Terms of Reference for a CEOS Biodiversity Virtual Constellation

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This document follows the format for a VC Terms of Reference that is outlined in Annex 3 of the CEOS Virtual Constellation Process Paper

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Introduction

Space-based Earth Observations (EO) provide global, periodic data from a unique perspective that complements in situ data. As a result, EO plays an essential role for understanding and monitoring biodiversity and for supporting decisions. The value of EO is expected to further increase as new sensors are deployed and as advances in science and technology enable the generation of innovative, higher quality, and more actionable EO data products (e.g., see the CEOS Ecosystem Extent Task Team White Paper). EO-based products are needed and utilized by a wide range of key stakeholders, including international agreements such as the Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands of International Importance, and the Convention to Combat Desertification, as well as by governments at all levels.

When the instruments, activities, and expertise provided by CEOS agencies are coordinated a Virtual Constellation is formed whose impact is greater than the sum of the individual efforts. The need for that coordination is the overarching motivation behind this proposal for a Biodiversity Virtual Constellation (B-VC). Its formulation, and the underpinning Implementation Plan, is a key outcome not only of the Biodiversity Study Team's work but of the Ecosystem Extent Task Team, and other work, that preceded it. With such coordination in mind, the Terms of Reference, augmented by the Implementation Plan, outlines the mission, objectives, activities, resources and other information that scope the Biodiversity Virtual Constellation.

Constellation Name: CEOS Biodiversity Virtual Constellation (B-VC)

Mission: Advance biodiversity understanding, monitoring, and application for the benefit of society by strengthening the community's use of space-based Earth observations and data products.

Objectives: The Biodiversity Virtual Constellation has three interrelated objectives that form the top-level drivers behind its activities.

1) **Maximize Impact**: Maximize the societal benefit of space-based Earth observation and derived data products for biodiversity understanding, monitoring, and decision making.
2) **Engage Users**: Maintain active dialogue with biodiversity stakeholders to support a continued understanding of evolving user needs and to tailor activities accordingly.
3) **Leverage CEOS's Collective Capabilities and Resources:** Align with and connect to CEOS Agency missions, observations, data products, and services and coordinate with the activities of CEOS Working Groups and Virtual Constellations.

Characterisation of the Measurements and Data Collections within Scope:

Understanding and monitoring biodiversity requires measurements from a variety of types of sources, including observations collected at the Earth surface, in the air, and in space. These measurements complement each other and enhance our understanding of the biosphere. Supporting the biodiversity community to better utilize the space-based EO components of this complex and diverse data landscape is the main objective of the B-VC, which addresses biodiversity in terrestrial, freshwater, coastal and marine ecosystems. All interested parties are invited to participate regardless of whether their support is for surface-based in situ, airborne, or spaceborne data and activities. This ensures opportunities for all to participate in the B-VC, including those with limited space-based capabilities but who still bring relevant and valuable supporting skills.

Characterisation of the Space Segment Concerned:

Many space-based Earth observing instruments operated by CEOS Agencies enable the characterization of the land surface and the marine environment, track their changes over time, and measure their organic and inorganic components. These capabilities, including both active and passive sensors, fall within the scope of the B-VC. Observations from existing missions have already shown their ability to help address many of the user needs identified in the Biodiversity Study Team's Stakeholder Assessment. However, forthcoming CEOS missions, particularly when combined with advancing science and technology, will greatly increase the degree to which these needs can be met; the B-VC will track these developments and adjust its activities accordingly.

Activities, Outcomes, and Deliverables:

1) Identify priority gaps in observations and data products and facilitate development of solutions to fill critical gaps
2) Facilitate enhancement of data processing and utilization tools needed to enable broader and more effective utilization of EO for biodiversity applications
3) Enhance existing Ecosystem Extent demonstrators, and explore possibilities for new prototype monitoring systems[2] to facilitate development and testing of EO products and capabilities as well as to engage users
4) Prioritize and implement capacity building initiatives through collaboration with CEOS WGCapD
5) Actively seek to increase biodiversity community engagement with EO data, tools and applications that support biodiversity understanding, monitoring, and decision making
6) Coordinate with GEO BON and its Global Biodiversity Observing System (GBiOS) concept to facilitate the wider use of space-based EO

[2] Similar to the demonstrators developed by the EETT, the purpose is no longer focused only on demonstrating capabilities but also to provide a laboratory to develop and test capabilities and facilitate user engagement

	3-year horizon	5-years or more horizon
Space Segment	• Develop plan to utilize forthcoming hyperspectral, L-band SAR, and lidar missions	• Update plans based on emerging experience
Ground Segment & Information Systems	• Identify and facilitate filling of priority data product gaps • Coordinate with GEO BON and GBiOS concept development	• Address additional data product gaps • Guide GEO BON on use of EO as GBiOS is implemented
Products and Services	• Facilitate enhancement of end user utilization tools • Engage with the biodiversity community	• Ongoing tool enhancement and community engagement

Implementation and Coordination Issues to be Addressed by SIT

Achievement of B-VC objectives will benefit from CEOS leadership's attention to the following implementation and coordination issues:

1) CEOS Agency participation in and support for B-VC membership and leadership
2) CEOS Agency support for development of new or enhanced product algorithms
3) CEOS Agency participation in and support for generation of biodiversity data products
4) CEOS Agency support for prototype monitoring system development activities
5) Increased adoption by CEOS agencies of recommended data product standards and other recommendations

Schedule:

The schedule for B-VC activities is as follows, recognizing that the detail and timeframe may evolve over time in accordance with CEOS Agency priorities and stakeholder needs:

Activity Topic	Milestones	Timeframe
Data product gaps	Prioritize needed products to fill observation and product gaps	Year 1-2
	Develop plan and methods to fill gaps	Years 1-3
	Implement product gap-filling plan (incremental, with partners)	Years 2-5+
Data utilization tools	Assess current tools and identify and prioritize enhancements	Years 1-3
	Develop plan and methods for enhancements	Years 2-4
	Implement tool enhancements (incremental, with partners)	Years 2-5+
Prototype monitoring system development	Continue development of the existing EETT demonstrators and seek new prototype options, including aquatic systems	Years 1, 2-5
Capacity building	Work with WGCapD to prioritize and enhance capacity building	Continuous
Stakeholder engagement	Outreach and engagement via informational webinars, brochures, and other means	Continuous
Space arm of GBiOS	Identify needs, gaps, and challenges (jointly with GEO BON)	Years 2-3
	Integrate space-based EO into the GBiOS concept and architecture (jointly with GEO BON)	Years 3-7+

Membership and Leadership:

The B-VC's membership consists of representatives of CEOS Agencies and their designees. Participation is open to all CEOS Agencies regardless of whether their support is for surface-based *in situ*, airborne, or spaceborne data and activities. Other organizations that have appropriate expertise and are willing to support and contribute to the priorities of the B-VC may also be invited to join as members.

To ensure smooth operation, the B-VC operates with a team of co-leads who are biodiversity experts selected from CEOS Agencies that concretely contribute to the outcomes of the B-VC. To promote membership diversity, the B-VC aims to attract membership across geographic regions. In the case where a co-lead or member, for any reason, cannot continue to serve in the VC, their Agency will have the first option to fill the position with an alternate. If the Agency chooses not to name or designate an alternate, the B-VC will seek biodiversity expert members from other CEOS Agencies that are actively contributing to the B-VC.

Current Co-Leads are:

- CSA: Lucie Viciano
- ESA: Marc Paganini
- NASA: Gary Geller

Resources:

Three categories of support will provide the resources to enable the activities of the Biodiversity Virtual Constellation so it can meet its objectives.

- **Biodiversity Virtual Constellation team members.** Member time and associated resources will be supported by their sponsor Agencies. Additionally, certain activities will benefit from support from CEOS Working Groups and Virtual Constellations that have the needed expertise. The B-VC and its members will largely focus on planning and facilitating biodiversity-relevant activities to increase utilization of space-based EO. While this will be supported by CEOS Agency involvement, the BST may invite members of the broader research and applied biodiversity communities to participate in the B-VC to support its activities; this includes people at universities, non-government organizations, commercial entities, and other organizations. Such in-kind participation is expected when aligned with specific B-VC activities; product development is a good example as it is a common activity at universities, often carried out by graduate students under faculty guidance.
- **Agency Research and Development Programs.** Some of the B-VC's planned activities, such as algorithm and product development and the prototype monitoring systems, align with Agency research and development programs that already support these types of activities, often by soliciting proposals. Universities, institutes, and NGOs have focused on EO utilization for biodiversity for many years, as evidenced by the many proposals that space Agencies have funded. The exceptionally high interest in ESA's BioSpace25 conference (February 2025)

illustrates the strong level of interest in this topic. It is noted that each of the three Ecosystem Extent Demonstrators was funded by a CEOS member Agency. Prototype systems like these include components that support the B-VC's planned activities and can support users seeking to enhance their use of space-based EO to meet their needs.

- **External Support.** Another source of support for B-VC activities is proposals submitted to non-CEOS Agency organizations by B-VC external partners. For example, a national science Agency or an Agency within an Environment Ministry may solicit proposals for work relevant to the B-VC's activities, such as development of a product or tool for which a biodiversity expert at a university then submits a proposal. An important role of the B-VC is to maintain engagement with such external partner members, so they are aware of, and encouraged, to submit such proposals as well as to engage with potential B-VC activities. By fostering connections with external partner members, the B-VC strengthens both its own activities and the broader engagement of the biodiversity community with EO.