Concept Paper for the Next Phase of the GEOSS Infrastructure

This document is submitted by the GEOSS Infrastructure Development Task Team to the Programme Board for discussion.

1 SCOPE

As requested by the 20th meeting of the Programme Board (May 2021), the GEOSS Infrastructure Development Task Team (GIDTT) has prepared a document describing the proposed concept for the next phase of the GEOSS infrastructure. The scope of this document is to provide an update on the current state of GEOSS infrastructure as well as thoughts on its potential evolution. Pending the outcome of upcoming deliberations in the Executive Committee and Plenary on the concept of GEOSS itself regarding its future evolution and characteristics, the supporting GEOSS digital ecosystem will be developed over three years (2022-2024) to be fully deployed and operational by 2025, the end of the second decade of GEO.

2 GEOSS INFRASTRUCTURE: CURRENT STATUS

As reported by the GIDTT at the 20th Programme Board meeting, over the past few years GEO has devoted considerable efforts to building the GEOSS infrastructure and functionalities that have made Earth observations discoverable and accessible. In order to address the Big Data revolution and provide the necessary scalability in GEOSS, the initial GEOSS Common Infrastructure has gradually evolved into the cloud-based GEOSS Platform, with the GEOSS Portal serving as the window for data discovery and access to the GEO community.

Currently, the GEOSS Portal offers a single Internet access point for users seeking data, imagery and analytical software packages covering all parts of the globe. It connects users to existing databases and portals and provides reliable, up-to-date, and user-friendly information – vital for the work of decision makers, planners, and emergency managers. Data providers who want their data accessible via the GEOSS Platform can register via the GEOSS Yellow Pages, which implements a simplified registration process with the data registered using native standards and formats via the GEO Discovery and Access Broker (DAB), maximizing interoperability. Today, GEOSS counts over 190 data providers, enabling the discovery of over 480 million single data granules via a user-centric Portal (with more than 2000 active sessions per month in the last 3 years) and machine-to-machine Application Programming Interfaces (APIs), with more than 15 000 unique clients for a total number of over 18 million finalized requests in the last 5 years.

3 PROPOSED EVOLUTIONARY APPROACH

The approach, proposed by this roadmap, to evolve the GEOSS infrastructure and develop a new implementation generation can be summarized in four concepts:

1. The GEOSS concept (defined in the GEO Strategic Plan 2016-25 and adopted by the 2012 Ministerial Declaration and GEO XII Plenary – see Annex A) is independent from any implementation technology. Therefore, the recommendation of the need to re-evaluate GEOSS refers to how the concept needs to be implemented to respond to the GEO community

needs and the evolving landscape of technologies, stakeholders, and analytical paradigms. Future GEOSS infrastructure will need to follow closely and support the evolution of the GEOSS concept and its implementation.

2. Recognizing the relevance of the Regional GEO Initiatives and the importance of engaging with GEO Members to better understand their needs and collect their requirements, future GEOSS architecture will be underpinned by the regional platforms that, in turn, will rely on the national systems and services.
3. Future GEOSS infrastructure analytical capacities will be largely provided at the regional/national level, along with the required scalable computing infrastructures – applying the multi-cloud and cloud continuum paradigms. This is to improve the engagement of the Small and Medium Enterprises (SMEs) and local stakeholders as well as to ensure GEOSS sustainability.
4. In future GEOSS infrastructure development, the past GEOSS development investments will be safeguarded as much as possible (e.g. the re-use of existing components/services).

4 FUTURE GEOSS ARCHITECTURAL APPROACH

Future GEOSS infrastructure will embrace the profound digital transformation of geospatial information and services to develop a modern and more effective implementation of the GEOSS concept.

The digital transformation of industry and society has moved most of the geospatial digital resources and capacities from the physical to the virtual dimension. The traditional provider-driven GEOSS approach focused on infrastructure development, mobilization and delivery of data. Whilst a valuable contribution, the resulting "ocean of data" has overwhelmed consumers, many of whom lack access to the critical services needed to exploit the data.

A whole systems approach is needed that democratizes data, digital services and bridges the divide between producers and consumers. The transformative infrastructure for GEOSS will employ a whole system ecosystems strategy that is user-driven, connecting producers, consumers, and services. The envisioned GEOSS Digital Platform Ecosystem will cultivate a community of practice to unleash data for evidence-based decision-making.

This shift from the traditional data sharing paradigm to the more effective geospatial digital ecosystem model to generate and share knowledge, virtually can be applied to the GEO value-chain framework, depicted in Figure 3. The digital ecosystem paradigm will also require interoperability of online data analytical services and digital resources orchestrations – which, in turns, needs virtual access to scalable computing resources.

In keeping with GEOSS philosophy, future GEOSS infrastructure implementation can be seen as a collection of task-oriented or dedicated regional and local systems, which pool their resources and capabilities together (in a flexible and scalable way) to create a new and more complex system that offers virtual data and analytics services (and performance) access, which will, in turn, result in more than simply the sum of the constituent systems.

4.1 Future GEOSS Infrastructure Traits

The main traits and characteristics of future GEOSS infrastructure should be:

- Ecosystem nature (i.e. flexibility, evolvability, composability);
- Focused on the GEO engagement priorities;
- Implicating Regional/Local stakeholders (see Figure 1);
- Focused on supporting the implementation of the mid-stream of the GEO value-chain;
- Building on a multi-cloud environment (i.e. multi-lateral and evolutionary approach).

The collaborative diagram representing the future GEOSS digital ecosystem is depicted in Figure 1 below.

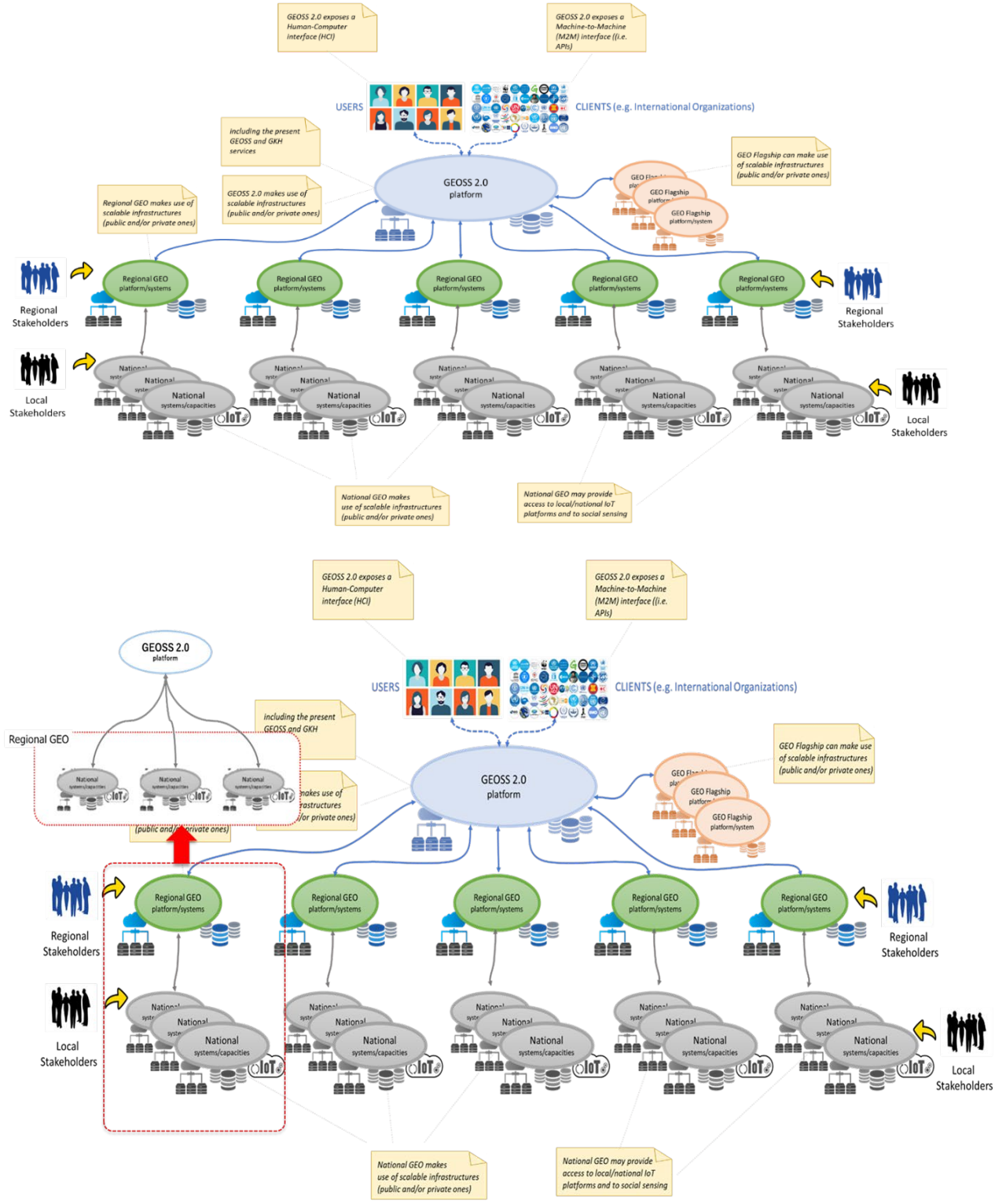

Figure 1: Proposed future GEOSS infrastructure

To ensure transparency and engage GEO stakeholders, as well as to communicate and mainstreaming the GEOSS value proposition, the GIDTT will deliver two important technical reports for public release:

- Updated GEOSS infrastructure interoperability architecture to support its sustainability and evolution; and
- Updated GEOSS infrastructure governance and scalability plan to support its sustainability and evolution including legal and ethical aspects, where relevant.

4.2 Future GEOSS Infrastructure Interoperability (technical interoperability) Model

4.2.1 Multi-cloud computing

Future GEOSS infrastructure will adopt a multi-cloud approach: utilizing different clouds from diverse cloud providers, including any mix of Infrastructure-, Platform-, or Software-as-a Service (IaaS, PaaS, or SaaS).

As opposed to cloud federations, the advantage of the multi-cloud approach is that cloud services providers do not have to agree to share resources for a given application and can include the use of private clouds and hybrid clouds with multiple public cloud components.

Adopting a multi-cloud approach requires the implementation of the virtual cloud paradigm, i.e., the development of a virtual layer between the heterogeneous cloud systems and the common applications development platform. The virtual cloud layer is also called to manage some security and performance challenges that characterize multi-cloud environments.

4.2.2 Cloud continuum

While cloud data centers are large facilities deployed in a limited number of locations, in a digitally transformed society, cloud users are spread everywhere (IoT and 5G enabled applications are significant examples). Commonly, clients and users are far from the cloud data centers that are managed by their preferred providers. Edge and/or fog computing infrastructure are likely to be closer to those devices and applications to bring computing capacity with lower response time.

In collaboration with the Regional GEOs, the future GEOSS infrastructure will support the paradigm of cloud continuum, being ready to leverage the IoT and 5G/6G revolutions.

4.3 Future GEOSS Infrastructure Organizational and Governance Model

Future GEOSS infrastructure will apply a collaborative governance style: the digital ecosystem constituent organizations recognize common objectives (i.e. the GEOSS value proposition), a designated ecosystem manager, and resources allocated for the ecosystem. However, the normal operational mode of the constituent systems is not subordinated to the ecosystem managed purpose, and they retain their independent ownership, objectives, funding, and development and sustainment approaches.

Future GEOSS infrastructure aims at developing a digital ecosystem of public and private resources and capacities, largely building such collaboration in the cyber-domain. Therefore, third party services and infrastructures (noticeably, edge and public clouds) will be utilized. For these reasons, in addition to the GEOSS Data Sharing and Data Management Principles, GEO is working on recognizing possible ethical and privacy principles within the Data Working Group, which should be considered by the design phase of future GEOSS infrastructure.

5 INTEGRATION OF GEO KNOWLEDGE HUB INTO GEOSS INFRASTRUCTURE

Integration of the information available in the GEO Knowledge Hub (GKH) with the GEOSS Platform will be a feature of the future GEOSS infrastructure. Besides providing access to descriptions and location of EO data, the long term aim of the GEOSS Platform is to enable its users to have access to methods, algorithms, software and reports available in the GKH. This capability was demonstrated at the GEO Week 2019.

The general idea for this path of evolution of the GEOSS Platform is the concept of developing and delivering knowledge packages via the GKH. A knowledge package is a complete, curated set of data, software, products, and reports that enables replication of an EO application. Organizing a knowledge package requires combining the access to data with the access to the resources (models, algorithms, specifications, fit for use, results, etc.) required to make use of the data. It also requires that the resulting knowledge package be organized inside the GEOSS Platform to make it easily discoverable, understandable, accessible, and usable. Thus, one possible scenario for integration would be for the user who discovers and accesses EO data via the GEOSS Portal being informed of potential applications of that data with links to the GKH. Conversely, a user searching for applications of EO in a given thematic area of the GKH would be informed of additional datasets available through the GEOSS Portal for scaling of that application in other geographic areas, perhaps leveraging analysis ready and other applicable datasets (such as in situ).

Figure 2 shows one possible integration of the GEOSS Portal and the GKH within the GEOSS Platform, in which the Platform will use the API of the InvenioRDM platform to extract information from the GKH. As open source software, InvenioRDM is designed from the ground up to be resilient to changing business requirements, including stable APIs. Naturally, the future evolution of the concept of GEOSS itself will have a bearing on the GEOSS Portal, and how the GKH and GEOSS Portal are integrated within it.

6 GEO MID-TERM EVALUATION REPORT

The 55th GEO Executive Committee meeting held on the 6-7th July 2021 included a presentation and discussion of the Mid-Term Evaluation (MTE) report, assessing the progress achieved so far in accomplishing the objectives of the GEO Strategic Plan 2016-2025. The extensive report highlighted key findings and recommendations for improvements including regarding the GEOSS infrastructure.

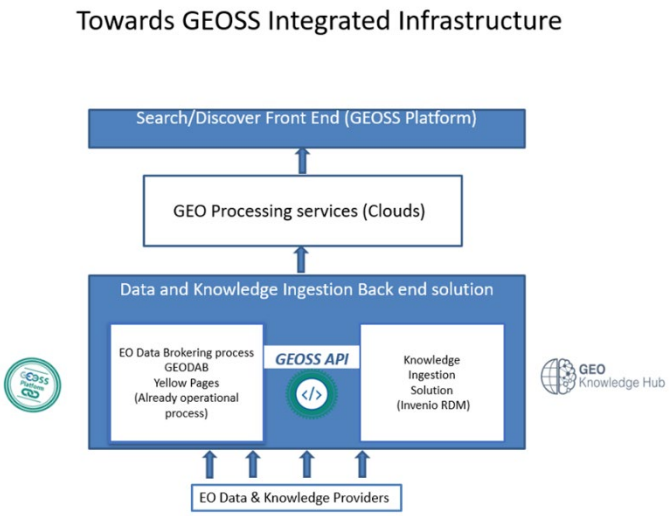

Figure 2: Possible model of integration of the GEOSS Portal and the GEO Knowledge Hub

6.1 GEO Stakeholders

The MTE report recognized a set of relevant GEO stakeholders and users, as depicted in Figure 3. The report classified GEO's stakeholders in three categories: Core, Primary or Internal, and Secondary/External. However, some fall under two categories as, for example, some space agencies are Participating Organizations, while the ones that are not Participating Organizations can be considered as secondary stakeholders.

Figure 3: GEO stakeholders (from the MTE report)

Therefore, the future GEOSS infrastructure will consider different categories of users: Academia, Commercial sector, Governments and Institutions, UN institutions, international organizations, statistical agencies, and citizens.

This heterogeneity requires the development of a flexible and evolvable framework. These are the traits of a digital ecosystem.

6.2 The GEO Value Chain

The MTE report introduced a GEO value-chain framework to be implemented, according to the GEO community members interviewed. The GEO value-chain framework consists of three main phases (up-stream, mid-stream, and down-stream phases) that can be described according to the six service steps. The framework is depicted in Figure 4 below.

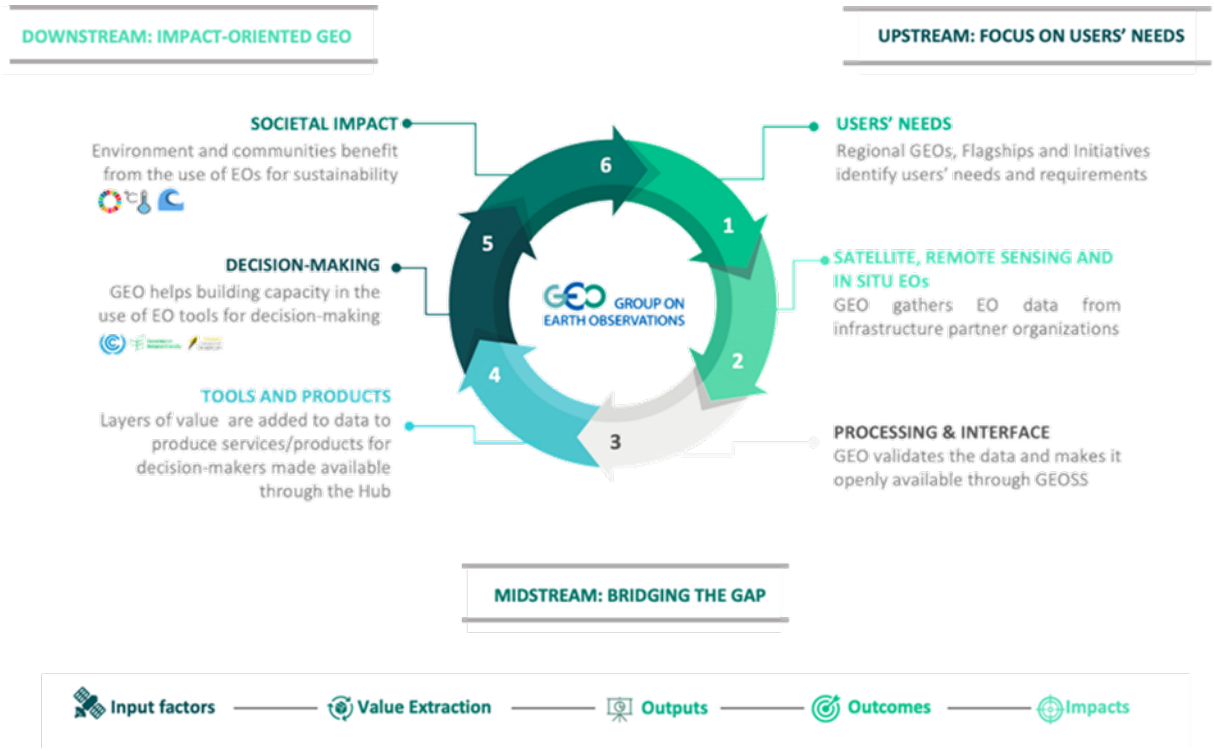

Figure 4: GEO Value Chain (from the MTE report)

Clearly, the future GEOSS infrastructure is called to support the entire value-chain framework focusing, in particular, on implementing the mid-stream steps and their closest ones – i.e. steps from 2 to 5.

Therefore, future GEOSS infrastructure will focus on bridging the users' needs and the GEO impact.

According to the MTE report, the value-chain sustainability ultimately depends on:

1. The ability to address a real (political/social) problem and having uptake at a high level of decision-making – this is also important for raising financial resources;
2. The capacity to clearly identify, involve, and address the needs of the users of the applications to be developed;
3. The need for local capacities, for example, technical expertise to develop and sustain the uptake of EO-derived products;
4. Continuous availability of data made openly and freely accessible and usable;
5. The capacity to provide an added-value (that is, a set of layers of value; for example: by generating information from data; by recognizing information patterns and creating knowledge; and by recommending smart actions from knowledge) to produce the actionable intelligence required by the decision-makers.

In 2005, the concept of system-of-systems for data access was revolutionary. Today, in keeping with GEOSS' uniqueness and revolutionary role, GEO must aim to develop a multi-lateral digital ecosystem to generate the intelligence required by decision-makers.

Finally, future GEOSS infrastructure development will engage the GEO stakeholders, be transparent, evolvable (leveraging the many technology revolutions), and improve its communication.

The GIDTT will develop a document defining the architecture of the future GEOSS. This will define its main operating principles (including organizational model and technological interoperability) and will be kept updated to detail the GEOSS evolution (over the time).

6.3 GEOSS Infrastructure connection to Regional GEOs

The MTE "recognized Regional GEOs can foster stakeholder engagement, recognize the needs, skills, knowledge and specific gaps in expertise of participating parties, thus fostering the co-development and co-design of solutions. Furthermore, they have direct access to users and can tailor solutions to their needs. Regional GEOs can address language and other barriers, such as geographic distance, which is harder to address from a global GEO perspective, thus favoring the inclusion and direct engagement of member states".

The future GEOSS infrastructure will thus build on the services/products offered by the Regional GEO or National infrastructures/systems. They can complement the existing GEOSS components (notably, one of them is the GKH) and capabilities to realize the steps of the GEO value-chain, which are presently missing.

Acknowledging that close collaboration with regional GEO is the key to design, develop and implement future GEOSS infrastructure. Consensus-building with sufficient feasibility study should be proceed in each phase of development.

7 FUTURE GEOSS INFRASTRUCTURE DEVELOPMENT ROADMAP

Future GEOSS infrastructure will be developed by adopting the DevOps methodology. This consists of a set of practices combining software development (Dev) and IT operations (Ops). This methodological approach allows to shorten the ecosystem development life cycle and provide continuous delivery with high software quality. The implementation roadmap will consider three main releases (milestones), one for each year –see Figure 5 below.

The main tasks of the Future GEOSS infrastructure development process are discussed below.

7.1 Task 1: Redesign GIDTT Synergies with Regional GEOs and other Foundational Tasks

Scope: To connect with and commit the Regional GEOs initiatives and the other Foundational Tasks to the GEOSS development.

Expected result: a new GIDTT structure that engages and represent user needs and the member expected impacts.

Actors: GEO Programme Board with the support of GIDTT, Regional GEOs, and the other Foundational Tasks.

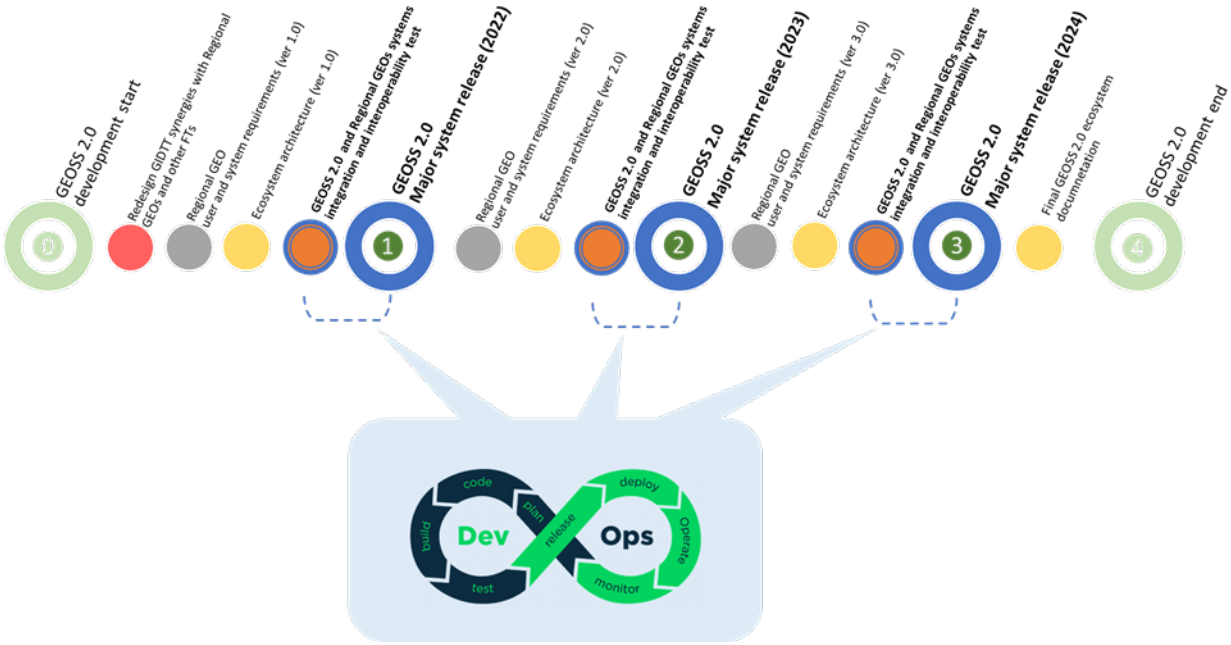

Figure 5: GEOSS 2.0 Development Roadmap

7.2 Task 2: Regional GEO User and System Requirements

Scope: to collect the requirements of the Regional GEO initiatives, as far as their user needs, available digital resources with their access interfaces, and the expected outcomes from their stakeholders. The focus must be on the strategic priority advancing a end-to-end use case approach.

Expected result: the provision of knowledge and digital resources (e.g. data, services, and products) according to the matrix depicted in Figure 6. This task continues for all the duration of the future GEOSS infrastructure development, three milestones are expected – according to the roadmap of Figure 5.

Actors: Regional GEOs, with the support of GIDTT.

AfriGEO	Engagement	Engagement	Engagement	Engagement
AO-GEO	Engagement	Engagement	Engagement	Engagement
EuroGEO	Engagement	Engagement	Engagement	Engagement
AmeriGEO	Engagement priority #1	Engagement priority #2	Engagement priority #3	Engagement priority #4
End-to-end use case				
Data resources				
Analytics and tools resources				
(scalable) computing infrastructure resources				
Decision support capacity				

Figure 6: End-to-end use cases and required digital resources to be provided by Regional GEOs

7.3 Task 3: Future GEOSS Ecosystem Architecture

Scope: to define and keep updated the future GEOSS architecture (i.e. technology interoperability as well as governance and scalability aspects).

Expected result: Architecture document release. This task continues for all the duration of GEOSS infrastructure development, three milestones are expected –according to the roadmap of Figure 5.

Actors: GIDTT with the support of Regional GEO initiatives.

7.4 Task 4: GEOSS Infrastructure and Regional Geo Systems integration and interoperability test

Scope: to implement the end-to-end use cases defined by the Regional GEO initiatives, contributing to the GEO engagement priorities – see task 2 outcomes.

Expected result: The effective and user-friendly implementation the end-to-end use cases defined by the Regional GEO initiatives. This task continues for all the duration of future GEOSS infrastructure development, three milestones are expected –according to the roadmap of Figure 5.

Actors: GIDTT and the Regional GEO initiatives.

7.5 Task 5: GEOSS Infrastructure Major System Release

Scope: to develop and release a major version of the future GEOSS ecosystem on the basis of the use cases defined by the Regional GEO initiative and the integration and interoperability tests done in task 4.

Expected result: Milestone release of future GEOSS ecosystem. This task (based on the DevOps methodology approach) continues for all the duration of GEOSS infrastructure development, three milestones (i.e. major releases) are expected (according to the roadmap of Figure 5), in the between minor releases will occur.

Actors: GIDTT and the Regional GEO initiatives.

8 FORESEEN RESOURCES TO DEVELOP FUTURE GEOSS INFRASTRUCTURE

Resources required to implement changes to the GEOSS infrastructure will depend in large part on the nature of GEOSS evolution, as a result of discussions within the Executive Committee and Plenary. Regardless, it is clear that contributions of resources will be needed from GEO Members, Participating Organizations and the Secretariat to implement GEOSS infrastructure, whatever nature it takes.

At this point in time, the European Commission has indicated it will contribute to the GEOSS infrastructure development through a dedicated activity funded by its Research and Development programme, and also the further development of the EuroGEO node of the ecosystem infrastructure.

Annex A: GEOSS Concept

"GEOSS is a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations within GEO. Further, GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services. Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making".

This definition of GEOSS is at the centre of the GEO Strategic Plan 2016-25: Implementing GEOSS adopted by the GEO XII Plenary and Mexico City Ministerial Declaration in 2015. It is a technology-neutral definition that sets the objectives of GEOSS and its core characteristics.

Annex B

Mid-Term Evaluation Findings and Recommendations Addressed by the GEOSS 2.0 development

The future GEOSS infrastructure principles and traits introduced in this document address all the findings (F) and recommendations (R) dealing with GEOSS, as discussed in the MTE report.

TABLE 1: MAIN MTE FINDINGS AND RECOMMENDATIONS DEALING WITH GEOSS

ID	Findings and Recommendation
	GEO ORGANIZATIONAL MODEL
	Mission
F1	"… to covering the downstream of the value chain, providing a platform for collaboration and representing a source of branding, recognition and trust"
	Value Proposition
F2	"A clearly defined value proposition is missing from messaging to members, but also to external partners, including UN institutions, and partners, such as the private sector".
F3	(It is required a) "greater interaction with individual members to better understand their needs and where GEO can contribute and what GEO can offer, for instance in convening, addressing capacity gaps, providing access to open Earth observation data or in the standing up of National GEOs."
F4	"GEO should agree on specific areas of focus where it can deliver, in light of developing technologies relative to its founding goals and its convening function".
F5	"… the next phase of GEO should be more action-oriented on what GEO can deliver and where it can make unique contributions to establish itself as a global leader in Earth observation".
	Communication and Engagement
R1	"From an operational point of view, GEO should improve internal and external communication, as well as synergies among the different elements of the Work Programme, GEO governance bodies and the Secretariat, and to all of GEO relevant stakeholders"
	Re-evaluating GEOSS
F6	"GEO needs to reassess the concept of GEOSS, what the main goals are, and whether the original concept of GEOSS remains relevant to the organization without modifications".
F7	"GEO should evaluate and decide what it wants or needs to pursue in terms of data infrastructure, producing data products, and user services, how GEOSS can integrate and execute the Knowledge Hub, and whether GEO has the capacity to carry this out"
F8	"GEO should establish its focus going forward in terms of which of these roles [convener, facilitator of access to open data, and user services --Ed.] should be prioritized given that it has limited resources and capacity".
F9	"There is a balance needed between support for the upstream and downstream of the Earth observation value chain. Clearly defining where GEO can have the most profound impact will help ensure a lack of mission or scope creep …"
R2	"GEO should consider assessing the concept of GEOSS in light of the recent evolution of GEO… [and] to explore to what extent the concept of GEOSS is still relevant to the organization as it no longer appears to define the core of GEO's activities as originally defined".
	POLICY AND USERS' INTERFACE
	Relations with the UN and other stakeholders
F10	"… there are opportunities to further improve relations with UN agencies both at a high policy level and at an operational level by deepening their collaboration with Regional, National GEOs and GEO Work Programme activities… [as well as] … multilateral development banks and statistical agencies…. Strengthening such engagement would contribute to the establishment of a comprehensive ecosystem

ID	Findings and Recommendation
	approach to the role of GEO in coordinating availability, access and use of Earth observations".
	Users' Needs
F11	"GEO has not developed a systematic mechanism to report on users' needs and requirements, ensuring that these are identified and addressed, especially when different needs emerge at a regional, national and local level".
R3	"A greater role should be taken by Regional GEOs in collecting tailored requirements for their regions".
	INTEROPERABILITY
	Internal processes and connections
F12	"The broad GEO Work programme would benefit from better coordination, improved communication and interoperability between GEO's implementation mechanisms".
F13	"An increasing level of interaction between Regional GEOs should be encouraged".
F14	"The new Knowledge Hub has a potential role to play in providing information to show how Initiatives, Community Activities, Flagships and Regional GEOs currently connect, placing an emphasis on the value chain of Earth observation to users and where GEO provides this across its different initiatives."
	External and technical Interoperability
F15	"Technology advances have significantly changed the original concept for the GEOSS …"
F16	"GEO would benefit from improved external connectivity with major Earth observation data portals, at all levels. Attention should be paid to links with global, regional and national data systems."
F17	"Particular attention should be made to improving the availability and integration of in situ observations within the GEO Portal …"
R4	"GEO should review the content of the GEOSS Implementation Plan to make sure it i) has good links with key global, regional and national data portals; ii) addresses gaps in the integration and availability of in situ data; and iii) plans for appropriate use of the Knowledge Hub within the GEOSS overarching structure to demonstrate the value of Earth observation to decision makers."
R5	"In particular, the work of the In Situ Subgroup of the Data Working Group should be strengthened to focus by GEO theme on in situ data gaps and access".
	REGIONAL GEOs
	Role of Regional GEOs:
F18	"Regional GEOs need to become more integrated into the functions of the GEO Work Programme and the overarching structure of GEO itself".
R6	"GEO should consider possible solutions to promote an increased engagement, coordination with, and contribution of Regional GEOs across GEO's governance structure and Implementation Mechanisms".
	THE PRIVATE SECTOR
	Engagement with the Private and Commercial Sectors
F19	"GEO Secretariat and Regional GEOs could play a role to help match and broker possible collaboration between commercial sector partners and Work Programme activities".
R7	"GEO should try to address the needs of different commercial sector players that might be interested in getting involved, considering possible barriers to engagement and differences related to geography and size".
R8	"Regional GEOs and the GEO Secretariat would be best placed to play a key role to foster engagement with the commercial sector by assuming a more central role in brokering engagement and matching potential partners at a regional and global level with GEO Work Programme activities."
	Cloud Credits and License Programmes
F20	"GEO should look at ways to make this engagement [cloud credits and licence programmes –Ed.] and the benefits derived from it become long-term by ensuring participants can retain and continue developing the skills acquired through the programme and that the programmes should become increasingly tied to the GEO Work Programme
	Small, Medium and Micro Enterprises

ID	Findings and Recommendation
F21	"Even though GEO's engagement has increased in recent years, respondents feel that GEO has so far shown little or no satisfactory engagement with the commercial sectors in SMMEs. GEO is perceived to engage more with multinational technology companies that conform with the GEO rules of procedure or afford the prospects of big grants"
F22	"Key informants feel that GEO should also engage more with SMMEs, diverse companies from different geographies and with different sizes, particularly in developing and least developed countries, with a clear plan to address structural barriers and equally pursue involvement with all of them".
	USE CASES ANALYSIS
F23	"… another key factor of success is the adoption of an ecosystem approach, aimed at involving an increasing number of stakeholders. This approach should however be underpinned by a clear definition of value and of the benefits that can be derived from the participation in the activity by each of these stakeholders"

TABLE 2: RELATIONSHIP OF FUTURE GEOSS FEATURES TO MTE FINDINGS AND RECOMMENDATIONS

GEOSS 2.0 paradigm and traits	MTE points addressed (see Table 1)
Model value	
Ecosystem nature (i.e. flexibility, evolvability, composability)	F3, F23, F5, R1, F6, F7, F8, R2, F10, F11, R3, F12, F14, F15, F16, R4, R5, R6, R7, F23
Focused on the engagement priorities	F2, F4, F5, R1, F8, R2, F10, F11, R3, R6, R8, F23
Technology and service value	
Hierarchically structured (including Global, Regional, and National levels)	F3, R1, F6, F8, R2, F10, F11, R3, F12, F13, F15, F16, F17, R4, F18, R6, R8, F21, F22, F23
Focused on supporting the implementation of the mid-stream of the GEO value-chain (see Figure 2)	F4, F5, F6, F7, F8, F9, R2, F14, F15, F17, R4, R5, F19, R7
Building on a multi-cloud environment (i.e. multi-lateral approach)	F5, F6, F9, F16, F17, R4, R5, F18, R6, R7, F20, F22,
Communication and Stakeholder engagement	
GEOSS 2.0 interoperability architecture is defined in a public document to support sustainability and evolution	F2, F6, F8, F9, R2, R3, F14, F15, F16, F17, R4, R5, R6, R7, F23
GEOSS 2.0 governance and scalability plan is defined in a public document to support sustainability and evolution	F2, F6, F7, F8, F9, R2, F11, R3, F13, R5, F18, R6, F19, R7, R8, F20, F21, F23