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CEOS Space-based Constellations for GEO

Understanding the Earth system is crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, reducing disaster losses, and achieving sustainable development. Observations of the Earth system constitute a critical input for advancing such an understanding. This has been the driving force behind the establishment of the Group on Earth Observations (GEO), four ministerial-level Earth Observation Summits, and the development of the Global Earth Observation System of Systems (GEOSS).

The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system. GEOSS will meet the need for timely, quality long-term global information as a basis for sound decision making, and will enhance delivery of benefits to society. It will provide the overall conceptual and organizational framework to build toward an integrated global Earth observing "system of systems." The implementation of GEOSS will seek to ensure effective consultation and cooperation, with international and national agencies sponsoring or cosponsoring the component observing systems upon which GEOSS will be built. GEOSS will capture the success of Earth observation research programs, and facilitate their transition to sustained operational use. It will provide a means to share observations and products with the system as a whole, and will take the necessary steps to ensure that the shared observations and products are accessible, comparable, and understandable, by supporting common standards and adaptation to users needs. GEOSS will include *in situ*, airborne, and space-based observations.

In support of GEO objectives and as a space component of GEOSS, CEOS has developed the concept of virtual, space-based Constellations. A CEOS Virtual Constellation is a set of space and ground segment capabilities operating together in a coordinated manner, in effect a virtual system that overlaps in coverage in order to meet a combined and common set of Earth Observation requirements. The individual satellites and ground segments can belong to a single or to multiple owners. The Constellation concept builds upon or serves to refocus already existing projects and activities. The Constellations effort provides a unique forum to achieve political visibility and increase mutual benefit among space and other environmental agencies in support of cross-cutting GEO Tasks and Targets. In particular, they offer opportunities to share experience in the development of algorithms; standardize data products and formats; exchange information regarding the calibration and validation of measurements; facilitate timely exchange of and access to data products from existing and planned missions; and facilitate planning of new missions—ranging from coordinating orbits to optimizing observational coverage to sharing implementation of mission components. The interim goal of a Constellation is to demonstrate the value of a collaborative partnership in addressing a key observational gap; the end goal is to sustain the routine collection of critical observations. Implementation of Constellation activities is ultimately dependent on the coordination of formal agreements among participating agencies.

GEO and GEOSS will benefit from this effort because Constellations can help agencies avoid duplication and overlap in Earth Observation efforts, close information gaps for all GEO Societal Benefit Areas (SBAs), and establish a globally sustained Earth Observation network.

Present Constellations: There are currently four existing CEOS Constellations as follows:

The **CEOS Constellation for Atmospheric Composition (ACC)** goal is to collect and deliver data to improve monitoring, assessment and predictive capabilities for changes in the ozone layer, air quality and climate forcing associated with changes in the environment through coordination of existing and future international space assets. The ACC Constellation directly addresses the SBAs of disasters, health, energy, climate, and ecosystems.

The **CEOS Constellation for Land Surface Imaging (LSI)** defines a broad range of detailed guidelines for optimal capabilities to acquire, receive, process, archive, and distribute land surface image data to the global user community now and in the future. Information from the LSI Constellation primarily benefits the SBAs of disasters, energy, climate, water, ecosystems, agriculture, and biodiversity.

The **CEOS Constellation for Ocean Surface Topography (OST)** has as its objective the implementation of a sustained, systematic capability to observe the topography of, and the significant wave height on, the surface of the global oceans ranging from basin-scale to mesoscale. It focuses on global sea level rise, the role of the oceans in climate, and operational oceanography. Information from the OST Constellation supports the SBAs of disasters, climate, water, and weather.

The **CEOS Constellation for Precipitation (PC)** establishes an international framework to guide, facilitate, and coordinate continued advancements of multi-satellite global precipitation missions. Through this framework, existing and planned missions can work synergistically to meet international user community requirements. Information from the PC Constellation primarily benefits the SBAs of disasters, climate, water, and weather.

Each of the current Constellations is defined by one or more parameters and one or more satellite measurement techniques.

- Single parameter with single measurement technique
  - **Ocean Surface Topography Constellation**: Altimetry supplemented with tide gauges
- Single parameter with multiple measurement techniques
  - **Precipitation Constellation**: Rain radar supplemented with microwave radiometry
- Multiple-parameter/domain-based with multiple measurement techniques
  - **Atmospheric Composition Constellation**: Various parameters (radiative and chemically active gases, aerosol, etc.) in the atmospheric column with multiple measurement techniques
  - **Land Surface Imaging Constellation**: Various parameters (related to land use/cover, fire, volcanic eruptions, etc.) with multiple measurement techniques

Each Constellation is unique and matures at its own pace. Constellation Leads/Co-Leads work together with the CEOS Strategic Implementation Team (SIT) Chair in addressing what SIT and CEOS, through its Agencies, might do to assist Constellation implementation. The CEOS Systems Engineering Office (SEO) is prepared to assist CEOS Constellations, as appropriate, to develop traceable system-level requirements to facilitate SBA impact assessments, perform instrument and mission gap analyses, and support future architecture planning. Constellation Leads/Co-Leads meet with the SIT Chair every four months; provide Task Team-related reports to the GEO Secretariat, as required; and provide reports, as requested, to SIT and CEOS Plenary Meetings.

It is recognized that data products from a given Constellation typically pass through an intermediate step – a *Service Provider* – where products are combined with those from different observing systems, satellite and/or *in-situ*, and are used in analyses and input models. Such Service Providers then provide services specifically tailored to the needs of different Societal Benefit Areas. While the domain of the Service Providers does not fully fall within the purview of CEOS, it is necessary for the Constellations to be able

to justify their support based on the real and potential impact from utilization of their data products by end-user customers in relevant Societal Benefit Areas.

It is emphasized that the Constellations and the services supported by them in most cases typically support multiple SBAs in a cross-cutting fashion (as noted in the descriptions of the above current Constellations).

Proposing New Constellations

New Constellation proposals will be addressed by CEOS SIT on a case-by-case basis in connection with procedures identified below. Lessons learned from the initial set of Constellations will also be taken into account when selecting new Constellations.

A new CEOS Constellation may be proposed by two or more CEOS Agencies. The initial proposal should be a short explanatory paper (two to three pages) provided to the SIT Chair at least four weeks in advance of an upcoming SIT Meeting.

The proposal for a new Constellation must address the following topics and questions:

- Objectives:
  - What parameter or set of parameters will serve as the focus for the proposed new Constellation and what specifically will the new Constellation do with the resulting observations? What space and/or ground segment capabilities are proposed for coordination?
- Vision:
  - What is the vision for the proposed Constellation?
  - If successful, what will the Constellation enable?
- Statement of Need:
  - Is there any community-based statement(s) of need or endorsements for the proposed Constellation?
  - What ongoing/existing capabilities and/or organizing constructs already exist, and is there duplication of effort that should be avoided? To what extent can CEOS make a unique contribution to meeting needs on the part of the proposed Constellation that are not already being met by ongoing/existing constructs?
  - How does the proposed Constellation relate to the Tasks, Targets, and SBAs of GEO?
- Measures of Success:
  - What are the present impediments to achieving success?
  - How might a Constellation help overcome the present impediments to achieving success?
  - What are other benefits of this Constellation?
  - To what extent might the proposed new Constellation complement (but not duplicate) existing Constellations and their planned activities?

  Note: Some Constellations will have more well defined measures of success than others.
- Collaborators: Who are the anticipated and other potential collaborators for this Constellation? Who will serve as the Lead/Co-Lead for the Constellation?
- Schedule: What activities will need to be completed to make the first concrete elements of the Constellation visible in a short time frame?

If the SIT Chair, in consultation with the CEOS Chair and the GEO Secretariat, determines the proposal should be considered for selection as a CEOS Constellation, the proposer(s) will be invited to make a presentation at the SIT Meeting with a complete proposal (less than ten pages) then due to the SIT Chair within ninety days of the SIT Meeting. Following receipt of the full proposal, the SIT Chair, in consultation with SIT Members, the CEOS Chair, and the GEO Secretariat Director, will decide whether to approve the candidate Constellation for development.