Copernicus evolution
LC-SPACE-02-EO-2018
LC-SPACE-03-EO-2018

Guidance Document for

Horizon 2020 Work Programme 2018-2020

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Contents

1. Scope of the document

The Regulation establishing the Copernicus Programme (EU 377/2014) notes in its preamble, that Copernicus should also benefit from the results provided by Horizon 2020, in particular through its activities in research and innovation for future Earth Observation technologies and applications. In this respect, the Commission is called upon to ensure appropriate synergy, transparency and clarity regarding the different aspects of Copernicus. This guidance document is thus designed to further elucidate the research needs as identified in the context of Copernicus evolution.
The Horizon 2020 Space work programme call 2018 includes the following topics with the titles:

- LC-SPACE-02-EO-2018: Copernicus evolution – Mission exploitation concepts
- LC-SPACE-03-EO-2018: Copernicus evolution - preparing for the next generation of Copernicus Marine Service ocean models

The guidelines are intended to assist applicants in preparing their proposals giving them useful information about the ongoing Copernicus evolution process for both the Services and the Space Component, describing also the activities of the task forces and expert groups dealing with the different thematic sectors: polar, agriculture, forestry and marine ocean models.

2. Copernicus evolution

The Copernicus Regulation (EU 377/2014) establishes the Union Earth observation and monitoring programme, containing a service component ensuing delivery of information in the areas of atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency

management and security. The scope of these different service components is further defined in Art 5 of the regulation.

Copernicus is driven by user needs, with a priority for public policy needs addressing European and global societal challenges. Thus, technology push cannot drive the key characteristics of the programme. Furthermore, integration of technologies and methods must be preceded by a demonstration of an adequate level of maturity.

The key principle for the Copernicus data policy is "free, full and open", in particular regarding Copernicus "essential data" addressing public policy goals and serving core users. A long-term stability in data policy is essential to allow the commercial sector (this applies to public services too) to establish business strategies. However, a balance needs to be struck between interests of users and security interests.

As required by public policy needs, the continuity and long-term sustainability of measurements is a key priority for Copernicus. We need to ensure the continued observation capacity needed by the established Copernicus services, and provide space infrastructure for the core user needs, while rationalizing where and when necessary. Ensuring the continuity of observations at least at the same quality as now does not imply perpetuating the current Sentinels. Nevertheless, we need to unequivocally commit to provide operationally a well-defined range of core data/information with a sustained and warranted performance, providing continuity of data within long time series.

Services are the key innovation of Copernicus, not reproduced by any of our peers but envied by many of them. Copernicus service provision is a key reference point for the global success of the programme, as providing not just space-borne data products - which could be done by space agencies alone -, but also validated, analysed and interpreted information that is tailored for non-specialised users (especially outside the space area), and in particular by policymakers. The Copernicus services organise and sustain unique expertise in their respective domains and form an essential and indispensable part of the value added by the programme.

Thus, the Copernicus services must be validated to assure the continued and routine availability of information, with a rationalisation based upon the experiences and lessons learnt so far. The evolving services' needs for observations should also be a key driver for the evolution of the Copernicus Space Component. Expanding the scope of services must be considered, in particular in areas which help to meet the policy challenges identified in the adopted Space Strategy for Europe in November 2016 , namely:

- ✓ CO2 Anthropogenic emissions monitoring (as part of the Climate Change and Atmosphere Services)
- ✓ Polar environment monitoring (as part at least of the Climate Change and Marine Services)
- ✓ Agriculture and forestry monitoring
- ✓ Hydrology monitoring covering all the fluid envelops like soil moisture, water, snow, atmosphere, ocean mass… (as part of the Climate Change and Land Services)

2.1. Evolution of the Copernicus Services

The continuity of the Copernicus services and information delivery for the users maintaining appropriate levels of capacity and quality will constitute a key objective. Many applications in the environmental or climate change domains rely on systematic and uninterrupted data provision. Services will evolve to build upon the experiences and lessons learnt so far and to reflect the advance of the state-of-the-art.

The Copernicus Services should evolve towards additional sectors that can be considered as cross cutting applications e.g. agriculture, cultural heritage, hydrology, energy, transport. In this context, each service should identify and illustrate its contribution to the economic sectors and societal benefit areas. Fundamentally all services should be able to focus on explicitly these sectors, which would then highlight the societal benefits of Copernicus and foster cross fertilization between services in each given sector area. This would also greatly help identifying the gaps in applications and prepare the grounds for prioritizing the Copernicus future evolution.

The consolidated value-added chain is needed to ensure that advanced high quality products are made available to the users. These products constitute therefore a robust basis for developing dedicated downstream applications and enhancing the information content through whatever analysis is appropriate.

For the downstream services and applications development, the direct involvement of national, regional and local authorities and final users in expanding the data and products exploitation is important for the use of space derived products in the real life of European citizen.

2.2. Evolution of the Copernicus Space Component

The evolution of the dedicated Copernicus Missions is driven by user needs and the anticipated gaps in the data available from contributing missions. The evolution is proposed to consist in the deployment of Expansion missions (mid-term) and Next Generation missions (long term) as illustrated in Figure 1. The Next Generation missions are intended to be the backbone of the Copernicus infrastructure after 2030, providing continuity to both, the current Sentinel constellation and the forthcoming Sentinel Expansion missions.

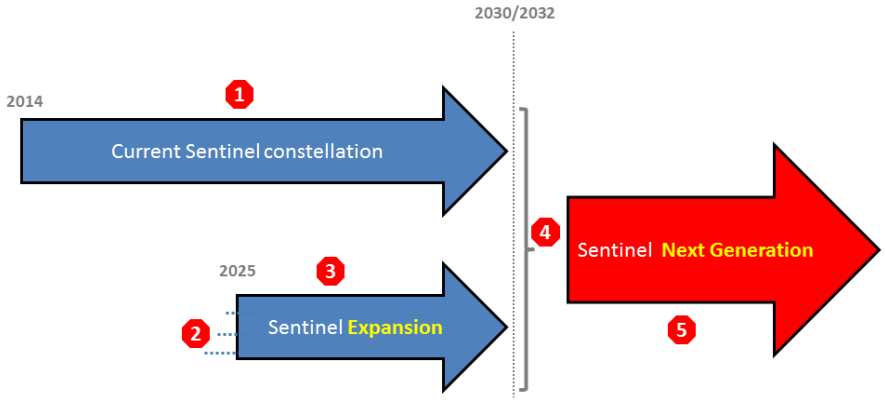

Figure 1: Copernicus dedicated missions from 2014 onward

Five questions marked as red circles in the figure remain to be answered during the forthcoming period:

1. What will be the lifetime of the missions of the current Sentinel constellation?
2. How many Sentinel Expansion missions will have to be developed?
3. What will be the lifetime of the Sentinel Expansion missions?
4. How many Sentinel Next Generation missions will have to be developed?
5. What will be the lifetime of the Sentinel Next Generation missions?

Another key question to be addressed is whether the succession of the first missions should be recurrent units, or newly developed satellites including changes due to evolving user requirements,

lessons learnt, technological advances and obsolescence. The considerations to be taken into account for this decision are closely linked to funding availability and the procurement approach applied.

The use of diverse platforms in Copernicus infrastructure can be considered and declined as follows:

- ✓ The use of High Altitude Platforms, and/or drone systems, must be explored, inter alia to address the security dimension of Copernicus
- ✓ The use of small missions and micro-satellites must be explored in the context of security and market-related applications, focussing on a capacity to ensure operational continuity and adaptability to changing user requirements, technology levels and related opportunities. Micro-satellites able to innovate in relatively short innovation cycles might also increase timeliness of observations.
- ✓ The contribution of in situ platforms to Copernicus must be reinforced and the involvement of such infrastructure will be deeply considered.
- ✓ The architecture of the system should be flexible enough to be able to encompass other emerging innovative models as well.

2.3. Commission – ESA Process

The Commission and ESA have finalised a joint roadmap for this process which has been distributed to ESA Member States (PB-EO), as well as EU Member States (Copernicus Committee and User Forum).

As a start, the Commission is convening together with ESA thematic Task Forces of experts which are tasked with defining additional requirements for the future space component that serve to meet highest-priority needs in support of EU policy domains:

- ✓ CO2 observations
- ✓ agriculture and forestry applications
- ✓ polar / ice and snow observations
- ✓ security applications,
- ✓ cultural heritage,
- ✓ energy.

In parallel, ESA and the Commission will carry out extensive consultations with Member States via the User Forum, Copernicus Committee, PB-EO, etc. in order to ensure that the Copernicus Space Component Evolution Plan properly reflects users' and Member States' needs and is well-coordinated with their national activities.

A key event presenting and discussing a first vision derived from a user requirements study and thematic workshops held in 2017 has been a workshop held with Member States on September 14. The subsequent section outlines key activities leading up to this event, and a summary of deliberations is to be found at http://copernicus.eu/library/detail/2594 . A particular deliverable from this event was a set of 6 specific studies on space instrumentation, to be conducted by ESA, which could provide relevant observation capacities for better monitoring the polar regions, and improving agriculture and forest monitoring. The 2018 call of Coordination and Support Actions LC-SPACE-02-EO-2018 is to provide further support to the Commission in its process to define the options for evolution of Copernicus, by assembling the key European stakeholders and competent entities who

are able to reach out through their respective networks, who have the required expertise to assess the needs for an end-to-end operational system, and those that may have specific expertise to answer the questions raised already in the user requirements process to date.

2.4. User Requirements Studies & Workshops

A dedicated study is running a user requirements gathering exercise (and is expected to deliver its results at the end of 2017) based on which the Commission should adopt a User Requirements Document (also reflecting its own policy priorities). Derived from these User Requirements will be the "Data Requirements for the evolution of the service component" to be handed over to ESA, who will then proceed to define the specific space architecture for its implementation covering both, evolution and expansion requirements.

A number of workshops have taken place in 2016 and 2017, during which the possible evolution of the space observations capabilities has been discussed. The following points emerged:

1. The Next Generation Climate Change Workshop has identified the need for "European operational fossil CO2 emissions monitoring capacity. The need for such a mission (better, for a range of such missions) emerges clearly from the conclusions of COP 21 and was unanimously supported by the participants.

2. The Polar & Snow workshop identified "A multi-mission approach as being suitable to address a large number of needs for both Polar Regions and snow cover monitoring."

3. The Agriculture & Forest Workshop has identified three high priority needs, two of which are the enhanced continuity of Sentinel 1 and Sentinel 2 missions, while the third one is a new thermal infrared (TIR) mission.

4. The Raw Materials workshop identified the need for a Hyperspectral mission. However, it is not clear yet if there is a public need for this type of observation.

In summary the following observation needs will be further investigated for environmental observations:

- ✓ **Priority 1:** Greenhouse gas monitoring, specifically on anthropogenic CO2 emissions, for which currently no satellite observations are available at the appropriate time and space resolutions.

- ✓ **Priority 2:**

  Monitoring the Polar regions, specifically the arctic for sea ice and weather.

  Monitoring Agriculture and Forestry, including water related parameters.

- ✓ **Priority 3:** Mining, biodiversity, soil moisture and other parameters, requiring observations in additional bands, currently not available.

2.5. Copernicus evolution and Horizon 2020 project execution – some practical timing considerations

Immediate service maintenance and enhancement in response to the Copernicus work programme is part of operational tasks delegated in the Copernicus funding context, while long-term evolutions will need input from R&D performed outside the programme.

Copernicus operational services are not static, but need to evolve with recognised and emerging user requirements and state of the art methodologies. While immediate service maintenance and enhancement in response to the Copernicus work programme is part of operational tasks, it is the long-term evolutions which can benefit from input from R&D performed outside the Copernicus

programme. A process has been put in place in the Copernicus services by the Entrusted Entities to review service evolution and any emerging adaptation needs as to their urgency, closeness to the operational delivery process, and availability of capacities.

Activities envisaged by applicants in project proposals under Horizon 2020 "Space" topics LC-SPACE-02-EO-2018 and LC-SPACE-03-EO-2018 should therefore target long-term services and space component evolution challenges based on the latest scientific state of the art.

It should be noted that funding of the H2020 project in no way commits the Commission or Copernicus service operators to deploy the outcomes from the research in the Copernicus operational services or infrastructures.

3. Call 2018

3.1. LC-SPACE-02-EO-2018: Copernicus evolution – Mission exploitation concepts

A. Preparation of a European capacity for monitoring the Polar Regions

The joint Communication by the European Commission and the High Representative of the Union for Foreign Affairs and Security Policy issued on 27 April 2016 to the European Parliament and the Council, proposing « An integrated European Union policy for the Arctic », highlights the strategic, environmental and socio-economic importance of the Arctic region including the Arctic Ocean and adjacent seas. The Arctic's fragile environment is also a direct and key indicator of the climate change which requires specific mitigation and adaptation actions as stipulated by the global agreement reached during the COP-21 held in Paris in December 2015. To this end, the « integrated EU Arctic policy » has identified and is addressing three priority areas:

1- Climate Change and Safeguarding the Arctic Environment (livelihoods of indigenous peoples, Arctic environment)
2- Sustainable Development in and around the Arctic (exploitation of natural resources e.g. fish, minerals, oil and gas), « Blue economy », safe and reliable navigation (NE Passage…)
3- International Cooperation on Arctic Issues (scientific research, EU and bilateral cooperation projects, fisheries management/ecosystems protection, commercial fishing)

To monitor on a continuous basis the vast and harsh Arctic environment, considering the sparse population and the lack of transport links, Space technologies are definitely essential tools including Earth observation, navigation and communication satellites. Although the existing Copernicus programme already offers operational thematic services in the fields of atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency management and security, new requirements from key Arctic users' communities for a dedicated Polar and Snow satellite mission have emerged over a recent past. These requirements were reviewed at a Polar and Snow workshop held in June 2016 and organised at the initiative of DG GROW and involving relevant EC DGs as well as 70 attendees coming from EU Member States and working on various domains 2016 (http://www.copernicus.eu/polar-snow-workshop).
This strong interest for a Polar and Snow mission was further reinforced when discussed in a wider international context, considering UN Conventions and pan-Arctic cooperation activities. This situation led DG GROW to set up in spring 2017 a new panel of European Polar Experts with the mandate to update and/or complete the review and analysis of the Users' needs, thus allowing the Commission to assess the relevance of the development of a « Copernicus expansion mission » dedicated to Polar and Snow monitoring. The terms of the Copernicus Regulation (REGULATION (EU) No 377/2014) constituted some key drivers for the actions of the Polar Expert Group. Based on the elements provided by the Copernicus Regulation:

- The mandate of the panel organised by the Commission focused on User Requirements consolidation. The advanced description or technical choices of the Polar mission shall be encompassed in a forthcoming round of activities to be coordinated by ESA (cf. Article 10 of the Copernicus Regulation).

- The requirements had to reflect the user needs, the highest priority being set on those expressed by the Copernicus Services and the Core users.

- The Polar mission had to be considered in the context of the Expansion mission only but it shall also be deeply studied in the wider context of the Copernicus Space Component which includes dedicated missions, contribution missions and 3rd party missions.

In addition to this legal basis, some programmatic and technical elements based on facts or existing components have been included when defining the baseline of the experts activities.

a) The Sentinel expansion missions, and the Polar mission will be part of them, will be operated in parallel with the Sentinel constellation currently under deployment and/or in operations. In this context, the Sentinel Expansion constellation will follow the same paradigm as the current Sentinel constellation, i.e. it will be based on a monitoring approach with a stable operation plan, provision of operational products and services including Cal/Val activities. In addition, the Polar Expansion mission will not foresee the possibility for on-demand rapid tasking of the satellite. The global architecture (Payload Data Ground Segment and its operations) should follow the same standards as the current constellation.

b) Near real time in-orbit tasking and quasi real time delivery of the products (e.g. as specified by EMSA) have not been considered in this expert group. It will be specifically addressed in another Expert Group or Task Force dedicated to the security domain.

c) The Artic policy document being a baseline driver for the expert group, the Antarctic being more related to Climate Change (when considered together with Arctic), the focus has been given on Arctic and related areas (adjacent seas…). Nevertheless, the observations over the Antarctic area have not been omitted and they have been considered as much as possible.

d) The requirements analysis has been considered relying on a multi-missions approach as pointed out at the 2016' Polar & Snow workshop organised by the European Commission. In addition, a gap analysis has been performed in the context of the existing missions, planned missions, 3rd countries programmes.

In April 2017, the Phase 1 activity of the Polar experts has enabled a thorough review/update of the key users requirements in terms of parameters/observations and services.

A list of high priority parameters together with their associated performance requirements was established taking into account the high level objectives of the EU Arctic Policy Communication as well as those of the Copernicus programme for the provision of operational products and services to well-identified users' communities. This list includes in order of priorities the following elements:

1. Floating Ice parameters,

2. Glaciers, caps and ice sheets parameters,

3. Sea level/sea level anomaly parameters,

4. All weather Sea Surface Temperature (SST),

5. Surface Albedo,

6. Surface Fresh water,

7. Snow,

8. Permafrost.

Starting in May 2017, the Phase 2, starting from the high priority parameter requirements established during the Phase 1, was aiming at identifying possible space instrumentation/clusters meeting the specified parameter performance requirements and leading to the development of a « Copernicus Expansion mission » dedicated to Polar and Snow monitoring. It was also made clear that a single Expansion mission, operating with the current Copernicus Sentinels (and the contributing missions), will not meet all the parameter specification requirements. As a consequence, such an Expansion mission has to concentrate on a smaller number of top operational priority objectives, namely:

- Floating ice and in particular sea ice concentration, the most important parameter for operational navigation in sea-ice infested zones and climate service.

- Ice sheets, Glaciers/Ice caps and Snow with the urgent need for monitoring the surface elevation and its temporal change in order to determine the mass balance of the ice bodies.

Based on these two priority requirements, the experts identified three generic instrumentation families capable to observe the associated geophysical parameters with the required spatio-temporal resolutions and coverage requirements namely:

1. **Imaging PMR**: A Passive Microwave Imaging Multi-Spectral Radiometer with ~10km resolution and spectral channels for SIC and SST retrievals and a swath width that offers at least daily revisits in the Polar Regions.
2. **SARIn altimeter**: A follow-on mission to CryoSat-2, specialised in nadir altimetry in Polar Regions.
3. **SP-InSAR**: A Synthetic Aperture Radar imager that includes single pass interferometric capabilities as demonstrated with Tandem-X. Such capability could be implemented as a passive bistatic follower with Sentinel-1.

For each considered instrumentation, the experts have proposed a detailed description of

1. The state-of-the-art, by reviewing development activities, mission studies and heritage from other missions,
2. Available technologies, by analysing the maturity of technology (TRL), the maturity of science (SRL) and processing,
3. Compatibility with a launch into 2025-2030 timeframe.

Based on these elements, the experts recommend retaining as **first priority** the Imaging PMR solution which:

- Meets the Joint EC Communication high priorities, in particular the provision of **operational sea-ice services** which are of prime importance for navigation safety in the Arctic and adjacent seas with at least daily revisits in polar regions,
- Offers the best solution from technical, scientific and operational viewpoints (operational daily observations of polar regions at almost all weather conditions, day and night),
- Provides high synergy with Metop-SG MWI and Scatterometer,
- Ensures improved continuity of AMSR-type instrument and of AMSR-2 data onGCOM-W1 close to end of life,
- Takes advantage of the longstanding experience of PMR development and data utilisation in Europe (starting with SMMR on Nimbus-7 between 1978 and 1987, DMSP/SSMI).

In addition to the provision of key polar parameters, the I- PMR mission, through the selection of well validated set of channels (e.g. frequencies between 6.8 and 89 GHz and dual polarization) will also be of high interest for the observation of non-polar regions in particular for the oceans (SST) and for land applications such as hydrology, snow cover extent, large scale soil characteristics (moisture), large scale vegetation extent monitoring and biomass, land surface temperature, flooding extent…
More generally, the use of I- PMR in synergy with active microwave sensors (e.g. wind scatterometer, radar altimeter, SAR) and with optical VIS/ IR sensors will provide powerful tools/techniques for the provision of improved accuracy geophysical ocean, land and atmosphere parameters.

B. Preparation of a European capacity for improving agriculture monitoring

The Copernicus Land Service has an extensive portfolio of products and, in this context, is already providing products which could be of relevance for agriculture monitoring. In the European component of the Copernicus Land Service, specific attention should be paid to the High Resolution Layers (HRL) developed at pan-European level by the European Environmental Agency (EEA). This includes the Grassland layer and the mapping of the Green Linear Elements. Specific information is also produced at Very High Resolution on regions of thematic interest. This covers the monitoring of riparian areas and of Natura 2000 sites. On a systematic and at a global level, the Global component of Copernicus Land Service is delivering mid-resolution biophysical variables. This 10 daily systematic production covers around 25 variables such as NDVI, FaPAR, LAI, DMP and Soil Moisture. These variables are essential for crop monitoring and yield forecasting at EU and Global scale. The Land service will also offer the possibility by the end of 2017 of downloading cloud free spatial and temporal mosaics of Sentinel 2 satellite data, providing with this activity, Analysis Ready Data.

The improvement of the European Copernicus capacity for agriculture monitoring should be understood in the context of a future potential revision of the Common Agriculture Policy and also in the framework of the efforts made at international level for agriculture monitoring, including G20-GEOGLAM initiative. Policy actors are mainly DG AGRI, DG ENV, DG JRC, EU Member States and UN institutions (FAO, WFP, IFAD).

In April 2016, a concept note on the potential evolution of the Land service in the Agriculture domain was presented by DG JRC to the Copernicus User Forum (http://copernicus.eu/sites/default/files/library/AGRI_Conceptnote.pdf). The note well received by the Member States can constitute the framework for the intervention of Copernicus in the domain. To consolidate the note, a limited expert panel including interested DGs was set up. Conclusions from these experts are expected by the end of 2017.

In line with the EC activities, European Space Agency took the initiative of launching in 2014 the 3 years Sentinel-2 for Agriculture (Sen2-Agri) project. The project was defined as a major contribution to the R&D and national capacity building components of the GEOGLAM initiative. The project has demonstrated the benefit of the Sentinel-2 mission for the agriculture domain across a range of crops and agricultural practices. The objectives were to provide validated algorithms, open source code and best practices to process Sentinel-2 data in an operational manner for major representative agriculture systems distributed all over the world. The entire project was driven by a user-oriented approach to address concrete user needs and requirements.

Of particular interest at European level and in the context of the Sen2-Agri project is the specific CzechAgri study initiated in 2015 as a R&D contribution to the preparation of future Copernicus components supporting agriculture. CzechAgri study is designed as a proof of concept to demonstrate the capacities of Sentinel 1 and 2 combined with open public information (Land Parcel Identification System in the case) for agriculture monitoring at national scale. The aim was to support the Czech paying agency in its activities related to the operation of the Integrated Administration and Control System (IACS) within the EU's Common Agricultural Policy. The focus was thus to support the administration and control of direct payments and the compliance with the sustainable agriculture

practices as well as LPIS management and update processes. Further details on this study are available from http://www.esa-sen2agri.org/wp-content/uploads/docs/CzechAgri%20Final%20Report%201.2.pdf .

Several dedicated meetings have taken also place in 2017 and 2018 to highlight the importance of Earth Observation and the new capacities offered by Copernicus for supporting the Agriculture domain, this includes between others :

- The NEREUS "When Space technology meet Agriculture" meeting in November 2016 held in Matera, Italy (http://www.nereus-regions.eu/SpaceMeetsAgriculture)
- The Netherlands Paying Agencies meeting held in April 2017 in Schiphol, The Netherlands.

The objectives of these meetings were mainly to present the existing pilot studies carried out in the EU Member States using Sentinel data and to define the priority requirements of the Agriculture sector and the CAP. The operational nature of the pilot studies is emphasized confirming the potential use of Sentinel data and Copernicus service for supporting the CAP.

DG JRC is maintaining a specific page on the subject at https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Copernicus_WS (also linked with specific technical meetings) as well as an observatory of pilot studies at https://g4cap.jrc.ec.europa.eu/g4cap/Default.aspx?tabid=354.

Recently and for information, the SEN4CAP project has been launched by ESA. It aims at providing to the European and national stakeholders of the European Common Agricultural Policy (CAP) validated algorithms, products and best practices for agriculture monitoring relevant for the management of the CAP. Special attention is given to provide evidence how Sentinel-1 and Sentinel-2 derived information can support the modernization and simplification of the CAP in the post 2020 timeframe. The SEN4CAP project is developed in close collaboration with DG-AGRI, DG-JRC, DG-GROW and in particular with a selected number of national European Paying Agencies. Demonstrations and use cases will be conducted in the context of the Paying Agency operations up to national scale addressing a range of monitoring aspects in the IACS cycle including the greening measures of the CAP.

On the H2020 research project side, specific attention could be paid to the RECAP (https://www.recap-h2020.eu/), APOLLO (http://apollo-h2020.eu/), SENSAGRI (http://ipl.uv.es/sensagri/index.php), DIANA (https://diana-h2020.eu/en/home/)projects. Some are directly linked to the improvement of the CAP, others are more oriented towards a direct support to farmers. The ESA EO4SD Agriculture and Rural Development and GEO-Rice projects are also of interest, as well as the ESA funded Food Security Thematic Exploitation Platform.

The improvement of the capacities for agriculture monitoring will also cover the environmental and climate matters related to agriculture, leading to a sustainable resource management. The EO capacities should clearly support the integration of environmental concerns into the Common Agriculture Policy at EU, MS and farmer level.

The Agriculture Global Dimension should be considered in the context of the support to the G20 GEOGLAM initiative, the new DG JRC ASAP Service, the FAO ASIS System, and the WFP VAM activities, including the specific African support in the framework of GMES and Africa.

The improvement of the monitoring capacities should be based on the current satellite capacities. Nevertheless, evolution in the Copernicus Space Component is foreseen in the mid-2020s to meet priority user needs not addressed by the existing infrastructure. A specific User Requirement workshop for Agriculture and Forestry was organised to cover this issue in June 2016. Conclusions are available at : http://copernicus.eu/agri-forestry-workshop.

In line with the conclusions of the workshop and the User Requirement Study launched by the Commission, and in order to support the agriculture sector, an expert panel on high resolution land surface temperature mission was set up by ESA with the contribution of the Commission in July 2017. The objective of the panel is clearly to evaluate the possibility of preparing a dedicated mission currently called Sentinel-8 in the frame of the Copernicus evolution with the overall objective of complementing Sentinel observation capabilities with high spatio-temporal resolution Thermal InfraRed observations over land and coastal regions in support of agriculture management services, and possibly a range of additional services. This mission would deploy one or more satellites with TIR instruments with the specific primary mission objective to support monitoring evapotranspiration (ET) rate at European and Global scale to capture the variability of Land Surface Temperature (LST) (and hence ET) enabling more robust estimates of potentially field-scale water productivity. The liaison with water abstraction and consumption detection is also obvious in the context of the safeguard of Europe's Water Resources.

The potential evolution of the Copernicus Space Component will not be limited to a TIR mission but improving the frequency of observation and the resolution of the current capacities can also be envisaged. Services are expected to be developed based on these new observation capacities.

C. Preparation of a European capacity for improving forest monitoring

The Copernicus Land Service is providing information on forest layer at European level within the five Pan EU High Resolution Layers. The Forest layer includes forest type and tree density information. Additional information is also provided in the local component with the mapping of the riparian areas and of the Natura 2000 sites. The Green Linear element activity is complementing the High Resolution Forest layer with the mapping, in the riparian areas, of hedgerows and tree groups. At global level, the global land component will deliver by the end of 2017 Sentinel 2 Level 3 data (spatial and temporal mosaics) to support REDD+ initiative. Forest degradation and deforestation mapping could also be envisaged respecting nevertheless national mandates.

The policy context of the forest monitoring improvement is the support to 2013 EU Forest Strategy, its implementation and its call for the setting up of Forest Information Systems. At global level, the policy is clearly for a support to the FLEGT and UN REDD+ Programs, including the GEO-GFOI initiative coordinated by FAO.

In 2016, a "Roadmap for future Copernicus service component for REDD+" note prepared by DG JRC and DG CLIMA was presented to the Copernicus User Forum for improving Copernicus intervention in the support of the REDD+ program (http://copernicus.eu/sites/default/files/library/REDD_Conceptnote.pdf). The note calls for a new dedicated Copernicus service component addressing high resolution forest area delineation and disturbance indicators. Such a component should be aimed at automated annual forest map at high resolution with main land cover classes with at least forest / non-forest distinction, potentially including a few forest types, i.e. supporting the assessment of a "natural forests" class, as defined and operationalized by UNFCCC Parties to comply with UNFCCCC Decision 11/CP.19.

Results and conclusions of several past FP7 projects can be considered, in priority the REDD related projects : ReCover (http://www.vtt.fi/sites/recover/en/recover-project-home) and REDDAF (https://www.reddaf.info/). In the current H2020 projects, Advanced-SAR (http://www.fgi.fi/advancedsar/) and EOMonDis (https://eomondis.info/) are of direct interest. The ESA GSE Forest Monitoring and ForMoSa (http://www.formosa.global/) projects are also to be potentially considered, as well as the ESA funded Forestry Thematic Exploitation Platform (https://forestry-tep.eo.esa.int/).

Specific attention could also be paid DG JRC activities in the field (http://forest.jrc.ec.europa.eu/) and to ReCaREDD project (http://forobs.jrc.ec.europa.eu/) managed by DG JRC which has the objective

of enhancing the capacity of institutions in tropical partner countries to report on forest degradation in a reliable and cost-efficient manner.

The improvement of the forest monitoring capacities should be first based on the current satellite capacities. Nevertheless, evolution in the Copernicus Space Component could be foreseen in the mid-2020s to meet priority user needs not addressed by the existing infrastructure. A specific User Requirement workshop for Agriculture and Forestry was organised to cover this issue in June 2016. Conclusions are available at : http://copernicus.eu/agri-forestry-workshop

The workshop, as well as the User Requirement Study launched by the Commission, highlighted that the Enhanced continuity of existing missions is the overarching requirement for forestry applications, including the request for higher resolution and better repeat cycle (revisit time) for S-1 and S-2. In addition to that, additional missions/sensors were also proposed: active/passive L-Band measurements, space-borne Lidar measurements and Hyperspectral measurements.

3.2. LC-SPACE-03-EO-2018: Copernicus evolution - preparing for the next generation of Copernicus Marine Service ocean models

The *Copernicus Marine Environment Monitoring Service* (CMEMS) provides regular and systematic core reference information on the state of the global ocean and regional seas. The analyses and forecasts produced by the service support any user requesting generic information on the state of the ocean and sea ice, and especially downstream service providers who use the information as an input to their own value-added services to end-users. The service is targeted around four main areas of benefits: Maritime Safety, Coastal and Marine Environment, Marine Resources, and Weather, Seasonal Forecasting and Climate activities. CMEMS mission includes:

- Provision of short-term forecasts and outlooks for marine conditions and, as appropriate, to downstream services for warnings of and/or rapid responses to extreme or hazardous events;
- Provision of detailed descriptions of the ocean state to initialize coupled ocean/atmosphere models to predict changes in the atmosphere/climate;
- Monitoring and reporting on past and present marine environmental conditions (physics and biogeochemistry), in particular, the response of the oceans to climate change and other stressors;
- Analysing and interpreting changes and trends of the marine environment;
- Providing an easy, efficient and timely information delivery service to users;
- Developing a communication and outreach plan and activities that allow European users to fully benefit from information and intelligence on the marine environment.

CMEMS products include high level data sets derived from satellite and in-situ observations (through Thematic Assembly Centres, TACs) and model reanalyses, analyses and forecasts (Monitoring and Forecasting Centres, MFCs). They are based on near real time data transmission, state-of-the-art data processing and advanced modelling and data assimilation techniques. The product uncertainties are assessed through rigorous internationally recognized quality assessment methods. Each of the CMEMS regional models (Mediterranean sea, Baltic sea, North West Shelf seas, Arctic ocean, Black Sea, Iberia-Biscay-Ireland seas) are nested or coupled with the global Mercator Ocean model providing the boundary conditions. CMEMS global and regionals models are also used to initialize and provide boundary conditions to a large range of coastal models operated by the downstream sector.

CMEMS service evolution

CMEMS services evolve based on requirements from its user's base and also taking into account the users 'requirements expressed in dedicated workshops such as:

- The polar and snow workshop held in June 2016 (http://www.copernicus.eu/polar-snow-workshop)
- The maritime security service workshop held in November 2016 http://www.emsa.europa.eu/copernicus/copernicus-workshops.html with the maritime surveillance products catalogue (http://www.emsa.europa.eu/emsa-documents/latest/item/3025-copernicus-maritime-surveillance-product-catalogue.html)
- The coastal user workshop held in June 2017 to consolidate coastal requirements http://workshop.copernicus.eu/coastal.

The CMEMS evolution also takes into account new scientific and technological achievements and opportunities regarding both satellite and in situ observations, modelling and assimilation capabilities, new communication and data processing technologies and the need to maintain competitiveness with respect to international players.

The CMEMS Service Evolution high level Strategy and its associated R&D priorities (Mercator Ocean, 2016; CMEMS STAC, 2017) (see http://marine.copernicus.eu/science-learning/service-evolution/service-evolution-strategy/) introduce a set of over-arching goals and associated actions and R&D priorities for evolving the service from its initial state toward a mature, state-of-the-art, leading to an innovative Copernicus Service.

Required R&D activities in this topic should focus on the development of a global model configuration targeting the kilometric resolution and based on solutions that can benefit at short to mid-term to the several CMEMS monitoring and forecasting centres. This should take into account as a priority, the R&D issues identified in the CMEMS service evolution strategy document (ref above). The list of R&D projects related to CMEMS service evolution and that could be considered complementary or useful for the present topic is available on http://marine.copernicus.eu/science-learning/service-evolution/rd-projects-funded-cmems/ .

The sub-mesoscale modelling capacity should also benefit from the existing and also the next generation of Copernicus high-resolution satellites. The assessment of new Earth Observation capacities and their impact on the quality of models outputs (global, regional or coastal), should take into account as far as possible (depending on the availability of simulated or precursor datasets) :

- The technologies and performances listed by the polar/snow task force relevant for the Arctic regional products (see LC-SPACE-02-EO-2018 , subtopic A)
- Future topography missions (e.g. wide swath altimetry) or also new concepts for ocean colour (geostationary or hyperspectral)
- The technologies and performances listed by the Hyperspectral task force relevant for biogeochemical products

The configuration, assessment and validation of the new model should be demonstrated with use cases representative at least of coastal, arctic applications, climate and biogeochemistry modelling.
The project could possibly benefit or interact with other Copernicus, ESA , FP7 or H2020 R&D projects in this area. The development of coastal, biogeochemical or climate models remains anyhow out of the scope of the R&D activities.
Consolidated research results will be preferred for validation purposes in order to be able to compare the potential added-value of a kilometric resolution of the global model compared to the existing one.