European Commission

Copernicus services in support to Cultural Heritage

Written by PwC
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pwc

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Directorate I — Space Policy, Copernicus and Defence
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Copernicus services in support to Cultural Heritage

Final report

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Executive Summary

Context and approach

The "Copernicus services in support to Cultural Heritage" study aims to support the European Commission in its assessment on the possibility of initiating an institutional action for promoting the use of Copernicus data for Cultural Heritage preservation, monitoring and management.

The Copernicus programme is one of the European flagship programmes, providing free and open data and information relying on satellite-based imagery, models and in-situ data. Beyond merely data and information, the Copernicus programme relies on state-of-the-art models to be used for societal and environmental purposes. The Copernicus programme is a public service designed to respond to policy and public administrations, as well as foster economic growth in Europe by:

- Supporting public users at local, national and European level;
- Helping Europe to maintain a prominent role in the international context;
- Strengthening intermediate users, downstream companies and value-added service providers.

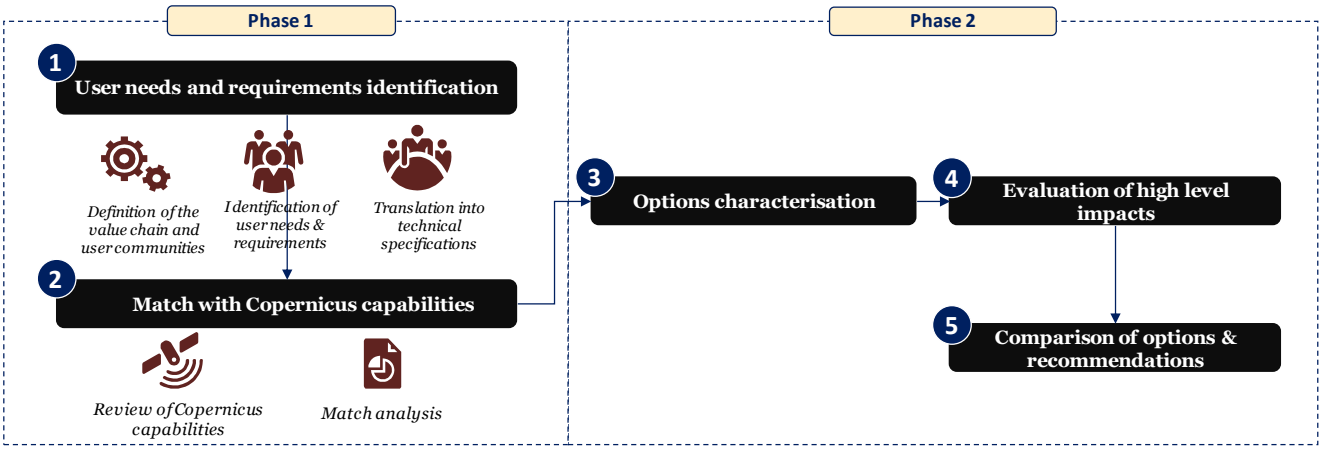
2018 has been selected as the European Year of Cultural Heritage to celebrate the diversity of Cultural Heritage across Europe and reinforce a sense of belonging to a common European space[1]. Cultural Heritage has a universal value for humankind as individuals, communities and societies that deserve to be protected and preserved for the next generations. The notion of Cultural Heritage includes[2]:

- **Tangible Heritage**: buildings and historic places, monuments, artefacts, etc., which are considered worthy of preservation for the future. These include objects significant to the archaeology, architecture, science or technology of a specific culture. Tangible Heritage does not include "Movable Cultural Heritage" (all Cultural Heritage that constitutes objects, such as paintings, sculptures, coins and manuscripts).
- **Natural Heritage**: natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas, which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty. Moreover, the focus of the study includes both land and underwater Cultural Heritage.

The study is structured around three main phases, as represented in the figure below:

[1] European Commission, consulted on May 22, 2018 [ONLINE] Available at: https://ec.europa.eu/culture/policy/culture-policies/cultural-heritage_en
[2] IBID

Figure 1: Study logic



1. Phase 1 – A characterization of the Cultural Heritage value chain offering a global overview on the main challenges and user communities involved in Cultural Heritage activities. This characterization aims at identifying and collecting **user community needs and requirements** related to Cultural Heritage preservation, monitoring and management, and at performing a **match analysis** exercise between Cultural Heritage user needs and requirements, and Copernicus capabilities (Copernicus core services products, Sentinels data, Copernicus contributing missions data);

2. Phase 2 – An evaluation of the potential impacts from different types of **institutional interventions** for promoting the use of Copernicus for Cultural Heritage preservation, monitoring and management. This last phase also includes recommendations on the way forward to stimulate such an intervention.

Phase 1 – Collection of Cultural Heritage user needs and requirements and match analysis with Copernicus capabilities

User needs and requirements identification

Cultural Heritage is structured around three segments that represent its value chain: the Creation segment; the Production segment; and the Transmission segment. Each segment is composed of a certain number of **activities that are broken down into tasks**.

- The Creation segment comprises: (i) prospection and exploration activities; (ii) operations activities; and (iii) recognition as Heritage activities.
- The Production segment comprises: (i) Tangible Heritage conservation activities; and (ii) Natural Heritage preservation activities.
- The Transmission segment comprises: (i) site management activities; (ii) aggregation of scientific knowledge activities; and (iii) development of commercial products activities.

These activities are performed by **six different user communities**: (i) the Cultural Heritage professional user community; (ii) the Natural Sciences user community; (iii) the National, Regional or Local authority user community; (iv) the site operator user community; (v) the urban planner user community; and (vi) the intermediate user community. These communities may intervene in a single segment of the value chain but are usually transverse (e.g. the site operator user community intervenes in all three segments, though not necessarily in all types of activities per segment).

The Cultural Heritage user communities have different demands for performing their activities. These demands have been aggregated into **nine high level user needs –** an overarching statement which describes the desire or wish of a user – that are split along the Cultural Heritage value chain and that address the trends taken by communities intervening along the value chain. These high level user needs are presented below.

Table 1: High level user needs per segment of the Cultural Heritage value chain

	High level user need
Creation segment	Study of the natural environment of the site for the detection of underground archaeological features
	Non-destructive analysis of the underground/underwater positioning of the CH features
	Non-destructive analysis of the surface positioning of the CH features
	Mapping of the cultural landscape of the site and identification of the specific risks it is exposed to
Production segment	Monitoring the evolution of the natural environment of the Tangible Heritage site
	Monitoring the evolution of the natural environment of the Natural Heritage site
	Observation of damage on the built structure of a Cultural Heritage site
	Drawing of conclusions to facilitate an emergency intervention
Transmission segment	Enable public access to the site

Each high level user need is composed of several user needs that are the type of information and data required by the Cultural Heritage user communities. These user needs are often cross-field; that is, they are useful for both Tangible and Natural Heritage or for both land and underwater environments. In total, the nine high level user needs are **split into 83 user needs** identified through stakeholder consultation and literature review. In order to define the Cultural Heritage community user needs, specific focus has been given to the tasks and activities within the Cultural Heritage value chain but also to the current developments and challenges faced by each segment. The consultation has also enabled the collection of CH user requirements, which refers to the user needs described by desired performances and attributes (type of land cover, geographic coverage and revisit time). The 83 user needs, split among 9 high level user needs, have led to the identification of 373 user requirements expressed by CH user communities.

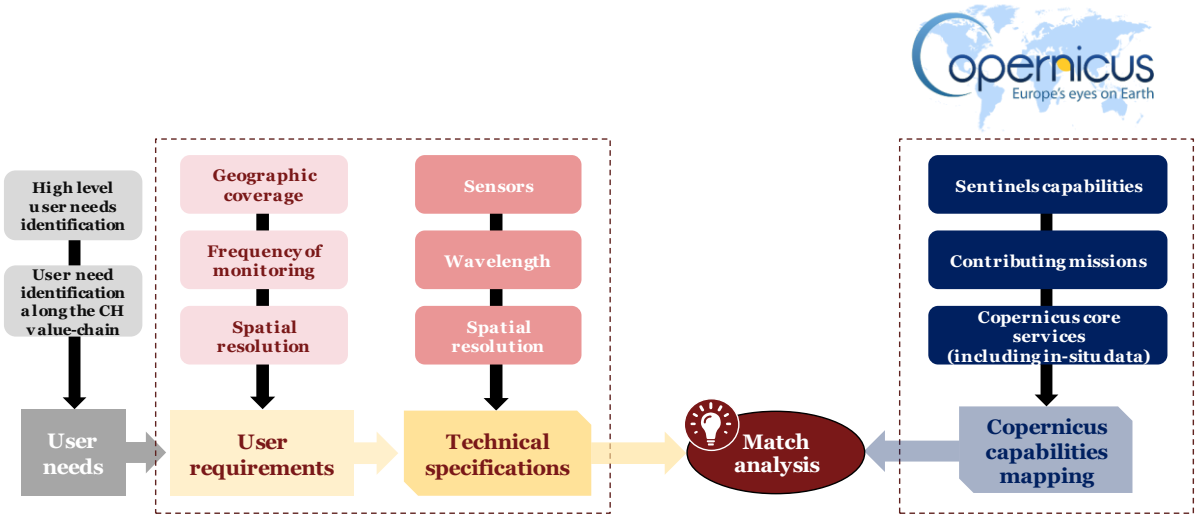
Those user requirements have then been translated into technical specifications to enable the matching analysis with Copernicus capabilities. Technical specifications refer to the translation of user requirements into existing Earth Observation technical solutions including sensors (e.g. multispectral, Synthetic Aperture Radar (SAR), hyperspectral, etc.), wavelength (e.g. near-infrared, C-band, X-band, etc.) and spatial resolution specifications. Sensors and wavelengths are only the first step in a long processing chain where models and other sources of data, such as in-situ data, are required to fully translate identified user requirements into real technical responses. Spatial resolution required by the user had to be translated to a range of spatial resolution specification by an external pool of experts (i.e. experts in remote sensing for Cultural Heritage) to mitigate responding biases (e.g. stakeholders tend to require the highest spatial resolution possible; not all stakeholders were expert in remote sensing) and to take in

consideration the specific context of each user requirement, assessing the original user need and it context and purpose (i.e. high level user need). This range of spatial resolution specification was necessary to support the match analysis between user requirements and Copernicus capabilities.

Matching user requirements with Copernicus capabilities

The mapping of CH user requirements, and their respective technical specifications, with Copernicus capabilities has been carried out on three different levels: Copernicus core services products, Sentinels capabilities and Copernicus contributing mission capabilities, as presented in the figure below.

Figure 2: Match analysis process



The first step consisted of assessing if there exists a Copernicus core service product that can cover the user requirement under study. The user requirement is considered covered if both the product resolution and timeliness match the user requirement (since the other attributes no different between the various user requirements). Should it not be the case, Sentinels capabilities are assessed to see if they can respond to the requirement even if it is not fully covered (i.e. with resolution, timeliness or both). If the user requirement cannot be covered by Sentinels, the analysis is further expanded to Contributing Missions, on which the same type of evaluation is performed. This assessment has been undertaken thanks to expert-targeted consultation and PwC analysis.

Following this analysis, a rating is given to the ability of Copernicus to respond to a user requirement and its technical specifications: (i) ***fully responding*** if both the timeliness and resolution required are covered by a Copernicus core product, Sentinels capabilities or Contributing Missions capabilities; (ii) ***partially responding*** if the current Copernicus capabilities only partly respond to the attributes (e.g. a 5-day revisit time is required and only a 6-day revisit time is currently available); (iii) ***not responding*** if one or two of the attributes (i.e. timeliness or spatial resolution) are not fully covered.

Considering **Cultural Heritage is not currently mentioned in the Delegation Agreements** of the Entrusted Entities in charge of the six Copernicus core services, no product has currently been developed specifically for Cultural Heritage activities. Nevertheless, Copernicus core services already have access to the relevant EO data sources (Sentinels and/or contributing missions), models and in-situ data sources, to enable them to respond to a large extent of Cultural Heritage user requirements. Moreover, **all six services can contribute to the user**

requirements, though some services are more key than others (e.g. a majority of relevant products come from the Land service).

Indeed, the analysis emphasised that **7.5% of the Cultural Heritage user requirements are already fully covered** by Copernicus core services products in their current form, and an additional **19.0% of user requirements are partially covered** by existing Copernicus core services products without adaptation. With the support of Sentinels and Contributing Missions capabilities, **50% of the user requirements could be fully covered**, while an additional 14% could be partially covered. Those partially covered user requirements could potentially be supported by the downstream industry that has access to very high resolution data and/or very high revisiting time imagery not available in the pool of Copernicus Contributing Missions.

By using all Copernicus capabilities (core services products, Sentinels and Contributing missions), 64.1% of CH user requirements could be covered. Nevertheless, 35.9% of CH user requirements will not be covered by the Copernicus programme (core services products, Sentinels and Contributing missions). First, 7% of the user requirements cannot be covered because the spatial or temporal resolution needed is not available within Copernicus. Second, 12.9% of the user requirements cannot be covered because they require specific sensors and/or wavelengths that are not available in the scope of the Copernicus programme (e.g. hyperspectral, lidar). However, such sensors and wavelengths exist on the commercial market, especially by using airborne sensors (e.g. UAV), hence downstream industries could then fully cover those user requirements. Finally, 16.1% of the Cultural Heritage user requirements cannot be covered by satellite-based imagery at all, as they require very specific in-situ measurements (e.g. Ground Penetrating Radar (GPR), in-situ bathymetric surveys, etc.) or complex value-added products (e.g. assessment of sites frequentation pattern).

Phase 2 – Impacts derived from the implementation of intervention options

An intervention from the European Commission could prove useful in enhancing the ability of Copernicus to respond to Cultural Heritage user requirements. These three options have been analysed through the lens of seven impacts split into several KPIs in order to compare them. The impacts were either categorised as economic (cost of the options, option implementation process, competitiveness, employment), strategic (EU leadership) or social (valorisation of Cultural Heritage, support to European knowledge).

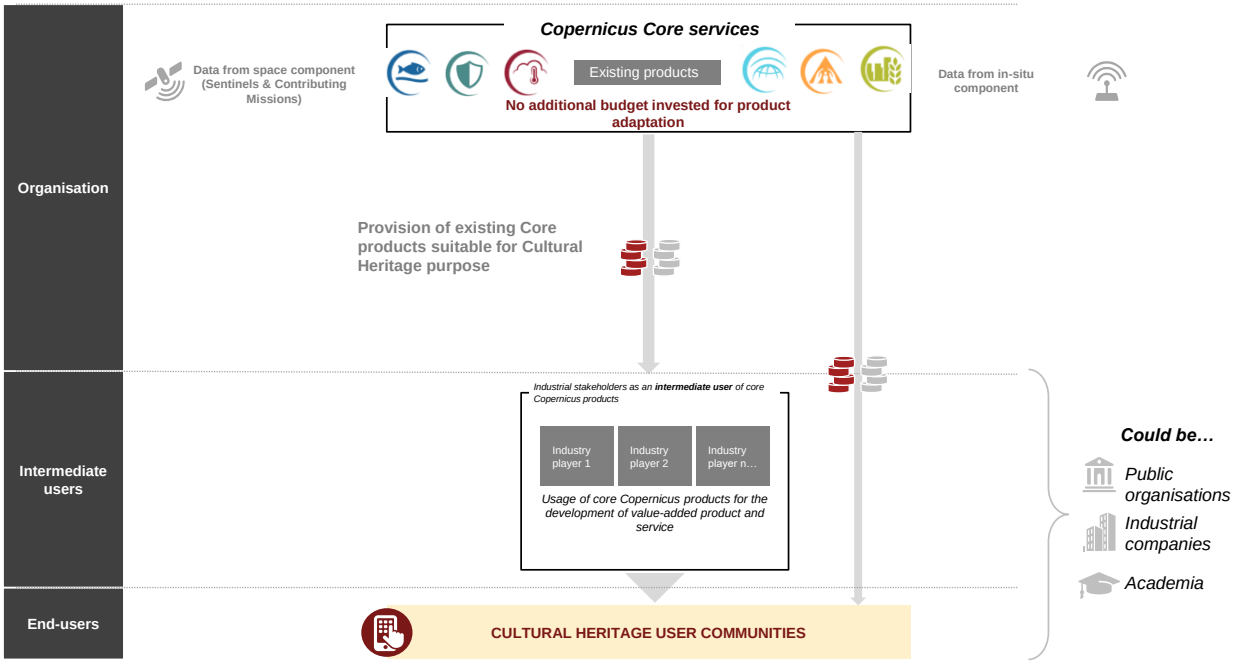
The characterisation of these options and the expected impacts derived from their implementation have been summarised in the next sections.

Option 1 – List of Copernicus products suitable for Cultural Heritage applications

Option 1 characterisation

Option 1 is relying on existing core products, data and information that are currently suitable for Cultural Heritage applications, but emphasising the existence of such products by raising awareness. The chart below summarises the scope of Option 1.

Figure 3: Detailed description of Option 1



As the governing body of the Copernicus programme, the European Commission would be in charge of investing money in communication and outreach activities. The European Commission would dedicate a budget for the implementation of Cultural Heritage promotion activities in order to raise awareness of the availability of Copernicus data and information that are suitable for specific Cultural Heritage activities and explain where and how users can find those products, data and information.

Under this option, management of the Copernicus data and products useful for Cultural Heritage would remain under the purview of each of the Copernicus services. The Copernicus services have currently developed products that can be used for Cultural Heritage activities, but that are tailored for other domains. As such, these products are not emphasised by the service platform through a specific category of Cultural Heritage products but are to be found among existing categories. In this context, the option would mostly respond to user communities with a certain level of technical knowledge, who are able to access and find relevant data and information on existing Copernicus core services and on the Scientific Data Hub. No budget would be dedicated to product development or tailoring of existing products to specific Cultural Heritage needs under option 1.

Under option 1, the Cultural Heritage communities can therefore either rely directly on existing Copernicus data and information or on value-added information products that rely on Copernicus data and information that has been transformed and enhanced by intermediate users (i.e. downstream companies).

Option 1 expected impacts

Option 1 would not provide a budget to develop new products tailored for Cultural Heritage user needs. As such, 7.5% of the Cultural Heritage user requirements would be fully covered by existing Copernicus core services products (an additional 3.2% of the Cultural Heritage user requirements could be covered by the Copernicus programme thanks to the Sentinels capabilities but this could only be done by downstream companies and technical Cultural Heritage user communities, as the Sentinels data would need to be processed and transformed) and an additional 20% of the Cultural Heritage user requirements would be partially covered by those products.

The economic impacts of option 1 would be rather marginal considering the low investment (EUR 75K per year) implied by this option (e.g. very few jobs would be supported, negligible enabled revenues over the period under scrutiny). Moreover, no strategic impact would arise from this option, whether positive or negative. Similarly, social impacts would be very marginal, as only European knowledge would be supported but to a lesser extent. This option presents one major advantage: it would be the most interesting in terms of cost and of easiness of implementation. These results are presented in the figure below.

Figure 4: Summary of the impact evaluation results for option 1

	Impact evaluation		Option 1 List of Copernicus products suitable for CH applications
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Between 7,5 & 11% fully covered 20% partially covered*
	Cost of the options	• Development and operation costs	*EUR 75 K per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 540 K and EUR 750 K for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 2.95 M and EUR 5.3 M for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 4.33 and 6.01 jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 6.19 and 11.14 jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

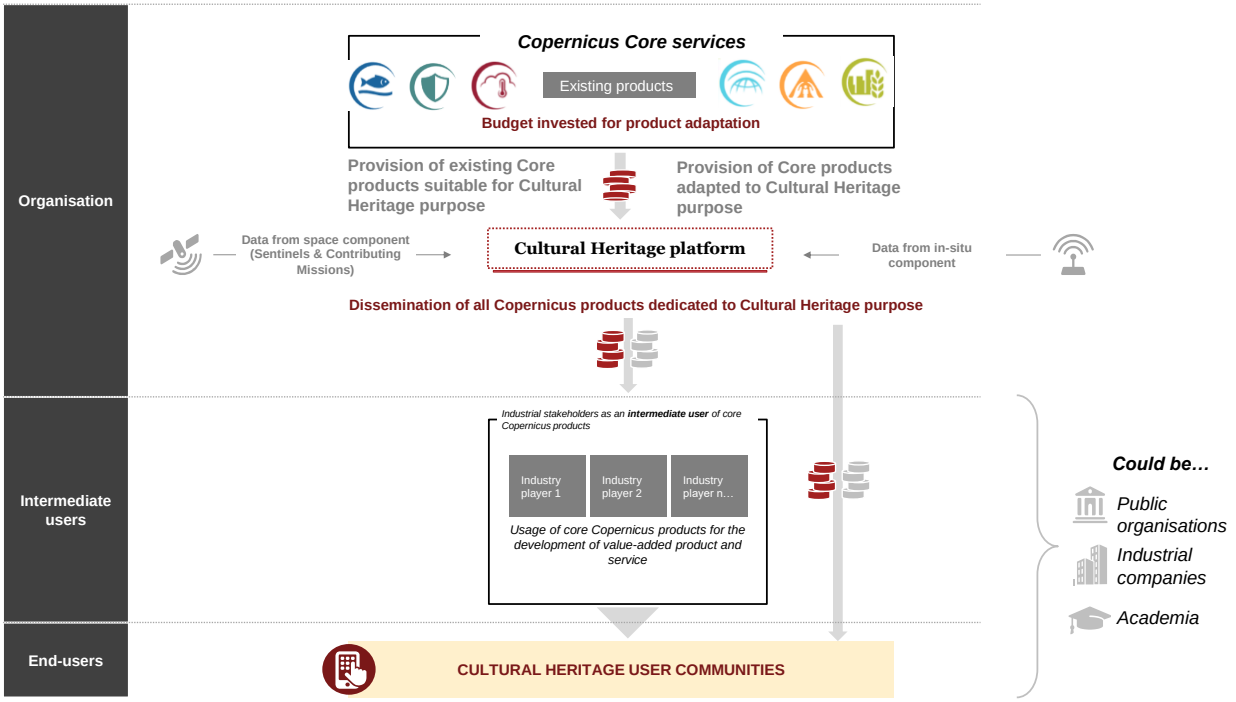
Option 2 – Cultural Heritage as part of one or more existing services

Option 2 characterisation

Option 2 aims at setting up a specific user interface in the form of a web-based platform (i.e. web-based front-end) fully dedicated to Cultural Heritage, where user communities could find existing Copernicus data and information suitable for Cultural Heritage activities, together with additional existing products from core services that have been adapted to Cultural Heritage needs.

The chart below summarises the scope of Option 2.

Figure 5: Detailed description of option 2



As the governing body of the European Earth Observation programme, the European Commission would be in charge of funding the creation of an interface that would centralise the access to all Copernicus data and information suitable for Cultural Heritage activities. The products found via this front-end would come from the six service platforms that offer accessible and relevant products for Cultural Heritage. This platform should benefit from the development of the DIAS platform, expected to be operational in the near future. Such an investment could have indirect impacts on Copernicus user uptake from Cultural Heritage communities, as this would ease access to Copernicus data and information.

The management of the Cultural Heritage platform would either be under the European Commission or from one of the existing Entrusted Entities. The Entrusted Entities would provide all the products that would feed the platform: they would either be proposed as is currently on the service website or be available in a way that makes them adaptable to the specific needs of Cultural Heritage user communities. The European Commission, under option 2, would provide a specific budget dedicated to product tailoring for each Copernicus core service, based on those products that are of interest for Cultural Heritage but require some adaptations. This option should also enable the European Commission to unlock specific grants and funding mechanisms to support R&D and knowledge creation in the field of Earth Observation applied to Cultural Heritage activities.

Under option 2, the Cultural Heritage communities can therefore either rely directly on Copernicus data and information provided by the platform (existing and tailored Copernicus products) or on value-added information products that rely on Copernicus data and information extracted from the Cultural Heritage platform that have been transformed and enhanced by intermediate users (i.e. downstream companies).

Option 2 expected impacts

Option 2 would dedicate a budget to the tailoring of existing products to Cultural Heritage user needs. As such, up to 49.8% of the Cultural Heritage user requirements could be covered under this option. An additional 14.2% of the Cultural Heritage user requirements could also be partially covered.

This option would present moderate to strong impacts, whether societal, economic or strategic. On the economic side, competitiveness of the downstream sector would be strong, and partnership and collaboration between Member States reinforced. However, this option would be quite complex to implement considering the great effort to achieve the expected process of centralisation of products and data. On the strategic level, this option would favour a European leadership on Cultural Heritage questions. As for social stakes, Cultural Heritage would rather be strongly valorised and European knowledge would also be largely supported. These results are presented in the figure below.

Figure 6: Summary of the impact evaluation' results for option 2

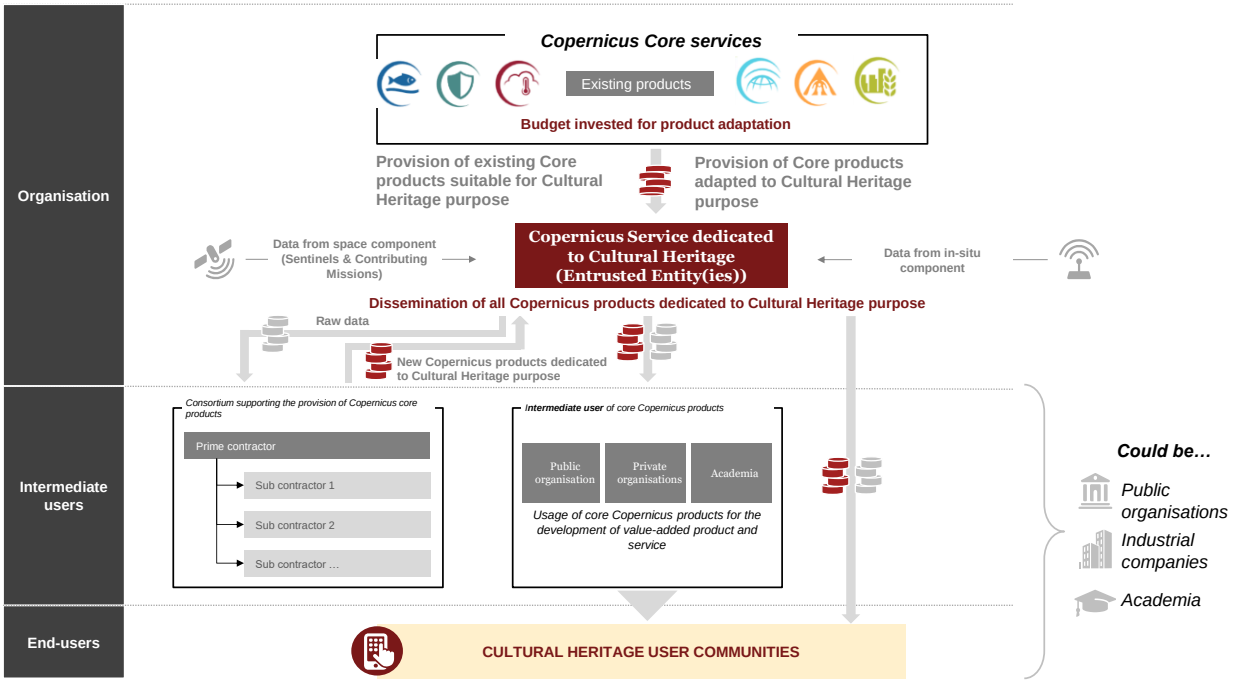
	Impact evaluation		Option 2 Cultural Heritage as part of one or more existing services
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Up to 50% fully covered* *14% partially covered*
	Cost of the options	• Development and operation costs	*EUR 1.5 M per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 10.8 M and EUR 15.0 M for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 58.9 M and EUR 106.1 M for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 86.5 and 120.1 jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 123.7 and 222.7 jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

Option 3 – Creation of a new Copernicus service dedicated to Cultural Heritage

Option 3 characterisation

Option 3 aims at creating a Copernicus Service, in addition to the existing ones (e.g. Land Monitoring service, Marine Monitoring service, etc.), which would be exclusively dedicated to Cultural Heritage. The chart below summarises the scope of Option 3.

Figure 7: Detailed description of option 3



The European Commission would be funding the creation of an additional Copernicus service fully dedicated to Cultural Heritage. The European Commission would need to issue a Delegation Agreement summarising all the activities expected from the Entrusted Entity that would be in charge of the Cultural Heritage service and the budget that would be dedicated to operation and management activities. Under option 3, the European Commission would be in charge of a long administrative process going from the choice of the appointed Entrusted Entity to the signature of the Delegation Agreement. The Cultural Heritage service would be either managed by one of the current Entrusted Entities (e.g. EEA) or by a new one.

The creation of a new service not only implies the appointment of an Entrusted Entity, but also of a **consortium of companies**, that would be in charge of the development of new Cultural Heritage products whereas the existing services would receive additional budgets for tailoring some of their products to Cultural Heritage needs. The Cultural Heritage user communities would be able to turn to a dedicated service providing specific products, data and information, together with a permanent feed-back loop from users to monitor the evolution of their needs. Such a service would be one-of-a-kind, implying that the more interesting Cultural Heritage products, data and information become available, the bigger the interest would be from the international community to turn to Copernicus. Moreover, as an Entrusted Entity would be in charge of the Copernicus Cultural Heritage service, it would benefit from additional funding to develop call for tenders through R&D tools in order to foster the development of Value-Added Services (VAS).

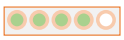
Option 3 expected impacts

Option 3 would provide a budget to tailor existing products to Cultural Heritage user needs but also funding to develop new products to respond to current needs not already covered. As such, up to 49.8% of the Cultural Heritage user requirements could be covered under this option. An additional 12.9% could potentially be fully covered thanks to the availability of additional capacity through the intermediary of the setting up of a Cultural Heritage service (e.g. additional sources of data from airborne sensors such as UAV to access hyperspectral or lidar capabilities). As for option 2, 14.2% of the Cultural Heritage user requirements would also be partially covered by the Copernicus programme.

This option would present strong to very strong impacts, whether societal, economic or strategic. Indeed, in terms of economic impacts, the competitiveness of the downstream sector would be very strong as well as the enabled revenues that can be expected by the downstream sector and the wider economic and societal impacts, which should be in the order of EUR 150 M and EUR 1 B respectively. As for strategic impact, the main difference with option 2 is the fact that data standardisation and the positioning of the EU as a leader in the field of Cultural Heritage would be even stronger. Similarly, social impacts would be slightly more developed than for option 2, notably with a gain in importance of digitisation. As a result, this option would be more complex and more costly to implement than option 2, but would generate significant benefits overall.

These results are presented in the figure below.

Figure 8: Summary of the impact evaluation' results for option 3

	Impact evaluation		Option 3 Creation of a new Copernicus service dedicated to Cultural Heritage
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Between 50% & 63% fully covered 14% partially covered*
	Cost of the options	• Development and operation costs	*EUR 14.7 M then EUR 20.9 M per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 137.6 M and EUR 191.1 M for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 749.5 M and EUR 1.35 B for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 1.1 K and 1.5 K jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 1.6 K and 2.8 K jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

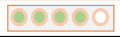
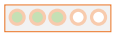
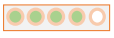
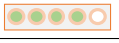
Conclusion

In conclusion, it appears that the impacts resulting from option 1 would be drastically different from the ones of option 2 and 3, whereas option 2 and 3 appear to be closer, with slight modifications in terms of results magnitude. Nevertheless, each option encompasses advantages and drawbacks:

- Option 1 would be the most interesting in terms of the budget and legal ease;
- Option 2 would be the most interesting in terms of cost to benefit ratio;
- Option 3 would be the most interesting in terms of overall benefits generated.

The main strength and weaknesses of each option with respect to one another are presented in the chart below:

Figure 9: Comparison of the three different intervention options under scrutiny

	Impact evaluation		Option 1 List of Copernicus products suitable for CH applications	Option 2 Cultural Heritage as part of one or more existing services	Option 3 Creation of a new Copernicus service dedicated to Cultural Heritage
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Between 7.5 & 11% fully covered 20% partially covered*	*Up to 50% fully covered 14% partially covered*	*Between 50% & 63% fully covered 14% partially covered*
	Cost of the options	• Development and operation costs	*EUR 75 K per year*	*EUR 1.5 M per year*	*EUR 14.7 M then EUR 20.9 M per year*
	Option implementation process	• Complexity of option implementation			
		• Administrative burden			
		• Partnership and collaboration between Member States			
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 540 K and EUR 750 K for 2019-2025*	*Between EUR 10.8 M and EUR 15.0 M for 2019-2025*	*Between EUR 137.6 M and EUR 191.1 M for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 2.95 M and EUR 5.3 M for 2019-2025*	*Between EUR 58.9 M and EUR 106.1 M for 2019-2025*	*Between EUR 749.5 M and EUR 1.35 B for 2019-2025*
	Competitiveness	• Competitive downstream sector			
		• R&D			
	Employment	• Direct jobs	*Between 4.33 and 6.01 jobs supported for 2019-2025*	*Between 86.5 and 120.1 jobs supported for 2019-2025*	*Between 1.1 K and 1.5 K jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 6.19 and 11.14 jobs supported for 2019-2025*	*Between 123.7 and 222.7 jobs supported for 2019-2025*	*Between 1.6 K and 2.8 K jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH			
		• Partnership and collaboration with third countries and IO			
		• Data standardisation			
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access			
		• Centralisation of data access			
	Support to European knowledge	• Academia + Education and knowledge sharing			

1 Introduction

1.1 Rationale for the study

2018 has been selected as the European Year of Cultural Heritage to celebrate the diversity of Cultural Heritage across Europe and reinforce a sense of belonging to a common European space[3]. Cultural Heritage has a universal value for humankind as individuals, communities and societies that deserve to be protected and preserved for the next generations. The notion of Cultural Heritage includes[3]:

- **Tangible Heritage**: various categories of monuments and sites, from cultural landscapes and sacred sites to archaeological complexes, individual architectural or artistic monuments and historic urban centres;
- **Intangible Heritage**: practices, representations, expressions, knowledge, skills - and the associated instruments, objects and cultural spaces - that people value. This includes language and oral traditions, performing arts, social practices and traditional craftsmanship;
- **Natural Heritage**: landscapes, flora and fauna;
- **Digital Heritage**: digital art, animation but also Heritage that has been digitalised in images, videos or records.

Cultural Heritage (CH) has been recognized as a strategic asset for a sustainable and peaceful Europe[4], stimulating the interest of the European Union (EU) and its Member States in the development of data and information to support Cultural Heritage conservation, monitoring and management. The protection and safeguarding of Cultural Heritage is also a key challenge faced by the EU, protecting European Heritages from damage derived from pollution, climate change, geo-hazards and armed conflicts, which requires very specific sets of data and products. More than only free and open data and information relying on satellite-based imagery and in-situ data, the Copernicus programme also offers state-of-the-art models to be used for societal and environmental purposes.

In this context of the European Year of Cultural Heritage, the European Commission (EC) is seeking to explore how its Earth observation programme Copernicus could provide support to Cultural Heritage communities. It is the first time that such an initiative targets an EO non-expert domain.

1.2 Objectives of the study

This study aims to support the European Commission in its assessment on the possibility of starting an institutional action for promoting the use of Copernicus for Cultural Heritage preservation, monitoring and management. Several options of intervention are investigated in this study through the assessment of high level impacts. More specifically, the study has five main objectives:

- Characterisation of Cultural Heritage value-chain;
- Collection of Cultural Heritage communities user needs;

[3] European Commission, consulted on May 22, 2018 [ONLINE] Available at: https://ec.europa.eu/culture/policy/culture-policies/cultural-heritage_en
[4] CHCFE. Cultural Heritage counts for Europe. 2015 .[ONLINE] see: http://blogs.encatc.org/culturalheritagecountsforeurope/wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf

- Matching of Cultural Heritage user needs with current Copernicus capabilities through the translation of user needs into user requirements and technical specifications;
- Characterisation of several intervention options for a structured Copernicus solution for Cultural Heritage;
- Identification and evaluation of high level impacts derived from these options;
- Presentation of recommendations on the way forward in implementing an EC intervention to support Cultural Heritage, within the frame of the Copernicus programme.

1.3 Taxonomy and definitions

A common terminology is required to facilitate the reader's comprehension. The following table presents subject matter definitions (non-exhaustive). Most in-use terminology relies on the taxonomy used by the European Commission and by UNESCO, two references in the field of Cultural Heritage. This taxonomy was also reviewed by external experts.

Table 2: Taxonomy for the study

Term	Definition
	Overall definitions
Cultural Heritage	Cultural Heritage consists of the resources inherited from the past in all forms and aspects - tangible, intangible, natural and digital (born digital and digitized), including monuments, sites, landscapes, skills, practices, knowledge and expressions of human creativity, as well as collections conserved and managed by public and private bodies such as museums, libraries and archives. It originates from the interaction between people and places through time and it is constantly evolving. These resources are of great value to society from a cultural, environmental, social and economic point of view and thus their sustainable management constitutes a strategic choice for the 21st century[5]. **In the report, Cultural Heritage will be used to designate Tangible Heritage and Natural Heritage only**, which are the two main types of Heritage relevant for this study**.**
Digital Heritage	Digital Heritage refers to resources that were created in digital form, for example digital art or animation, or that have been digitalised as a way to preserve them (including text, images, video, and records).
Intangible Heritage	Intangible Heritage refers to traditions or living expressions inherited from ancestors and passed on to their descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts.
Natural Heritage	Natural Heritage refers to: • Natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; • Geological and physiographical formations and precisely delineated areas, which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;

[5] Council conclusions of 21 May 2014 on cultural heritage as a strategic resource for a sustainable Europe 2014/C 183/08. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52014XG0614(08)&from=EN

	• Natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.[6]
Tangible Heritage	Tangible Heritage refers to buildings and historic places, monuments, artefacts, etc., which are considered worthy of preservation for the future. These include objects significant to the archaeology, or architecture, science or technology of a specific culture. Tangible Heritage does not include Movable Cultural Heritage that is all Cultural Heritage that constitute objects, such as paintings, sculptures, coins and manuscripts.
Value chain definitions	
Value chain	A value chain is a schematic representation of how value is created among a set of activities, involving several user communities. The term value here does not only refer to the economic monetary benefits but to the larger value a given Cultural Heritage asset acquires by being restored and open to everyone; this value includes for example cultural significance.[7]
Segment	A segment is a section of a value chain. Cultural Heritage sites do not always run through all the segments of the value chain.
Creation segment	The "Creation" segment of the Cultural Heritage value chain refers to all activities related to the discovery of heritage, such as prospection, excavation operations and formal recognition of a site as Cultural Heritage.
Production segment	The "Production" segment of the Cultural Heritage value chain refers to all activities where sites are monitored, restored and maintenance is performed for conservation and preservation purposes.
Conservation	Actions that are undertaken in order to foster the protection of tangible cultural sites.
Preservation	Actions that are undertaken in order to foster the protection of natural sites.
Transmission segment	The "Transmission" segment of the Cultural Heritage value chain is where Natural or Tangible cultural sites are prepared for public access.
User needs definitions	
User community	A user community is a group of users who are part of the same community (e.g. site operators). Nevertheless, the same user community can include a mix of governmental and non-governmental organisations. In this context, different users that are part of the same user community may have different needs based on where they are located in the value chain and the type of activities carried out (e.g. monitoring of buried structure versus maintenance of a tangible site), the type of environment they are interested in (land versus sea) and the type of land cover they are interested in (e.g. grasslands, jungles, deserts, coastal areas, urban areas, etc.).
Activities	Activities are the actions performed by a user community within the different segments that compose the Cultural Heritage value chain, for

[6]UNESCO, 1970.Basic Texts of the 1972 World Heritage Convention. P. 19. [ONLINE] Available at: http://whc.unesco.org/uploads/activities/documents/activity-562-4.pdf
[7] Burra Charter, ICOMOS Australia, 1999

	example conservation and preservation of Cultural Heritage.
Domains	The domains are the types of Cultural Heritage that user communities work with – Tangible Heritage vs Natural Heritage, sea versus land.
Land cover	The land cover refers to the type of environment in which a user need is applied. The scope of the study considers the following types of field for Cultural Heritage[8]: • Land: o Rural or forested areas o Urban and sub-urban o Scrub and grassland o Mountainous/hilly regions o Rainforest o Tundra o Inland waters o Alluvial plain or Floodplain • Sea: o Water surface o Underwater • Land/sea: o Frozen/glacial areas o Coastal areas
High level user need	A high level user need is an overarching statement which describes the desire or wish of a user. A high level user need is then a category including several user needs.
User needs	In order to achieve their high level user needs, user communities rely on several types of data and information, which are referred to as user needs.
User requirements	User requirements are the user needs translated into desired performances and attributes (e.g. periodicity, area extension, area location, minimum detail).
Technical specifications	Technical specifications are the translation of user requirements into specific requirements in terms of sensors, spatial resolution and wavelength.
Terminology for impact evaluation	
Full Time Equivalent (FTE)	A full-time equivalent is a unit to measure employed persons or students in a way that makes them comparable although they may work or study a different number of hours per week.
GDP (Gross Domestic Product)	The GDP is the monetary value of all the finished goods and services produced within a country's borders in a specific time period.
GVA (Gross Value Added)	The GVA is a productivity metric that measures the contribution to an economy, producer, sector or region. It provides a monetary value for the amount of goods and services that have been produced, less the cost of all inputs that are directly attributable to that production.
Spillover	Spillover is an economic term referring to the indirect impact a given investment or infrastructure may have on the economy and society, stimulating innovation and knowledge creation.
Value Added Services	Value Added Services here refer to services and products resulting from the

[8] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. *Routledge. New York, United States.*

(VAS) exploitation of Earth observation data being processed and turned into geo-information products, usable by the final users.

1.4 Introduction to Cultural Heritage

Cultural Heritage is a sign or a symbol created by, or given meaning by human activity, that is intentionally protected, conserved or revived, instead of being left to natural decay, oblivion, or destruction. The purpose is the transmission to future generations of its values (i.e. cultural, historical, aesthetic, archaeological, scientific, ethnological, anthropological value), which are considered relevant by a community or group of reference[9]. Cultural Heritage encompasses a broad spectrum of resources inherited from the past in all forms and aspects. Cultural Heritage can be distinguished as Tangible Heritage (e.g. historical buildings, archaeological sites, etc.), Tangible Movable Heritage (e.g. paintings), Intangible Heritage (e.g. cultural practices, language), Natural Heritage (e.g. landscape, flora and fauna) and Digital Heritage (resources that were created in digital form, for example digital art or animation, or that have been digitalised as a way to preserve them, including text, images, video, and records)[10].

Cultural Heritage has gained an increasing recognition as a catalyst for social and economic development and as such, has witnessed an important conceptual evolution and policy developments at both European and international levels[11]. This evolution is the consequence of the important changes that have been faced by the global cultural landscape over the last few decades[12]. From the digital revolution, to the development of new technologies, and to social and political events that have caused a series of conflicts, multiple factors have recently affected the Cultural Heritage ecosystem. All in all, this ecosystem is impacted by technological developments that offer new opportunities for professionals and citizens on the one hand, while on the other hand, Natural and Tangible Heritage are being threatened by anthropogenic actions (e.g. vandalism, conflicts etc.), geo-hazards and the effects of climate change (e.g. earthquakes, landslides, storms, etc.). Cultural Heritage is therefore currently challenged mainly on two levels: first, to address these threats and strengthen its protection measures of sites, and secondly, to seize new technologies to foster Cultural Heritage development and diffusion.

When considering Europe, Cultural Heritage is characterised by a rich and diverse mosaic of cultural and creative expressions: with 453 registered sites, Europe as a region accounts for almost half of UNESCO's World Heritage List[13]. As such, culture, and in particular Cultural Heritage, has become an integral part of the internal and external action of the European Union.

While Cultural Heritage policy is primarily the responsibility of Member States and of regional and local authorities, the EU has been increasingly committed to safeguarding and enhancing Europe's Cultural Heritage through a number of policies and programmes. As Article 3.3 of the Lisbon Treaty states: "The Union shall respect its rich cultural and linguistic diversity, and [...] ensure that Europe's cultural heritage is safeguarded and enhanced". The Treaty on the Functioning of the European Union gives the Commission the specific tasks of contributing to the blossoming of culture in the Member States, while respecting their diversity, and bringing "the common cultural heritage to the fore" (art. 167 TFEU)[14]. In order to assist and complement the

[9] Creative Europe Call EACEA 32/2017 and EACEA 35/2017 - Guidelines, p. 7. Available at : https://eacea.ec.europa.eu/sites/eacea-site/files/3._guidelines_coop_2018_eacea_32_2017_and_35_2017_0.pdf

[10] "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Towards an integrated approach to cultural heritage for Europe" 22/07/2014, [ONLINE] Available at http://ec.europa.eu/assets/eac/culture/library/publications/2014-heritage-communication_en.pdf

[11] Daniel Théron. Heritage and beyond. Daniel.2009. Council of Europe Publishing

[12] Europea Nostra. 'Cultural Heritage Counts for Europe' (CHCFE) 2015 [ONLINE] Available at: http://blogs.encatc.org/culturalheritagecountsforeurope/wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf

[13] European Commission - Fact Sheet. European Year of Cultural Heritage 2018. Brussels, 7 December 2017 [ONLINE] Available at: http://europa.eu/rapid/press-release_MEMO-17-5066_en.htm

[14] European Commission, 2018 [ONLINE] Available at: https://ec.europa.eu/culture/policy/culture-policies/cultural-heritage_en

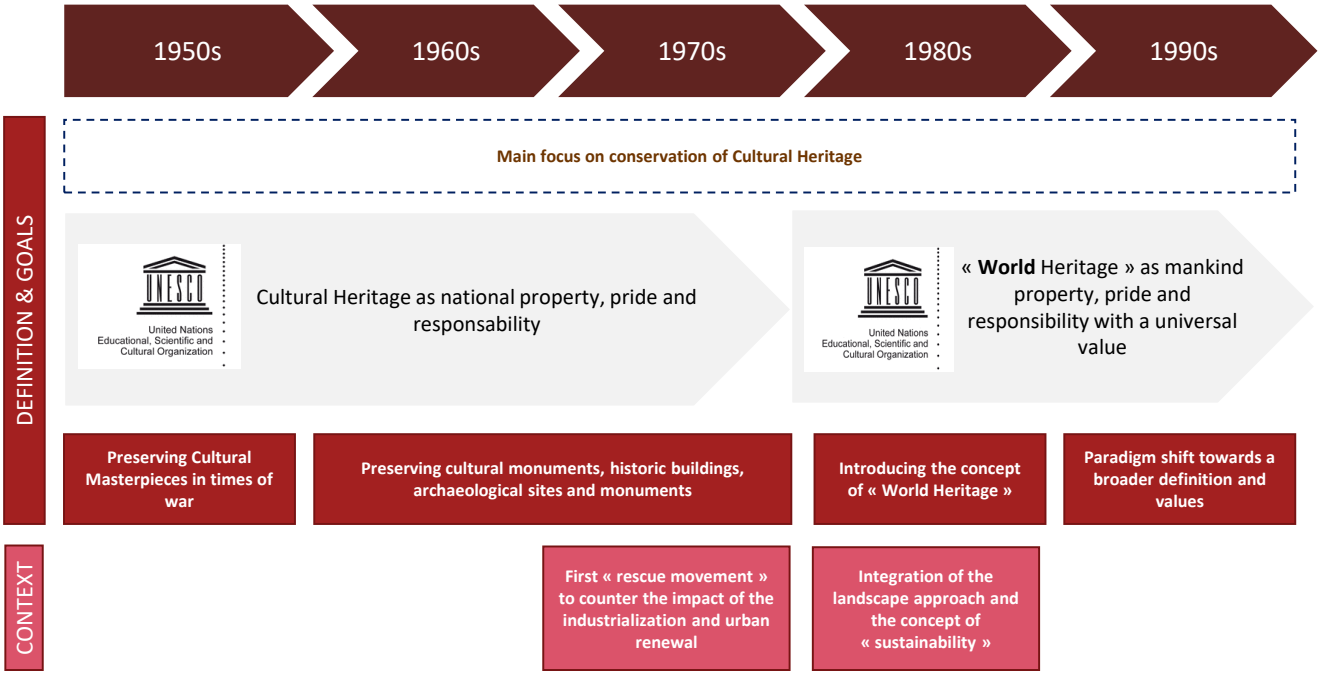
actions of the Member States in preserving and promoting Europe's Cultural Heritage, the EU has carried a large range of policies, programmes and funding[15].

Before understanding the context in which this study is undertaken, it is necessary to understand what stands behind the definition of Cultural Heritage in the European context, as it has been an evolving term and a field which is facing new challenges.

1.4.1 From Cultural Heritage conservation to Cultural Heritage valorisation

The concept of "Cultural Heritage" has evolved since World War II. The twentieth century was characterised by an increasingly broader understanding of what is to be considered as Cultural Heritage and by the international recognition of its universal value and significance. While Heritage was initially related to the conservation of buildings, monuments and archaeological sites from a national perspective, the 1972 UNESCO Convention on World Heritage carried the first deep paradigm shift for the Heritage community. A timeline summarising this process is displayed in the chart below.

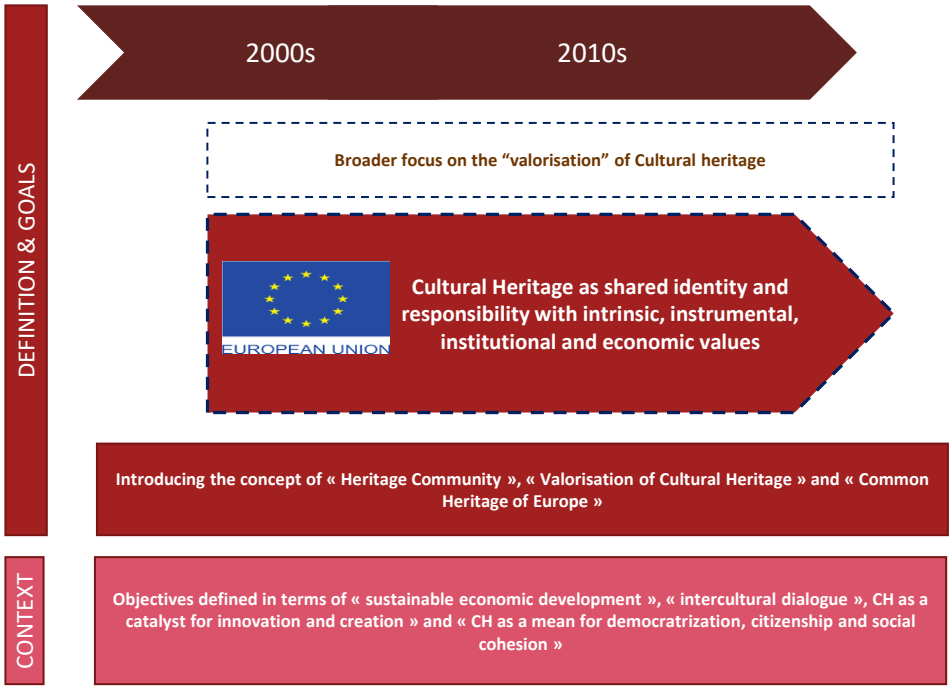
Figure 10: "Cultural Heritage" since World War II, an evolving concept (1/2) [16]



Heritage thus became a matter for the international community, leading to further cooperation for preservation and conservation of what could be considered "Humankind's property"[17]. It should be considered that this phenomenon happened within the context of the third industrial revolution, urban renewal and the development of new technologies. In this context, the scientific community needs to be alerted to the risks of changes linked to these events, as well as discover unknown sites and new technical possibilities to monitor them.

[15] European Commission. Mapping of Cultural Heritage actions in European Union policies, programmes and activities. 2017. [ONLINE] Available at: https://ec.europa.eu/culture/sites/culture/files/2014-heritage-mapping-version-2017_en.pdf
[16] Daniel Théron. Heritage and beyond. Daniel.2009. Council of Europe Publishing
[17] Ibid.

Figure 11: "Cultural Heritage" since World War II, an evolving concept (2/2)

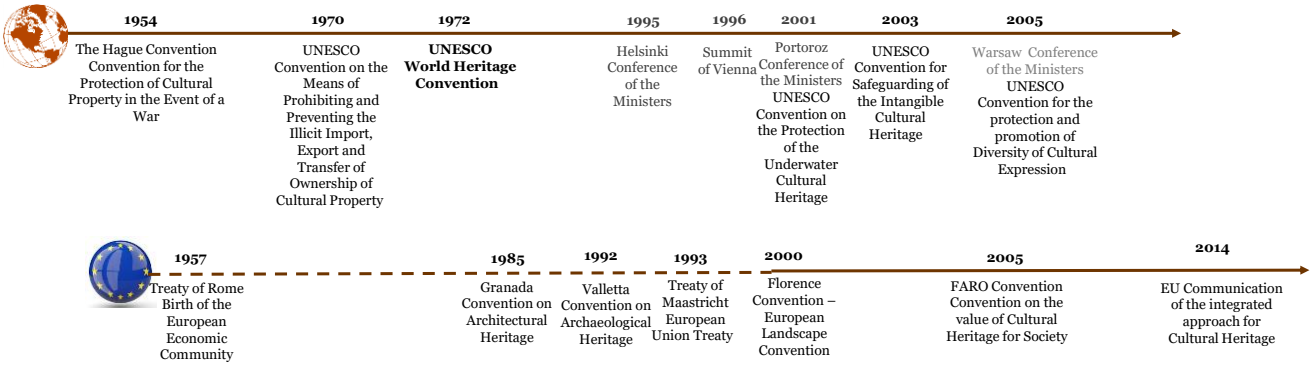


By the end of the Cold War and the official birth of the "European Union" in 1993, the second paradigm shift had taken place. Based on an enlargement of the significance carried by Heritage, it evolved from being considered for its intrinsic value (as a piece of history and of value for itself) to a wider understanding of the potential behind Heritage in terms of institutional (universal pride and social cohesion, cultural life), instrumental (education) and economic value (development of activities and tourism). A new integrated approach taken by the Council of Europe and the European Commission defined a transdisciplinary understanding of Cultural Heritage that would not only integrate the notion of conservation of Heritage for itself, but would rather focus on the valorisation of Heritage as a means for the fostering of European democracy and citizenship, to strengthen intercultural dialogue among European countries, raise the profile of the Heritage professionals acting as catalysts on creation and innovation, and last but not least, as a means to carry sustainable economic development.

This evolving concept is apparent through the evolution of international and European legal frameworks. As the figure below shows, key conventions carried the integration of new understandings of what Cultural Heritage is and how it should be protected and fostered. Within the European context, specific regulations were designed in support of Member States to foster the European network of Cultural Heritage, which led to the recent development of the new EU Cultural Heritage "integrated approach" of Cultural Heritage for Europe[18].

[18] Daniel Théron. Heritage and beyond. Daniel.2009. Council of Europe Publishing

Figure 12: Considering Cultural Heritage: International and European legal evolution



Among a large development of policies and regulations, it is worth noting some key steps which helped to define the EU approach to Cultural Heritage such as:

The **Faro Convention**[19]**,** signed in 2005, provided a definition of a European "shared identity" and "shared responsibility" through culture, hence following the will of Jean Monnet, a founding father of the European Union. While the aim of the 1972 UNESCO Word Heritage Convention was to value major items as humankind's Heritage, which was a first necessary milestone, the European approach instead presented the first holistic definition of Cultural Heritage. The Faro Convention embraces cultural diversity not only through its intrinsic value, but mostly through its impacts on society, the need for sustainable management and the way it conveys a driving force for dialogue, democracy and peace in Europe and worldwide. The preservation of Heritage cannot be a finality in itself but needs to "become an object of furthering well-being of individuals and the wider expectations of Society".

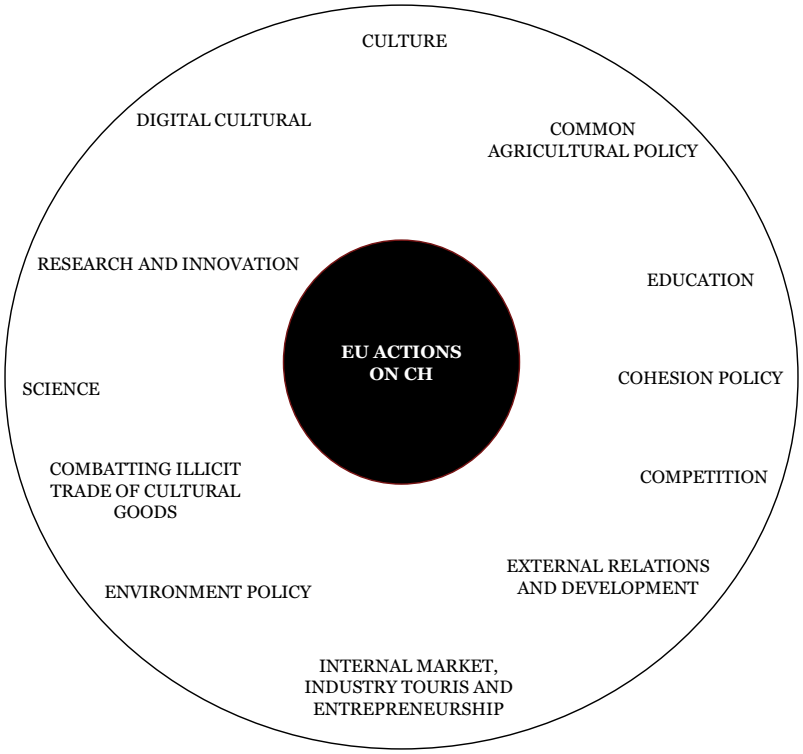
2014 is considered a time of "**policy momentum**[20]", during which a series of far-reaching policy documents adopted by the Council of the European Union were produced, namely:

- "The Conclusions on Cultural Heritage as a Strategic Resource for a Sustainable Europe", adopted on 21 May 2014;
- "The Conclusions on Participatory Governance of Cultural Heritage", adopted on 25 November 2014;
- "The Communication towards an Integrated Approach to Cultural Heritage for Europe", adopted on the 20th May 2014 and which seeks to "combine the promotion and protection of cultural diversity, democratic governance and democratic innovation"[21].

On this basis, policy collaboration on Cultural Heritage among EU Member States has been pursued and has permitted a continuous development of Cultural Heritage and its impact on the European economy and society, in 12 strategic fields (as illustrated in the figure below), 4 main European funds and 3 key EU actions [22].

[19] Daniel Théron. Heritage and beyond. Daniel.2009. Council of Europe Publishing
[20] John Bold and Robert Pickard An integrated approach to cultural heritage - The Council of Europe's Technical Co-operation and Consultancy Programme (2018) [ONLINE] see: https://book.coe.int/eur/en/cultural-heritage/7537-an-integrated-approach-to-cultural-heritage-the-council-of-europes-technical-co-operation-and-consultancy-programme.html
[21] John Bold and Robert Pickard An integrated approach to cultural heritage - The Council of Europe's Technical Co-operation and Consultancy Programme (2018) [ONLINE] see: https://book.coe.int/eur/en/cultural-heritage/7537-an-integrated-approach-to-cultural-heritage-the-council-of-europes-technical-co-operation-and-consultancy-programme.html
[22] European Commission. Mapping of Cultural Heritage actions in European Union policies, programmes and activities. 2017. [ONLINE] Available at: https://ec.europa.eu/culture/sites/culture/files/2014-heritage-mapping-version-2017_en.pdf

Figure 13: EU actions in Cultural Heritage affected 12 strategic fields of action [23]



To conduct programmes and policies applying to Cultural Heritage, Cultural Heritage user communities can have access to EU funds that cover a wide range of actors and activities from the public, the non-for-profit and the private sector:

- The European Regional Development Fund (ERDF);
- The European Social Fund (ESF);
- The European Agricultural Fund for Rural Development (EAFRD);
- The European Maritime and Fisheries Fund (EMFF).

More specifically, Cultural Heritage management has become one of the investment priorities for the EU structural and investment funds. In the 2007-2013 period, out of a total of EUR 347 B[24] for cohesion policy, the European Regional Development Fund allocated EUR 3.2 B[25] for the protection and preservation of cultural heritage, EUR 2.2 B[26] for the development of cultural infrastructure and EUR 553 M[27] for cultural services, which also benefited Cultural Heritage[28].

Last but not least, the EU has established three specific actions dedicated to Cultural Heritage in order to foster its development and protection:

- The European Heritage Days, and in 2018, the European Heritage Year;
- The EU Prize for Cultural Heritage;
- The European Heritage Label (EHL).

[23] European Commission. Mapping of Cultural Heritage actions in European Union policies, programmes and activities. August 2017. [ONLINE] Available at: https://ec.europa.eu/culture/sites/culture/files/2014-heritage-mapping-version-2017_en.pdf
[24] European Commission. Supporting cultural heritage. 2018 [ONLINE] Available at: https://ec.europa.eu/culture/policy/culture-policies/cultural-heritage_en
[25] Ibid.
[26] Ibid
[27] Ibid.
[28] Ibid.

To summarize, the notion of Cultural Heritage has been an evolving concept which has been taking an increasingly important role in the EU development. The aim of the EU is to generate political will to foster the potential behind its large range of sites and monuments, to seize the opportunities presented by new technologies and eventually, to be capable of facing the challenges brought by both climate change and anthropogenic risks.

1.5 Impacts of Cultural Heritage

1.5.1 Economic impacts

In the European Union, the government expenditure on recreation, culture and religion account for about 1% of the GDP[29] and about 2.2% of the total EU government expenditures[30]. Though Cultural Heritage is only part of what culture entails, it implies that its economic impact is non-negligible[31]. However, Cultural Heritage has the specificity that it may take a long time before having a return on investment[32]. An analysis of the Gross Value Added (GVA) helps understand the magnitude of the impact of Cultural Heritage. The GVA is defined as the "output (at basic prices) minus intermediate consumption (at purchaser prices). The sum of GVA over all industries or sectors plus taxes on products minus subsidies on products gives gross domestic product (GDP)"[33]. The GVA here includes the goods and services attributable to Cultural Heritage (e.g. revenues from the exploitation of touristic sites).

When looking at the GVA resulting from Cultural Heritage-related activities (e.g. conservation, maintenance, management, and exhibition) as well as expenditures resulting from touristic activities in the UK (which is the country that has performed the most advanced impact assessments on Cultural Heritage), in particular Scotland and Wales, it accounts for between 1.4% and 1.9% of the country's GVA[34]. Besides, it should be noted that about half of this GVA is usually directly attributable to the expenditures linked to tourism[35]. This strong impact of tourism can be explained by the fact that, according to 2/3 of European citizens, the presence of Cultural Heritage is a determining factor in their choice of a holiday destination[36] and that Europe is a privileged destination for tourists[37]. As a result, Cultural Heritage in Europe generates about EUR 300 B of yearly GVA[38]. When it comes to Natural Heritage, taking the example of the Natura 2000 network, which regroups European protected areas whose biodiversity should be preserved[39], it appears that the benefits generated by Natural sites are considerable: direct yearly benefits resulting from Natura 2000 sites amount to between EUR 200 B and EUR 300 B and recreational benefits to between EUR 5 B and EUR 9 B[40]. These Natura 2000 sites are already monitored by Copernicus through the Land service and the Copernicus programme can already support several activities related to Cultural Heritage (as presented in section 4 – Copernicus capabilities in response to user requirements).

[29] Eurostat website. Available at: http://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20170807-1
[30] Eurostat website. Available at: http://ec.europa.eu/eurostat/data/database
[31] European Commission, 2016, Towards an EU strategy for international cultural relations (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016JC0029&from=EN
[32] CHCFE Consortium, 2015, Cultural heritage Counts for Europe (Online). Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf
[33] Eurostat Website. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Gross_value_added
[34] Note: The UK is the most advanced country in terms of Cultural Heritage impact assessment. As such, examples from the UK have been used to emphasise the potential impact of Cultural Heritage in monetary terms.
[35] The Social and Economic Value of Cultural Heritage: literature review by Cornelia Dümcke and Mikhail Gnedovsky EENC Paper, July 2013 [ONLINE] Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
[36] European Commission, 2017, Special Eurobarometer 466: Cultural Heritage
[37] CHCFE Consortium, 2015, Cultural heritage Counts for Europe (Online). Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf
[38] Nypan, T., A proposal for a design to develop European statistics on the socio-economic contributions of the physical cultural heritage (Online). Available at: http://ehhf.eu/sites/default/files/DESIGN%20FOR%20DEVELOPING_FINAL_june.pdf
[39] European Commission website. Available at: http://ec.europa.eu/environment/nature/natura2000/index_en.htm
[40] European Commission, 2013, The economic benefits of the Natura 2000 Network (Online). Available at: http://ec.europa.eu/environment/nature/natura2000/financing/docs/ENV-12-018_LR_Final1.pdf

The evolution of a GVA in a sector is directly linked to employment. Two types of jobs can be concerned: (i) direct jobs, which refer to all employment positions created as a result of the intervention of the EC with Copernicus in favour of Cultural Heritage. As such, it comprises all jobs that are linked to the use of Earth Observation (EO) or of Geospatial Information Systems (GIS) for Cultural Heritage, also called the downstream sector; (ii) indirect jobs, which refer to all employment positions created as a result of the use of products and services made available by the downstream sector on Cultural Heritage (e.g. in the field of conservation-related construction; repair and maintenance; cultural tourism, but also small and medium-sized enterprises (SMEs) and start-ups, in the creative industries[41]) as well as induced jobs that are jobs created to support the spending of people (e.g. tourists) on Cultural Heritage.

The Decision on a European Year for Cultural Heritage (2018) from the European Parliament and the Council has the goal to "*enhance the contribution of Europe's cultural heritage to society and the economy, through its direct and indirect economic potential, which includes the capacity to underpin the cultural and creative sectors, including small and medium-sized enterprises, and to inspire creation and innovation, to promote sustainable development and tourism, to enhance social cohesion and to generate long-term employment*"[42]. As of 2009, there were about 306,000 people employed in the Cultural Heritage sector (administration, research institutes and businesses executing restoration or maintenance works on Cultural Heritage objects/sites) in Europe and 7.8 million jobs induced in other sectors by Cultural Heritage-related activities: for each Full Time Equivalent (FTE) job in the field of Cultural Heritage, about 27 induced jobs are created in other sectors, which is far above most industrial domains[43]. It has been estimated that FTE jobs in the Built Heritage sector represent on average between 1% and 2% of the employed population in Europe[44]. At the scale of France, a country containing several heritage sites and monuments, it is estimated that every 10,000 visitors of Cultural Heritage sites enable the support of 1.15 full-time jobs and 0.15 part-time job related to Heritage institutions[45]. These values emphasise the impact of tourism on employment and therefore the importance of the preservation of Natural Heritage sites and the conservation of Cultural Heritage buildings. This impact of Cultural Heritage on job creation is also directly felt by European citizens, as 79% of them agree with the fact that Cultural Heritage-related activities have the ability to foster employment[46].

Besides the impact on employment, Cultural Heritage can positively contribute to the quality of life of European citizens through a regeneration of its environment. The impact of Cultural Heritage in a territory tends to be measured in economic terms (e.g. in Wales, the historical environment is assumed to be the source for 20% of the tourism of the country[47]), but other variables, taking into account more globally the impact on a city's dynamic, are key too. These are especially interesting in the sense that local public authorities integrate such considerations in their cultural policy. The economic benefits of tourism indeed have a wide reach: beyond Cultural Heritage structures and tourism-related businesses (e.g. restaurants, housing), the development of a territory globally profits from the attraction of visitors: rise of the "brand" of the city, creative industries development, indirect job creation, investments, community cohesion, preservation of broader areas (the conservation of a Cultural Heritage site implies often harmonious and preserved surroundings), diversification and increase in quality of education programmes, etc. Among these, urban rehabilitation is key. For instance, there has been an action programme for urban rehabilitation in Oporto, Portugal, which received both public and private funds as part of its territorial strategy: the rehabilitation was accompanied by

[41] CHCFE Consortium, 2015, Cultural Heritage Counts for Europe (Online). Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf
[42] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[43] CHCFE Consortium, 2015, Cultural heritage Counts for Europe (Online). Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf
[44] The Social and Economic Value of Cultural Heritage: literature review by Cornelia Dümcke and Mikhail Gnedovsky EENC Paper, July 2013 [ONLINE] Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
[45] Greffe, X., 2004, Is heritage an asset or a liability?, Journal of Cultural Heritage, 5(3), pp. 301-309.
[46] European Commission, 2017, Special Eurobarometer 466: Cultural Heritage
[47] The Social and Economic Value of Cultural Heritage: literature review by Cornelia Dümcke and Mikhail Gnedovsky EENC Paper, July 2013 [ONLINE] Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf

the development of new commercial activities as well as the building of touristic accommodation and facilities in order to revitalise both historic buildings and the public space[48]. Based on literature, the alignment of Cultural Heritage conservation and city regeneration can be summed up by the notion of "integrated conservation approach", which designates the local economic and social development induced by a Cultural Heritage conservation plan.

The different activities related to Cultural Heritage conservation, can be supported by satellite imagery and in particular by Copernicus data and information. Indeed, there could be cost reduction for site managers as they could replace current costly activities by satellite imagery. This can be illustrated with the case study of the ITACA project for Cultural Heritage. This project aimed at supporting the work of archaeologists and managers of Cultural Heritage in coastal areas by providing them with a set of tools facilitating their activities (e.g. investigations, monitoring, operations, risk management). More precisely, two services have been developed: a location and monitoring service, aimed at identifying shapes; and a management and operation service, aimed at sharing information on the management of underwater sites. These services had the aim to help monitor ship wrecks, ruins and historical artefacts now submerged as well as searching for potential ancient ship wrecks. Such activities are supported by bathymetry data, maps of underwater currents, sea level changes or coastal erosion information. The final result is not the replacement of on-site staff in charge of the previously mentioned activities but the gain in time and thus in expenses linked to coastal Cultural Heritage activities[49]. Indeed, it has been estimated that satellite imagery in the case of ITACA could help save about 50% of the cost of a normal discovery/monitoring campaign; this is non-negligible when one takes into account that the cost of a discovery/monitoring campaign is of EUR 423,800 for 20 days diving, with the biggest expense being ship rental[50]. Thanks to satellite imagery, and thus anticipated knowledge of the area under study, the latter cost could be drastically reduced.

1.5.2 Societal impacts

The Decision on a European Year for Cultural Heritage (2018) from the European Parliament and the Council highlights the fact that dedicating a year to Cultural heritage should help "*promote cultural heritage as a source of inspiration for contemporary creation and innovation, and highlight the potential for cross-fertilisation and stronger interaction between the cultural heritage sector and other cultural and creative sectors*"[51]. Cultural Heritage can indeed be a catalyser for creativity by fostering the development of SMEs in the field of tourism capitalising on cultural sites, by supporting individuals in engaging in artistic actions or by incentivising application developers to create Value Added Services (VAS) in the field of Cultural Heritage management, conservation or exhibition. This, in the end, plays a major role in the support to development at European level as stated in the Cultural and Creative Cities report: "*Culture is understood to be a key driver of growth and job creation, enhancing creativity and innovation through processes of cross-fertilisation. Culture furthermore fosters a sense of belonging and cohesion among citizens; improves quality of life and the attractiveness of cities and regions for citizens, tourists, businesses and investors; and ultimately promotes peace, inter-cultural dialogue and socio-economic development within and beyond national borders"*[52].

For instance, the research, innovation and development of techniques of conservation and preservation of Cultural Heritage sites has a beneficial impact also on the field itself. More particularly, the increasing use of space technologies for the detection, monitoring, preservation and conservation activities related to Cultural Heritage has been disruptive for the field - it allowed Cultural Heritage communities to abandon the systematic use of techniques that have

[48] European Commission, 2015, Getting cultural heritage to work for Europe (Online). Available at: https://www.kowi.de/Portaldata/2/Resources/horizon2020/coop/H2020-Report-Expert-Group-Cultural-Heritage.pdf
[49] ITACA Report Summary. Available at : https://cordis.europa.eu/result/rcn/196660_en.html
[50] Pavone, R., Tiliacos, E. & Ciccarelli, S., 2014, Economic benefits expected from Earth observation applications. The case of the EU FP7 ITACA project (Online). Available at: http://www.golfpeople.eu/wp-content/uploads/2014/09/IAC-2014-Paper_Draft_V.2.pdf
[51] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[52] European Commission, 2017, The Cultural and Creative Cities Monitor (Online). Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC107331/kj0218783enn.pdf

proved to pose a risk to the integrity of Heritage at the profit of non-invasive techniques allowed by remote sensing. But this goes even further than replacing potentially damaging techniques as it also creates new monitoring opportunities that did not exist before. These apply to the detection of underground sites, to the decision-making with regards to excavation, to the monitoring of the site for preservation and conservation purposes and to the development of activities surrounding the exposition of the site to general public and to scientific research. The field thus directly benefits from the development of innovations and the disposal of technical tools to enrich the current procedures. For instance, the CORDIS "Heritage at Risk" report emphasised how critical the safeguarding of Cultural Heritage from neglect, pollution, natural hazards and climate change is for the future generations. As a result, several projects have been launched capitalising on space technologies to protect Heritage: for instance, the HERITAGE PLUS project under FP7, which was comprised of three transnational initiatives, had the aim to "*identify vulnerable sites*" and to offer "*practical manuals on threats for policy-makers, global organisations and NGOs*"[53].

The Decision on a European Year for Cultural Heritage (2018) from the European Parliament and the Council also reminds that "*The ideals, principles and values embedded in Europe's cultural heritage constitute a shared source of remembrance, understanding, identity, dialogue, cohesion and creativity for Europe*"[54]. In parallel, several studies emphasise that an efficient management of Cultural Heritage can support social inclusion and cohesion, foster community empowerment or help shape the identity of a territory[55]. Indeed, Cultural Heritage has a strong role to play in the enhancement of a cohesive community feeling in Europe.

According to consultation with citizens from the European Union, over 4/5 think Cultural Heritage is important to them, to their local community, and to their region, and over 90% feel it is important for their country. Moreover, 80% are proud of the Cultural Heritage from their country or region and 70% feel pride of the Cultural Heritage from another European country or region[56]. Such percentages reflect the actions of the European Union (under Article 167 of the Treaty on the Functioning of the European Union (TFEU)) that tries to protect and foster cultural diversity between EU Member States and in parallel works on emphasizing that there is a common European Cultural Heritage. In that sense, the European Heritage Label, which is awarded to Heritage sites that contribute to the European culture, history and building of the EU, convey the ideas that the labelled sites share common symbols and heritage[57]. Besides, Cultural Heritage sites have a social impact as they can work as community hubs where European or international citizens interact, create networks, and thus create ties[58] (e.g. an open and facilitated access to Heritage sites for all audiences can help break down social barriers[59]).

All this, in the end, leads to 70% of European citizens acknowledging the fact that Cultural Heritage can enhance the feeling of belonging to a European community and 80% considering that the diversity of the European Cultural Heritage makes it unique and gives it a specific value[60]. This is key as cohesion is usually built on the sharing of common feelings, values and ideas.

[53] CORDIS website. Available at: https://cordis.europa.eu/article/id/400947-heritage-at-risk-eu-research-and-innovation-for-a-more-resilient-cultural-heritage_en.html
[54] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[55] The Social and Economic Value of Cultural Heritage: literature review by Cornelia Dümcke and Mikhail Gnedovsky EENC Paper, July 2013 [ONLINE] Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
[56] European Commission, 2017, Special Eurobarometer 466: Cultural Heritage
[57] European Heritage Label, 2016, Panel Report on Monitoring (Online). Available at: https://ec.europa.eu/programmes/creative-europe/sites/creative-europe/files/ehl-report-2016_en.pdf
[58] Murzyn-Kupisz, M. & Działek, J., 2013, *Cultural heritage in building and enhancing social capital*. Journal of Cultural Heritage Management and Sustainable Development, pp. 35-54
[59] The Social and Economic Value of Cultural Heritage: literature review by Cornelia Dümcke and Mikhail Gnedovsky EENC Paper, July 2013 [ONLINE] Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
[60] European Commission, 2017, Special Eurobarometer 466: Cultural Heritage

1.5.3 Environmental impacts

The Decision on a European Year for Cultural Heritage (2018) from the European Parliament and the Council emphasises among its objectives that "*synergies between cultural heritage and environment policies by integrating cultural heritage into environmental, architectural and planning policies, and by promoting energy-efficiency*" should be encouraged[61]. Already in 2002, the Director of the World Heritage Center, Francesco Bandarin, stated that: "*Cultural and natural heritage sites around the world can only be protected if the continued degradation of the global environment is reversed, while improving the lives of those living in poverty*". Indeed, Cultural Heritage is threatened by global environmental issues such as climate change, geo-hazards, air or water pollution, etc.[62]. As a result, Heritage buildings may be damaged or natural sites endangered (e.g. marine salts can affect coastal monuments, pollution can be corrosive to buildings, stability of monuments may be at risk)[63]. For instance, if there is no anticipation of the impact of tourism and more precisely on the flow of visitors, Cultural Heritage sites can deteriorate, since anthropogenic activities generate air pollution that can be dangerous to buildings and the environment[64]. In order to prevent degradation of Cultural Heritage and protect the environment, preventive measures can be taken, in particular with the support of satellite imagery. The Copernicus programme has been designed to respond to environmental and climate change challenges, hence it can help detect potential degradation to Cultural Heritage.

1.6 The Copernicus programme

The Copernicus programme is one of the European flagship programmes, providing free and open data and information relying on satellite-based imagery, models and in-situ data. More than simply data and information, the Copernicus programme relies on state-of-the-art models to be used for societal and environmental purposes. The Copernicus programme is a public service designed to respond to policy and public administrations, and foster economic growth in Europe by:

- Supporting public users at local, national and European level;
- Helping Europe to maintain a prominent role in the international context;
- Strengthening intermediate users, downstream companies and value-added service providers.

Initially developed to focus on environment and security – the former name of the Copernicus programme was Global Monitoring for Environment and Security (GMES) – the Copernicus programme has developed several specific services providing free data and information, enabling applications in a vast variety of fields (i.e. agriculture, biodiversity protection, air quality, search and rescue, etc.). Even if the programme is considered an Earth Observation programme, it is providing much more than satellite-based imagery by offering a free and open access to many information products developed by its six core services.

The European Commission (EC) is managing the Copernicus programme and its 3 main components: Space, Services and In-situ components. The high level structure of the Copernicus programme is presented in the figure below.

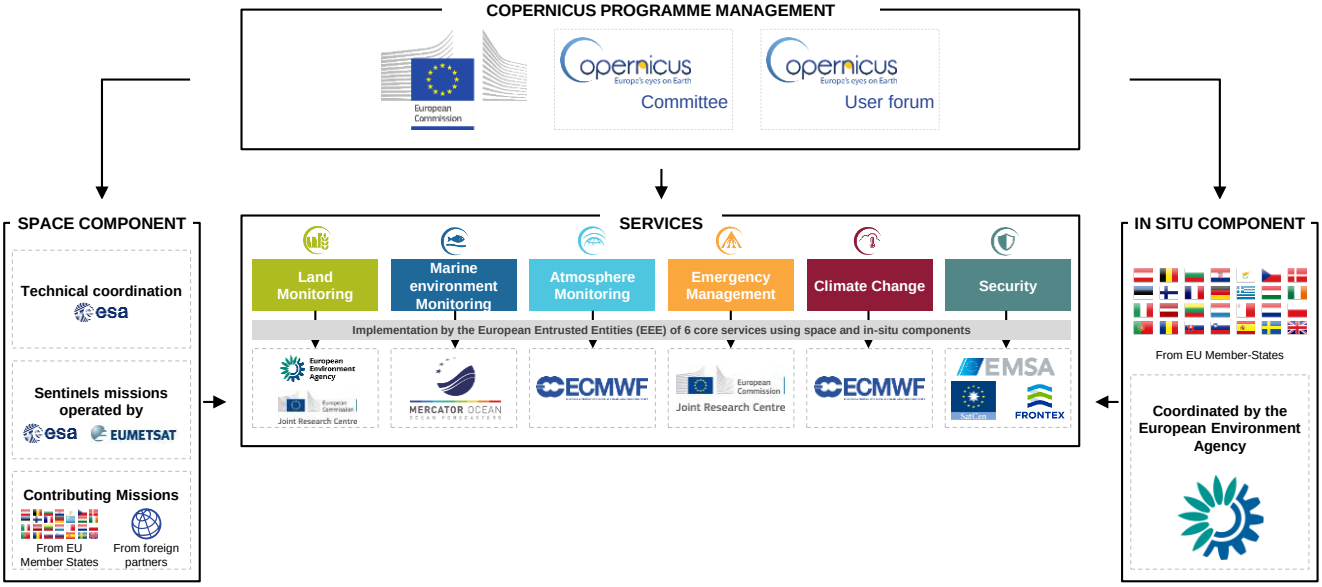
[61] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN

[62] NSW Heritage Office, 2004, Heritage and Sustainability: a discussion paper (Online). Available at: http://www.environment.nsw.gov.au/resources/heritagebranch/heritage/research/sustainability.pdf and The Atlas of Climate Change impact on European Cultural Heritage: scientific analysis and management studies, ISBN-13: 978-0857282835

[63] European Commission, 2008, Preserving our heritage, Improving our environment (Online). Available at: https://www.si.edu/mci/downloads/CHRESP%202008/Cultural%20Heritage_Volume1_20081105_web.pdf

[64] Sablier, M. & Garrigues, P., 2014, Cultural heritage and its environment: an issue of interest for Environmental Science and Pollution Research (Online). Available at: https://hal.archives-ouvertes.fr/hal-01483919/document

Figure 14: High level structure of the Copernicus programme



The Copernicus Space Component deals with the procurement, launch, operation and the distribution of Sentinels data and of contributing missions' data. The technical coordination and procurement for the Sentinels fleet are led by ESA and operated by collaboration between ESA and EUMETSAT. This element also includes the procurement of the overall space infrastructure, including satellite design, satellite manufacturing (procurement to the industry), satellite launches and ground infrastructure manufacturing (procurement to the industry). Finally, ESA is also in charge of acquisition, storage and distribution of the Sentinels data via the ESA Scientific Hub platform. As a transnational space agency collaborating with all the European national space agencies, ESA has access to several national EO programmes' data, including the archives of such programmes. This additional data source is called "contributing missions" and provides, for registered users, access to a wide range of commercial (i.e. Worldview, SPOT, TerraSAR, Radarsat 2, etc.) and civilian (i.e. Landsat, COSMO-SkyMed, RISAT, etc.) EO data sources. This data sources offer in some cases higher spatial resolution than the Sentinels spacecraft, to support the development of specific information products provided by Copernicus core services. However, the access to contributing missions is based on restrictions and so not fully open to everyone.[65] For obvious reasons, high and very high resolution imagery is only open to a restricted list of authorized users in the field of security and emergency.

The Copernicus In-situ component offers access to observation from the ground, sea and airborne sensors but also licensed reference and ancillary data licensed; in-situ data are not freely available for Copernicus users. The in-situ component supports the space component in offering access to sustainable and reliable data to produce, validate and calibrate Copernicus products for the services component. The In-situ component is implemented in two tiers:

- At the level of the service: each core service is in charge of daily operation and ingestion of specific in-situ data of interest per thematic (marine service, land monitoring, etc.) to offer valuable products for their end-users. This means that specific sources of in-situ data are tailored for each core service[66]
- At the programme level: the European Environment Agency manages the cross-cutting service offering general in-situ data accessible through specific agreements with data providers/networks at programme level[66]

65 EC, 2016. Study to examine the socio-economic impact of Copernicus in the EU.
Report on the Copernicus downstream sector and user benefits. Report prepared by PwC.
66 Group on Earth Observation (GEO), 2016. Cross-cutting Coordination of the Copernicus In Situ Component.

The Copernicus Services component aims to deliver data and products freely available for a wide variety of users. These services integrate data from the Space and In-situ components, together with state-of-the-art models, in order to offer Copernicus products tailored to the needs of specific end-users. To better reach end-users, six different core services were developed or are currently being developed in different areas:

- Copernicus Land Monitoring Service (CLMS);
- Copernicus Marine Environment Monitoring Service (CMEMS);
- Copernicus Atmosphere Monitoring Service (CAMS);
- Copernicus Climate Change Services (C3S);
- Copernicus Emergency Management Service (EMS);
- Copernicus Security Service (CSS).

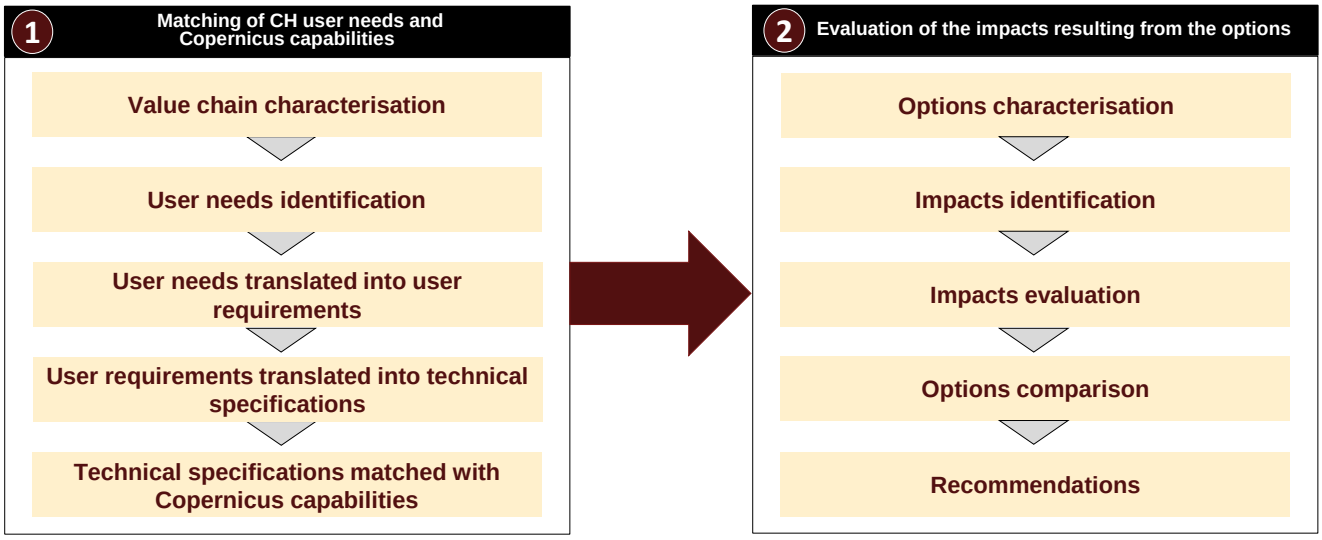
The Copernicus services were designed to respond to very specific needs of the European society, targeting specifically public authorities but also research and scientific communities. Nevertheless, the quantity and quality of the data and products offered by services also respond to commercial end-user needs. In this context, most of the products provided for free and openly accessible for everyone were designed with an objective of ensuring the European downstream industry would not be directly harmed.

2 Detailed methodological approach for the study

This chapter introduces the methodology used to analyse the possibility of starting an institutional action to promote the use of Copernicus Data & Information for Cultural Heritage preservation, monitoring and management.

The overall methodology relies on two key phases, each one split into five major steps, as illustrated in the chart below.

Figure 15: Overall approach of the study

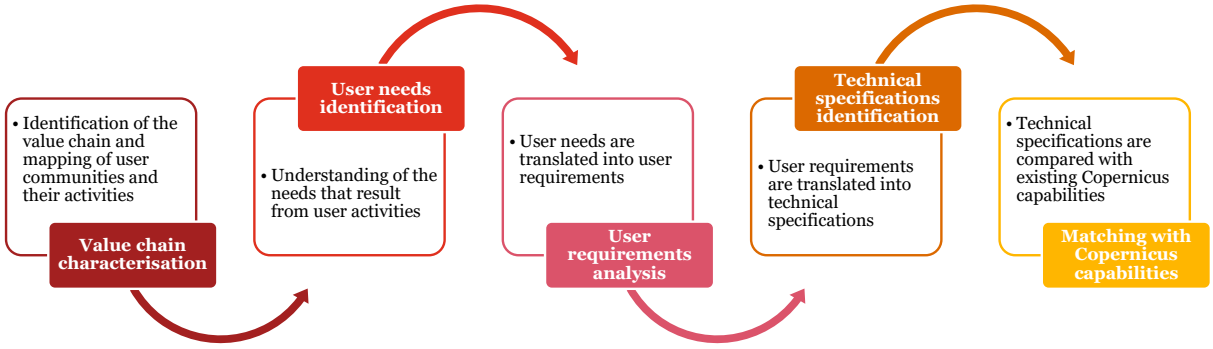


All these different steps are described in more detail in the next sections.

2.1 Phase 1 – Matching Cultural Heritage user needs with Copernicus capabilities

The five-step approach of Phase 1 is illustrated in the chart below.

Figure 16: Overall approach of phase 1



2.1.1 Value chain characterisation

In order to define accurately the Cultural Heritage domain, its value chain needed to be clearly identified and a mapping of relevant user communities performed.

A value chain is a schematic representation of how value is created among a set of tasks and activities. In the case of Cultural Heritage, desk research has enabled the identification of tasks and activities, and an understanding of how to group them into segments, which represent the main parts of the value chain. The tasks and activities are undertaken by user communities.

A user community is a group of users who are part of the same community (e.g. site operators). Nevertheless, the same user community can include a mix of governmental and non-governmental organisations. In this context, different users that are part of the same user community may have different needs based on where they are located in the value chain, the type of activities that they carry out (e.g. monitoring of a natural site versus maintenance of a tangible site), and the type of environment they are interested in (land versus sea).

It should also be pointed out that Copernicus core users have been identified throughout the user communities. As defined in the Copernicus Regulation 377, Copernicus "core users" are:

"Union institutions and bodies, European, national, regional or local authorities entrusted with the definition, implementation, enforcement or monitoring of a public service or policy in the areas: atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency management and security" and therefore a particular attention should be given to their needs".

The organisation of stakeholders in user communities ensured a mapping of the overall spectrum of Cultural Heritage stakeholders in order to facilitate the understanding of their task and activities, and hence of the segment of the value chain they intervene in. This mapping results from desk research and is calibrated and verified through direct stakeholder consultation. It is composed of the following communities: Cultural Heritage professional user community, Natural Sciences user community, Site operator user community, Urban planner user community, Intermediate user community and National, Regional or Local authority user community (in charge of Cultural Heritage recognition). The different Cultural Heritage user communities are detailed and further explained in section 3.1.

2.1.2 High level user needs and user needs identification

Once user communities have been identified and mapped along the value chain, the high level user needs resulting from their activities and tasks were identified.

From a generic point of view, a high level user need is an overarching statement which describes the desire or wish of a user. Within the specific case of Cultural Heritage, high level user needs have been defined as demands that are formulated by user communities to carry out their tasks and activities; hence identifying high level user needs requires an understanding of the type of process that is undertaken by each user community along the value chain. The user communities also expressed specific user needs related to the segments and activities of the value chain they are involved in (e.g. creation vs. production segment). These user needs are clustered in the different high level user needs. In order to determine these, two means of data collection were used:

- A literature review aimed at defining a first set of user needs;
- A direct stakeholder consultation and a web-based survey aimed at validating and complementing the list of user needs.

2.1.3 User requirements analysis

Once the high level user needs and the user needs have been identified, the next step was to translate them into user requirements. User requirements are the user needs translated into desired performances and attributes. User requirements go a step further in the sense that they bring more precision to the user needs.

They can be characterised by the provision of information on:

- Type of land cover of interest for user communities: grasslands, jungles, deserts, coastal areas, sea, urban areas, etc.
- Geographic coverage: size of the area to monitor
- Revisit time: frequency of monitoring (e.g. once per month, once per week, etc.)
- Spatial resolution: size of the smallest possible feature that can be detected (expressed in meter)

The translation into requirements is essential as, depending on the user community and the segment of the value chain that is considered, a single user need could result in different user requirements. As such, user requirements bring characterisation to user needs (e.g. weekly monitoring of motion in a building labelled as Cultural heritage in an urban area). In order to determine these user requirements, a similar methodology to the collection of user needs was used - a mix of desk research and stakeholder consultation (direct consultation and web-based survey).

2.1.4 Technical specifications identification

User requirements are then translated into technical specifications. Technical specifications are defining the type of Earth Observation-related (EO) data and information needed, such as:

- Type of sensor (e.g. optical)
- Wavelength (e.g. X-band)
- Spatial resolution specifications (e.g. 10x10m)

As such, the technical specifications enable the full and precise characterisation of the EO solution required to respond to the user requirement. This activity was undertaken by PwC's external experts, Nextant Applications and Innovative Solutions (NAIS)[67].

2.1.5 Matching the analysis with Copernicus capabilities

The last step of the first phase consisted of matching Copernicus capabilities with the technical specifications previously identified. This activity comprised of two steps:

- Mapping the wide range of products offered by the different Copernicus core services and the data provided by the Sentinels and contributing missions;
- Performing a match analysis aimed at assessing the Copernicus capabilities with regards to the technical specifications identified (i.e. which technical specification could be covered with current data and products, which technical specification could be covered but would require some adaptations in the products offered (i.e. low efforts required to develop such products) and finally which technical specification cannot currently be covered (i.e. medium and high efforts required to develop such products)).

The mapping relied on PwC experience (i.e. past assignments) on the Copernicus programme, whilst the second step was carried out by PwC with support by expert consultations (i.e. NAIS, Copernicus Entrusted Entities in charge of the Copernicus core services, ESA). An example of the overall process of Phase 1 is illustrated in the box below.

ILLUSTRATION OF THE APPROACH TO MATCH USER NEEDS WITH COPERNICUS CAPABILITIES

An example of the approach matching Cultural Heritage user needs with Copernicus capabilities would be:

- **Value-chain characterisation**: Production segment, Cultural Heritage Conservation
- **User needs identified**: Ground motion monitoring of a Cultural Heritage site
- **User requirements**: Weekly monitoring of motion in a building labelled as Cultural heritage in an urban area
- **Technical specifications**: C-band SAR (Synthetic Aperture Radar) data with 5x20 on-ground resolution, weekly revisit time
- **Matching with Copernicus capabilities**: Such data is provided by Sentinel-1A/B and could be provided through a new product on ground motion

The output of this phase is a traceability matrix identifying a list of existing Copernicus data and information responding to the technical specifications, including a clear identification of "ready to use" Copernicus products suitable for Cultural Heritage, "adaptable" Copernicus products, and new Copernicus products required. A specific focus is given to the assessment of what possible

[67] NAIS (Nextant Applications and Innovative Solutions) is an Italian company contributing to this study as external experts. They have been notably working on the ITACA and ARTEK projects

future Copernicus Evolution capabilities (e.g. hyperspectral, thermal infrared, etc.) could offer to Cultural Heritage user communities.

This exercise has been supported by a large stakeholder consultation, as illustrated in the box below.

Stakeholder consultation

Introduction[68]

The objective of the consultation was to identify stakeholders' user needs along the value chain, first by confirming and qualifying the analysis provided on the basis of the desk research, and second, by identifying and/or confirming the user requirements linked to those needs and dependant on the nature of intervention (type of Cultural Heritage, land cover, environment) of given stakeholders.

The targeted stakeholder consultation undertaken in the frame of this study was performed in two ways. First of all, an online questionnaire was sent out to key stakeholders intervening through the whole Cultural Heritage value chain. Secondly, face-to-face and phone interviews with key stakeholders and experts were conducted.

All stakeholders were identified to ensure the coverage of the Cultural Heritage value chain with the largest geographical diversity possible.

Definition of the list of stakeholders

Online survey

A list of 422 stakeholders was defined by PwC with the support of the EC. The objective of the list was to identify a large number of stakeholders intervening in one or more segments of the Cultural Heritage value chain as well as experts capable of providing an overview of the state of Cultural Heritage needs and development. On top of this targeted public consultation, the online link was shared amongst user communities and made publicly available on the Copernicus, EARSC, Eurisy and Nereus websites.

It is worth noting that **stakeholders from the same entity have answered the survey as one single respondent**, providing therefore a limited yet representative answer for their community of stakeholders.

Direct interviews

The phone interviews involved direct interaction with targeted stakeholders in the form of semi-structured interviews. 39 experts and key stakeholders were contacted and 22 interviews were conducted.

Results of the stakeholders consultation

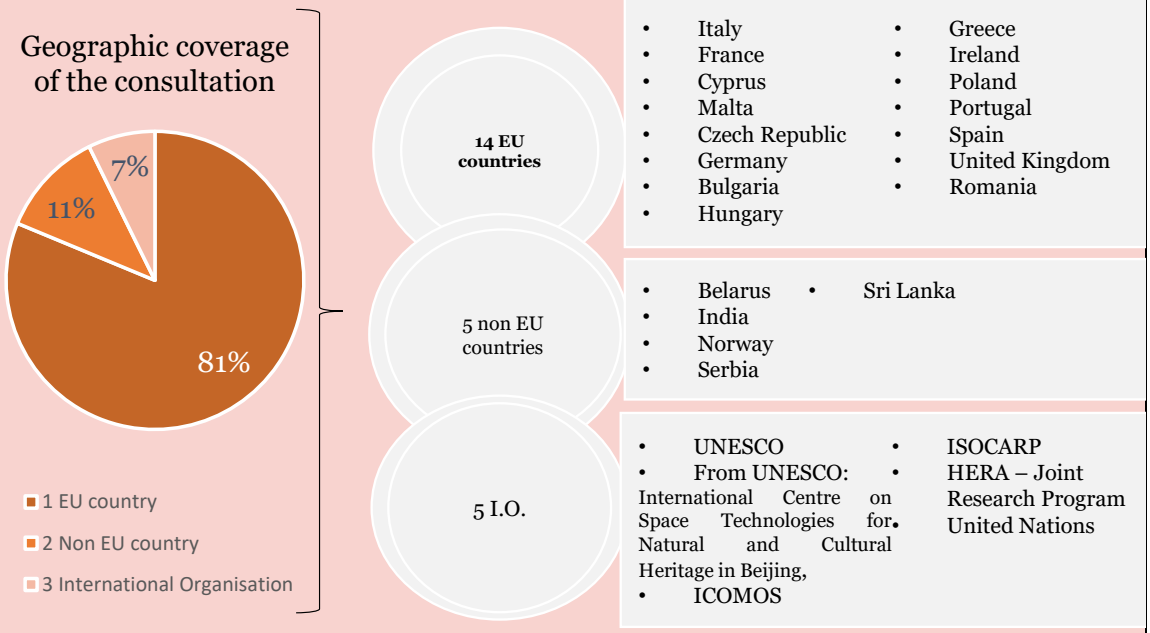
The online survey and the phone interviews were very complementary to reach the relevant user communities in order to have representative sample of respondents, as illustrated in the table below.

[68] See details in Annex A

Respondents	Distributed	Answered	Response rate
Online survey	383 +Public access on specific websites	67	About 18%
Phone interviews	39	22	56%
Total	422	89	21%

The online survey was opened to the public from April 15th until May 25th 2018, and gathered a total of 67 answers from 19 different countries and 5 international organisations. As a reminder, these answers should be considered as representative of the need of a given stakeholder entity and not an individual answer, therefore justifying its relative representativeness. 22 phone interviews were conducted from March 2018 to May 2018 with key stakeholders. The consultation's geographic coverage provides a high representativeness of European Countries and a lowest one for non EU countries and organisation. Therefore, all consequent results of distribution among the CH value chain, types of working environments and needs will be mostly representative of the European practices and requirements.

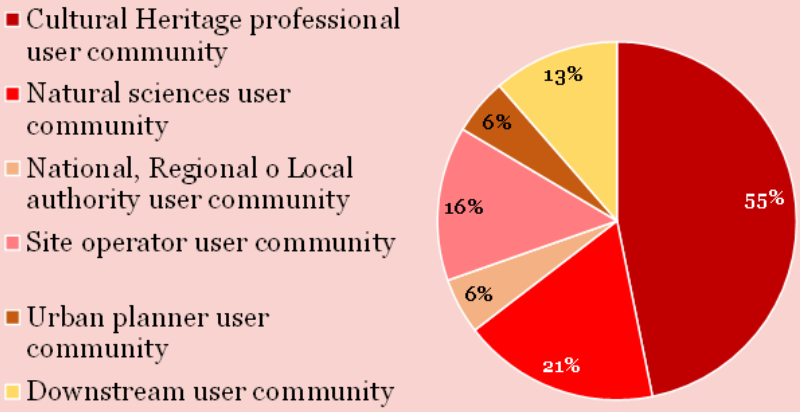
Figure 17: Geographic coverage of the consultation (Sources: PwC analysis)



Distribution of the stakeholders

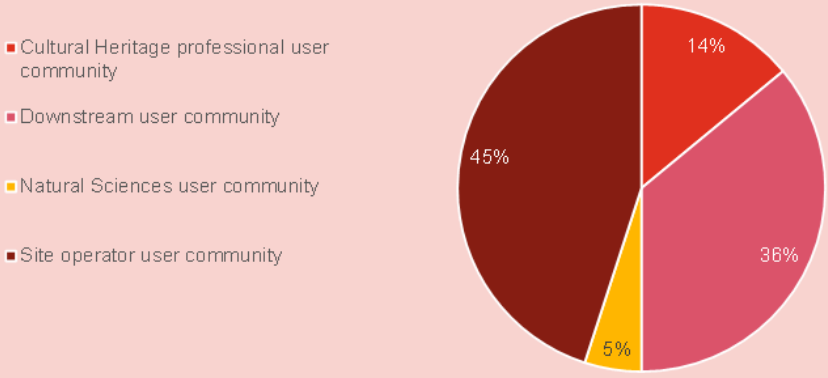
The overall consultation was satisfactory in terms of representation and collecting of user needs for all user communities, intervening on all Cultural Heritage land covers and types of environment, as presented in the figures below.

Figure 18: User communities' representativeness in the online questionnaire (Source: PwC analysis)



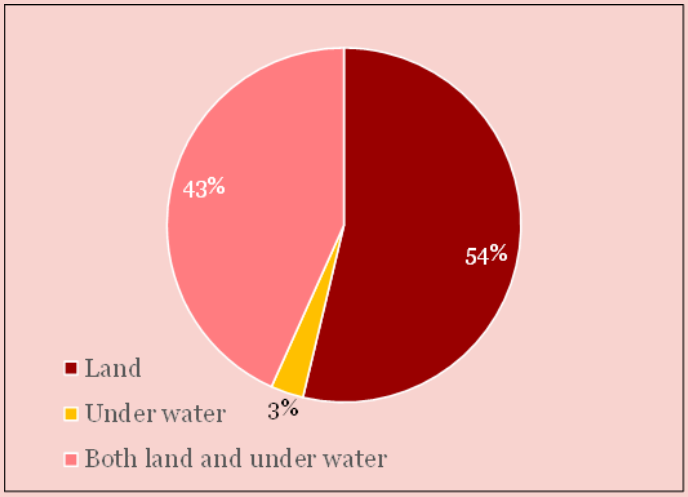
One out of two stakeholders identifies himself as belonging to the CH professional user community. Definitions were provided to respondents so as to make sure all respondents would share the same understanding of each user community. It is however interesting to note that stakeholders from the academia could identify themselves as CH professionals. This phenomenon should imply that 55% of the respondents can represent a large part of the CH community intervening through the different segments of the value chain, as they might also intervene in site operation activities or urban planning but will not consider themselves as "urban planners" or "site operators" per say. As such, the list of institutions and profiles of respondents answering as "CH professionals", which are provided in this analysis, should not be perceived as an unbalanced distribution of user communities.

Figure 19: User communities' representativeness in interviews (Source: PwC analysis)



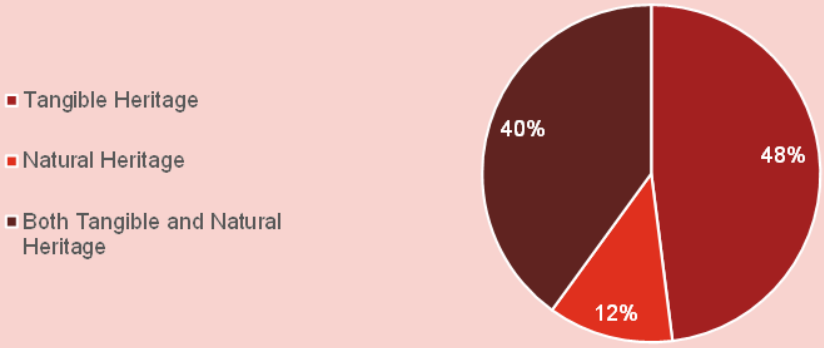
Phone interviews which were conducted permitted to complete the lack of participation to the survey from certain user communities such as site operators and the downstream user community mostly. As it appears in the chart, the distribution of user communities among the 22 interviews allowed the gathering of important qualitative information for less represented user communities in the online survey.

Figure 20: Environment of intervention of the stakeholders (Source: PwC analysis)



Where do user communities intervene and can they be characterised by certain specificities? As the chart indicates, it appears that the CH user communities are characterised by their global approach to Cultural Heritage. Indeed, half the respondents indicated intervening in both land and underwater environments. As the analysis of the study will present, this was highly representative of the upcoming integrated approach to Cultural Heritage, not only in terms of Tangible and Natural Heritage but also in terms of types of environment. It appears that there will not be a specific demand for underwater environments specialist but rather, in the context of CH, a more global demand linking land and under water land covers. As a conclusion, as almost 100% of respondents work in the land environment, this should thus be considered as a priority. Underwater will be present for almost 60% of respondents, allowing the conclusion that the CH needs will not be specific to a certain environment at this current state.

Figure 21: Heritage fields of interest to the stakeholders (Source: PwC analysis)



While 48% of respondents are involved in Tangible Heritage, 40% intervene in both Tangible Heritage and Natural Heritage, as seen in the graph. As announced in the previous chart, these numbers confirm the tendency of user communities to have a global intervention in Cultural Heritage, creating therefore a homogenous global demand for an integrated approach of the two types of Cultural Heritage which should be preserved and monitored with the same performance. Further on, the study will provide information about the current state of activities actually conducted in the field. However it should be pointed that the stakeholders consultation confirms that 98% of users intervene in Tangible Heritage.

Table 3: Distribution of user communities interest along types of heritage and environments (Source: PwC analysis)

How to read this table: 66% of all stakeholders who responded to the survey intervene in urban and sub-urban land covers.

	Land cover requested by respondents	
Type of environment	**Land cover**	**% total respondents**
Land	Urban and sub-urban	66%
	Rural or forested areas	63%
	Mountainous/hilly regions	50%
	Scrub and grassland	43%
	Coastal (for both Land & Sea)	43%
	Rainforest	29%
	Alluvial plain or Floodplain	25%
	Waterlogged/wetland	18%
	Frozen/glacial areas	15%
	Inland waters (e.g. lakes, rivers)	19%
Sea	Costal	37%
	Under-sea	24%
	Water surface	21%

How are characterised the environments, land and under water, in terms of specific land cover? After understanding, all in all, in which environments and types of CH user communities intervene, the consultation allowed to confirm that the CH user communities did intervene mostly in urban and sub-urban areas (as showed by the literature review). Next to this intervention, respondents intervene in rural and forested areas as well as mountainous and hilly regions. This is coherent with the idea that most respondents work in land environments and less work in inland water environments. Also, it emphasizes the difficulties that might appear to CH communities as their role with CH environments are confronted with urban and sub-urban development and challenges (social, economic, ecological, etc.).

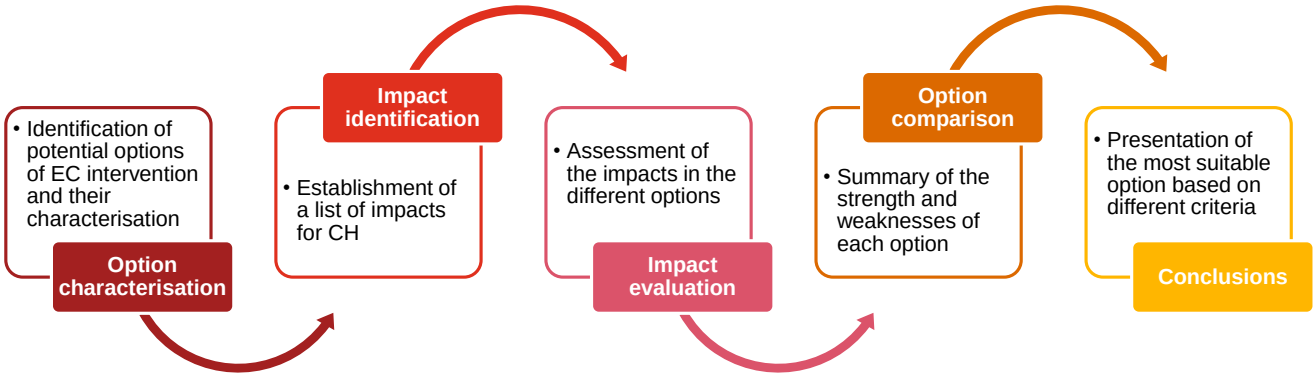
In terms of data, given the balanced distribution of stakeholders within types of Cultural Heritage, environments and land covers, the collected data can be considered satisfactory.

2.2 Phase 2 – Evaluation of the impacts resulting from the options

The second phase of the methodology was a direct result of the first phase, as the matching of user needs with Copernicus capabilities helped refine the options under scrutiny and differentiate between them.

The second phase of the methodology also consisted of a five-step approach, as illustrated below:

Figure 22: Overall approach of phase 2



2.2.1 Option characterisation

Before being able to carry out a high level assessment of potential impacts, the different options under scrutiny needed to be characterised. The initial proposal of the considered options has been further refined and formulated thanks to literature review and expert consultation.

An intervention from the European Commission could take several forms, and so the options illustrate several ways in which the European Commission, through the Copernicus Programme, could contribute to support Cultural Heritage. The different options under investigation are presented in the chart below and are developed in further details in Chapter 5 - Options for an intervention from the European Commission.

Figure 23: List of options under scrutiny

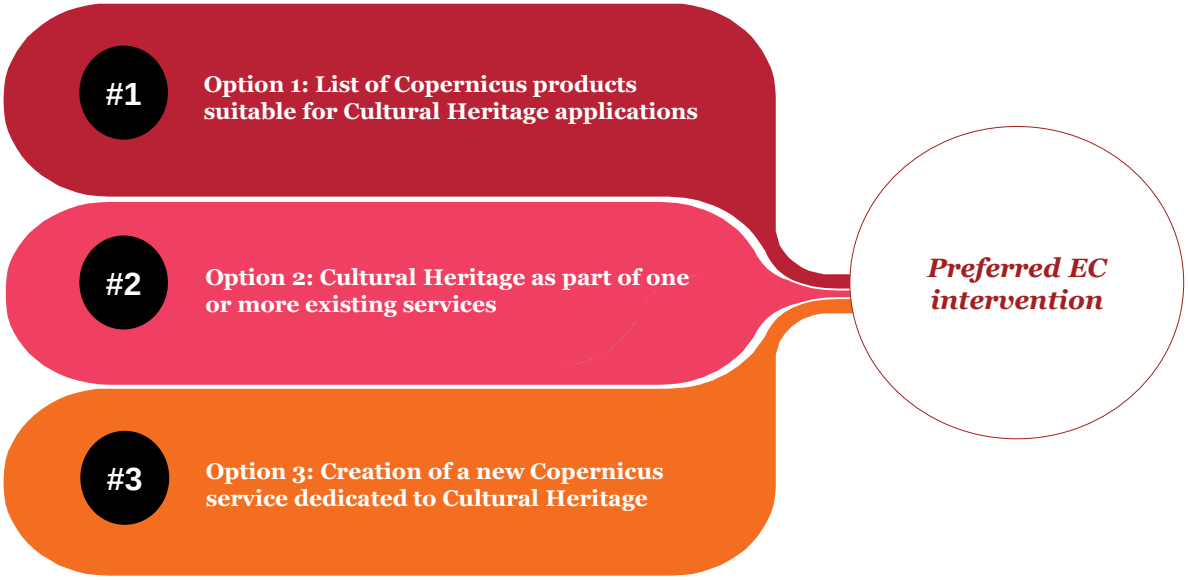


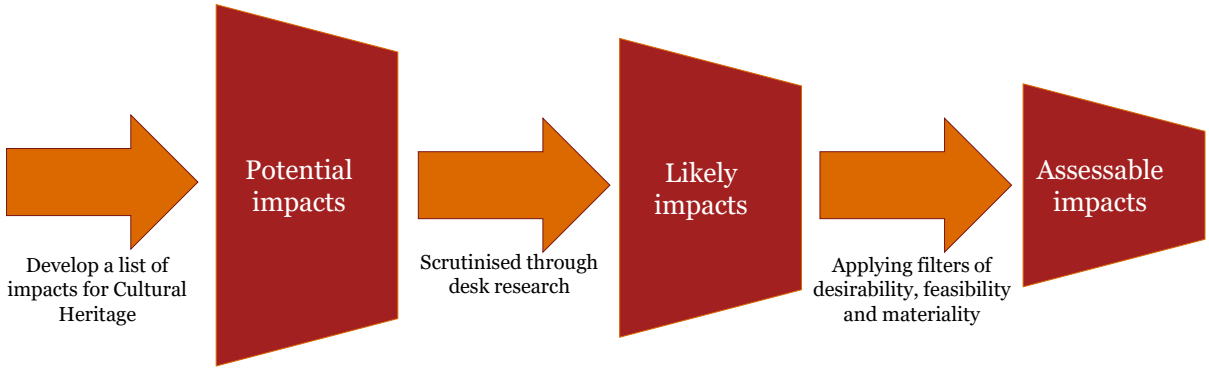
Table 4: Option characterisation

Module	Products
Option 1	This option relies on existing Copernicus products within each service that could be suitable for Cultural Heritage purpose. Though there will be no intervention to set up a specific component dedicated to Cultural Heritage, efforts will be put on raising awareness on the existence of products useful for Cultural Heritage applications and promotion of market uptake activities. This option would offer Copernicus products, data (Sentinels, contributing missions) and information based on: • Products currently offered by the Copernicus programme and suitable for Cultural Heritage purposes.
Option 2	This option consists of the implementation of a dedicated web interface (later referred to as front-end) facilitating the access to Copernicus data and information relevant for CH purpose. This interface would be fully designed for Cultural Heritage purposes and would offer Copernicus products adapted to fit Cultural Heritage user communities' needs. This option would offer Copernicus products, data (Sentinels, contributing missions and in-situ data) and information based on : • Products currently offered by the Copernicus programme and suitable for Cultural Heritage purposes; • Products currently offered by the Copernicus programme, adapted to Cultural Heritage user communities' needs.
Option 3	This option relies on the creation of a new Copernicus service exclusively dedicated to Cultural Heritage, offering Copernicus products, data (Sentinels, contributing missions) and information based on: • Products currently offered by the Copernicus programme and suitable for Cultural Heritage purposes; • Products currently offered by the Copernicus programme, adapted to Cultural Heritage user communities' needs; • New products tailored to Cultural Heritage user communities' needs.

2.2.2 Impact identification

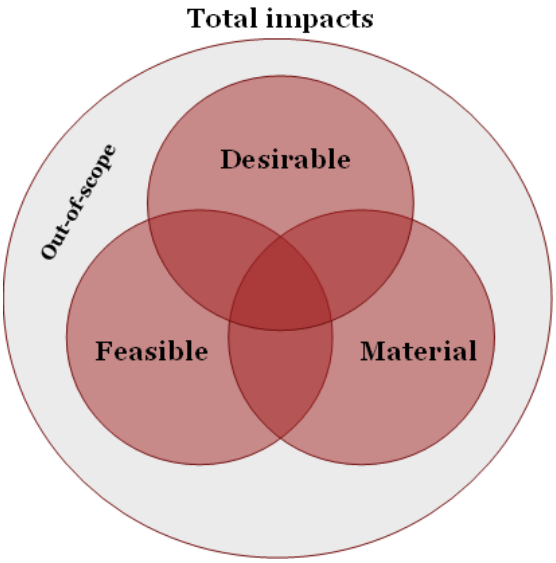
In order to be able to compare the different options, a list of assessable impacts was defined based on a long-list of potential impacts. The process to identify assessable impacts is illustrated below.

Figure 24: Characterisation of assessable impacts



This process consisted of (i) establishing a list of extensive potential high level impacts based on the literature review on Cultural Heritage (long list), (ii) scrutinising it through further research (mix of desk research and stakeholder consultation) to assess which of them were more likely to occur, and (iii) narrowing down this list through filters. The various filters used are presented below:

Figure 25: Filters of the impact evaluation



- **Desirability** is determined on the basis of how important certain impacts are considered for the European Commission and for Cultural Heritage in general.
- **Feasibility** represents the ability to assess a specific impact, determined on the basis of data availability and quality.
- **Materiality** is determined through research on the basis of the expected magnitude of the impacts assessed.

The final list of impacts is the result of a literature review centred around Cultural Heritage-oriented reports and EU publications on Cultural Heritage (e.g. the EU's "Towards an integrated approach to cultural heritage for Europe"[69], Strategic framework - European Agenda for

[69] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the Regions "Towards an integrated approach to cultural heritage for Europe. [ONLINE] Available at : http://ec.europa.eu/assets/eac/culture/library/publications/2014-heritage-communication_en.pdf

Culture[70], Heritage Impact Assessments for Cultural World Heritage properties[71], European Cultural Heritage Counts[72]. See bibliography for further references.) as well as on a review of EU's main global strategies and legal publications (e.g. EU 2020 strategy[73], the Better Regulation[74], the decision on a European Year of Cultural Heritage[75]. See bibliography for further references). These impacts take into account the main orientations that stand out of these documents. In particular the objectives of EU 2020's strategy of smart, inclusive and sustainable growth are reflected. After the extraction from the literature of all impacts, a second step consisted of reorganising them into the four categories of impacts: societal, environmental, economic or strategic.

2.2.3 Impact evaluation

In order to assess the different impacts, a certain number of KPIs per impact have been defined. The choice of KPIs is based on the literature review of past studies that have been involved in impact evaluations of the Cultural Heritage sector (e.g. The social and economic value of Cultural Heritage[76], The Costs and Benefits of UK World Heritage Site Status[77], Cultural Heritage Counts for Europe[78]. See bibliography for further references.). This literature review is associated with the study team's experience with impact evaluation in order to select the most relevant metrics to be analysed.

These KPIs can be either monetary (e.g. enabled revenues, costs of options, etc.) or non-monetary (e.g. sustainable development, academia, etc.). Quantitative impact evaluation relied on the assessment of these two categories of impacts, presented in the following sections.

2.2.3.1 Monetary indicators

Benefits assessment was based on desk research and user community consultation for each option considered. The assessment focused on the order of magnitude of economic benefits for Cultural Heritage user communities that could be provided by Copernicus products, data and information. Examples of benefits could be additional revenues for intermediate users (i.e. companies offering data processing services or geospatial-based applications).

The cost analysis was performed by using relevant information from Copernicus core services with regards to the cost of developing new dedicated services or implementing promotion of market uptake activities, and potential other indications from desk research and expert consultation. Cost analysis was performed at high level, aiming at assessing an order of magnitude of cost rather than providing a traditional financial analysis.

2.2.3.2 Non-monetary indicators

On the top of monetary impacts, wider non-monetary impacts were also considered. Non-monetary indicators are impacts that cannot be turned into monetary values (i.e. in euros) but

[70] Strategic framework - European Agenda for Culture [ONLINE] Available at : https://ec.europa.eu/culture/policy/strategic-framework_en
[71] Guidance on Heritage Impact Assessments for Cultural World Heritage Properties [ONLINE] Available at : https://www.icomos.org/world_heritage/HIA_20110201.pdf
[72] CHCFE Consortium, 2015, Cultural heritage Counts for Europe (Online). Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf
[73] Europe 2020, A European strategy for smart, sustainable and inclusive growth [ONLINE] Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf
[74] Better regulation: why and how [ONLINE] Available at https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
[75] Decision (EU) 2017/864 of the European Parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) [ONLINE] Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[76] The Social and Economic Value of Cultural Heritage: literature review, European Expert Network on Culture [ONLINE] Available at : https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
[77] The Costs and Benefits of UK World Heritage Site Status A literature review for the Department for Culture, Media and Sport, PwC [ONLINE] Available at : https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/78450/PwC__literaturereview.pdf
[78] Cultural Heritage counts for Europe [ONLINE] Available at : http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf

are still highly important and relevant. Examples of non-monetary impacts can be the contribution to European leadership in the field of Cultural Heritage, or the EU geospatial industry's competitiveness. These indicators were assessed by using a Likert scale in order to transform qualitative data into quantitative information. The way a Likert scale assessment is performed is illustrated below.

Figure 26: Likert scale proposed to grade the different wider impacts (Sources: PwC)

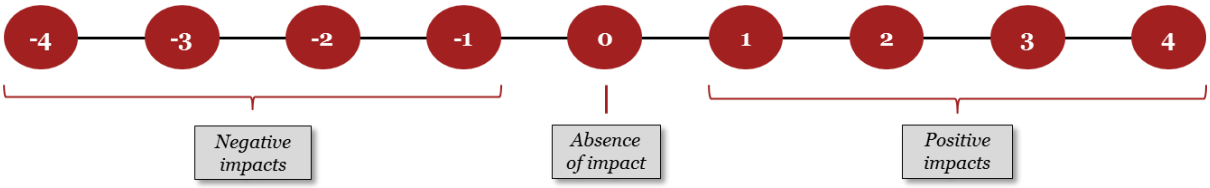


Table 5: Description of the Likert scale grades (Sources: PwC)

Negative impact	Absence of impact	Positive impact
Level -1: Marginal negative impact.	Level 0: Absence of impact.	Level 1: Marginal impact.
Level -2: Moderate negative impact.		Level 2: Moderate impact.
Level -3: Strong negative impact		Level 3: Strong impact
Level -4: Very strong negative impact.		Level 4: Very strong impact.

For each impact assessed during this consultation, experts were asked to express their personal views on the potential magnitude of each impact based on a **Likert scale**. The scale proposed ranges from **a very strong negative impact (-4), to an absence of impact (0), to a very strong positive impact (+4)**, following the order of magnitude illustrated and described in the figure and table above.

2.2.4 Option comparison

The option comparison step consisted of summarising the results of the impact evaluation by option and comparing them against each other. This step fully integrated the results from phase 1 on the matching of Copernicus capabilities with user needs, in the sense that each impact was analysed keeping in mind whether, for each option, Copernicus could respond to it based on the following categories of products:

- Existing Copernicus products that already answer Cultural Heritage technical specifications;
- Existing Copernicus products that require adaptation to be used in support to technical specifications;

- New products that could be developed using Copernicus data to answer technical specifications.

2.2.5 Conclusions and recommendations

The conclusion consisted of determining the most suitable option based on the results of the option comparison. PwC did not select an option to be pushed forward but provided the advantages and drawbacks of each option, notably taking into considerations the order of magnitude of costs versus order of magnitude of benefits.

3 User needs assessment

This chapter introduces the results of the analysis regarding the needs of the Cultural Heritage user communities. These results are the output of comprehensive desk research and consultation with stakeholders. More details on the stakeholder consultation are available in Annex A.

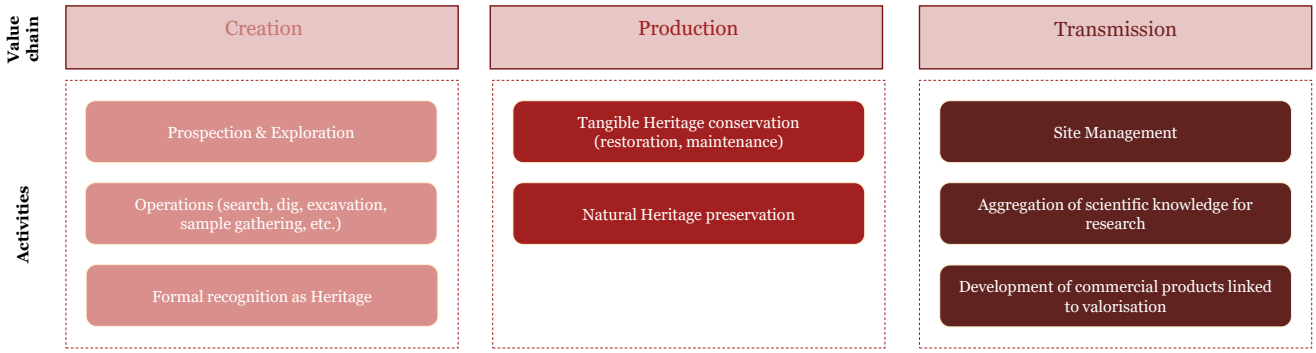
In this chapter, the following outcomes are presented: (i) the mapping of the Cultural Heritage value chain and of the user communities and (ii) the mapping of activities and of the related user needs.

3.1 Cultural Heritage value chain and user communities

A value chain aims at mapping all major activities creating value[79] in a given domain. The rationale for drawing the value chain of Cultural Heritage activities is the following: in order to be able to capture the needs of the Cultural Heritage user communities, one needs to understand the overall activities performed, from the discovery of a site all the way to the capitalisation coming from the provision of public access to the site. By segmenting the value chain with regards to the activities performed, it becomes possible to map the user communities intervening in each part of the value chain, and thus to later understand their needs.

For the purpose of this study, the Cultural Heritage value chain has been developed relying on commonly accepted taxonomy extracted from desk research, and discussed and verified with experts from the field. The Cultural Heritage value chain is illustrated in the chart below.

Figure 27: Value chain linked to Tangible Heritage and Natural Heritage



Research shows that the Cultural Heritage value chain, for both Tangible Heritage and Natural Heritage, relies on three major segments:

- **Creation**: The "Creation" segment includes activities such as prospection, operations and formal recognition of the sites as Cultural Heritage. After the site is classified as Cultural Heritage, cultural significance80 of the site is publically recognised.
- **Production**: The "Production" segment includes all activities related to site monitoring, restoration and maintenance performed for conservation and preservation purposes. "Conservation" and "preservation" refer to actions that are undertaken in order to foster the protection of, respectively, Tangible Heritage and Natural Heritage. This segment is

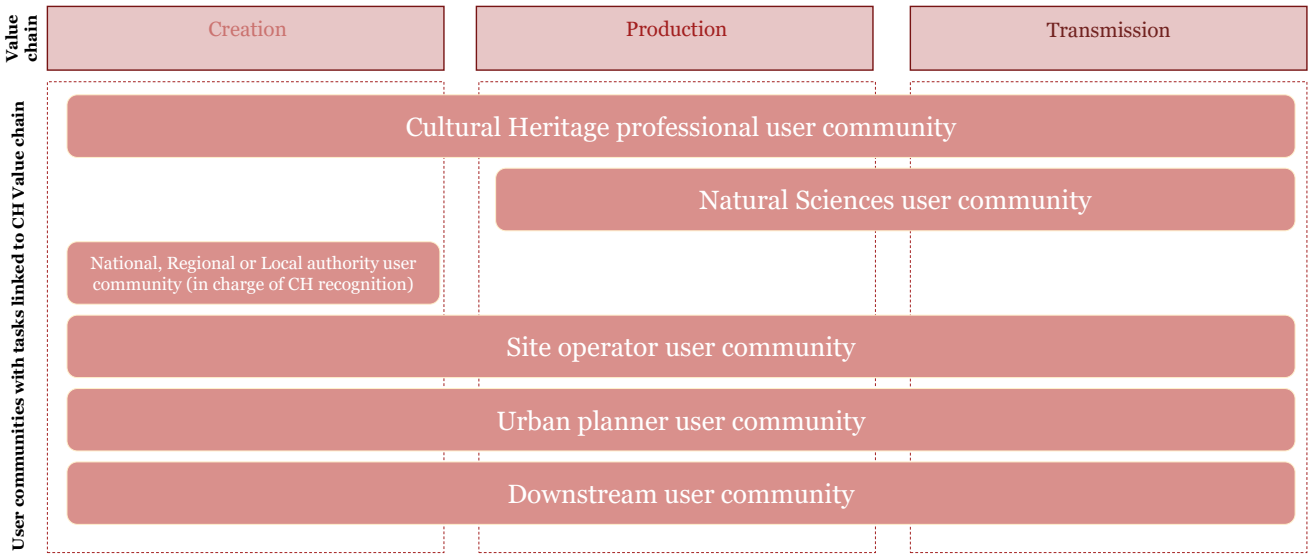
[79] The term value refers here to the usefulness of something, and not to its monetary value.
[80] Burra Charter, ICOMOS Australia, 1999

structured around making and keeping the site exploitable and reducing the risk of damages linked to, for instance, geo-hazards or human conflicts.

- **Transmission**: The "Transmission" segment refers to activities related to the development of commercial products linked to the enhancement of Cultural Heritage assets (in particular for the development of touristic valorisation), site management, and aggregation of scientific knowledge for research. The latter consolidates all the activities linked to the utilisation of scientific data, for example through publications of research. On the other hand, the former activities aim at making a Cultural Heritage site accessible to the general public. The type of activities ranges from developing 3D models of sites for tourists, constructing support infrastructures (e.g. roads, accommodation, etc.) to enhancing the touristic exploitation of a site. Examples of such Cultural Heritage sites that are accessible to the public include Pompeii, the Colosseum, the Eiffel Tower or the Primal forest of Poland.

Each of these segments rely on a set of different main activities which are relevant to one or several user communities. Nevertheless, a single user community can regroup different users, including both governmental and non-governmental organisations, and perform different types of activities. Within the large diversity of stakeholders intervening in the Cultural Heritage field, six user communities have been identified as sharing common key activities along the value chain, as illustrated in the chart below.

Figure 28: User communities mapped on the value chain



The following paragraphs present the six user communities and their characteristics. The objective here is to describe the user communities to facilitate the understanding of the high level user needs and of the user needs in subsequent sections.

Cultural Heritage professional user community (Tangible Heritage):

The Cultural Heritage professional user community regroups several types of actors intervening on Tangible Heritage sites on land and in the sea. This user community includes archaeologists, architects, engineers, historians, conservators, and Geospatial Information Systems (GIS) specialists. This user community contains both governmental actors (e.g. national experts working for Cultural Heritage authorities or UNESCO specialists) and private actors (e.g. Cultural heritage experts working for private foundations). Examples of professionals notably include professors at the Heidelberg University (public research centre and university).

Natural Sciences user community (Natural Heritage):

The Natural Sciences user community regroups the users interested in monitoring and preserving Natural Heritage sites. This community is very large and includes biologists surveying the state of the biodiversity of the flora and fauna in a given area, biologists monitoring the effects of climate change on sea environment, zoologists (e.g. ornithologists, mammologists, herpetologists, etc.) and all actors interested in natural sciences such as environmental scientists. An example would be professionals working on projects such as the Okavango wilderness project (a National Geographic Society project), where experts in mammalian terrestrial ecology, African herpetology and botany map the Okavango delta.

Site operator user community:

The site operator user community refers to all actors in charge of administrating and protecting/maintaining a Cultural Heritage site, should it be a Tangible Heritage site or a Natural Heritage site. This user community intervenes across the whole Cultural Heritage value chain. For example, a Tangible Heritage site operator can simultaneously be interested in activities related to exhibition, in activities related to the maintenance and protection of a site, as well as in other activities related to exploration around or within the Cultural Heritage site or to monitoring and discovering new archaeological features. Site operators can either be governmental (e.g. municipalities, local or regional administration such as Ministries of Culture, national research centres, etc.) or non-governmental (e.g. private foundations, real estate companies).

Urban planner user community:

Urban planners refer to a wide plethora of actors in charge of land use planning, strategic urban planning, transportation planning, environmental planning or economic development planning, for instance. In the scope of this study, the urban planner user community refers to local, regional and/or national bodies designing, organising, regulating and supporting the development of infrastructures (e.g. roads, water supply, electricity supply, etc.) and/or urbanisation plans[81]. Urban planners are primarily in charge of developing and revitalising parts of cities, building on the various economic, architectural, and social challenges. But this user community also supports other user communities' activities by facilitating access to the Cultural Heritage sites (e.g. construction or upgrade of roads, etc.).

Intermediate user community:

The intermediate user community includes all actors involved in the exploitation of Earth Observation (EO) space data and the provision of EO-related products and services to end users. This includes, in particular, geo-information organisations (public and private), whose core business is to process satellite imagery and transform it into value-added information products for specific end users. This user community intervenes across the value chain, to support Cultural Heritage user communities by providing them with additional sources of EO data, value-added information products or/and services (e.g. consultancy)[82].

National, Regional or Local authority user community (in charge of Cultural Heritage recognition):

This user community includes all governmental actors intervening in the request and the validation of formal recognition of a Cultural Heritage asset, either at national (e.g. listed monuments at national level; listed natural sites at national level) or at international level (e.g.

[81] Urban planning, 2017, Encyclopaedia Britannica, [ONLINE] Available at https://www.britannica.com/topic/urban-planning
Government of Canada, 2018. List of Jobs Titles – Urban and land use planners (NOC 2153-A).
[82] EC, 2017. Copernicus ex-ante benefits assessment. *To be published.*

UNESCO World Heritage). This is the user community where there is a majority of Copernicus core users.

3.2 Mapping of activities, user needs, and user requirements

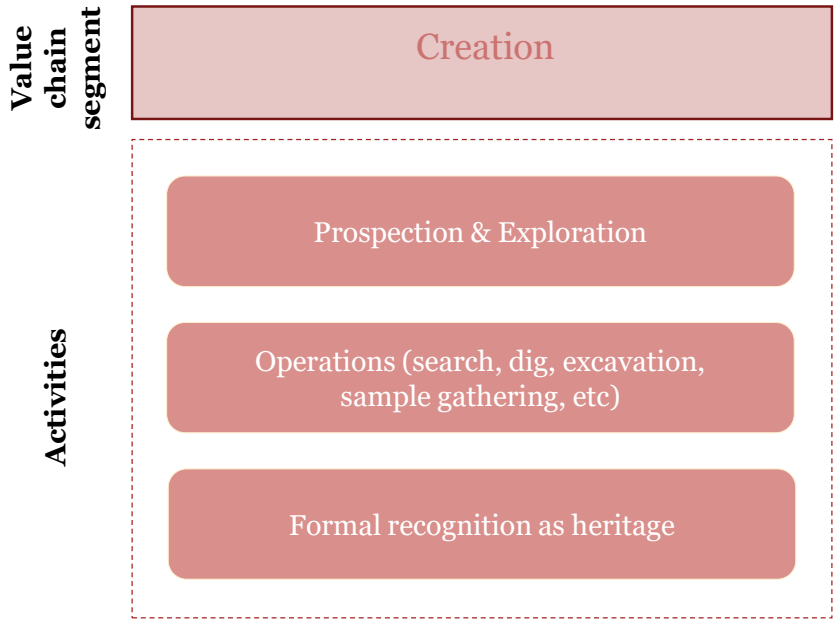
This section aims at presenting the user needs assessment, split across the three segments of the Cultural Heritage value chain, with the activities being presented in depth. These outputs rely on an extensive literature review, user communities' consultation and discussion with external experts (NAIS). This exercise has capitalised on different European projects in the field of Cultural Heritage (e.g. financed by the European Commission within the H2020 framework or sponsored by ESA), including SASMAP, ARROWS, ARCHEOSUB, HERCULES, STORM, ITACA and Artek. The study of the activities and tasks related to each segment of the Cultural Heritage value chain has enabled an understanding of the needs of user communities intervening at these stages.

3.2.1 Creation segment

Definition

The Creation segment integrates all activities from the discovery of a site to its formal recognition as "Cultural Heritage". These activities can be segmented into three main categories: prospection activities, operation activities and activities associated with the formal recognition of a site as Cultural Heritage as illustrated in the chart below.

Figure 29: Main activities included in the segment "Creation" of the CH value-chain



User communities involved in the "Creation" segment of the CH value-chain

At this stage of the value chain, the main user communities intervening are the Cultural Heritage professionals and national, regional and local authorities in charge of Cultural Heritage recognition. Collaboration with site operators and urban planners are common as they can

include excavation teams. All these user communities can take charge of pursuing a candidacy for a Cultural Heritage label. As such, conclusions from the stakeholder consultation have identified that the diversity of user communities taking part in these activities share common needs, as they work together from the perspective of performing a preliminary assessment of the site, to possibly conduct excavation and mostly gather sufficient data to apply for the recognition of the given site by a Heritage label.

Context of the development of the Creation segment

New technologies for new methods of prospection: the development of non-invasive prospection methods

Identification of the high level user needs and of the user needs is required, in order to analyse the ones that can be optimised by the use of new technologies. Indeed, it is worth noting that the Creation segment is impacted by the opportunities brought by new technologies. It appears that the use of data is being increasingly requested to perform prospection tasks, for instance. Going from the traditional invasive archaeological methods, where data was gathered in-situ and which were time consuming and financially costly, the development of new technologies and non-invasive methods of site prospection have allowed a greater efficiency in the conduction of Creation activities.

The development of a stronger legal framework at the local, regional and national level

Moreover, as explained in the introduction, the Cultural Heritage environment has been framed by a strong legal framework - meaning that any activity of prospection aiming at the recognition and protection of a site must fulfil specific requirements, be conducted under specific national or local rules and provide as much data as possible to provide evidence of the necessity for a site to be labelled. Heritage management is thus deeply challenged by new and stronger requirements based on an increasing ethical complexity[83]. Indeed, the global order has been reshaped by human rights, neo-colonialism, legal pluralism, or sustainable development challenges, among others, in which Cultural Heritage sites have been recognised for their key societal value. Therefore, prospection and excavation of Cultural Heritage sites must meet the requirements of a complex ethical and legal framework. Nowadays, national legal frameworks encourage the use of non-invasive methods for prospection and operation activities[84] to prevent any risk of deterioration or social conflict linked with an excavation operation. It is therefore key for excavation teams to gather as much data and information as possible for their understanding of the site to limit the need and the perimeter of excavation activities. Yet, preliminary data seems to be sufficient to enter the process of a site's recognition (see "recognition processes" within the "Recognition" description).

Towards a more efficient approach of prospection, operation and recognition activities

What is the impact of this contextual evolution on user needs? With enough relevant data, the use of invasive methods can be limited to a strict minimum. This can impact the financial implications of proceeding to a demand of formal recognition as Heritage and represents a strong incentive for user communities to increase and modify their participation in the Creation segment. Moreover, this can open the Creation segment to a larger scope of user communities that would not be restricted by technical (excavation methods) or financial constraints to intervene in the Creation segment.

3.2.1.1 Creation - Prospection

Definition

[83] "The fusion of law and ethics in cultural heritage management: The 21st century confronts archaeology". Hilary A. Soderland, (2014)
[84] Brian K. Duffy, Excavation reports guidelines for authors. 2006 [Online] Available at: https://www.archaeology.ie/sites/default/files/media/publications/excavation-reports-guidelines-for-authors.pdf

In terms of process, prospection activities are mainly composed of three activities: (i) identifying a potential Cultural Heritage site, (ii) verifying the conditions to conduct survey operations, and (iii) conducting preliminary research including non-destructive assessment and/or field assessment and evaluation.

Table 6: Summary of prospection tasks and their description

Tasks	Description
Identify potential Cultural Heritage sites	Identify presence of potential new site or structures; Provide spatial identification of the structure.
Verify the fulfilment of the conditions for conducting research **(And possibly design the project of research)**	Data on area of research; Objective of the research; Define expected results; Organisation of research; Define measures to protect the site / area of discovery; Define type of project, scope, direction, methods and timing of research and protection measures; Budget for research.
Conduct preliminary research including non-destructive assessment and / or field assessment and evaluation	Conduct preliminary geological mapping and geostructure; Conduct preliminary geobotanical prospection; Conduct preliminary geochemistry prospection; Conduct preliminary chemical prospection; Conduct preliminary geomorphology prospection.

Process and user needs for prospection activities

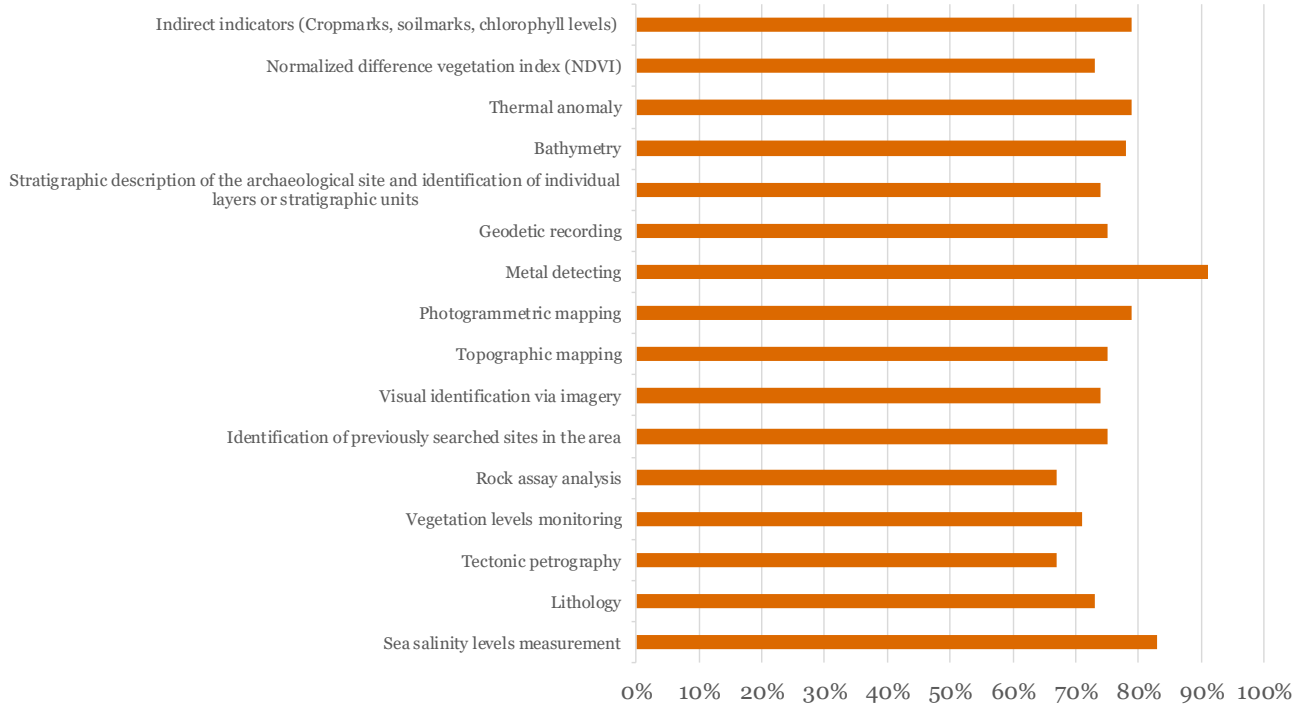
Even if most Cultural Heritage sites have already been discovered, or can come in the form of an existing city (e.g. Rome, México City, Liverpool, etc.), a city centre, a monument, and have been formally recognised as such, it is important to identify the implication of the search of a new CH site in the context of this study. Therefore, the value chain includes prospection activities which refer to the search for undiscovered sites and/or not yet officially recognised (i.e. officially recognised as culturally important sites. To conduct this activity, (which is mostly performed by CH professionals), user communities need to **study the natural environment of the site for the detection of underground features** to identify the possibilities and the risk related to conducting invasive research and / or excavation activities.

The presence of underground buildings (e.g. forming a line which indicates the presence of an ancient Roman road) can be highlighted by indirect indicators such as cropmarks and soil marks[85], which both mark a particular trend for how vegetation is growing. The study of cropmarks and soil marks can also be done through a multi-temporal analysis, which can help discover such patterns overtime. Indirect indicators indeed seem to be a primary need of user communities according to the PwC survey. Another indicator to be considered is the

[85] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.; Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels; Rosa Lasaponara, Remote sensing for Cultural Heritage: from documentation to risk estimation and preservation, 24 April 2017, Brussels

identification, with a Normalised Difference Vegetation Index (NDVI)[86], of the density of the vegetation. This is shown by the different wavelengths of visible and near-infrared sunlight reflected by the vegetation[87], and it helps indicate the presence of archaeological remains by showing anomalies in the way vegetation grows. In addition, because the presence of underground constructions can influence plant composition, it is interesting for prospectors to be able to detect changes in chlorophyll levels (included in indirect indicators) on the plants of the studied area[88]. Thermal anomalies can also be detected in order to identify a difference in the temperature of the soil, especially in a desert-type area because sand is a heat conductor, which would indicate the presence of underground Tangible Heritage. These variables are land-attached, but it is also possible to identify underwater Tangible Heritage through visual identification via imagery[89]. Once the mentioned variables indicate the potential presence of structures underground or underwater, user communities involved in this segment need to be provided with the non-destructive analysis of the underground / underwater positioning of the Cultural Heritage features, notably in terms of depth (this can be provided by the stratigraphic description of the site and identification of individual layers or stratigraphic units of the area[90]).

Figure 30: Main user needs required for prospection activities (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 30 (i.e. percentage of users interested in each user need) due to lack of information.

[86] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[87] Measuring Vegetation (NDVI and EVI), NASA Earth Observatory [ONLINE] Available at: https://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php
[88] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[89] Council of Europe, Guidelines on Cultural Heritage, Technical tools for Heritage conservation and management, 2012; Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017; Margarete van Ess, Remote sensing as a crucial tool for Cultural Heritage preservation: case studies from the Near East, 24 April 2017, Brussels; Elke Selter, UNESCO's use of satellites for monitoring heritage sites in conflict-affected areas, 24 April 2017, Brussels
[90] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels

Table 7: Summary of the other user needs for the prospection activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Mapping of frequentation patterns
Ground motion monitoring
3D reconstruction
Elevation modelling
Map regression

The **results of the PwC survey** indicate an important role for metal detecting and sea salinity level measurements for more than 80% of the respondents intervening in this segment of the value chain. Nine "user needs" have been identified as key for 75% or more of the respondents. However, as presented in the figure, the survey also showed a global homogeneity in the needs of all user communities at this level of the value chain, with all user needs being required by more than 65% of respondents.

In the need of archaeological interventions, at this point, user communities need to verify the fulfilment of the conditions for conducting archaeological research; that is to say, designing the project of archaeological research by providing relevant information to support the case for excavation. This includes obtaining data on the area of the site and presenting the objective and expected results of the excavation as well as the scope and methodology that have been chosen for the operation (when relevant, the measures that have been identified to protect the site throughout the excavation process can be noted). The global organisation and the budget of the research are generally required. It is worth noting that only 10 to 15% of excavation demands are granted. For all sites which are considered for excavation, prospection activities include providing **basic spatial identification** of the new structure from **general spatial characteristics** to a description of the **global state of the site**, with supporting documentation, in order to characterise a potential Cultural Heritage site. This **mapping of the cultural landscape of the site and identification of the specific risks it is exposed to** is essential. In order to be granted an excavation permit, aerial photo documentation is key for both land and sea environments. More precisely, topographic maps[91] and photogrammetric maps[92] provide a detailed understanding of natural and human-made features in the area (e.g. reliefs), to which a stratigraphic analysis[93] can be added. Combined with these tools, (i) the identification of previously searched sites in the area[94] and (ii) the mapping of recorded damage[95] help provide context for the potential search as well as support for its justification. In

[91] Margarete VAN ESS, Helmut BECKER, Jörg FASSBINDER, Ralf KIEFL, Iris LINGENFELDER, Gunter SCHREIER and Adrian ZEVENBERGEN, Detection of looting activities at archaeological sites in Iraq using Ikonos imagery
[92] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
[93] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
[94] Council of Europe, Guidelines on Cultural Heritage, Technical tools for Heritage conservation and management, 2012
[95] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US; Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017; Branka Cuca, Earth observation imagery and geoinformation data for Cultural Heritage and landscapes - regional perspective, 24 April 2017; Rosa Lasaponara, Remote sensing for Cultural Heritage: from documentation to risk estimation and preservation, 24 April 2017, Brussels; Cristina Sabbioni, Antonia Pasqua Recchia, The Joint Programming Initiative on Cultural Heritage: European perspective, 24 April 2017, Brussels; Luca Rossi, The Sendai framework for disaster risk reduction: Cultural Heritage, disaster resilience, and climate change, 24 April 2017, Elke Selter, UNESCO's use of satellites for monitoring heritage sites in conflict-affected areas, 24 April 2017, Brussels

the case of underwater Heritage, bathymetric[96] analysis is needed to support the case for underwater search.

Once this basic data has been gathered, the prospection activities end with the conducting of **preliminary research** that includes **non-destructive analysis of the surface positioning of the Cultural Heritage features** (e.g. through remote sensing or trial trenching), in order to extract the maximum level of information that can support, or in the contrary counter-indicate, the need for an excavation – which can have very negative impacts on the sites (i.e. destructive impacts). To prepare for operation activities, preliminary research can be undertaken through a non-destructive assessment and evaluation. Depending on the nature of the site, specific prospection activities can be conducted. For this purpose, the following activities can be conducted: (i) geological and geo-structural mapping (with rock assay analysis[97], stratigraphy[98] (land) or bathymetry[99] (sea)), (ii) geobotanical prospection (with vegetation levels monitoring (studied under high resolution), to better characterise the cultural landscape), (iii) geochemistry prospection for land sites (with the detection of metal[100], and tectonic petrography[101]), (iv) chemical prospection (with the study of sea salinity measurements[102] in the case of a water environment) and (v) geomorphology prospection (with lithology[103]).

3.2.1.2 Creation - Operations

Definition

The operations segment concentrates all research activities requiring invasive interventions over a site for research or data collecting purposes. It should be noted that operation activities are not a systematic step of the Cultural Heritage value chain, as they will mainly appear in the process of archaeological activities requiring excavation activities. Preventive or rescue research are also applicable to natural heritage sites in need of protection. The description for those activities, however, is not supplied here.

Table 8: Summary of operation tasks and their description

Tasks	Description
Identify adequate methodology for research	Define the possibility for standard research
Provide technical documentation	Provide spatial identification of the new archaeological / site's structure
Conduct research or excavation operations: proceed to either standard research, preventive research or rescue research	Implement a defined methodology, possibly including the following steps (i.e. in case of archaeological research): ◦ Lay squares with strings and sand bags, define a starting and ending point. ◦ Break the soil with shovels and picks, brushed, ice picks …and identify stratigraphic relationships ◦ Screen the excavated soil ◦ Photograph in-situ

[96] Stelios Bollanos, User needs in monitoring coastal archaeological sites: the potential of Copernicus, 24 April 2017, Brussels; Radoslaw Guzinski , Elias Spondylis, Myrto Michalis, Sebastiano Tusa, Giacoma Brancato, and Lorenzo Minno, Exploring the Utility of Bathymetry Maps Derived With Multispectral Satellite Observations in the Field of Underwater Archaeology
[97] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[98] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
[99] Radoslaw Guzinski et al., Exploring the Utility of Bathymetry Maps Derived With Multispectral Satellite Observations in the Field of Underwater Archaeology; https://cordis.europa.eu/result/rcn/196660_en.html
[100] Margarete VAN ESS et al., Detection of looting activities at archaeological sites in Iraq using Ikonos imagery
[101] Daniele Spizzichino, PROTEGHO, satellite techniques for risk monitoring and for conservation policies, 24 April 2017, Brussels; Luca Rossi, The Sendai framework for disaster risk reduction: Cultural Heritage, disaster resilience, and climate change, 24 April 2017, Brussels
[102] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels
[103] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.

◦ Wash and clean found objects
◦ Begin recording the process of the site for later fields reports
◦ Analyse the data for the excavation report to be published and presented

◦Publish results and documentation

Process and user needs for operation activities

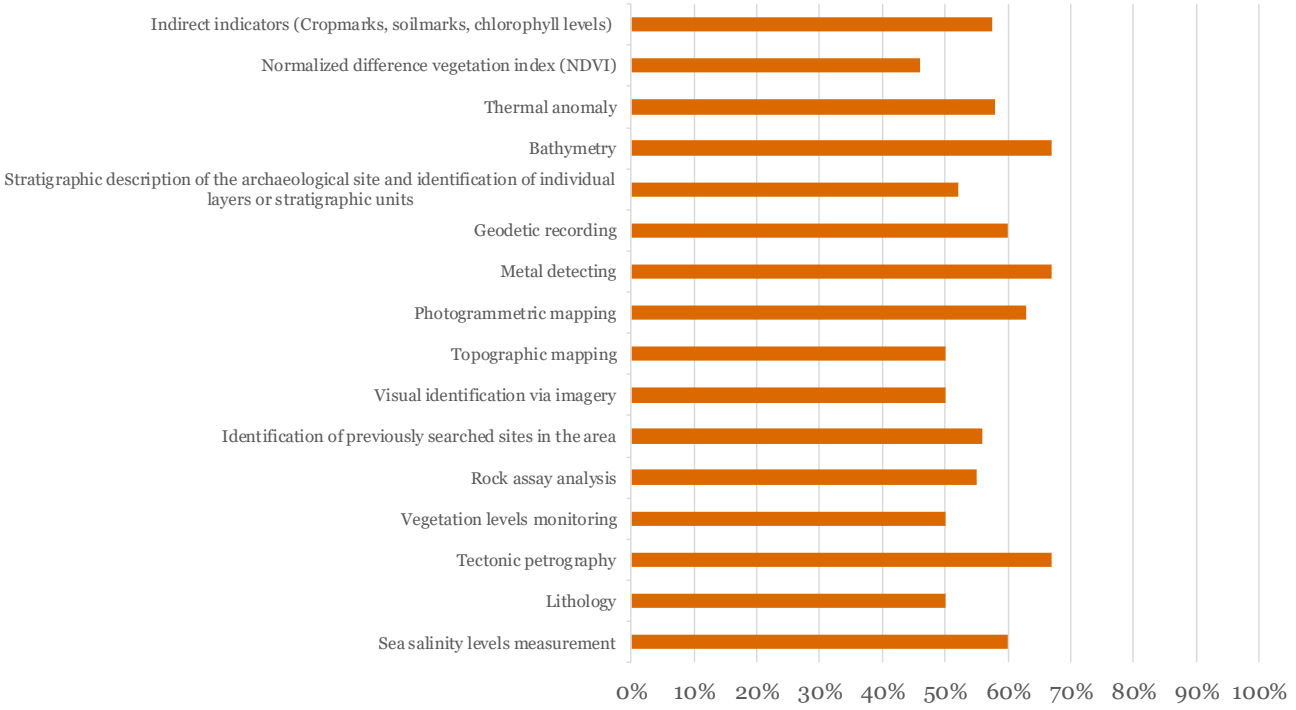
To begin operation activities, the excavation team[104] uses preliminary research to determine the adequate method to proceed to the excavation of a site, depending on the nature of the site, its environmental exposure and other identified risks that might appear when proceeding to an invasive research method such as excavation. Research or excavation operations can follow (i) a *standard method* when there is no critical risk that has been identified, (ii) *preventive methods* to avoid harming more fragile sites or (iii) *rescue methods* when the excavation is conducted over a damaged archaeological site.

To identify the adequate methodology for excavation, among standard, preventive or rescue archaeological research methods, user communities can additionally conduct geodetic recordings - recording the geometric shape, orientation in space and gravity field where the site is situated in order to understand the Cultural Heritage's Earth-related features. In the case of land, the stratigraphic description and the identification of individual layers or stratigraphic units[105] of the archaeological site allow the identification of the positioning of a site in terms of underground layers, and potentially to determine the time of construction.

Once the appropriate methodology has been identified, the excavation can be planned and conducted. The excavation operations include research activities as well as the recording and reporting of the site's study. Operation activities can be concluded during the writing and the publication of archaeological reports. Data collection is then necessary to feed the excavation report to be published and presented in order to justify the official recognition of the site as Cultural Heritage and more globally to index all relevant information for the excavation. Everything is described: for instance, the appearance of the heritage found, the period of time in which it is considered to have been produced and the contextualisation vis-à-vis other searches in the area. For this, all information previously collected is used.

[104] The excavation team can be composed by a Director of excavation, a site or area supervisor, a square supervisor. The excavation activities can also be supported by volunteers and scientific experts and well as architects when it is relevant.
[105] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels

Figure 31: Main user needs required for operation activities (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 31 (i.e. percentage of users interested in each user need) due to lack of information.

Table 9: Summary of the other user needs for the operations activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Mapping of frequentation patterns
Ground motion monitoring
3D reconstruction
Elevation modelling
Map regression

The **results of the PwC survey** indicate a global homogeneity in user needs for operation activities, with more than 50% of respondents requiring indirect indicators, thermal anomaly, bathymetry, geodetic recording, stratigraphy, etc. Key user needs however have been identified as bathymetry, tectonic petrography and metal detecting as they are required by almost 70% of respondents intervening in operation activities.

The following nature of information can be required in the conducting of an excavation operation, depending on the considered perimeters:

- The information used to identify the on-land positioning of the site: (i) the indirect indicators (i.e. multi temporal analysis of cropmarks and soil marks[106] and the chlorophyll levels[107]), (ii)

[106] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.; Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
Rosa Lasaponara, Remote sensing for Cultural Heritage: from documentation to risk estimation and preservation, 24 April 2017, Brussels

the NDVI[108], (iii) the visual identification via imagery[109], but also (iv) monitoring of vegetation levels to better characterise the cultural landscape.

- The information used to provide geological data regarding the positioning of the site underground, or underwater: (i) the stratigraphic[110] or bathymetric[111] description to identify the positioning of the site in terms of underground layers, (ii) the topographic[112] and photogrammetric[113] maps which provide an understanding of the area's reliefs, (iii) the rock assay analysis[114], which can provide chronological indication, (iv) tectonic petrography[115], that is the rock description of the geological structures, (v) lithology[116], which describes the nature of the rocks in the studied area and gives indications of its geological composition, (vi) geodetic recording[117], which describes with geometric standards the shape of the structure to investigate, and its orientation in space, with regards to the gravity field in which it is located.
- The information used to place the site into a more global context: (i) the identification of previously searched sites in the area[118], which provides an understanding of the potential expected similarities to be drawn with the studied site. The comparison with previous research can be used to qualify the site exposure to risks (e.g. geo-hazards, human conflicts) or to record the damage to support the case for recognition and conservation.
- Finally, other types of information can be looked at, at this stage of the value chain, such as (i) metal detecting[119], to support the indication of the presence of structures underground as a remote sensing archaeological tool to identify the location of historic trails for instance, and (ii) sea salinity levels[120].

3.2.1.3 Creation - Recognition

Definition

The formal recognition of Cultural Heritage follows specific processes at local, national or international levels that all require responding to specific criteria in order to receive an official labelling. Two of the major labels are the European Heritage Label (EHL) and UNESCO's World Heritage recognition (World Heritage Label (WHL)), though others, notably at local and national level, exist and are very important as countries are responsible for the listing and the protection of their own Heritage. These two labels do not have the same aim: the EHL celebrates sites symbolising European ideals, values, history and integration whereas the WHL celebrates and protects Cultural heritage sites as such[121]. In order to be recognised at European level with the

[107] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[108] Ibid
[109] Council of Europe, Guidelines on Cultural Heritage, Technical tools for Heritage conservation and management, 2012; Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017; Margarete van Ess, Remote sensing as a crucial tool for Cultural Heritage preservation: case studies from the Near East, 24 April 2017, Brussels; Elke Selter, UNESCO's use of satellites for monitoring heritage sites in conflict-affected areas, 24 April 2017, Brussels
[110] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
[111] Stelios Bollanos, User needs in monitoring coastal archaeological sites: the potential of Copernicus, 24 April 2017, Brussels; Radoslaw Guzinski et al., Exploring the Utility of Bathymetry Maps Derived With Multispectral Satellite Observations in the Field of Underwater Archaeology
[112] Margarete VAN ESS et al., Detection of looting activities at archaeological sites in Iraq using Ikonos imagery
[113] Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels
[114] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[115] Daniele Spizzichino, PROTEGHO, satellite techniques for risk monitoring and for conservation policies, 24 April 2017, Brussels; Luca Rossi, The Sendai framework for disaster risk reduction: Cultural Heritage, disaster resilience, and climate change, 24 April 2017, Brussels
[116] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
[117] Margarete VAN ESS et al., Detection of looting activities at archaeological sites in Iraq using Ikonos imagery; Stelios Bollanos, User needs in monitoring coastal archaeological sites: the potential of Copernicus, 24 April 2017, Brussels
[118] Council of Europe, Guidelines on Cultural Heritage, Technical tools for Heritage conservation and management, 2012
[119] Melissa Connor and Douglas D. Scott, Metal detector use in archaeology: an introduction, Historical Archaeology, Vol. 32, No 4 (1998), pp. 76-85
[120] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Cristina Sabbioni, Antonia Pasqua Recchia, The Joint Programming Initiative on Cultural Heritage: European perspective, 24 April 2017, Brussels
[121] European Commission website. Available at: https://ec.europa.eu/programmes/creative-europe/actions/heritage-label_en

former, sites should already be recognised at national level[122] as Heritage before being authorised to apply for the EHL. As for the latter, each country proposes what is called a "tentative list", composed of sites that are deemed worth of receiving UNESCO's recognition. No recognition at national or local level is mandatory for a site to be part of the tentative list; however, they are generally already recognised at local or national level in order to be considered. For local, national as well as for European or International recognition, user communities need to proceed to the inventory of the site (ensemble of buildings, monuments, reserves, etc.) and to provide a report meeting the label's requirements.

Table 10: Summary of recognition tasks and their description

Tasks	Description
Proceed to inventory	Name and characterise the site: monuments, ensemble of buildings, conservation areas, archaeology sites and reserves, etc.; Describe the site and geographical characteristics; Present the general state and condition; Support documentation.
Provide a research report (when relevant)	Provide an introduction for the report including: Aims and objectives of the research conducted (e.g. excavation if relevant, research over monuments, palaces, industrial heritage, city centres, …); Indication of archaeological significance before the operation; Dates of commencement and termination of the operation; Locational data; Present Historical background; Present and analyse the excavation; Describe the area excavated with overall plan showing all cuttings (including a presentation of topographical and other surveys conducted and reference to any previous investigation/excavation carried out at the site if relevant); Describe the methodology including finds retrieval and sampling strategies; Indicate reasons for selected strategies; Provide a full narrative description of the operation including stratigraphic information, phasing (if relevant), reference to significant finds when describing contexts and interpretation; Present the condition of site post excavation if relevant (e.g. has it been backfilled?); Present the finds Catalogue finds. Entries should include appropriate measurements, descriptions, associations and contexts; Provide a detailed description, assessment and illustration of the significant finds or groups/categories of finds; Discuss the results and conclude; Provide when possible specialist appendices/reports (e.g. e reports on dating, soils, paleo-environmental data, human remains, artefact conservation, site or monument conservation, environmental assessment for sites of natural/cultural significance, etc.)
Apply for national recognition of the Heritage asset (following local and national procedures) OR to a label or other formal recognition	[EHL] Apply for one, several sites or transnational sites; [EHL] Submit a candidacy meeting the 3 criteria (cultural significance, participation to European promotion and operational capability to implement a project or work plan, e.g. ensuring sound management including objectives and indicators); [UNESCO] Countries that have signed the World Heritage Convention provide a "tentative list" of sites to be nominated for WH recognition;

[122] "European Heritage Label guidelines for candidate sites", European Heritage Label [ONLINE] Available at https://ec.europa.eu/programmes/creative-europe/sites/creative-europe/files/files/ehl-guidelines-for-candidate-sites_en.pdf

[UNESCO] The candidacy is evaluated by two Advisory Bodies (the International Council on Monuments and Sites (ICOMOS) and the International Union for Conservation of Nature (IUCN)) and the World Heritage Committee.

Process and user needs for recognition activities

The first step of the formal recognition of a site as Heritage is to provide an updated inventory of the site, including its description and geographical and geometrical characteristics, its general state and condition at the time of the candidacy and supporting documentation.

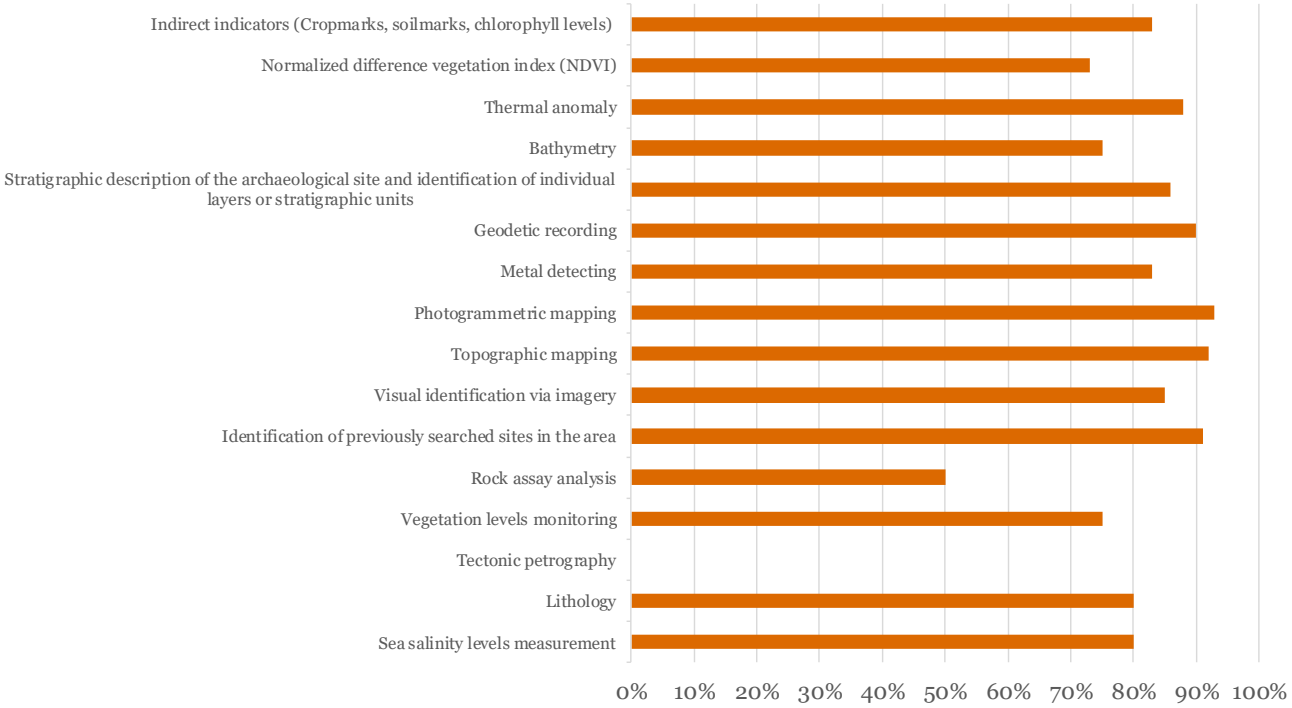
When delivering a research report, specific information needs to be gathered. In terms of tasks, the writing of a report seeks to provide a general introduction with the aims and objectives of the conducted research and/or excavation. The report should also include available historical background and a presentation and analysis of the site and, in relevant cases, of undertaken excavation. In the case of archaeological research, an indication of the archaeological significance before the excavation, location data as well as dating of the excavation conducted should be added. The report should describe the area with an overall plan showing all perimeters. The report should also present the methodology, provide a full narrative description of the conducted research, as well as the state of the site by the end of the excavation, if relevant. Applying sites which haven't required any invasive research methods, such as city centres (e.g. Valeta, Malta), forests (e.g Bois du Cazier, Belgium) and so on, should provide the description and analysis of the sites as well as any conducted research. Finally, the report should include the findings of the research, the discussion of the results and their related conclusions. Appendices and analysis can be provided based on scientific expertise to support the analysis and the conclusion of the report. In the end, the objective is to publish the report and its documentation for scientific purposes and to demonstrate the need and coherence of a Heritage label.

As previously described, every country imposes its own Heritage recognition process and procedures. User communities who work for the recognition of a site usually need to obtain national recognition to access candidacy for a broader recognition. European processes to Heritage Label differ from the ones at the international level such as the UNESCO recognition of World Heritage. The EHL process relies on a written candidacy based on research reports and a site management project which have met three criteria for recognition (cultural significance[123], participation to European promotion, and promotion and operational capability). Once the label has been granted, the EHL imposes an 18-month monitoring of the site to confirm its capacity to be managed and protected. The EHL is confirmed with the final validation of their monitoring report (which can include recommendations). Monitoring activities will be described at the analysis of the second segment of the value chain, referred to as the "Production segment".

To conclude the analysis of the Creation segment, it should be noted that the user communities involved make inventories of the Heritage assets in the context of candidacies for official recognition. At this point, all the information provided during the building of the research report, listed above, is thus analysed in light of the recognition criteria.

[123] Burra Charter, ICOMOS Australia, 1999

Figure 32: Summary of user needs for recognition activities (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 32 (i.e. percentage of users interested in each user need) due to lack of information.

Table 11: Summary of the other user needs for the recognition activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Mapping of frequentation patterns
Ground motion monitoring
3D reconstruction
Elevation modelling
Map regression

The **results of the PwC survey** indicate key data required for this segment of the value chain is concentrated in providing a global overview of the sites features (photogrammetric mapping, topographic mapping) as well as historical background with the identification of previously searched sites. For this part of the segment, most user needs identified are required by 80% to 95% of respondents.

3.2.1.4 Conclusion

Given the nature of the user needs in the context of Creation activities and tasks, it appears that remote sensing data and information will be able to meet user communities' main challenges (namely, implementing non-invasive research methods and gathering data for research and recognition candidacies). Remote sensing data and information constitute a key input for all prospection, operation and recognition activities, and provide support for empirical (the collection

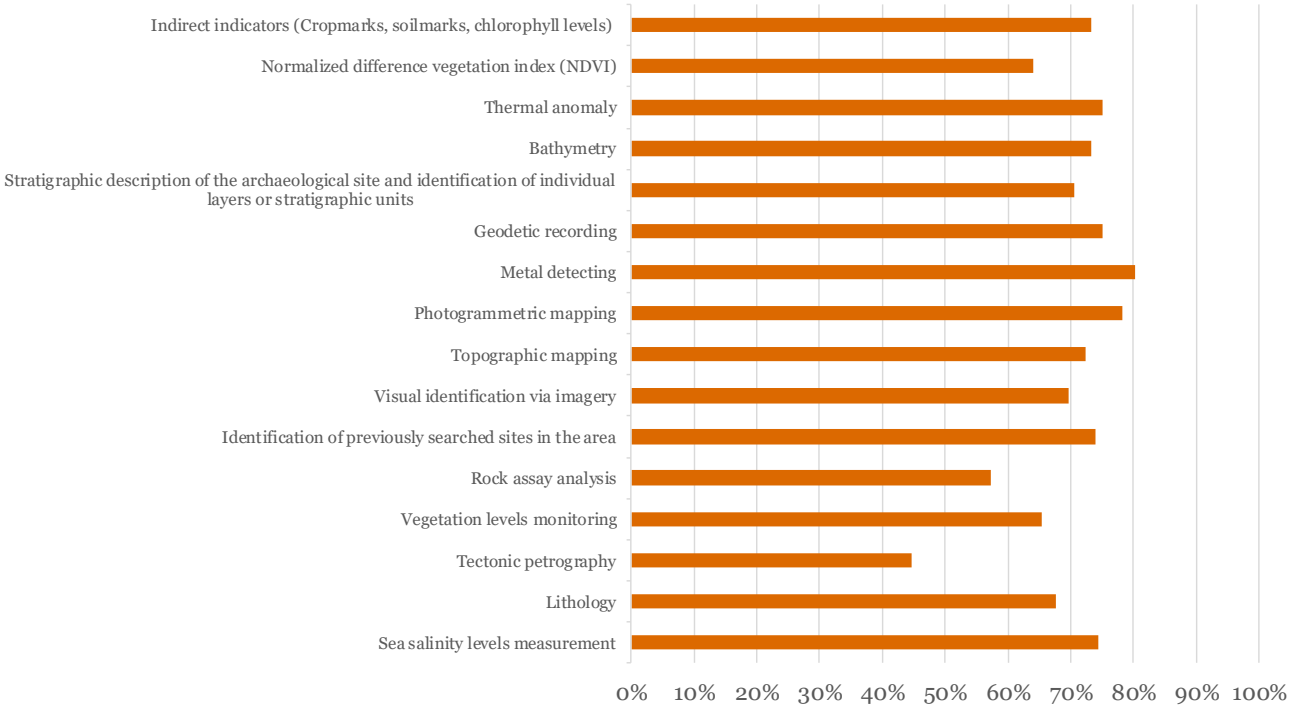
of data leads to the creation of a scientific theory), processual (the emitted theory is later validated by collection of data from research or specifically excavation) scientific knowledge, and globally supports evidence to recognition. In all presented cases, the user needs are localised and require sufficiently high precision (especially to detect changes in chlorophyll levels or in cropmarks). The collection of data in this segment is particularly crucial, as it feeds the analysis and activities realised further down the value chain, and thus need to be as precise, exhaustive and informative as possible to allow a maximised valorisation of the site.

In terms of user needs, data and activities can be synthesised in four high level user needs (see table below) with 22 user needs collected to fulfil them (see graph below). These will be re-analysed further on in the analysis to see to what extent Copernicus could respond to these needs. All high level user needs can be considered relevant, as the user needs they gathered are required by 50% or more of respondents to the survey, indicating key user needs for all user communities taking part in this segment of the value chain.

Table 12: Summary of high level user needs for the Creation segment

High level user needs for the Creation segment
Study of the natural environment of the site for the detection of underground archaeological features
Non-destructive analysis of the underground / underwater positioning of the CH features
Non-destructive analysis of the surface positioning of the CH features
Mapping of the cultural landscape of the site and identification of the specific risks it is exposed to

Figure 33: Summary of user needs for the Creation segment (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 33 (i.e. percentage of users interested in each user need) due to lack of information.

Table 13: Summary of the other user needs for the Creation segment mentioned during the interviews (Source: stakeholder consultation)

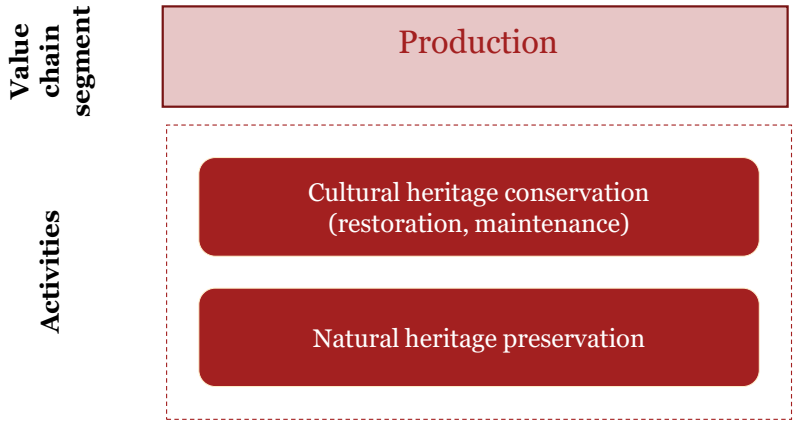
Other user needs expressed during the interviews
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Mapping of frequentation patterns
Ground motion monitoring
3D reconstruction
Elevation modelling
Map regression

3.2.2 Production segment

Definition

The production segment integrates all activities of conservation of Tangible Heritage and preservation of Natural Heritage. These include the monitoring of a site, and also the emergency monitoring or intervention for the protection of a site; the definition of conservation and preservation plans which allow the identification of the need for further research on specific areas of the site or for restoration work to be performed; but also includes any protective measures or intervention that have been identified based on monitoring or on the conservation/preservation plan, as illustrated in the chart below.

Figure 34: Main activities included in the segment "Production" of the Cultural Heritage value chain



User communities

Within this segment, the Cultural Heritage professional user community will continue to have a prominent role along with the Natural sciences user community, who take part in the monitoring and protection of sites in collaboration with site operators and local authorities.

Context of development of the Production segment

A global unbalance between Natural and Tangible Heritage in terms of monitoring

Based on desk research and consultation with stakeholders, there are many similarities between the user needs used for Conservation (Tangible Heritage) and Preservation (Natural Heritage), as they share common objectives and features. However, the stakeholder consultation has highlighted the specific gap at this level of the value chain between how Natural Heritage is monitored compared to Tangible Heritage. Indeed, almost all European Natural Heritage sites are covered and follow specific processes of preservation, while for Tangible Heritage, the definition and implementation of conservation management plans has not been generalized in practice.

The perspective of a global Cultural Heritage site's integrated site management approach

The intention for the Cultural Heritage community is to develop means for an integrated approach to monitor and protect Tangible Heritage and Natural Heritage. In the case of touristic activities for instance, Tangible Heritage is exposed to anthropogenic impacts, while Natural Heritage is mostly exposed to the effects of climate change and anthropogenic phenomenon. In that sense, the systematic approaches to damage prevention and site monitoring, for example, are something stakeholders should consider within an integrated approach, as Tangible Heritage monitoring could capitalise on Natural Heritage monitoring. Therefore, if the user needs are mostly similar, the demand should be higher from the Tangible Heritage side to fill this gap and pursue the project of a global Cultural Heritage Management approach.

Table 14: Summary of Production activities and tasks

Activity	Tasks
Conservation	Proceed to the revision of research and coordinate existing data to update or create inventory Monitoring and risk prevention of a site; Perform conservation activities.
Preservation	Proceed to the revision of research and coordinate existing data to update or create inventory Monitoring and risk prevention of a site; Perform preservation activities.

3.2.2.1 Production – Conservation and Preservation

Overview of the process and user needs for conservation and preservation activities

Table 15: Summary of Production and Conservation tasks and their description

Tasks	Description
Proceed to the revision of research and coordination of existing data to update or create inventory	Collect existing data from previous research and monitoring over the site Coordinate existing data to update existing inventory Possibly call for further research to update data for inventory
Monitoring and risk prevention of a site;	Monitoring and recording of : ○ Environmental data ○ Geo-hazards ○ Hydrological hazards ○ Biological hazards ○ Meteorological hazards

	○ Endemic / Pandemic events ○ Anthropogenic risks ○ Climate change
	Report collected data
	Organise interventions or emergency interventions
Perform restauration activities	Organise and coordinate a restauration intervention
	Perform restauration

The Production segment includes activities of monitoring, recording and reporting of all types of Cultural Heritage sites from archaeological sites, natural sites, to monuments and buildings (e.g. the Eiffel Tower). User communities can proceed to a revision of existing research and data to support monitoring and restauration activities. Within the Production segment, two sub-categories of user communities can be distinguished: monitoring-oriented user communities (monitoring officers, preservation or conservation officers) on the one hand and action-oriented user communities on the other hand (technicians, scientific experts, volunteers, etc.) intervening for specific needs related to conservation and preservation of a site. In this segment of the value chain, action-oriented user communities can intervene in the conducting of research, for instance a site manager or operator will participate in the documentation of the research processes and results.

The monitoring, recording and reporting on a site, mainly in relation to risk prevention, is carried out by monitoring-oriented user communities. In the case of conservation activities, the PwC survey indicate that monitoring activities are global and include the monitoring of environmental data as well as biological, hydrological and geo-hazards for more than 60% of respondents, with more than 50% of respondents indicating the monitoring of anthropogenic and climate change as key in their activities. Meteorological hazards have been identified as key for 50% of respondents, which is still relevant for the analysis. On the other hand, preservation activities share the primary need of monitoring environmental data (72% of respondents), but as natural environments are involved, will rather focus on geo-hazards and climate change monitoring according to the PwC survey. Biological hazards, meteorological hazards and endemic / pandemic events monitoring seems of less importance to user communities as less than 50% of the respondents (intervening in these activities) indicated this as part of their practices. This information is presented in the next two charts below:

Figure 35: Main monitoring activities implemented in conservation activities (Source: stakeholder consultation)

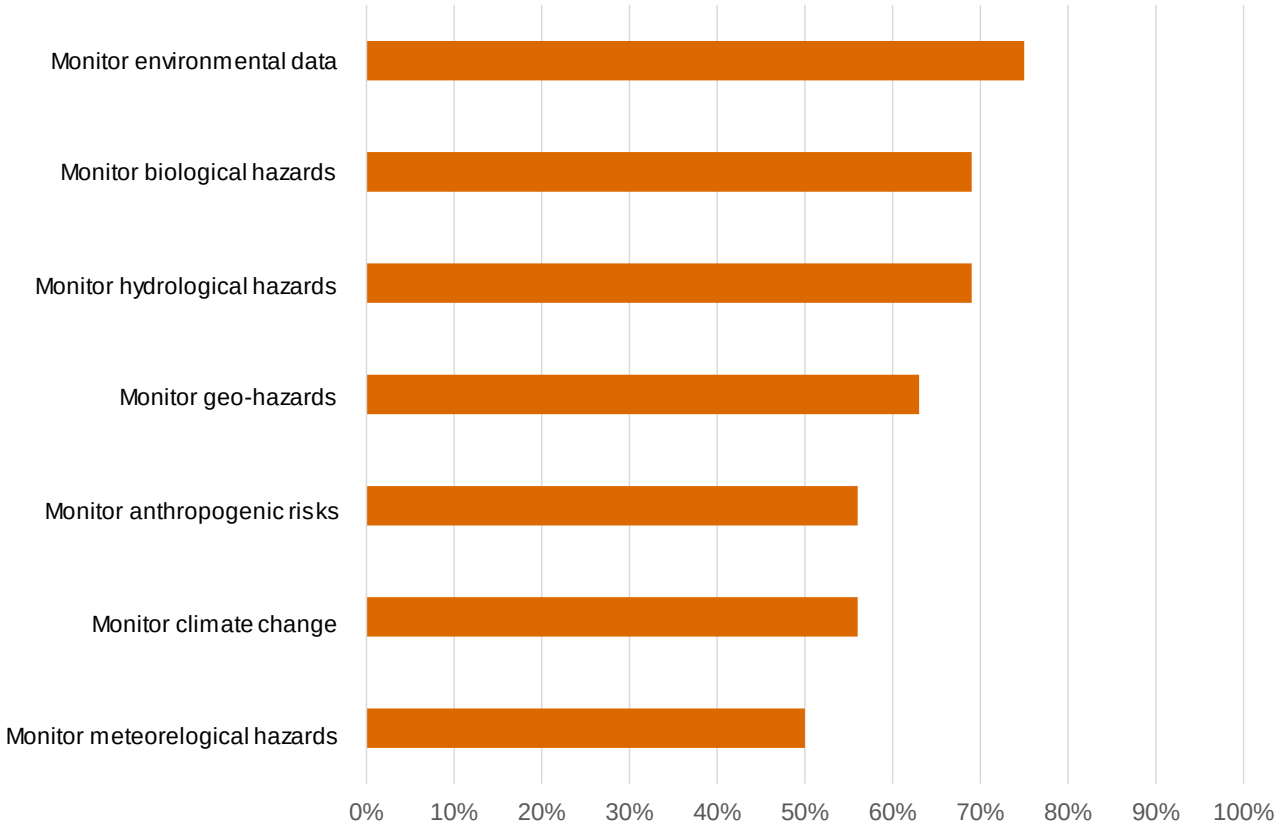
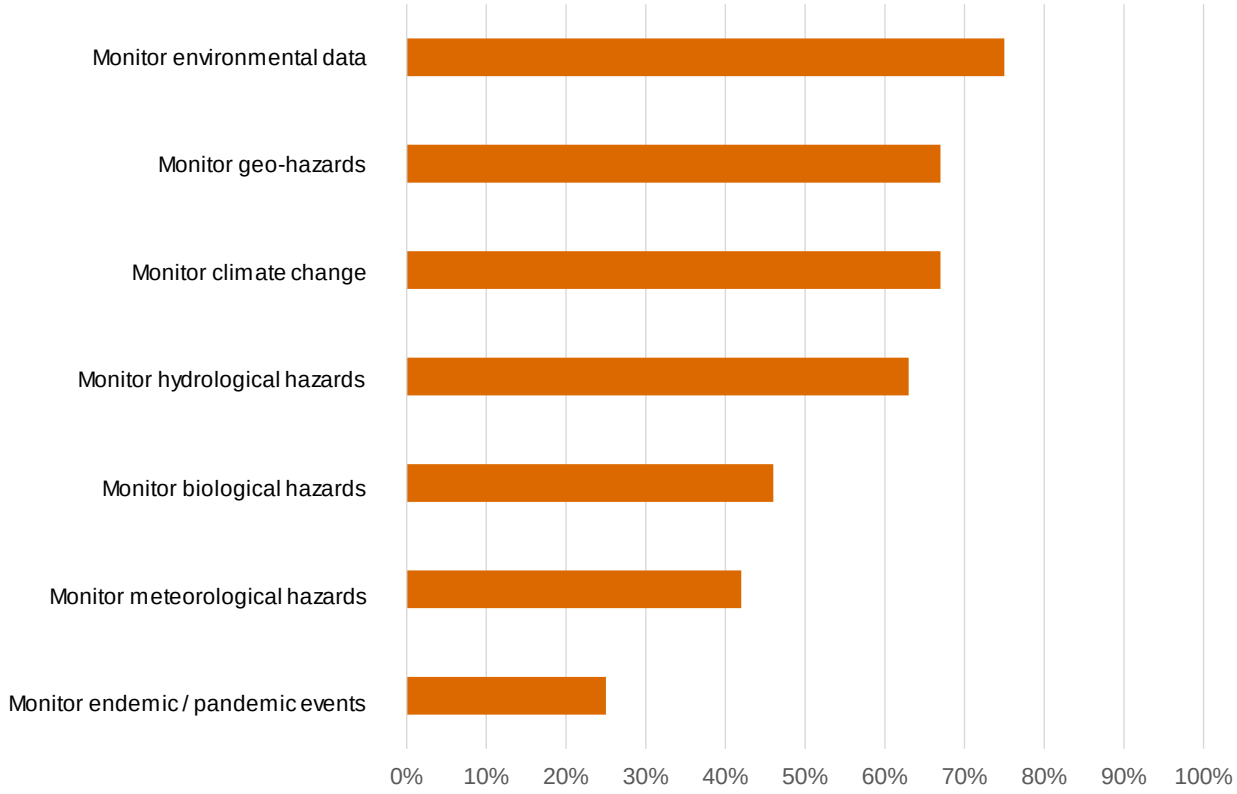


Figure 36: Main monitoring activities implemented in preservation activities (Source: stakeholder consultation)



It appears that monitoring tasks are performed by a very diverse range of user communities (e.g. site operators, scientific experts, etc.). A key example is the case of the increasing importance of monitoring Natural and Tangible Heritage sites in conflict areas, notably outside Europe. User communities performing them are not technical profiles, but still need access to key information to provide immediate decision-making on prevention or protection action. As monitoring activities are performed by non-technical users (i.e. users not trained to use products requiring a certain level of specific knowledge such as satellite imagery), the stakeholder consultation highlighted the need for easy access to structured information products. Based on stakeholder consultation, it seems that, as of today, there remains a limit to the number of sources or quantity of available data. Furthermore, there is a need for centralised sources of data to facilitate a monitoring operation in the situation of an emergency and more generally for standard monitoring purposes, which are currently greatly diversified.

To begin with, user communities need to **map the cultural landscape of the site and identify the specific risks** it is exposed to and observe the damage on the built structure of a Cultural Heritage site. This requires updated information on land use of the surrounding area, (ii) the evaluation of the site's exposure to all potential risks (e.g. geo-hazards) because of its location, positioning, and surroundings, (iii) the analysis of the material composition of visible parts to understand the overall structure and identify potential damage. The prior can be defined as a first step to define a site's management plan and then conduct monitoring activities.

To **monitor the evolution of the natural environment of a Tangible Heritage or Natural Heritage site**, user communities need to detect, delineate and monitor damages that can be observed (e.g. deterioration of a building, signs of mineralisation, illegal forest cut, illegal looting, etc.). For this purpose and for both land and sea Heritage, they need to conduct map regressions[124] to delimitate, by comparing images in time, the coverage of the observed

[124] Margarete VAN ESS et al., Detection of looting activities at archaeological sites in Iraq using Ikonos imagery; A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017

damage. Finally, in the case of an emergency event, such as flash floods or fires, real-time monitoring[125] supports the work of user communities in **drawing conclusions in order to facilitate an emergency intervention.**

On the other hand, user communities need to conduct a constant **environmental (climate change, geo-hazards, pandemic events, etc.) monitoring** and modelling of the area, mostly to identify and prevent potential risks. For this purpose, in the particular case of underwater Tangible Heritage, they look at factors for overtime damage on a built structure: water pollution[126], coastal erosion[127], water currents, hydrological changes[128], sediments levels[129] (as they show evolutions in marine ecosystem which can impact the undersea structure), and sea salinity levels[130]. Needs related to water natural sites are very similar, as Natural Heritage communities are also interested in water pollution, water currents, sediment levels[131] and sea salinity levels. In the case of both land and underwater Heritage, certain variables are analysed for their tendency to be inherent factors of damage: air pollution[132], insolation[133], atmospheric moisture[134], wind direction and speed[135], and temperature[136]. Other variables are however monitored for their capacity to indicate evolutions that could eventually cause damage, such as (i) rainfall erosivity, which allows the analysis of the impact of rainfall on the erosion of a site over time (for both Natural and Tangible Heritage), (ii) ground motion[137], to identify potential seismic risks, (iii) and the water level[138] itself, to predict potential flooding, (iv) the evolution of soil distribution and composition[139], which can help predict evolutions in the ecosystem of the Natural or Tangible Heritage site. In the particular case of Natural Heritage, user communities monitor the evolutions observed on all features of the protected site, including (i) wildlife tracking[140], to monitor alive and potentially dead wildlife as a damage observation in itself as well as a factor to understand the risks of damage posed to the studied wildlife, (ii) water quality[141], (iii) forest coverage[142], to identify signs of deforestation, (iv) ice cover (sea) or snow cover (land), to monitor the evolution of the coverage of ice on a natural site, as well as a potential factor for the rise of sea level, (v) coastal erosion[143], (vi) vegetation levels [144] and (vii) the

[125] Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017, Brussels; Peter Spruyt, Emergency Management Service (CEMS), 24 April 2017, Brussels; Margarete van Ess, Remote sensing as a crucial tool for Cultural Heritage preservation: case studies from the Near East, 24 April 2017, Brussels; Elke Selter, UNESCO's use of satellites for monitoring heritage sites in conflict-affected areas, 24 April 2017, Brussels

[126] Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; Jordan Firas Alawneh, Fadi Balawi and Mohammed Waheeb, Environmental pollution, a threat to the archaeological sites, heritage and tourism in Zarqa

[127] Stelios Bollanos, User needs in monitoring coastal archaeological sites: the potential of Copernicus, 24 April 2017, Brussels

[128] Conserving Cultural Landscapes: Challenges and New Directions edited by Ken Taylor, Archer St. Clair, Nora J. Mitchell

[129] D. J.Gregory, Development of Tools and Techniques to Survey, Assess, Stabilise, Monitor and Preserve Underwater Archaeological Sites: Sasmap, International Journal of Heritage in the Digital Era, 2012

[130] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels

[131] D. J.Gregory, Development of Tools and Techniques to Survey, Assess, Stabilise, Monitor and Preserve Underwater Archaeological Sites: Sasmap, International Journal of Heritage in the Digital Era, 2012

[132] Dario Camuffo, Microclimate for cultural heritage, Second edition, 2014; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; Rosa Lasaponara, Remote sensing for Cultural Heritage: from documentation to risk estimation and preservation, 24 April 2017, Brussels; The Effects of Air Pollution on Cultural Heritage Editors: Watt, J., Tidblad, J., Kucera, V., Hamilton, R. (Eds.)

[133] Dario Camuffo, Microclimate for cultural heritage, Second edition, 2014

[134] Ibid; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; C. SABBIONI et al., Vulnerability of Cultural Heritage to climate change

[135] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; C. SABBIONI et al., Vulnerability of Cultural Heritage to climate change

[136] Dario Camuffo, Microclimate for cultural heritage, Second edition, 2014; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; C. SABBIONI, M. CASSAR, P. BRIMBLECOMBE, R.A. LEFEVRE, Vulnerability of Cultural Heritage to climate change

[137] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Daniele Spizzichino, PROTEGHO, satellite techniques for risk monitoring and for conservation policies, 24 April 2017, Brussels; Luca Rossi, The Sendai framework for disaster risk reduction: Cultural Heritage, disaster resilience, and climate change, 24 April 2017, Brussels

[138] A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; UNESCO, The impacts of climate change on world heritage properties

[139] Margarete VAN ESS et al,, Detection of looting activities at archaeological sites in Iraq using Ikonos imagery; A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Chris Stewart, Philippe Martimort, Earth observation applied to Cultural Heritage Applications: current capabilities, limitations and future perspectives, 24 April 2017, Brussels

[140] Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels

[141] Ibid

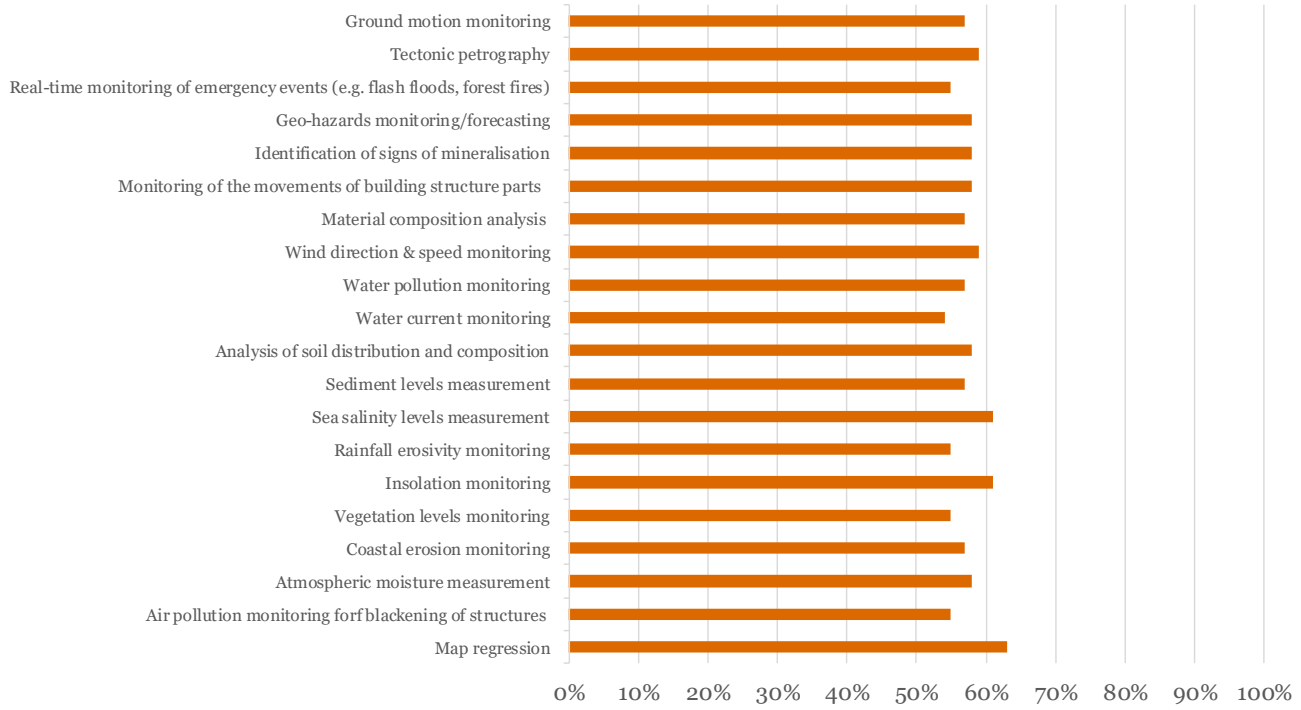
[142] Ibid; Paul Siqueira et al., SAR, InSAR and Lidar studies for measuring vegetation structure over the Harvard forest region

[143] Stelios Bollanos, User needs in monitoring coastal archaeological sites: the potential of Copernicus, 24 April 2017, Brussels

[144] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.

evolution of the typology of vegetation of the natural site[145] (e.g. trees, shrubs, etc.). These user needs are presented in the charts below by type of activity:

Figure 37: Summary of user needs for conservation activities (Source: stakeholder consultation)



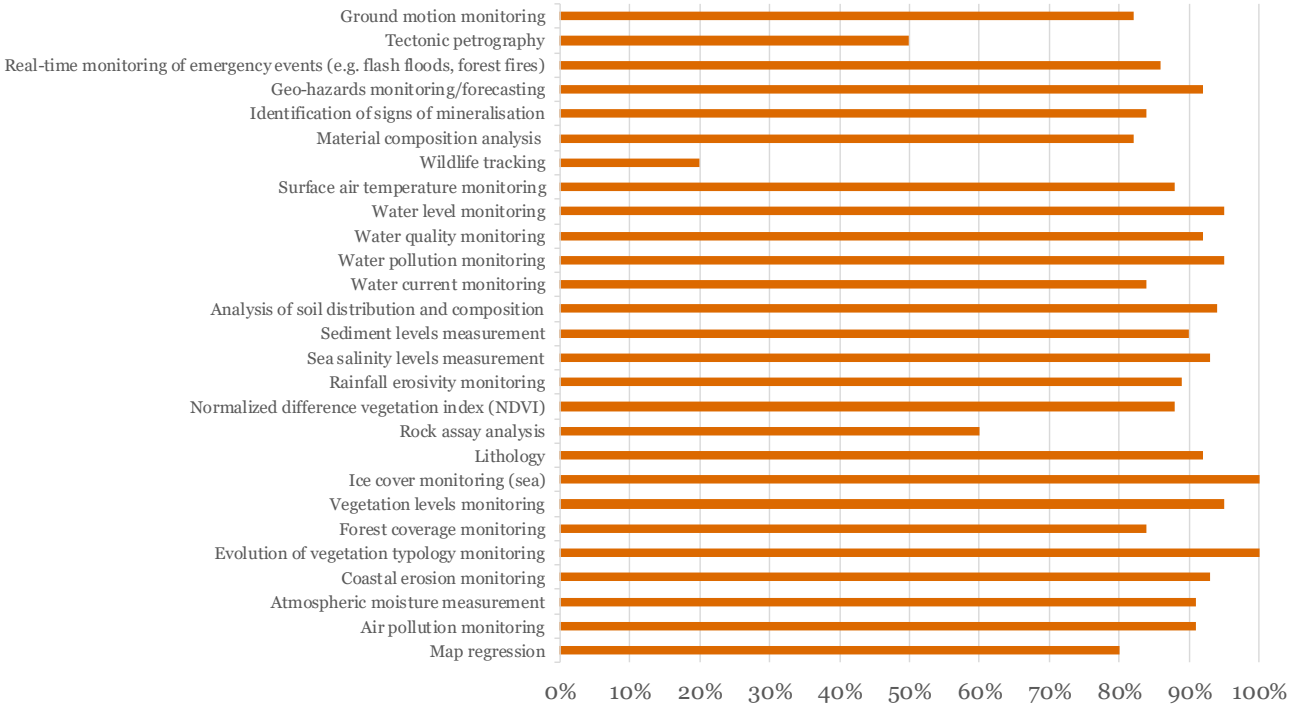
Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 37 (i.e. percentage of users interested in each user need) due to lack of information.

Table 16: Summary of the other user needs for the conservation activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Ice cover monitoring (sea) / Snow cover monitoring (land)
Evolution of vegetation typology monitoring
Water quality monitoring
Hydrological changes monitoring

[145] Paul Siqueira et al., SAR, InSAR and Lidar studies for measuring vegetation structure over the Harvard forest region

Figure 38: Summary of user needs for preservation activities (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 38 (i.e. percentage of users interested in each user need) due to lack of information.

Table 17: Summary of the other user needs for the preservation activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Hydrological changes monitoring
Monitoring of the movements of building structure parts

The **results of the PwC survey** indicate that conversation user needs are quite homogenous while preservation user needs are more heterogeneous. This can be understood in the context in which preservation activities are more developed in practice and show specificities to a wider range of environments, while conservation activities are less developed and therefore more basic and commonly shared by relevant user communities. Indeed, most user needs are required by between 50% and 60% of respondents intervening in conservation activities. Preservation activities, as they refer to Natural Heritage sites will be more heterogeneous given the higher diversity of environments which can be considered.

3.2.2.2 Conclusion

The user communities that intervene in the Production segment thus need to collect data to support the creation and update of the inventory of data collected on the site, as well as the environmental monitoring and modelling activities for both conservation of Tangible Heritage and preservation of Natural Heritage.

The categorisation of the "Production" user needs as presented above highlight the extent to which Earth observation satellites can support the related user communities. For both Natural

and Tangible Heritage, non-technical users, such as international organisations that intervene on the monitoring of sites (e.g. in the case of armed conflicts, or in prevention of geo-hazards), need to access **processed data** that is sufficiently comprehensive and informative for them, and for which IT skills are not required. In the particular case of Natural Heritage, needs are for both current information on biodiversity and vegetation density (e.g. in the case of observed deforestation) that **provide a very large spatial coverage** and for data that provides an understanding of climate change adaptation. Environmental data such as temperature changes[146] and levels of humidity in the atmosphere are thus particularly key. At this stage, it appears that there are issues related to the process and timeframe within which information can be accessed during emergency events: (i) authorities in charge of monitoring activities are not always able to activate the provision of **emergency data** themselves and (ii) there is a lack of provision of real-time data. These two elements both constitute particular challenges for user communities in the case of an emergency.

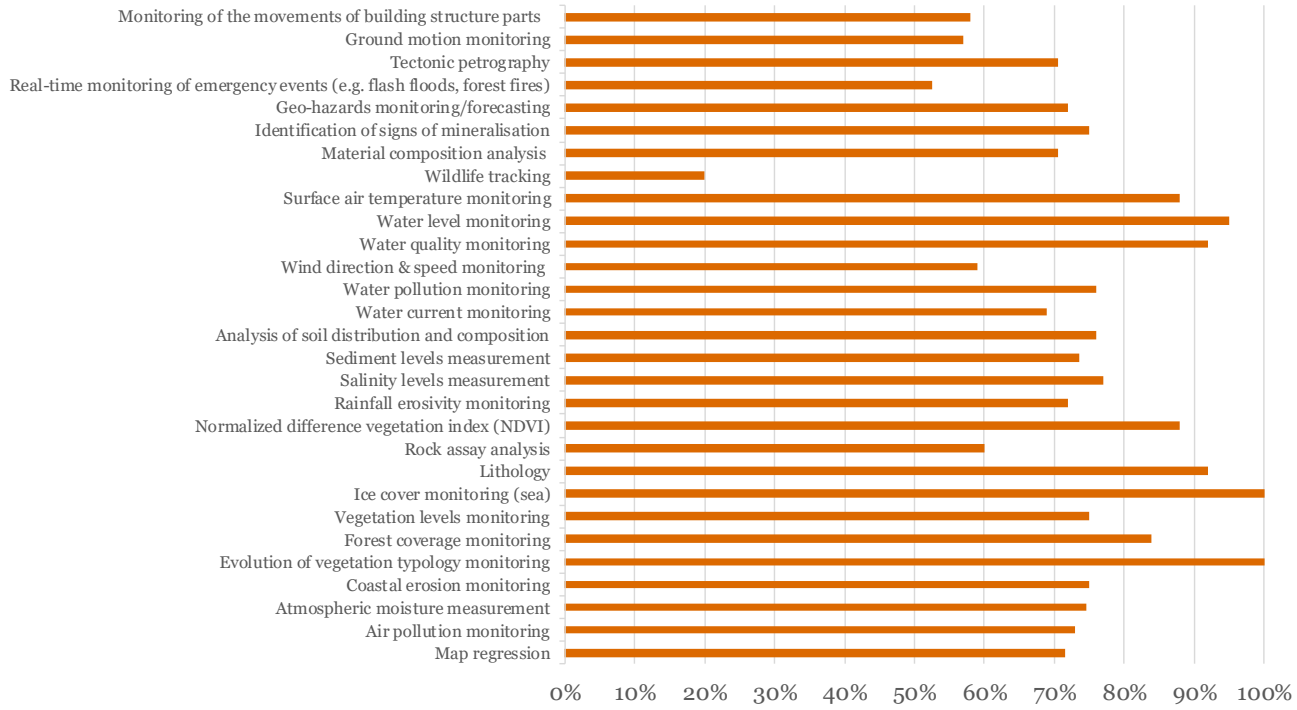
Four high level user needs have been identified overall for this segment, with 30 user needs collected to fulfil them.

Table 18: Summary of high level user needs for production activities

High level user needs for the Production segment
Monitoring of the evolution of the natural environment of the Tangible Heritage site
Monitoring of the evolution of the natural environment of the Natural Heritage site
Observation of damage on the built structure of a Cultural Heritage site
Drawing of conclusions to facilitate an emergency intervention

[146] Dario Camuffo, Microclimate for cultural heritage, Second edition, 2014; A Holistic EO technology approach for improving resilience of CH assets, 24 April 2017, Brussels; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; C. SABBIONI et al., Vulnerability of Cultural Heritage to climate change

Figure 39: Summary of user needs for the Production segment (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 39 (i.e. percentage of users interested in each user need) due to lack of information.

Table 19: Summary of the other user needs for the Production segment mentioned during the interviews (Source: stakeholder consultation)

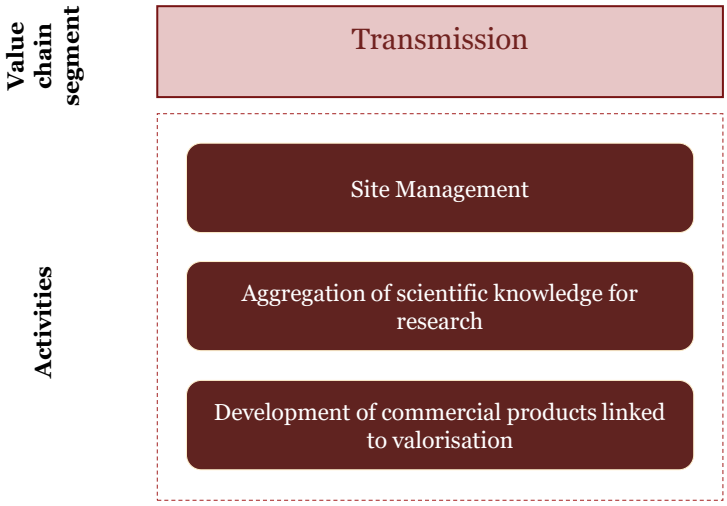
Other user needs expressed during the interviews
Hydrological changes monitoring

3.2.3 Transmission segment

Definition

The Transmission segment includes all activities related to providing public access to Cultural Heritage sites, from site management for touristic purposes, to support and conduct of research work on site for scientific and societal reasons, and the development of commercial products linked to site valorisation. This segment of the value chain undertakes the valorisation of the site for social and scientific purposes, and therefore it carries new possibilities for Cultural Heritage to be a strategic asset for the international outreach of EU values. The activities included in the Transmission segment are illustrated in the chart below.

Figure 40: Main activities included in the segment "Transmission" of the Cultural Heritage value chain



User communities

User communities intervening in the Transmission segment are in charge of creating the link between a Cultural Heritage site and the public (e.g. general public, the education field, research field, private companies) for purposes that go beyond conservation and preservation. This segment of the value chain thus includes a broader range of user communities, as it involves 5 out of the 6 user communities (excluding the national, regional or local authority user community in charge of Cultural Heritage recognition). It should be noted that as the number of downstream entities is limited, their participation to the PwC survey can be considered low (10% of participants indicated their intervention in the Transmission segment). However, the stakeholder consultation made clear that all Cultural Heritage communities see the development of Copernicus as a possibility for downstream actors to provide them with more accessible processed data, since the demand would be increasing. Therefore, the downstream user community should be considered a key component of the current state and the future development of the Transmission segment.

Context of the development of the Transmission segment

Development of a broader access to Cultural Heritage

Governments, private companies and citizens are being stimulated by European-wide initiatives to foster Cultural Heritage accessibility and impact on society. Indeed, the European Year of Cultural Heritage, among other EU initiatives, is aiming at triggering the development of Transmission activities. This segment of the value chain could therefore be highly stimulated through 2018 onwards. In that sense, it should be noted that the specific use of technology is creating a whole new visitor experience and how visitors can identify with Heritage sites as a means of fostering identity and a sense of belonging to a community. Moreover, it provides new possibilities for more efficient site management. Along with this stimulation brought by new technologies, the role of Cultural Heritage appears to be expanding and becoming more democratic.

The window of opportunities brought by new technologies and the perspective of digitisation of culture and site management

Digitisation and online accessibility lend Cultural Heritage a much greater visibility. This not only attracts visitors, tourists and researchers, but can also boost business to regional economies. Digitisation and digital preservation through the development of 3D-capturing, 3D-processing and tools for text digitisation or preservation of audio-visual material is being developed. As such, this part of the Cultural Heritage value chain should be highly stimulated and require

specific data to be fostered. It is estimated that only around 20% of Europe's collections have been digitised so far, leaving therefore about 80% of resources still to be digitised[147].

In terms of activities, the Transmission segment relies on three key activities: site management, aggregation of scientific knowledge for research, and the development of commercial products serving the valorisation of a site. The latter two activities are presented jointly, as their need for collected data is similar. Moreover, given the nature of the activities conducted in this segment of the value chain, **all the user needs that have been identified for previous segments should be considered at this point as exploitable for research or commercial activities**.

Table 20: Overview of the Transmission segment

Activity	Tasks
Site management activities	Planning of capacity for public access Frequentation monitoring
Development of commercial products activities	Creation of products for Tangible / Natural Heritage communities
Aggregation of scientific knowledge	Access to collected raw data on a platform

3.2.3.1 Transmission – Conducting site management

Definition

Site management includes planning activities, monitoring, and managing a site for public exhibition purposes, including societal (e.g. scientific and education) and economic (e.g. tourism) use. Regarding scientific activities for a site, it includes the support or conduct of specific projects, and potential partnerships with external institutions intervening on the site, such as academic programs (students, PhD or researchers' research projects), private research programs, and international organisations' programs (such as the EC, UNESCO, etc.), which are **seeking further understanding of the site or site's specific features that are not directly related to Cultural Heritage conservation/preservation** (this would be activities belonging to the Production segment). Last but not least, digitisation has carried great potential and therefore great challenges for the Cultural Heritage sector. Digitisation opens possibilities in terms of the means of Transmission of Cultural Heritage to all generations and beyond physical frontiers, opening up multiple possibilities for education and access to the general public. This is for instance translated into the use of new technologies to digitise Culture through 3D modelling of sites[148] (Tangible and Natural Heritage sites), in-situ 3D experiences, or live access to a site through the internet.

Table 21: Overview of the site management tasks and their description

Tasks	Description
Planning of capacity for public access (all temporal basis included)	Define scope (how much will be done); Define expected "performance" of the site; Define quality (what specific standards need to be met); Define global costs;

[147] Source: EC. Advanced 3D modelling for accessing and understanding European cultural assets. [ONLINE] see: https://cordis.europa.eu/programme/rcn/664971_en.html

[148] Tamara Brizard, Willem Derde, Neil Silberman, Basic guidelines for Cultural Heritage professionals in the use of information technologies, The Interactive Institute, 2007; Vlahakis, Ioannidis, Karigiannis, Tsotros, Gounaris, Stricker, Gleue, Daehne, Almeida, Archeoguide: An augmented reality guide for archaeological sites, Computer Graphics in Art History and archaeology, 2002; Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.

	Define timeframes for each action.
Monitoring site and frequentation	Monitoring of the site's frequentation patterns and other aspects of the management system; Verify that the management system is delivering the right results (outputs and outcomes); Establish what remedial measures or new initiatives to take in the event of shortcomings; Define timeframes for each defined action; Define measures to increase the effectiveness of the management system.
Support and monitor scientific activities on site	Design research projects or select research projects based on: Technical documentation; Data on area of archaeological research; Objective of the archaeological research; Expected results; Type, scope, direction, methods and timing of research and protection measures; Measures to protect the site/area of discovery; Organization of research; Budget for archaeological research; Technical documentation; Photo-documentation; Create partnerships with the scientific field.

Process and user needs for site management activities

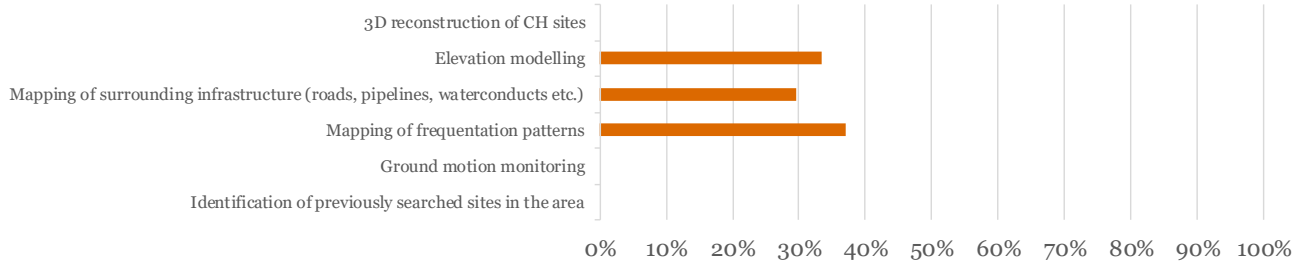
The process of planning on-site management is the task that defines the operability of a site, in order to enable public access to it. This particular task is specifically monitored by institutions such as the European Heritage Label (EHL), to provide and/or maintain a valid Heritage label. It includes defining a scope of Transmission to the public, and the extent and means with which the site can be accessed by the public. It must define the expectations from the site in terms of touristic and scientific activities, standards of services linked to these activities, frequentation capabilities, calendar projections, etc. Projecting costs and expected incomes to be linked to the financial needs identified by the site management group is also necessary. In order to pursue these tasks, the site operators user community relies on key data such as elevation models[149] to create a very detailed scanning of the area's environmental features, in order to determine the possibilities for potential constructions that would ease public access[150]. Moreover, they need to be provided with the mapping of already existing infrastructures[151] (roads, pipelines, water conducts, etc.) that can also ease public access, as the PwC survey has confirmed.

As a consequence, the second task to be considered is the monitoring of the site and its frequentation, which includes monitoring the effectiveness of the site management system itself, but also verifying that it produces the expected results with minimal to no negative impact over the site's conservation or preservation. Accordingly, additional tasks include defining measures to improve the management system itself or tackle specific identified issues, as well as their time frame of implementation, in terms of day-to-day activities or a specific one-time action. A key

[149] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.; Margarete VAN ESS et al., Detection of looting activities at archaeological sites in Iraq using Ikonos imagery
[150] Expert consultation
[151] Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels; Maria Libera Battagliere, COSMO-Skymed Contribution to Cultural Heritage Monitoring, 24 April 2017; Rosa Lasaponara, Remote sensing for Cultural Heritage: from documentation to risk estimation and preservation, 24 April 2017, Brussels
Council of Europe, Guidelines on Cultural Heritage, Technical tools for Heritage conservation and management, 2012

relevant need for this task is the monitoring of frequentation patterns[152] to keep track of the touristic impact on the site and prevent damages which would be linked to human frequentation. Monitoring the number of visitors as well as the patterns of their displacements on the site thus serves management purposes as well as preservation/conservation purposes. Moreover, imagery and site monitoring are necessary to prevent or respond to any degradation of a site, but will be mostly considered by user communities from the Production segment rather than the ones from the Transmission segment as the PwC survey results suggest.

Figure 41: Overview of site management user needs (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 41 (i.e. percentage of users interested in each user need) due to lack of information.

Table 22: Summary of the other user needs for the site management activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Human conflict risk monitoring

The **results of the PwC survey** indicate that tasks of planning and frequentation monitoring require three key user needs to implement site management processes: elevation modelling, mapping of surrounding infrastructure and frequentation patterns.

3.2.3.2 Transmission - Aggregating data for research and producing commercial products

Definition

Transmission activities also include supporting the conduct of research work that is not directly related to the preservation or conservation of the site. This includes working in partnership or collaboration with external public or private institutions seeking to develop a project over the whole site or over specific features of the site. These activities imply collaboration in terms of access to the site, prevention of risks related to the project and possible access to available data. At this level, the main element is therefore access to inventory and collected raw data on a platform for research purposes, which will depend on the nature of the project and the nature of the site considered.

The aggregation of scientific knowledge for research is the link between conducted research on a site and public access to knowledge. Therefore, it refers to the publication of articles by the

[152] Tamara Brizard, Willem Derde, Neil Silberman, Basic guidelines for Cultural Heritage professionals in the use of information technologies, The Interactive Institute, 2007; Dr Ozlem Adiyaman, Earth observation with Copernicus to: protect, monitor, document, present and share our common heritage, our cultural and natural UNESCO World Heritage sites, 24 April 2017, Brussels

Natural sciences user community, which will need **access to inventory and other available data**.

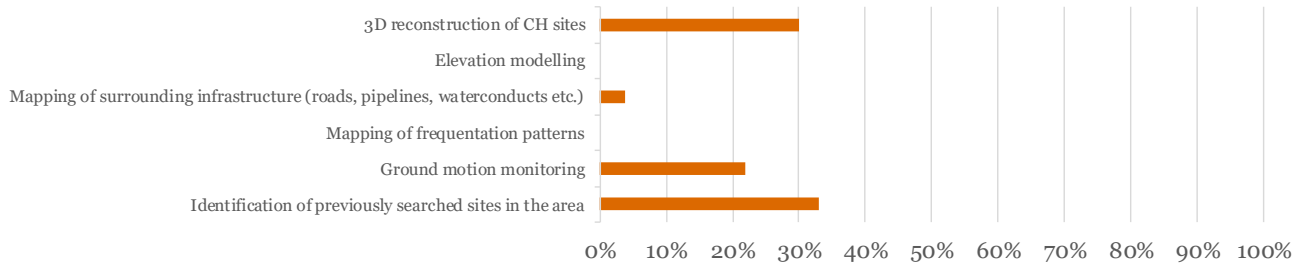
Table 23: Overview of data aggregation and commercial product design tasks and their description

Tasks	Description
Aggregation of scientific knowledge for research	Publish articles based on conducted research on site; Share data from inventory and recent research on site.
Development of commercial products linked to valorisation of the CH assets	Creation of 3D experience for visitors (3D modelling of monuments); Creation of database products for CH communities.

The development of commercial products is at the core of Cultural Heritage development for the public, and is carried out by the Cultural Heritage professional user community and the intermediate user community (e.g. value-added product developers). These user communities face the challenge of understanding how technology can bring Cultural Heritage closer to the public and/or to professionals. One key example for this activity is the creation of 3D modelling of monuments, which can provide a 3D experience to the public, on site or online. Satellite imagery of the site on which visitors are expected will serve as a basis for the 3D modelling[153] of the site, either as existing (e.g. Cliffs of Moher) or as existed (e.g. Temple of Jerusalem).

To sum up, both activities are characterised by the gathering of existing or recently collected data either for research and public knowledge purposes, or for the creation of commercial products. All user needs can be considered for this section, as they might intervene in the publication of research papers, the inventory of a site or the creation of a new product capable of valuing a site.

Figure 42: Overview of "aggregation of data for research and producing commercial products" user needs (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 42 (i.e. percentage of users interested in each user need) due to lack of information.

[153] Tamara Brizard, Willem Derde, Neil Silberman, Basic guidelines for Cultural Heritage professionals in the use of information technologies, The Interactive Institute, 2007; Vlahakis, Ioannidis, Karigiannis, Tsotros, Gounaris, Stricker, Gleue, Daehne, Almeida, Archeoguide: An augmented reality guide for archaeological sites, Computer Graphics in Art History and archaeology, 2002; Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.

Table 24: Summary of the other user needs for aggregation of data for research and producing commercial products activities mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Human conflict risk monitoring

The **results of the PwC survey** indicate that the **aggregation of data** requires three main user needs to implement site management processes: 3D reconstruction of Cultural Heritage sites, ground motion monitoring and identification of previously searched areas.

3.2.3.3 Conclusion

As extracted from the stakeholder consultation, the Transmission segment of the value chain faces key challenges. First, site management lacks proper institutionalisation of the use of site management plans, which weakens site monitoring. Providing site operators with **systematic accessible data** would be key to facilitating the definition and implementation of site management plans. Secondly, it appears that this phenomenon can be differentiated if it is Tangible Heritage or Natural Heritage that is considered. In fact, even if data is available for European Natural Heritage sites, it appears that site operators working on Tangible Heritage lack data and thus they cannot implement or share good practices. As a consequence, answering to the demand of Tangible Heritage site operators could appear as a priority, in particular, for the **monitoring of changes linked to human impact as well as the effects of touristic activities**.

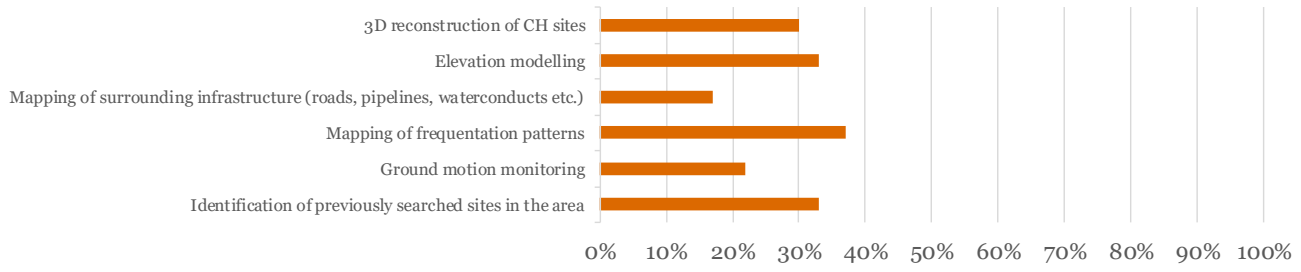
On the other hand, this segment is disrupted by the development of new technologies and the opportunity to create a strengthened link between the general public and Heritage sites. In that sense, the **Digital Elevation Model (DEM) should play a major role in the development of 3D experiences**, as the gathering of specific datasets for Cultural Heritage sites might be of primary interest for education and scientific purposes.

One high level user need has been identified for this segment.

Table 25: Summary of the high level user need for Transmission activities

High level user needs for the Transmission segment
Enable public access to the site

Figure 43: Summary of user needs for Transmission activities (Source: stakeholder consultation)



Additional user needs have been expressed during direct interviews as complementary to the proposed list, and illustrated in the table below. These "*other user needs*" are only listed and not expressed in the same format than in Figure 43 (i.e. percentage of users interested in each user need) due to lack of information.

Table 26: Summary of the other user needs for the Transmission segment mentioned during the interviews (Source: stakeholder consultation)

Other user needs expressed during the interviews
Human conflict risk monitoring

3.2.4 Overall conclusion of high level and specific user needs

The Cultural Heritage value chain is characterised by cross-field user needs for user communities mostly intervening in both types of environments: Tangible Heritage and Natural Heritage on the one hand, land and underwater environment on the other. In the same logic, the study has identified user needs which are cross Cultural Heritage land covers and environments (43% of user needs have been identified for both land and underwater environments on the one hand, and 40% for both Tangible and Natural Heritage) which allow to conclude to a global homogenous demand for 9 high level user needs which are declined in 51 user needs.

This being said, this conclusion needs to be contextualised in what appears as the main challenge along the Cultural Heritage value chain: the gap between what is done today for Natural Heritage environments compared to Tangible Heritage environments. In fact, as Natural Heritage is mostly covered and efficiently monitored, direct consultation highlighted the expectations of stakeholders to work towards an integrated approach of Natural Heritage and Tangible Heritage. Even though collected data is easily used for monitoring and site management purpose, the Cultural Heritage communities intervening in Tangible Heritage are lacking a clear process of site monitoring. By comparing needs in both environments and identifying their similarities, one key conclusion is the coherence between this more integrated approach in which Tangible Heritage could benefit from best practices from the Natural Heritage community, in order to foster its global development and sustainability.

Table 27: Summary of user needs organised by high level user needs (Source: stakeholder consultation)

#	High level user need	User needs
1	**Study of the natural environment of the site for the detection of underground archaeological features**	Indirect indicators
		Normalized difference vegetation index (NDVI)
		Thermal anomaly
		Map regression
2	**Non-destructive analysis of the underground / underwater positioning of the CH features**	Bathymetry
		Stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units
		Geodetic recording
		Metal detecting

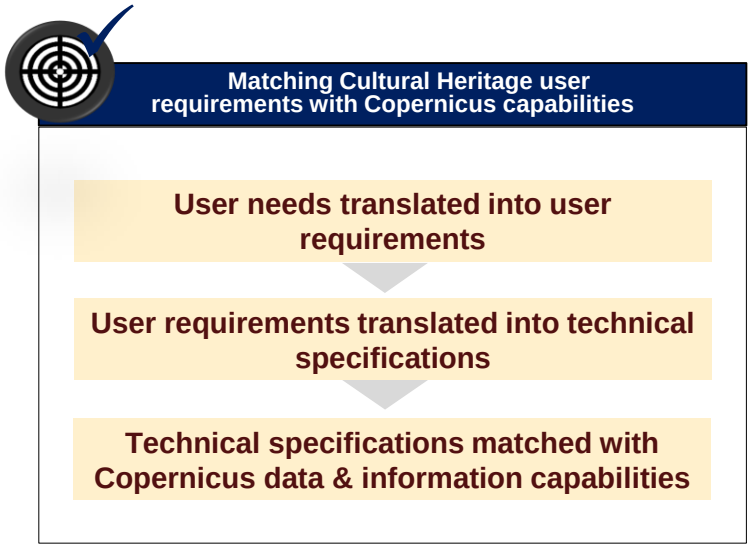
3	**Non-destructive analysis of the surface positioning of the CH features**	Elevation modelling
		Geodetic recording
		Photogrammetric mapping
		Topographic mapping
		Visual identification via imagery
		Identification of previously searched sites in the area
		Rock assay analysis
		Vegetation levels monitoring
		Tectonic petrography
		Lithology
		Sea salinity levels measurement
		3D reconstruction
4	**Mapping of the cultural landscape of the site and identification of the specific risks it is exposed to**	Ground motion monitoring
		Mapping of frequentation patterns
		Identification of previously searched sites in the area
		Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
		Photogrammetric mapping
		Topographic mapping
		Tectonic petrography
		Visual identification via imagery
5	**Monitoring of the evolution of the natural environment of the CH site**	Map regression
		Air pollution monitoring
		Atmospheric moisture measurement
		Coastal erosion monitoring (under and above the sea)
		Evolution of vegetation typology monitoring
		Vegetation levels monitoring
		Ice cover monitoring (sea)/Snow cover monitoring (land)
		Insolation monitoring
		Rainfall erosivity monitoring
		Sea salinity levels measurement
		Sediment levels measurement
		Analysis of soil distribution and composition
		Water current monitoring
		Water pollution monitoring
		Water quality monitoring
		Wind direction & speed monitoring
		Hydrological changes monitoring
6	**of the evolution of the natural environment of the**	Map regression
		Air pollution monitoring

		Atmospheric moisture measurement
		Coastal erosion monitoring (under and above the sea)
		Evolution of vegetation typology monitoring
		Forest coverage monitoring
		Vegetation levels monitoring
		Ice cover monitoring (sea)/Snow cover monitoring (land)
		Lithology
		Rock assay analysis
		Normalized difference vegetation index (NDVI)
		Rainfall erosivity monitoring
		Sea salinity levels measurement
		Sediment levels measurement
		Analysis of soil distribution and composition
		Water current monitoring
		Water pollution monitoring
		Water quality monitoring
		Water level monitoring
		Hydrological changes monitoring
		Temperature monitoring
		Wildlife tracking
7	**Observation of damage on the built structure of a CH site**	Material composition analysis
		Monitoring of the movements of building structure parts
		Identification of signs of mineralisation
		Map regression
8	**Drawing of conclusions to facilitate an emergency intervention**	Geo-hazards monitoring/forecasting
		Human conflict risk monitoring
		Real-time monitoring of emergency events (e.g. flash floods, forest fires)
		Tectonic petrography
		Ground motion monitoring
		Map regression
9	**Enable public access to the site**	Identification of previously searched sites in the area
		Ground motion monitoring
		Mapping of frequentation patterns
		Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
		Elevation modelling
		3D reconstruction

4 Copernicus capabilities in response to user requirements

This chapter illustrates how Copernicus data and information capabilities have been matched with previously identified Cultural Heritage user needs. For this purpose, user needs have been characterised into user requirements, which have then been translated into technical specifications thanks to the support of external experts. These technical specifications have enabled the matching with Copernicus data and information capabilities. The full process is illustrated in the chart below.

Figure 44: High level approach, match analysis between Cultural heritage user requirements and Copernicus data and information capabilities



These different steps are detailed in the following sections.

4.1 Characterisation of user requirements

User requirements refer to the translation of user needs, previously identified in Chapter 3, into desired performances and attributes. In this sense, user requirements are complementing and characterising user needs by defining the:

- **Type of land cover** of interest from users: land (e.g. grasslands, urban areas, desert, etc.), sea (e.g. coastal, water surface, underwater)[154];
- **Geographical coverage**: size of the area to be monitored[155]:
  - Local detailed scale: this is the scale of a single building or a small conservation site;
  - Local scale: this is the scale related to a whole zone that can include several buildings or sites, or one large one;
  - Regional scale: This is the scale representing areas that cover vast zones;

[154] The different land cover of interest from Cultural Heritage user communities are illustrated in Annex C.
[155] The geographic coverage that is considered for this study has been inspired by the taxonomy of the PROTHEGO project. More details available: http://www.prothego.eu/

  - National scale: This is the scale covering a whole country, than will encompass several regions;
  - Global scale: This is the scale covering planet Earth;
- **Frequency of monitoring**: frequency to which users would like to receive updated data and/or information;
- **Spatial resolution**: size of the smallest possible feature that can be detected (expressed in meter).

These requirements were collected during stakeholder consultation (i.e. interviews and survey) and **are directly expressed by the different Cultural Heritage user communities**.

Desk research and stakeholder consultation have pinpointed the fact that differentiation of land covers is mostly relevant for the high level user need 1 "Study of the natural environment of the site for the detection of underground archaeological features". Past human activities have impacts on natural landscape that differs from one land cover to another, leading to **specific user requirements for the discovery of underground features**. "Land cover" is therefore not a significant differentiating factor in the analysis, as land and sea needs are expressed into specific user needs (e.g. vegetation level monitoring versus sea salinity level measurement or water current monitoring).

Each user need has been split into several user requirements taking into account users frequencies' requests (hourly, daily, weekly and monthly & more) and spatial resolution (Very high resolution; High resolution; Low and medium resolution).

The result of this analysis is a list of user requirements expressed by CH user communities. This list is available in Annex D.

The detailed analysis of the user requirements stresses interesting conclusions on CH user communities:

- **Geographic coverage** – In average, 46,3% of users have expressed a requirement for "Local-detailed" and "Local" scales, highlighting a strong interest from CH user communities in local monitoring;
- **Frequency of monitoring** – In average, 43,2% of users have expressed a requirement for "Monthly and more" monitoring versus only 13,5% for "Hourly" monitoring;
- **Spatial resolution** – In average, 41,1% of user have expressed a requirement for "Very high resolution (less than 1m)" versus 25% for "Low and Medium resolution (more than 5 meter)". The requirements related to spatial resolution are highly dependent of each user need in the context of it high level user need (i.e. what the user wants to achieve).

4.2 Translation of user requirements into technical specifications

Technical specifications refer to the translation of user requirements into—existing Earth Observation technical solutions including sensors (e.g. multispectral, Synthetic Aperture Radar (SAR), hyperspectral, etc.), wavelength (e.g. near-infrared, C-band, X-band, etc.) and spatial resolution specification. Sensors and wavelength are only a first step of a long processing chain where models and other sources of data, such as in-situ data, are required to fully translate identified user requirements into real technical responses. Spatial resolution required by the user had to be translated to a range of spatial resolution specification by an external pool of experts (i.e. expert in remote sensing for Cultural Heritage) to mitigate responding biases (e.g. stakeholders tend to require the highest spatial resolution possible; not all stakeholders were expert in remote sensing) and to take in consideration the specific context of each user

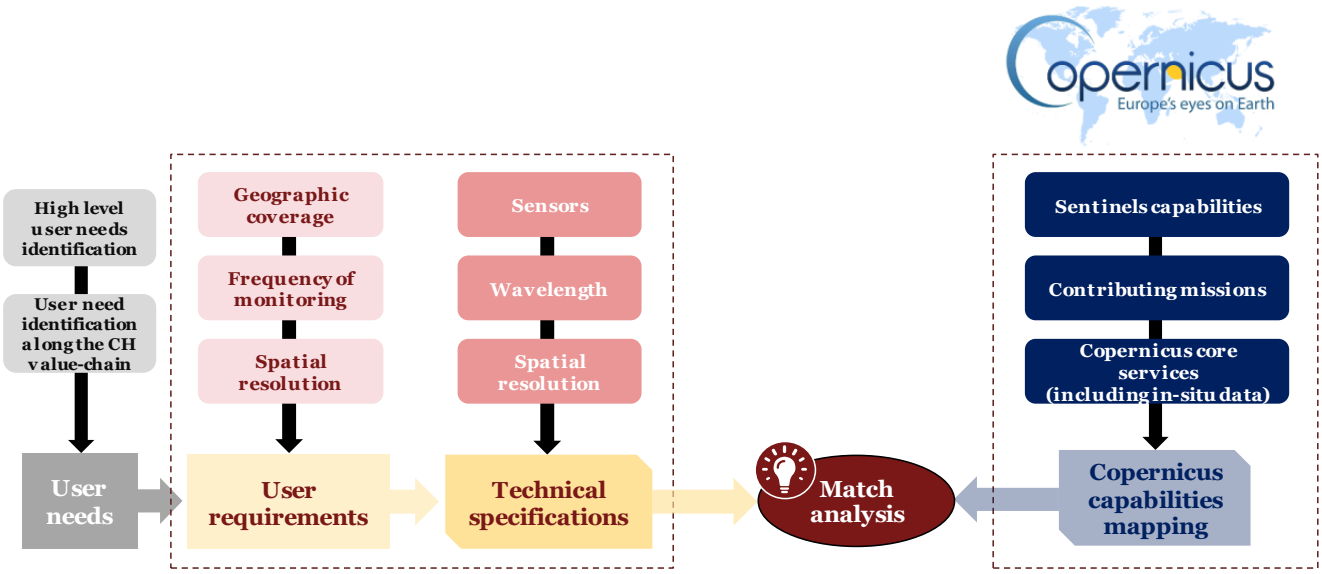
requirement, assessing the original user need and it context and purpose (i.e. high level user need). This range of spatial resolution specification was necessary to support the match analysis between user requirements and Copernicus capabilities carried out in the next section.

The result of this analysis is a list of 373 technical specifications related to the CH user requirements. The full list is available in Annex D.

4.3 Matching user requirements with Copernicus capabilities

Once translated into user requirements & technical specifications, each user need has been mapped to Copernicus capabilities as illustrated in the chart below.

Figure 45: Graphical illustration of the match analysis



The rationale behind the approach used was, in a first step, to assess if the Copernicus core services offer one or several products that could respond to a specific CH user requirement (**Phase 1**). If the user requirement was not fully covered by existing Copernicus core service product(s) – or if no Copernicus core service product(s) could cover this specific user requirement – the second phase aimed at understanding if the free and open Sentinels data could cover this requirement, by analyzing the sensors, wavelengths, spatial and temporal resolutions offered by the Sentinel fleet (**Phase 2**). If a user requirement was not fully covered by Sentinels data, the third phase aimed at understanding if some Copernicus contributing missions could cover this requirement, by analyzing the sensors, wavelengths, spatial and temporal resolutions offered by those contributing missions (**Phase 3**).

The overall match analysis exercise has been carried out following the approach described below:

1. **Copernicus core services product(s):** the match analysis starts by first identifying, when possible, Copernicus core service product(s) that can cover user requirements
   a. Identification of one (or several) Copernicus core service product responding to a user requirement;
   b. Comparison of the product resolution with the spatial resolution required;
   c. Comparison of the product timeliness with the temporal resolution required by users (i.e. frequency of monitoring).

2. **Sentinels capabilities:** the second step aims at assessing if Sentinels capabilities could respond to user requirements & technical specifications
   a. Identification of a Sentinel satellite matching the sensor & wavelength requested;
   b. Comparison of Sentinel spatial resolution with the spatial resolution required;
   c. Comparison of Sentinel temporal resolution with the temporal resolution required by users (i.e. frequency of monitoring).
3. **Contributing missions capabilities:** the third step aims at assessing if Copernicus contributing mission(s) could respond to user requirements & technical specifications
   a. Identification of one or several contributing missions matching the sensor & wavelength requested;
   b. Comparison of contributing mission(s) spatial resolution with the spatial resolution required;
   c. Comparison of contributing mission(s) temporal resolution with the temporal resolution required by users (i.e. frequency of monitoring).
4. **Match analysis:** the fourth and last step aims at bringing together the three level of analysis (Copernicus core services products, Sentinels data, Contributing missions data) in order to highlight categories of user requirements that are:
5. **Fully responding:** the user requirement can fully be covered (for both spatial & temporal resolution) by Copernicus core services, Sentinels and/or contributing mission(s);
6. **Partially responding:** the user requirement can partially be covered by Copernicus core services, Sentinels and/or contributing mission(s), meaning that the spatial resolution of one of these three capabilities (Copernicus core services products, Sentinels data, Contributing missions(s) data) is matching part of the spatial resolution requested (i.e. technical specifications provide a range of spatial resolution) or part of the temporal resolution[156];
7. **Not responding:** the user requirement cannot be covered because:
   a. Satellite-based remote sensing cannot respond to the requirement;
   b. Spatial and/or temporal resolution requested is not available;
   c. Capability (sensors and/or wavelengths) required to respond to the user requirements cannot be covered by Sentinels and/or contributing missions (e.g. hyperspectral, lidar, etc.).

This match analysis has been supported by expert consultation from each of the six Copernicus core services and Copernicus space segment (ESA). The result of the analysis produced a matrix presenting Copernicus core services products, Sentinels and contributing mission(s) data that could answer Cultural Heritage user requirements presented in **Annex D**.

The next sub-sections aim at presenting the synthesis of the match analysis' results, assessing the proportion of user requirements that could be covered by Copernicus capabilities, following the three phases previously identified, including additional qualitative assessment on the possible contribution of the different Copernicus core services.

4.3.1 Phase 1 – Match analysis between user requirements and Copernicus core service products

The first phase of the matching analysis was carried out at the level of Copernicus core services products:

[156] This statement only applies to hourly request, when a satellite is offering less than one day revisiting time but not a one-hour revisiting time

- **7.5% of overall user requirements** (28) **are fully covered by existing Copernicus core services' products** (i.e. both spatial and temporal resolution);
- **19.0% of overall user requirements** (71) **are partially covered by existing Copernicus core services' products, meaning that a Copernicus product exists but its spatial resolution and/or temporal resolution can partially cover the user requirement** (i.e. technical specifications provide a range of spatial resolution);
- **73.5% of overall user requirements** (274) **are not covered by existing Copernicus core services products**. This result is further detailed below:
  - 125 user requirements (33.5% of overall user requirements) could be directly covered by existing Copernicus core services products, but the spatial and temporal resolutions of these products do not match at all user requirements;
  - 89 user requirements (23.9% of overall user requirements) could not be directly covered by any existing Copernicus core service products (i.e. no product currently exists to respond to those user requirements);
  - 60 user requirements (16.1% of overall user requirements) cannot be covered using satellite-based imagery.

The match analysis has highlighted the fact that CH user communities have very different needs and requirements that cannot be covered by a single Copernicus core service. Indeed, the six Copernicus core services are all offering products of great interest for CH user communities. However, user requirements often require a very local monitoring (i.e. geographical coverage) and very high resolution imagery, which are not always available in the current form of the Copernicus products offered. As such, it requires the adaptation of those products or the development of new ones to better respond to CH user requirements.

The next sub-sections highlight results from the match analysis for each of the six core services.

Copernicus Land Monitoring Service

The Copernicus Land Monitoring Service (CLMS) provides geographical information on land cover and on variables related, for instance, to the vegetation state or the water cycle. CLMS currently offers several products responding to CH user communities' requirements, such as land surface temperature, EU DEM, NDVI products or Urban Atlas products. These products are often only partially responding to CH user requirements but they could be tailored to specifically respond to CH user communities. As an example, CLMS is currently producing NDVI products with a spatial resolution of around 10m (based on Sentinel-2) but most CH user communities require very high resolution imagery (under 2m). European Images Mosaic (Very High Resolution) is offering an interesting online visualization interface where users can zoom and access very high spatial resolution (2-2.5m) over Europe which could be of great interest for Tangible Heritage user communities, for indirect indicators monitoring for example. CLMS also offers interesting products for Natural Heritage over Europe and Africa sites such as Natura2000 products (though emblematic natural sites are not specifically targeted). On the top of all CLMS products discussed above, the probable extension of the Land Monitoring service to the provision of ground motion products could be of great interest for CH user communities, especially for CH site operators, as it could help monitoring vertical small motion movement of land.

The table below lists all the CMLS products that are deemed useful for CH user communities. For more details on the match analysis, please refer to **Annex D**.

Table 28: List of CLMS products of interest for CH user communities (Sources: PwC analysis)

Land Monitoring Service	
Copernicus core service product	**User requirements corresponding**
Imagery & Reference Data,	• Indirect indicators (Cropmarks,

European Images Mosaic, Very High Resolution	soilmarks, chlorophyll levels) • Map regression • Photogrammetric mapping • Topographic mapping • Identification of previously searched sites in the area • Vegetation level monitoring • 3D reconstruction
Global, NDVI	• Normalized difference vegetation index (NDVI) • Vegetation level monitoring
Global, Land Surface Temperature	• Thermal anomaly
Imagery & Reference Data, EU-DEM	• Elevation modelling • Topographic mapping
Local, Urban Atlas	• Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Pan-European, High Resolution Layers, Forest	• Evolution of vegetation typology • Vegetation level monitoring • Forest coverage monitoring
Pan-European, High Resolution Layers, Grassland	• Evolution of vegetation typology • Vegetation level monitoring
Pan-European, High Resolution Layers, Water & Wetness	• Hydrological changes monitoring
Local, Natura 2000	• Evolution of vegetation typology monitoring • Vegetation level monitoring • Forest coverage monitoring
Global, Lake Water Quality products	• Water quality monitoring

Copernicus Marine Environment Monitoring Service

The Copernicus Marine Environment Monitoring Service (CMEMS) aims at digitizing and characterizing the ocean, performing ocean modelling and forecasting its evolutions. CMEMS offers a large set of products characterizing all possible indicators & models related to sea, such as sea level, sea salinity level, sea ice monitoring, water current monitoring, etc. Given the specificity of the CH users' communities' needs, "Regional Sea analysis" should be of higher interest for CH user communities than "Global Sea analysis" in order to access products with local monitoring and higher spatial resolution for area such as the Mediterranean Sea or the Black Sea. Forecasts derived from "Current velocity" and "Wind" products can specifically be of great interest for sub-marine tangible and natural sites operators, to support planning of diving activities for example. Finally, "Sea Surface Height" products can offer very interesting insights for CH professionals and site operators of Tangible and Natural Heritage sites on coastal areas, including near-real time in-situ monitoring, on local sea surface height and sea level anomalies in

the Mediterranean Sea, Baltic Sea, Black Sea and European regional seas (e.g. European North West Shelf seas, Iberia-Biscay-Ireland Regional seas).

The table below provides the categories of products offered by CMEMS that could be of interest for CH user communities. For more details on the match analysis, please refer to **Annex D**.

Table 29: List of CMEMS products of interest for CH user communities (Sources: PwC analysis)

Marine Environment Monitoring Service	
Copernicus core service product	**User requirements**
Regional & Global Sea analysis, Sea ice	• Ice cover monitoring (sea)
Regional & Global Sea analysis, Salinity	• Salinity levels measurement
Ocean Colour Thematic Center (OC TAC), CHL & OPTICS	• Sediment levels measurement
Regional & Global Sea analysis, Current Velocity	• Water current monitoring
Regional & Global Sea analysis, Wind	• Wind direction & speed monitoring
Regional & Global Sea analysis, Sea Surface Height	• Water level monitoring
Regional & Global Sea analysis, Temperature	• Sea surface temperature monitoring

Copernicus Climate Change Service

The Copernicus Climate Change Service (C3S) aims at providing information about the past, present and future climate. C3S is specifically monitoring Essential Climate Variables (ECVs) and forecasting their evolution.

C3S has internally long historical databases related to climate variables that are of great interest for CH user communities (for both land and sea users). C3S has temporal series dating from 1950 up to now on several variables, enabling user communities to assess frequencies of specific events such as droughts or floods for example. "Water Quantity Indicators" products can offer interesting insights related to water runoff, wetness, river flow, snow water equivalent or soil water content for Europe. On another hand, "Water Quality Indicators" products are able to provide CH user communities with past, present and future estimate of nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads or water temperature in Europe. More than water quantity and quality information, C3S is also offering interesting products related to sea monitoring such as "Sea surface temperature" or "Sea level". It also offers specific monitoring and forecasting of sea ice type, edge, thickness and concentration. C3S should also be able to provide interesting products for coastal monitoring as they already have internally most of the necessary raw data.

Finally, C3S is also providing the Seasonal Multi System which offers seasonal forecasts that could be interesting for CH user communities, even if it does not respond directly to any specific CH user requirement collected.

The table below provides the categories of products offered by C3S that could be of interest for CH user communities. For more details on the match analysis, please refer to **Annex D**.

Table 30: List of C3S products of interest for CH user communities (Sources: PwC analysis)

Climate Change Monitoring Service	
Copernicus core service product	**User requirements**
ERA5 Climate Reanalysis	• Wind direction & speed monitoring
Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	• Water quality monitoring • Water pollution monitoring
Water quantity indicators (water runoff, wetness, river flow, snow water equivalent, soil water content, etc.)	• Hydrological changes monitoring
Sea Ice (thickness, edge, concentration, type)	• Ice cover monitoring (sea)
Sea level	• Water level monitoring
Sea Surface Temperature	• Sea surface temperature monitoring

Copernicus Atmospheric Monitoring Service

The Copernicus Atmospheric Monitoring Service (CAMS) provides consistent information related to air pollution and health, solar energy, greenhouse gases and climate forcing.

CAMS is already providing 3 types of inputs of high interest for CH user communities dealing with:

- Chemical composition of the atmosphere ("Global forecast of aerosol" and "European-Scale Air Quality Analysis") impacting the soil for both Tangible (e.g. blackening of built structures) and Natural heritage;
- Acid precipitation monitoring (raw data in Europe), leading to damages for both Tangible and Natural Heritage;
- Insolation monitoring ("Clear Sky Radiation"), which plays a key role in ageing of built structure's surface and stained-glass.

CAMS have internally many raw data that could lead to the development of specific products targeting CH user communities but they would need additional support (e.g. additional funding) to transform these raw data into specific products. As for now, they have long temporal series in their data set (i.e. past data), but they cannot perform forecasts; the need to perform such type of forecasts has been pointed out by current CAMS' users.

The table below lists all the CAMS products that are of interest for CH user communities. For more details on the match analysis, please refer to **Annex D**.

Table 31: List of CAMS products of interest for CH user communities (Sources: PwC analysis)

Atmosphere Monitoring Service	
Copernicus core service product	**User requirements**
CAMS, Global forecast of	• Air pollution monitoring for

aerosol	blackening of built structures • Air pollution monitoring (natural heritage sites)
CAMS, European-Scale air quality analysis	• Air pollution monitoring for blackening of structures • Air pollution monitoring (natural heritage sites)
Clear-Sky Radiation (McClear)	• Insolation monitoring
Clear-Sky Radiation (Heliosat-4)	• Insolation monitoring

Copernicus Emergency Management Service and Copernicus in Support to EU External Actions

The Copernicus Emergency Monitoring (Copernicus EMS) and Security services are peculiar as they are reserved for EU authorized users, hence not open to all user communities. Security and Emergency products related to Cultural Heritage are already well covered in the current scope of the Copernicus programme, thanks to the Copernicus EMS and the Copernicus Security Service in support of EU External Actions. Nevertheless, having a dedicated intervention in the field of Cultural Heritage could support these two services in raising awareness of their own Cultural Heritage activities, allowing them to access additional funding to better serve Cultural Heritage purposes and design additional CH-specific products. More details on the offer related to CH proposed by these two services are available in the **section 4.4**.

The tables below list the types of products offered by the Copernicus EMS and Copernicus in Support to EU External Actions of interest for CH purposes. For more details on the match analysis, please refer to **Annex D**.

Table 32: List of Copernicus EMS products of interest for CH user communities (Sources: PwC analysis)

Security Service	
Copernicus core service product	**User requirements**
Global flood awareness system	• Hydrological changes monitoring
On-demand Mapping	• Real-time monitoring of emergency events (e.g. flash floods, forest fires)
Ealy Warning and Monitoring System	• Real-time monitoring of emergency events (e.g. flash floods, forest fires)

Table 33: List of Copernicus for EU External Actions products of interest for CH user communities (Sources: PwC analysis)

Security Service	
Copernicus core service product	**User requirements**

Damage Assessment	• Human conflict risk monitoring
Activity Monitoring	• Human conflict risk monitoring

4.3.2 Phase 2 – Match analysis between user requirements and Sentinels capabilities

The second phase of the analysis aimed at assessing if Sentinels capabilities can help covering user requirements that are not fully covered by Copernicus core services products. To be considered partially covered, both spatial & temporal resolution of the Sentinels had to match the user requirement; if the spatial resolution was matching but the temporal resolution was not matching, the user requirement was considered not covered by Sentinels capabilities.

As highlighted previously, **7.5% of user requirements can be fully covered by Copernicus core services products (Phase 1)**. Those requirements have then not been matched with Sentinels capabilities, as they are already covered.

The results of the second phase of the matching analysis are presented below:

- **3.2% of overall user requirements** (12) **could be fully covered by Sentinels capabilities** (i.e. both spatial and temporal resolution);
- **20.1% of overall user requirements** (75) **could be partially covered by Sentinels capabilities**, meaning that a Sentinel payload could respond to the user requirement but its spatial resolution and/or temporal resolution could only be partially covered (i.e. technical specifications provide a range of spatial resolution);
- **69.2% of overall user requirements** (258) **could not be covered by existing Sentinels capabilities**. This result can be further detailed:
  - 148 user requirements (39.7% of overall user requirements) could not be covered by Sentinels capabilities, because Sentinels spatial and/or temporal resolutions do not match at all user requirements;
  - 50 user requirements (13.4% of overall user requirements) could not be covered by Sentinels capabilities, as the sensors and/or wavelength required is not available within the Sentinels fleet (e.g. hyperspectral, SAR L-Band);
  - 60 user requirements (16.1% of overall user requirements) could not be covered using satellite-based imagery.

4.3.3 Phase 3 – Match analysis between user requirements and Copernicus Contributing missions

The third phase of the analysis aimed at assessing if Copernicus contributing missions could help covering user requirements that are not fully covered by Copernicus core services products and/or Sentinels capabilities. To be considered partially covered, both spatial & temporal resolutions of the contributing mission(s) needed to match the user requirement; if the spatial resolution was matching but the temporal resolution was not, the user requirement was considered not covered by Copernicus contributing missions.

10.7% of user requirements (40) can be fully covered by Copernicus core services products and/or Sentinels capabilities (Phase 1 & 2). Those requirements have not been matched with Copernicus contributing missions, as they are already covered by Copernicus core services products and/or Sentinels capabilities.

The results of the third phase of the matching analysis are presented below:

- **39.1% of overall user requirements** (146) **could be fully covered by Copernicus contributing missions** (i.e. both spatial and temporal resolutions);
- **14.2% of overall user requirements** (53) **could be partially covered by Copernicus contributing missions meaning that one (or more) Copernicus contributing mission exists but its spatial resolution and/or temporal resolution could only be partially covered** (i.e. technical specifications provide a range of spatial resolution);
- **35.9% of overall user requirements** (134) **could not be covered by existing Copernicus contributing missions**. This result can be further detailed:
  - 26 user requirements (7.0% of overall user requirements) could not be covered by Copernicus contributing mission, because their spatial and/or temporal resolution did not match user requirements;
  - 48 user requirements (12.9% of overall user requirements) could not be covered by Copernicus contributing missions, as the sensors and/or wavelengths required are not available in the pool of contributing missions (e.g. hyperspectral, lidar);
  - 60 user requirements (16.1% of overall user requirements) cannot be covered using satellite-based imagery.

4.3.4 Conclusion of the match analysis

The results of the match analysis clearly show that the Copernicus programme could cover a large part of the CH user requirements. In fact, **7.5% of CH user requirements (28) are already fully covered by Copernicus core services products in their current form,** and an additional 34.9% of user requirements (130) are partially covered. The **use of Sentinels data** could be **fully covering 3.2% of additional** CH user requirements (12), leading to **10.7% of user requirements (40) being fully covered.**

The use of Copernicus contributing missions to cover CH user requirements could be highly beneficial for CH user communities. Indeed, on the top of the 10.7% of CH user requirements (40) fully covered by Copernicus core services products and Sentinels capabilities, an **additional 39.1% of CH user requirements (146)** could be **fully covered thanks to Copernicus contributing missions,** leading to an overall **49.8% of CH user requirements (186) fully covered by Copernicus capabilities.** An **additional 14.2%** of CH user requirements (53) could **be partially covered** thanks to Copernicus contributing missions. Those partially covered user requirements could potentially be covered by the downstream industry having access to very high resolution data and/or very high revisiting time imagery not available in the pool of Copernicus contributing missions.

By using all Copernicus capabilities (core services products, Sentinels and Contributing missions), **35.9% of user requirements** (134) will still **not be covered by the Copernicus programme.** Indeed, 7.0% of CH user requirements (26) could not be covered because the spatial and/or temporal resolution required by users are not available within Copernicus. **12.9% of CH user requirements** (48) require **specific sensors and/or wavelengths that are not available in the scope of the Copernicus programme** (e.g. hyperspectral, lidar) in order to be covered. Nevertheless, **such sensors and wavelengths exist on the commercial market** so the **downstream industry could then fully cover those user requirements**. Finally, 16.1% of CH user requirements cannot be covered by satellite-based imagery, as they require very specific in-situ measurements (e.g. Ground Penetrating Radar (GPR), in-situ bathymetric surveys, etc.) or complex value-added products (e.g. assessment of sites frequentation pattern).

The tables below present the list of products currently offered by the different Copernicus core services that are suitable for Cultural Heritage and could respond to CH user requirements. For more details on this list, please refer to the detailed match analysis presented in **Annex D**.

Table 34: List of all Copernicus core services' products of interest for CH user communities (Sources: PwC analysis)

Land Monitoring Service	
Copernicus core service product	User requirements corresponding
Imagery & Reference Data, European Images Mosaic, Very High Resolution	• Indirect indicators (Cropmarks, soilmarks, chlorophyll levels) • Map regression • Photogrammetric mapping • Topographic mapping • Identification of previously searched sites in the area • Vegetation level monitoring • 3D reconstruction
Global, NDVI	• Normalized difference vegetation index (NDVI) • Vegetation level monitoring
Global, Land Surface Temperature	• Thermal anomaly
Imagery & Reference Data, EU-DEM	• Elevation modelling • Topographic mapping
Local, Urban Atlas	• Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)
Pan-European, High Resolution Layers, Forest	• Evolution of vegetation typology • Vegetation level monitoring • Forest coverage monitoring
Pan-European, High Resolution Layers, Grassland	• Evolution of vegetation typology • Vegetation level monitoring
Pan-European, High Resolution Layers, Water & Wetness	• Hydrological changes monitoring
Local, Natura 2000	• Evolution of vegetation typology monitoring • Vegetation level monitoring • Forest coverage monitoring
Global, Lake Water Quality products	• Water quality monitoring
Marine Environment Monitoring Service	
Copernicus core service product	User requirements
Regional & Global Sea analysis, Sea ice	• Ice cover monitoring (sea)
Regional & Global Sea analysis, Salinity	• Salinity levels measurement
Ocean Colour Thematic Center (OC TAC), CHL & OPTICS	• Sediment levels measurement
Regional & Global Sea analysis, Current Velocity	• Water current monitoring

Regional & Global Sea analysis, Wind	• Wind direction & speed monitoring
Regional & Global Sea analysis, Sea Surface Height	• Water level monitoring
Regional & Global Sea analysis, Temperature	• Sea surface temperature monitoring
Climate Change Monitoring Service	
Copernicus core service product	User requirements
ERA5 Climate Reanalysis	• Wind direction & speed monitoring
Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	• Water quality monitoring • Water pollution monitoring
Water quantity indicators (water runoff, wetness, river flow, snow water equivalent, soil water content, etc.)	• Hydrological changes monitoring
Sea Ice (thickness, edge, concentration, type)	• Ice cover monitoring (sea)
Sea level	• Water level monitoring
Sea Surface Temperature	• Sea surface temperature monitoring
Atmosphere Monitoring Service	
Copernicus core service product	User requirements
CAMS, Global forecast of aerosol	• Air pollution monitoring for blackening of built structures • Air pollution monitoring (natural heritage sites)
CAMS, European-Scale air quality analysis	• Air pollution monitoring for blackening of structures • Air pollution monitoring (natural heritage sites)
Clear-Sky Radiation (McClear)	• Insolation monitoring
Clear-Sky Radiation (Heliosat-4)	• Insolation monitoring
Emergency Monitoring Service	
Copernicus core service product	User requirements
Global flood awareness system	• Hydrological changes monitoring
On-demand Mapping	• Real-time monitoring of emergency events (e.g. flash floods, forest fires)
Ealy Warning and Monitoring System	• Real-time monitoring of emergency events (e.g. flash floods, forest fires)
Security Service	
Copernicus core service product	User requirements

Damage Assessment	• Human conflict risk monitoring
Activity Monitoring	• Human conflict risk monitoring

These tables only present existing products offered by each Copernicus core service that, in their current forms, already respond somehow to CH user requirements. Nevertheless, it was highlighted several times during interviews with Copernicus entrusted entities that they often already have internally the necessary raw data (imagery & in-situ data) and models to cover specific CH user requirements by developing additional products, or adapting existing ones. However, until Cultural Heritage will be included in their delegations agreements, entrusted entities do not have the mandate to develop such specific products in their current budget.

The downstream industry could also play a significant role by developing additional products tailored to CH, as a large part of CH user communities are not experts in remote sensing and thus are not always able to use directly satellite imagery.

4.4 Specific capabilities offered by the Copernicus programme for security & emergency purposes

Beyond the needs already analysed in the preceding sections, there exists other Cultural Heritage needs related to Emergency (i.e. geo-hazards mitigation & response) and Security (i.e. protection of Cultural Heritage from man-made destruction). These needs have been expressed and analysed in the **High level user need 8 – Drawing of conclusions to facilitate an emergency intervention**. As stated in the match analysis, the Copernicus programme already has specific capabilities related to Emergency response and Security. The following sub-sections introduce Copernicus capabilities for these purposes.

4.4.1 Security purpose: the protection and safeguarding of Cultural Heritage from man-made destruction

4.4.1.1 Introduction

Man-made destruction related to Cultural Heritage is affecting both Tangible Heritage and Natural Heritage. It can be divided into three main categories:

- **Non-hidden site destruction due to religious and fundamental reasons**: as a display of power over a certain area or location, individuals decide to intentionally destroy non-hidden Heritage considered as offensive. This category is most relevant to Tangible Heritage, rather than to Natural Heritage;
- **Non-hidden site destruction indirectly (e.g. war zone):** the destruction of non-hidden Cultural Heritage sites is a side-effect of a local human-made crisis (e.g. war), rather than being intentionally destroyed. This category is relevant for both Tangible Heritage and Natural Heritage;
- **Poaching of hidden archaeological artefacts**: sponsored by private money, individuals illegally excavate archaeological sites in order to find artefacts and sell them on black market. This category is mostly relevant to Tangible Heritage, instead of Natural Heritage.

Man-made destruction of Cultural Heritage is a growing concern worldwide (e.g. Bamiyan buddha destruction in Afghanistan, Palmyra destruction in Syria, etc.). Many countries have at-risk Cultural Heritage sites and hence have interest to collaborate with the EU in this field.

4.4.1.2 Copernicus in support of EU External Action

The EU Satellite Centre (SatCen) is in charge of the Copernicus Security service in support of EU External Action (Copernicus SEA). Since May 2017, the service is fully operational and it provides authorized EU users in security and defence with a range of EO-based security products, including dedicated Cultural Heritage products. This service is not fully open as for the Land, Marine Atmosphere and Climate Change Monitoring Services; it is reserved for authorized EU users and select authorized third parties (e.g. UN) only.

The mandate of the Copernicus SEA is to respond to authorized users' requests outside of EU borders related to Cultural Heritages sites in danger. In order to monitor and mitigate these man-made destructions, specific analysis capabilities are necessary, such as expertise in archaeology and history, or a security and defense background, but also the access to very high resolution (VHR) optical imagery. The Copernicus SEA has a specific access to VHR optical contributing missions (e.g. Pleiades) for this purpose.

The action of SatCen in the field of Cultural Heritage can be split into two main activities:

- **Damage assessment**: change detection products (based on the ability to assess damage related to a specific Cultural Heritage site in a crisis area, available on demand;
- **Activity analysis**: EO-based products analysing pre and post human activity over Cultural Heritage sites, available on demand and/or for monitoring activities.

As for now, the Copernicus SEA focuses mostly on Tangible Heritage and it does not specifically look at Natural Heritage sites, since these activities are not currently in their core activities. Nevertheless, armed conflicts could heavily impact natural landscapes and hence natural heritage sites. SatCen has the internal expertise and capacity to cover both Tangible Heritage and Natural Heritage. Additional products specifically tailored to the needs of Cultural Heritage communities could be added to the Copernicus SEA service evolution if requested by the EC.

The overall needs related to the protection of Cultural Heritage from man-made destruction are summarised in the table below.

Table 35: Summary of the protection of cultural heritage needs from man-made destruction

Specific Needs related to the protection of Cultural Heritage from man-made destruction		**Capabilities of the Copernicus SEA**
Tangible Heritage	Monitoring of intentional site destruction due to religious and fundamental reasons	Fully covered by Copernicus SEA through two existing products: "Damage assessment" & "Activity analysis"
	Monitoring of unintentional site destruction (e.g. war zone)	
	Monitoring illegal looting of archaeological artefacts	
Natural Heritage	Monitoring of unintentional site destruction (e.g. war zone)	Currently not covered by Copernicus SEA outside of EU Possible adaptations of "Damage assessment" and "Activity Monitoring" products

4.4.2 Emergency purpose: Protection and safeguarding of Cultural Heritage from geo-hazards

4.4.2.1 Introduction

Heritage sites are continuously impacted by geo-hazards, including natural disasters (e.g. landslides, earthquakes, fires, etc.) and extreme meteorological events (e.g. heavy rains, drought, etc.), leading to irreversible damages and destruction.[157] The protection and safeguarding of Heritage from geo-hazards can be split in four main categories:

- **Geo-hazard risk mappings**– mapping of Heritage sites that can be subjected to damage in cases of extreme meteorological events (e.g. torrential rains leading to rapid flooding or landslides) or natural disasters (e.g. risk of earthquakes, risk of volcanic eruptions, etc.);
- **Geo-hazard early warning** – alarms raised related to Heritage sites that may be impacted/damaged by a geo-hazard in the near future;
- **Geo-hazard monitoring** – monitoring of Heritage sites during a specific geo-hazard to support damages mitigation and damages assessment;
- **Geo-hazard damage assessment** – assessment of damage to Heritage sites due to a specific geo-hazard.

The capacity of performing these four categories of activities is key for the protection and safeguarding of Heritage sites in Europe and worldwide. However, when a geo-hazard occurs, civil protection agencies in charge of emergency response and mitigation naturally focus first on human life protection and damage prevention on land use (e.g. critical infrastructure, farms, industries, etc.). In general, the safeguarding of Cultural Heritage is usually not a major concern of civil protection agencies. Often, there is a lack of communication between Cultural Heritage communities and local and national civil protection agencies, leading to a low awareness about Heritage sites with civil protection communities.

4.4.2.2 Copernicus Emergency Monitoring Service

The Joint Research Centre (JRC) is the Entrusted Entity for the Copernicus Emergency Monitoring Service (EMS) that provides information for disaster risk and recovery as well as for emergency response related to natural disasters, extreme meteorological events and accidental man-made disasters (e.g. chemical spills, nuclear spills, etc.). The Copernicus EMS targets authorised users from civil protection agencies as well as UN agencies and international NGOs and offers specifically:

- **On-demand mapping**: provision of rapid maps for emergency response, and risk and recovery maps for prevention and planning;
- **Early warning and monitoring system**: provision of geo-hazard forecast and monitoring to support situational awareness, and decision-making for prevention and preparedness purposes.

Cultural Heritage is not the main focus of the EMS as it is not currently a specific mandate of the service. However, authorised users have already activated cultural heritage-specific requests for rapid mapping, as well as risk and recovery products, so the EMS has already the capacity to cover fully Cultural Heritage-specific needs for on-demand mapping (e.g. damage assessment), for both Tangible Heritage and Natural Heritage. For the specific case of Natural Heritage sites, there is currently no real consistency cross-check with Natura 2000 sites though there are some

[157] PROTection of European Cultural HEritage from GeO-hazards (PROTHEGO) project. Website link: http://www.prothego.eu/project.html

ongoing projects. Nevertheless, the EMS is using the same portfolio for Tangible and Natural Heritage. For an early warning and monitoring system, the current EMS portfolio does not provide specific Cultural Heritage-related offers, but it is foreseen to be included in the expansion of the Risk & Recovery Mapping service of the EMS.

The overall needs related to the protection of Cultural Heritage from geo-hazards are summarised in the table below.

Table 36: Summary of the protection of Cultural Heritage needs from geo-hazard events

Specific Needs related to the protection of Cultural Heritage from geo-hazards		**Capabilities of the Copernicus EMS**
Tangible Heritage & Natural Heritage	Geo-hazard risk mappings	Fully covered by Copernicus EMS
	Geo-hazard early warning	
	Geo-hazard monitoring	
	Geo-hazard damage assessment	

5 Options for an intervention from the European Commission

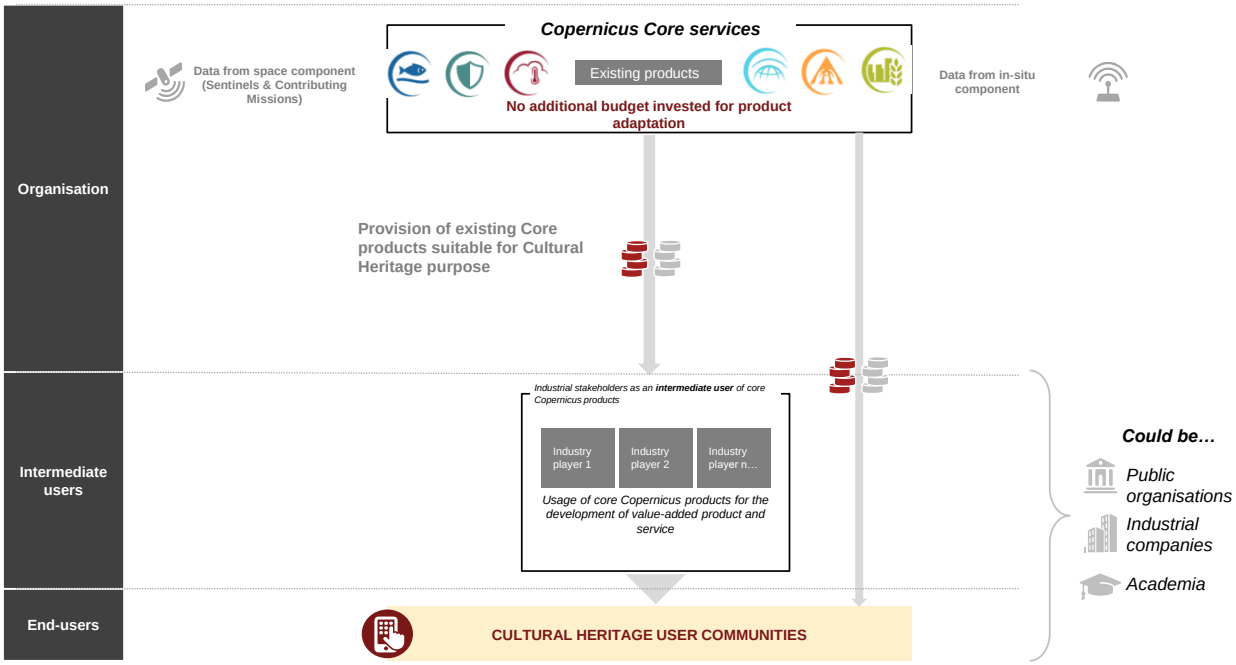
Previous chapters have isolated the Cultural Heritage value chain and the different user needs associated to the different activities carried out by Cultural Heritage user communities. Those needs have been first translated into user requirements and then into technical specifications, in order to understand how Copernicus capabilities could cover those specifications. This analysis has demonstrated that the Copernicus programme is able to respond to a large part of the Cultural Heritage user needs either through existing core products, existing core products which must be adapted in order to be suitable for Cultural Heritage purposes, and additional products not currently existing within the Copernicus programme but that could be developed.

An institutional action to promote the use of Copernicus for Cultural Heritage monitoring, conservation/preservation and management would then be required to enable this match between Copernicus capabilities and Cultural Heritage user needs[158]. This intervention could take several forms and the next section aims at characterising the different options under scrutiny.

5.1 Option 1: List of Copernicus products suitable for Cultural Heritage applications

Option 1 consists of relying on existing core products, data and information that are currently suitable for Cultural Heritage applications, but emphasising the existence of such products by raising awareness. The chart below summarises the scope of option 1.

Figure 46: Option 1 description – Cultural Heritage as a list of existing Copernicus products



[158] Note that the match between user needs and Copernicus capabilities is enabled by three intermediate steps: first user needs are translated into user requirements (1st step), then user requirements are translated into technical specifications (2nd step) and finally technical specifications are matched with Copernicus capabilities (3rd step).

As the governing body of the Copernicus programme, the European Commission would be in charge of investing money in communication and outreach activities. This is aimed at two things: first, raising awareness regarding the existence and availability of Copernicus data and products that might be of interest for several Cultural Heritage activities (i.e. efforts on market uptake activities); second, improving ease of access to such type of information. These communication activities should be carried out by the European Commission itself, which would dedicate a budget for the implementation of Cultural Heritage promotion activities in order to raise awareness of the availability of Copernicus data and information that are suitable for specific Cultural Heritage activities (e.g. workshop organisation, publications, outreach events, etc.) and explain where and how users can find those products, data and information. Thus, under option 1, the main role of the European Commission would be to **ensure the implementation of awareness raising activities thanks to a dedicated budget** for Cultural Heritage.

Under this option, management of the Copernicus data and products useful for Cultural Heritage would remain under the purview of each of the Copernicus services. The Copernicus services have currently developed products that can be used for Cultural Heritage activities, but that are tailored for other domains. As such, these products are not emphasised by the service platform through a specific category of Cultural Heritage products but are to be found among existing categories.

In this context, the option would mostly respond to user communities with a certain level of technical knowledge, who are able to access and find relevant data and information on existing Copernicus core services and on the Scientific Data Hub.

No budget would be dedicated to product development or tailoring of existing products to specific Cultural Heritage needs under option 1. As such, under option 1, the **product availability would be as it exists to date**. This implies that there would be no new standards created besides those currently existing with Copernicus.

Under option 1, the Cultural Heritage communities can therefore either rely:

- Directly on existing Copernicus data and information;
- On value-added information products that rely on Copernicus data and information that have been transformed and enhanced by intermediate users (i.e. downstream companies).

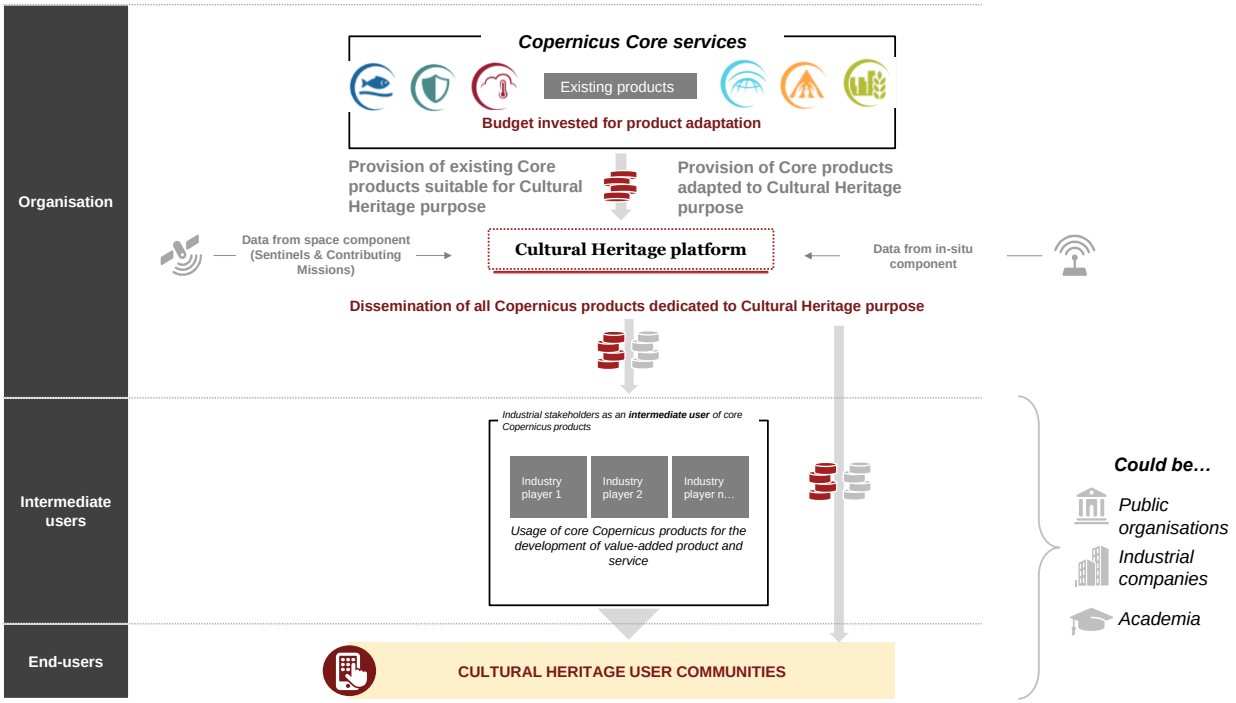
Overall, option 1 can be summarised with the following points:

- Reliance on existing core products, data and information without the development of new products nor the adaptation of current products;
- Availability of products on currently existing Copernicus core services platforms;
- Budget investment for awareness raising and market uptake activities.

5.2 Option 2: Cultural Heritage as part of one or more existing services

Option 2 consists of setting up a specific user platform in the form of a web-based interface (i.e. web-based front-end) fully dedicated to Cultural Heritage, where user communities could find existing Copernicus data and information suitable for Cultural Heritage activities together with additional existing products from core services that have been adapted to Cultural Heritage needs. This platform would likely be leveraging on the DIAS initiatives currently being developed. The chart below summarises the scope of option 2.

Figure 47: Option 2 description – Cultural Heritage as a dedicated interface part of the Copernicus programme



As the governing body of the European Earth observation programme, the European Commission would be in charge of funding the creation of an interface that would centralise the access to all Copernicus data and information suitable for Cultural Heritage activities. The products found via this front-end would come from the six service platforms that offer accessible and relevant products for Cultural Heritage. A specific access to Sentinels and contributing missions' (e.g. direct link to Scientific Hub) data would also be available on the platform. This platform should benefit from the development of the DIAS platform, expected to be operational in the near future; the DIAS initiative should ease data dissemination, hence the Cultural Heritage web interface should capitalise on this. As such, under option 2, a **budget would be dedicated to the development of a digital environment (e.g. application programme interface (API)) where user would be able to easily access directly all products suitable for Cultural Heritage, hence setting-up a front-end dedicated to Cultural Heritage**. Such an investment could have **indirect impacts on Copernicus user uptake from Cultural Heritage communities, as this would ease access to Copernicus** data and information.

The management of the Cultural Heritage platform would either be under the European Commission or from one of the existing Entrusted Entities. The interface should be similar to what is currently done on the Copernicus Climate Change Service website with the Sectoral Information System, which provides specific information in dedicated areas (e.g. water, energy, insurance, etc.)[159]. The Entrusted Entities would provide all the products that would feed the platform: they would either be proposed as is currently on the service website or be available in a way that makes them adaptable to the specific needs of Cultural Heritage user communities. The European Commission, under option 2, would dedicate a **specific budget dedicated to product tailoring** for each Copernicus core service, based on those products that are of interest for Cultural Heritage but require some adaptations. The provision of tailored products should favour the development of standards on Cultural Heritage. Indeed, the availability of adaptable products should foster user uptake and push for more standardisation for Copernicus and especially Cultural Heritage. This option should also enable the European Commission to **unlock**

[159] https://climate.copernicus.eu/sectoral-information-system

specific grants and funding mechanisms to support R&D and knowledge creation in the field of Earth Observation applied to Cultural Heritage activities.

Under option 2, the Cultural Heritage communities can therefore either rely:

- Directly on Copernicus data and information provided by the platform;
- On value-added information products that rely on Copernicus data and information extracted from the Cultural Heritage platform that have been transformed and enhanced by intermediate users (i.e. downstream companies).

Under option 2, the Cultural Heritage communities can therefore pick both existing and tailored Copernicus products on a Cultural Heritage interface, or rely on value-added products resulting from the transformation of these data and products by intermediate users.

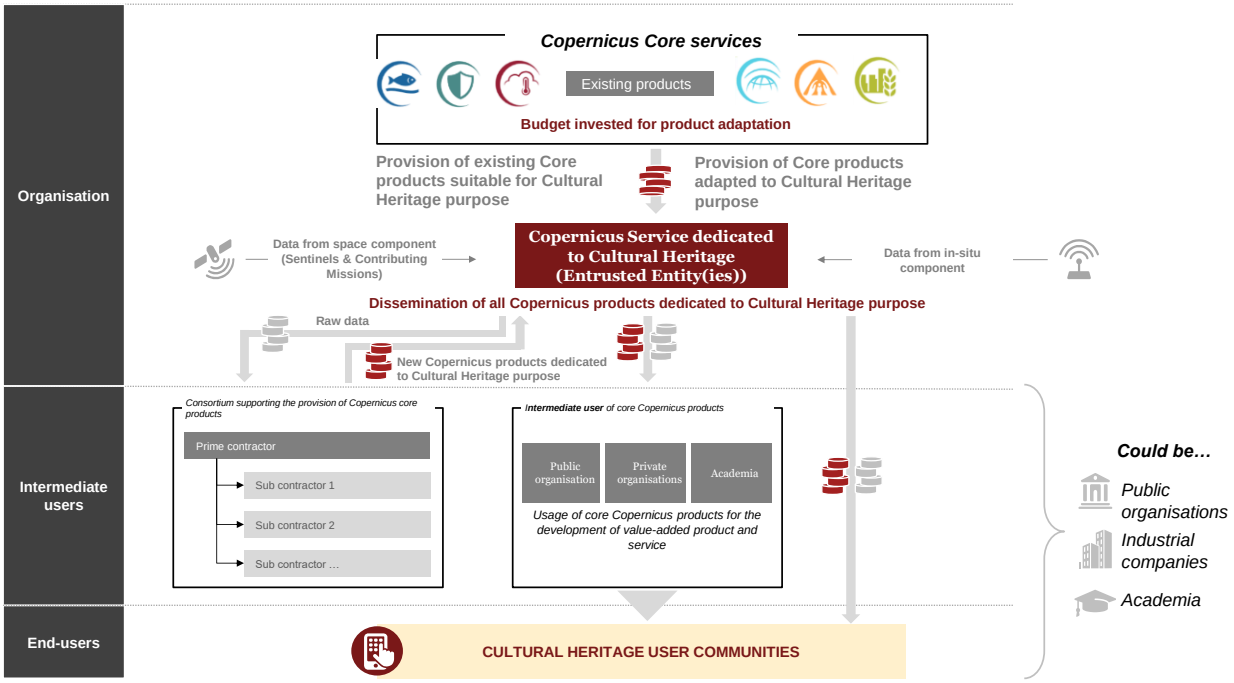
Overall, option 2 can be summarised with the following points:

- Reliance on existing core products, data and information as well as on the adaptation of current products;
- Availability of products on a dedicated Cultural Heritage platform (probably hosted on DIAS initiatives);
- Budget investment to raise awareness and support R&D and knowledge creation.

5.3 Option 3: Creation of a new Copernicus service dedicated to Cultural Heritage

Option 3 consists of the creation of a Copernicus Service, in addition to the existing ones (e.g. Land Monitoring service, Emergency Management service, Marine Monitoring service, etc.), which would be exclusively dedicated to Cultural Heritage. The chart below summarises the scope of option 3.

Figure 48: Option 3 description – Cultural Heritage as a new Copernicus service



The European Commission would be funding the creation of an additional Copernicus service fully dedicated to Cultural Heritage. This implies major changes in terms of governance when compared to options 1 and 2. Indeed, the European Commission would need to issue a Delegation Agreement summarising all the activities expected from the Entrusted Entity that would be in charge of the Cultural Heritage service and the **budget that would be dedicated to operation and management activities**. For the existing Entrusted Entities, the Delegation Agreements forecasted yearly commitments of about EUR 14.7 M per year over the 2014-2016 period, with values between entities ranging from EUR 7.2 M to EUR 19.8 M per year on average[160]. The Copernicus Cultural Heritage service should be less demanding (i.e. in terms of resources) than the Land or the Marine service, but still impactful. Under option 3, the European Commission would be in charge of a long **administrative process going from the choice of the appointed Entrusted Entity to the signature of the Delegation Agreement**. The Cultural Heritage service would be either **managed by one of the current Entrusted Entities (e.g. EEA) or by a new one**.

The creation of a new service not only implies the appointment of an Entrusted Entity, but also of a **consortium of companies**. This consortium would be composed of a prime contractor and several sub-contractors that are usually public organisations, industrial companies or university research centres. The consortium would be in charge of the development of new Cultural Heritage products whereas the existing services would receive additional budgets for tailoring some of their products to Cultural Heritage needs (i.e. as for option 2), and the Entrusted Entity in charge of the new Cultural Heritage service would gather everything on a dedicated interface. The development of new products as well as tailoring activities would be supported by Sentinel data, contributing mission data and in-situ data used for calibration purposes. More in-situ data should be available than in the other options, as the appointment of an Entrusted Entity in charge of a service implies the collection and centralisation of all necessary in-situ data for product provision. Additionally to a single front-end, a core service is also in charge of collecting user needs in order to support the evolution of the service (e.g. the need for new type of products) and the Copernicus programme (e.g. the need for new type of sensors).

Under option 3, the Cultural Heritage user communities would be able to turn to a dedicated service providing specific products, data and information, together with a permanent feed-back

[160] European Commission, 2017, Interim evaluation of Copernicus

loop from users to monitor the evolution of their needs. Such a service would be one-of-a-kind, implying that the more interesting Cultural Heritage products, data and information become available, the bigger the interest would be from the international community to turn to Copernicus. As a result, this would foster the uptake of Copernicus Cultural Heritage standards globally, especially for the development of models or algorithms. Moreover, as an Entrusted Entity would be in charge of the Copernicus Cultural Heritage service, it would benefit from additional funding to develop call for tenders through R&D tools in order to foster the development of Value-Added Services (VAS), and so supporting the competitiveness of the downstream industry (i.e. intermediate users community) in Europe. This additional funding would have positive impact on knowledge spillovers related to the use of EO in the field of Cultural Heritage but also for European digital heritage.

Overall, option 3 can be summarised with the following points:

- Development of new products complementary to existing core products, data and information and to adapted products;
- Creation of a new Copernicus service dedicated to Cultural Heritage;
- Appointment of a consortium of companies in charge of the development of new products and services in support of Cultural Heritage purposes.

5.4 Summary of the main differences between options

The main differences between the three options are summarised in the table below.

Table 37: Summary of differences between intervention options

	Option 1	Option 2	Option 3
Budget	Budget to support user uptake	Budget to support user uptake; Budget for the development of a dedicated web-based interface; Budget for product tailoring; Budget for grants and funding mechanisms.	Budget to support user uptake; Budget for setting up a Copernicus service (including the development of a dedicated web-based interface); Budget for product tailoring; Budget for grants and funding mechanisms.
Legal implications	N/A	Issuing of a legal document enabling platform creation	Issuing of a Delegation agreement
Management	N/A	EC or one of the EEE	EEE (existing or new one)

Data & information access	No centralisation of access to Copernicus data & information suitable for CH activities	Centralisation of Copernicus data & information suitable for CH activities (web-based platform)	Centralisation of Copernicus data & information suitable for CH activities (web-based platform)
Products development	No tailoring of existing Copernicus products No creation of new Copernicus products tailored to CH needs	Tailoring of existing Copernicus products to CH needs; No creation of new Copernicus products tailored to CH needs.	Tailoring of existing Copernicus products to CH needs; Creation of new Copernicus products tailored to CH needs.
Standardisation	No specific impact	Incentives towards standardisation	Major incentives towards standardisation

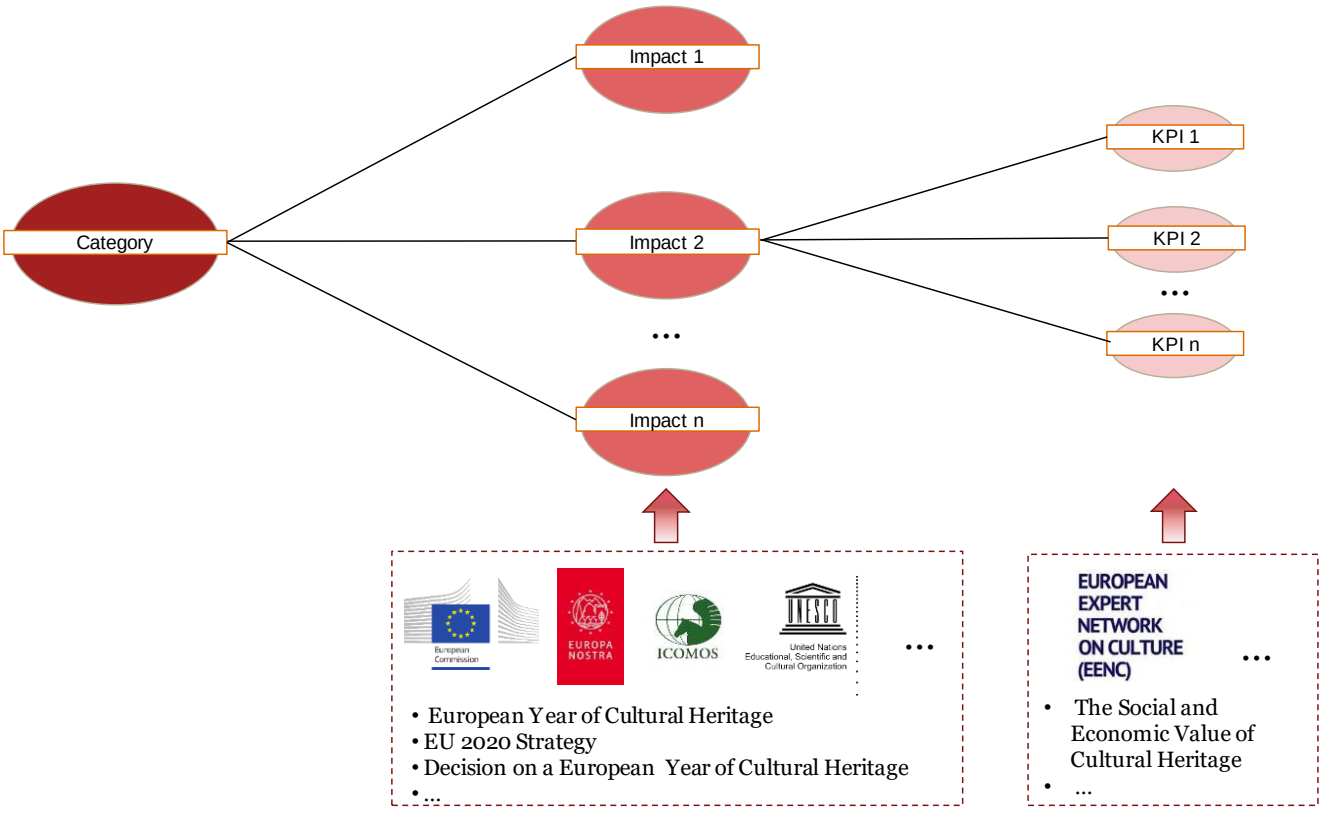
6 Impacts derived from the implementation of the different option

6.1 Presentation of impacts

The different options mentioned in the section hereinabove have been analysed through the lens of predefined impacts and Key Performance Indicators (KPIs) common to all options, to ensure comparability between options. **As the analysis is an impact evaluation and not an impact assessment, the objective is to give an order of magnitude of the impacts generated by each option rather than an accurate cost-benefit analysis.**

The final list of impacts is composed of seven impacts. Each impact is characterised as either economic, societal or strategic and is split into several KPIs, which are metrics that enable the assessment of the impact. The chart below illustrates the approach used to derive the different KPIs to be looked at.

Figure 49: Different steps included in the impact definition process



The following list of impacts and related KPIs presents how each KPI has been analysed. Some KPIs appear as less precise than others: these are the KPIs assessed through a Likert scale. Indeed, they are rather concept indicators than metric indicators as they cannot be directly measured (e.g. in Euros, number of visitors, etc.) and have been assessed through stakeholder consultation.

Table 38: Categorisation of impacts and KPIs

Category	Impacts	KPIs	Evaluation approach
Economic	Cost of the options	Costs to develop and operate the different options	Quantitative (monetary)
	Option implementation process	Complexity of option implementation	Quantitative (Likert scale)
		Administrative burden	Quantitative (Likert scale)
		Partnerships and collaborations between Member States	Quantitative (Likert scale)
	Competitiveness	Enabled revenues for the downstream sector	Quantitative (monetary)
		Wider economic and societal impacts	Quantitative (monetary)
		Competitive downstream sector	Quantitative (Likert scale)
		R&D (e.g. skills, knowledge, innovation)	Quantitative (Likert scale)
	Employment	Direct job creation	Quantitative (monetary)
		Indirect and induced job creation	Quantitative (monetary)
Strategic	EU Leadership	Positioning of EU as a leader in the field of Cultural Heritage	Quantitative (Likert scale)
		Partnerships & collaborations with third countries and international organisations	Quantitative (Likert scale)
		Standardisation of data	Quantitative (Likert scale)
Societal	Valorisation of Cultural Heritage	Increased visibility of the Cultural Heritage sector through digitisation and online access	Quantitative (Likert scale)
		Centralisation of data access for the Cultural Heritage communities	Quantitative (Likert scale)
	Support to European knowledge	Academia (e.g. publications, conferences); education and knowledge sharing within the Cultural Heritage user communities	Quantitative (Likert scale)

Once the evaluation of all KPIs has been performed, a summary with the strengths and weaknesses of the impacts per option is presented.

6.1.1 Assumptions

In the following evaluation, several assumptions have been taken. The first one refers to the timeframe most relevant to evaluate the impacts. Considering one of the options include the setup of a service, which takes years to be fully operational, **all options will be quantitatively analysed over a 7-year time period**: two years to make the service operational and five more years to analyse the service once operational. Intervention options all begin in 2019, as a starting date was required for the analysis of impacts.

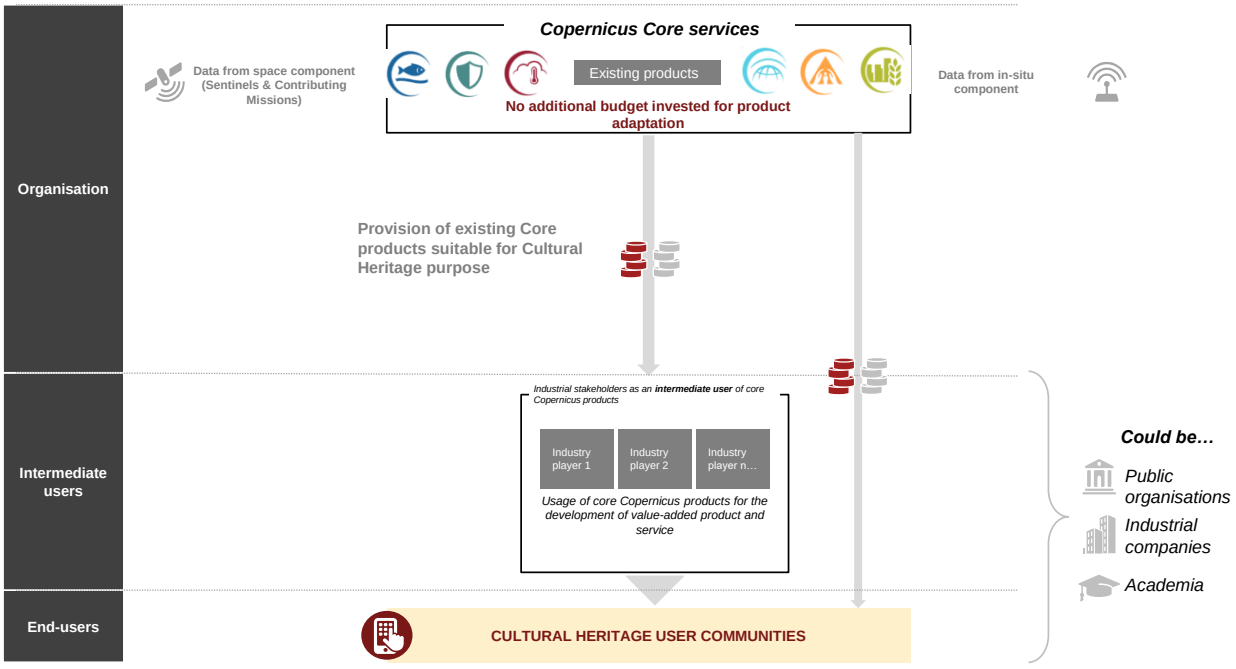
Moreover, all costs of implementation of the options have been considered constant over the time period under scrutiny, with the exception of option 3, which evolves overtime; in reality, these values could vary each year depending on the specific needs of the option and its impacts, but these have been smoothed in this analysis as there is no evidence of a potential cost evolution over time.

Finally, all **quantitative values derived from options evaluation are indicative**. The aim of such assessment is to help give order of magnitudes of the options, and not concrete and definitive impacts evaluation.

6.1.2 Impact evaluation of option 1

The evaluation of option 1 consists of the analysis of the impacts resulting from increased efforts on awareness raising and market uptake activities from the European Commission, in order to promote the currently existing Copernicus products, data and information that could be suitable for Cultural Heritage applications. As a reminder from Chapter 5, option 1 is illustrated below.

Figure 50: Option 1 description – Cultural Heritage as a list of existing Copernicus products



6.1.2.1 User requirements covered by option 1

Option 1 is expected to rely on a list of existing Copernicus products, and so no specific budget will be made available to Copernicus core services for the adaptation of existing products to respond to the needs of CH users' communities. Additionally, no budget will be made available to develop new products tailored for CH user needs.

Under option 1, 7,5% of CH user requirements would be fully covered by existing Copernicus core services products and an additional 19% of CH user requirements would be partially covered by those products (please refer to the section 4.3.4 for more details on the match analysis). An additional 3,2% and 1,1% of CH user requirements could be respectively fully and partially covered by the Copernicus programme thanks to the Sentinels capabilities. Nevertheless, these 3,2% of user requirements could only be covered for downstream companies and technical CH user communities, as the Sentinels data would need to be processed and transformed into information products to respond to user requirements (again, please refer to section 4.3 for more details on the match analysis).

As a conclusion, under option 1:

- Between 7,5 and 10,7% of CH user requirements would be fully covered;
- 19,0% and 20,1% of CH user requirement would be partially covered.

6.1.2.2 Economic impacts

6.1.2.2.1 Cost of the options

Cost of option 1	**EUR 75 K per year**

The implementation of option 1 would imply little investment; the development cost of this option would be nil as no new infrastructure would be needed and the operating costs would be minimal, as they consist of the launch of awareness raising and market uptake activities, that is workshops and outreach events organisation, press and media publications, use cases development or newsletter implementation, as well as communication on where and how users can find Copernicus products, data and information suitable for Cultural Heritage. The latter partly corresponds to cross-cutting activities as defined in the Copernicus Regulation. Indeed, cross-cutting activities include communication and dissemination activities, users and potential capacity building activities, activities to support the uptake of Copernicus data and products, taking stock of Copernicus uptake and the evolution of the Copernicus programme, the evolution of Copernicus data distribution and user access, and the acquisition of indefeasible rights of use on the high-bandwidth transatlantic submarine telecommunication cable[161]. An analysis of the 2016 budget for the service component determined that cross-cutting activities represent about 10% of the service component budget, and that what corresponds to the awareness raising and market uptake activities described above represents 5% of the service component budget[162]. As such, this value is used as a proxy to determine the cost of the awareness raising activities included in option 1. This 5% is applied to the cost of option 2, as awareness raising activities are expected to be similar in both options. Thus, the implementation of option 1 would cost around EUR 75 K per year.

6.1.2.2.2 Option implementation process

Complexity of option implementation	-4 ○ ○ ○ ○ **0** ○ ○ ○ ○ 4

The awareness raising and market uptake activities would be dealt with either by the European Commission itself or by the Entrusted Entities in charge of the existing Copernicus core services. In both cases, the complexity of implementation would be non-existent as it would only imply an increase of the budget dedicated to promotion and communication activities, which is a budget line that already exists for the different entities.

[161] European Commission, 2016, ANNEX to the Commission Implementing Decision on the adoption of the 2016 Copernicus Work Programme (Online). Available at: http://ec.europa.eu/transparency/regdoc/rep/3/2016/EN/3-2016-743-EN-F1-1-ANNEX-1.PDF
[162] European Commission, 2016, ANNEX to the Commission Implementing Decision on the adoption of the 2016 Copernicus Work Programme (Online). Available at: http://ec.europa.eu/transparency/regdoc/rep/3/2016/EN/3-2016-743-EN-F1-1-ANNEX-1.PDF

Administrative burden	-4 ○ ○ ○ ○ ● ○ ○ ○ ○ 4

As for public authorities, option 1 should not result in any specific new heavy administrative burden. Administrative burden here refers to all the administrative tasks that are necessary to be implemented in order to access Copernicus data and products. Indeed, nothing would change on how to access the Copernicus products, data and information, as this option focuses on awareness raising and users still have to interact directly with each of the Copernicus services. Hence the current administrative frame of public authorities should not be greatly interfered with by the European Commission intervention of option 1.

Partnerships and collaborations between Member States	-4 ○ ○ ○ ○ ● ○ ○ ○ ○ 4

As Cultural Heritage is a global issue, European Member States are incentivised to cooperate and collaborate with one another to conserve and preserve European Heritage. Option 1 would be expected to marginally favour partnerships between Member States. Indeed, Copernicus already provides the necessary resources for Member States to engage in cross-country collaborations, notably in the form of communication and project calls.

6.1.2.2.3 Competitiveness

Enabled revenues	**Between EUR 540 K and EUR 750 K over 2019-2025**

Under option 1, EUR 75 K would be invested for awareness raising activities each year and this would be expected to enable additional revenues for the downstream sector for Cultural Heritage, which comprises developers of products and services linked to the use of Earth Observation (EO) or of Geospatial Information Systems (GIS).

Based on a proxy analysing the impacts of Copernicus on the revenues of all types of intermediate users with respect to the amount invested by the European Commission, enabled revenues are assumed to range between 1.03 and 1.43 of the investment[163], meaning that for each euro invested in the Copernicus programme, service-related activities between EUR 1.03 and EUR 1.43 are created within the European downstream industry. As such, yearly enabled revenues for the downstream sector would range from EUR 77 K and EUR 107 K, with an average at EUR 92 K. Looking at the larger time frame of 2019-2025, which is a period that could enable a stronger uptake of Cultural Heritage data and information, enabled revenues for the downstream sector would range from EUR 540 K to EUR 750 K, with an average at EUR 645 K. As a result, revenues of the downstream sector would not drastically increase, especially because it would still be complicated for downstream companies to reach to Entrusted Entities for support on product development, as the current catalogue would remain unchanged.

Wider economic & societal impacts	**Between EUR 2.95 M and EUR 5.3 Mover 2019-2025**

Wider economic and societal impacts refer to the benefits to the wider society of an EC intervention in the field of Cultural Heritage. These impacts take into account indirect economic impacts (e.g. additional tourism revenues, additional consumption, renovation and construction to support CH, etc.) and societal and environmental impacts (e.g. protection of Cultural Heritage, environment protection, etc.).

In the case of option 1, wider economic and societal impacts would be expected to range between EUR 420 K and EUR 760 K, with an average of EUR 570 K each year, and a cumulated value over the 2019 – 2025 period ranging between EUR 2.95 M and EUR 5.3 M, with an average of EUR 4.0 M. These values stem from a proxy based on societal and wider impacts to end users

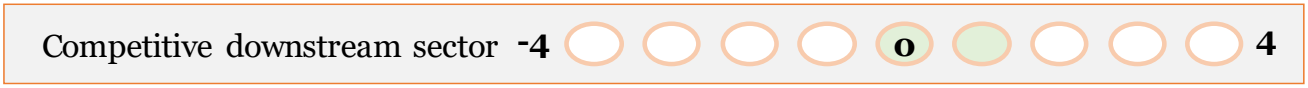
[163] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

(thus excluding intermediate users, that is to say the downstream sector) of the Copernicus programme: each EUR 1 invested should generate between EUR 5.61 and EUR 10.1[164].

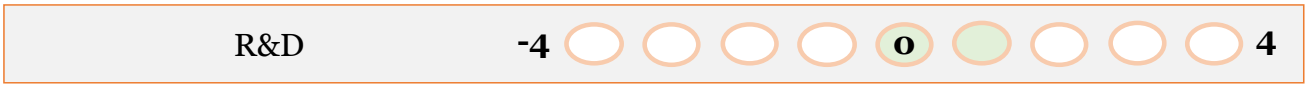
The table below summarises the overall expected monetary benefits derived from option 1 over the period 2019 – 2025.

Table 39: Option 1 expected monetary benefits over the period 2019 - 2025

	Enabled revenues for intermediate users	**Wider impacts for end users**
Low scenario	EUR 0.54 M	EUR 2.95 M
Average scenario	EUR 0.65 M	EUR 4.0 M
High scenario	EUR 0.75 M	EUR 5.30 M



With regards to the results of the enabled revenues for the downstream sector dealing with Cultural Heritage activities, it can be expected that their competitiveness would be quite marginal. Under option 1, intermediate users would not have any new data or information tailored to their needs. The downstream sector would only be aware of the availability of free and open Copernicus data that sometimes corresponds to their needs but that they were not previously aware of and that they could have potentially been paying for before.



The implementation of option 1 would be associated with marginal efforts in R&D. The sole difference between option 1 and the current situation regarding Cultural Heritage would be the effort on awareness raising and market uptake activities. However, the user communities that would be concerned by such promotion campaigns would be those with a certain level of technical knowledge on Earth Observation and on Copernicus, since these user communities would have to find by themselves the different Copernicus services that may have products relevant to their activities, even though these have not been flagged as suitable for Cultural Heritage. Or they would have to go directly to the Scientific Hub, implying that they would have to be aware of the type of products they need in terms of technical specifications (sensor, resolution, frequency, etc.). Stakeholder consultation with experts on Cultural Heritage has indeed emphasised that their lack of understanding of Earth Observation data was a barrier to their use of Copernicus, considering the way the products are currently made available. Moreover, there would be no availability of specific grants and funding schemes under option 1. Thus, even if more technical users would be reached, they would not be supported by public investment. As such, it would be hard under option 1 to capitalise on knowledge, innovation and skills creation as the audience of Copernicus would remain limited.

6.1.2.2.4 Employment

Investing in Cultural Heritage through the Copernicus programme would have an impact on employment, both on direct jobs (that is, employment in the downstream sector) but also on induced jobs (employment related to the impact of the use of products from the downstream sector).

[164] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

It is expected that for each EUR 1 M generated by the downstream industry, 8 jobs are supported in the downstream[165]. As such, under option 1, building on the previous results of enabled revenues, it could be expected that between 0.62 and 0.86 jobs are supported each year, leading to a cumulated value of between 4.33 and 6.01 jobs to be supported over 2019-2025, with an average at 5.17 jobs.

Indirect and induced jobs	**Between 6.19 and 11.14 jobs supported over 2019-2025**

Similarly, for each EUR 1 M generated as societal and wider impacts, 2.1 induced jobs are supported. As such, building on previous results of wider and societal impacts, it could be expected that between 0.88 and 1.59 jobs would be supported each year, leading to a cumulated value of between 6.19 and 11.14 jobs that would be supported over 2019-2025, with an average at 8.39 jobs.

The table below summarises the overall expected employment impacts derived from option 1 over the period 2019 – 2025.

Table 40: Option 1 expected jobs supported over the period 2019 - 2025

	Direct jobs (downstream)	**Induced jobs**
Low scenario	4.33	6.19
Average scenario	5.17	8.39
High scenario	6.01	11.14

As such, the impact on employment would be rather marginal in the case of option 1, which is notably due to the fact that there is no novelty in what is made available by the Copernicus programme.

6.1.2.3 Strategic impacts

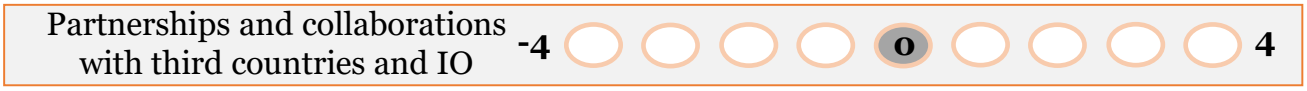
6.1.2.3.1 EU leadership

Positioning of EU as a leader in the field of CH	**-4** ○ ○ ○ ○ **0** ○ ○ ○ ○ **4**

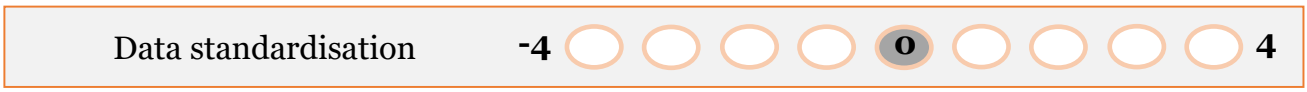
The European Year of Cultural Heritage is, among other objectives, meant to "*highlight the potential of cooperation in matters of cultural heritage for developing stronger ties within the Union and with countries outside the Union and for encouraging intercultural dialogue, post-conflict reconciliation and conflict prevention*"[166]. It is indeed an attribute of Cultural Heritage: act as a tribune for the continent's aura in the world. In more specific terms, communicating the European capacity to provide Cultural Heritage communities with specific tools to perform their activities does have an impact on how Europe is considered in the field of Cultural Heritage. Along with a strengthened position on the international scene when it comes to Cultural Heritage, Europe gains a paramount place within international partnerships and collaborations with third countries and international organisations. "*Culture is recognised as an important element of the European Union's cooperation programmes and instruments, and in its bilateral agreements with third countries. A wide variety of cultural projects and programmes have been implemented for many years as part of EU technical and financial assistance*"[167]. In the light of this analysis,

[165] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment
[166] Decision on a European Year of CH (2018) [ONLINE] Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[167] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a European agenda for culture in a globalizing world {SEC(2007) 570} /* COM/2007/0242 final

option 1 would not provide Europe with a strengthened positioning in the field of Cultural Heritage.



Option 1 would not bring any novelty to what the Copernicus programme can offer, as its main goal is to work on raising awareness as to the existence of the programme. First targets of awareness raising and market uptake activities will be Europeans: as a European programme, if Copernicus is not known in its own region for its usefulness for Cultural Heritage activities, it will be difficult for it to be exported further. Indeed, a European uptake could irradiate and incentivise users in other parts of the world. As such, it is very unlikely that collaborations and partnerships with third countries would be stimulated as a result of the implementation of option 1. As for international organisations, they are usually aware of all the means that can support their activity, especially as, in the case of Copernicus, the data is open and free. Stakeholder consultation has emphasised that Copernicus could be an alternative to the data they are currently using but what it would cost them in terms of change of process is not worth it at this time, considering the current availability of products suitable for Cultural Heritage. As such, option 1 will not change anything in the state of partnerships and collaborations with third countries and International Organisations.

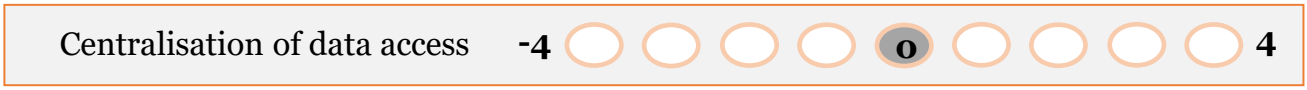


As a consequence of a reinforced position worldwide, Europe would be able to gain bargaining power and influence in terms of the design of Cultural Heritage data standards for education and R&D. However, under option 1, the EU does not appear as a leader in the field of Cultural Heritage thanks to its capabilities for site management and monitoring but rather thanks to the Heritage itself (e.g. over half of the sites labelled with UNESCO's World Heritage Label (WHL) are localised in Europe). As such, data standards would not be specifically fostered and the situation would remain as is today, that is without any intervention from the European Commission.

6.1.2.4 Societal impacts

6.1.2.4.1 Valorisation of Cultural Heritage

As part of the Digital Agenda under the Europe 2020 Strategy[168], the European Commission is taking measures for "*promoting digitisation and online accessibility of our cultural heritage*". Moreover, it is highlighted in the Declaration of a European Year for Cultural Heritage (2018) that one of the objectives is to "*promote solutions which make cultural heritage accessible to all, including via digital means, by removing social, cultural and physical barriers, taking into account people with special needs*"[169]. However, option 1 would not increase the visibility of the Cultural Heritage sector thanks to digitisation and online access. Indeed, the main activity under option 1 would be awareness raising, which would target technical users by informing them of the existence of specific products suitable for their needs.

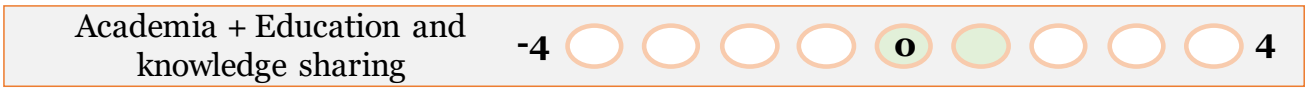


As for the centralisation of data, which is supposed to ease access to potential Copernicus Cultural Heritage products users, option 1 would have no effect at all. Indeed, nothing would be

[168] European Commission website. Available at: https://ec.europa.eu/digital-single-market/en/europe-2020-strategy
[169] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN

expected to change as to the way products, data and information suitable for Cultural Heritage are made available to interested user communities. Products would still be spread across several Copernicus service platforms and on the Scientific Hub, letting users engage in a time-consuming approach to find what they are looking for. This variety of portals and repositories can be confusing and even discouraging for users[170].

6.1.2.4.2 Support to European knowledge



The impact of option 1 on academic production (e.g. publications, conferences papers, patents, white papers, etc.) and on education and knowledge sharing within the Cultural Heritage communities (e.g. training and capacity building in the field of Earth Observation) would be marginal. As previously explained, option 1 aims at raising awareness on the existence of Copernicus products, data and information suitable to Cultural Heritage activities. However, these would mostly target users with a certain level of technical knowledge on Earth Observation (EO) and Geospatial Information System (GIS), hence no specific increase in the number of academic production on the topic should be expected. As for education and knowledge sharing, no new training would be put in place in the frame of option 1, hence the only effect that could be expected is a stronger registration to current trainings provided by the existing Copernicus services.

6.1.2.5 Conclusion

The results of the impact evaluation of option 1 can be summarised in the following figure:

[170] European Commission, 2017, Interim evaluation of Copernicus

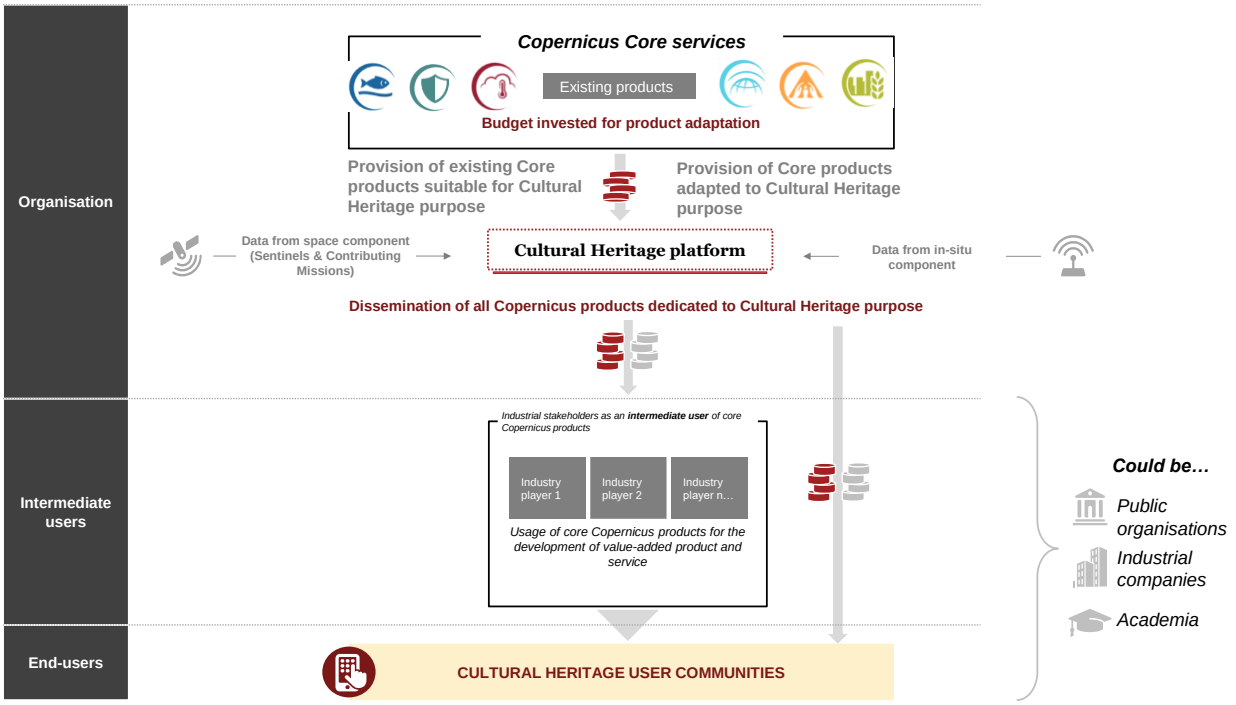
Figure 51: Summary of the impact evaluation of option 1

	Impact evaluation		Option 1 List of Copernicus products suitable for CH applications
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Between 7,5 & 11% fully covered 20% partially covered*
	Cost of the options	• Development and operation costs	*EUR 75 K per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 540 K and EUR 750 K for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 2.95 M and EUR 5.3 M for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 4.33 and 6.01 jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 6.19 and 11.14 jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

6.1.3 Impact evaluation of option 2

The evaluation of option 2 consists of the analysis of the impacts resulting from the implementation of a user interface in the form of a web-based interface fully dedicated to Cultural Heritage, comprised of existing products from core services that have been adapted to Cultural Heritage needs in addition to current Copernicus products, data and information. As a reminder from Chapter 5, option 2 is illustrated below.

Figure 52: Option 2 description – Cultural Heritage as a dedicated interface part of the Copernicus programme



6.1.3.1 User requirements covered by option 2

Option 2 is expected to provide a centralised access for Copernicus data and information suitable for Cultural Heritage communities. Under option 2, dedicated budget to adapt existing products and develop new ones is available for existing Copernicus core services.

Depending on the budget allocated to Copernicus core services to adapt existing products and/or to develop new products tailored to CH requirements, option 2 could be fully covering up to 49,8% of CH user requirements. An additional 14.2% of CH user requirements could also be partially covered. For more details on the match analysis, please refer to section 4.3.4.

As a conclusion, under option 2:

- Up to 50% of CH user requirements could be fully covered by the Copernicus programme;
- 14% of CH user requirements could be partially covered by the Copernicus programme.
-

6.1.3.2 Economic impacts

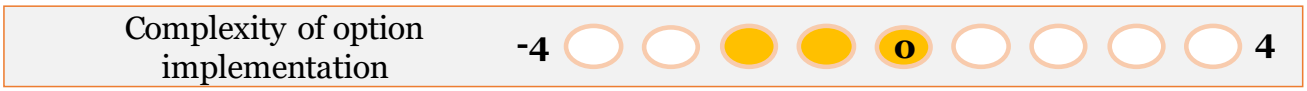
6.1.3.2.1 Cost of the options

Cost of option 2	**EUR 1.5 M per year**

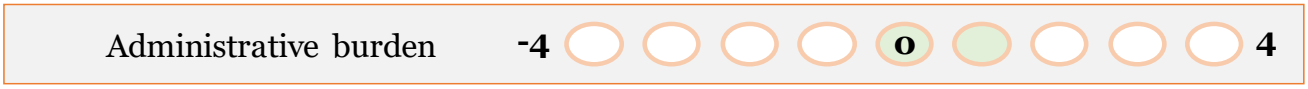
The implementation of option 2 would imply significant investments: (i) for the development of an infrastructure in the shape of a front-end dedicated to Cultural Heritage, with a specific access to Sentinels, contributing missions (e.g. direct link to Scientific Hub) data, as well as the products suitable for Cultural Heritage and already available in the six Copernicus services platforms; (ii) for the continuous operations of the platform, including the tailoring of existing Copernicus products to the needs of the Cultural Heritage community.

Although the Cultural Heritage web interface would be expected to leverage on the DIAS initiatives, its implementation would most likely be as from scratch. As previously explained in the section on option characterisation, the interface should resemble what has been done by the Copernicus Climate Change Service with its Sectorial Information Systems (SIS). A small SIS, composed of 2-3 use cases, should cost around EUR 150-200K, whereas a major SIS, such as the energy one, cost almost 10 times this price, hence about EUR 1.5M. Based on this information, a proxy can be derived for the yearly cost of option 2: depending on the ambitions put on a Cultural Heritage platform by the European Commission, its cost would vary in-between these two values but it would more likely be close to the larger value, given the importance of a Cultural Heritage platform compared to the content of the smallest SIS[171]. As such, a total cost of the option could be estimated at EUR 1.5 M.

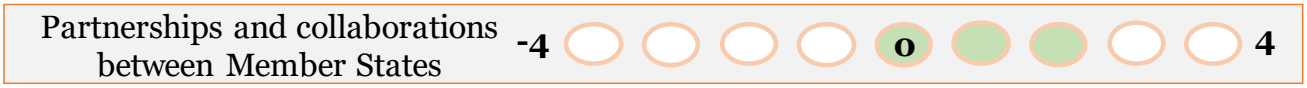
6.1.3.2.2 Option implementation process



The management of the platform would either be handled by the European Commission or by one of the Entrusted Entities in charge of the existing Copernicus core services. In both cases, complexity of implementation is expected to be high. The entity in charge of the platform would have to deal with each of the six Copernicus core services to gather all products suitable for Cultural Heritage, but would also have to negotiate the adaptation of products with Copernicus Entrusted Entities in order to match the needs of Cultural Heritage user communities. This can be expected to be a long and difficult process, but it would result in a drastic change for users, who would have most of the tools necessary for their activities within reach.



Moreover, option 2 should not be an administrative burden for public authorities in charge of Cultural Heritage: on the contrary, it should slightly simplify the administrative tasks linked to the downloading of data. The main change for users would be the location of the products that are to be centralised in a single place instead of being spread among several websites. The format of data would remain as is and data and products would still be owned by the six Copernicus services. As such, the current processes applied by public authorities using Copernicus should not drastically evolve but should be slightly facilitated with the one-stop shop, hence there would be a reduction of the administrative burden.



If access to Copernicus data and information suitable for Cultural Heritage-related activities is simplified under option 2, leading to a probable user uptake increase, it does not imply that partnerships and collaborations between Member States on Cultural Heritage issues would drastically increase. Indeed, the impact would be rather moderate. There would be slightly more resources available thanks to the tailoring of some Copernicus products, more visibility and a centralising tool. This should ease cross-country collaborations and can incentivise Member States to engage in the collaborative process, notably considering the need to define common standards and possible best practices.

[171] PwC analysis and expert consultation

6.1.3.2.3 Competitiveness

Enabled revenues	**Between EUR 10.82 M and EUR 15.02 M over 2019-2025**

Under option 2, EUR 1.5 M would be invested for the development of a web interface fully dedicated to Cultural Heritage. Intermediate users, who are part of the downstream sector, would be able to access the platform and find all products suitable for Cultural Heritage, including existing products that would have been specifically tailored to Cultural Heritage needs in the frame of this option.

Based on a proxy analysing the impacts of Copernicus on the revenues of all types of intermediate users with respect to the investment of the European Commission, enabled revenues would represent between 1.03 and 1.43 of the amount invested[172][173], meaning that for each euro invested in the Copernicus programme, service-related activities between EUR 1.03 and EUR 1.43 are created within the European downstream industry. As such, yearly enabled revenues for the downstream sector would range between EUR 1.55 M and EUR 2.15 M, with an average of EUR 1.85 M. Looking at the larger time frame of 2019-2025, which should enable a stronger uptake of Cultural Heritage products, data and information, enabled revenues for the downstream sector would range from EUR 10.82 M to EUR 15.02 M, with an average of EUR 12.92 M. As a result, revenues of the downstream sector would increase, not thanks to the availability of new products, data and information but thanks to a simplification of access and a better communication regarding the existence of Copernicus products suitable for Cultural Heritage, which might lead to cost reduction for intermediate users used to buying fee-based products that are actually provided by Copernicus.

Wider economic & societal impacts	**Between EUR 58.91 M and EUR 106.05 Mover 2019-2025**

Wider economic and societal impacts refers to the benefits to the wider society of an EC intervention in the field of Cultural Heritage. These impacts take into account indirect economic impacts (e.g. additional tourism revenues, additional consumption, renovation and construction to support CH, etc.) and societal and environmental impacts (e.g. protection of Cultural Heritage, environment protection, etc.).

Wider economic and societal impacts would be expected to range between EUR 8.42 M and EUR 15.15 M, with an average of EUR 11.42 M each year, and a cumulated value over the 2019 – 2025 period ranging between EUR 58.91 M and EUR 106.05 M, with an average of EUR 79.91 M. These values stem from a proxy based on wider impacts to end users (thus excluding intermediate users, that is to say the downstream sector) of the Copernicus programme: each EUR 1 invested is expected to generate between EUR 5.61 and EUR 10.1[174].

The table below summarises the overall expected monetary benefits derived from option 2 over the period 2019 – 2025.

Table 41: Option 2 expected monetary benefits over the period 2019 - 2025

	Enabled revenues for intermediate users	**Wider impacts for end users**
Low scenario	EUR 10.82 M	EUR 58.91 M
Average scenario	EUR 12.92 M	EUR 79.91 M
High scenario	EUR 15.02 M	EUR 106.05 M

[172] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment
[173] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment
[174] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

Competitive downstream sector	-4					o				4

The competitiveness of intermediate users is expected to be strong under option 2, as emphasised by the strong results in terms of enabled revenues for the downstream sector. Indeed, there would be a one-stop shop for all Cultural Heritage products, data and information and there would not be any competition from a consortium of companies appointed to the development of new Copernicus products by the European Commission. As such, the downstream sector would be free to organise itself to develop new Value-Added Services (VAS) and products for Cultural Heritage purpose. In this option, 52% of the user needs are fully covered and 12% are partially covered, hence there is a better ability to respond to the demand of users and this should lead to an increase in the offers provided by downstream actors.

R&D	-4					o				4

Efforts in R&D would be quite strong in the case of option 2. First of all, developing a platform dedicated to Cultural Heritage would favour user uptake, especially among categories of users with low level of technical knowledge on satellite imagery - all products would be clustered by needs on the Copernicus Cultural Heritage web interface to help users pick products and data most fitted to their requests. Stakeholder consultation has highlighted that some Cultural Heritage experts are relying on third parties to extract satellite data for them before analysing the results of this data themselves. This intermediary would become unnecessary should Copernicus products be presented in a clearer manner. Second, option 2 would be linked to the ability to unlock specific grants and funding mechanisms such as the Copernicus Masters aimed at supporting R&D through innovation, skills creation and knowledge transfer on Earth Observation and/or Cultural Heritage. For instance, in 2016, the winner of the Copernicus Masters was "SpaceToPlace – EO to Empower UNESCO Site Managers"[175]. This service is aimed at facilitating access and use of Copernicus products, data and information for Cultural Heritage activities of UNESCO experts. Such a service could be developed thanks to grants resulting from Copernicus, and similar to the ones that could result from the implementation of option 2. As a result, option 2 would be in line with the European Cultural Heritage Year objective to "*support the development of specialised skills and improve knowledge management and knowledge transfer in the cultural heritage sector, taking into account the implications of the digital shift*"[176].

6.1.3.2.4 Employment

Direct jobs	**Between 86.52 and 120.12 jobs supported over 2019-2025**

Considering that for each EUR 1 M generated by the downstream industry, 8 jobs are supported in the downstream[177], under option 2, building on the previous results of enabled revenues, between 12.36 and 17.16 jobs should be supported each year, leading to a cumulated value of between 86.52 and 120.12 jobs that would be supported over 2019-2025, with an average of 103.32 jobs supported.

Indirect and induced jobs	**Between 123.70 and 222.71 jobs supported over 2019-2025**

Similarly, for each EUR 1 M generated as societal and wider impacts, 2.1 induced jobs are supported. As such, building on previous results of wider and societal impacts, between 17.67 and 31.82 jobs should be supported each year, leading to a cumulated value of between 123.70

[175] Copernicus Masters website. Available at: https://www.copernicus-masters.com/winner/spacetoplace-eo-empower-unesco-site-managers/
[176] Decision (EU) 2017/864 of the European parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage (2018) (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
[177] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

and 222.71 jobs to be supported over the 2019-2025 period, with an average of 167.80 jobs supported.

The table below summarises the overall expected employment impacts derived from option 2 over the period 2019 – 2025.

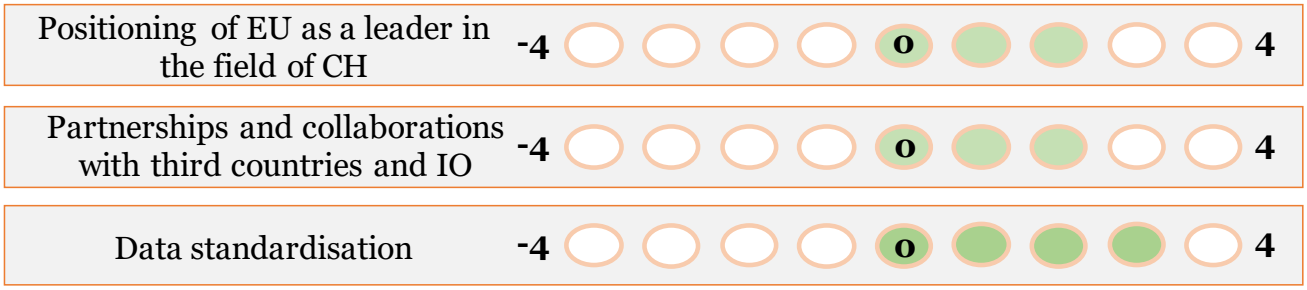
Table 42: Option 2 expected jobs supported over the period 2019 - 2025

	Direct jobs (downstream)	Induced jobs
Low scenario	86.52	123.70
Average scenario	103.32	167.80
High scenario	120.12	222.71

As such, the impact on employment should be moderate in the case of option 2, which is notably due to the fact that the only main difference with the current situation would be the way data is made accessible to users (i.e. in a single platform gathering all data relevant to Cultural Heritage) but with no major innovation in terms of products (though some tailoring of current products will be done to make them match user needs).

6.1.3.3 Strategic impacts

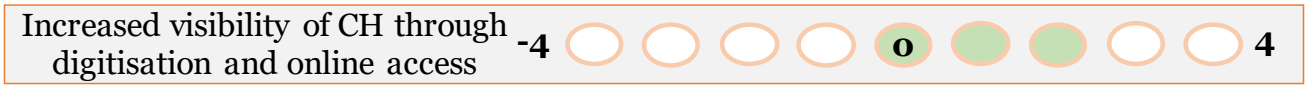
6.1.3.3.1 EU leadership



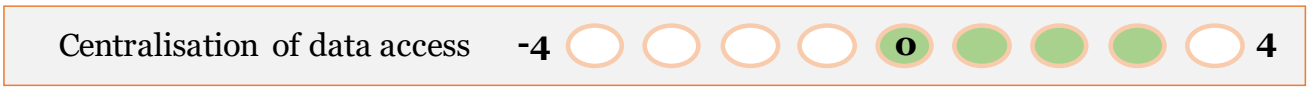
Option 2 would have a moderate impact with regards to the strengthening of Europe's position in the field of Cultural Heritage on the international stage. The important factor here would be the communication of European support to Cultural Heritage communities, which should lead to the recognition of its institutions and their work as a reference in the field of Cultural Heritage. Europe would thus be able to participate in the design of international data standards intended for Cultural Heritage communities. Indeed, standardisation is expected to be strong, as having a single centralised database for Cultural Heritage providing free and open data to all Cultural heritage user communities would be one-of-a-kind. There is currently no such platform gathering all satellite products suitable for Cultural Heritage. As everything would be collected on the platform, all user communities, whether European or international, would be attracted and would start using the same standards and models, since the process would be simplified. Hence, there should be a reciprocal effect between the EU leadership in the field of Cultural Heritage and data standardisation: the former should push for more standardisation and the latter should reinforce Europe's soft power. This, in the end, would ease potential partnerships and collaborations with third countries and international organisations as all groups would use similar standards for their activities, and thus should be able to work together.

6.1.3.4 Societal impacts

6.1.3.4.1 Valorisation of Cultural Heritage

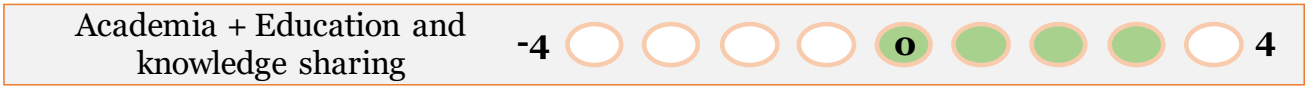


The creation of a dedicated Cultural Heritage interface is expected to moderately impact the visibility of Cultural Heritage via digitisation and online access. Indeed, all elements relevant to the provision of digital data on Cultural Heritage and to the development of online content on Cultural Heritage would be gathered in a single place. Considering that about half of European citizens are using digital media for Cultural Heritage related activities such as viewing online content[178], hence that digitisation and online access is a large interest to users, it implies that the interface could have a role to play in the satisfaction of users' expectations. However, this remains in the hand of the site managers' willingness and ability to push for online content: with option 2, they would have a simplified tool providing satellite imagery useful for digital content, but depending on their level of technical knowledge they may not always be able to capitalise on it (as no user support is provided).



Option 2 would strongly simplify data centralisation, as its purpose is to gather all data and information suitable for Cultural Heritage via a single web interface, leveraging on DIAS initiatives. Instead of having to jump from a Copernicus service website to another or to the Scientific Hub, users would now be logged into a single interface for all open and free Copernicus data and information they need.

6.1.3.4.2 Support to European knowledge



The impact of option 2 on the support to European knowledge through academia and knowledge sharing is expected to be strong. The setup of a single platform dedicated to Cultural Heritage, accompanied by the tailoring of current products to adapt them to the needs of the user communities, will favour an uptake of Copernicus products, data and information. Several Member States are eager to share knowledge in order to protect their Heritage. This would take the form of sustainable strategies developed through training and skills development capitalising on knowledge transfer between countries[179]. As this option relies on geospatial technology and leverages on the DIAS, it is expected to enforce knowledge sharing in this particular format[180].

6.1.3.5 Conclusion

The results of the impact evaluation of option 2 can be summarised in the following figure:

[178] European Commission, 2017, Special Eurobarometer 466: Cultural Heritage
[179] European Commission, 2016, Towards an EU strategy for international cultural relations (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016JC0029&from=EN
[180] Expert consultation

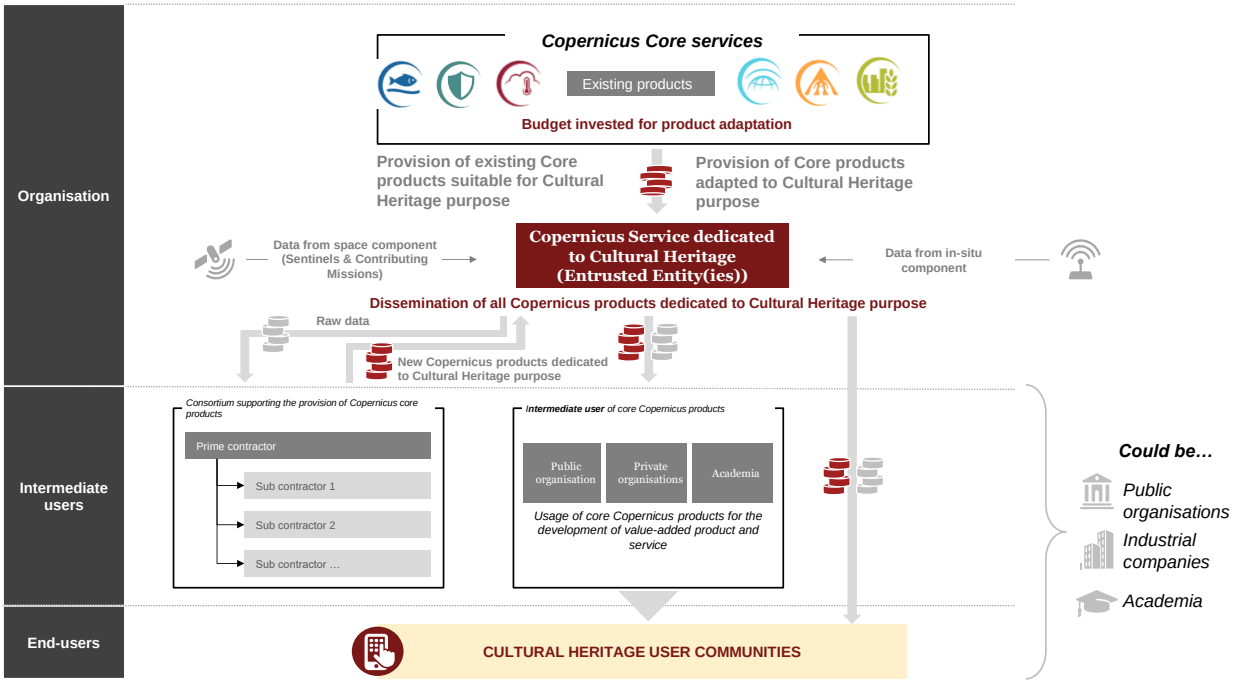
Figure 53: Summary of the impact evaluation of option 2

	Impact evaluation		Option 2 Cultural Heritage as part of one or more existing services
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Up to 50% fully covered* *14% partially covered*
	Cost of the options	• Development and operation costs	*EUR 1.5 M per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 10.8 M and EUR 15.0 M for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 58.9 M and EUR 106.1 M for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 86.5 and 120.1 jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 123.7 and 222.7 jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

6.1.4 Impact evaluation of option 3

The evaluation of option 3 consists of the analysis of the impacts resulting from the creation of a new Copernicus service exclusively dedicated to Cultural Heritage. As a reminder from Chapter 5, option 3 is illustrated below.

Figure 54: Option 3 description – Cultural Heritage as a new Copernicus service



6.1.4.1 User requirements covered by option 3

Option 3 is expected to push for the development of a new Copernicus core service dedicated to Cultural Heritage, with a dedicated budget to adapt existing Copernicus products that are not currently fully matching CH user requirements, but also for developing additional products and potentially collecting new sources of in-situ data to calibrate specific Copernicus core services products for CH purposes. The development of new Copernicus core service fully dedicated to CH could have significant impact on the choice of additional sources of data from airborne sensors (e.g. UAV) to access new type of sensors such as hyperspectral and lidar capabilities.

Option 3 could be fully covering up to 49,8% of CH user requirements, plus an additional 12,9% that could potentially be fully covered thanks to the availability of additional capacity derived from new UAV-based sensors. As for option 2, 14,2% of CH user requirements would also be partially covered by the Copernicus programme. For more details on the match analysis, please refer to section 4.3.4.

As a conclusion, under option 3:

- Between 50 and 63% of CH user requirements could be fully covered by the Copernicus programme;
- 14% of CH user requirements could be partially covered by the Copernicus programme.

6.1.4.2 Economic impacts

6.1.4.2.1 Cost of the options

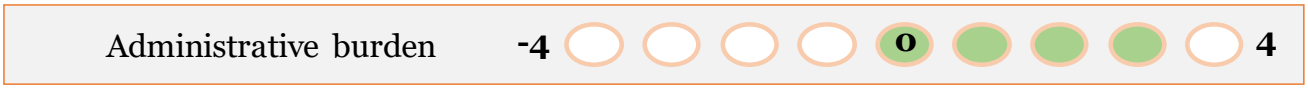
Cost of option 3	**EUR 14.7 M then EUR 20.9 M per year**

Option 3 would be particularly costly to implement as it consists of: (i) the creation of a new service implying several phases, from proof-of-concept to being operational, which takes a couple of years; (ii) the operation of the service itself, including the development of new

products by a consortium of companies. As previously explained in the section on option characterisation, the new service would be managed by a new Entrusted Entity or by an existing one already in charge of one of the core services. Analysing the Delegation Agreements of the current Entrusted Entities, it appears that the European Commission has committed on average EUR 14.7 M per service per year over the 2014-2016 period, with values ranging from EUR 7.2 M for the Emergency service to EUR 19.9 M for the Climate Change service[181]. When looking at the commitments forecasted in the Delegation Agreements over the 2016-2020 period, the average yearly commitment per service per year is of EUR 20.9 M, with yearly values ranging from EUR 11.0 M for the Atmosphere service to EUR 38.9 M for the Climate Change service. These yearly values are higher when looking at the 2016-2020 period than at the 2014-2016 period, as most services were not fully operational by 2016[182]. The Copernicus Cultural Heritage service should follow a similar trend, with a small investment in the first two years of its implementation, and an uptake in the next five years. It should also be less demanding (i.e. in terms of resources) than major services (e.g. Land Monitoring or Climate Change). As such, the cost of operations of the option can be estimated as the average of all services, that is EUR 14.7 M per year in 2019 and 2020, and EUR 20.9 M in the 2021 – 2025 period.

6.1.4.2.2 Option implementation process

In order to set-up a service, an Entrusted Entity would have to be chosen and then appointed by means of a Delegation Agreement. A Delegation Agreement is a legal act that gives power and duty to the Entrusted Entity (e.g. tasks and budget of the Entrusted Entity are precisely defined). Choosing the correct Entrusted Entity and implementing such an agreement would be a particularly complex and time-consuming process. Moreover, the designated Entrusted Entity would have to appoint a consortium of companies, composed of a prime contractor and sub-contractors (either public organisations, academia, or private companies) which would be in charge of the development of Copernicus Cultural Heritage products. A single product cannot be available on several platforms under the same form, hence useful existing products would have to be redeveloped by the consortium, leveraging on current knowledge of other Copernicus services: this represents a lack in efficiency. The consortium would also develop new products capitalising on Sentinel, contributing missions and in-situ data for calibration purposes. In particular, an Entrusted Entity in charge of a Copernicus service has access to more in-situ data available at national level or by international organisations. This implies a certain level of complexity for accessing data and notably signing Memorandum of Understandings with entities for the sharing of such data.



No new administrative burden would be felt by public authorities willing to use Copernicus Cultural Heritage products, on the contrary, the administrative processes should be significantly simplified. Indeed, instead of being spread among the different Copernicus services, all Cultural Heritage products would be gathered on a single website dedicated to the Cultural Heritage service. This website would be organised exactly as the ones from the other Copernicus services and the process to download data would be similar. As such, the data access would be eased thanks to the gathering of all Cultural Heritage products in a single place with user support provided by the service in case of issues. This option would provide a one-stop shop with no need to go on other services for data useful for Cultural Heritage activities.

[181] European Commission, 2017, Interim evaluation of Copernicus
[182] European Commission, 2016, ANNEX to the Commission Implementing Decision on the adoption of the 2016 Copernicus Work Programme (Online). Available at: http://ec.europa.eu/transparency/regdoc/rep/3/2016/EN/3-2016-743-EN-F1-1-ANNEX-1.PDF

Partnerships and collaborations between Member States	-4					0				4

Partnerships and collaborations between Member States on Cultural Heritage-related topics should be strongly fostered by the implementation of a Cultural Heritage service under option 3. Indeed, the development of such a service would imply the set-up of a user support channel aimed at collecting user needs in terms of new products from the Cultural Heritage user communities, and new data sources needed (e.g. hyperspectral data, specific in-situ data, etc.). As such, Member States could interact with the Cultural Heritage Entrusted Entity in order to incentivise the development of products tailored to their specific needs. Having such potential involvement in what the Cultural Heritage service could provide would foster Member States to jointly reflect on the common key Cultural Heritage issues, in order to push for the development of the required products.

6.1.4.2.3 Competitiveness

Enabled revenues	**Between EUR 137.61 M and EUR 191.05 M over 2019-2025**

Under option 3, the yearly investment into the Cultural Heritage service would evolve, growing after the first two years, which is considered the necessary period for a sufficient user uptake. Based on a proxy analysing the impacts of Copernicus on the revenues of all types of intermediate users with respect to the investment of the European Commission, enabled revenues should represent between 1.03 and 1.43 of the money invested[183], meaning that for each euro invested in the Copernicus programme, service-related activities between EUR 1.03 and EUR 1.43 are created within the European downstream industry. As such, considering option 3 consists of a EUR 14.66 M investment from the European Commission in 2019-2020 and a EUR 20.85 M investment for 2021 - 2025, yearly enabled revenues for the downstream sector would range from EUR 15.1 M and EUR 20.97 M, with an average of EUR 18.04 M in 2019 and 2020, and from EUR 21.48 M and EUR 29.92 M, with an average of EUR 25.65 M for 2021 - 2025. Looking at the overall time frame of 2019-2025, enabled revenues for the downstream sector should range from EUR 137.61 M to EUR 191.05 M, with an average of EUR 164.33 M. As a result, revenues of the downstream sector would drastically increase, especially thanks to the development of new products by the consortium of companies for the Cultural Heritage service.

Wider economic & societal impacts	**Between EUR 749.51 M and EUR 1.35 B over 2019-2025**

Wider economic and societal impacts refer to the benefits to the wider society of an EC intervention in the field of Cultural Heritage. These impacts take into account indirect economic impacts (e.g. additional tourism revenues, additional consumption, renovation and construction to support Cultural Heritage, etc.) and societal and environmental impacts (e.g. protection of Cultural Heritage, environment protection, etc.).

In the case of option 3, wider economic and societal impacts would be expected to range between EUR 82.27 M and EUR 148.11 M, with an average of EUR 111.60 M in 2019 and 2020, and between EUR 116.99 M and EUR 210.63 M, with an average of EUR 158.70 M in 2021-2025, for a cumulated value over the 2019 – 2025 period ranging between EUR 749.51 M and EUR 1.35 B, with an average of EUR 1.0 B. These values stem from a proxy based on wider impacts to end users (thus excluding intermediate users, that is to say the downstream sector) of the Copernicus programme: each EUR 1 invested is expected to generate between EUR 5.61 and EUR 10.1[184].

The table below summarises the overall expected monetary benefits derived from option 3 over the period 2019 – 2025.

[183] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment
[184] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

Table 43: Option 3 expected monetary benefits over the period 2019 - 2025

	Enabled revenues for intermediate users	Wider impacts for end users
Low scenario	EUR 137.61 M	EUR 749.51 M
Average scenario	EUR 164.33 M	EUR 1.02 B
High scenario	EUR 191.05 M	EUR 1.35 B

Competitive downstream sector	-4					0				4

Taking into account the results of the enabled revenues for the downstream sector dealing with Cultural Heritage activities, it is expected that the competitiveness of intermediate users would be strong. Indeed, the market would be provided with more products (including new ones currently not existing even fee-based) and could develop new competing Value-Added services at lesser cost. However, it should not be forgotten that Cultural Heritage is a rather niche sector and the consortium of companies appointed by the Entrusted Entity in charge of the Cultural Heritage service could destroy the market by developing new products tailored to Cultural Heritage needs for free, leaving little space for other intermediate users to develop products and services competitive enough. As it is essential to the European Commission that the development of Copernicus products in general do not negatively affect the market, dedicated attention should be put on the effects of the development of new products by the consortium of companies.

R&D	-4					0				4

Efforts in R&D would be very strong under option 3. The implementation of a dedicated Copernicus service would not only positively affect user uptake but it could also unlock various grants and funding mechanisms supporting Earth Observation and/or Cultural Heritage. Indeed, user communities with low levels of technical knowledge on Earth Observation would find a direct contact person to turn to in the Copernicus Cultural Heritage service and would be able to gather all products, data and information matching their needs. As for grants and funding mechanisms, the availability of a Cultural Heritage service should foster the European Commission to increase the share of Earth Observation or Cultural Heritage in their R&D tools, on a larger scale than option 2 for instance. Moreover, having an Entrusted Entity in charge of a dedicated service implies that budget lines are available for R&D activities but also for project calls aimed at stimulating the downstream sector for the development of Cultural Heritage-related products. All of this combined should foster the development of skills and the transfer of knowledge related to Earth Observation for Cultural Heritage in Europe, but also at a wider scale. As a result, the number of prizes awarded for Cultural Heritage related activities through the Copernicus Masters could increase, for instance.

6.1.4.2.4 Employment

Direct jobs	**Between 1,100.88 and 1,528.41 jobs supported over 2019-2025**

Considering that for each EUR 1 M generated by the downstream industry, 8 jobs are supported in the downstream sector[185], under option 3, building on the previous results of enabled revenues, between 120.84 and 167.77 jobs should be supported in 2019 and 2020, and between 171.84 and 238.58 each year in the 2021-2025 period, leading to a cumulated value of between 1,100.88 and 1,528.41 jobs to be supported over 2019-2025, with an average at 1,314.64 jobs supported.

[185] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment

Indirect and induced jobs	**Between 1,573.97 and 2,833.70 jobs supported over 2019-2025**

Similarly, for each EUR 1 M generated as societal and wider impacts, 2.1 induced jobs are supported. As such, building on previous results of wider and societal impacts[186], between 172.77 and 311.04 jobs should be supported in 2019 and 2020, and between 245.69 and 442.32 each year in the 2021-2025 period, leading to a cumulated value of between 1,573.97 and 2,833.70 jobs supported over 2019-2025, with an average of 2,135.70 jobs supported.

The table below summarises the overall expected employment impacts derived from option 1 over the period 2019 – 2025.

Table 44: Option 3 expected jobs supported over the period 2019 - 2025

	Direct jobs (downstream)	**Induced jobs**
Low scenario	1,100.88	1,573.97
Average scenario	1,314.64	2,135.10
High scenario	1,528.41	2,833.70

The impact on employment is expected to be strong in the case of option 3. Indeed, as a consortium of companies would be appointed by the Entrusted Entity in charge of the Cultural heritage service to develop new products, several downstream jobs would directly be supported and these new products would generate new opportunities supporting jobs in the wider society.

6.1.4.3 Strategic impacts

6.1.4.3.1 EU leadership

Positioning of EU as a leader in the field of CH	-4 ○ ○ ○ ○ **0** ● ● ● ○ 4

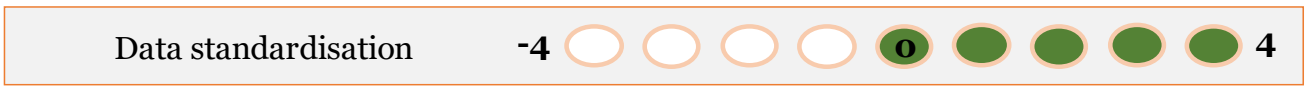
The setup of a dedicated Copernicus Cultural Heritage service is expected to have a strong strategic influence on the way Europe is positioned on the international stage for Heritage topics. Indeed, the service would enable the distribution of several products that are key in the management of Cultural Heritage sites as well as in their conservation and preservation, and would also provide user support to site operators, no matter their position on the value chain. As such, it can be expected that new experiences would be provided to visitors of Cultural Heritage sites[187] thanks to an alternative use of satellite imagery (e.g. satellite imagery could be used to show visitors an evolution of a site overtime, notably for the discovery of archaeological sites). These aspects could enable Europe to be positioned as a worldwide leader in the field of Cultural Heritage enhancement.

Partnerships and collaborations with third countries and IO	-4 ○ ○ ○ ○ **0** ● ● ○ ○ 4

Option 3 would have a moderate impact on partnerships and collaborations with third countries and international organisations. Indeed, having a Copernicus Cultural Heritage service could support ongoing interactions between European countries and international organisations or non-European countries. The Copernicus Cultural Heritage Service could be a tool serving an ongoing diplomatic strategy. Having a thematic service dedicated to Cultural Heritage would make this

[186] European Commission, 2018, Copernicus ex-ante economic, environmental and societal impact assessment
[187] Expert consultation

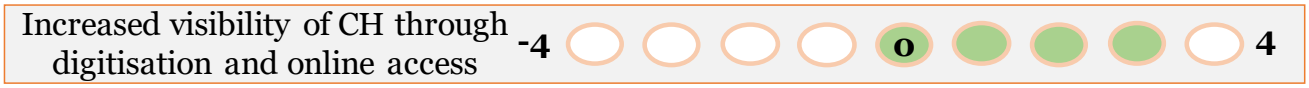
topic more visible among entities in which Copernicus is part and that participate to the global dimension of the programme, such as CEOSS or GEOS. As such, partnerships and collaborations could be facilitated.



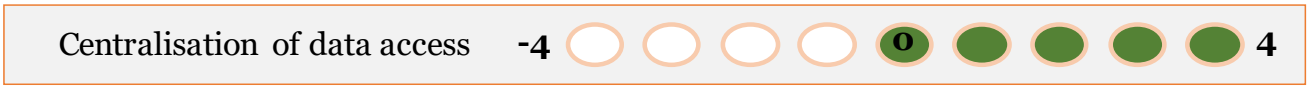
Data standardisation could be strongly fostered in the case of option 3, as the Copernicus Cultural Heritage service would be a showcase for what is done in terms of satellite imagery for Cultural Heritage. Indeed, this would be the first time that Cultural Heritage would have such tools for its activities, gathered in a single website and supported by a team of experts. Moreover, considering Copernicus data and information for Cultural Heritage would be free and open, there would be no equivalent in the world. Given the large availability of products dedicated to Cultural Heritage and matching the user communities' needs, best practices are likely to emerge at European level and evolve to a more global level. As such, under option 3, there would be a unique central database dedicated to Cultural Heritage, which would also provide support for its users, hence creating an attractiveness that is expected to lead to the adoption of Copernicus standards and models worldwide.

6.1.4.4 Societal impacts

6.1.4.4.1 Valorisation of Cultural Heritage

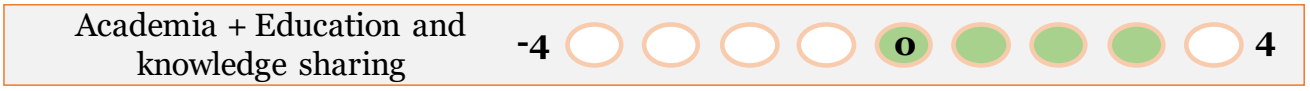


In the past ten years, Europe has been investing a significant amount into Information and Communication Technologies (ICT) in support of culture and science. For instance, between 2006 and 2009, the European Commission dedicated a budget of EUR 51.1 M to research projects notably aimed at developing ICT to favour access to and experience of Cultural Heritage[188]. This emphasises the importance given by Europe to this topic and it should have a particular place under option 3. The visibility of Cultural Heritage should be increased through digitisation and online access thanks to two main aspects: first, new products responding to the specific need of digitising Cultural Heritage could be developed by the consortium of companies appointed by the Entrusted Entity in charge of the service; second, the Entrusted Entity would be able to provide user support, hence to advise site managers on how to capitalise on Copernicus products, data and information for digitisation purposes. Digitisation should notably enhance tourism experience, through 3D modelling of Heritage sites, for instance.



Under option 3, data centralisation would be very high, as the Entrusted Entity would have a website dedicated to Cultural Heritage and gathering all products, data and information matching the user needs. More than just data, support to users would be facilitated, as one single Entity would be in charge of responding to users questions on all Cultural Heritage products, whereas currently several services may be contacted provided that the products used have been downloaded from different Copernicus services website.

6.1.4.4.2 Support to European knowledge



The implementation of option 3 is expected to have a strong impact on the support to European

[188] European Commission, 2016, Towards an EU strategy for international cultural relations (Online). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016JC0029&from=EN

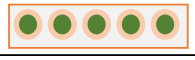
knowledge. Indeed, this option could work as a stimulus for the creation of a user community embracing academia[189]. Implementing a Copernicus service dedicated to Cultural Heritage implies having an Entrusted Entity fully devoted to Cultural Heritage matters. Among the tasks devolved to an Entrusted Entity, there is the implementation of awareness raising activities that notably include trainings and workshops, which in the end favour knowledge sharing. The staff of the Entrusted Entities is composed of experts on Cultural Heritage matters and could therefore support any user community and even develop academic content. For instance, the Entrusted Entity in charge of the Copernicus Cultural Heritage service could take part in the Climate for Culture project. This project aims at investigating the impact climate change could have on European Cultural Heritage. The team was initially composed of scientists, site managers, restorers, economists, engineers or politicians that created a European network[190]. Being supported by Earth Observation experts with specific tools to respond to the network's needs, as would be the case with the new Cultural Heritage service, could be key for future work.

6.1.4.5 Conclusion

The results of the impact evaluation of option 3 can be summarised in the following figure:

[189] Expert consultation
[190] Climate for Culture website. Available at: https://www.climateforculture.eu/

Figure 55: Summary of the impact evaluation of option 3

	Impact evaluation		Option 3 Creation of a new Copernicus service dedicated to Cultural Heritage
Economic	Capabilities matching	• Percentage of user requirements covered by the option	*Between 50% & 63% fully covered* *14% partially covered*
	Cost of the options	• Development and operation costs	*EUR 14.7 M then EUR 20.9 M per year*
	Option implementation process	• Complexity of option implementation	
		• Administrative burden	
		• Partnership and collaboration between Member States	
	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 137.6 M and EUR 191.1 M for 2019-2025*
		• Wider economic and societal impacts	*Between EUR 749.5 M and EUR 1.35 B for 2019-2025*
	Competitiveness	• Competitive downstream sector	
		• R&D	
	Employment	• Direct jobs	*Between 1.1 K and 1.5 K jobs supported for 2019-2025*
		• Indirect and induced jobs	*Between 1.6 K and 2.8 K jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH	
		• Partnership and collaboration with third countries and IO	
		• Data standardisation	
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access	
		• Centralisation of data access	
	Support to European knowledge	• Academia + Education and knowledge sharing	

6.2 Summary and comparison of the impacts per options

This section aims at summarising all results presented hereinabove and at introducing the main key aspects of each option.

	Impact evaluation		Option 1 List of Copernicus products suitable for CH applications	Option 2 Cultural Heritage as part of one or more existing services	Option 3 Creation of a new Copernicus service dedicated to Cultural Heritage
	Capabilities matching	• Percentage of user requirements covered by the option	*Between 7,5 & 11% fully covered 20% partially covered*	*Up to 50% fully covered 14% partially covered*	*Between 50% & 63% fully covered 14% partially covered*
Economic	Cost of the options	• Development and operation costs	*EUR 75 K per year*	*EUR 1.5 M per year*	*EUR 14.7 M then EUR 20.9 M per year*
Economic	Option implementation process	• Complexity of option implementation			
Economic		• Administrative burden			
Economic		• Partnership and collaboration between Member States			
Economic	Advantages derived from the options	• Enabled revenues for the downstream sector	*Between EUR 540 K and EUR 750 K for 2019-2025*	*Between EUR 10.8 M and EUR 15.0 M for 2019-2025*	*Between EUR 137.6 M and EUR 191.1 M for 2019-2025*
Economic		• Wider economic and societal impacts	*Between EUR 2.95 M and EUR 5.3 M for 2019-2025*	*Between EUR 58.9 M and EUR 106.1 M for 2019-2025*	*Between EUR 749.5 M and EUR 1.35 B for 2019-2025*
Economic	Competitiveness	• Competitive downstream sector			
Economic		• R&D			
Economic	Employment	• Direct jobs	*Between 4.33 and 6.01 jobs supported for 2019-2025*	*Between 86.5 and 120.1 jobs supported for 2019-2025*	*Between 1.1 K and 1.5 K jobs supported for 2019-2025*
Economic		• Indirect and induced jobs	*Between 6.19 and 11.14 jobs supported for 2019-2025*	*Between 123.7 and 222.7 jobs supported for 2019-2025*	*Between 1.6 K and 2.8 K jobs supported for 2019-2025*
Strategic	EU leadership	• Positioning of EU at a leader in the field of CH			
Strategic		• Partnership and collaboration with third countries and IO			
Strategic		• Data standardisation			
Social	Valorisation of CH	• Increased visibility of CH through digitisation and online access			
Social		• Centralisation of data access			
Social	Support to European knowledge	• Academia + Education and knowledge sharing			

7 Conclusion and recommendations

This study aimed at supporting the European Commission in its assessment on the possibility of starting an institutional action for promoting the use of Copernicus for Cultural Heritage preservation, monitoring and management. For this purpose, the study has identified Cultural Heritage user needs and requirements in order to understand to what extent they can be addressed by Copernicus capabilities. Following this match assessment, several options of intervention have been characterised and investigated through the assessment of high-level impacts.

7.1 Cultural Heritage user needs & requirements and Copernicus capabilities

The study has assessed Cultural Heritage user community needs and requirements related to Cultural Heritage preservation, monitoring and management. This exercise has led to the collection, through consultation (direct interview and survey) and desk research**, of 83 user needs split among 9 high-level user needs** (i.e. purpose of Cultural Heritage activities). These needs are **useful for both Tangible and Natural Heritage** and for both land and underwater environment.

The different user needs have then been characterised and defined through the collection of user requirements; user requirements refer to the user needs defined by desired performances and attributes (type of land cover, geographic coverage, frequency of monitoring and spatial resolution). These user requirements have then been translated into technical specifications (sensors, wavelength and spatial resolution specification) to support the match analysis with the Copernicus capabilities. This match analysis has been carried out on three different levels: Copernicus core services products, Sentinels capabilities and Copernicus contributing mission capabilities.

CH is currently not mentioned in the delegation agreements of any of the entrusted entities in charge of the six Copernicus core services. In this context, specific products tailored to CH purposes therefore cannot be directly developed by entrusted entities. Nevertheless, Copernicus core services already have access to the relevant EO data sources (Sentinels and/or contributing missions), models and in-situ data sources so they could be able to respond to a large extent of CH user requirements.

The results of the match analysis clearly shows that the Copernicus programme could cover a large part of the CH user requirements. In fact, 7,5% of CH user requirements are already fully covered by Copernicus core services products in their current form, and an additional 19,0% of user requirements are partially covered by existing Copernicus core services products in their current form. The access to Sentinels capabilities and Copernicus contributing missions could be fully covering 50% of CH user requirements; an additional 14% of CH user requirements could be partially covered thanks to Sentinels capabilities and Copernicus contributing missions. Those partially covered user requirements could potentially be covered by the downstream industry having access to very high resolution data and/or very high revisiting time imagery not available in the pool of Copernicus contributing missions.

By using all Copernicus capabilities (core services products, Sentinels and Contributing missions), 64.1% of CH user requirements could be covered. As for the 35.9% of CH user requirements not covered:

- **7,0%** of CH user requirements (26) could not be covered because the spatial and/or temporal resolution required by users are not available within Copernicus;
- **12,9%** of CH user requirements require specific sensors and/or wavelengths that are not available in the scope of the Copernicus programme (e.g. hyperspectral, lidar) in order to be covered. Nevertheless, such sensors and wavelengths exist on the commercial market, especially by using airborne sensors (e.g. UAV), so the downstream industry could then fully cover those user requirements;
- **16,1%** of CH user requirements cannot be covered by satellite-based imagery, as they require very specific in-situ measurements (e.g. Ground Penetrating Radar (GPR), in-situ bathymetric surveys, etc.) or complex value-added products (e.g. assessment of sites frequentation pattern).

7.2 Impact evaluation

An intervention from the European Commission could prove useful in enhancing the ability of Copernicus to respond to Cultural Heritage user needs. Three options have been envisaged:

- **Option 1:** relying on existing core products, data and information that are currently suitable for Cultural Heritage applications, but emphasising the existence of such products by raising awareness;
- **Option 2**: setting up a specific user interface in the form of a web-based platform (i.e. web-based front-end) fully dedicated to Cultural Heritage, where user communities could find existing Copernicus data and information suitable for Cultural Heritage activities, together with additional products that have been adapted and/or developed specifically for Cultural Heritage purposes;
- **Option 3:** creating a Copernicus Service, in addition to the existing ones (e.g. Land Monitoring service, Marine Monitoring service, etc.), which would be exclusively dedicated to Cultural Heritage.

These three options have been analysed through the lens of seven impacts split into several KPIs in order to compare them. Building on the main results of the impact evaluation, a first observation can be made: the impacts resulting from option 1 would be drastically different from the ones of option 2 and 3, whereas option 2 and 3 appear to be closer in terms of impact results.

Option 1 would have no positive nor negative strategic impact and few societal impacts (on support to European knowledge). As for economic impacts, these would be marginal. The option would not be able to respond to Cultural Heritage communities' expectations, as only 9% of the user requirements would be fully covered, and 46% additional user requirements could be partially covered. However, this option presents one major advantage: it would be the most interesting in terms of cost and of easiness of implementation.

Option 2 would present moderate to strong impacts, whether societal, economic or strategic. This option could fully cover 52 % of Cultural Heritage user requirements and partially for 12% of them. Option 2 would be more complex and costly to implement than option 1; however, it would produce significant results in terms of competitiveness of the downstream sector and of social impacts. Option 2would notably facilitate data access and dissemination by offering a one-stop shop for Cultural Heritage products and data, possibly leveraging on the DIAS initiative, and stimulating the development and dissemination of European standards in the field of EO applied to Cultural Heritage.

Option 3 would present strong to very strong impacts, whether social, economic or strategic. This option would also be more complex and more costly to implement than option 2, but would generate significant benefits overall: the advantages derived from the options, i.e. enabled revenues for the downstream sector and wider economic and societal impacts, would be respectively 10 to 15 times larger. Also, option 3 could cover 64% of overall user requirements, plus a potential additional 16% of user requirements that could be somehow addressed thanks to the collection of specific in-situ data to calibrate specific Copernicus Cultural Heritage products. As in option 2, this option would ease data access and dissemination by offering a one-stop shop for Cultural Heritage user communities, and hence strongly impacting the development and dissemination of European standards in the field of EO applied to Cultural Heritage.

As such, each option encompasses advantages and drawbacks:

- Option 1 would be the most interesting in terms of the budget and legal ease;
- Option 2 would be the most interesting in terms of cost-to-benefit ratio;
- Option 3 would be the most interesting in terms of overall benefits generated.

7.3 Recommendations

Several recommendations can be provided to enhance the role of Copernicus in support of Cultural Heritage.

1. The different Copernicus core services have already internally the relevant sources of satellite imagery (e.g. Sentinels, Contributing missions), models and in-situ data sources to cover a large part of the user requirements expressed by CH user communities. Nevertheless, as of today, Cultural Heritage is not directly mentioned in any delegation agreement of the Copernicus core services' entrusted entities, then not further encouraging the development of specific products and/or adaptation of existing ones to respond to the needs of Cultural Heritage users' communities.
2. As stated in the Interim evaluation of Copernicus, "Copernicus services should evolve to include or expand on applications related to (…) cultural heritage preservation (e.g. archaeology, art, etc.) (…). These developments may either be achieved within existing services or lead to the development of new services". This statement emphasises the need for an intervention from the European Commission towards Cultural Heritage. The expansion of applications related to Cultural Heritage can ~~only~~ be performed within the frame of Option 2 or 3, since these are the only options that provide product adaptation or the creation of new products. Nevertheless, option 1 will already be a starting point to raise awareness about the availability of Copernicus products and data addressing specific Cultural Heritage user requirements.
3. As stated in the Interim evaluation of Copernicus, "The multi-channel access to the Copernicus products (…) is confusing for some users. The uptake of Copernicus services would benefit from unified access, offering a single interface for each product". A similar recommendation applies here for Cultural Heritage, as the dissemination of products among the different services impacts the willingness and the ability of users to make comprehensive use of Copernicus products currently suitable for Cultural Heritage. Indeed, all user communities have pointed out their interest for centralised access to data for Cultural heritage purposes. Option 2 and 3 would enable the provision of this unified access through their single interface fully dedicated to Cultural Heritage, possibly leveraging on DIAS initiatives.
4. As stated in the Interim evaluation of Copernicus, "There is a need to expand communication and user uptake activities beyond specialists' communities, by broadcasting more cases, showing concrete examples to users. This would enable the

potential user base to be expanded to include the Science community more broadly, as well as downstream companies". Copernicus services are producing core products requested by EU Member States in order not to disrupt the SMEs-led downstream market. Specialist communities (in general EO experts part) are the main users of the currently available Copernicus products suitable for Cultural Heritage but efforts need to be made to reach new user communities, such as urban planners or CH site operators. Copernicus for Cultural Heritage could in this context contribute to the widening of the impact of Earth Observation on usually non-technical domains. Such an intervention would make Copernicus known to a non-EO specialist sector and promote many promising developments in downstream applications development, such as tourism-related activities.

5. As stated in the Interim evaluation of Copernicus, "*There has been a considerable uptake of Copernicus data by the European Commission, but it could be further promoted*". An intervention in the frame of Copernicus for Cultural Heritage could be a good opportunity to demonstrate how Copernicus can be useful to all Directorate-Generals (DGs) of the European Commission, including DG for Education, Youth, Sport and Culture (former Directorate-General for Education and Culture (EAC)). A successful initiative in the field of Cultural Heritage could serve as a flagship of the multiple potential uses of Copernicus to support decision-makers, as well as supporting dissemination and user uptake of Copernicus data and information.
6. The development of new technologies and the possibilities brought by digitisation strengthen existing needs and create new ones. As such, specific emphasis should be put on the way Copernicus can contribute to digitisation in the case of Cultural Heritage, notably as digital modelling of Cultural Heritage sites is key both for conservation activities but also for the reconstruction of sites affected by geo-hazards or human conflicts. As these are currently increasing with the effect of climate changes and the complicated geopolitical context in some regions of the world, the contribution of Copernicus to digitisation should be strongly promoted.
7. An intervention of the European Commission should play a key role in data standardisation (stronger in option 2 and 3 than in option 1) and could lead to a scenario where the European Union is setting the standards in the field of Cultural Heritage. As such, it is important to push for an efficient intervention to enable the European Union to be a leader in the field of Cultural Heritage, enhancing European Union soft power and geopolitical reach.
8. Some Cultural Heritage user needs are linked to very specific user requirements and technical specifications that cannot be covered with satellite imagery:
    a. For instance, there currently does not exist any satellite capable of providing an hourly revisit time or very high resolution for detailed local areas, especially for multispectral (RGB, NIR). These user needs could however be covered by aerial data (e.g. UAVs). Moreover, aerial data could also offer new sensors, currently not available via satellites (e.g. lidar, hyperspectral). As such, it would prove interesting to integrate this data into Copernicus products.
    b. Moreover, some Cultural Heritage user needs are linked to very specific user requirements and technical specifications that could be covered with satellite imagery, but that are not part of Copernicus. Additional contributing missions could notably cover some, especially related to L-band SAR on which no high resolution is currently available. New capabilities included in the Copernicus future generation could also play this role, by enhancing Copernicus capacities with additional Thermal Infrared bands and/or hyperspectral ones.
9. Security and Emergency products related to Cultural Heritage are already well covered in the current scope of the Copernicus programme, thanks to the Copernicus Emergency Monitoring Services (EMS) and Copernicus Security Service in support of EU External Actions. Such services are reserved for EU authorized users and their products are therefore not fully open and accessible. Nevertheless, having a dedicated intervention in

the field of Cultural Heritage in Europe, by mentioning Cultural Heritage in their delegation agreement, could support the Copernicus EMS and Copernicus Security Service in support of EU External Actions in raising awareness of their own Cultural Heritage activities, potentially allowing them to access additional funding to better serve Cultural Heritage purposes. For example, even if Natural Heritage is covered by those services, no specific products tailored to the monitoring of Natural Heritage sites is currently available in the catalogue of products of the Copernicus EMS and Copernicus Security Service in support of EU External Actions. An intervention in the field of Cultural Heritage could then enable those two services to access specific funding to develop such products.

Appendix/Annex

Annex A - Consultation activities

Types of stakeholders consulted

The targeted user communities for the interviews and online survey have been selected on the basis of specific criteria.

First, on the coverage of the entire value chain as presented in the "user needs identification" section (hence from the creation, production and transmission segments). These users span from public authorities and international organisations, to academia, private companies (e.g. downstream companies) and researchers (e.g. architects, engineers, biologists, historians, etc.). This is also to be complemented by interviews with stakeholders in the supply chain, such as Earth observation imagery providers or Copernicus product providers.

Second, on a global geographic coverage, as Copernicus is meant to serve worldwide user communities of Cultural Heritage. User communities in charge of cultural or natural sites outside Europe should also be consulted. These two elements will ensure a global understanding of Cultural Heritage stakes and of how Copernicus can better fit user requirements.

Types of consultation activities

The study used two different methods for the consultation:

- **Face-to-face/telephone interviews**: the face-to-face/telephone interviews method implies direct interactions with selected users in the form of semi-structured interviews. For these interviews, a series of guidelines have been defined and was used to ensure that all questions and topics were addressed during the interviews.
- **Targeted consultation** by means of an online questionnaire: targeted consultation implies the distribution of an online questionnaire to a large number of stakeholders from all user communities. The majority of questions in the questionnaire are in closed form (i.e. one or more options from a list of pre-defined answers). Users were also given the possibility of completing their answer with an open text box. Questions were generalised so that all types of users with the right level of involvement can answer them.

Online survey

A list of 422 stakeholders was defined by PwC with the support of the EC, and NAIS. The objective of the list was to identify a large number of stakeholders intervening in one or more segments of the CH value chain as well as experts capable of providing an overview of the state of the CH needs and development.

It is worth noticing that stakeholders from the same institution have sometime answered to the survey as one, providing therefore a limited but yet representative answer for their community of stakeholders.

As a whole, the list of stakeholders included stakeholders from the international, public and private sectors (industry, SMEs) as well as research and academic entities to cover the Cultural Heritage value chain.

The online survey was opened to the public from April 15th until May 25th 2018, and gathered a total of 67 answers from 19 different countries and 5 International Organisations. As a reminder,

each of these answers should be considered as representative of the needs of a given stakeholder entity and not an individual answer, therefore justifying its relative representativeness. 22 phone interviews were conducted from March 2018 to May 2018 with key stakeholders, thus providing a satisfactory representation of EU and non EU countries working in the CH environment

Interviews

The phone interviews involved direct interaction with selected interviewees in the form of semi-structured interviews. 39 experts and key stakeholders were contacted and 22 interviews were conducted.

Results of the stakeholder consultation

The online survey and the phone interviews were very complementary as the first one collected key data information for all user community but participation of site operators and downstream user community was under representative. Their needs were mainly collected through direct interviews providing strong qualitative data for those communities in addition to a reliable overview of the value chain with the experts.

Table 45: Reach of stakeholder consultation

Targeted public	**More than 400 stakeholders**
Public reached	>20%
Geographical coverage	Representative sample
Value chain coverage	Representative sample
User communities coverage	Satisfactory
Field and environment coverage	Balanced

Table 46: Quantity of stakeholder distributed and reached

Respondents	Distributed	Answered	Response rate
Online survey	383 +Public access on specific websites	67	About 18%
Phone interviews	39	22	56%
Total	422	89	21%

The status of the interview consultation is presented in the charts below:

Figure 57: Distribution of stakeholder along the value chain

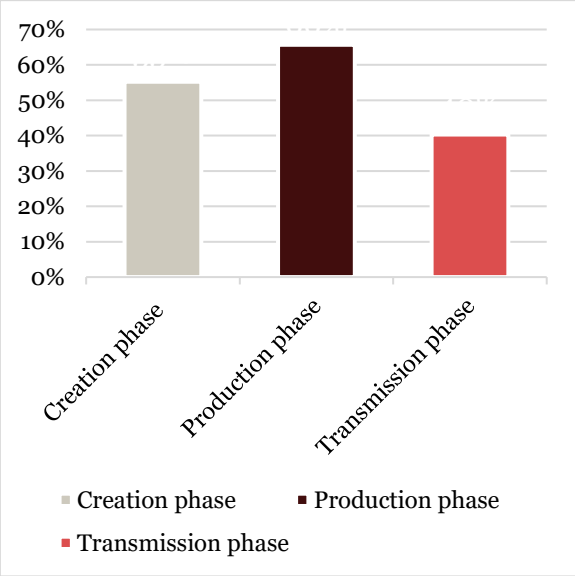
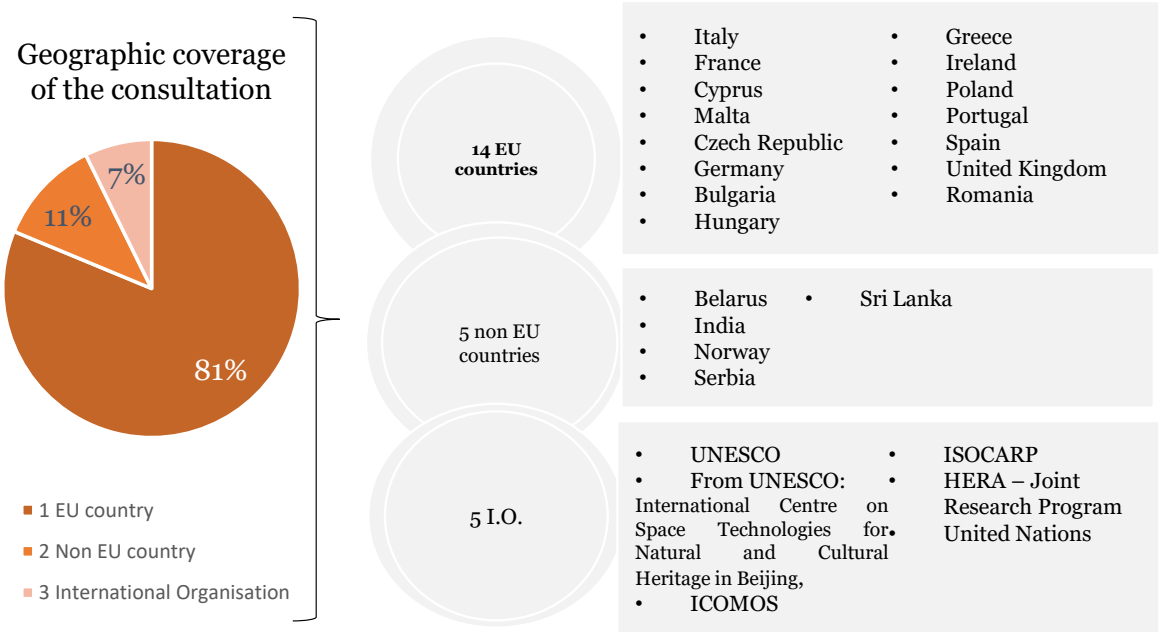


Figure 58: Stakeholder direct consultation status

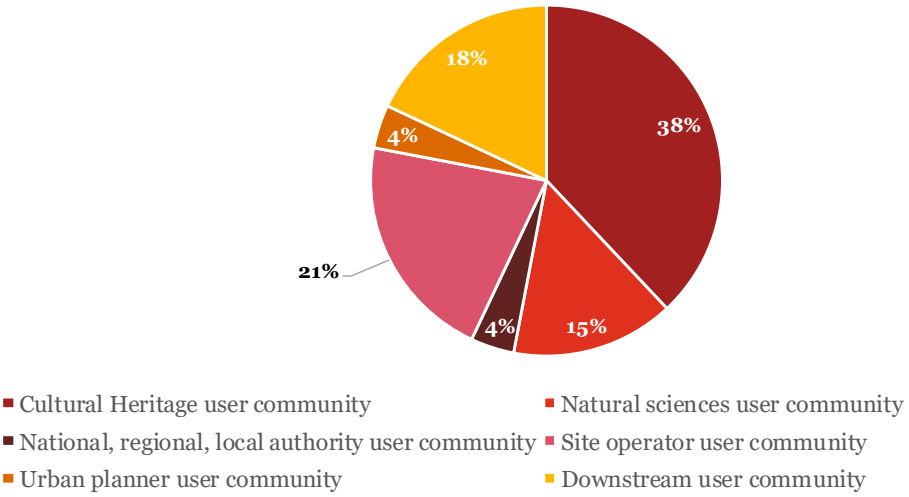


The overall consultation was satisfactory in terms of representation and collecting of needs for all user communities, intervening in all CH land covers and type of environments as presented in the figures below.

Representation of user communities

The chart below illustrates the repartition of stakeholders per type of user communities, for a total number of 89 respondents.

Figure 59: Repartition of user communities within the stakeholder consultation (including both survey and direct interviews)



On the top of their belonging to specific user communities, respondents were mainly from governmental or research organization (70%) which should also be balanced when considering the taxonomy as few stakeholders could identify themselves as belonging to more than one type of organization. Eventually, it would appear that the limited amount of SMEs or other private organization working in the CH field could explain the humble answer rate to the survey.

Table 47: Repartition of the nature of organisations that the stakeholders identify themselves with

Nature of organisation	Answered
Governmental organisation	70%
Non-governmental organisation	14%
Private organisation	16%
Total	100%

*Table 48: Repartition of the type of organisations that the stakeholders identify themselves with**

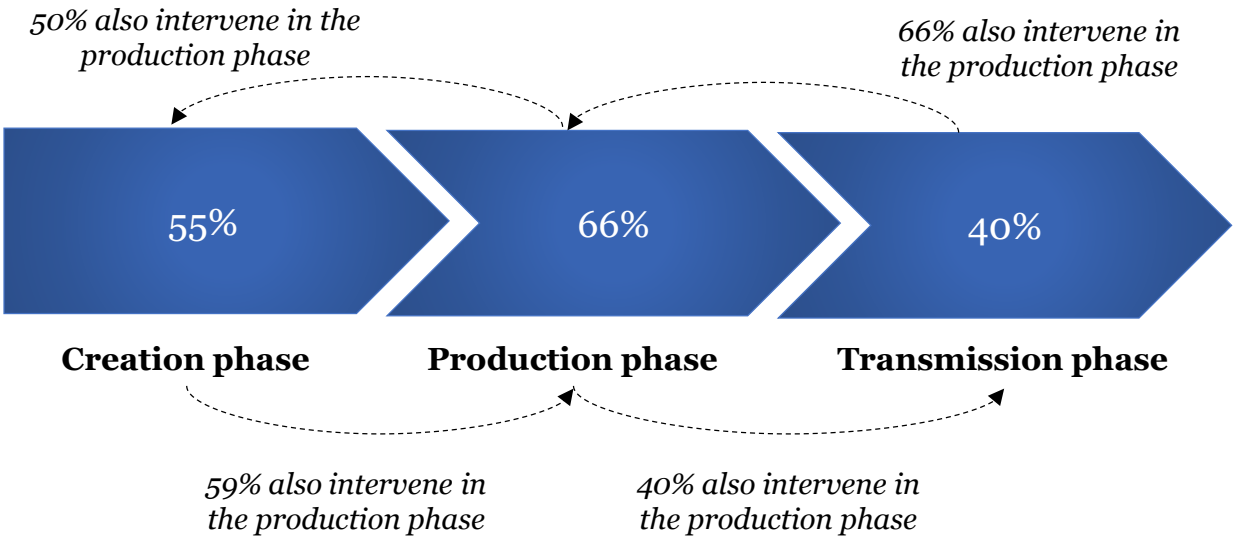
Type of organisation	Answered
Research center / organisation	70%
Value added services companies	14%
Public and private foundations	9%
Other type of organisation including associations, UN and National Heritage bodies	24%

*It should be noted organisations could identify themselves in more than one category

Distribution along the value chain

It appears that 66% of respondents intervene in the production phase, 55% in the creation phase and 40% in the transmission phase. As it appears in the figure below, stakeholders tend to identify themselves in more than one segment of the value chain.

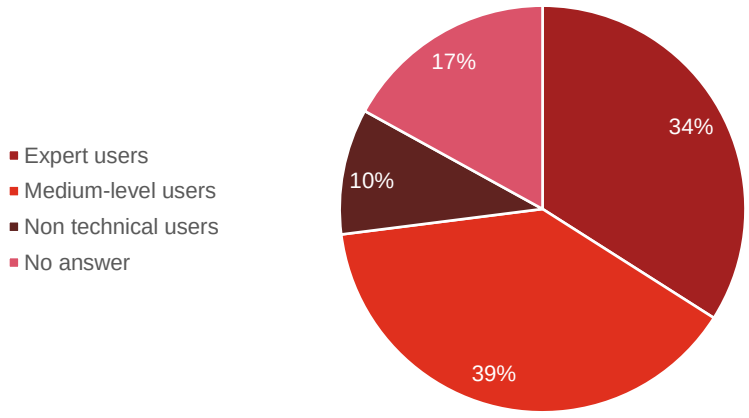
Figure 60: Identification of the stakeholders among the value chain



Level of expertise of the stakeholders in Earth Observation

More than 70% of stakeholders who responded to the survey defined themselves as medium-level users or expert users of EO data. This show that pool of consulted stakeholders would be able to provide a knowledgeable point of view on the technical requirements and can be considered as reliable information.

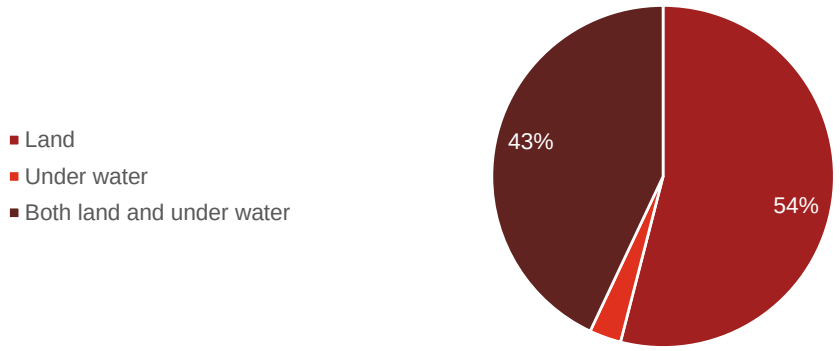
Figure 61: Level of expertise of users



Nature of interventions within the CH land covers and environments

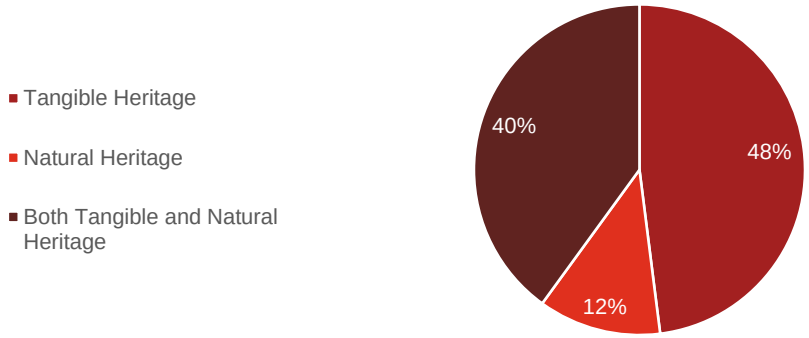
The survey provided a good representativeness of needs in both Heritage fields and both main types of environment (land and water). In terms of environment, interest for Land was the highest at 54%, closely followed by both Land and Underwater (at 43%) and finally stakeholders who were only interested in underwater environments were the least represented, at 3%.

Figure 62: Environment of intervention of the stakeholders



48% of respondents intervene in Tangible Heritage, 40% intervene in both Tangible Heritage and Natural Heritage.

Figure 63: Heritage fields of interest to the stakeholders



Consequently, close to 50% of stakeholders will require information from land and/or underwater environments. The same stands for Tangible and Natural Heritage accordingly.

In terms of land covers, as seen in the table below, all of the land covers are of interest to the stakeholders, with a particular interest for urban and peri-urban land covers as well as rural or forested areas.

Table 49: Land covers of interest to the stakeholders (multiple answers possible)*

***How to read the table**: Out of 100% of respondents intervening in land covers, 66% work in urban and sur-urban areas*

Type	Field	% total respondents
Land	Urban and sub-urban	66%
	Rural or forested areas	63%
	Mountainous/hilly regions	50%
	Scrub and grassland	43%
	Coastal	43%
	Rainforest	29%
	Alluvial plain or Floodplain	25%
	Waterlogged/wetland	18%
	Frozen/glacial areas	15%
	Inland waters (e.g. lakes, rivers)	19%
Sea	Undersea	24%
	Costal	37%
	Water surface	21%

As it is shown in the table above, stakeholders appear to not be specialized in one specific field but rather work in multiple environments through their activities.

Results of the questionnaire

User needs for the creation segment of the value chain by activity

How to read the table: *ex. 81% of respondents intervening in the creation segment and who conduct prospection activities, use NDVI when conducting identification of potential CH sites. 50% also use it to verify the conditions to conduct survey operations and 88% also use it for preliminary research.*

User needs (1/2)	Prospection activities				Operation activities			Recognition activities	
	Identify potential Cultural Heritage sites	Verify the conditions for conducting survey operations	Conduct preliminary research including non-destructive assessment and or field assessment and evaluation	Other*	Identify adequate methodology for intervention	Proceed to intervention	Other*	Inventory of Heritage assets in the context of a candidacy for recognition	Other*
Normalized difference vegetation index (method for measuring vegetation vigor in satellite imagery)	81%	50%	88%	25%	100%	25%	13%	83%	33%
Multitemporal analysis over the same area to detect anomalies that can reveal past structures (e.g. through the identification of cropmarks, soil marks, ecc.)	82%	71%	94%	24%	100%	50%	20%	87%	27%
Chlorophyll levels measurement	71%	57%	100%	29%	100%	50%	25%	83%	33%
Stratigraphy (i.e. depth, inclination, etc)	56%	78%	89%	11%	86%	57%	14%	86%	29%
Visual identification via imagery	79%	58%	84%	21%	100%	38%	13%	85%	31%
Topographic mapping	74%	68%	84%	26%	90%	40%	20%	92%	23%
Photogrammetric mapping	72%	72%	94%	17%	100%	63%	25%	93%	21%
Identification of previously searched sites in the area	75%	67%	83%	25%	83%	67%	17%	91%	27%
Other*	50%	50%	100%	50%	67%	0%	67%	67%	67%
Thermal anomaly detection	63%	75%	100%	25%	100%	50%	25%	88%	25%

User needs for the creation segment of the value chain by type of heritage the stakeholders were interested in

User needs (2/2)	Prospection activities				Operation activities			Recognition activities	
	Identify potential Cultural Heritage sites	Verify the conditions for conducting survey operations	Conduct preliminary research including non-destructive assessment and or field assessment and evaluation	Other	Identify adequate methodology for intervention	Proceed to intervention	Other	Inventory of Heritage assets in the context of a candidacy for recognition	Other
Material composition analysis	58%	67%	100%	8%	86%	57%	14%	86%	29%
Constatation of damage on buildings or natural environments	75%	58%	83%	25%	100%	29%	29%	83%	25%
Bathymetry	67%	67%	100%	33%	100%	50%	50%	75%	50%
Evaluation of the site's exposure to natural and human risks	67%	61%	89%	22%	100%	56%	22%	83%	25%
Rock assay analysis	33%	67%	100%	33%	100%	33%	33%	50%	50%
High resolution monitoring of vegetation levels	63%	63%	88%	38%	100%	33%	17%	75%	38%
Metal detecting	86%	86%	100%	29%	100%	67%	33%	83%	17%
Tectonic petrography	50%	50%	100%	50%	100%	50%	50%	0%	100%
Signs of mineralisation identification	67%	67%	100%	33%	100%	33%	33%	67%	33%
Salinity levels measurement	67%	83%	100%	17%	100%	60%	20%	80%	20%
Lithology	40%	80%	100%	20%	75%	50%	25%	80%	40%
Geodetic recording (geometric shape, orientation in space, gravity field)	75%	75%	75%	38%	100%	60%	20%	90%	30%

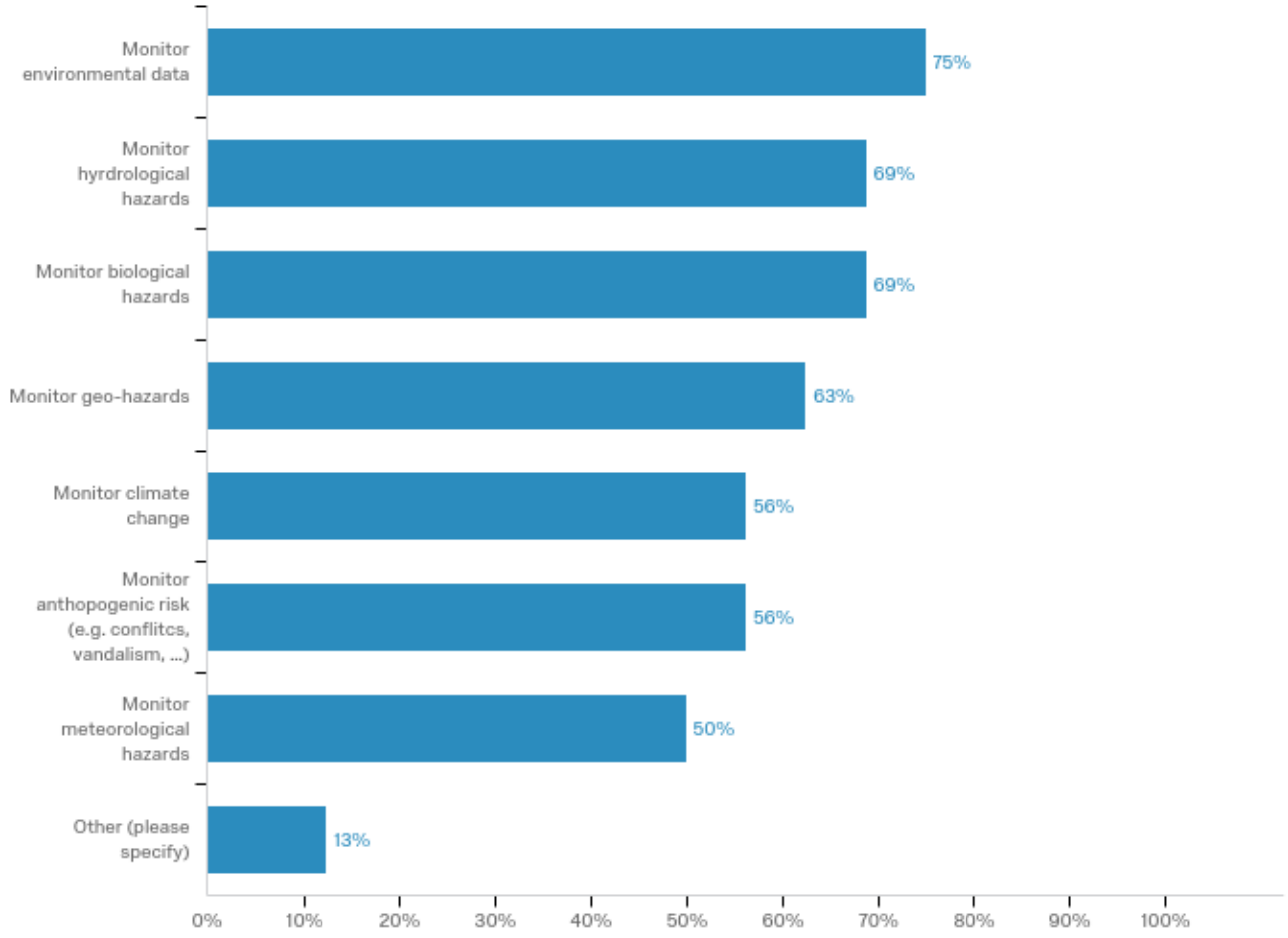
How to read the table: ex. For 33% of respondents working in the creation segment, the use of signs of mineralization is necessary when working with ICH.

User needs for the creation phase	Immovable Cultural Heritage	Natural Cultural Heritage	Both Immovable Cultural and Natural Cultural Heritage	TOTAL
Tectonic petrography	0%	0%	100%	100%
Metal detecting	29%	0%	71%	100%
Signs of mineralisation identification	33%	0%	67%	100%
Rock assay analysis	33%	0%	67%	100%
Bathymetry	33%	0%	67%	100%
High resolution monitoring of vegetation levels	25%	17%	58%	100%
Lithology	43%	0%	57%	100%
Topographic mapping	39%	4%	57%	100%
Constatation of damage on buildings or natural environments	38%	6%	56%	100%
Photogrammetric mapping	45%	0%	55%	100%
Thermal anomaly detection	36%	9%	55%	100%
Evaluation of the site's exposure to natural and human risks	36%	9%	55%	100%
Visual identification via imagery	43%	4%	52%	100%
Total	36%	4%	60%	100%
Salinity levels measurement	50%	0%	50%	100%
Material composition analysis	50%	0%	50%	100%
Identification of previously searched sites in the area	50%	0%	50%	100%
Geodetic recording (geometric shape, orientation in space, gravity field)	42%	8%	50%	100%
Normalized difference vegetation index (method for measuring vegetation vigor in satellite imagery)	35%	15%	50%	100%
Stratigraphy (i.e. depth, inclination, etc)	55%	0%	45%	100%
Chlorophyll levels measurement	44%	11%	44%	100%
Multitemporal analysis over the same area to detect anomalies that can reveal past structures (e.g. through the identification of cropmarks, soil marks, ecc.)	55%	5%	41%	100%

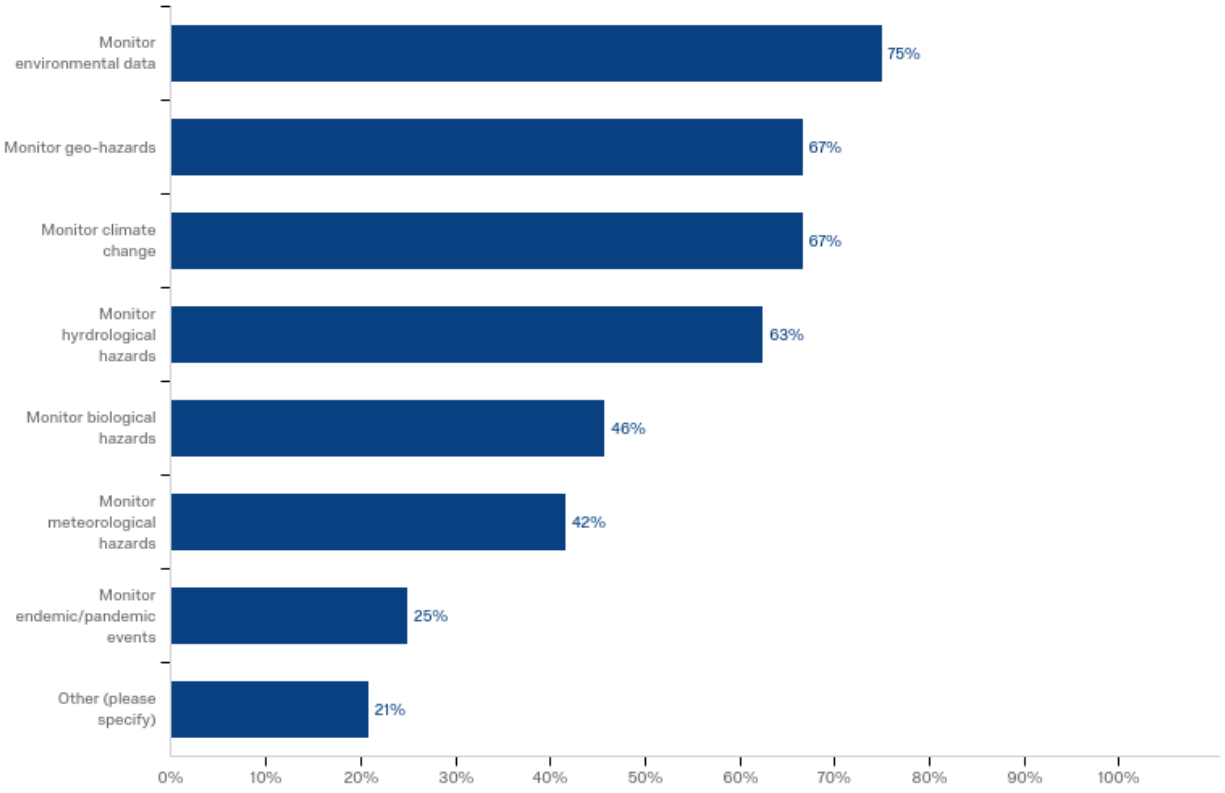
How to read the table: ex. For 52% of respondents working in the creation segment, visual identification via imagery is necessary to land environments.

User needs for the creation phase	Land	Under water	Both land and under water	TOTAL
Visual identification via imagery	52%	0%	48%	100%
Topographic mapping	52%	0%	48%	100%
Thermal anomaly detection	45%	0%	55%	100%
Tectonic petrography	50%	0%	50%	100%
Stratigraphy (i.e. depth, inclination, etc)	55%	0%	45%	100%
Signs of mineralisation identification	0%	0%	100%	100%
Salinity levels measurement	17%	0%	83%	100%
Rock assay analysis	0%	0%	100%	100%
Photogrammetric mapping	50%	0%	50%	100%
Normalized difference vegetation index (method for measuring vegetation vigor in satellite imagery)	45%	0%	55%	100%
Metal detecting	43%	0%	57%	100%
Material composition analysis	43%	0%	57%	100%
Lithology	43%	0%	57%	100%
Identification of previously searched sites in the area	50%	0%	50%	100%
High resolution monitoring of vegetation levels	50%	0%	50%	100%
Geodetic recording (geometric shape, orientation in space, gravity field)	58%	0%	42%	100%
Evaluation of the site's exposure to natural and human risks	55%	0%	45%	100%
Constation of damage on buildings or natural environments	44%	0%	56%	100%
Chlorophyll levels measurement	44%	0%	56%	100%
Bathymetry	0%	0%	100%	100%
Average %	40%	0%	60%	100%

Types of monitoring conducted within conservation activities



Types of monitoring conducted within preservation activities



User needs for the production segment of the value chain by tasks of conservation and preservation activities performed by the user communities

How to read the table: ex. For 57% of respondents intervening in the production segment, cropmarks are needed to conduct conservation activities.

User needs for the production segment (1/2)	Conservation activities	User needs for the production segment (1/2)	Preservation activities
Cropmarks (Multitemporal analysis)	57%	Cropmarks (Multitemporal analysis)	86%
Soil marks (Multitemporal analysis)	55%	Soil marks (Multitemporal analysis)	87%
Chlorophyll levels measurement	51%	Chlorophyll levels measurement	85%
Normalized difference vegetation index	57%	Normalized difference vegetation index	88%
Visual identification via imagery	53%	Visual identification via imagery	79%
Stratigraphy (e.g. depth)	57%	Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	82%
Topographic mapping	52%	Topographic mapping	79%
Photogrammetric mapping	58%	Photogrammetric mapping	81%
Identification of previously searched sites in the area	58%	Identification and collect of information on existing cultural heritage sites in the area	80%
Material composition analysis	60%	Material composition analysis	82%
Constatation of damage on buildings or natural environments	56%	Constation of damage on buildings or natural environments	86%
Bathymetry	63%	Bathymetry	88%
Evaluation of the site's exposure to natural and human risks	57%	Evaluation of the site's exposure to natural and human risks	83%
Rock assay analysis	70%	Rock assay analysis	60%
Higher resolution of vegetation levels	58%	High resolution monitoring of vegetation levels	95%
Metal detecting	58%	Metal detecting	89%
Tectonic petrography	53%	Tectonic petrography	50%
Signs of mineralisation identification	67%	Signs of mineralisation identification	84%
Salinity levels measurement	67%	Salinity levels measurement	93%
Lithology	53%	Lithology	92%
Geodetic recording (geometric shape, orientation in space, gravity field)	48%	Geodetic recording (geometric shape, orientation in space, gravity field)	86%
Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	60%	Map regression	80%

Uset needs for the production segment (2/2)	Conservation activities	User needs for the production segment (2/2)	Preservation activities
Gravity field	50%	Real-time monitoring of emergency events (e.g. flash floods, forest fires)	86%
Stratigraphic description of the archeological site and identification of individual layers or stratigraphic units	62%	Coastal erosion monitoring (under and above the sea)	93%
Map regression	67%	Rainfall erosivity monitoring	89%
Real-time monitoring of emergency events (e.g. flash floods)	58%	Ground motion monitoring	82%
Monitoring of the movements of building structure parts	62%	Water level monitoring	95%
Coastal erosion monitoring (under and above the sea)	62%	Air pollution monitoring	91%
Rainfall erosivity monitoring	58%	Water pollution monitoring	95%
Ground motion	60%	Atmospheric moisture measurement	91%
Water level monitoring	60%	Wind direction & speed monitoring	90%
Air pollution monitoring	59%	Temperature monitoring	88%
Water pollution monitoring	60%	Elevation modelling	89%
Atmospheric moisture measurement	63%	Water current monitoring	84%
Wind direction & speed monitoring	63%	Sediment levels measurement	90%
Temperature monitoring	62%	Wildlife tracking	20%
Elevation modelling	65%	Forest coverage monitoring	84%
Water current monitoring	57%	Water quality monitoring	92%
Sediment levels measurement	63%	Ice cover monitoring (sea) / Snow cover monitoring (land)	100%
Geo-hazard monitoring/forecasting	60%	Insolation monitoring	88%
Analysis of soil distribution and composition	60%	Geo-hazard monitoring/forecasting	92%
Insolation monitoring	69%	Grassland levels measurement	75%
Other	100%	Evolution of vegetation typology monitoring	100%
		Analysis of soil distribution and composition	94%
		Other	83%

How to read the table: ex. For 69% of respondents conducting conservation activities, 50% use cropmarks to perform restauration activities, 56% also use chlorophyll levels measurement.

Production segment	Conservation activities (1/2)				
User needs for conservation activities	Proceed to the revision of archeological research (coordination of existing data to update existing inventory)	Perform restauration activities	Monitoring of a site	Conduct the risk prevention of a site	Other
Cropmarks (Multitemporal analysis)	69%	50%	88%	63%	13%
Soil marks (Multitemporal analysis)	71%	47%	88%	59%	12%
Chlorophyll levels measurement	56%	56%	78%	56%	11%
Normalized difference vegetation index	60%	47%	100%	67%	13%
Visual identification via imagery	61%	44%	89%	61%	11%
Stratigraphy (e.g. depth)	83%	50%	83%	67%	0%
Topographic mapping	65%	53%	82%	53%	6%
Photogrammetric mapping	71%	62%	90%	67%	0%
Identification of previously searched sites in the area	82%	45%	91%	64%	9%
Material composition analysis	80%	60%	87%	73%	0%
Constatation of damage on buildings or natural environments	62%	57%	86%	67%	10%
Bathymetry	67%	67%	100%	83%	0%
Evaluation of the site's exposure to natural and human risks	63%	58%	84%	68%	11%
Rock assay analysis	100%	50%	100%	100%	0%
Higher resolution of vegetation levels	64%	55%	91%	73%	9%
Metal detecting	67%	78%	78%	67%	0%
Tectonic petrography	100%	67%	67%	33%	0%
Signs of mineralisation identification	100%	33%	100%	100%	0%
Salinity levels measurement	78%	78%	89%	89%	0%
Lithology	78%	44%	78%	56%	11%
Geodetic recording (geometric shape, orientation in space, gravity field)	63%	38%	88%	50%	0%
Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	89%	56%	89%	67%	0%
Gravity field	50%	50%	100%	50%	0%

Production segment	Conservation activities (2/2)				
User needs for conservation activities	Proceed to the revision of archeological research (coordination of existing data to update existing inventory)	Perform restauration activities	Monitoring of a site	Conduct the risk prevention of a site	Other
Stratigraphic description of the archeological site and identification of individual layers or stratigraphic units	100%	60%	80%	70%	0%
Map regression	83%	67%	100%	83%	0%
Real-time monitoring of emergency events (e.g. flash floods)	69%	44%	94%	69%	13%
Monitoring of the movements of building structure parts	72%	56%	94%	78%	11%
Coastal erosion monitoring (under and above the sea)	73%	45%	100%	82%	9%
Rainfall erosivity monitoring	73%	64%	82%	73%	0%
Ground motion	55%	55%	100%	73%	18%
Water level monitoring	67%	75%	83%	75%	0%
Air pollution monitoring	67%	67%	87%	73%	0%
Water pollution monitoring	73%	73%	82%	73%	0%
Atmospheric moisture measurement	77%	62%	92%	85%	0%
Wind direction & speed monitoring	75%	67%	92%	83%	0%
Temperature monitoring	75%	58%	92%	83%	0%
Elevation modelling	75%	67%	100%	83%	0%
Water current monitoring	83%	50%	83%	67%	0%
Sediment levels measurement	75%	63%	88%	88%	0%
Geo-hazard monitoring/forecasting	75%	67%	83%	67%	8%
Analysis of soil distribution and composition	80%	50%	90%	70%	10%
Insolation monitoring	86%	57%	100%	100%	0%
Other	100%	100%	100%	100%	100%

User needs for the production segment of the value chain by environment interesting to the stakeholders for conservation activities

User need for conservation activities	Land	Under water	Both land and under water	Total
Cropmarks (Multitemporal analysis)	56,3%	0,0%	43,8%	100,0%
Soil marks (Multitemporal analysis)	58,8%	0,0%	41,2%	100,0%
Chlorophyll levels measurement	33,3%	0,0%	66,7%	100,0%
Normalized difference vegetation index	66,7%	0,0%	33,3%	100,0%
Visual identification via imagery	66,7%	0,0%	33,3%	100,0%
Stratigraphy (e.g. depth)	50,0%	0,0%	50,0%	100,0%
Topographic mapping	58,8%	0,0%	41,2%	100,0%
Photogrammetric mapping	66,7%	0,0%	33,3%	100,0%
Identification of previously searched sites in the area	54,6%	0,0%	45,5%	100,0%
Material composition analysis	40,0%	0,0%	60,0%	100,0%
Constatation of damage on buildings or natural environments	52,4%	0,0%	47,6%	100,0%
Bathymetry	16,7%	0,0%	83,3%	100,0%
Evaluation of the site's exposure to natural and human risks	52,6%	0,0%	47,4%	100,0%
Rock assay analysis	0,0%	0,0%	100,0%	100,0%
Higher resolution of vegetation levels	36,4%	0,0%	63,6%	100,0%
Metal detecting	55,6%	0,0%	44,4%	100,0%
Tectonic petrography	66,7%	0,0%	33,3%	100,0%
Signs of mineralisation identification	0,0%	0,0%	100,0%	100,0%
Salinity levels measurement	22,2%	0,0%	77,8%	100,0%
Lithology	44,4%	0,0%	55,6%	100,0%
Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	62,5%	0,0%	37,5%	100,0%
Gravity field				0,0%
Stratigraphic description of the archeological site and identification of individual layers or stratigraphic units	55,6%	0,0%	44,4%	100,0%
Map regression	50,0%	0,0%	50,0%	100,0%
Real-time monitoring of emergency events (e.g. flash floods)				0,0%
Monitoring of the movements of building structure parts	60,0%	0,0%	40,0%	100,0%
Coastal erosion monitoring (under and above the sea)	50,0%	0,0%	50,0%	100,0%
Rainfall erosivity monitoring	56,3%	0,0%	43,8%	100,0%
Ground motion	50,0%	0,0%	50,0%	100,0%
Water level monitoring	27,3%	0,0%	72,7%	100,0%
Air pollution monitoring	36,4%	0,0%	63,6%	100,0%
Water pollution monitoring	45,5%	0,0%	54,6%	100,0%
Atmospheric moisture measurement	25,0%	0,0%	75,0%	100,0%
Wind direction & speed monitoring	33,3%	0,0%	66,7%	100,0%
Temperature monitoring	27,3%	0,0%	72,7%	100,0%
Elevation modelling	38,5%	0,0%	61,5%	100,0%
Water current monitoring	41,7%	0,0%	58,3%	100,0%
Sediment levels measurement	33,3%	0,0%	66,7%	100,0%
Geo-hazard monitoring/forecasting	41,7%	0,0%	58,3%	100,0%

Analysis of soil distribution and composition	50,0%	0,0%	50,0%	100,0%
Insolation monitoring	50,0%	0,0%	50,0%	100,0%

User needs for the production segment of the value chain by environment interesting to the stakeholders for preservation activities

User need for preservation activities	Land	Under water	Both land and under water	TOTAL
Cropmarks (Multitemporal analysis)	50%	0%	50%	100%
Soil marks (Multitemporal analysis)	53%	0%	47%	100%
Chlorophyll levels measurement	30%	0%	70%	100%
Normalized difference vegetation index	67%	0%	33%	100%
Visual identification via imagery	68%	0%	32%	100%
Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	45%	0%	55%	100%
Topographic mapping	69%	0%	31%	100%
Photogrammetric mapping	62%	0%	38%	100%
Identification and collect of information on existing cultural heritage sites in the area	65%	0%	35%	100%
Material composition analysis	44%	0%	56%	100%
Constation of damage on buildings or natural environments	57%	0%	43%	100%
Bathymetry	0%	0%	100%	100%
Evaluation of the site's exposure to natural and human risks	53%	0%	47%	100%
Rock assay analysis	40%	0%	60%	100%
High resolution monitoring of vegetation levels	40%	0%	60%	100%
Metal detecting	56%	0%	44%	100%
Tectonic petrography	0%	0%	100%	100%
Signs of mineralisation identification	33%	0%	67%	100%
Salinity levels measurement	29%	0%	71%	100%
Lithology	33%	0%	67%	100%
Geodetic recording (geometric shape, orientation in space, gravity field)	71%	0%	29%	100%
Map regression	50%	0%	50%	100%
Real-time monitoring of emergency events (e.g. flash floods, forest fires)	57%	0%	43%	100%
Coastal erosion monitoring (under and above the sea)	29%	0%	71%	100%
Rainfall erosivity monitoring	33%	0%	67%	100%
Ground motion monitoring	38%	0%	63%	100%
Water level monitoring	50%	0%	50%	100%
Air pollution monitoring	36%	0%	64%	100%
Water pollution monitoring	30%	0%	70%	100%
Atmospheric moisture measurement	27%	0%	73%	100%
Wind direction & speed monitoring	40%	0%	60%	100%
Temperature monitoring	33%	0%	67%	100%
Elevation modelling	56%	0%	44%	100%
Water current monitoring	67%	0%	33%	100%
Sediment levels measurement	20%	0%	80%	100%
Wildlife tracking	0%	0%	100%	100%
Forest coverage monitoring	33%	0%	67%	100%
Water quality monitoring	0%	0%	100%	100%
Ice cover monitoring (sea) / Snow cover monitoring (land)	0%	0%	100%	100%
Insolation monitoring	0%	0%	100%	100%
Geo-hazard monitoring/forecasting	60%	0%	40%	100%
Grassland levels measurement	25%	0%	75%	100%
Evolution of vegetation typology monitoring	38%	0%	63%	100%
Analysis of soil distribution and composition	33%	0%	67%	100%
Other (please, specify)	0%	0%	100%	100%

User needs for the transmission segment of the value chain by activity performed by the stakeholders

How to read the tables: ex. Out of 100% of respondents who intervene in site management activities, 61% need to plan the capacity for public access, and 41% also need to monitor frequentation.

User needs for the transmission phase	Site management activities			
	Elevation modelling	Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	Mapping of frequentation patterns	Other
Planning of capacity for public access	61%	54%	54%	8%
Frequentation monitoring	41%	50%	75%	8%
Other (please, specify)	0%	0%	0%	0%

User needs for the transmission phase	Aggregation of scientific knowledge
Coastal erosion monitoring (under and above the sea)	100% of respondents intervening in the transmission phase (applicable to all)
Rainfall erosivity monitoring	100%
Ground motion monitoring	100%
Water level monitoring	100%
Air pollution monitoring	100%
Water pollution monitoring	100%
Atmospheric moisture monitoring	100%
Atmospheric moisture measurement	100%
Temperature monitoring	100%
Elevation modelling	100%
Salinity levels measurement	100%
Water current monitoring	100%
Sediment levels measurement	100%
Wildlife monitoring	100%
Forest coverage monitoring	100%
Water quality monitoring	100%
Ice cover monitoring (sea) / Snow cover monitoring (land)	100%
Insolation monitoring	100%
Geo-hazard monitoring/forecasting	100%
Stratigrapy (stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units)	100%
Grassland levels measurement	100%
Evolution of vegetation typology monitoring	100%
Analysis of soil distribution and composition	100%
Lithology	100%

Cropmarks (Multitemporal analysis)	100%
Soil marks (Multitemporal analysis)	100%
Chlorophyll levels measurement	100%
Normalized difference vegetation index	100%
Visual identification via imagery	100%
Topographic mapping	100%
Photogrammetric mapping	100%
Identification and collect of information on existing cultural heritage sites in the area	100%
Material composition analysis	100%
Constation of damage on buildings or natural environments	100%
Bathymetry	100%
Evaluation of the site's exposure to natural (e.g. sun, flooding, etc.) and human risks (e.g. pollution, chemical, etc.)	100%
Rock assay analysis	100%
High resolution monitoring of vegetation levels	100%
Metal detecting	100%
Tectonic petrography	0%
Signs of mineralisation identification	100%
Geodetic recording (geometric shape, orientation in space, gravity field)	100%
Constatation of damage on buildings or natural environments	100%

User needs for the transmission segment of the value chain by environment interesting to the stakeholders

	User need	Land	Under water	Both land and under water	Total
Development of commercial products activities	Photogrammetry	80%	0%	20%	100%
	Database access (access to collected raw data on a platform)	67%	0%	33%	100%
	Other (please specify)	50%	0%	50%	100%

	User need	Land	Under water	Both land and under water	Total

Site management	Elevation modelling	67%	0%	33%	100%
	Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	50%	0%	50%	100%
	Mapping of frequentation patterns	40%	20%	40%	100%
	Other (please, specify)	0%	0%	100%	100%

Overview of user requirements in terms of perimeter (per type of perimeter, value chain segment and type of heritage

***How to read the tables**: Out of 100% respondents, 16% require data with global perimeters, 34% require national perimeters. As respondents could answers to several requirements at the same time, the upcoming table do not represent a distribution but rather a percentage of out 100% of the respondents.*

#	Perimeter per value chain segment	Creation	Production	Transmission	Total
1	Very local level perimeters (e.g. house scale)	34%	44%	22%	100%

#	Overview of perimeter	Total %
1	Very local level perimeters (e.g. house scale)	40%
2	Local perimeters (e.g. city scale)	55%
3	Regional	49%
4	National	34%
5	Global (continental scale)	16%

2	Local perimeters (e.g. city scale)	33%	43%	24%	100%
3	Regional	37%	40%	23%	100%
4	National	34%	37%	29%	100%
5	Global (continental scale)	35%	40%	25%	100%

#	Perimeter	Immovable Cultural Heritage	Natural Cultural Heritage	Both Immovable Cultural and Natural Cultural Heritage	Total
1	Very local level perimeters (e.g. house scale)	56%	4%	40%	100%
2	Local perimeters (e.g. city scale)	43%	11%	46%	100%
3	Regional	42%	10%	48%	100%
4	National	39%	9%	52%	100%
5	Global (continental scale)	18%	27%	55%	100%

Overview of user requirements in terms of resolution

#	Resolution per environment	Land	Under water	Both land and under water	Total
1	Low and medium resolution (more than 5 meter)	50%	0%	50%	100%
2	High resolution (between 1 and 5 meter)	53%	3%	44%	100%
3	Very high resolution (less than 1 meter)	53%	0%	47%	100%
4	Other (please specify)	25%	0%	75%	100%

Overview of resolution required in terms of type of field

#	1	2	3	4
Resolution per field	Low and medium resolution (more than 5 meter)	High resolution (between 1 and 5 meter)	Very high resolution (less than 1 meter)	Other (please specify)
Rural or forested areas (Land)	11%	14%	13%	8%
Urban and sub-urban (Land)	12%	14%	13%	8%
Scrub and grassland (Land)	9%	11%	11%	4%
Mountainous/hilly regions (Land)	11%	11%	12%	12%
Rainforest (Land)	6%	6%	6%	8%
Water surface (Sea)	7%	5%	6%	8%
Underwater (Sea)	5%	5%	4%	4%
Tundra (Land)	2%	2%	3%	4%
Alluvial plain or Floodplain (Land)	6%	7%	7%	8%
Frozen/glacial areas (Land)	7%	4%	4%	8%
Frozen/glacial areas (Sea)	1%	1%	1%	0%
Waterlogged/wetland (Land)	5%	5%	5%	4%
Coastal (Sea/Land)	10%	8%	10%	8%
Coastal (Sea)	5%	6%	5%	8%
Other (please, specify)	3%	3%	3%	8%
TOTAL	100%	100%	100%	100%

Overview of requirements in terms of frequency per user community

#	Frequency per UC	Cultural Heritage professional user community	Natural sciences user community	National, Regional o Local authority user community	Site operator user community	Urban planner user community	Downstream user community	TOTAL
1	Every year	53%	26%	7%	0%	7%	7%	100%
2	Every month	43%	32%	10%	0%	5%	10%	100%
3	Every week	53%	26%	7%	0%	7%	7%	100%

4	Every day	50%	40%	10%	0%	0%	0%	100%
5	Every hour	30%	60%	10%	0%	0%	0%	100%

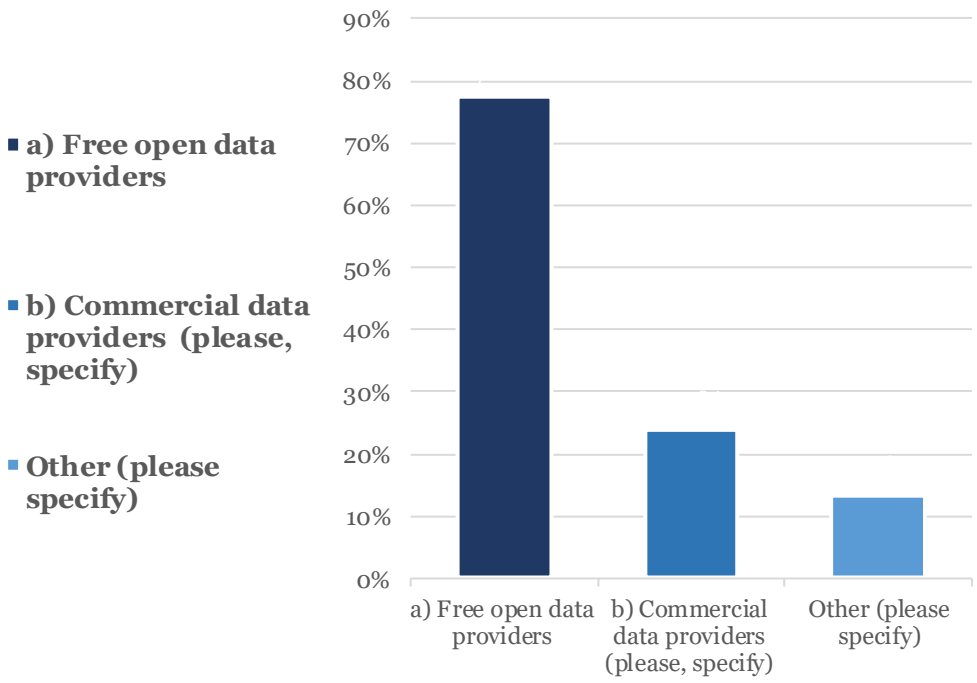
Overview of requirements in terms of frequency per segment of the value chain

#	Frequency	Creation	Production	Transmission	TOTAL
1	Every year	40%	44%	16%	100%
2	Every month	39%	45%	16%	100%
3	Every week	33%	44%	23%	100%
4	Every day	42%	37%	21%	100%
5	Every hour	39%	39%	22%	100%

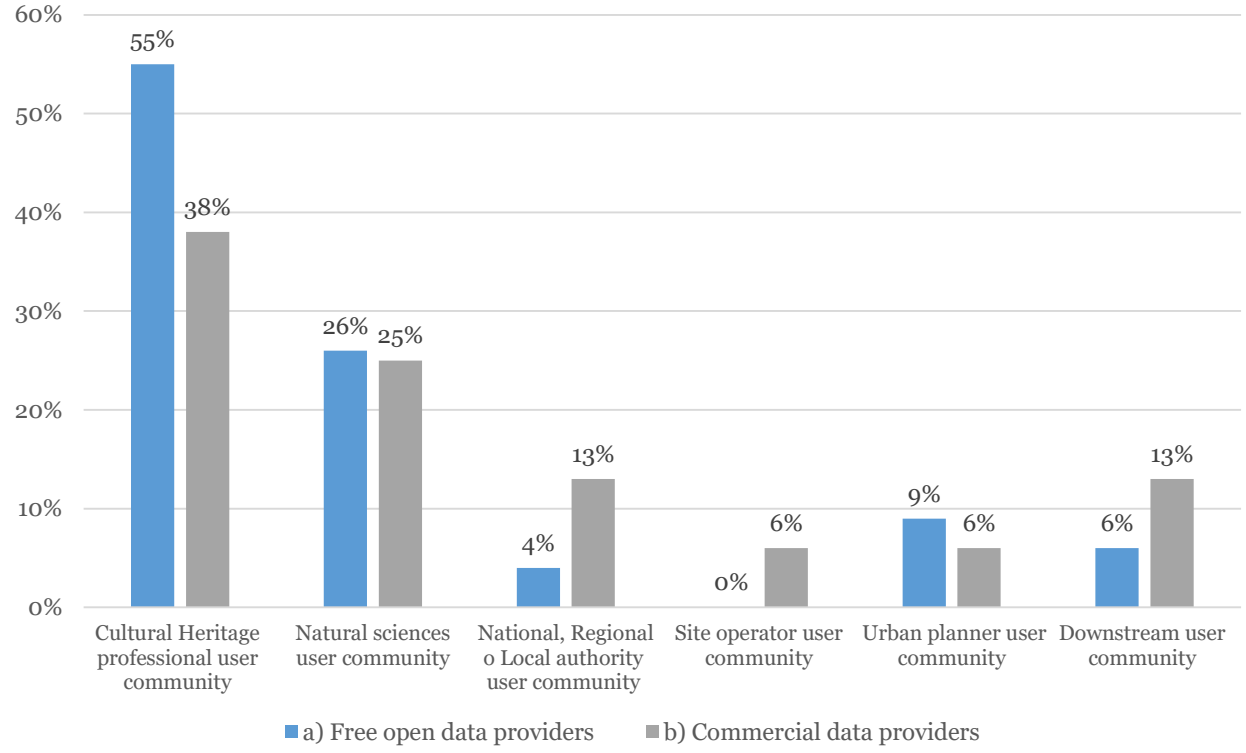
Overview of requirements in terms of frequency in total for all stakeholders

#	Frequency	%
1	Every year	18%
2	Every month	27%
3	Every week	19%
4	Every day	14%
5	Every hour	12%
6	Other	10%
TOTAL	Total	100%

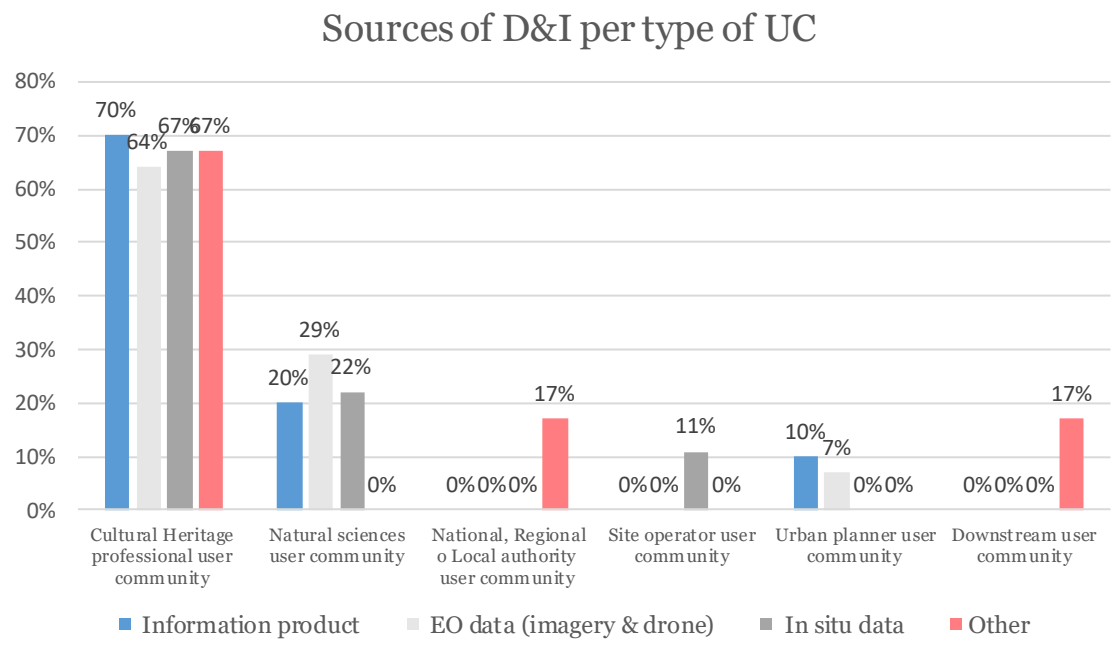
Current sources of D&I: General results



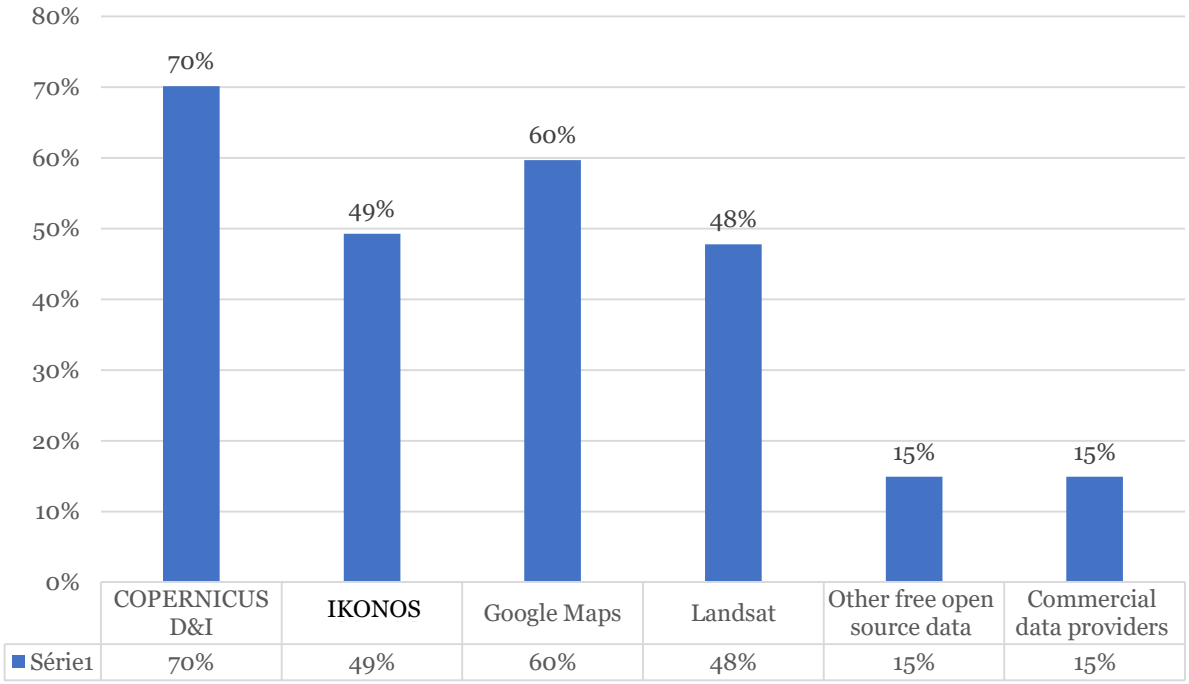
Current sources of D&I: Use of type of data per UC



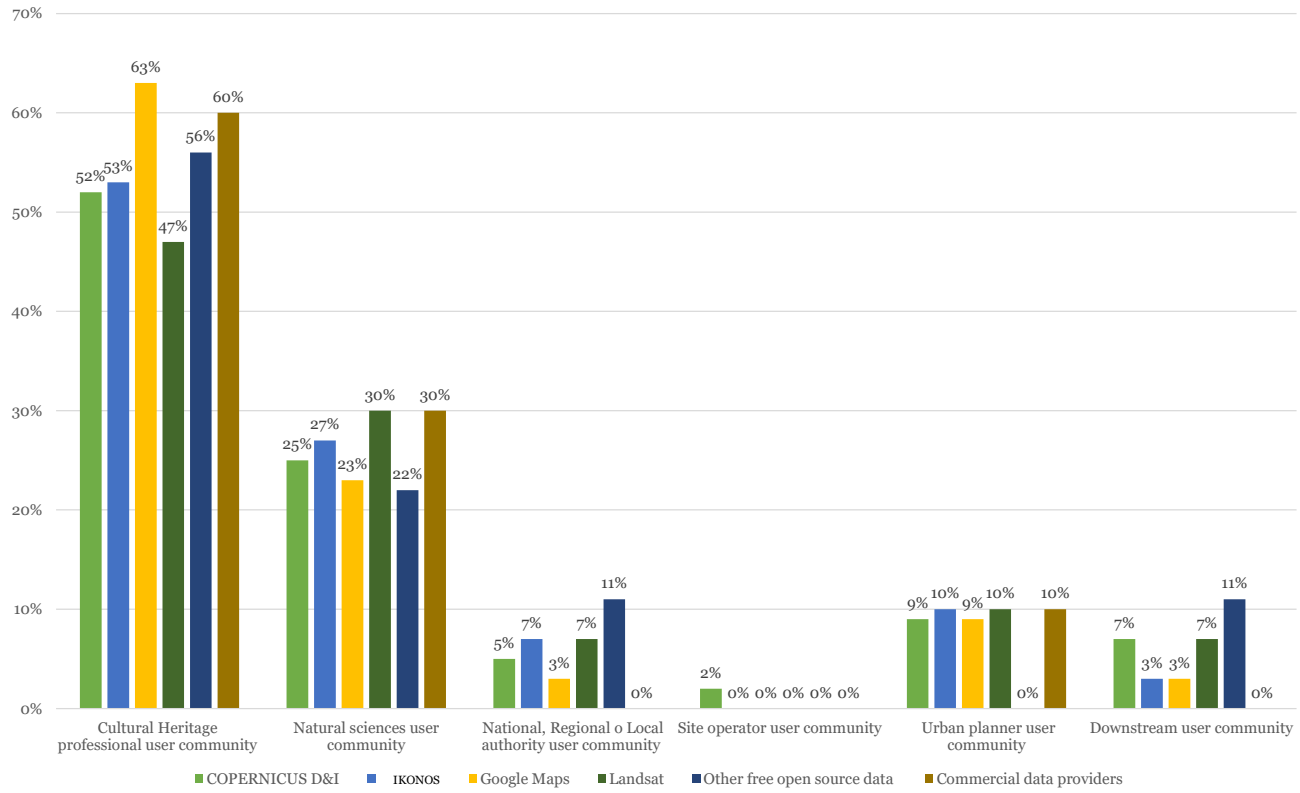
Current sources of D&I: Sources of D&I per UC



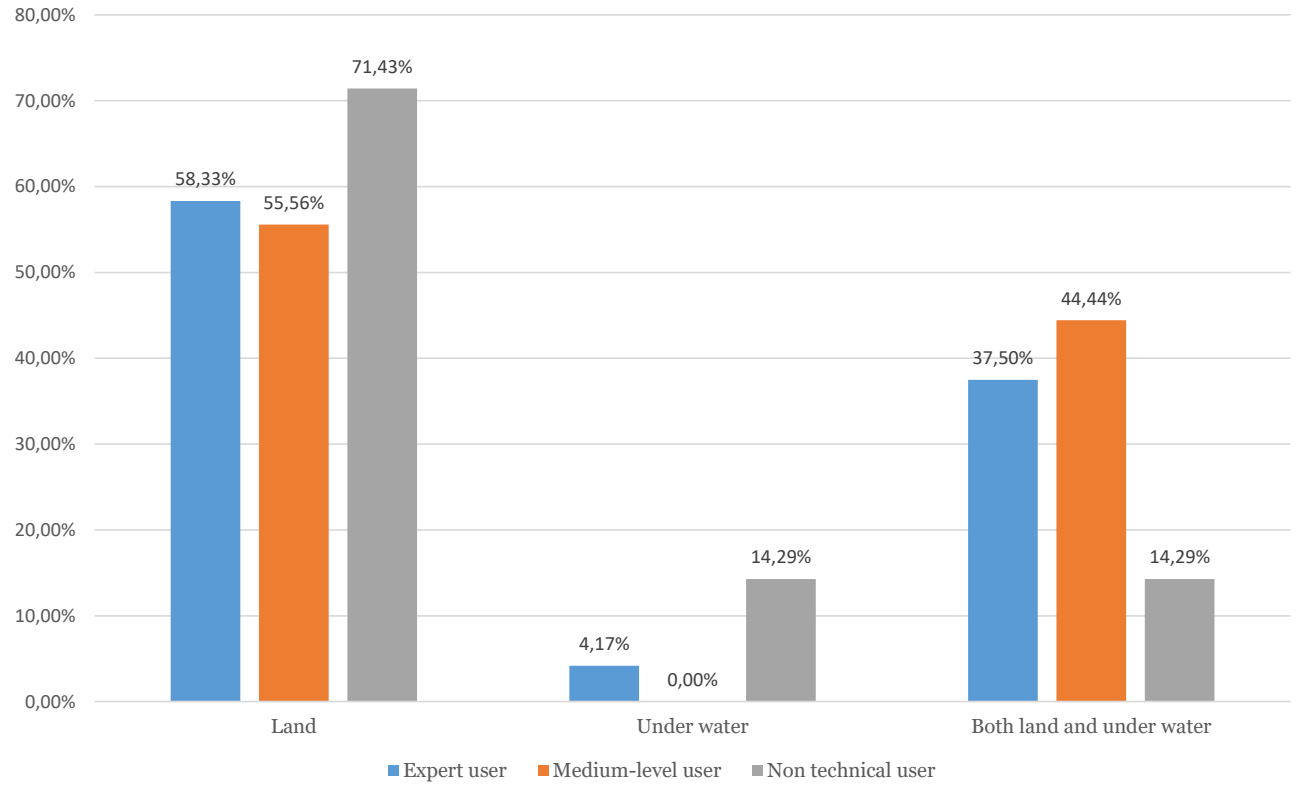
Potential future sources of D&I: general results per type of data



Potential future sources of D&I: general results per UC



Levels of expertise in EO of users by environment



Annex B – Bibliography

1. Key Space Policy documents

- Publicly available data from e.g. Eurostat, the OECD, business associations and independent research institutions that indicate amounts of space budgets/financing in the EU.
- Lisbon treaty – Title referring to Space
- Communication on "Space Strategy for Europe" COM(2016) 705
- Council Conclusions on "A Space Strategy for Europe" 9817/17
- European Parliament Resolution on "A Space Strategy for Europe"
- Other Key Space Policy documents available on DG GROW website (http://ec.europa.eu/growth/sectors/space/index_en.htm)

2. Studies

- Booz & Company, Evaluation of socio-economic impacts from space activities in the EU, 2013, available at: http://bookshop.europa.eu/en/evaluation-of-socio-economic-impacts-from-space-activities-in-the-eu-pbNB0214633/
- PwC - Strategy& (formerly Booz and Co), Study to examine the GDP impact of space activities in EU, final report August 2015
- OECD, The space economy at a glance, edition 2014, available at: http://www.oecd.org/sti/the-space-economy-at-a-glance-2014-9789264217294-en.htm
- Flash Eurobarometer 355 - Space activities, available at: http://ec.europa.eu/public_opinion/flash/fl_355_sum_en.pdf
- World heritage and tourism in a changing climate, UNESCO
- Satellite-Based Damage Assessment of Cultural Heritage Sites, 2015, Summary Report of Iraq, Nepal, Syria & Yemen, UNOSAT
- "The protection of cultural heritage: Rules, practices, and education", 2017, G7 meeting of Experts
- ICOMOS, 2011, Guidance on Heritage Impact Assessments for Cultural World Heritage Properties. Available at: https://www.icomos.org/world_heritage/HIA_20110201.pdf
- European Commission, 2016, 2018 European Year of Cultural Heritage. Available at: https://europa.eu/cultural-heritage/toolkits_en
- Interreg, 2018, Safeguarding cultural heritage from natural and man-made disasters. Available at: http://www.interreg-central.eu/Content.Node/protecCHt2save-Conference-20180123.pdf
- European Commission, 2015, CLIMATE FOR CULTURE (Damage risk assessment, economic impact and mitigation strategies for sustainable preservation of cultural heritage in the times of climate change). Available at: https://cordis.europa.eu/result/rcn/165682_en.html
- European Expert Network on Culture (EENC), 2013, The Social and Economic Value of Cultural Heritage: literature review. Available at: https://pdfs.semanticscholar.org/3a70/d26f9adf6b277216b8f3acf7909927bf2bc5.pdf
- The CHCFE consortium, 2015, Cultural Heritage Counts for Europe. Available at: http://blogs.encatc.org/culturalheritagecountsforeurope//wp-content/uploads/2015/06/CHCfE_FULL-REPORT_v2.pdf

- European heritage Label, 2017, European Heritage Label Guidelines for candidate sites. Available at: https://ec.europa.eu/programmes/creative-europe/sites/creative-europe/files/files/ehl-guidelines-for-candidate-sites_en.pdf
- European Heritage Label, 2016, panel Report on Monitoring. Available at: https://ec.europa.eu/programmes/creative-europe/sites/creative-europe/files/ehl-report-2016_en.pdf
- European Commission, 2017, Special Eurobarometer 466: Cultural Heritage. Available at: https://data.europa.eu/euodp/data/dataset/S2150_88_1_466_ENG
- UK government, 2007, The Costs and Benefits of UK World Heritage Site Status. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/78450/PwC__literaturereview.pdf
- "The protection of cultural heritage: Rules, practices, and education", 2017, G7 meeting of Experts
- European Commission, Mapping the Creative Value Chains, A study on the economy of culture in the digital age, Final report
- UNESCO, Managing cultural world heritage, Resource manual, 2013

3. Other

- Parcak, S., 2009. Satellite Remote Sensing for Archaeology. New York, US.
- A holistic EO technology approach for improving resilience of CH assets: the Heracles project, Dr Elissavet Kavoulaki, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Copernicus and Natura 2000, Fotios Papoulias (DG ENV), 24 April 2017, Copernicus for Cultural Heritage Workshop
- Copernicus Programme Potential for Cultural Heritage, Peter Breger, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Cosmo-Skymed Contribution to CH Monitoring, Maria Libera Battagliere, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Earth Observation imagery and geoinformation data for Cultural heritage and Landscapes - regional perspective, Branka Cuca, 24 April 2017, Copernicus for Cultural Heritage Workshop
- UNESCO Culture Sector - UNESCO's use of satellites for monitoring heritage sites in conflict-affected areas, Ms Elke Selter, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Remote Sensing as a crucial tool for Cultural Heritage preservation: case studies from the Near East , Dr h.c. Margarete van Ess, 24 April 2017, Copernicus for Cultural Heritage Workshop
- UNISDR, Luca Rossi, 24 April 2017, Copernicus for Cultural Heritage Workshop
- PROTection of European Cultural HEritage from GeO-hazards: satellite techniques for risk monitoring and conservation policies, Dr Daniele Spizzichino, 24 April 2017, Copernicus for Cultural Heritage Workshop
- User needs in monitoring Coastal Archaeological sites. The potential role of Copernicus, Stelios Bollanos, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Use of Copernicus data to support sustainable and cost effective landscape monitoring, Grega Milcinski, 24 April 2017, Copernicus for Cultural Heritage Workshop
- The Joint Programming Initiative on Cultural Heritage (JPICH): the European perspective, Prof Cristina Sabbioni, 24 April 2017, Copernicus for Cultural Heritage Workshop
- From Space to Place: requirements and Potentials of Earth Observation for UNESCO World Heritage preservation and communication, Prof Dr Alexander Siegmund, 24 April 2017, Copernicus for Cultural Heritage Workshop

- TECNALIA - New perspectives of industrial research in Cultural Heritage, Dr Isabel Rodriguez-Maribona, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Mission (im-)possible: potential vs expectations and practice in applying remote sensing data in culture heritage protection and management, Prof Włodzimierz Rączkowski, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Remote sensing for Cultural Heritage: from risk estimation to preservation strategies, Dr Rosa Lasaponara, 24 April 2017, Copernicus for Cultural Heritage Workshop
- Presentation: Heritage Impact Assessment: Evaluating Development at Heritage Sites. Available at: http://whc.unesco.org/document/139492
- Roders A. P., Bond A. & Teller J., 2013, Determining effectiveness in heritage impact assessments. Available at: http://conferences.iaia.org/2013/pdf/Final%20papers%20review%20process%2013/Determining%20effectiveness%20in%20heritage%20impact%20assessments.pdf
- European Commission, Horizon 2020: Cultural Heritage and European Identities, List of projects 2014-2017. Available at: https://ec.europa.eu/info/sites/info/files/conferences/synopsis_cultural_heritage.pdf
- Europa Nostra website. Available at: http://www.europanostra.org/our-work/policy/european-year-cultural-heritage/
- European Commission, 2010, The European Agenda for Culture – progress towards shared goals. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010SC0904&from=EN
- RESOLUTION OF THE COUNCIL of 16 November 2007 on a European Agenda for Culture. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007G1129(01)&from=EN
- European Commission, 2016, Towards an EU strategy for international cultural relations. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016JC0029&from=EN
- European Commission website on Culture. Available at: https://ec.europa.eu/culture/policy/strategic-framework_en
- European Commission Press release. Available at: http://europa.eu/rapid/press-release_MEMO-17-5066_en.htm#_ftn1
- European Commission, Better Regulation. Available at: https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
- European Commission, 2017, Decision on a European Year of Cultural Heritage (2018). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0864&from=EN
- European Commission, 2014, Conclusions of the Council and of the Representatives of the Governments of the Member States, meeting within the Council, on a Work Plan for Culture (2015-2018). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XG1223(02)&from=EN
- European Commission, 2014, Towards an integrated approach to cultural heritage for Europe. Available at: http://ec.europa.eu/assets/eac/culture/library/publications/2014-heritage-communication_en.pdf
- European Commission, 2010, EUROPE 2020 A strategy for smart, sustainable and inclusive growth. Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

- Vlahakis, Vassilios; Ioannidis, Nikolaos; Karigiannis, John; Tsotros, Manolis; Gounaris, Michael; Stricker, Didier; Gleue, Tim; Daehne, Patrick; Almeida, Luis; Archeoguide: An augmented reality guide for archaeological sites, Computer graphics in Art History and Archaeology, September/October 2002
- Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology, Glossary of Archaeological terms, 2004Siqueira, Paul; Ahmed, Razi; Chapman, Bruce; SAR, InSAR and Lidar studies for measuring vegetation structure over the Harvard forest region
- Brizard, Tamara; Derde, Willem; Silberman, Neil; Basic guidelines for Cultural Heritage Professionals in the Use of Information Technologies, How can ICT support cultural heritage?
- Rogiero-Candelera; Lazzari; Cano; Science and Technology for the Conservation of Cultural Heritage, 2013
- Camuffo, Dario; Microclimate for cultural heritage, Second edition, 2014

Annex C – Land cover of interest for Cultural Heritage user communities

Depending on the type of field, the features of the environment will differ – for example, rainforests will have different vegetation covers compared to deserts or urban areas, affecting the user requirements linked to the user need and hence having different technical specificities. The characterisation of the landscapes is therefore of the utmost importance for Cultural Heritage user communities, both for Tangible Heritage and Natural Heritage. The categories have been chosen based on the consolidation of several sources - first of all, the experts participating in the study, as well as through the literature review[191].

- Land
  - **Rural or forested areas**: Generally defined as areas that are sparsely populated, rural areas may include forested areas. These are in turn forests that have a less intense canopy than rainforests and are usually exposed to warm summers and cool winters[192];
  - **Urban and peri-urban**: Urban landscapes are dominated by human presence – man-made structures with significant human activities. Examples of such landscapes are towns and cities. Urban landscapes comprise of permanent structures, transportation corridors, and transportation features[193] with a high density of population;
  - **Scrub and grassland**: With grass as a dominant type of vegetation, grasslands are usually located between deserts and forests and have different names depending on the area where they are located: names include the savanna, steppe, prairie or pampas. They are generally flat and are present on all continents except for Antarctica[194];
  - **Mountainous/hilly regions**: Generally characterised by lower temperatures and harsher weather, mountains and hilly regions are elevated parts of the land with thin soils and in some cases reduced oxygen present in the air[195];
  - **Desert**: Deserts are areas of land that receive less than 25 centimetres of water per year, which include areas not only in sand deserts, but also arid regions in temperate areas.[196] Overall, deserts cover more than 20% of the Earth.
  - **Rainforest**: Rainforests are forests in tropical regions that receive very high rainfall. One of their specificities is that due to the canopy of the trees and their lush vegetation, sunlight cannot reach the forest floor. Overall, rainforests cover 6% of the Earth[197];
  - **Tundra**: Area that is characterised by a treeless frozen soil and most often permafrost[198], found for example in the Arctic, covered most of the year by snow[199];
  - **Inland waters**: This type of land cover refers to permanent water bodies inland from the coastal zone and areas whose properties and use are dominated by the permanent, seasonal, or intermittent occurrence of flooded conditions. Inland waters include rivers, lakes, floodplains, reservoirs, wetlands, and inland saline systems.[200]

[191] In particular, "Satellite remote sensing for archaeology" by Sarah Parcak
192 Temperate coniferous forest, BBC, 2014 [ONLINE] Available at http://www.bbc.co.uk/nature/habitats/Temperate_coniferous_forest
193 UK Office for National Statistics, Tim Pateman, 2011 "Rural and urban areas: comparing lives using rural/urban classifications" and "The definition of urban areas", UK Office for National Statistics
194 Grasslands, BBC, 2014 [ONLINE] Available at https://www.nationalgeographic.com/environment/habitats/grasslands/
195 Mountains, BBC, 2014 [ONLINE] Available at http://www.bbc.co.uk/nature/habitats/Mountain
196 Deserts and shrub lands, BBC, 2014 [ONLINE] Available at http://www.bbc.co.uk/nature/habitats/Deserts_and_xeric_shrublands
197 Tropical and subtropical moist broadleaf forests, BBC, 2014 [ONLINE] Available at http://www.bbc.co.uk/nature/habitats/Tropical_and_subtropical_moist_broadleaf_forests
198 Tundra, BBC, 2014 [ONLINE] Available at http://www.bbc.co.uk/nature/habitats/Tundra
199 Tundra, National Geographic, 2018 [ONLINE] Available at https://www.nationalgeographic.com/environment/habitats/tundra-biome/
[200] Millennium Ecosystem Assessment, 2005. Synthesis Report.
Link: https://www.greenfacts.org/glossary/ghi/inland-waters.htm

  - **Alluvial plain or Floodplain**: This type of field refers to a flat area of land located next to a stream or river, which is composed of sediments and can be flooded by the body of water it is next to[201];
  - **Waterlogged/wetland**: Area of land covered by water, either fresh or salted, such as marshes or ponds[202], important for the environment due to the filtration qualities of such land covers;
- Sea:
  - **Water Surface:** Surface of a body of water, should it be salt water or fresh surface water.
  - **Underwater:** Considered as the area of a body of water that is below 6m depth.
- Land/sea:
  - **Frozen/glacial areas:** Thickened ice mass created through the deposit of snow over many years, present in mountains and on the poles. Overall, glaciers occupy 10% of the land on Earth[203];
  - **Coastal:** Coastal areas is a field at the juncture of Land and Sea, and can be defined as areas within 10 km of the sea[204].

Overall, it can be pointed out that amongst stakeholders, there is no disparity in the interest shown by user communities interested in Natural Heritage and those interested in Tangible Heritage. All user communities intervene in all types of land covers, and no field was deemed uninteresting to stakeholders. The only specificity would be for urban planners that are mostly intervening in urban and peri-urban land covers (100% of urban planners have a unique interest for urban and peri-urban land covers).

Desk research and stakeholder consultation has pinpointed the fact that differentiation of land covers is mostly relevant for the high level user need 1 "Study of the natural environment of the site for the detection of underground archaeological features". Past human activities have impacts on natural landscape that differs from one land cover to another, leading to specific user requirements for the discovery of underground features.

The land covers are therefore not a significant differentiating factor in the analysis.

201 Floodplain, Encyclopaedia Britannica, 2018 [ONLINE] Available at https://www.britannica.com/science/floodplain
202 Wetlands, WWF, 2018 [ONLINE] Available at https://www.worldwildlife.org/habitats/wetlands
203 Glaciers, National Snow and Ice data center, 2018 [ONLINE] Available at https://nsidc.org/cryosphere/glaciers/questions/what.html
204Coastal area, Eurostat, 2017 [ONLINE] Available at http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Coastal_area

Annex D – Copernicus capabilities in response to CH user requirements (detailed matching analysis)

The next pages are displaying the detailed match analysis of the Copernicus capabilities in response to CH user requirements. The overall match analysis exercise has been carried out following the approach described below:

1. **Copernicus core services product(s):** the match analysis starts by first identifying, when possible, Copernicus core service product(s) that can cover user requirements
    a. Identification of one (or several) Copernicus core service product responding to user need;
    b. Comparison of the product resolution with the spatial resolution required;
    c. Comparison of the product timeliness with the temporal resolution required by users (i.e. frequency of monitoring).
2. **Sentinels capabilities:** the second step aims at assessing if Sentinels capabilities could respond to user requirements & technical specifications
    a. Identification of a Sentinel satellite matching the sensor & wavelength requested;
    b. Comparison of Sentinel spatial resolution with the spatial resolution required;
    c. Comparison of Sentinel temporal resolution with the temporal resolution required by users (i.e. frequency of monitoring).
3. **Contributing missions capabilities:** the third step aims at assessing if Copernicus contributing mission(s) could respond to user requirements & technical specifications
    d. Identification of one or several contributing missions matching the sensor & wavelength requested;
    e. Comparison of contributing mission(s) spatial resolution with the spatial resolution required;
    f. Comparison of contributing mission(s) temporal resolution with the temporal resolution required by users (i.e. frequency of monitoring).
4. **Match analysis:** the fourth and last step aims at bringing together the three level of analysis (Copernicus core services products, Sentinels data, Contributing missions data) in order to highlight categories of user requirements that are:
    a. **Fully responding:** user requirement can fully be covered (for both spatial & temporal resolution) by Copernicus core services, Sentinels and/or contributing mission(s) ***(appearing in green in the tables of the match analysis)***;
    b. **Partially responding:** user requirement can partially be covered by Copernicus core services, Sentinels and/or contributing mission(s), meaning that the spatial resolution of one of these three capabilities (Copernicus core services products, Sentinels data, Contributing missions(s) data) is matching part of the spatial resolution requested (i.e. technical specifications provide a range of spatial resolution) or part of the temporal resolution[205] ***(appearing in yellow in the tables of the match analysis)***;
    c. **Not responding:** user requirement cannot be covered because ***(appearing in red in the tables of the match analysis)***:

[205] This statement only applies to hourly request, when a satellite is offering less than one day revisiting time but not a one-hour revisiting time

› Satellite-based remote sensing cannot respond to the requirement;

› Spatial and/or temporal resolution requested is not available;

› Capability required to respond to the user requirements cannot be covered by Sentinels and/or contributing missions (e.g. hyperspectral, lidar, etc.).

This match analysis has been supported by expert consultation from each of the six Copernicus core services and Copernicus space segment (ESA). The result of the analysis produced a non-exhaustive matrix presenting Copernicus core services products, Sentinels and contributing mission(s) data that could answer Cultural Heritage user requirements presented in the next pages.

To carry out this matching exercise, several assumptions had to be taken in consideration.

- **Specific technical assumptions related to spatial resolution**
  - There is currently no multispectral data (RGB, NIR, SWIFT) able to match request of very high resolution (up to 0.3m) but some contributing missions (e.g. WorldView 3 & 4) offer 0.3 m spatial resolution in panchromatic. In fact, pan-sharpening techniques could be applied to multispectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m from WorldView 3 & 4), taking as assumption pan-sharpening applied to multispectral bands does not introduce significant artifacts. In this context, requests for very high resolution multispectral data (up to 0.3 m) were considered covered when a contributing mission (e.g. WorldView 4, Pleiades) was able to provide 0.3 m panchromatic resolution;

Some user requirements has led to technical specifications requiring very high resolution of SAR L-band. Nevertheless, there is currently no very high resolution SAR L-band available in the scope of the Copernicus programme (Sentinels & Contributing missions). When a user requirement required very high resolution for C-band, X-band and L-band, and that C-band and X-band requests were fully covered, the user requirement was considered covered (spatial resolution matching analysis).

To facilitate reading, the matching has been organised per high level user need.

1. _High level user need 1 – Study of the natural environment of the site for the detection of underground / underwater archaeological features

a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products					
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Indirect indicators (Cropmarks, soilmarks, chlorophyll levels)	31	20,2%	29,8%	25,3%	18,8%	6,0%	Hourly	9,0%	27,2%	30,4%	42,4%	Multispectral	RGB, NIR	0,30 up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	16,6%										Daily	Every 3 years	#
							Weekly	27,2%										Weekly	Every 3 years	#
							Monthly and more	47,2%										Monthly and more	Every 3 years	#
Normalized difference vegetation index (NDVI)	20	17,0%	26,4%	28,3%	18,9%	9,4%	Hourly	10,8%	27,5%	32,5%	40,0%	Multispectral	RGB, NIR	1 m up to 10 m	CLMS, Global, NDVI	300m	#	Hourly	3 times a month	#
							Daily	13,5%										Daily	3 times a month	#
							Weekly	21,6%										Weekly	3 times a month	#
							Monthly and more	54,1%										Monthly and more	3 times a month	#
Thermal anomaly	11	15,4%	26,9%	30,8%	23,1%	3,8%	Hourly	12,5%	28,6%	28,6%	42,9%	Thermal	TIR	0.30 m up to 10 m	CLMS, Global, Land surface temperature	@5km	#	Hourly	Hoursly	#
							Daily	16,7%										Daily	Hoursly	#
							Weekly	25,0%										Weekly	10 days	#
							Monthly and more	45,8%										Monthly and more	10 days	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Map regression	N/A	x	x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB-NIR	0.30 up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	up to 2,5m	#	Hourly Every 3 years	#
							Daily	N/A										Daily Every 3 years	#
							Weekly	N/A										Weekly Every 3 years	#
							Monthly and more	N/A										Monthly and more Every 3 years	#
												SAR	X-band, C-band	0.30 up to 10 m			#	Hourly Every 3 years	#
																		Daily Every 3 years	#
																		Weekly Every 3 years	#
																		Monthly and more Every 3 years	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities				
																Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of Sentinel matching technical specifications	Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Indirect indicators (Cropmarks, soilmarks, chlorophyll levels)	31	20,2%	29,8%	25,3%	18,8%	6,0%	Hourly	9,0%	27,2%	30,4%	42,4%	Multispectral	RGB, NIR	0,30 up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly 5 days	1
							Daily	16,6%										Daily 5 days	1
							Weekly	27,2%										Weekly 5 days	3
							Monthly and more	47,2%										Monthly and more 5 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Normalized difference vegetation index (NDVI)	20	17,0%	26,4%	28,3%	18,9%	9,4%	Hourly	10,8%	27,5%	32,5%	40,0%	Multispectral	RGB, NIR	1 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	13,5%										Daily	5 days	1
							Weekly	21,6%										Weekly	5 days	
							Monthly and more	54,1%										Monthly and more	5 days	
Thermal anomaly	11	15,4%	26,9%	30,8%	23,1%	3,8%	Hourly	12,5%	28,6%	28,6%	42,9%	Thermal	TIR	0.30 m up to 10 m	Sentinel 3	1km (TIR)	2	Hourly	2 days	1
							Daily	16,7%										Daily	2 days	1
							Weekly	25,0%										Weekly	2 days	
							Monthly and more	45,8%										Monthly and more	2 days	
Map regression	N/A	x	x	x			Hourly		N/A	N/A	N/A	Multispectral	RGB-NIR	0.30 up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	N/A										Daily	5 days	1
							Weekly	N/A										Weekly	5 days	3
							Monthly and more	N/A										Monthly and more	5 days	3
							Hourly	N/A				SAR	X-band, C-band	0.30 up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, X-band is not available	2	Hourly	6 days	1
							Daily	N/A										Daily	6 days	1
							Weekly	N/A										Weekly	6 days	3
							Monthly and more	N/A										Monthly and more	6 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution	Grade
Indirect indicators (Cropmarks, soilmarks, chlorophyll levels)	31	20,2%	29,8%	25,3%	18,8%	6,0%	Hourly	9,0%	27,2%	30,4%	42,4%	Multispectral	RGB, NIR	0,30 up to 2 m	Mission group 2	WorldView 2, 3 & 4 GeoEye 1 Pleiades	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 1 day for Pleiades	2
							Daily	16,6%											Daily	Less than one day for Worldview 3 & 4 1 day for Pleiades	
							Weekly	27,2%											Weekly	Less than one day for Worldview 3 & 4 1 day for Pleiades	
							Monthly and more	47,2%											Monthly and more	Less than one day for Worldview 3 & 4 1 day for Pleiades	
Normalized difference vegetation index (NDVI)	20	17,0%	26,4%	28,3%	18,9%	9,4%	Hourly	10,8%	27,5%	32,5%	40,0%	Multispectral	RGB, NIR	1 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	13,5%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
							Weekly	21,6%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
							Monthly and more	54,1%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
Thermal anomaly	11	15,4%	26,9%	30,8%	23,1%	3,8%	Hourly	12,5%	28,6%	28,6%	42,9%	Thermal	TIR	0,30 m up to 10 m	Mission group 2	Landsat-8	30 m	2		Hourly	16 days for Landsat 8	1
							Daily	16,7%											Daily	16 days for Landsat 8	1
							Weekly	25,0%											Weekly	16 days for Landsat 8	1
							Monthly and more	45,8%											Monthly and more	16 days for Landsat 8	3
Map regression	N/A	x	x	x			Hourly		N/A	N/A	N/A	Multispectral	RGB-NIR	0.30 up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	N/A											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
							Weekly	N/A											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
							Monthly and more	N/A											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	
							Hourly	N/A				SAR	X-band, C-band	0.30 up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	N/A											Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	N/A											Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	N/A											Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3

2. High level user need 2 – Non-destructive analysis of the underground / underwater positioning of the CH features

a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
															Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Bathymetry	6	23,5%	23,5%	23,5%	23,5%	5,9%	Hourly	13,3%	26,7%	33,3%	40,0%	Radar altimeters (in-situ)	N/A	up to 2 m	No product		#	Hourly	#
							Daily	20,0%										Daily	#
							Weekly	20,0%										Weekly	#
							Monthly and more	46,7%										Monthly and more	#
Stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units	11	28,0%	28,0%	24,0%	16,0%	4,0%	Hourly	6,7%	26,7%	26,6%	46,7%	GPR	N/A	few cm up to 2 m	No product		#	Hourly	#
							Daily	20,0%										Daily	#
							Weekly	20,0%										Weekly	#
							Monthly and more	53,3%										Monthly and more	#
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%	GPR	N/A	few cm up to 2 m	No product		#	Hourly	#
							Daily	26,3%										Daily	#
							Weekly	26,3%										Weekly	#
							Monthly and more	42,1%										Monthly and more	#
Metal detecting	7	25,0%	25,0%	18,8%	25,0%	6,3%	Hourly	18,8%	26,7%	40,0%	33,3%	GPR	N/A	few cm up to 2 m	No product		#	Hourly	#
							Daily	18,8%										Daily	#
							Weekly	18,8%										Weekly	#
							Monthly and more	43,8%										Monthly and more	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities				
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Bathymetry	6	23,5%	23,5%	23,5%	23,5%	5,9%	Hourly	13,3%	26,7%	33,3%	40,0%	Radar altimeters (in-situ)	N/A	up to 2 m	N/A			Hourly	
							Daily	20,0%							N/A			Daily	
							Weekly	20,0%							N/A			Weekly	
							Monthly and more	46,7%							N/A			Monthly and more	
Stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units	11	28,0%	28,0%	24,0%	16,0%	4,0%	Hourly	6,7%	26,7%	26,6%	46,7%	GPR	N/A	few cm up to 2 m	N/A			Hourly	
							Daily	20,0%							N/A			Daily	
							Weekly	20,0%							N/A			Weekly	
							Monthly and more	53,3%							N/A			Monthly and more	
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%	GPR	N/A	few cm up to 2 m	N/A			Hourly	
							Daily	26,3%							N/A			Daily	
							Weekly	26,3%							N/A			Weekly	
							Monthly and more	42,1%							N/A			Monthly and more	
Metal detecting	7	25,0%	25,0%	18,8%	25,0%	6,3%	Hourly	18,8%	26,7%	40,0%	33,3%	GPR	N/A	few cm up to 2 m	N/A			Hourly	
							Daily	18,8%							N/A			Daily	
							Weekly	18,8%							N/A			Weekly	
							Monthly and more	43,8%							N/A			Monthly and more	

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution	Grade
Bathymetry	6	23,5%	23,5%	23,5%	23,5%	5,9%	Hourly	13,3%	26,7%	33,3%	40,0%	Radar altimeters (in-situ)	N/A	up to 2 m	N/A					Hourly	
							Daily	20,0%							N/A					Daily	
							Weekly	20,0%							N/A					Weekly	
							Monthly and more	46,7%							N/A					Monthly and more	
Stratigraphic description of the archaeological site and identification of individual layers or stratigraphic units	11	28,0%	28,0%	24,0%	16,0%	4,0%	Hourly	6,7%	26,7%	26,6%	46,7%	GPR	N/A	few cm up to 2 m	N/A					Hourly	
							Daily	20,0%							N/A					Daily	
							Weekly	20,0%							N/A					Weekly	
							Monthly and more	53,3%							N/A					Monthly and more	
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%	GPR	N/A	few cm up to 2 m	N/A					Hourly	
							Daily	26,3%							N/A					Daily	
							Weekly	26,3%							N/A					Weekly	
							Monthly and more	42,1%							N/A					Monthly and more	
Metal detecting	7	25,0%	25,0%	18,8%	25,0%	6,3%	Hourly	18,8%	26,7%	40,0%	33,3%	GPR	N/A	few cm up to 2 m	N/A					Hourly	
							Daily	18,8%							N/A					Daily	
							Weekly	18,8%							N/A					Weekly	
							Monthly and more	43,8%							N/A					Monthly and more	

3. High level user need 3 - Non-destructive analysis of the surface positioning of the CH features

a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Elevation modelling	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR	X band	up to 5 m	CLMS, Imagery & Refence Data, EU-DEM	25m	#	Hourly	No refresh (for now) #
							Daily	N/A										Daily	No refresh (for now) #
							Weekly	N/A										Weekly	No refresh (for now) #
							Monthly and more	N/A										Monthly and more	No refresh (for now) #
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%				No product		#	Hourly	
							Daily	26,3%										Daily	
							Weekly	26,3%										Weekly	
							Monthly and more	42,1%										Monthly and more	
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years #
							Daily	15,2%										Daily	Every 3 years #
							Weekly	21,2%										Weekly	Every 3 years #
							Monthly and more	51,5%										Monthly and more	Every 3 years #
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution CLMS, Imagery & Refence Data, EU-DEM	Mosaic: up to 2,5m EU-DEM: 25m	#	Hourly	Every 3 years #
							Daily	12,5%										Daily	Every 3 years #
							Weekly	20,0%										Weekly	Every 3 years #
							Monthly and more	52,5%										Monthly and more	Every 3 years #
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5 m	#	Hourly	Every 3 years #
							Daily	14,3%										Daily	Every 3 years #
							Weekly	20,0%										Weekly	Every 3 years #
							Monthly and more	54,3%										Monthly and more	Every 3 years #

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	#
							Daily	18,5%										Daily	#
							Weekly	25,9%										Weekly	#
							Monthly and more	51,9%										Monthly and more	#
Rock assay analysis	3	37,5%	37,5%	12,5%	12,5%	0,0%	Hourly	16,7%	33,3%	33,3%	33,3%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No product	N/A	#	Hourly	N/A
							Daily	16,7%										Daily	N/A
							Weekly	16,7%										Weekly	N/A
							Monthly and more	50,0%										Monthly and more	N/A
Vegetation levels monitoring	12	15,6%	28,1%	28,1%	18,8%	9,4%	Hourly	15,4%	31,8%	27,3%	40,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	CLMS, Global, NDVI CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	NDVI = 300m Mosaic = Up to 2,5m	#	Hourly	NDVI: 3 times per month Mosaic: 3 years	#
							Daily	11,5%										Daily	NDVI: 3 times per month Mosaic: 3 years	#
							Weekly	23,1%										Weekly	NDVI: 3 times per month Mosaic: 3 years	#
							Monthly and more	50,0%										Monthly and more	NDVI: 3 times per month Mosaic: 3 years	#
Tectonic petrography	3	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%				No product		#	Hourly		
							Daily	0,0%										Daily		
							Weekly	50,0%										Weekly	N/A	
							Monthly and more	50,0%										Monthly and more	N/A	
Lithology	7	27,8%	33,3%	22,2%	16,7%	0,0%	Hourly	13,3%	30,8%	30,8%	38,5%				No product		#	Hourly		
							Daily	20,0%										Daily		
							Weekly	26,7%										Weekly		
							Monthly and more	40,0%										Monthly and more		
Salinity levels measurement	6	31,3%	31,3%	18,8%	18,8%	0,0%	Hourly	14,3%	30,8%	30,8%	38,5%	SAR	L-band	2 km up to 10 km	CMEMS, Regional & Global Sea analysis, Salinity	2-28 km	#	Hourly	Hourly	#
							Daily	21,4%										Daily	daily	#
							Weekly	14,3%										Weekly	Weekly	#
							Monthly and more	50,0%										Monthly and more	monthly	#

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Copernicus core services products					
															Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
3D reconstruction	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	up to 0,3 cm	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	N/A										Daily	Every 3 years	#
							Weekly	N/A										Weekly	Every 3 years	#
							Monthly and more	N/A										Monthly and more	Every 3 years	#
												Lidar	from 600 nm up to 1500 nm	up to 5 cm	No product		#	Hourly		#
																		Daily		#
																		Weekly		#
																		Monthly and more		#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Sentinels capabilities					
															Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of Sentinel matching technical specifications	Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Elevation modelling	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR	X band	up to 5 m	Sentinel 1	No X-band available	1	Hourly	N/A	1
							Daily	N/A										Daily	N/A	1
							Weekly	N/A										Weekly	N/A	1
							Monthly and more	N/A										Monthly and more	N/A	1
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%							Hourly		
							Daily	26,3%										Daily		
							Weekly	26,3%										Weekly		
							Monthly and more	42,1%										Monthly and more		

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities				
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB	1	Hourly	5 days	1
							Daily	15,2%										Daily	5 days	1
							Weekly	21,2%										Weekly	5 days	3
							Monthly and more	51,5%										Monthly and more	5 days	3
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB	2	Hourly	5 days	1
							Daily	12,5%										Daily	5 days	1
							Weekly	20,0%										Weekly	5 days	3
							Monthly and more	52,5%										Monthly and more	5 days	3
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	14,3%										Daily	5 days	1
							Weekly	20,0%										Weekly	5 days	3
							Monthly and more	54,3%										Monthly and more	5 days	3
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	18,5%										Daily	5 days	1
							Weekly	25,9%										Weekly	5 days	3
							Monthly and more	51,9%										Monthly and more	5 days	3
Rock assay analysis	3	37,5%	37,5%	12,5%	12,5%	0,0%	Hourly	16,7%	33.3%	33.3%	33.3%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	Potential evolution of Copernicus			Hourly		
							Daily	16,7%										Daily		
							Weekly	16,7%										Weekly		
							Monthly and more	50,0%										Monthly and more		
Vegetation levels monitoring	12	15,6%	28,1%	28,1%	18,8%	9,4%	Hourly	15,4%	31,8%	27,3%	40,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	11,5%										Daily	5 days	1
							Weekly	23,1%										Weekly	5 days	3
							Monthly and more	50,0%										Monthly and more	5 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Tectonic petrography	3	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%							Hourly		
							Daily	0,0%										Daily		
							Weekly	50,0%										Weekly	N/A	
							Monthly and more	50,0%										Monthly and more	N/A	
Lithology	7	27,8%	33,3%	22,2%	16,7%	0,0%	Hourly	13,3%	30,8%	30,8%	38,5%							Hourly		
							Daily	20,0%										Daily		
							Weekly	26,7%										Weekly		
							Monthly and more	40,0%										Monthly and more		
Salinity levels measurement	6	31,3%	31,3%	18,8%	18,8%	0,0%	Hourly	14,3%	30,8%	30,8%	38,5%	SAR	L-band	1 km up to 10 km		No L-band available	1	Hourly	N/A	
							Daily	21,4%										Daily	N/A	
							Weekly	14,3%										Weekly	N/A	
3D reconstruction	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	up to 0,3 cm	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	N/A										Daily	5 days	1
							Weekly	N/A										Weekly	5 days	3
							Monthly and more	N/A										Monthly and more	5 days	3
							Hourly	N/A				Lidar	from 600 nm up to 1500 nm	up to 5 cm	No lidar available	N/A		Hourly		
							Daily	N/A										Daily		
							Weekly	N/A										Weekly		
							Monthly and more	N/A										Monthly and more		

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Elevation modelling	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR	X band	up to 5 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band)	Up to 0,25m in X-band from TerraSAR-X	3		Hourly	Less than one day for COSMO SkyMed (X-band)	2
							Daily	N/A												Daily	Less than one day for COSMO SkyMed (X-band)	3
							Weekly	N/A												Weekly	Less than one day for COSMO SkyMed (X-band)	3
							Monthly and more	N/A												Monthly and more	Less than one day for COSMO SkyMed (X-band)	3
Geodetic recording	12	21,7%	21,7%	30,4%	17,4%	8,7%	Hourly	5,3%	19,0%	33,3%	47,6%									Hourly		
							Daily	26,3%												Daily		
							Weekly	26,3%												Weekly		
							Monthly and more	42,1%												Monthly and more		
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB)	2
							Daily	15,2%												Daily	Less than one day for Worldview 3 & 4 (RGB)	3
							Weekly	21,2%												Weekly	Less than one day for Worldview 3 & 4 (RGB)	3
							Monthly and more	51,5%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB)	3
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB)	2
							Daily	12,5%												Daily	Less than one day for Worldview 3 & 4 (RGB)	3
							Weekly	20,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB)	3
							Monthly and more	52,5%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB)	3
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	14,3%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	20,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	54,3%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	18,5%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	25,9%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	51,9%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Rock assay analysis	3	37,5%	37,5%	12,5%	12,5%	0,0%	Hourly	16,7%	33,3%	33,3%	33,3%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No hyperspectral capacity (possible future contributing missions)					Hourly		
							Daily	16,7%												Daily		
							Weekly	16,7%												Weekly		
							Monthly and more	50,0%												Monthly and more		

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Vegetation levels monitoring	12	15,6%	28,1%	28,1%	18,8%	9,4%	Hourly	15,4%	31,8%	27,3%	40,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	11,5%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	23,1%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	50,0%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Tectonic petrography	3	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%									Hourly		
							Daily	0,0%												Daily		
							Weekly	50,0%												Weekly	N/A	
							Monthly and more	50,0%												Monthly and more	N/A	
Lithology	7	27,8%	33,3%	22,2%	16,7%	0,0%	Hourly	13,3%	30,8%	30,8%	38,5%									Hourly		
							Daily	20,0%												Daily		
							Weekly	26,7%												Weekly		
							Monthly and more	40,0%												Monthly and more		
Salinity levels measurement	6	31,3%	31,3%	18,8%	18,8%	0,0%	Hourly	14,3%	30,8%	30,8%	38,5%	SAR	L-band	1 km up to 10 km	Mission group 1	SMOS (L-band)	15 km in L-band from SMOS	1		Hourly	27 days for SMOS	1
							Daily	21,4%												Daily	27 days for SMOS	1
							Weekly	14,3%												Weekly	27 days for SMOS	1
3D reconstruction	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	up to 0,3 cm	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	N/A												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	N/A												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	N/A												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Hourly	N/A				Lidar	from 600 nm up to 1500 nm	up to 5 cm	No lidar available					Hourly		
							Daily	N/A												Daily		
							Weekly	N/A												Weekly		
							Monthly and more	N/A												Monthly and more		

4. High level user need 4 – Mapping of the cultural landscape of the site and identification of the specific risks it is exposed to

a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products					
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Ground motion monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	1 m up to 50 m	No product		#	Hourly		#
							Daily	N/A										Daily		#
							Weekly	N/A										Weekly		#
							Monthly and more	N/A										Monthly and more		#
Mapping of frequentation patterns	N/A	x	x				Hourly	N/A	N/A	N/A	N/A				No product		#	Hourly		#
							Daily	N/A										Daily		#
							Weekly	N/A										Weekly		#
							Monthly and more	N/A										Monthly and more		#
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	18,5%										Daily	Every 3 years	#
							Weekly	25,9%										Weekly	Every 3 years	#
							Monthly and more	51,9%										Monthly and more	Every 3 years	#
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	0.30 m up to 10 m	CLMS, Local, Urban atlas	10m	#	Hourly	Every 6 years	#
							Daily	N/A										Daily	Every 6 years	#
							Weekly	N/A										Weekly	Every 6 years	#
							Monthly and more	N/A										Monthly and more	Every 6 years	#
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	15,2%										Daily	Every 3 years	#
							Weekly	21,2%										Weekly	Every 3 years	#
							Monthly and more	51,5%										Monthly and more	Every 3 years	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Mosaic: up to 2,5m	#	Hourly	Every 3 years (Mosaic); 6 years (Urban Atlas)	#
							Daily	12,5%								EU-DEM: 25m		Daily	Every 3 years (Mosaic); 6 years (Urban Atlas)	#
							Weekly	20,0%							CLMS, Imagery & Refence Data, EU-DEM			Weekly	Every 3 years (Mosaic); 6 years (Urban Atlas)	#
							Monthly and more	52,5%										Monthly and more	Every 3 years (Mosaic); 6 years (Urban Atlas)	#
Tectonic petrography	2	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%				No product		#	Hourly		
							Daily	0,0%										Daily		
							Weekly	50,0%										Weekly	N/A	
							Monthly and more	50,0%										Monthly and more	N/A	
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	14,3%										Daily	Every 3 years	#
							Weekly	20,0%										Weekly	Every 3 years	#
							Monthly and more	54,3%										Monthly and more	Every 3 years	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Ground motion monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, X-band and L-band are not available	2	Hourly	6 days	1
							Daily	N/A										Daily	6 days	1
							Weekly	N/A										Weekly	6 days	3
							Monthly and more	N/A										Monthly and more	6 days	3
Mapping of frequentation patterns	N/A	x	x				Hourly	N/A	N/A	N/A	N/A							Hourly		
							Daily	N/A										Daily		
							Weekly	N/A										Weekly		
							Monthly and more	N/A										Monthly and more		
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	18,5%										Daily	5 days	1
							Weekly	25,9%										Weekly	5 days	3
							Monthly and more	51,9%										Monthly and more	5 days	3
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	0.30 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	N/A										Daily	5 days	1
							Weekly	N/A										Weekly	5 days	3
							Monthly and more	N/A										Monthly and more	5 days	3
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB	1	Hourly	5 days	1
							Daily	15,2%										Daily	5 days	1
							Weekly	21,2%										Weekly	5 days	3
							Monthly and more	51,5%										Monthly and more	5 days	3
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB	2	Hourly	5 days	1
							Daily	12,5%										Daily	5 days	1
							Weekly	20,0%										Weekly	5 days	3
							Monthly and more	52,5%										Monthly and more	5 days	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Sentinels capabilities					
														Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Tectonic petrography	2	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%							Hourly	
							Daily	0,0%										Daily	
							Weekly	50,0%										Weekly	N/A	
							Monthly and more	50,0%										Monthly and more	N/A	
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	14,3%										Daily	5 days	1
							Weekly	20,0%										Weekly	5 days	3
							Monthly and more	54,3%										Monthly and more	5 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution		Grade
Ground motion monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0.25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2 15 km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	N/A												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	N/A												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	N/A												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Mapping of frequentation patterns	N/A	x	x				Hourly	N/A	N/A	N/A	N/A									Hourly		
							Daily	N/A												Daily		
							Weekly	N/A												Weekly		
							Monthly and more	N/A												Monthly and more		
Identification of previously searched sites in the area	16	22,7%	27,3%	27,3%	18,2%	4,5%	Hourly	3,7%	25,8%	32,3%	41,9%	Multispectral	RGB, NIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	18,5%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	25,9%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	51,9%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution	Grade
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR	0.30 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	N/A												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	N/A												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	N/A												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Photogrammetric mapping	22	22,2%	25,9%	27,8%	16,7%	7,4%	Hourly	12,1%	20,0%	37,5%	42,5%	Multispectral	RGB	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB)	2
							Daily	15,2%												Daily	Less than one day for Worldview 3 & 4 (RGB)	3
							Weekly	21,2%												Weekly	Less than one day for Worldview 3 & 4 (RGB)	3
							Monthly and more	51,5%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB)	3
Topographic mapping	23	21,7%	25,0%	28,3%	16,7%	8,3%	Hourly	15,0%	23,8%	35,7%	40,5%	Multispectral	RGB	0.30 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB)	2
							Daily	12,5%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB)	3
							Weekly	20,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB)	3
							Monthly and more	52,5%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB)	3
Tectonic petrography	2	33,3%	33,3%	0,0%	33,3%	0,0%	Hourly	0,0%	25,0%	50,0%	25,0%									Hourly		
							Daily	0,0%												Daily		
							Weekly	50,0%												Weekly		
							Monthly and more	50,0%												Monthly and more		
Visual identification via imagery	23	18,6%	25,4%	28,8%	18,6%	8,5%	Hourly	11,4%	23,8%	33,3%	42,9%	Multispectral	RGB, NIR	0.30 m up to 5 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	14,3%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	20,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	54,3%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

5. High level user need 5 – Monitoring of the evolution of the natural environment of the CH site
   a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
															Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Map regression	6	12,5%	18,8%	18,8%	31,3%	18,8%	Hourly	18,8%	25,0%	41,7%	33,3%	Multispectral	RGB-NIR	0.30 up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	#
							Daily	18,8%										Every 3 years	#
							Weekly	31,3%										Daily	#
							Monthly and more	31,3%										Every 3 years	#
																		Weekly	#
																		Every 3 years	#
												SAR	X-band, C-band	0.30 up to 10 m			#	Hourly	#
																		Every 3 years	#
																		Daily	#
																		Every 3 years	#
																		Weekly	#
																		Every 3 years	#
																		Monthly and more	#
																		Every 3 years	#
Air pollution monitoring to prevent damages & blackening of buildings	15	23,1%	28,2%	20,5%	17,9%	10,3%	Hourly	18,5%	26,9%	34,6%	38,5%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	CAMS, Global forecast of aerosol CAMS, European-Scale air quality analysis	80 km/ 10-20 km	#	Hourly	#
							Daily	22,2%										daily	#
							Weekly	25,9%										Daily	#
							Monthly and more	33,3%										daily	#
																		Weekly	#
																		daily	#
																		Monthly and more	#
																		daily	#
Atmospheric moisture measurement	13	22,9%	25,7%	20,0%	20,0%	11,4%	Hourly	18,5%	30,4%	30,4%	39,1%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	No product		#	Hourly	#
							Daily	22,2%										N/A	#
							Weekly	25,9%										Daily	#
							Monthly and more	33,3%										N/A	#
																		Weekly	#
																		N/A	#
																		Monthly and more	#
																		N/A	#
Coastal erosion monitoring	11	20,0%	25,7%	25,7%	20,0%	8,6%	Hourly	16,7%	25,0%	30,0%	45,0%	SAR	X-band, C-band, L-band	1 m up to 50 m			#	Hourly	#
							Daily	20,8%											#
							Weekly	29,2%										Daily	#
							Monthly and more	33,3%											#
																		Weekly	#
																			#
																		Monthly and more	#
												Multispectral	RGB, NIR	0,5m up to 10m			#	Hourly	#
																			#
																		Daily	#
																			#
																		Weekly	#
																			#
																		Monthly and more	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Evolution of vegetation typology monitoring	N/A			x		x	Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	CLMS, Local, Natura 2000 CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution CLMS, Pan-European, High Resolution Layers, Forest CLMS, Pan-European, High Resolution Layers, Grassland	Natura2000: 10 m Mosaic: Up to 2,5m Forest: 20m Grassland: 20m	#	Hourly	Natura2000: once every 4 years Mosaic, Forest, Grassland: once every 3 years	#
							Daily	N/A										Daily	Natura2000: once every 4 years Mosaic, Forest, Grassland: once every 3 years	#
							Weekly	N/A										Weekly	Natura2000: once every 4 years Mosaic, Forest, Grassland: once every 3 years	#
							Monthly and more	N/A										Monthly and more	Natura2000: once every 4 years Mosaic, Forest, Grassland: once every 3 years	#
Vegetation levels monitoring	11	15,6%	25,0%	28,1%	21,9%	9,4%	Hourly	12,0%	36,8%	26,3%	36,8%	Multispectral	RGB, NIR	0.30 m up to 2 m	CLMS, Local, Natura 2000 CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution CLMS, Pan-European, High Resolution Layers, Forest CLMS, Pan-European, High Resolution Layers, Grassland CLMS, Global, NDVI	Natura2000: 10 m Mosaic: up to 2,5 m Forest: 20m Grassland: 20m NDVI: 300m	#	Hourly	Natura2000, : once every 4 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Daily	24,0%										Daily	Natura2000, : once every 4 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Weekly	24,0%										Weekly	Natura2000, : once every 4 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Monthly and more	40,0%										Monthly and more	Natura2000, : once every 4 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
Ice cover monitoring (sea)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	up to 10 m	CMEMS, Regional & Global Sea analysis, Sea Ice C3S, Sea Ice (thickness, edge, concentration, type)	CMEMS Sea Ice: Up to 1km C3S Sea Ice: Thickness: 1-10km Concentration: 40 -50 km Edge: 15km Type: 40 - 70 km	#	Hourly	Hourly	#
							Daily	N/A										Daily	daily	#
							Weekly	N/A										Weekly	Weekly	#
							Monthly and more	N/A										Monthly and more	monthly	#
							Hourly					Multispectral	RGB, NIR, SWIR	up to 10 m	CMEMS, Regional & Global Sea analysis, Sea Ice C3S, Sea Ice (thickness, edge, concentration, type)	CMEMS Sea Ice: Up to 1km C3S Sea Ice: Thickness: 1-10km Concentration: 40 -50 km Edge: 15km Type: 40 - 70 km	#	Hourly	Hourly	#
							Daily											Daily	daily	#
							Weekly											Weekly	Weekly	#
							Monthly and more											Monthly and more	monthly	#
Insolation monitoring	7	24,0%	28,0%	20,0%	16,0%	12,0%	Hourly	21,4%	23,1%	30,8%	46,2%	Multispectral	VIS (0.5-0.9 µm) Water Vapour (WV) (5.7-7.1 µm) Thermal InfraRed (TIR) (10.5-12.5 µm)	5km up to 10km	CAMS, Clear-Sky Radiation, McClear & Heliosat-4	50 - 150 km	#	Hourly	Hourly	#
							Daily	21,4%										Daily	Dayly	#
							Weekly	28,6%										Weekly	Weekly	#
							Monthly and more	28,6%										Monthly and more	monthly	#
Rainfall erosivity monitoring	11	22,6%	29,0%	22,6%	19,4%	6,5%	Hourly	13,6%	27,3%	31,8%	40,9%				No product		#	Hourly		#
							Daily	22,7%										Daily		#
							Weekly	22,7%										Weekly		#
							Monthly and more	40,9%										Monthly and more		#

User needs		User requirements											Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user							Copernicus core services products				
																Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Sea salinity levels measurement	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	18,2%	30,0%	30,0%	40,0%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	CMEMS, Regional & Global Sea analysis, Salinity	2-28 km	#	Hourly	#
							Daily	22,7%										Daily	#
							Weekly	18,2%										Weekly	#
							Monthly and more	40,9%										Monthly and more	#
Sediment levels measurement	8	20,8%	25,0%	20,8%	20,8%	12,5%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	CMEMS, Ocean Colour Thematic Center (OC TAC), CHL & OPTICS	1km	#	Hourly	#
							Daily	17,4%										Daily	#
							Weekly	21,7%										Weekly	#
							Monthly and more	43,5%										Monthly and more	#
Analysis of soil distribution and composition	10	16,7%	23,3%	23,3%	26,7%	1O%	Hourly	12,0%	25,0%	30,0%	45,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No product		#	Hourly	#
							Daily	20,0%										Daily	#
							Weekly	24,0%										Weekly	#
							Monthly and more	44,0%										Monthly and more	#
Water current monitoring	6	25,0%	25,0%	25,0%	20,0%	5,0%	Hourly	16,7%	31,3%	31,3%	37,5%	SAR	C-band	up to 50 km	CMEMS, Regional & Global Sea analysis, Current Velocity	2 - 28 km	#	Hourly	#
							Daily	16,7%										Daily	#
							Weekly	22,2%										Weekly	#
							Monthly and more	44,4%										Monthly and more	#
Water pollution monitoring	11	22,2%	25,9%	18,5%	22,2%	11,1%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	C3S, Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	Models are using different type of data & resolutions	#	Hourly	#
							Daily	26,1%										Daily	#
							Weekly	26,1%										Weekly	#
							Monthly and more	30,4%										Monthly and more	#
Water quality monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	CLMS, Lake Water Quality products C3S, Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	Lake Water Quality products: 300m Water quality indicators: models are using different type of data & resolutions	#	Hourly	#
							Daily	N/A										Daily	3 days (Lake Water) and daily (Water Quality indicators)	#
							Weekly	N/A										Weekly	3 days (Lake Water)	#
							Monthly and more	N/A										Monthly and more	3 days (Lake Water) and monthly (Water Quality indicators)	#

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Copernicus core services products				
															Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Wind direction & speed monitoring	12	22,2%	27,8%	22,2%	16,7%	11,1%	Hourly	20,0%	29,2%	37,5%	33,3%	SAR	C-band, Ku-band	1 km up to 25 km	CMEMS, Regional & Global Sea analysis, Wind C3S, EAR5 Climate Reanalysis	Sea analysis, Wind: 1 km ERA5: 31km	#	Hourly / Hourly	#
							Daily	16,0%										Daily / daily	#
							Weekly	24,0%										Weekly / monthly	#
							Monthly and more	40,0%										Monthly and more / monthly	#
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	EMS, Global Flood Awareness system CLMS, Pan-European, High Resolution Layers, Water & Wetness C3S, Water quantity indicators (water runnoff, wetness, river flow, snow water equivalent, soil water content, etc.)	Global Flood Awareness Systel: 32 km CLMS, Pan-European, High Resolution Layers, Water & Wetness : 20 - 100m Water quantity indicators: models are using different type of data & resolutions	#	Hourly / daily	#
							Daily	N/A										Daily / daily	#
							Weekly	N/A										Weekly / daily	#
							Monthly and more	N/A										Monthly and more / daily	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Sentinels capabilities					
															Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of Sentinel matching technical specifications	Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Map regression	6	12,5%	18,8%	18,8%	31,3%	18,8%	Hourly	18,8%	25,0%	41,7%	33,3%	Multispectral	RGB-NIR	0.30 up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly / 5 days	1
							Daily	18,8%										Daily / 5 days	1
							Weekly	31,3%										Weekly / 5 days	3
							Monthly and more	31,3%										Monthly and more / 5 days	3
							Hourly	18,8%				SAR	X-band, C-band	0.30 up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly / 6 days	1
							Daily	18,8%										Daily / 6 days	1
							Weekly	31,3%										Weekly / 6 days	3
							Monthly and more	31,3%										Monthly and more / 6 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities				
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Air pollution monitoring to prevent damages & blackening of buildings	15	23,1%	28,2%	20,5%	17,9%	10,3%	Hourly	18,5%	26,9%	34,6%	38,5%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Sentinel 5P	Spatial resolution 7km	2	Hourly / Daily	1
							Daily	22,2%										Daily / Daily	3
							Weekly	25,9%										Weekly / Daily	3
							Monthly and more	33,3%										Monthly and more / Daily	3
Atmospheric moisture measurement	13	22,9%	25,7%	20,0%	20,0%	11,4%	Hourly	18,5%	30,4%	30,4%	39,1%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Sentinel 3	Sentinel 3 (OLCI): 300m to 1,2km	1	Hourly / 2 days	1
							Daily	22,2%										Daily / 2 days	1
							Weekly	25,9%										Weekly / 2 days	3
							Monthly and more	33,3%										Monthly and more / 2 days	3
Coastal erosion monitoring	11	20,0%	25,7%	25,7%	20,0%	8,6%	Hourly	16,7%	25,0%	30,0%	45,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	2	Hourly / 6 days	1
							Daily	20,8%										Daily / 6 days	1
							Weekly	29,2%										Weekly / 6 days	3
							Monthly and more	33,3%										Monthly and more / 6 days	3
							Hourly	16,7%				Multispectral	RGB, NIR	0,5m up to 10m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly / 5 days	1
							Daily	20,8%										Daily / 5 days	1
							Weekly	29,2%										Weekly / 5 days	3
							Monthly and more	33,3%										Monthly and more / 5 days	3
Evolution of vegetation typology monitoring	N/A			x		x	Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	1	Hourly / 5 days	1
							Daily	N/A										Daily / 5 days	1
							Weekly	N/A										Weekly / 5 days	3
							Monthly and more	N/A										Monthly and more / 5 days	3
Vegetation levels monitoring	11	15,6%	25,0%	28,1%	21,9%	9,4%	Hourly	12,0%	36,8%	26,3%	36,8%	Multispectral	RGB, NIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly / 5 days	1
							Daily	24,0%										Daily / 5 days	1
							Weekly	24,0%										Weekly / 5 days	3
							Monthly and more	40,0%										Monthly and more / 5 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities				
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Ice cover monitoring (sea)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are available	2	Hourly 6 days	1
							Daily	N/A										Daily 6 days	1
							Weekly	N/A										Weekly 6 days	3
							Monthly and more	N/A										Monthly and more 6 days	3
							Hourly	N/A				Multispectral	RGB, NIR, SWIR	up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	3	Hourly 5 days	1
							Daily	N/A										Daily 5 days	1
							Weekly	N/A										Weekly 5 days	3
							Monthly and more	N/A										Monthly and more 5 days	3
Insolation monitoring	7	24,0%	28,0%	20,0%	16,0%	12,0%	Hourly	21,4%	23,1%	30,8%	46,2%	Multispectral	VIS (0.5-0.9 µm) Water Vapour (WV) (5.7-7.1 µm) Thermal InfraRed (TIR) (10.5-12.5 µm)	5km up to 10km	Sentinel 3	Sentinel 3 (OLCI): 300m to 1,2km	3	Hourly 2 days	1
							Daily	21,4%										Daily 2 days	1
							Weekly	28,6%										Weekly 2 days	3
							Monthly and more	28,6%										Monthly and more 2 days	3
Rainfall erosivity monitoring	11	22,6%	29,0%	22,6%	19,4%	6,5%	Hourly	13,6%	27,3%	31,8%	40,9%							Hourly	
							Daily	22,7%										Daily	
							Weekly	22,7%										Weekly	
							Monthly and more	40,9%										Monthly and more	
Sea salinity levels measurement	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	18,2%	30,0%	30,0%	40,0%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	Sentinel 3	Microwave Radiomater (20 km)	1	Hourly 2 days	1
							Daily	22,7%										Daily 2 days	1
							Weekly	18,2%										Weekly 2 days	3
							Monthly and more	40,9%										Monthly and more 2 days	3
Sediment levels measurement	8	20,8%	25,0%	20,8%	20,8%	12,5%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	Sentinel-3	300m up to 1,2km (OLCI)	2	Hourly 2 days	1
							Daily	17,4%										Daily 2 days	1
							Weekly	21,7%										Weekly 2 days	3
							Monthly and more	43,5%										Monthly and more 2 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Analysis of soil distribution and composition	10	16,7%	23,3%	23,3%	26,7%	10%	Hourly	12,0%	25,0%	30,0%	45,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	Potential evolution of Copernicus			Hourly		
							Daily	20,0%										Daily		
							Weekly	24,0%										Weekly		
							Monthly and more	44,0%										Monthly and more		
Water current monitoring	6	25,0%	25,0%	25,0%	20,0%	5,0%	Hourly	16,7%	31,3%	31,3%	37,5%	SAR	C-band	up to 50 km	Sentinel 1	Minimum 5m resolution for C-band	3	Hourly	6 days	1
							Daily	16,7%										Daily	6 days	1
							Weekly	22,2%										Weekly	6 days	3
							Monthly and more	44,4%										Monthly and more	6 days	3
Water pollution monitoring	11	22,2%	25,9%	18,5%	22,2%	11,1%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Sentinel-3	300m up to 1,2km (OLCI)	1	Hourly	2 days	1
							Daily	26,1%										Daily	2 days	1
							Weekly	26,1%										Weekly	2 days	3
							Monthly and more	30,4%										Monthly and more	2 days	3
Water quality monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Sentinel-3	300m up to 1,2km (OLCI)	1	Hourly	2 days	1
							Daily	N/A										Daily	2 days	1
							Weekly	N/A										Weekly	2 days	3
							Monthly and more	N/A										Monthly and more	2 days	3
Wind direction & speed monitoring	12	22,2%	27,8%	22,2%	16,7%	11,1%	Hourly	20,0%	29,2%	37,5%	33,3%	SAR	C-band, Ku-band	1 km up to 25 km	Sentinel 3	Minimum 300m resolution for C-band Minimum 300m for Ku-band (after SAR processing)	3	Hourly	2 days	1
							Daily	16,0%										Daily	2 days	1
							Weekly	24,0%										Weekly	2 days	3
							Monthly and more	40,0%										Monthly and more	2 days	3
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly	6 days	1
							Daily	N/A										Daily	6 days	1
							Weekly	N/A										Weekly	6 days	3
							Monthly and more	N/A										Monthly and more	6 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution		Grade
Map regression	6	12,5%	18,8%	18,8%	31,3%	18,8%	Hourly	18,8%	25,0%	41,7%	33,3%	Multispectral	RGB-NIR	0.30 up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	18,8%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	31,3%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	31,3%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Hourly	18,8%				SAR	X-band, C-band	0.30 up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	18,8%											Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	31,3%											Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	31,3%											Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Air pollution monitoring to prevent damages & blackening of buildings	15	23,1%	28,2%	20,5%	17,9%	10,3%	Hourly	18,5%	26,9%	34,6%	38,5%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	3		Hourly	Archives	1
							Daily	22,2%											Daily	Archives	1
							Weekly	25,9%											Weekly	Archives	1
							Monthly and more	33,3%											Monthly and more	Archives	1
Atmospheric moisture measurement	13	22,9%	25,7%	20,0%	20,0%	11,4%	Hourly	18,5%	30,4%	30,4%	39,1%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	3		Hourly	Archives	1
							Daily	22,2%											Daily	Archives	1
							Weekly	25,9%											Weekly	Archives	1
							Monthly and more	33,3%											Monthly and more	Archives	1
Coastal erosion monitoring	11	20,0%	25,7%	25,7%	20,0%	8,6%	Hourly	16,7%	25,0%	30,0%	45,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2 15 km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	2
							Daily	20,8%											Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Weekly	29,2%											Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Monthly and more	33,3%											Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Hourly	16,7%				Multispectral	RGB, NIR	0,5m up to 10m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	20,8%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	29,2%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	33,3%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Evolution of vegetation typology monitoring	N/A			x		x	Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	N/A												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	N/A												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	N/A												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Vegetation levels monitoring	11	15,6%	25,0%	28,1%	21,9%	9,4%	Hourly	12,0%	36,8%	26,3%	36,8%	Multispectral	RGB, NIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	24,0%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	24,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	40,0%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Ice cover monitoring (sea)	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band, L-band	up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2 15 km in L-band from SMOS	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	N/A												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	N/A												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	N/A												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Hourly	N/A				Multispectral	RGB, NIR, SWIR	up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	N/A												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	N/A												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	N/A												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Insolation monitoring	7	24,0%	28,0%	20,0%	16,0%	12,0%	Hourly	21,4%	23,1%	30,8%	46,2%	Multispectral	VIS (0.5-0.9 µm) Water Vapour (WV) (5.7-7.1 µm) Thermal InfraRed (TIR) (10.5-12.5 µm)	5km up to 10km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	3		Hourly	Archives	1
							Daily	21,4%												Daily	Archives	1
							Weekly	28,6%												Weekly	Archives	1
							Monthly and more	28,6%												Monthly and more	Archives	1
Rainfall erosivity monitoring	11	22,6%	29,0%	22,6%	19,4%	6,5%	Hourly	13,6%	27,3%	31,8%	40,9%									Hourly		
							Daily	22,7%												Daily		
							Weekly	22,7%												Weekly		
							Monthly and more	40,9%												Monthly and more		

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution	Grade
Sea salinity levels measurement	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	18,2%	30,0%	30,0%	40,0%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	Mission group 1	SMOS	15Km	1		Hourly 26 days for SMOS	1
							Daily	22,7%												Daily 26 days for SMOS	1
							Weekly	18,2%												Weekly 26 days for SMOS	1
							Monthly and more	40,9%												Monthly and more 26 days for SMOS	3
Sediment levels measurement	8	20,8%	25,0%	20,8%	20,8%	12,5%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	2	There is currently no high resolution satellite data to respond to this user need	Hourly Archives	1
							Daily	17,4%												Daily Archives	1
							Weekly	21,7%												Weekly Archives	1
							Monthly and more	43,5%												Monthly and more Archives	1
Analysis of soil distribution and composition	10	16,7%	23,3%	23,3%	26,7%	10%	Hourly	12,0%	25,0%	30,0%	45,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No hyperspectral capacity available					Hourly	
							Daily	20,0%												Daily	
							Weekly	24,0%												Weekly	
							Monthly and more	44,0%												Monthly and more	
Water current monitoring	6	25,0%	25,0%	25,0%	20,0%	5,0%	Hourly	16,7%	31,3%	31,3%	37,5%	SAR	C-band	up to 50 km	Mission group 1	Radarsat-2 (C-band)	Up to 1m in C-band from Radarsat-2	3		Hourly 1 day for Radarsat-2 (C-band)	1
							Daily	16,7%												Daily 1 day for Radarsat-2 (C-band)	3
							Weekly	22,2%												Weekly 1 day for Radarsat-2 (C-band)	3
							Monthly and more	44,4%												Monthly and more 1 day for Radarsat-2 (C-band)	3
Water pollution monitoring	11	22,2%	25,9%	18,5%	22,2%	11,1%	Hourly	17,4%	30,0%	35,0%	35,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	1	There is currently no high resolution satellite data to respond to this user need	Hourly Archives	1
							Daily	26,1%												Daily Archives	1
							Weekly	26,1%												Weekly Archives	1
							Monthly and more	30,4%												Monthly and more Archives	1
Water quality monitoring	N/A		x	x			Hourly	N/A	N/A	N/A	N/A	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	1	There is currently no high resolution satellite data to respond to this user need	Hourly Archives	1
							Daily	N/A												Daily Archives	1
							Weekly	N/A												Weekly Archives	1
							Monthly and more	N/A												Monthly and more Archives	1

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution	Grade
Wind direction & speed monitoring	12	22,2%	27,8%	22,2%	16,7%	11,1%	Hourly	20,0%	29,2%	37,5%	33,3%	SAR	C-band, Ku-band	1 km up to 25 km	Mission group 1	Radarsat-2 (C-band) ERS (Ku-Band)	Up to 1m in C-band from Radarsat-2 Up to 25m in Ku-Band for ERS	3		Hourly 1 day for Radarsat-2 (C-band)	1
							Daily	16,0%												Daily 1 day for Radarsat-2 (C-band)	3
							Weekly	24,0%												Weekly 1 day for Radarsat-2 (C-band)	3
							Monthly and more	40,0%												Monthly and more 1 day for Radarsat-2 (C-band)	3
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2	3		Hourly Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	N/A												Daily Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	N/A												Weekly Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	N/A												Monthly and more Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3

6. High level user need 6 - Monitoring of the evolution of the natural environment of the NH site
   a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products					
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Map regression	10	12,5%	21,9%	21,9%	28,1%	15,6%	Hourly	11,1%	20,0%	26,7%	53,3%	Mulispectral	RGB-NIR	0.30 up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	11,1%										Daily	Every 3 years	#
							Weekly	33,3%										Weekly	Every 3 years	#
							Monthly and more	44,4%										Monthly and more	Every 3 years	#
												SAR	X-band, C-band	0.30 up to 10 m			#	Hourly	Every 3 years	#
																		Daily	Every 3 years	#
																		Weekly	Every 3 years	#
																		Monthly and more	Every 3 years	#
Air pollution monitoring to prevent damages on NH sites	11	21,9%	25,0%	18,8%	21,9%	12,5%	Hourly	23,8%	22,2%	33,3%	44,4%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	CAMS, Global forecast of aerosol CAMS, European-Scale air quality analysis	80 km/ 10-20 km	#	Hourly	daily	#
							Daily	19,0%										Daily	daily	#
							Weekly	23,8%										Weekly	daily	#
							Monthly and more	33,3%										Monthly and more	daily	#
Atmospheric moisture measurement	11	20,0%	23,3%	20,0%	23,3%	13,3%	Hourly	19,0%	27,8%	33,3%	38,9%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	No product		#	Hourly		#
							Daily	23,8%										Daily		#
							Weekly	23,8%										Weekly		#
							Monthly and more	33,3%										Monthly and more		#
Coastal erosion monitoring	7	20,0%	24,0%	20,0%	20,0%	16,0%	Hourly	23,5%	28,6%	35,7%	35,7%	SAR	X-band, C-band, L-band	1 m up to 50 m			#	Hourly		#
							Daily	17,6%										Daily		#
							Weekly	17,6%										Weekly		#
							Monthly and more	41,2%										Monthly and more		#
												Multispectral	RGB, NIR	1 m up to 50 m			#	Hourly		#
																		Daily		#
																		Weekly		#
																		Monthly and more		#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user			Sensors	Wavelength	Spatial resolution specification	Copernicus core services products					
															Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)					Current product spatial resolution	Grade	Current product timeliness		Grade
Evolution of vegetation typology monitoring	8	16,7%	29,2%	25,0%	20,8%	8,3%	Hourly	10,5%	26,7%	26,6%	46,7%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	CLMS, Local, Natura 2000 CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution CLMS, Pan-European, High Resolution Layers, Forest CLMS, Pan-European, High Resolution Layers, Grassland	Natura2000: 10 m Mosaic: Up to 2,5m Forest: 20m Grassland: 20m	#	Hourly	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years	#
							Daily	15,8%										Daily	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years	#
							Weekly	26,3%										Weekly	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years	#
							Monthly and more	47,4%										Monthly and more	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years	#
Forest coverage monitoring	6	11,1%	27,8%	22,2%	22,2%	16,7%	Hourly	17,6%	25,0%	33,3%	41,7%	Multispectral	RGB, NIR, SWIR	up to 20 m	CLMS, Local, Natura 2000 CLMS, Pan-European, High Resolution Layers, Forest CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Natura2000: 10 m Forest: 20m Mosaic: Up to 2,5m	#	Hourly	Natura2000: every 6 years Mosaic, Forest: every 3 years	#
							Daily	17,6%										Daily	Natura2000: every 6 years Mosaic, Forest: every 3 years	#
							Weekly	23,5%										Weekly	Natura2000: every 6 years Mosaic, Forest: every 3 years	#
							Monthly and more	41,2%										Monthly and more	Natura2000: every 6 years Mosaic, Forest: every 3 years	#
Vegetation levels monitoring	10	15,4%	26,9%	23,1%	26,9%	7,7%	Hourly	9,5%	23,5%	29,4%	47,1%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	CLMS, Local, Natura 2000 CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution CLMS, Pan-European, High Resolution Layers, Forest CLMS, Pan-European, High Resolution Layers, Grassland CLMS, Global, NDVI	Natura2000: 10 m Mosaic: up to 2,5 m Forest: 20m Grassland: 20m NDVI: 300m	#	Hourly	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Daily	19,0%										Daily	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Weekly	28,6%										Weekly	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
							Monthly and more	42,9%										Monthly and more	Natura2000, : once every 6 years Mosaic, Forest, Grassland: once every 3 years NDVI: 3 times per month	#
Ice cover monitoring (sea)	4	15,4%	23,1%	30,8%	23,1%	7,7%	Hourly	14,3%	40,0%	30,0%	30,0%	Multispectral	RGB, NIR, SWIR	up to 10 m	CMEMS, Regional & Global Sea analysis, Sea Ice C3S, Sea Ice (thickness, edge, concentration, type)	CMEMS Sea Ice: Up to 1km C3S Sea Ice: Thickness: 1-10km Concentration: 40 -50 km Edge: 15km Type: 40 - 70 km	#	Hourly	Hourly	#
							Daily	28,6%										Daily	daily	#
																		Weekly	Weekly	#
																		Monthly and more	monthly	#
							Weekly	21,4%				SAR	X-band, C-band, L-band	up to 10 m	CMEMS, Regional & Global Sea analysis, Sea Ice C3S, Sea Ice (thickness, edge, concentration, type)	CMEMS Sea Ice: Up to 1km C3S Sea Ice: Thickness: 1-10km Concentration: 40 -50 km Edge: 15km Type: 40 - 70 km	#	Hourly	Hourly	#
																		Daily	daily	#
																		Weekly	Weekly	#
							Monthly and more	35,7%										Monthly and more	monthly	#

User needs		User requirements											Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user							Copernicus core services products				
																Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Lithology	6	19,0%	23,8%	23,8%	23,8%	9,5%	Hourly	12,5%	30,8%	30,8%	38,5%	In-situ data			No product		#	Hourly		#
							Daily	18,8%										Daily		#
							Weekly	25,0%										Weekly		#
							Monthly and more	43,8%										Monthly and more		#
												Hyperspectral			No product		#	Hourly		#
																		Daily		#
																		Weekly		#
																		Monthly and more		#
Rock assay analysis	5	27,3%	36,4%	18,2%	9,1%	9,1%	Hourly	0,0%	28,6%	28,6%	42,8%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No product		#	Hourly		
							Daily	20,0%										Daily		#
							Weekly	0,0%										Weekly		
							Monthly and more	80,0%										Monthly and more		#
Normalized difference vegetation index (NDVI)	12	16,1%	25,8%	22,6%	25,8%	9,7%	Hourly	5,6%	16,7%	27,8%	55,6%	Multispectral	RED, NIR	up to 20 m	CLMS, Global, NDVI	300m	#	Hourly	3 times a month	#
							Daily	16,7%										Daily	3 times a month	#
							Weekly	27,8%										Weekly	3 times a month	#
							Monthly and more	50,0%										Monthly and more	3 times a month	#
Rainfall erosivity monitoring	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	15,0%	26,3%	31,6%	42,1%				No product		#	Hourly		#
							Daily	20,0%										Daily		#
							Weekly	15,0%										Weekly		#
							Monthly and more	50,0%										Monthly and more		#
Sea salinity levels measurement	7	23,8%	28,6%	23,8%	19,0%	4,8%	Hourly	17,6%	28,5%	28,6%	42,9%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	CMEMS, Regional & Global Sea analysis, Salinity	2 - 28 km	#	Hourly	Hourly	#
							Daily	23,5%										Daily	daily	#
							Weekly	17,6%										Weekly	Weekly	#
							Monthly and more	41,2%										Monthly and more	monthly	#
Sediment levels measurement	5	14,3%	28,6%	21,4%	28,6%	7,1%	Hourly	12,5%	27,3%	27,3%	45,4%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	CMEMS, Ocean Colour Thematic Center (OC TAC), CHL & OPTICS	1km	#	Hourly	Daily	#
							Daily	18,8%										Daily	Daily	#
							Weekly	25,0%										Weekly	Weekly	#
							Monthly and more	43,8%										Monthly and more	monthly	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Analysis of soil distribution and composition	6	22,2%	33,3%	22,2%	16,7%	5,6%	Hourly	11,8%	26,7%	33,3%	40,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No product		#	Hourly	#
							Daily	17,6%										Daily	#
							Weekly	17,6%										Weekly	#
							Monthly and more	52,9%										Monthly and more	#
Water current monitoring	6	11,8%	17,6%	29,4%	23,5%	17,6%	Hourly	16,7%	30,0%	30,0%	40,0%	SAR	C-band	up to 50 km	CMEMS, Regional & Global Sea analysis, Current Velocity	4-20 km	#	Hourly	Hourly	#
							Daily	16,7%										Daily	daily	#
							Weekly	25,0%										Weekly	Weekly	#
							Monthly and more	41,7%										Monthly and more	monthly	#
Water pollution monitoring	10	20,7%	24,1%	17,2%	24,1%	13,8%	Hourly	20,0%	23,5%	35,3%	41,2%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	C3S, Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	Water quality indicators: models are using different type of data & resolutions	#	Hourly		#
							Daily	20,0%										Daily	daily	#
							Weekly	25,0%										Weekly	Weekly	#
							Monthly and more	35,0%										Monthly and more	monthly	#
Water quality monitoring	3	16,7%	25,0%	25,0%	25,0%	8,3%	Hourly	15,4%	33,3%	33,3%	3330,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	CLMS, Lake Water Quality products C3S, Water quality indicators (nitrogen concentration, nitrogen loads, phosphorous concentrations, phosphorous loads, water temperature.)	Lake Water Quality products: 300m Water quality indicators: models are using different type of data & resolutions	#	Hourly	3 days	#
							Daily	23,1%										Daily	3 days (Lake Water) and daily (Water Quality indicators)	#
							Weekly	23,1%										Weekly	3 days (Lake Water	#
							Monthly and more	38,5%										Monthly and more	3 days (Lake Water) and monthly (Water Quality indicators)	#
Water level monitoring	16	25,0%	27,8%	22,2%	16,7%	8,3%	Hourly	16,7%	28,0%	32,0%	40,0%	SAR	Ka band, Ku band, C band	up to 25 km	CMEMS, Regional & Global Sea analysis, Sea Surface Height C3S, Sea level	CMEMS, Sea surface height: 2 - 28 km C3S, Sea level: 10 km	#	Hourly	Hourly	#
							Daily	25,0%										Daily	daily	#
							Weekly	16,7%										Weekly	Weekly	#
							Monthly and more	41,7%										Monthly and more	monthly	#
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	EMS, Global Flood Awareness system CLMS, Pan-European, High Resolution Layers, Water & Wetness C3S, Water quantity indicators (water runnoff, wetness, river flow, snow water equivalent, soil water content, etc.)	EMS, Global Flood Awareness System: 32 km CLMS, Pan-European, High Resolution Layers, Water & Wetness : 20 - 100m Water quantity indicators: models are using different type of data & resolutions	#	Hourly	daily	#
							Daily	N/A										Daily	daily	#
							Weekly	N/A										Weekly	Weekly	#
							Monthly and more	N/A										Monthly and more	daily	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
															Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Sea surface temperature monitoring	12	19,4%	22,6%	22,6%	22,6%	12,9%	Hourly	19,0%	27,8%	33,3%	38,9%	Thermal	TIR	up to 30 m	CMEMS, Regional & Global Sea analysis, Temperature C3S, Sea Surface Temperature	CMEMS, Sea analysis Temperature: 1 km C3S, Sea Surface Temperature: 4km	#	Hourly	#
							Daily	23,8%										Daily	#
							Weekly	23,8%										Weekly	#
							Monthly and more	33,3%										Monthly and more	#
Wildlife tracking	3	11,1%	33,3%	22,2%	22,2%	11,1%	Hourly	11,1%	28,6%	28,5%	42,9%				No product		#	Hourly	#
							Daily	22,2%										Daily	#
							Weekly	22,2%										Weekly	#
							Monthly and more	44,4%										Monthly and more	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Map regression	10	12,5%	21,9%	21,9%	28,1%	15,6%	Hourly	11,1%	20,0%	26,7%	53,3%	Mulispectral	RGB-NIR	0.30 up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	11,1%										Daily	5 days	1
							Weekly	33,3%										Weekly	5 days	3
							Monthly and more	44,4%										Monthly and more	5 days	3
							Hourly	11,1%				SAR	X-band, C-band	0.30 up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly	6 days	1
							Daily	11,1%										Daily	6 days	1
							Weekly	33,3%										Weekly	6 days	3
							Monthly and more	44,4%										Monthly and more	6 days	3
Air pollution monitoring to prevent damages on NH sites	11	21,9%	25,0%	18,8%	21,9%	12,5%	Hourly	23,8%	22,2%	33,3%	44,4%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Sentinel 5P	Spatial resolution 7km	2	Hourly	Daily	1
							Daily	19,0%										Daily	Daily	3
							Weekly	23,8%										Weekly	Daily	3
							Monthly and more	33,3%										Monthly and more	Daily	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Atmospheric moisture measurement	11	20,0%	23,3%	20,0%	23,3%	13,3%	Hourly	19,0%	27,8%	33,3%	38,9%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Sentinel 3	Sentinel 3 (OLCI): 300m to 1,2km	2	Hourly	2 days	1
							Daily	23,8%										Daily	2 days	1
							Weekly	23,8%										Weekly	2 days	3
							Monthly and more	33,3%										Monthly and more	2 days	3
Coastal erosion monitoring	7	20,0%	24,0%	20,0%	20,0%	16,0%	Hourly	23,5%	28,6%	35,7%	35,7%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	2	Hourly	6 days	1
							Daily	17,6%										Daily	6 days	1
							Weekly	17,6%										Weekly	6 days	3
							Monthly and more	41,2%										Monthly and more	6 days	3
							Hourly	23,5%				Multispectral	RGB, NIR	1 m up to 50 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	17,6%										Daily	5 days	1
							Weekly	17,6%										Weekly	5 days	3
							Monthly and more	41,2%										Monthly and more	5 days	3
Evolution of vegetation typology monitoring	8	16,7%	29,2%	25,0%	20,8%	8,3%	Hourly	10,5%	26,7%	26,6%	46,7%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	1	Hourly	5 days	1
							Daily	15,8%										Daily	5 days	1
							Weekly	26,3%										Weekly	5 days	3
							Monthly and more	47,4%										Monthly and more	5 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Forest coverage monitoring	6	11,1%	27,8%	22,2%	22,2%	16,7%	Hourly	17,6%	25,0%	33,3%	41,7%	Multispectral	RGB, NIR, SWIR	up to 20 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	3	Hourly	5 days	1
							Daily	17,6%										Daily	5 days	1
							Weekly	23,5%										Weekly	5 days	3
							Monthly and more	41,2%										Monthly and more	5 days	3
Vegetation levels monitoring	10	15,4%	26,9%	23,1%	26,9%	7,7%	Hourly	9,5%	23,5%	29,4%	47,1%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	1	Hourly	5 days	1
							Daily	19,0%										Daily	5 days	1
							Weekly	28,6%										Weekly	5 days	3
							Monthly and more	42,9%										Monthly and more	5 days	3
Ice cover monitoring (sea)	4	15,4%	23,1%	30,8%	23,1%	7,7%	Hourly	14,3%	40,0%	30,0%	30,0%	Multispectral	RGB, NIR, SWIR	up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	3	Hourly	5 days	1
							Daily	28,6%										Daily	5 days	1
							Weekly	21,4%										Weekly	5 days	3
							Monthly and more	35,7%										Monthly and more	5 days	3
							Hourly	14,3%				SAR	X-band, C-band, L-band	up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	2	Hourly	6 days	1
							Daily	28,6%										Daily	6 days	1
							Weekly	21,4%										Weekly	6 days	3
							Monthly and more	35,7%										Monthly and more	6 days	3
Lithology	6	19,0%	23,8%	23,8%	23,8%	9,5%	Hourly	12,5%	30,8%	30,8%	38,5%	In-situ data			N/A			Hourly		
							Daily	18,8%										Daily		
							Weekly	25,0%										Weekly		
							Monthly and more	43,8%										Monthly and more		
							Hourly	12,5%				Hyperspectral			Potential evolution of Copernicus			Hourly		
							Daily	18,8%										Daily		
							Weekly	25,0%										Weekly		
							Monthly and more	43,8%										Monthly and more		

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Rock assay analysis	5	27,3%	36,4%	18,2%	9,1%	9,1%	Hourly	0,0%	28,6%	28,6%	42,8%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	Potential evolution of Copernicus	N/A	1	Hourly		1
							Daily	20,0%										Daily	N/A	1
							Weekly	0,0%										Weekly		1
							Monthly and more	80,0%										Monthly and more	N/A	1
Normalized difference vegetation index (NDVI)	12	16,1%	25,8%	22,6%	25,8%	9,7%	Hourly	5,6%	16,7%	27,8%	55,6%	Multispectral	RED, NIR	up to 20 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	3	Hourly	5 days	1
							Daily	16,7%										Daily	5 days	1
							Weekly	27,8%										Weekly	5 days	3
							Monthly and more	50,0%										Monthly and more	5 days	3
Rainfall erosivity monitoring	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	15,0%	26,3%	31,6%	42,1%							Hourly		
							Daily	20,0%										Daily		
							Weekly	15,0%										Weekly		
							Monthly and more	50,0%										Monthly and more		
Sea salinity levels measurement	7	23,8%	28,6%	23,8%	19,0%	4,8%	Hourly	17,6%	28,5%	28,6%	42,9%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	Sentinel 3	Microwave Radiomater (20 km)	1	Hourly		
							Daily	23,5%										Daily		
							Weekly	17,6%										Weekly		
							Monthly and more	41,2%										Monthly and more		
Sediment levels measurement	5	14,3%	28,6%	21,4%	28,6%	7,1%	Hourly	12,5%	27,3%	27,3%	45,4%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	Sentinel-3	300m up to 1,2km (OLCI)	2	Hourly	2 days	1
							Daily	18,8%										Daily	2 days	1
							Weekly	25,0%										Weekly	2 days	3
							Monthly and more	43,8%										Monthly and more	2 days	3
Analysis of soil distribution and composition	6	22,2%	33,3%	22,2%	16,7%	5,6%	Hourly	11,8%	26,7%	33,3%	40,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	Potential evolution of Copernicus			Hourly		
							Daily	17,6%										Daily		
							Weekly	17,6%										Weekly		
							Monthly and more	52,9%										Monthly and more		

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Water current monitoring	6	11,8%	17,6%	29,4%	23,5%	17,6%	Hourly	16,7%	30,0%	30,0%	40,0%	SAR	C-band	up to 50 km	Sentinel 1	Minimum 5m resolution for C-band	3	Hourly	6 days	1
							Daily	16,7%										Daily	6 days	1
							Weekly	25,0%										Weekly	6 days	3
							Monthly and more	41,7%										Monthly and more	6 days	3
Water pollution monitoring	10	20,7%	24,1%	17,2%	24,1%	13,8%	Hourly	20,0%	23,5%	35,3%	41,2%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	2	Hourly	5 days	1
							Daily	20,0%										Daily	5 days	1
							Weekly	25,0%										Weekly	5 days	3
							Monthly and more	35,0%										Monthly and more	5 days	3
Water quality monitoring	3	16,7%	25,0%	25,0%	25,0%	8,3%	Hourly	15,4%	33,3%	33,3%	3330,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR Minimum 20m resolution for SWIR	2	Hourly	5 days	1
							Daily	23,1%										Daily	5 days	1
							Weekly	23,1%										Weekly	5 days	3
							Monthly and more	38,5%										Monthly and more	5 days	3
Water level monitoring	16	25,0%	27,8%	22,2%	16,7%	8,3%	Hourly	16,7%	28,0%	32,0%	40,0%	SAR	Ka band, Ku band, C band	up to 25 km	Sentinel 3	Minimum 300m resolution for C-band Minimum 300m for Ku-band (after SAR processing) No Ka-band available	3	Hourly	2 days	1
							Daily	25,0%										Daily	2 days	2
							Weekly	16,7%										Weekly	2 days	3
							Monthly and more	41,7%										Monthly and more	2 days	3
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly	6 days	1
							Daily	N/A										Daily	6 days	1
							Weekly	N/A										Weekly	6 days	3
							Monthly and more	N/A										Monthly and more	6 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user			Sensors	Wavelength	Spatial resolution specification	Sentinels capabilities				
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)					Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Sea surface temperature monitoring	12	19,4%	22,6%	22,6%	22,6%	12,9%	Hourly	19,0%	27,8%	33,3%	38,9%	Thermal	TIR	up to 30 m	Sentinel 3	Minimum 1 km (SLSTR)	2	Hourly 2 days	1
							Daily	23,8%										Daily 2 days	2
							Weekly	23,8%										Weekly 2 days	3
							Monthly and more	33,3%										Monthly and more 2 days	3
Wildlife tracking	3	11,1%	33,3%	22,2%	22,2%	11,1%	Hourly	11,1%	28,6%	28,5%	42,9%							Hourly	
							Daily	22,2%										Daily	
							Weekly	22,2%										Weekly	
							Monthly and more	44,4%										Monthly and more	

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user			Sensors	Wavelength	Spatial resolution specification	Contributing Missions capabilities						
															Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)				Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution	Grade
Map regression	10	12,5%	21,9%	21,9%	28,1%	15,6%	Hourly	11,1%	20,0%	26,7%	53,3%	Mulispectral	RGB-NIR	0.30 up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	11,1%											Daily Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	33,3%											Weekly Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	44,4%											Monthly and more Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Hourly	11,1%				SAR	X-band, C-band	0.30 up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2	3		Hourly Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	11,1%											Daily Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	33,3%											Weekly Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	44,4%											Monthly and more Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Air pollution monitoring to prevent damages on NH sites	11	21,9%	25,0%	18,8%	21,9%	12,5%	Hourly	23,8%	22,2%	33,3%	44,4%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Others	ENVISAT				Hourly Archives	1
							Daily	19,0%												Daily Archives	1
							Weekly	23,8%												Weekly Archives	1
							Monthly and more	33,3%												Monthly and more Archives	1

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Atmospheric moisture measurement	11	20,0%	23,3%	20,0%	23,3%	13,3%	Hourly	19,0%	27,8%	33,3%	38,9%	Multispectral	from 270 nm up to 2385 nm	up to 1 km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	3	There is currently no high resolution satellite data to respond to this user need	Hourly	Archives	1
							Daily	23,8%												Daily	Archives	1
							Weekly	23,8%												Weekly	Archives	1
							Monthly and more	33,3%												Monthly and more	Archives	1
Coastal erosion monitoring	7	20,0%	24,0%	20,0%	20,0%	16,0%	Hourly	23,5%	28,6%	35,7%	35,7%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2 Up to 15 km for L-band	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	2
							Daily	17,6%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Weekly	17,6%												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Monthly and more	41,2%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Hourly	23,5%				Multispectral	RGB, NIR	1 m up to 50 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	17,6%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	17,6%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	41,2%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Evolution of vegetation typology monitoring	8	16,7%	29,2%	25,0%	20,8%	8,3%	Hourly	10,5%	26,7%	26,6%	46,7%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	15,8%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	26,3%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	47,4%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Forest coverage monitoring	6	11,1%	27,8%	22,2%	22,2%	16,7%	Hourly	17,6%	25,0%	33,3%	41,7%	Multispectral	RGB, NIR, SWIR	up to 20 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	17,6%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	23,5%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	41,2%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Vegetation levels monitoring	10	15,4%	26,9%	23,1%	26,9%	7,7%	Hourly	9,5%	23,5%	29,4%	47,1%	Multispectral	RGB, NIR, SWIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3	In case the user actually needs a 0,3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	19,0%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	28,6%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	42,9%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Ice cover monitoring (sea)	4	15,4%	23,1%	30,8%	23,1%	7,7%	Hourly	14,3%	40,0%	30,0%	30,0%	Multispectral	RGB, NIR, SWIR	up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	28,6%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	21,4%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	35,7%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Hourly	14,3%				SAR	X-band, C-band, L-band	up to 10 m	Mission group 1 Others	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2 Up to 15 km for L-band	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	2
							Daily	28,6%											Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Weekly	21,4%											Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Monthly and more	35,7%											Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
Lithology	6	19,0%	23,8%	23,8%	23,8%	9,5%	Hourly	12,5%	30,8%	30,8%	38,5%	In-situ data			N/A					Hourly		
							Daily	18,8%											Daily		
							Weekly	25,0%											Weekly		
							Monthly and more	43,8%											Monthly and more		
							Hourly	12,5%				Hyperspectral			No hyperspectral capacity (possible future contributing missions)					Hourly		
							Daily	18,8%											Daily		
							Weekly	25,0%											Weekly		
							Monthly and more	43,8%											Monthly and more		
Rock assay analysis	5	27,3%	36,4%	18,2%	9,1%	9,1%	Hourly	0,0%	28,6%	28,6%	42,8%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No hyperspectral capacity (possible future contributing missions)	N/A	N/A			Hourly		
							Daily	20,0%											Daily	N/A	
							Weekly	0,0%											Weekly		
							Monthly and more	80,0%											Monthly and more	N/A	
Normalized difference vegetation index (NDVI)	12	16,1%	25,8%	22,6%	25,8%	9,7%	Hourly	5,6%	16,7%	27,8%	55,6%	Multispectral	RED, NIR	up to 20 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	16,7%											Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	27,8%											Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	50,0%											Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution		Grade
Rainfall erosivity monitoring	9	23,3%	26,7%	20,0%	20,0%	10,0%	Hourly	15,0%	26,3%	31,6%	42,1%									Hourly		
							Daily	20,0%												Daily		
							Weekly	15,0%												Weekly		
							Monthly and more	50,0%												Monthly and more		
Sea salinity levels measurement	7	23,8%	28,6%	23,8%	19,0%	4,8%	Hourly	17,6%	28,5%	28,6%	42,9%	SAR --> Microwave Radiometer	L-band	1 km up to 10 km	Mission group 1	SMOS	15Km	1		Hourly	26 days for SMOS	1
							Daily	23,5%												Daily	26 days for SMOS	1
							Weekly	17,6%												Weekly	26 days for SMOS	1
							Monthly and more	41,2%												Monthly and more	26 days for SMOS	3
Sediment levels measurement	5	14,3%	28,6%	21,4%	28,6%	7,1%	Hourly	12,5%	27,3%	27,3%	45,4%	Multispectral	RGB, NIR, SWIR	10 m up to 1 km	Others	ENVISAT	Up to 1km (open ocean) Up to 260m (coastal zones)	2	There is currently no high resolution satellite data to respond to this user need	Hourly		
							Daily	18,8%												Daily	Archives	
							Weekly	25,0%												Weekly	Archives	
							Monthly and more	43,8%												Monthly and more	Archives	
Analysis of soil distribution and composition	6	22,2%	33,3%	22,2%	16,7%	5,6%	Hourly	11,8%	26,7%	33,3%	40,0%	Hyperspectral	~350 nm up to ~ 2580	0.30 m up to 5 m	No hyperspectral capacity (possible future contributing missions)					Hourly		
							Daily	17,6%												Daily		
							Weekly	17,6%												Weekly		
							Monthly and more	52,9%												Monthly and more		
Water current monitoring	6	11,8%	17,6%	29,4%	23,5%	17,6%	Hourly	16,7%	30,0%	30,0%	40,0%	SAR	C-band	up to 50 km	Mission group 1	Radarsat-2 (C-band)	Up to 1m in C-band from Radarsat-2	3		Hourly	1 day for Radarsat-2 (C-band)	1
							Daily	16,7%												Daily	1 day for Radarsat-2 (C-band)	3
							Weekly	25,0%												Weekly	1 day for Radarsat-2 (C-band)	3
							Monthly and more	41,7%												Monthly and more	1 day for Radarsat-2 (C-band)	3
Water pollution monitoring	10	20,7%	24,1%	17,2%	24,1%	13,8%	Hourly	20,0%	23,5%	35,3%	41,2%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	20,0%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	25,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	35,0%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Water quality monitoring	3	16,7%	25,0%	25,0%	25,0%	8,3%	Hourly	15,4%	33,3%	33,3%	3330,0%	Multispectral	RGB, NIR, SWIR	0.30 m up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1 Up to 3,7m in SWIR from WorldView3	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	23,1%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	23,1%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	38,5%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution	Grade
Water level monitoring	16	25,0%	27,8%	22,2%	16,7%	8,3%	Hourly	16,7%	28,0%	32,0%	40,0%	SAR	Ka band, Ku band, C band	up to 25 km	Mission group 1 Other missions	Radarsat-2 (C-band) ERS (Ku-band) No Ka available	Up to 1m in C-band from Radarsat-2 Up to 25m in Ku-Band for ERS No Ka-band available	2		Hourly	1 day for Radarsat-2 (C-band)	1
							Daily	25,0%												Daily	1 day for Radarsat-2 (C-band)	3
							Weekly	16,7%												Weekly	1 day for Radarsat-2 (C-band)	3
							Monthly and more	41,7%												Monthly and more	1 day for Radarsat-2 (C-band)	3
Hydrological changes monitoring	N/A		x				Hourly	N/A	N/A	N/A	N/A	SAR	X-band, C-band	1 m to 25 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	2
							Daily	N/A												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Weekly	N/A												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Monthly and more	N/A												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
Sea surface temperature monitoring	12	19,4%	22,6%	22,6%	22,6%	12,9%	Hourly	19,0%	27,8%	33,3%	38,9%	Thermal	TIR	up to 30 m	Mission Group 2	Landsat 7 & 8	Up to 60m from Landsat 7	2		Hourly	16 days for Landsat 7 & 8	1
							Daily	23,8%												Daily	16 days for Landsat 7 & 8	1
							Weekly	23,8%												Weekly	16 days for Landsat 7 & 8	1
							Monthly and more	33,3%												Monthly and more	16 days for Landsat 7 & 8	3
Wildlife tracking	3	11,1%	33,3%	22,2%	22,2%	11,1%	Hourly	11,1%	28,6%	28,5%	42,9%									Hourly		
							Daily	22,2%												Daily		
							Weekly	22,2%												Weekly		
							Monthly and more	44,4%												Monthly and more		

7. High level user need 7 – Observation of damage on the built structure of a CH site

a. Matching user requirements with Copernicus core services products

User needs		User requirements											Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user							Copernicus core services products				
																	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)		Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness	Grade
Material composition analysis	31	21,0%	24,7%	22,2%	23,5%	8,6%	Hourly	16,7%	20,8%	27,1%	52,1%		Hyperspectral	~350 nm up to ~ 2577	0.30 m up to 5 m	No product		#	Hourly	#
							Daily	18,5%											Daily	#
							Weekly	29,6%											Weekly	#
							Monthly and more	35,2%											Monthly and more	#
Monitoring of the movements of building structure parts	18	22,9%	25,0%	22,9%	18,8%	10,4%	Hourly	16,1%	20,7%	34,5%	44,8%		SAR	X-band, C-band, L-band	1 m up to 50 m	No product		#	Hourly	#
							Daily	19,4%											Daily	#
							Weekly	25,8%											Weekly	#
							Monthly and more	38,7%											Monthly and more	#
Identification of signs of mineralisation	6	23,5%	23,5%	17,6%	29,4%	5,9%	Hourly	17,6%	23,1%	30,8%	46,1%					No product		#	Hourly	#
							Daily	29,4%											Daily	#
							Weekly	17,6%											Weekly	#
							Monthly and more	35,3%											Monthly and more	#
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%		Mulispectral	RGB-NIR	0.30 up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	14,7%											Daily	Every 3 years	#
																			Weekly	Every 3 years	#
																			Monthly and more	Every 3 years	#
							Weekly	32,4%					SAR	X-band, C-band	0.30 up to 10 m			#	Hourly	Every 3 years	#
																			Daily	Every 3 years	#
																			Weekly	Every 3 years	#
							Monthly and more	38,2%											Monthly and more	Every 3 years	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Material composition analysis	31	21,0%	24,7%	22,2%	23,5%	8,6%	Hourly	16,7%	20,8%	27,1%	52,1%	Hyperspectral	~350 nm up to ~ 2577	0.30 m up to 5 m	Potential evolution of Copernicus			Hourly		
							Daily	18,5%										Daily		
							Weekly	29,6%										Weekly		
							Monthly and more	35,2%										Monthly and more		
Monitoring of the movements of building structure parts	18	22,9%	25,0%	22,9%	18,8%	10,4%	Hourly	16,1%	20,7%	34,5%	44,8%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	2	Hourly	6 days	1
							Daily	19,4%										Daily	6 days	1
							Weekly	25,8%										Weekly	6 days	3
							Monthly and more	38,7%										Monthly and more	6 days	3
Identification of signs of mineralisation	6	23,5%	23,5%	17,6%	29,4%	5,9%	Hourly	17,6%	23,1%	30,8%	46,1%							Hourly		
							Daily	29,4%										Daily		
							Weekly	17,6%										Weekly		
							Monthly and more	35,3%										Monthly and more		
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%	Mulispectral	RGB-NIR	0.30 up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	14,7%										Daily	5 days	1
							Weekly	32,4%										Weekly	5 days	3
							Monthly and more	38,2%										Monthly and more	5 days	3
							Hourly	14,7%				SAR	X-band, C-band	0.30 up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly	6 days	1
							Daily	14,7%										Daily	6 days	1
							Weekly	32,4%										Weekly	6 days	3
							Monthly and more	38,2%										Monthly and more	6 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities							
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities							
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributiong Mission(s) temporal resolution		Grade
Material composition analysis	31	21,0%	24,7%	22,2%	23,5%	8,6%	Hourly	16,7%	20,8%	27,1%	52,1%	Hyperspectral	~350 nm up to ~2577	0.30 m up to 5 m	No hyperspectral capacity (possible future contributing missions)					Hourly		
							Daily	18,5%												Daily		
							Weekly	29,6%												Weekly		
							Monthly and more	35,2%												Monthly and more		
Monitoring of the movements of building structure parts	18	22,9%	25,0%	22,9%	18,8%	10,4%	Hourly	16,1%	20,7%	34,5%	44,8%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2 Up to 15km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	2
							Daily	19,4%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
							Weekly	25,8%												Weekly	Less than one day for COSMO SkyMed (X-band) No L-band available	3
							Monthly and more	38,7%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band) No L-band available	3
Identification of signs of mineralisation	6	23,5%	23,5%	17,6%	29,4%	5,9%	Hourly	17,6%	23,1%	30,8%	46,1%									Hourly		
							Daily	29,4%												Daily		
							Weekly	17,6%												Weekly		
							Monthly and more	35,3%												Monthly and more		
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%	Mulispectral	RGB-NIR	0.30 up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	14,7%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	32,4%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	38,2%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Hourly	14,7%				SAR	X-band, C-band	0.30 up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	14,7%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	32,4%												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	38,2%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3

8. High level user need 8 – Drawing of conclusions to facilitate an emergency intervention

a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Geo-hazards monitoring/forecasting	22	22,4%	29,3%	22,4%	13,8%	12,1%	Hourly	16,2%	20,5%	38,5%	41,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	No product		#	Hourly		#
							Daily	18,9%										Daily		#
							Weekly	21,6%										Weekly		#
							Monthly and more	43,2%										Monthly and more		#
Real-time monitoring of emergency events (e.g. flash floods, forest fires)	30	18,1%	25,3%	22,9%	21,7%	12,0%	Hourly	16,1%	22,4%	32,7%	44,9%	SAR	X-band, C-band, L-band	0,3 m up to 50 m	EMS activation	On-demand Mapping & Ealy Warning and Monitoring System	#	Hourly	Near real time	#
							Daily	16,1%										Daily	Near real time	#
							Weekly	29,0%										Weekly	Near real time	#
							Monthly and more	38,7%										Monthly and more	Near real time	#
Human conflict risk monitoring	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR Multispectral	X-band, C-band, L-band RGB, NIR	0,3 m up to 50 m (for both SAR & multispectral)	Security Service activation	Damage assessment (Very high resolution) Activity analysis (Very high resolution)	#	Hourly	Near real time	#
							Daily	N/A										Daily	Near real time	#
							Weekly	N/A										Weekly	Near real time	#
							Monthly and more	N/A										Monthly and more	Near real time	#
Tectonic petrography	4	20,0%	20,0%	20,0%	30,0%	10,0%	Hourly	14,3%	16,7%	50,0%	33,3%				No product		#	Hourly		#
							Daily	14,3%										Daily		#
							Weekly	42,9%										Weekly		#
							Monthly and more	28,6%										Monthly and more		#
Ground motion monitoring	19	18,2%	25,5%	25,5%	21,8%	9,1%	Hourly	12,2%	22,2%	36,1%	41,7%	SAR	X-band, C-band, L-band	1 m up to 50 m	No product		#	Hourly		#
							Daily	22,0%										Daily		#
							Weekly	22,0%										Weekly		#
							Monthly and more	43,9%										Monthly and more		#

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Copernicus core services products				
														Name of products matching user requirement	Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Current product spatial resolution	Grade	Current product timeliness	Grade
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%	Mulispectral	RGB-NIR	0.30 up to 10 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly Every 3 years	#
							Daily	14,7%										Daily Every 3 years	#
							Weekly	32,4%										Weekly Every 3 years	#
							Monthly and more	38,2%										Monthly and more Every 3 years	#
												SAR	X-band, C-band	0.30 up to 10 m			#	Hourly Every 3 years	#
																		Daily Every 3 years	#
																		Weekly Every 3 years	#
																		Monthly and more Every 3 years	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Sentinels capabilities				
														Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution	Grade
Geo-hazards monitoring/forecasting	22	22,4%	29,3%	22,4%	13,8%	12,1%	Hourly	16,2%	20,5%	38,5%	41,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	2	Hourly 6 days	1
							Daily	18,9%										Daily 6 days	1
							Weekly	21,6%										Weekly 6 days	3
							Monthly and more	43,2%										Monthly and more 6 days	3
Real-time monitoring of emergency events (e.g. flash floods, forest fires)	30	18,1%	25,3%	22,9%	21,7%	12,0%	Hourly	16,1%	22,4%	32,7%	44,9%	SAR	X-band, C-band, L-band	0,3 m up to 50 m	N/A	N/A		Hourly	
							Daily	16,1%										Daily	
							Weekly	29,0%										Weekly	
							Monthly and more	38,7%										Monthly and more	

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Human conflict risk monitoring	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR Multispectral	X-band, C-band, L-band RGB, NIR	0,3 m up to 50 m (for both SAR & multispectral)	N/A	N/A		Hourly		
							Daily	N/A										Daily		
							Weekly	N/A										Weekly		
							Monthly and more	N/A										Monthly and more		
Tectonic petrography	4	20,0%	20,0%	20,0%	30,0%	10,0%	Hourly	14,3%	16,7%	50,0%	33,3%							Hourly		
							Daily	14,3%										Daily		
							Weekly	42,9%										Weekly		
							Monthly and more	28,6%										Monthly and more		
Ground motion monitoring	19	18,2%	25,5%	25,5%	21,8%	9,1%	Hourly	12,2%	22,2%	36,1%	41,7%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	##	Hourly	6 days	1
							Daily	22,0%										Daily	6 days	1
							Weekly	22,0%										Weekly	6 days	3
							Monthly and more	43,9%										Monthly and more	6 days	3
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%	Mulispectral	RGB-NIR	0.30 up to 10 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	2	Hourly	5 days	1
							Daily	14,7%										Daily	5 days	1
																		Weekly	5 days	3
																		Monthly and more	5 days	3
							Weekly	32,4%				SAR	X-band, C-band	0.30 up to 10 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band is not available	2	Hourly	6 days	1
																		Daily	6 days	1
																		Weekly	6 days	3
							Monthly and more	38,2%										Monthly and more	6 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution	Grade
Geo-hazards monitoring/forecasting	22	22,4%	29,3%	22,4%	13,8%	12,1%	Hourly	16,2%	20,5%	38,5%	41,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2 Up to 15km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	18,9%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	21,6%												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	43,2%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Real-time monitoring of emergency events (e.g. flash floods, forest fires)	30	18,1%	25,3%	22,9%	21,7%	12,0%	Hourly	16,1%	22,4%	32,7%	44,9%	SAR	X-band, C-band, L-band	0,3 m up to 50 m	N/A	N/A	N/A			Hourly	N/A	3
							Daily	16,1%												Daily	N/A	3
							Weekly	29,0%												Weekly	N/A	3
							Monthly and more	38,7%												Monthly and more	N/A	3
Human conflict risk monitoring	N/A	x	x				Hourly	N/A	N/A	N/A	N/A	SAR Multispectral	X-band, C-band, L-band RGB, NIR	0,3 m up to 50 m (for both SAR & multispectral)	N/A	N/A	N/A			Hourly	N/A	3
							Daily	N/A												Daily	N/A	3
							Weekly	N/A												Weekly	N/A	3
							Monthly and more	N/A												Monthly and more	N/A	3
Tectonic petrography	4	20,0%	20,0%	20,0%	30,0%	10,0%	Hourly	14,3%	16,7%	50,0%	33,3%									Hourly		
							Daily	14,3%												Daily		
							Weekly	42,9%												Weekly		
							Monthly and more	28,6%												Monthly and more		
Ground motion monitoring	19	18,2%	25,5%	25,5%	21,8%	9,1%	Hourly	12,2%	22,2%	36,1%	41,7%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2 Up to 15km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
							Daily	22,0%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	22,0%												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	43,9%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Map regression	16	12,5%	20,8%	20,8%	29,2%	16,7%	Hourly	14,7%	22,2%	33,3%	44,4%	Mulispectral	RGB-NIR	0.30 up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1.5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	14,7%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	32,4%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	38,2%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
												SAR	X-band, C-band	0.30 up to 10 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1 m in C-band from Radarsat-2	3		Hourly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	2
																				Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
																				Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
																				Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3

9. High level user need 9 – Enable public access to the site
   a. Matching user requirements with Copernicus core services products

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities				
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products				
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Identification of previously searched sites in the area	9	20,0%	25,0%	25,0%	20,0%	10,0%	Hourly	11,1%	8,3%	41,7%	50,0%	Multispectral	RGB, NIR	0.30 m up to 2 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	11,1%										Daily	Every 3 years	#
							Weekly	33,3%										Weekly	Every 3 years	#
							Monthly and more	44,4%										Monthly and more	Every 3 years	#
Ground motion monitoring	6	6,3%	25,0%	25,0%	31,3%	12,5%	Hourly	0,0%	0,0%	40,0%	60,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	No product		#	Hourly		
							Daily	20,0%										Daily		#
							Weekly	40,0%										Weekly		#
							Monthly and more	40,0%										Monthly and more		#
Mapping of frequentation patterns	10	21,1%	26,3%	15,8%	26,3%	10,5%	Hourly	30,0%	14,3%	57,1%	28,6%				No product		#	Hourly		#
							Daily	20,0%										Daily		#
							Weekly	30,0%										Weekly		#
							Monthly and more	20,0%										Monthly and more		#
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	8	28,6%	28,6%	19,0%	19,0%	4,8%	Hourly	10,0%	20,0%	40,0%	40,0%	Multispectral	RGB, NIR	up to 10 m	CLMS, Local, Urban atlas	10 m	#	Hourly	Every 6 years	#
							Daily	20,0%										Daily	Every 6 years	#
							Weekly	20,0%										Weekly	Every 6 years	#
							Monthly and more	50,0%										Monthly and more	Every 6 years	#

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Copernicus core services products					
																Match analysis of Copernicus product spatial resolution		Match analysis of Copernicus product temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of products matching user requirement	Current product spatial resolution	Grade	Current product timeliness		Grade
Elevation modelling	12	25,0%	25,0%	25,0%	15,6%	9,4%	Hourly	11,8%	16,7%	38,9%	44,4%	Optical	stereo pair	up to 5 m	CLMS, Imagery & Refence Data, EU-DEM	25m	#	Hourly	Every 4 years	#
							Daily	5,9%										Daily	Every 4 years	#
							Weekly	23,5%										Weekly	Every 4 years	#
							Monthly and more	58,8%										Monthly and more	Every 4 years	#
												SAR	X-band	up to 5 m	CLMS, Imagery & Refence Data, EU-DEM	25m	#	Hourly	Every 4 years	#
																		Daily	Every 4 years	#
																		Weekly	Every 4 years	#
																		Monthly and more	Every 4 years	#
3D reconstruction of CH or NH site	8	20,8%	29,2%	20,8%	16,7%	12,5%	Hourly	11,1%	20,0%	40,0%	40,0%	Multispectral	RGB	up to 0,5 m	CLMS, Imagerey & Refence Data, European Images Mosaic, Very High Resolution	Up to 2,5m	#	Hourly	Every 3 years	#
							Daily	11,1%										Daily	Every 3 years	#
							Weekly	33,3%										Weekly	Every 3 years	#
							Monthly and more	44,4%										Monthly and more	Every 3 years	#

b. Matching user requirements with Sentinels capabilities

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
																Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Name of Sentinel matching technical specifications	Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Identification of previously searched sites in the area	9	20,0%	25,0%	25,0%	20,0%	10,0%	Hourly	11,1%	8,3%	41,7%	50,0%	Multispectral	RGB, NIR	0.30 m up to 2 m	Sentinel 2	Minimum 10 m resolution for RGB & NIR	1	Hourly	5 days	1
							Daily	11,1%										Daily	5 days	1
							Weekly	33,3%										Weekly	5 days	3
							Monthly and more	44,4%										Monthly and more	5 days	3

User needs		User requirements										Technical specifications			Mapping Copernicus Capabilities					
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user						Sentinels capabilities					
															Name of Sentinel matching technical specifications	Match analysis of Sentinel spatial resolution		Match analysis of Sentinel temporal resolution		
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification		Sentinel spatial resolution	Grade	Sentinel temporal resolution		Grade
Ground motion monitoring	6	6,3%	25,0%	25,0%	31,3%	12,5%	Hourly	0,0%	0,0%	40,0%	60,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Sentinel 1	Minimum 5m resolution for C-band, but X-band and L-band are not available	##	Hourly		
							Daily	20,0%										Daily	6 days	1
							Weekly	40,0%										Weekly	6 days	3
							Monthly and more	40,0%										Monthly and more	6 days	3
Mapping of frequentation patterns	10	21,1%	26,3%	15,8%	26,3%	10,5%	Hourly	30,0%	14,3%	57,1%	28,6%							Hourly		
							Daily	20,0%										Daily		
							Weekly	30,0%										Weekly		
							Monthly and more	20,0%										Monthly and more		
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	8	28,6%	28,6%	19,0%	19,0%	4,8%	Hourly	10,0%	20,0%	40,0%	40,0%	Multispectral	RGB, NIR	up to 10 m	Sentinel 2	Spatial resolution matching for both RGB & NIR	3	Hourly	5 days	1
							Daily	20,0%										Daily	5 days	1
							Weekly	20,0%										Weekly	5 days	3
							Monthly and more	50,0%										Monthly and more	5 days	3
Elevation modelling	12	25,0%	25,0%	25,0%	15,6%	9,4%	Hourly	11,8%	16,7%	38,9%	44,4%	Optical	stereo pair	up to 5 m		No stereo available		Hourly		
							Daily	5,9%										Daily		
							Weekly	23,5%										Weekly		
							Monthly and more	58,8%										Monthly and more		
							Hourly	11,8%				SAR	X-band	up to 5 m		No X-band available		Hourly		
							Daily	5,9%										Daily		
							Weekly	23,5%										Weekly		
							Monthly and more	58,8%										Monthly and more		
3D reconstruction of CH or NH site	8	20,8%	29,2%	20,8%	16,7%	12,5%	Hourly	11,1%	20,0%	40,0%	40,0%	Multispectral	RGB	up to 0,5 m	Sentinel 2	Minimum 10 m resolution for RGB	1	Hourly	5 days	1
							Daily	11,1%										Daily	5 days	1
							Weekly	33,3%										Weekly	5 days	3
							Monthly and more	44,4%										Monthly and more	5 days	3

c. Matching user requirements with Copernicus contributing missions

User needs		User requirements									Technical specifications			Mapping Copernicus Capabilities						
		Geographical coverage					Frequency of monitoring		Spatial resolution expressed by user					Contributing Missions capabilities						
														Name of contributing missions matching technical specifications		Match analysis of Contributing Mission(s) spatial resolution			Match analysis of Contributing Mission(s) temporal resolution	
		Local detailed	Local	Regional	National	Global	Frequency expressed by user	% of users requiring this specific frequency for this user need	Low and medium resolution (more than 5m)	High resolution (between 1 and 5m)	Very high resolution (less than 1m)	Sensors	Wavelength	Spatial resolution specification	Mission Group	Contributing Mission(s) of interest	Contributing Mission(s) spatial resolution	Grade	Additional comments (complementing matching analysis)	Contributing Mission(s) temporal resolution	Grade
Identification of previously searched sites in the area	9	20,0%	25,0%	25,0%	20,0%	10,0%	Hourly	11,1%	8,3%	41,7%	50,0%	Multispectral	RGB, NIR	0.30 m up to 2 m	Mission group 2	WorldView 2, 3 & 4 Pleiades GeoEye 1	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	11,1%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	33,3%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	44,4%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Ground motion monitoring	6	6,3%	25,0%	25,0%	31,3%	12,5%	Hourly	0,0%	0,0%	40,0%	60,0%	SAR	X-band, C-band, L-band	1 m up to 50 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band) Radarsat-2 (C-band) SMOS (L-band)	Up to 0,25m in X-band from TerraSAR-X Up to 1m in C-band from Radarsat-2 Up to 15km in L-band from SMOS	3	There is currently no high resolution L-band available, but the technical specification could be fully cover in X-band and C-band	Hourly		
							Daily	20,0%												Daily	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Weekly	40,0%												Weekly	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
							Monthly and more	40,0%												Monthly and more	Less than one day for COSMO SkyMed (X-band) 1 day for Radarsat-2 (C-band)	3
Mapping of frequentation patterns	10	21,1%	26,3%	15,8%	26,3%	10,5%	Hourly	30,0%	14,3%	57,1%	28,6%									Hourly		
							Daily	20,0%												Daily		
							Weekly	30,0%												Weekly		
							Monthly and more	20,0%												Monthly and more		
Mapping of surrounding infrastructure (roads, pipelines, waterconducts etc.)	8	28,6%	28,6%	19,0%	19,0%	4,8%	Hourly	10,0%	20,0%	40,0%	40,0%	Multispectral	RGB, NIR	up to 10 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4 Up to 1,5 m in NIR from GeoEye 1	3		Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	20,0%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	20,0%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	50,0%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
Elevation modelling	12	25,0%	25,0%	25,0%	15,6%	9,4%	Hourly	11,8%	16,7%	38,9%	44,4%	Optical	stereo pair	up to 5 m	Mission group 2	WorldView 2,3 & 4 GeoEye 1 Ikonos-2 SPOT 5, 6 & 7	Up to 1,24m	3		Hourly	Less than one day for Worldview 3 & 4	2
							Daily	5,9%												Daily	Less than one day for Worldview 3 & 4	3
							Weekly	23,5%												Weekly	Less than one day for Worldview 3 & 4	3
							Monthly and more	58,8%												Monthly and more	Less than one day for Worldview 3 & 4	3
							Hourly	11,8%				SAR	X-band	up to 5 m	Mission group 1	COSMO-SkyMed (X-band) TerraSAR-X (X-band) Kompsat-5 (X-band)	Up to 0,25m in X-band from TerraSAR-X	3		Hourly	Less than one day for COSMO SkyMed (X-band)	2
							Daily	5,9%												Daily	Less than one day for COSMO SkyMed (X-band)	3
							Weekly	23,5%												Weekly	Less than one day for COSMO SkyMed (X-band)	3
							Monthly and more	58,8%												Monthly and more	Less than one day for COSMO SkyMed (X-band)	3
3D reconstruction of CH or NH site	8	20,8%	29,2%	20,8%	16,7%	12,5%	Hourly	11,1%	20,0%	40,0%	40,0%	Multispectral	RGB	up to 0,5 m	Mission group 2	WorldView 2, 3 & 4 Pleiades Deimos 2 Ikonos-2 GeoEye 1 DubaiSAT-2 TH constellation	Up to 1,24m in RGB from Worldview 3 & 4	3	In case the user actually needs a 0.3 m Multi-Spectral (MS) (e.g. RGB and NIR) image, that is not currently provided by any satellite mission, pan-sharpening techniques could be apply to multi spectral bands to increase their spatial resolution to the one offered by the panchromatic band (0.3 m) (WorldView 3 & 4)	Hourly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	2
							Daily	11,1%												Daily	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Weekly	33,3%												Weekly	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3
							Monthly and more	44,4%												Monthly and more	Less than one day for Worldview 3 & 4 (RGB) 1 day for Pleiades (RGB & NIR)	3

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Acronyms

API	Application Programme Interface
CH	Cultural Heritage
Copernicus EE	Copernicus Entrusted Entities
D&I	Data and Information
EC	European Commission
EO	Earth Observation
EU	European Union
GIS	Geographic Information System
MS	Member States
NAIS	Nextant Applications and Innovative Solutions
NH	Natural Heritage
PwC	Pricewaterhouse Coopers
ToR	Terms of Reference
API	Application Programme Interface
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