Space exploration could lead to new societal and cultural paradigms as humanity learns to live and work beyond Earth.

In essence, new space represents a transformational shift in how humanity views and utilizes the final frontier, making it a critical driver of progress in the 21st century and beyond.

About OGC

The Open Geospatial Consortium (OGC) is a membership organization dedicated to using the power of geography and technology to solve problems faced by people and the planet. OGC unlocks value and opportunity for its members through Standards, Innovation, and Collaboration. Our membership represents a diverse and active global community drawn from government, industry, academia, international development agencies, research & scientific organizations, civil society, and advocates.

Visit ogc.org for more information about our work.

About GeoHuntsville

GeoHuntsville is a collaborative initiative based in Huntsville, Alabama. It capitalizes on the city's unique position as a center of technological innovation and its history of collaboration in aerospace, defense, and engineering.