e-shape

EuroGEOSS Showcases: Applications Powered by Europe

D4.3 Maturity Indicators Expansion

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ABSTRACT

The **EO Maturity Indicators Methodology** aims at providing decision makers (primarily) and other value chain actors (e.g. research institutes, companies, user communities) with a robust tool that helps them to assess the current state of Earth Observation Activities in their country. This **serves a simple yet very important purpose**: for organisations entrusted with the design, development and exploitation of EO activities (including budgeting and prioritisation) to be able to draft future plans and manage ongoing initiatives, it is crucial to know current strengths, weaknesses and gaps. In developing a good level of "knowing thyself" around EO activities, one needs to have a good grasp of how advanced is the **stakeholder ecosystem**, how well developed the enabling **infrastructure**, how widespread the level of **uptake** across different domains, how well established the **partnerships** with other actors, and, finally, how well structured the **innovation** environment.

Recognising this mission, the current report builds on the work done under the H2020 GEO-CRADLE project, were the EO Maturity Indicators methodology was originally developed. In that context, a set of indicators was devised to assess the maturity of EO-related activities in a country. These indicators were originally grouped in three pillars: Capacities, Cooperation and National Uptake & Awareness. These were used to run the methodology in the Balkans, Middle East and North Africa, the regions covered by the GEO-CRADLE project, whereby 11 countries were analysed in total. Since then, with the same set of indicators, Philippines has also been independently analysed proving the replicability and strength of the methodology. With each implementation, more insights on strengths and weaknesses of the methodology became apparent. Using them as lessons learned enables improvements of the approach.

Thus, within the scope of e-shape, whereby a much larger and more heterogenous sample of countries (virtually any) is considered, improvements are necessary. Hence the **aim of this work has been to upgrade and upscale the methodology**, in order to address every possible aspect that will arise. To that end, a thorough review was performed, based on the following steps:

- **Review of the Methodology on a single-indicator-basis**, scrutinising the degree of applicability, the relevance and the ease of access to the data.
- **Reconsidering the number of pillars** (now five: **Stakeholder ecosystem, Infrastructure, Uptake, Partnerships, Innovation**) to reflect the complexity and interconnectivity of the underlying indicators.
- **Developing the maturity levels for each indicator**, thus allowing to provide rich context for those intending to implement the methodology
- **Researching into complementary analyses** (standardization, benchmarking, percentile assessment) that could potentially enrich the outputs of the methodology
- **Pre-selecting countries within e-shape to be the pilots for implementation** of the improved Methodology and defined a **timeline** for execution.
- Lastly, **proposing visualisation improvements** reflecting the upscaled Methodology.

The upgrades presented in this report form part of a living process which will be informed through additional insights and fine-tuned appropriately as more countries are assessed. Ultimately, the aim is to further strengthen the methodology, ideally including contributions by the greater EO community to that effect, so that it can be (i) implemented regularly by competent agencies across the globe, (ii) used in a modular fashion to dive into specific domains. For the latter point, a first effort will be executed under e-shape, to make a concrete link with the penetration of EO in different downstream sectors represented by the different pilots in the project.

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1 INTRODUCTION

Earth Observation (EO) data and services can support the informed implementation of numerous policies, help in addressing key societal challenges, and boost economic prosperity, competitiveness and growth. The importance of sustained EO data and innovative EO-based services has been underlined in several high-level fora and strategic communications. For instance, EO is seen as a key enabling technology for the achievement of the 2030 sustainable development goals agenda (Art. 76). Similarly, the G7 Environment Ministers 2016 Communiqué on Climate Change notes that *"We recognise the necessity of robust EO to enhance our ability to measure and monitor Greenhouse Gas (GHG) emissions"*. Furthermore, the G7 Science and Technology Ministers 2016 Communiqué Art. 6 on Open Science recognises that *"Fundamental to the progress of open science is the continued investment by governments and others, such as the Global EO System of Systems (GEOSS) of GEO, in suitable infrastructures and services for data collection, analysis, preservation and dissemination"*. The role of EO as a key driver for smart specialisation strategies at the regional level has also been highlighted.

Against this backdrop, a wide range of international and national efforts are currently under way. At the international level, GEO is working to improve the availability, access and use of Earth observations for the benefit of society. Similarly, Copernicus - the one-of-a-kind European Earth Observation Programme - brings not only a plethora of data in the hands of various stakeholders, it also brings these stakeholders closer together to make best use of this data. And this is precisely the **key to unlock the wide range of benefits EO data enables**[1]: understanding the needs on the demand side helps to develop the capacities of the supply side to meet them; understanding the capabilities of the supply side helps to build the capacity of the demand side to make the most out of them. This dynamic process requires constructing a full picture of the current state-of-play of EO activities at national level and a solid monitoring approach on how they progress over time. Eventually, by identifying gaps, the competent stakeholders at national and international level can efficiently mobilise resources to address them.

To that end, the development and implementation of the **EO Maturity Indicators methodology** as an independent, reliable, robust and replicable way to assess the state and progress of different aspects of EO activities has been pioneered at national level. This methodology, first introduced in the Horizon 2020, GEO-CRADLE project[2], has proven to be a powerful tool to highlight strengths and weaknesses, communicate on identified gaps, and guide future EO activities. Within e-shape, the aim is to strengthen and extend the methodology so that it can be applied in a straightforward way by relevant stakeholders across the globe. To that end, following a thorough methodological review a set of "upgrades" are proposed and an implementation plan is laid out to test these upgrades both in countries covered by the e-shape partnership and, ideally, beyond. But before moving into these considerations, it is instructive to recall the context within which the original methodology was developed and explain the scope for its expansion.

1.1 The EO Maturity Indicators Methodology

The EO Maturity Indicators methodology ("the methodology"), was first developed within the EU-funded H2020 GEO-CRADLE project. This project – now a GEO Initiative[3] - has sought to coordinate EO activities and capacities in North Africa, Middle East and the Balkans. This has been pursued over the past 4 years by fostering the creation of an integrated ecosystem of EO stakeholders, running pilot services in support

[1] See for instance the Sentinel Benefits Study: http://earsc.org/Sebs/

[2] http://geocradle.eu/en/regional-capacities/maturity-level/

[3] https://www.earthobservations.org/documents/gwp20_22/GEO-CRADLE.pdf

of user needs and regional priorities, and developing a series of tools that promote the implementation of GEOSS and Copernicus. Among them, the EO Maturity Indicators was designed as an analytical tool that allows the quantitative measurement of the current EO capabilities in a given country and their evolution over time. To that end, a set of indicators was defined across three main fields: "Capacities", "Cooperation" and "National Uptake and Awareness". For each of the indicators, a methodology was developed to allow the assessment of its maturity level. In parallel, a standardized process was established for the collection and analysis of the necessary data. This entails primary research by organizations with deep involvement in national and international EO activities, enhancement through publicly accessible data sources and a cross-validation of findings by renowned national experts. This approach was tested over a period of 15 months, through the mobilisation of the GEO-CRADLE country partners, covering 11 countries from the Balkans, Middle East and North Africa. After analysing the collected data, a standardised visualisation in the form of a "maturity card" was developed. The results of the implementation of the methodology were highly appreciated by the GEO Secretariat and the country representatives.

This appreciation has recently materialised in the first third-party application of the methodology in the Philippines, as part of the EU-DOST Copernicus Project[4], funded by the European Commission's DG DEVCO. In this context, Dr Peter Zeil and his colleagues within the EU-DOST partnership have applied the methodology to assess the current maturity of EO activities in the Philippines. This effort has proven an important aspect of the methodology, namely that it is simple to implement and reproduce. It also brought to light, however, important lessons learned with regards to the robustness of data collection and comparative analysis. These, added to the ones already extracted during GEO-CRADLE, drive the need for strengthening the methodology.

1.2 Scope for expansion

e-shape is a flagship EU project that brings together 54 partners representing 20 countries. Among its primary objectives is the **upscaling** of EO solutions towards a wider realisation of the benefits they bring to their users. In that regard, e-shape will generate a number of strategic outputs that will strengthen the capacity not only of the project partners but also of the wider EO ecosystem. One of these strategic outputs is an upgrade and a generalization of the EO maturity indicators methodology. As discussed above, the implementation of this approach can constitute a prime tool for decision makers, industry and other actors requiring an accurate understanding of where a country stands in order to plan their strategic activities, promote policies or expand their business. To carry this task, a critical review of the strengths and weaknesses of the current methodology is necessary. From this assessment, the needed upgrades can be proposed, tested and eventually consolidated, in order for the tool to be readily useable at a wider scale. This is precisely the scope for expansion that will be discussed hereafter.

[4] https://businessmirror.com.ph/2020/02/09/copernicus-space-program-to-boost-earth-observation-projects-in-phl/

2 METHODOLOGICAL REVIEW

A critical review of the current methodology's strengths and weaknesses is a requirement to allow for improvement, strengthening and generalisation. The intrinsic **problematics with the process of elaborating such methodology**, i.e. one that aims at building a universal approach for measuring a very diverse set of aspects and how these can be addressed, should be considered. To that end:

- The core aim is to keep a clear focus on the primary objectives that the whole process is devised to address. This means **asking the right questions throughout** and ignoring temptations to divert or sidetrack it.
- Once the objectives are clearly set, **robust mechanisms for data collection and analysis** shall be put in place: this includes substantial amount of desk research, gap analyses, exploring remedies for the latter and ideally learning from past errors, by creating an open and continuously-improving methodology on a living document.
- **Communicating results in a clear way** is particularly important, as a balance needs to be struck between the intrinsic complexity and often sensitivity of the collected data and the simplicity of the messages that can be extracted.

Before diving into each of the above dimensions separately, the specificity and the scope of the methodological review will be briefly discussed. Noting that there is no need to turn the existing methodology upside down - it works and has been successfully implemented by independent researchers in different countries - our focus will rather be on addressing specific indicators, their relevance, ease to measure, generalisation and their potential for upscaling. This is particularly important in a "modular" Methodology, where countries can select which indicators they have interest in and implement only these. And while it should also be possible, in principle, to objectively assess the overall EO maturity *vis-á-vis* that of another country, the primary goal of the Methodology implementation (for reasons explained in greater detail in subsequent chapters) is rather to monitor the EO maturity evolution of one particularly country over time.

In the following sections we refer to the methodology as implemented under GEO-CRADLE and address the needs for improvement inherent for its upscaling and application to e-shape and the operational aspects of such undertaking. The solutions proposed to tackle said needs will be discussed further, in Chapter 3.

2.1 Asking the right questions

The objective of the EO maturity indicators methodology is to provide a reliable and robust assessment of the state of EO-related activities in a given country. But can the *status quo* be assessed? And how do we ensure that these assessments provide a complete picture that can endure time and be reproduced independently of the methodology's implementors?

Since its inception, the methodology has sought to provide answers to three main questions, which in its original version translated into three fundamental **pillars:**

- EO capacities: What is the state-of-play of EO capacities in a given country?
- Cooperation and collaboration: Is the country engaged in international collaboration (under GEO, Copernicus and beyond) and what impact does this have?
- National uptake: What is the current uptake and penetration of EO in policy and decision-making?

In the following, these pillars/questions will be considered into details, and the underlying indicators will be detailed. **The intention of the methodological review at this point is to assess whether these top-level pillars, but also their underlying components are designed optimally and allow to draw a picture compliant to our experience.**

2.1.1 What is the state-of-play of **EO capacities** in a given country?

The "capacity" pillar is the one that unites the most number - and the most diverse set - of individual indicators. In fact, it reflects how subjective, and yet necessary, a methodology can be. In practice, it is the only way to assess an indicator as complex as "EO capacity".

First, **national infrastructure** is considered (Table 2.1), identifying parameters that characterise the level of infrastructure development in a given country. This has proven to range from fully deployed and "mature" countries having their own designated space authority and operating their own satellites, to others (most in fact) who tend to rely solely on access to 3rd party missions. Of course, there is a possibility to have countries with a very low or zero development levels of these indicators. This aspect *in prima vista* may seem present in multiple countries: for instance, few countries have access to high-performance computing facilities or possess advanced modelling capabilities. While in the context of GEO-CRADLE this seemed as a scenario of rather low probability in the pre-selected Balkans-Middle East-N. Africa (BAMENA) region, it should not be forgotten the intention for universal applicability of the methodology. Thus, in the context of e-shape, while the initial assessment will be carried out in a few rather advanced countries in Europe, we intend to promote its application to potentially each country in the world independently of the EO maturity, or of the lack thereof, at this stage.

Under "**Critical Mass of EO researchers**" (Table 2.2) we aimed at assessing the maturity level of this component through indicators cascading from public sector activities: such as the number of public bodies using EO and the extent of its use, the quantity and quality of EO-related university courses and cited scientific publications. Notably, a well-established EO scene in the academic world can be an indicator not only for current interest into the EO on behalf of the State (who typically finances programmes according to a set of political priorities), but also for upcoming enhanced development of the EO industry (as industry benefits from both the scientific findings and from the specialised human resources coming from the academia).

Last, but not least, we took into consideration the existing **industry base** (Table 2.3) (numbers of companies and employees) and its potential to grow through clusters and similar structures. Thanks to benefits such as the free and open data of Copernicus, numerous small and medium companies create products, sell them and make a living. It is indeed a relatively novel approach to think of satellite data as an opportunity for companies (and not solely as expressed in the Copernicus regulation, as aimed at providing benefits to Member States and their institutions). It is true that for our purposes, these companies are contributing to the advancement of the maturity level of the country they are in. From a global perspective, however these same small and medium enterprises have an even greater importance, as they are undeniably the backbone of many economies and oftentimes act as hubs where excellence happens, at a pace unmatched by the public sector.

Beyond this panoramic view of the three groups of indicators falling under the "Capacities" pillar, we have performed a methodological review of each indicator. This is reflected onto the table presented above and will guide the proposed methodological upgrades discussed in Chapter 3 – note that the same approach will be followed for each pillar.

Pillar	Group of indicators	Indicators	Description of the indicator	Methodological Review
Capacities	National infrastructure	Space agency or designated Space Authority	This dimension looks at the key players involved in space activities at the national level. Idea of the hierarchy, organisation chart and how do they relate with other institutions.	This indicator is relevant. Remains to be seen until what extent the hierarchy can be associated to a level of maturity.
		Own space-borne capacity	Request to country representative information on space borne capacity operated by the country. (N. of satellites operated by the country and the type of mission)	This indicator is relevant and shall be kept.
		Access to 3rd party missions (own ground stations)	Request to country representative and thematic experts in the country but also in the region if they know who operates the ground station. (satellite operator or 3rd party mission / including meteo).	This indicator is relevant and shall be kept.
		Ground-based facilities	Requested additional inputs on the number of organisations operating the equipment necessary to control and to acquire data from EO satellites (active or passive remote sensors, meteo /atmospheric/water sensors, etc.) (Total number of Organisations with ground based/in-situ capacities. Number of stations - Location & region)	This indicator is relevant and shall be kept.
		In-situ monitoring networks	Requested additional inputs on the number of organisations operating the equipment necessary to control and to acquire data from in-situ (active or passive remote sensors, meteo /atmospheric/water sensors, etc.) (Total number of Organisations with ground based/in-situ capacities. Number of stations - Location & region	This indicator is relevant and shall be kept.
		Modelling and computing capacities	If organisations do have the modelling and computing processing capacities (high- performance computer (HPC)) then they are asked to provide a short description of what it is used for. It is important to have an overview on the number of models (i.e. models for atmospheric modelling, what those are, what is the status and the research owner. (Total number of Organisations with modelling & processing capacities and Total number of models)	This is a relevant indicator. However, modelling and computing capabilities are not always at the same level, and should better be kept as separate indicators.
		EO data exploitation platforms (provision of VA services and products)	Request about coordinating monitoring networks, integrated analysis & modelling capacity. Names of organisations with data exploitation products (Type of organisation according to classification system)	This indicator is relevant and shall be kept.

Table EO maturity indicators considered under the "Capacity" pillar/National Infrastructure in GEO-CRADLE

Pillar	Group of indicators	Indicators	Description of the indicator	Methodological Review
Capacities	Critical Mass of EO researchers	Number of public organizations	Country partners should be able to provide the names of the organisations and what they do (the classification - information of those institutions activity and areas). It is assumed that these organisations do not go beyond in the value chain. So any public organisation that represents more than user they will appear in section 1.1.	This indicator is relevant and shall be kept.
		Number of researchers (in Univ. & R&D labs)	Request to country representative more information on the number of departments & size of the research group. (the number of researchers) – How many researchers are employed	This indicator is relevant and shall be kept.
		Courses being offered in universities, its diversity and maturity offered	Request to country representative & desk research on the number of courses offered: Information about the quantity of courses and the investment in the future. The country partner should provide a table including information on the courses related to eo / country. It will include the following parameters: (i) title (ii) type (master/post-graduate...) (iii) duration (iv) graduation requirements (v) start year (vi) estimate n. of students/course (vii) organisation partners (lecturing or sponsoring) (viii) academic performance(impact of the project)...	This indicator is relevant and shall be kept. However, what is considered a "course" shall be defined.
		Relevant Publications	Request to country representative & desk research about paper published in the last 5/3 years. Maybe reproduce a table with Title / Type (thesis research, article, scientific paper) / Publication (magazine, website) / N. citations / N. downloads	This indicator is relevant and shall be kept.

Table 2-1 EO maturity indicators considered under the "Capacity" pillar/Critical mass of EO researchers in GEO-CRADLE

Pillar	Group of indicators	Indicators	Description of the indicator	Methodological Review

Capacities	Industry Base	Number of companies	Request number the companies and the number of commercial actors surveyed and its location. It should be related with EARSC classification on type of activity: (i) Satellite operator: defined as the owner of a satellite system (ii) Data reception and distribution: owner or operator of a ground station (EO). (iii) Data reseller: satellite or other data from non-EU sources (iv) Value- adding services: company using EO data to produce products (v) Downstream / GIS services: but with a satellite data element. (vi) Consultancy - studies / analyses not VA services. (vii) Hardware / software provision Where the industry is in operation: Are the country partners aware on the quality management? or standard processes within these companies?	This indicator is relevant and shall be kept.
		Scale of companies (large/medium/small/ micro)	EARSC request to country representative & desk research on the type of companies and split by size.	This indicator is relevant and shall be kept.
		Employment numbers, levels and changes	EARSC request to country representative & desk research (estimated employees per company companies (company website)	Difficult to track, especially for start-ups where there are few people actually employed.
		Resellers or local representatives of European companies	EARSC request to country representative & desk research on the number of data providers resellers & partners	The indicator is not relevant and should not be kept.
		Existence of Clusters	EARSC request to country representative & desk research on ITC clusters	This indicator is relevant and shall be kept.

Table 2-2 EO maturity indicators considered under the "Capacity" pillar/Industry base in GEO-CRADLE

2.1.2 Is the country engaged in **international collaboration** (under GEO, Copernicus and beyond) and what impact does this have?

International collaboration is a key aspect for the development of a country. Same is true when it comes down to the development of EO capacities, and is true for both underdeveloped countries and for countries on top of the competitive game, as long as they are willing to overcome the limitations of their own, more or less restricted, abilities. As can be readily seen in Table 2.4, the groups of indicators developed under GEO-CRADLE were to a large extent driven by the specific context in which the project operated: it was an effort contributing to GEO – and eventually becoming a GEO Initiative; it had strong roots in and contribution to Copernicus-related activities; it was tightly linked to specific international efforts (e.g. INSPIRE in Europe); finally, it was funded by the EU Framework Programme (Horizon 2020). Before discussing how this pillar should evolve (see chapter 3) it is instructive to look into each of these groups and the indicators therein.

First, we considered a country's **involvement in the GEO** ecosystem as a mean to assess EO maturity. The members of GEO are currently 108, and in principle each UN-recognised country can become a member. The membership in GEO, once acquired, proves a certain commitment, and possibly a current position, by a country within the EO ecosystem. However, we tried to go deeper and consider the involvement GEO members have within the organization: e.g. data contribution, participation in initiatives, etc. While the central position of GEO within the methodology can be explained by the specificity of the GEO-CRADLE project, the GEO indicators themselves shall nonetheless be kept as an evaluation criterion in the upscaled version of the methodology. Moreover, acknowledging the significance of the SDGs, their examination shall be more significant and included in the "Collaboration under GEO"- group of indicators, distinct from the participation in GEO.

The **impact of Copernicus** group considers the national organisations involved in the programme. It ought to be detailed in order to assess more fully the uptake of Copernicus in the said country. We have also considered the remark that Copernicus is mainly focused on Europe: it is true that EU Member States have unmatched access to data (and so do third countries when an appropriate bilateral agreement is in place - in the case of the United States, Australia, Brazil, Chile, Columbia, India, Ukraine, Serbia, the African Union). Nonetheless, it is not advisable for our purposes to allow for other EO programmes to be substituting Copernicus in the Methodology, as there are no comparable programmes as such, and the rationale behind the methodology itself is to understand the level of uptake of key initiatives such as Copernicus itself.

Once we move on to the group of **participation to other international efforts** and the underlying indicators it is easy to notice that they have little in common and while some of them present very relevant data (this will be discussed in Table 2-2) grouping them altogether, brings little to the Methodology and can be needlessly confusing.

With regards to **R&D participation in EU projects**, this may need to be re-imagined. Funding is equally important when it comes from sources other than the EU and this is true for both Member States and third countries.

Pillar	Group of indicators	Indicators	Description of the indicator	Methodological Review
Cooperation	Collaboration through GEO	Participation in GEO or to projects/initiatives which are linked to GEOSS	- Participation in GEO activities, "active contribution to GEO networks" - Designated representative in GEO actions	This indicator is essential and suitable to reflect EO maturity.
		Specific actions on Sustainable Development Goals (SDG´s)	Measures activity in contributing to SDGs, with 5-10 SDGs considered optimal	This indicator is valuable. However, GEO is overlapping, contributing to, but not structured around the SDG. Hence, the indicator shall be moved to another section.
		Designated GEO office	Existence of designated office	This indicator is of little relevance: other potential indicators as involvement in GEO initiatives, exchange of data and investment into GEO will be more relevant to assess EO maturity (as well as concretely, the level of involvement in GEO).
		Provision of data to GEOSS	Exchange on datasets and metadata types shared through state infrastructure or directly through GEODAB	This indicator is crucial to asses actual involvement in GEO/GEOSS.
	Impact of Copernicus	Organisations involved in projects linked to Copernicus	Numbers of projects/organisations related to/using Copernicus services/EEs.	Copernicus is essential for assessing the EO maturity of a country. Because of that, its role within the methodology shall be reflected through multiple and more precise indicators.
	Participation to other international efforts	ESA	Level of involvement, i.e. cooperating state or a member state	To be considered if countries might be granted an equivalent status if they collaborate with agencies other than ESA (e.g. NASA, JAXA, ISRO).
		Meteorological: WMO, EUMETSAT,	Country participation to EUMETSAT and WMO	187 out of 195 counties worldwide in WMO. The Member states of EUMETSAT are exclusively European (+ Turkey) The relevance of this indicator is to be questioned.
		UN system as UN-GGIM, ...	Participation to UN programmes or relations with UN institutions; activeness of the participation and number of participated bodies as a factor	This is a relevant indicator and we will keep it. Some extra indicators may be added to ensure we are having a more holistic view of the UN-ecosystem.

		Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)	Involvement with Infrastructure for Spatial Information.	Consider alternatives for non-EU countries? The focus shall be on "infrastructure for spatial information", instead on INSPIRE-compliance specifically.
		Participation in Standardization organizations i.e. as OGC...	- involvement of public and private organisations with standardisation organisations dealing with promotion of the FAIR data principles	This is a relevant indicator and we will keep it.
	Availability of EU funding	R&D participation or other EU programmes	- R&D participation or other EU programmes	The indicator shall be reviewed. Funding is important, and not only when it comes from EU programmes - for both EU and third states.

Table 2-3 Methodological review for the "Cooperation and collaboration" pillar in GEO-CRADLE

2.1.3 What is the current **uptake** and penetration of EO in policy and decision-making?

The third and final pillar we had considered is the national **uptake of EO** (Table 2.5): existence of channels for proliferation of knowledge (networking events and data portals), penetration into policy and decision-making, as well as actual use and capacity building practices within the country.

The selection of those pillars was very much driven by the specific activities undertaken in GEO-CRADLE. This allowed to shed light in important parameters but, in light of widening the applicability of the assessment, has significant shortcomings too. For instance, when looking into the **networking initiatives**, and the two groups of indicators thereunder, we can directly conclude that they are too different to be put under the same denominator.

Similarly, we can highlight some areas of improvement in relation to "**national policies implementation**". Here the aim should be to capture the extent to which EO informs the drafting of well-informed policies and how it enables their efficient implementation/monitoring. At this stage, however, the indicator on *policy* was only measuring the latter perspective. The other element measured under this group was *budget/investment*. This is clearly not linked to policy *per se* and as such should be moved under another pillar/group. Moreover, it is a composite indicator in its current form (e.g. budget for Earth sciences is different than ministerial budget for EO etc.). It is important to ensure that these differences are reflected if not in dedicated indicators, on the appropriate levels for this one.

Finally, we had looked into **penetration** with the intention to measure the real extent to which EO data is used in operational contexts. Nonetheless, the current set of indicators falling thereunder is not fully serving this purpose. The *use of geo-information* is definitely pointing in the right direction but does introduce an overlap with the *policy* ones. On the other hand, the *capacity building EO focused actions* is firstly not in the right group, secondly too broadly defined.

These observations are summarised at indicator level on the table below.

Pillar	Group of indicators	Indicators	Description of the indicator	Methodological Review
National Uptake & Awareness	Networking initiatives	Networking initiatives (events and thematic workshops)	Occurrence of events in which specialised groups or a wider audience can engage in EO-related topics	This indicator sought to capture the intensity of networking opportunities by essentially quantifying the volume of such events. It is certainly a meaningful indicator - advanced countries would have more such opportunities. At this stage, it only looks into numbers and not into impact, quality of attendance, foreign participation, etc.
		Data Portals	Existence of platforms or gateways in general providing access to EO data	This indicator is firstly under the wrong group - the existence of Data Portals should not be associated with networking initiatives. Secondly, the definition of what consists a "data portal" has not been provided. This should be revised.
	National Policies Implementation	Policy	Level of use of EO for policy monitoring	The indicator focussed on whether the monitoring of national policy implementation makes use of EO. In this regard, it did not measure whether national policies with explicit or implicit mention of EO exist. Thus, the indicator currently captures half the picture.
		Budget & investment (internal to the country)	Level and breakdown of budget allocated to EO-related activities within the country	The levels reveal a composite indicator: budget for earth sciences, ministry budgets for EO, budget for GEO activities
	Penetration	Use of Geo-information	Awareness of EO by government agencies and level/type of use	This indicator presents a conceptual overlap with the "policy" one. To alleviate this, a focus on EO for operational governmental activities (excluding policy monitoring) is proposed
		Capacity building EO focused actions	Existence of nationally organised EO-related capacity building activities	This indicator is not associated with "penetration". It should be moved to an appropriate group.

Table 2-4 Methodological review for the "National Uptake & Awareness" pillar in GEO-CRADLE

2.1.4 Conclusion

The analysis performed above allows us to shed light on the two important aspects we set out to clarify in this part of the methodological review. Firstly, we wanted to assess whether we are asking the right questions. Here the conclusion is that **whilst the questions asked have been correct, they led to the development of pillars that present important inconsistencies**: some indicators were grouped within formations with which they share little in common (e.g. networking and portals), whilst others were "wrongly" grouped, resulting in overlaps within the Methodology (e.g. EO data exploitation being grouped under infrastructure).

Moreover, we wanted to understand whether these are all the questions we should have been asking. In this case, we can conclude that **additional questions can be raised, resulting in a rearrangement of existing indicators, giving rise to new pillars and, consequently, new indicator groups**. This is particularly true in light of our aim to scale up the methodology and ensure that it can be applied more universally and robustly. For instance, does a country have an environment that promotes innovation? Is the stakeholder ecosystem in a given country well developed? These questions, together with a modified version of the existing ones will guide the methodological upgrade discussed in Chapter 3.

2.2 Implementing a robust data collection and analysis approach

High-quality data collection, data analysis and assessment are crucial elements for a successful methodology. In the present section, we revise how this was conducted under GEO-CRADLE. While the methodology implemented therein has been successful, we argue that there is however room for further improvement, as suggested by both our experience from GEO-CRADLE, and by other, inherent to upscaling ventures, challenges. Specific recommendations for improvement are discussed at length in section 3.2 *Strengthening the data collection and analysis process.*

2.2.1 Data collection

Collecting enough information of adequate quality and validity is a challenging task especially when considering the diversity of topics that the different indicators cover. During GEO-CRADLE, this was tackled by mobilising "country partners" (typically the leading research institute on EO in the country) towards:

- **Drawing from existing literature and databases**: This entailed at first the identification of appropriate background resources (mostly accessible online in the local language) and then the extraction of relevant information.
- **Running targeted surveys**: GEO-CRADLE was specific in the sense that a thorough gap analysis had to be performed. To that end, country partners were asked to disseminate a dedicated survey among their networks and help structure the inputs collected.
- **Consulting subject-matter experts**: Each country partner had to solicit the involvement of recognised experts in EO activities serving both as a primary source of information and as a means to validate collected inputs.

Thus, following these three routes, country partners undertook to collect and provide the necessary, up-to-date information against the list of pillars predefined in the methodology (capacities, cooperation and uptake). The information gathering was under the responsibility of country partners and so was the judgement on the most appropriate method. Thus, each country partner opted for a different assessment approach depending on the availability and reliability of information. This meant adopting a variety of strategies to deliver results such as own knowledge, bibliographic review, web-based information, interviews: including by relying on existing networks, asking for referrals to other EO actors or organising workshops with key EO actors. However the information often needed to be further validated and there were still information gaps at the end of this phase due to failure of key EO actors to respond to the survey, and due to lack of adequate capacity among the country partners themselves.

Eventually, this has underlined the complexity and difficulty of the task as well as the need for adequate resources and guidance to perform it. In the case of GEO-CRADLE partners, several noted that resources used to collect data for the maturity assessment were often hard to get to, especially since the requested information is nor centralised neither updated regularly. The volume of data collected was an issue in some of the countries and might have contributed to the "bias" of some of the indicators. Subsequent

desk research filled in the information holes as best possible, using the outcomes of the gap analysis deliverable. This was particularly done in cases where some country capacities had to be validated[5].

Overall, the data collection process as performed under GEO-CRADLE, has highlighted intrinsic difficulties across the participating countries which require capacity building efforts to overcome. In view of this, the work performed under e-shape shall seek to strengthen this process and propose ways for consistent data collection going forward. This is discussed in section 3.2.

2.2.2 Analysis of data & Assessment

This section concerns the analysis and interpretation of the data gathered. The type of data analysis depends on the type of the information collected. Raw data are available at the first stage of information gathering and are not directly usable *per se*, but should be aggregated and transformed into inputs which can be used to assess the maturity level for each of the indicators. The main tool used for this in GEO-CRADLE was Excel, whereby appropriate spreadsheets were created to host the information. When all the inputs from the different countries for all the indicators were stored in these spreadsheets a cross-country, cross-indicator analysis was made possible. This allowed to understand (i) gaps – in the sense of lacking information altogether, (ii) disparities – in the sense of the quality or even type of data collected (i.e. inputs that were not really addressing the indicator at hand). For the latter, it was sometimes observed that very detailed data might be needed for a particular parameter, whereas in others a rough indication might suffice. Moreover, once all data was collected, a revision of some of the indicators themselves was conducted. In other words, whilst the indicator originally guided the data collection process, at a 2nd stage the data collected guided the definition of the appropriate indicator. Finally, once all data was collected the decision on how to split maturity levels was enabled. In other words, the appropriate ranges could be "seen" and reflected onto the corresponding maturity levels as needed.

Following the initial data analysis, the assessment of the current situation of the implementation of EO-related activities in a given country was made possible. This assessment was first done within the spreadsheets and subsequently transposed to the maturity cards. These were presented to the stakeholders involved in the process in each country with the aim to identify inconsistencies, contradictions or gaps. The validation of the country assessments was repeated during a second round of interviews with professionals outside the consortium.

All the experts were requested, during a conference call, to review and validate the visualisation outcomes of the assessment of the maturity of the EO activities in their countries. This new discussion provided experts views on the different maturity levels (L0 to L4), which indicators & sub-indicators were assigned. These experts (industry, academia, government organisations, research) provided an independent view that greatly enhanced the information collected. Based on these enhancements, small adjustments were made on the indicators and their assessments.

Looking at the data analysis and assessment process as performed in GEO-CRADLE, we consider that the key for its successful implementation lies in the ability of country partners to tap into the different data collection routes, and mobilise a good network of external experts to provide validation in one or multiple iterations. The outcomes of this analysis and assessment process, reflected by the various indicators, can be integrated into the decision-making on a national scale. However, for this to happen in practice, the findings and conclusions from the complex data processing shall be available in a simple, clear and standardized format.

[5] A more detailed recap of GEO-CRADLE data collection is provided in Annex III

2.3 Presenting findings in a standardised format

It is essential that the outcomes of the described work are presented in a simple and standardised way, to make it easy to compare results: not primarily between countries, but first and foremost between one country and all the other countries, as well as for a single country over different periods of time. The reason being that the outcomes shall incentivise countries to regularly assess their EO Maturity, aim and act towards enhancing it (i.e. reaching a higher maturity level). Moreover, the methodology and the standardized outcome should be straight-forward enough for any country can take them and, with the right data in hand, assess its own maturity, as well as for executives and whoever else has access to the outcome, to be able to interpret a valuable amount of data in the shortest possible time.

This outcome was achieved in GEO-CRADLE through the so called “maturity cards”: visualisation based on a quasi-quantitative approach summarising the outcome of how well each country is performing against a given indicator and against each pillar. It has proven to be a powerful mean for transmitting information in a clear and straight-forward way. An example of maturity card is presented below, while questions of adaptability to the current upscaling of the methodology are discussed in Chapter 3.

Egypt

Assessment (ranged)

CAPACITY		COOPERATION		UPTAKE	

Score card

maturity indicators	indicators	level	maturity indicators	indicators	level	maturity indicators	indicators	level
capacity	infrastructure		cooperation	collaboration GEO		uptake	networking	
	eo reserach			impact Copernicus			policy	
	industry base			international			penetration	
				funding				

Detail evaluation

capacity	indicator	level
infrastructure	space authority	
	space borne	
	access 3rd party missions	
	ground based	
	in-situ	
	modelling & computing	
	eo data exploitation	
eo research	n. public organizations	
	n. researchers	
	courses offered	
	publications	
industry base	n. companies	
	employment	
	resellers, partnerships	
	clusters	

cooperation	indicator	level
collaboration GEO	participation GEO	
	specific actions on SDG´s	
	designated GEO office	
	provision data to GEOSS	
impact Copernicus	projects	
international	ESA	
	meteorological	
	UN / Int. agreements	
	INSPIRE	
	standardization	
funding	R&D participation	

uptake	indicator	level
networking	networking	
	data portals	
policy	policy	
	budget & investment	
penetration	use	
	capacity building	

LEGEND eo maturity card ○ initial ◣ basic ◠ intermediate ◔ advanced ● optimized

Figure 2-1 Maturity card created within GEO-CRADLE

2.4 Contextualising the results

Before we venture into the proposed methodological upgrades, it is important to recall the context in which the original methodology was developed and explain the context in which the new implementation will take place.

GEO-CRADLE[6], both during its H2020 project phase and its subsequent realisation as a GEO Initiative, has been looking to coordinate EO activities in the Balkans, Middle East and North Africa regions. To coordinate a wide range of EO activities, it is critical to understand a) the state of play in these countries, b) the challenges they face and for which EO capacities can be exploited to produce solutions.

This is precisely what GEO-CRADLE did: it started by inventorying the regional EO capacities and user needs and then looked into potential gaps[7] or shortcomings. This gap analysis provided the raw material for the original definition of parameters that would be assessed as "Maturity Indicators". **Naturally, the pillars, groups of indicators, and individual indicators alike were, to a large extent, mirroring the findings of the areas covered by the gap analysis and the overall directions of the GEO-CRADLE project itself.**

Moreover, given the tangible contribution of GEO-CRADLE to specific priorities[8] in the region, certain areas (e.g. data portals, in-situ networks) were closely investigated in the gap analysis and echoed in the maturity indicators methodology. All this served to produce a fully-fledged roadmap for future implementation of GEOSS and Copernicus in the region[9]. This explains to a large extent why certain dimensions (e.g. Copernicus and GEOSS related indicators) were so pronounced in the original methodology. It also sheds light on how the results of the first two cycles of implementation of the methodology should be viewed – **they were produced within the context of GEO-CRADLE and with the aim to lay out a path for future expansion**.

This expansion is organically integrated within the current context of e-shape (see section 1.2 too). We now have a pan-European reach (and even beyond), multiple additional sectors in focus (i.e. 7 showcases with numerous pilots) and a mission to foster the maximum exploitation of European EO assets/activities and GEO outputs alike. This means that e-shape acts as a bridge between all European EO activities and between Europe and the GEO community. The EO Maturity Indicators Methodology can provide a significant contribution to this overall context, as it can highlight the state-of-play of EO activities both inside and beyond Europe at a country level. Therefore, **the methodological upgrade needs to allow an effective generalization and upscaling of the current components and methods**. This is precisely what we propose in the next chapters.

[6] http://geocradle.eu/en/

[7] The GEO-CRADLE gap analysis: http://geocradle.eu/wp-content/uploads/2017/03/D3.1.pdf

[8] The GEO-CRADLE Priorities Action Plan: http://geocradle.eu/wp-content/uploads/2016/07/D3.3.pdf

[9] The GEO-CRADLE Roadmap: http://geocradle.eu/wp-content/uploads/2016/07/D5.7-Roadmap-for-future-implementation_v13.pdf

3 PROPOSED METHODOLOGY UPGRADES

The EO Maturity Indicators methodology is a living one. It has been developed as an iterative approach, with two cycles carried out across during the lifetime of the H2020 GEO-CRADLE project and an independent application in 2019/20. So far, 12 countries have been assessed using this methodology: 11 in the BAMENA region and the 1 in South-East Asia (Philippines). All these implementations have helped to underline its strengths and expose its weaknesses. In that spirit, a methodological review has been presented in the previous chapter tackling the different dimensions that require further thought and, eventually, methodological improvements. These improvements are hereafter discussed into details.

3.1 Refining the pillars, groups and indicators

As discussed in section 2.1 previously, the ability of the methodology to capture the maturity of EO activities in a given country, first and foremost relies on raising the right questions and then deploying the necessary means to construct complete and reliable answers. The original methodology developed under GEO-CRADLE, was based on 3 pillars: Capacities, Cooperation and Uptake. These pillars, and the groups of indicators falling thereunder, have produced a good overall picture of EO maturity. Nonetheless, they did not represent the full picture and had some notable inconsistencies (see section 2.1). Recognising this, **we propose that the methodology should now be structured around five fundamental pillars:**

- **Stakeholders ecosystem**
- **Infrastructure**
- **Uptake**
- **Partnerships**
- **Innovation**

Each new pillar is discussed below along with the new groups of underlying indicators, while the respective criteria for the assessment of the maturity level are contained in Annex I.

3.1.1 Stakeholder Ecosystem

The aim of the first new pillar is to assess how well developed the EO stakeholder ecosystem is in a given country. Each stakeholder group should be considered separately.

First, **institutional framework** should be analysed. Is there a solid **governance** model in place, with clear responsibilities between different stakeholders and strong leadership? Does this governance model extend to the point where different ministries have their own geospatial departments entrusted with the production, sharing, exploitation of EO data? Is there a designated space agency or equivalent authority with a clear mission to coordinate national EO-related activities? How many **public service bodies** in the country use or produce EO data? What is the number of **staff** associated with EO tasks in governmental agencies and institutions? What is the **national budget** for EO activities? Is it centrally managed or are there EO-related budget in multiple ministries/agencies too? These are all critical questions in order to understand the maturity of the country at a governmental/institutional level. More indicators related to how the government uses EO data are spread in other pillars.

Secondly, we need to understand if there is a thriving **industry**. To that end we must capture the number of **companies**, their **average scale** (large/medium/small), the related levels of **employment**, the percentage of them that are simply **resellers**, and, finally their total **sales**. Similarly, when looking into the strength of the **academia** we must number of **researchers** active in the field of Earth Observation, and the volume and quality of their scientific **publications**.

Finally, when looking into the **Education and Skills** landscape in a country, we shall look into **university courses** – especially those specialised in EO, as well as **training programmes** aimed at building the skills of the current or future workforce. The table below presents the overview of indicators under this pillar.

Pillar	Group of indicators	#	Indicators	Description
Stakeholders Ecosystem	Government and Institutions	1	Governance	Maturity and strength of the governance model at country level
		2	Public Service Bodies	Number of entities at national, regional, local level using or producing EO data
		3	Staff	Employment numbers of people working on EO-tasks in governmental agencies and associated institutions
		4	Budget	Volume of annual investment in EO-related activities (upstream, downstream, mid)
	Industry	5	Companies (number)	Number of companies active in acquiring and supplying EO data and/or delivering geo-information services/products suitable
		6	Companies (scale)	Composition of industry base with regards to company size:(micro <10, small<50, medium <250)
		7	Companies (employment)	Estimated total employment among industry
		8	Resellers	Percentage of companies who operate only as resellers of international companies
		9	Sales	Volume of sales (as documented in their annual revenues) by companies incorporated in the country
	Academia	10	Researchers	Number of researchers working on Earth Observation topics
		11	Publications	Number and impact of relevant scientific publications within the last 5 years *(e.g.: indexed in Elsevier's Scopus and Compendex, publications in journals ranked in JRC among the top 30% of journals in the (G)EO field)*
	Education and Skills	12	University courses	Dedicated or tightly linked to EO courses offered at university level
		13	Training programmes	Training programmes focussed on the development of EO-related skills

Table 3-1 Indicators under the "Stakeholder Ecosystem" Pillar. The details on the associated levels are provided in Annex I.

3.1.2 Infrastructure

Sufficiently advanced infrastructure is a necessary requisite for EO maturity and technological advancement within a country. Due to its importance and mostly clear boundaries, we have deemed appropriate to represent the related indicators under a new and dedicated pillar.

We do that by firstly looking into **the space component**. This includes both **operating own satellites** and having **access to third party missions** through own **ground-based facilities**.

Equally important is the **in situ component** and the number of **in situ networks** within the country's territory**.**

A third essential indicator under this pillar of EO maturity is related to **modelling and computing capacities.** Under the **modelling** segment we will investigate the number and type of proprietary models available, while the **computing** one will provide information of the available HPC capacities and their level of sophistication. While often considered as two faces of the same coin, it is important to notice that, as proved by our experience within GEO-CRADLE, modelling and computing do not always go hand-in-hand (i.e. most often counties have developed several models even when the hardware for computing within this country is limited or non-present). Thus, we have chosen to combine the two into one group, while simultaneously keeping these as separate indicators.

Lastly in the Infrastructure pillar, we examine the **data exploitation infrastructure**. This ranges from the access to data through **data portals and gateways**, to the **data handling** tools available in the country (from basic to data cubes). Another element we consider is the presence and extent of **value-added services exploitation platforms** allowing to benefit from data services or advanced products levels.

Pillar	Group of indicators	#	Indicators	Description
National infrastructure	Space component	14	Operation of own satellites	If the country itself operates own satellite missions (public and private)
		15	Access to third party missions	Not owned nor operated by the country. Either a satellite operator or 3rd party mission/ including meteo.
		16	Ground-based facilities	Number of stations.
	In situ component	17	In situ monitoring networks	Number of in situ networks within the country or providing data to international networks.
	Modelling and computing capacities	18	Modelling	Measuring both number and quality of models (i.e. models for atmospheric modelling, what those are, what is the status).
		19	Computing	Availability of computing processing capacities (high-performance computers: HPC), assessing who these belong to (i.e. total number of organizations with computing capacities) and how advanced they are.
	Data exploitation infrastructure	20	Data portals and gateways (data access)	Number of data portals originating from the country.
		21	Data handling (incl. data cubes)	Tools for data-handling available through portals in the country
		22	Value-added services exploitation platforms (services/advanced products level)	Number of existing VAS exploitation platforms (access to thematic products or services)

Table 3-2 Indicators under the "Infrastructure" Pillar. The details on the associated levels are provided in Annex I.

3.1.3 Uptake

This pillar builds on what was previously "National Uptake and Awareness". Now renamed as "**uptake"**, this pillar seeks to assess the level of uptake of EO data and services in a given country. To that end, it

places strong focus on the **public sector**, looking specifically into the use of **EO for policy making** (both informing well-designed policy and contributing to efficient monitoring of policy implementation). In addition, the use of **EO for operational governmental activities**, excluding policy monitoring is assessed. This is an important distinction because beyond the policy-making part, EO can be used for emergency management, land use/land cover monitoring and much more. In this regard, the extent to which a country has adopted practices that allow **EO Data Sharing** is key. Without it many ministries or agencies often find themselves unable to exploit the capabilities offered by EO.

The next important area assessed under this pillar is **penetration**. This is now totally changed in comparison with the previous version of the EO maturity indicators. In this revised version of the indicators, it shall be attempted – to the extent possible – to analyse the level of **uptake of EO in key economic sectors**. This can be done with smart proxies and appropriate market sizing approaches.

Nonetheless, it is proposed that this has an "optional" character as its feasibility needs to be assessed over a critical mass of countries. In any case, this shall be guided by EARSC top-level taxonomy with regards to the sectors that should be assessed. This is a novel concept that relies on the modularity of the Maturity Indicators approach and shall be tested within e-shape[10]. A first endeavour in that direction can be undertaken within e-shape in connection to the showcases and the pilots therein. In practice, a separate "maturity card" could be generated assessing penetration in the sectors targeted by e-shape across the analysed countries.

Another critical area underpinning and eventually enabling uptake, is that of **awareness**. Here we want to highlight the number and impact of **EO-focused events** as a means for capacity building and networking. Other areas associated with awareness could include communication activities (both traditional and digital – incl. social media). At this stage, however, we consider this a challenging indicator given its loosely defined components.

Finally, this pillar will entail the assessment of **data uptake** in its purest sense this means looking at the volume of Copernicus/Sentinel (or equivalent) number of product downloads per year. Equivalent perspectives can be found when considering the Landsat or other openly accessible satellites. But at this stage, and with the countries covered by e-shape in focus, we propose to concentrate on Copernicus.

Pillar	Group of indicators	#	Indicators	Description
Uptake	Public Sector Uptake	23	EO for policy making	Exploitation of EO as a policy making and policy monitoring tool
		24	EO for operational public activities	Use of EO in operational activities of governmental agencies (including local and regional, excl. policy)
		25	EO Data Sharing	Level of adoption of data sharing practices
	Awareness	26	EO focussed events	Occurrence of events allowing both awareness (for general audiences) and networking (for specialised audiences) around EO
	Data Uptake	27	Uptake of Copernicus data (or equivalent)	Volume of Copernicus/Sentinel (or equivalent) number of product downloads per year

Table 3-3 Indicators under the "Uptake" Pillar. The details on the associated levels are provided in Annex I.

[10] A sample maturity card has been produced and is presented in Annex II

3.1.4 Partnerships

The role of international collaboration for assessing EO maturity has been discussed under the previous chapter, since the idea was as well present in the GEO-CRADLE methodology. Here a new structure is proposed, where each of the indicators has been reviewed and re-grouped as necessary, towards creating a complete overview of **partnerships**.

Our choice is to maintain the group of indicators measuring a country's **involvement in GEO.** However, it has been reviewed and to concentrate on a country's **financial contribution** to GEOSS projects and initiatives, and its involvement into **GEO Flagships** and **GEO initiatives**. It is also expected to gather information relative to the volume and quality of **data provided to GEOSS.**

Equally essential for the whole Methodology, within e-shape and beyond, is measuring the **involvement in the Copernicus programme**. This shall be done by assessing several aspects: the **financial contribution** of a country into the programme, as well as the **contribution to the Copernicus Services** (i.e. by looking at what part of the budget of each Copernicus Service goes for services provided by actors within the specific country). Complementary, the participation into **Copernicus-related R&D projects is considered**.

Further, R&D involvement is examined from a different point of view: not anymore *vis-á-vis* its focus on Copernicus, but more in general, by looking at funding from **International financial institutions or other funds.** Oftentimes the source is the **EU Framework Programmes** (or equivalent). The availability of **other EU funding is considered** (e.g. DEVCO) to be an optional indicator, as it is potentially less relevant in comparison (but can in some cases provide valuable information). Outside of the EU-system, primary source of funding for R&D projects that we take into consideration are the **international financial institutions** (International Monetary Fund and the five multilateral development banks: the World Bank Group, the African Development Bank, the Asian Development Bank, the Inter-American Development Bank, and the European Bank for Reconstruction and Development). For all the indicators in this group, we consider primarily the amount of funding which has been received by the country in question.

Other forms of partnerships are evaluated within the group assessing **participation in other international efforts**: here the engagement with other international institutions and efforts is looked into, and how this relates to the EO maturity level of a country. First, the country's **involvement in ESA activities** is considered (i.e. status of ESA member state or ESA cooperating state, and what any of these entails). It is worth noting that while within the context of e-shape it is essential to keep the focus on ESA and on the European EO landscape. In principle in a non-European context this indicator should be adjusted and EO maturity measured *vis-á-vis* collaboration with another space agency or an equivalent institution.

Moreover, we will collect information relative to the **involvement of EO in SDG reporting,** as well as in **other Global Agenda Initiatives.** In line with these, the ongoing relation between a country and the UN and the former's **involvement in UN Ecosystem activities** related to EO is considered. Lastly**,** adherence to standardisation efforts is assessed through two indicators: **involvement in spatial data infrastructure efforts** (INSPIRE and equivalent initiatives) and **involvement in standardisation and interoperability efforts** (e.g. through participation in the Open Geospatial Consortium or in other international organizations dealing with interoperability, standards, etc).

Pillar	Group of indicators	#	Indicators	Description
Partnerships	Involvement in GEO	28	Financial Contribution	Financial contribution to GEO or to projects/initiatives which are linked to GEOSS
		29	GEO Flagships	Involvement in GEO Flagships
		30	GEO Initiatives	Involvement in GEO Initiatives

		31	Provision of data to GEOSS	Volume and quality of datasets contributed to GEOSS
	Involvement in Copernicus	32	Financial contribution	Financial contribution to the Copernicus programme
		33	Contribution for Copernicus Services Provision	We look into involvement into Copernicus Services for services provision as carried out by public or private organisations within the specific country.
		34	Copernicus-related R&D projects	Participation into Copernicus-related R&D projects (*within the past 3 years*)
	Participation in other international efforts	35	Involvement in ESA activities or equivalent	Level of involvement implied by the status of ESA member state or ESA cooperating state, and the information beyond these terms.
		36	Involvement in SDG Reporting	Exploitation of EO as a tool to support SDG reporting (*within the past 3 years*)
		37	Involvement in other Global Agenda Initiatives	Exploitation of EO as a tool in relevant Global Agenda initiatives and conventions (other than SDGs)
		38	Involvement in UN Ecosystem activities	Country participation to UN EO-focused programmes and relations with UN institutions (UNITAR, UNOSAT, UN-OOSA, UN-SPIDER, UNEP, etc.).
		39	Involvement in Spatial Data Infrastructure Efforts	Involvement with Infrastructure for Spatial Information (INSPIRE or other. Possibly monitoring of n. of reports about the implementation and use of their infrastructures for spatial information)
		40	Involvement in Standardisation and Interoperability Efforts	Country participation in other international organisations dealing with interoperability, standards, e.g. such as OGC

Table 3-4 Indicators under the "Partnerships" Pillar. The details on the associated levels are provided in Annex I.

3.1.5 Innovation

The support and development of innovation is an indicator for the competitiveness of the EO market, but also a trusted proxy for how this same market will grow in the near future. The primary importance that innovation plays in the EO realm cannot be emphasized enough (equally to other fast-growing business, and even more to those heavily relying on R&D). To make this even more clear, a specific pillar was added to the Methodology: by grouping some of the previously existing relevant indicators and by further expanding the selection with "new" ones, in order to achieve a more comprehensive analysis of the innovative landscape.

There relevance to measuring the potential for sustainable growth of the sector promoted by **innovation support mechanisms**. Thus, the number of **clusters or innovation hubs** able to support an EO startup or

a pre-startup in their early stages of their development are looked into, as well as the overall available **funding for EO startups.**

Another interesting parameter regards the competitiveness and innovation potential for EO **startup creation**. Ideally, this would be done by providing information about the **total number of EO startups** and about the **creation rate**, as noted in the national registry of companies. This will allow to set the baseline for conclusions. However, it is the specific information related to their **annual revenue** which - if available, would really make a difference and effectively show the competitive landscape of the country.

This being said, innovation and competitiveness should be looked into in the light of the value created by companies under the form of intellectual property assets. The role of **patents** comes to mind in fast developing R&D ecosystems. It is fair to admit that it may be challenging to distinguish among the total number of filed **software** and **hardware** patents, those with EO-relevance. Nonetheless, it is a very important indicator and should be considered, whenever possible. Moreover, it shall not be excluded *a priori* that this knowledge is not available to the experts in charge of implementing the Methodology.

Lastly in the "Innovation" pillar we take a look into the **capital investment**: from the perspective of existence and overall amount of **venture funds,** and of total of **capital raised** by national players in the EO sector.

Pillar	Group of indicators	#	Indicators	Description
Innovation	Innovation Support Mechanisms	43	Clusters or Innovation Hubs	Number of clusters and innovation hubs in a country
		44	Funding for startups	Amount of available funding for startups
	Startup Creation	45	Total number of EO startups	Number of existing startups (*created within the last 3 years*)
		46	Creation Rate	Creation rate of startups (*for the past year*)
		47	Annual Revenue	Average annual revenue of startups
	Patents	48	Hardware	Number of patents registered for hardware innovation
		49	Software	Number of patents registered for software innovation
	Capital Investment	50	Venture Funds	Existence of available venture funds
		51	Capital raised	Amount of investment raised by national players in the space sector

Table 3-5 Indicators under the "Innovation" Pillar. The details on the associated levels are provided in Annex I.

3.2 Strengthening the data collection and analysis process

The robustness of data collection and analysis processes are critical for the quality of the methodology. As discussed in section 2.2, already since the first two cycles of implementation during GEO-CRADLE, a lot of effort has been placed in strengthening these processes. However, barriers such as inaccessibility to certain information, lack of capacity among implementors and resource constraints have been often limiting the quality of inputs, their interpretation and their transformation into meaningful outputs. All this has been so far applicable to the implementation cycles taking place within EU funded projects (first GEO-CRADLE, then DOST-Copernicus and now e-shape). In view, however, of expanding this to a broader context and a more regular frequency, certain steps need to take place. These are discussed below.

3.2.1 Data Collection

Before the data collection process starts, there are certain recommendations to be followed: **communication and consultation strategy** shall be designed, to explain clearly the initiative of "data gathering" and encourage the highest possible participation rate with the country partner representatives. This communication reflects the understanding of prevailing country stakeholders needs. This notification should also include items reflecting privacy rules, GDPR and all the controlled procedures for collecting, storing and accessing data.

The **country partner** is usually a research institution, public service body or EO company within the country – with the necessary legitimacy given either by formal nomination by appropriate bodies (e.g. GEO Focal points) or by their participation in flagship projects (if the implementation is supported by such a project, see for example GEO-CRADLE and now e-shape[11] . Within the data collection process, the country partner should make use of the expertise of other **national experts.** While suggestions may be provided, and certainly will be, when requested by a country partner, this last one has the responsibility for implementing the methodology and is free to choose the most appropriate mean to gather any set of data (e.g. desktop research, own knowledge, networking, event organising etc).

Nonetheless, before the data collection begins, country partners are guided through a **set of issues to monitor the information gathering**. National experts contributing to the data gathering should understand indicators are observable and provide measurable evidence of change, and the information shall be passed to them in a clear way by the country partner. As this is a modular methodology, there is no requirement for all the questions, nor for all the indicators, to be followed.

The following set of bullets presents the **issues to be considered while introducing the data gathering** to country partners and ideally also to national experts. However, in the ideal case, the country partner will conduct a leadership role and engage with experts.

- **Introduction of the methodology**: The methodology may be complex and has multiple interpretations, therefore it is highly recommended to spend some time to go through this brief explanation and discussion on the maturity indicators methodology with the country partners.

- **Debate on the main EO policy issues in the country:** Country partners can decide the best approach to meet the needs of assessment through all proposed pillars (**stakeholder's ecosystem, infrastructure, uptake, partnerships and innovation**) as countries may have different needs.

- **Why should countries collect these data**: Which are the priorities of the country? The overall purpose is the measurement and assessment of the EO performance and effectively manage the outcomes to improve and achieve future country goals. The maturity indicators are considered an essential tool, providing quality insights to direct the implementation of EO activities in each country and/or to assess if investments in the EO sector are fruitful. These insights are backed by an extensive collection of qualitative and quantitative data. The maturity indicators can also support decision-making for future actions and help to focus attention on what matters most, serving as risk triggers and early warning signs.

- **Interpretation of the pillar and indicators**: Why are they needed? What type of data? Those questions refer to the set of pillars and their indicators. Effective indicators demonstrate progress towards the EO maturity. The selection of indicators is a mix between quantitative and qualitative items, however

[11] For e-shape the discussion of such country partners is done in chapter 4.

each one is specific and measurable. Quality control is an important aspect which must be carefully addressed, and this organised in several steps: first, we make sure to transmit all the information needed for the data gathering as precisely as possible, and support the collecting party throughout to make sure they do not face issues meeting the instructions. Moreover, each input is cross-validated with other datasets or desktop research (or contacting experts, when necessary), to make sure no discrepancies may occur. Beside the existence of these mechanisms, we have provided with relatively simple indicators which offer a useful 'initial step' as they provide a common language of communication and help to understand performance in an immediate and visual manner.

- **Generic overview of the indicators**: Providing guidance on the major pillars and sub-pillars.

- **Identification of experts for the data gathering:** Looking for experts for specific elements of information to complete the collection of data. These experts specialise in their own domain and getting information form them is fundamental for the data gathering. The recommendation is to select experts from a diverse group of stakeholders from the public and private sector.

- **Availability of data for collection.** How will the data supporting the indicators be collected? Data collection methodology usually depends on the category and type of the indicator. The applicability of the criteria developed will depend on the indicator in focus and its purpose. The following methods are considered.
  1. **Desk research** drawing from existing literature and databases.
  2. Presenting and running **dedicated surveys** where possible mobilising structures such as GEO offices or Copernicus networks (in Europe). The primary advantage of surveys is that they allow the collection of information from a large audience.
  3. **Stakeholders (experts) interviews**. The interviews are one-on-one evaluations and provide the holistic picture of the country programs and activities allowing to ask for clarifications on responses as they come. They have high degree of confidence on the data. It is recommended to anticipate and address key stakeholder concerns and questions about the project during the interview phase. Qualitative and quantitative data generated under this process will be generally gathered from more than one country expert which will help to better understand the country situation and to provide descriptive details and quantitative figures. The recommendation stands for at least 4 interviews from: government, research organisation, industry and academia, adding to the contact country partner. It is recommended that those experts compile the information with contributions from other colleagues.

- **Where do countries collect data at national, regional, local levels?** How to structure this type of information? Ideally data capture should also allow sub-national disaggregation in order to assess trends at the different levels if is related to a big country, but also to allow the identification of missing data at regional level. For small countries disaggregation is not needed while for large countries the country partner may consider a local/regional component for coordination between the different levels of governance. There is a need to push for sustained cooperation and networking engagement to have data updated and validated over time.

- **When is the data collection taking place?** Ideally annual/biannual data gathering. Data can be collected and analysed on ad-hoc basis in response to country needs, understanding the engagement on EO capacities. The best practice is to collect data on an ongoing, permanent basis, and to analyse this data as often as needed, in order to generate discussion and stimulate support actions for implementation of EO activities in each country.

- **Who is taking care of the data gathering per country?** Determining who will collect the data is key: involving country partners and identifying and involving stakeholders right from the beginning. It is suggested that the country partner is somehow involved in the planning and design, and throughout the evaluation exercise in information collection, analysis, evaluation reporting and result sharing. The country partner will hold the country's "leadership". The discussions should be centred around institutional, academic, research or industry perspectives and experiences in the country, which is used to complete a cross check of the methodology and the specific assessment of the indicators. In this step, the ability of country partners to access data, analyse them, and synthetize the findings is heavily relied on.

Aside from these specific recommendations, we would like to **propose the establishment of regular intelligence gathering processes supported by existing "structures" in the EO ecosystem**. This would be the only feasible approach in view of scaling up the implementation. In practice, this would mean mobilising actors with the mission to promote greater uptake of EO at national level as well as coordination of national EO activities with those carried out through international efforts.

In Europe, this could be **well served by existing "structures" and/or governance bodies within the Copernicus Ecosystem**. For instance, the **Copernicus Relays**[12] network operates in a hub-and-spoke model, whereby national actors are acting as a link with the European Commission, "relaying" information in a two-way fashion.

This model seems well suited for the purpose of finding the facts that could be fed into the *EO Maturity Indicators Methodology*. It success however relies on a renewed mission given to the Relays alongside more stringent criteria on the selection of those who can perform such a mission. In addition, the necessary resources (i.e. funding) should be provided to the new set of Copernicus Relays, together with tools and trainings (e.g. with regard to monitoring certain aspects). Similarly, this could be pursued through the Copernicus Framework Partnership Agreement[13], whereby the intelligence gathering, and fact-finding could become a horizontal action performed by the **members of the FPA**. Alternatively, the **organisations representing the Member States at the Copernicus User Forum** could be solicited for this purpose. It is worth noting that the need to establish such a robust mechanism for local intelligence gathering was strongly recommended in the recent study for EC DG DEFIS on "*Boosting the use of Copernicus: Evaluation, Gap analysis and recommendations*"[14]. It should also be noted that several organisations participating in e-shape have strong ties with all these structures/bodies.

Within the framework of GEO, the data collection process could be facilitated by the GEO Principals. In their role to coordinate GEO-related activities in their countries and then contribute to the GEO Plenary. Reporting on progress and shaping future priorities, GEO Principals would be perfectly positioned to lead the implementation of *EO Maturity Indicators* fact-finding. This concept has been already discussed with the GEO Secretariat at the time of the inception of the methodology and was, back then, strongly encouraged. Within e-shape we aim to return to this prospect (see also chapter 4 on this subject).

3.2.2 Data Analysis

Similar to data collection, if the implementation of the methodology is to expand, existing structures should be mobilised for data analysis purposes. In this case, the key is to provide adequate training and guidelines on how to implement the methodology. This is the aim of the capacity building module currently developed by e-shape under Task 4.2. This will provide concrete guidelines that should help first

[12] https://www.copernicus.eu/en/opportunities/public-authorities/copernicus-relays

[13] https://www.copernicus.eu/en/opportunities/public-authorities/framework-partnership-agreement

[14] https://www.copernicus.eu/en/events/events/workshop-boosting-uptake-copernicus

the project partners (see chapter 4) and then external parties to implement the methodology, collect the necessary data, and analyse them. In that regard, lessons learned from the independently performed assessment in the Philippines will be also incorporated. Finally, a dedicated webinar will be produced allowing for wider dissemination of the methodology and the associated guidelines.

3.3 Introduction of complementary analyses

The *EO Maturity Indicators Methodology* provides an assessment of performance of a given country against specific indicators at a given point in time. The objectivity of this assessment is directly tied to several parameters:

- The **robustness of the defined levels**: Indicators that have levels with a purely quantitative distribution (e.g. number of companies) are in that sense robust. Other indicators (e.g. the governance model) are by construction not quantitatively assessed and thus less robust.
- The **quality of input data:** Much of the information collected is hard to come by. Most countries are not regularly producing reports presenting the figures needed for the application of our methodology. Moreover, there is significant disparity in the format and timeframes certain aspects are reported – thus we often have to analyse data from different years, which are then "localised" through structured interviews with experts.
- The **ability of the analysts** to interpret the inputs: Given the often-unstructured nature of the input data, the analysts synthesising the inputs and transforming them into specific levels introduce a certain amount of subjectivity in the process.

These three elements are recognised as factors limiting the robustness of the methodology – they are, of course, intrinsic to any performance assessment methodology. Beyond these, it should also be recognised that the performance of a country in a given sector cannot be viewed in isolation from the rest of the economy. To illustrate this point, one should consider, for instance, that no serious sports analyst would compare the number of gold medals won by American athletes in the Olympics versus those won by Vanuatu athletes. The size of the two countries, their annual spending in sport activities, etc. are key factors enabling or limiting them from competing for the most medals. Similarly, e.g. when we look at the maturity of a country with regards to Earth Observation activities, one should keep in mind some bigger-picture aspects, such as annual GDP, percentage of that GDP dedicated to research and innovation, etc.

Following this chain of thought, it becomes clear that some form of **normalisation** is required to ensure that meaningful results are obtained and that we do not end up comparing apples to oranges. This is not a trivial process; instead it requires special attention to the properties of the data we collect and the objectives of the methodology itself (as served through composite indicators). The key aspects to be taken into account are whether hard (quantitative) or soft (qualitative) data is available, whether exceptional performance or lack thereof should be rewarded/penalised, whether absolute performance makes sense, whether a given country can serve as a reference point/benchmark, etc.

The above observations naturally raise the question: which complementary analyses or methods should we implement to put the findings of the *EO Maturity Indicators Methodology* into context? This is a question raised already when developing the original version of the methodology. At the time of GEO-CRADLE, three approaches were considered: **(i)** ranking of indicators across countries, **(ii)** simple normalisation and **(iii)** benchmarking. The first, as abundantly shown, has guided the development of the methodological components in the existing EO Maturity Indicators approach. In contrast, the other two were dismissed during GEO-CRADLE as the complexity of implementing them exceeded the scope of the

project and the available resources. In this methodological review, however, we revisit these approaches together with a few more and propose a pragmatic way forward as discussed below[15].

3.3.1 Ranking of indicators across countries

This is precisely what has been currently guiding our methodology. For each indicator, a range of values (hard/quantitative or soft/qualitative) were defined, against which the levels of maturity are defined. In effect, in the two cycles of implementation during GEO-CRADLE, the performance of each country against each indicator were documented in the different types of evidence provide by country experts and translated it into the aforementioned levels. Small fine-tuning of the levels was done once more data points for more countries were established. Overall, this process ensured independence from outliers (both well and bad performing). Most importantly, this approach has proven to be simple, reproducible and intuitive. However, as implied at the beginning of this section 3.4, this approach hinders the ability to directly compare different countries. So far, this has not really been an issue; the key driver of our methodology was to show progress over time, identify best practices and, eventually, support capacity building. Going forward, however, it is recognised that unlocking the ability to establish comparison over similar (otherwise) countries might be of value.

Suggested action: Maintain this approach and improve the quality/robustness of assigning values to different levels by implementing more assessments and gathering a critical mass of information.

3.3.2 Standardisation (z-score)

This approach shows how far from the mean (of a population) a given data point is. In practice, one has to calculate the mean μ and the standard deviation σ. Then with the simple formula $z = (x – \mu) / \sigma$, one can see how far a given measurement x is from the average performance of the whole population. In our case, we could implement this approach either within the ranges (e.g. when measuring the number of companies, the level of investment, etc.) or across the range (e.g. when looking at a specific indicator and seeing how the population performs from 0-4). In principle, adding such a measure next to the absolute number would help to provide better contextual comparison.

Suggested action: Test this approach in the new implementation and as more data points and country assessments become available in order to contextualise findings.

3.3.3 Re-scaling

In this approach, each indicator for a given country at a given time is calculated as the ratio of the difference between the raw indicator value and the minimum value divided by the range. In that sense, it differs from standardisation as it uses the range rather than the standard deviation. Whilst this approach would have certain benefits if only hard/quantitative data were used in our methodology, the fact that soft data is also used makes it not applicable.

Suggested action: Dismiss

3.3.4 Benchmarking (distance to a reference country)

This method relies on establishing a reference country “x” (either best performer or most reliably documented performer) and then dividing the measured indicator of a country “y” with the value of the indicator of country “x”. This approach has been widely in use: either against a pre-defined value (e.g. in

[15] We have used as a baseline the guidelines provided by the Joint Research Centre’s (JRC) Competence Centre on Composite Indicators and Scoreboards – see here: https://composite-indicators.jrc.ec.europa.eu/

Climate Agreements stating CO2 emissions of x% by a certain year) or specific countries (e.g. United States or Japan are benchmark countries for the composite indicators built in the frame of the EU Lisbon agenda).

Another approach is to assign value 1 to the average country in a given sample and then see how other countries perform in comparison to this average – they receive then scores based on the distance from that reference country. This could only be applied in our case for the levels (and not the ranges because they often rely on soft/qualitative data). Overall, it seems that systematic issues connected to the subjectivity of assigned levels (especially when soft data is involved) and the small sample of countries analysed would be carried over to the averaging (i.e. what we would consider an average country might end up not being an average country at all).

Similarly, one could take the best performer as the point of reference, which however is rather difficult to establish given the fact that this is a novel methodology against very few countries have been tested. Nonetheless, there could be value in presenting a country's performance for a given indicator next to the top performer, i.e. instead of simply noting a score of 3.2, noting 3.2/3.8. This does provide perspective, albeit a dynamic one as more countries are assessed or more data becomes available.

Suggested action: Test, in the new implementation, the meaningfulness of noting absolute score next to the top performer score for each group of indicators.

3.3.5 Percentile Assessment

This approach would look into the percentage of countries scoring across the different levels of a given indicator. For instance, the percentage of countries scoring level 1, 2, 3, 4 for the indicator on startup creation. Then one could compare a given country's absolute performance against this distribution. For instance, by having score 3.2 a given country is in the top 10% of countries.

Suggested action: Test, in the new implementation, the meaningfulness of noting absolute score next to relevant percentage for each group of indicators.

In conclusion, this methodological review proposes that certain approaches are tested and, if found meaningful, adopted in the new implementation cycle. More on the implementation itself follows below.

3.4 Visualisation improvements

The final visualisation output of the Methodology, as discussed in Section 2.3, is the **Maturity Card**. Since its conception, it has been tested in GEO-CRADLE, as well as implemented independently. In principle, none of these experiences has identified drawbacks of the format and therefore we aim at diverging from what has already been in use as little as possible.

Nonetheless, a simple re-systemisation is needed, as single indicators have changed, and pillars have been re-defined and enlarged in number and are now five (Section 2.1). Moreover, any of the suggested instruments for complementary analysis: standardization, benchmarking, percentile assessment, if implemented, will need a sound and intuitive graphic expression (e.g. colour code, a second "reference" circle, percentage number). However, an actual adoption of any of them can only be put in place (As discussed in Section 3.2) after a round of testing and once data from an adequate amount of countries have been gathered. A model of the proposed Maturity card for e-shape can be found in Annex II. An additional model is provided in Annex II for the case of the "penetration" indicator, which – as discussed in 3.1.3 – could be used to generate insights on the uptake of EO in key economic sectors.

4 IMPLEMENTATION PLAN IN E-SHAPE

All the improvements discussed in Chapter 3: concerning both single indicators and methodological approaches, will help create a better EO Maturity Indicators methodology, to be implemented within the context of e-shape, and potentially upscaled to further needs. Therefore a selection of countries in which the methodology will be carried out within e-shape is discussed below, alongside a few more outside of the project. In addition, a dedicated note on the implementation of the "penetration" indicator assessment for the sectors covered by the e-shape Showcases/pilots is provided.

4.1 Implementation in countries represented in the e-shape project

While the ultimate vision is for the methodology to be broadly adopted and regularly deployed, a new step in that direction will be carried out within countries represented in e-shape. The ones already earmarked and discussed below are Belgium, Czechia, Finland, Germany, Greece, Italy, and Portugal.

There are two reasons for said selection: first, for each selected country, we have a project partner capable of conducting the assignment both in terms of capacities and in terms of assigned resources (i.e. person-months in the given e-shape task). Second, all the selected countries are suitable candidates for obtaining interesting samples from the assessment: the obvious common point being that as European countries and EU Member States they do share some similarities. Notably, all of them contribute to Copernicus and are actively engaged represented within the corresponding ecosystem; for instance, within the project itself there are some countries' delegates to the Copernicus User Forum – which shall contribute to the quality of data input into the Methodology, as well as provide extra impetus.

On the other hand, some of these "similar" countries have taken very diverse paths towards EO maturity. Few are well-developed and leaders in EO (Germany and Italy have among the highest numbers of registered EO companies in Europe)[16]. Others are pioneering the use of EO in policies where other countries struggle to implement, independently of EU common policies and are championing innovation (see Finland below). A third group of smaller countries (Belgium, Czech Republic, Greece, Portugal) with more-limited but fast growing EO capacities is also considered. It is particularly intriguing to follow the last group's potential for advancement and see how this will be reflected in a series of EO Maturity Indicators implementations executed over several years. This is particularly applicable to the case of Greece, as the only country from the list being previously examined under GEO-CRADLE and which shall 1) show the progress of the country within the past couple of years and 2) serve as a validation case for the "new" methodology.

4.1.1 Greece

Greece is the only country in the current expansion that has been already assessed during GEO-CRADLE. At the time, the performance of Greece stood out in the group of BAMENA countries covered. This time, however, it will be particularly interesting to see the progress of the country *vis-à-vis* EO activities in a more advanced group. It must be noted that in the meantime Greece saw the creation of the Hellenic Space Agency and the return to post-economic crisis operation of the EO sector. Another interesting aspect is the fact that because of the crisis, Greek actors relied on international collaborations leading to an increase of competitiveness of Greek research institutes and companies alike.

[16] EARSC EO Industry Survey Report (2019): http://earsc.org/file_download/554/Industry+survey+2019+10_09_2019+Final+version.pdf

4.1.2 Germany

Germany has the World's fourth strongest economy, as well as excellent innovation capacity and industry strength. Germany is the third European country by number of EO companies, and enjoys a competitive market divided between few big players and a multitude of startups.

A founding member of ESA, the country hosts ESA-ESOC, as well as EUMETSAT. Germany has a strong research base in the space domain with institutes such as Fraunhofer and Helmholtz[17]. Important player in the German, and in the European EO scene is the German Aerospace Center – DLR. DLR's own remote sensing data center has attracted many EO companies and clusters to its surroundings in Bavaria.

For federal states like Germany, it would be valuable to consider EO Maturity levels for different regions, rather than simply on a country level, with the necessary adjustments. However, while admitting the peculiarity of the case and the interest it would represent (for the validation of the Methodology, but even more for the country itself), this may be considered at a later stage of the implementation, and outside of e-shape.

4.1.3 Italy

Founding member of ESA, Italy takes the fifth place in Europe for the number of registered EO companies. The EO history of Italy dates back to 1964, when Italy launched its first satellite – San Marco-1, becoming only the fifth country worldwide to have done so. Nowadays the industry is characterised by the presence of a few big players on one side (mostly privatised defence companies), and multiple startups, clusters and accelerators on the other. Italy has a particularly active GEO community.

Notably, the ESA Centre for Earth Observation (ESRIN) is located close to the country's capital, and we are interested to show if this has impact on other actors of the EO value chain within the country (e.g. industry, academia).

4.1.4 Belgium

Founding member of ESA and home of the Agency's REDU station. Particularly active research community (the Belgian Science Policy Office, the Flemish Institute for Technological Research, and academia). Different EO-companies are present in Belgium, including plenty offering consultancy services to the EO domain. Nonetheless, there are much fewer companies in Belgium than in countries with similar profile and size (e.g. the Netherlands).

4.1.5 Finland

Finland has been using EO for a while with ambitions for an even more progressive and systematic use.[18] Just recently, the use of EO was promoted under the Finnish presidency of the Council of the European Union. Moreover, Finland is promoting the use of EO where other countries do not use it[19] (e.g. promoting its use for the implementation of the Water Framework Directive[20]). The industrial landscape, on the other

[17] The branch of Helmholtz most involved in EO and Copernicus-related activities is The German Research Centre for Geosciences (GFZ): https://www.gfz-potsdam.de/en/home/

[18] T. Pulkkinen, M. Alho (Editors): *Space Research in Finland, report to COSPAR 2016,* 46p., 2016: http://www.cospar.fi/reports/Rep2016.pdf

[19] Satellite-assisted monitoring of water quality to support the implementation of the Water Framework Directive: https://zenodo.org/record/3556478#.XnOezIhKjb0

[20] Copernicus Earth Observation (EO) data for monitoring and assessments of Water Framework Directive: https://circabc.europa.eu/sd/a/a6292efc-bd96-40eb-894f-bb2a355f684e/WMD2019-1_Item%206b_EO_WFD_YM%20Romania.pdf

hand is extremely thriving and competitive, with the country ranking third in innovation worldwide in 2019.

4.1.6 Czech Republic

The country does not currently have a space agency and the coordination role of pure space science related activities is assigned to the Czech Space Office, a non-profit association co-financed by the Ministry of Education, Youth and Sports. Nonetheless, the country has recently been active and successful in its advocacy to be host the European Union Agency for the Space Programme (EUSPA). It would be valuable to follow the country's progress in EO maturity by assessing it over a period of time and see how similar policy decisions reflect on the overall Maturity and on the company landscape and competitiveness.

4.1.7 Portugal

Most of the country's EO efforts and funding go into the marine sector.[21] Since 2013 the country has its Earth Observation Working Group, and since 2019 its own space agency – Portugal Space which aims to be an instrument for the implementation of the country's ambitious space policy over the new decade. Portugal is an emerging but active hub for a number of small startups and clusters. We are interested to follow the creation of Space agency and the consequences of its 2020-2030 space policy on the EO sector through the EO Maturity Indicator Methodology.

4.2 Implementation in countries outside the project

One of our main objectives in conducting this methodological review was to enable the implementation of the methodology in and for any country. The first instance of such independent implementation (Philippines) has been very encouraging. It did, however, also show that certain aspects (now fully incorporated in this revised methodology) were too EU-centric. In light of this, and following up on the excellent traction built with the GEO Secretariat, we will explore possibilities for implementation outside the countries represented in e-shape. Discussions have already opened to that effect with countries such as South Africa, where the next GEO Week should take place. The feedback has been very positive but the details need to be discussed before we can see this implementation happening for certain. Similarly, other avenues such as GMES & Africa will be explored as well as links with other initiatives as discussed in 4.4 below.

4.3 Implementation of "penetration" indicator for sectors covered by e-shape

As discussed earlier (see 3.1.3), this methodological review has yielded a new indicator that presents special interest, namely the "uptake of EO in key economic sectors". Given the importance of EO uptake in the context of e-shape in specific sectors, but also more generally, we propose that a first attempt to measure this indicator is undertaken within e-shape. To that end, the baseline for implementation will be the sectors covered by e-shape showcases and the pilots therein. In practice, when conducting the implementation of the full methodology across the selected countries (see above), extra effort will be placed **on assessing EO uptake in agriculture, health, energy, ecosystems, water, disasters and climate related activities**. For each of such "sector" we will define a set of indicators corresponding to different application areas whereby EO plays a significant role. At present, and for illustration purposes only, such a visualisation is presented at the end of Annex II.

[21] Copernicus and Earth Observation in Portugal (Roundtable – Sustainable Development in the Space Sector, May 2014): http://marine.copernicus.eu/documents/UW_2014/5_Portugal_Focus-20th_JUNE_PM/COPERNICUS_and_EO_in_PORTUGAL.pdf

4.4 Links with other methodologies and initiatives

Integrated Geospatial Information Framework

The **Integrated Geospatial Information Framework (IGIF)** developed by United Nations Initiative on Global Geospatial Information Management (*UN-GGIM*) provides a basis and guide for developing, strengthening geospatial information management at country level and it is anchored by strategic pathways. **e-shape** is currently updating the "indicators methodology to assess the maturity of EO capacities at national level". The EO maturity indicator methodology is based on five major pillars covering **stakeholder's ecosystem, infrastructure, uptake, partnerships and innovation** and each of those have indicators in which we recognise alignment with the jigsaw puzzle that IGIF is anchored, those are **data, innovation, education, standards, governance, finance, policy & legal, communication and partnerships.**

The 2030 Agenda[22] recognses that timely, available and accessible geospatial information, integrated with statistics and other information, with combined analyses, are prerequisite for good policy-making and supporting and tracking development progress. However, there is still a lack of awareness, understanding and uptake of the vital and integrative role of geospatial information, particularly in developing countries. Both exercises: the integrated geospatial information framework and the methodology to assess the maturity of EO capacities at national level, have strong component on awareness raising and can be best leveraged and used in the future within the country activities.

It is assumed under the EO maturity methodology that countries consider how they best implement the assessment and how to sustain their own Integrated Geospatial Information Management Strategy through a Country-level Action Plan. Both contain components and tools to assist countries in their efforts to better understand the national capacities, demonstrating national leadership and developing capacity to take positive steps in the future, i.e. setting the context on why Earth observation and geospatial are critical elements for the country development.

The table below shows a tentative matching between the vision and mission and goals of each of the framework and methodology respectively:

	EO maturity indicators *(discussion in progress)*	**Integrated Geospatial Information Framework**	**Communality**
Vision	The Vision for the EO maturity is empowering countries by monitoring and assessing the 5 pillars: stakeholder's ecosystem, infrastructure, uptake, partnerships and innovation.	The Vision recognizes the responsibility for countries to plan for and provide better outcomes for future generations, and our collective aspiration to 'leave no one behind'.	Gain insight into the current situation of EO related activities and capacities and how it should pursue the desirable situation for future generations.
Mission	The Mission is to provide country leadership, build capacities and foster cooperation to structure the collection of information, perform analysis, synthezise	The Mission is designed to stimulate action towards bridging the geospatial digital divide; to find sustainable solutions for social, economic and environmental development; and to influence inclusive and transformative societal change for all	Evidence and capacities to support decision-making in future actions and focus attention on what matters most, offering solutions for social, economic but also environmental challenges.

[22] Transforming our world: the 2030 Agenda for Sustainable Development, UNGA https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

	the findings, and draw lessons for the 5 pillars.	citizens according to national priorities and circumstances.	
Goal	The Goal is to increase the value of the information and availability of the different pillars for future assessments through (i) strategic collaboration between actors (ii) political commitment to stimulate policies development (iii) coordinated effort to improve national infrastructure and data capabilities (iv) increase awareness & engagement with other sectors and users (v) harmonised training offer and upskilling (vi) standardisation measures (vii) use EO as innovative context for socioeconomic benefits.	The goal set bridge with: (i) effective geospatial information management (ii) sustainable education and training programs (iii) increased capacity, capability & knowledge transfer (v) international cooperation and partnership leveraged (vi) integrated geospatial information systems & services (vii) enhanced national engagement and communication (viii) economic return on investment (ix) enriched societal value and benefits.	Present simplicity and straightforward set of goals measured by indicators which pave the way for the continuous monitoring of the uptake and exploitation of EO assets and services.

Table 4-1 Tentative matching between IGIF and EO Maturity methodologies

The Integrated Geospatial Information Framework (IGIF) provides a basis and guide for developing, integrating and strengthening geospatial information management. The approach builds on 9 core elements. A parallel between each of the nine components, and the EO indicators is drawn hereafter:

IGIF	EO indicators
The **governance pathway** establishes leadership, governance model and institutional arrangements as means to strengthen multi-disciplinary and multi-sectoral participation and a commitment to achieving an IGIF.	In the EO maturity methodology we propose an analysis of the **government and institutions**. The current governance model is studied with clear responsibilities between different stakeholders and strong leadership.
The **policy and legal pathway** establishes a robust legal and policy framework that is essential to institute appropriate national geospatial information legislation and policy that enables the availability, accessibility, exchange, application and management of geospatial information.	The EO maturity investigates the penetration of **EO in policy** and decision-making.
The **financial pathway** develops financial partnerships and identifies the investment needs and funding sources for delivering integrated geospatial information management.	The **financial contribution** to the EO maturity is related to the country support of the EO programmes.
The **data pathway** establishes best practice collection and management of integrated geospatial information that is appropriate to cross sector and multidisciplinary collaboration.	The data is being considered by the EO maturity methodology under the **infrastructure** pillar representing indicators on the space, in situ, modelling and data exploitation components.

The **innovation pathway** recognises that technology and processes are continuously evolving; creating enhanced opportunities for innovation and creativity to enable governments to quickly bridge the digital divide.	The EO maturity addresses innovation through the **competitiveness of the EO market** but is also a trusted proxy for how this same market will grow in the near future.
The **standards pathway** enables different information systems to communicate and exchange data, enable knowledge discovery and inferencing between systems using unambiguous meaning, and provide users with lawful access to and reuse of geospatial information.	The EO maturity methodology ensures the involvement in **standardisation and interoperability efforts.**
The **partnership pathway** establishes effective cross-sector and interdisciplinary cooperation, industry and private sector partnerships as well as the international cooperation.	The EO maturity brings this pillar with a set of indicators such involvement in **GEO, in Copernicus, participation in other international efforts or involvement in international R&D effort**s and each of those have sub indicators contribution to the mapping to the complete overview of partnerships.
The **capacity and education pathway** increase the awareness and level of understanding of geospatial information. Including developing and strengthening the skills, processes and resources that organizations require to utilise geospatial information for decision-making or business activities.	When looking into the **Education and Skills** landscape in a country under the EO maturity, we shall look into university courses and training programmes aimed at building the skills of the current or future workforce.
The **communication & engagement pathway** recognise effective and efficient communication and engagement processes to encourage greater input from stakeholders.	Communication is addressed under the EO maturity within the Uptake pillar with indicators related to public sector uptake, penetration, awareness and data uptake.

Table 4-2 shows both frameworks and the alignment of strategic pathways, the pillars and the indicators.

More activities of engagement with the Integrated Geospatial Information Framework are planned in the coming months, especially on the alignment and coordination of activities across national capabilities.

4.5 Timeline

The methodology defined herein requires that a strict timeline considering all the steps of implementation is enacted in collaboration with the country partners.

The end outcome of the implementation within e-shape will be discussed in *D4.7 Maturity Indicators Implementation Report (M30)*, eighteen months from now. The breakdown of the whole process is visualised in figure 4.2.

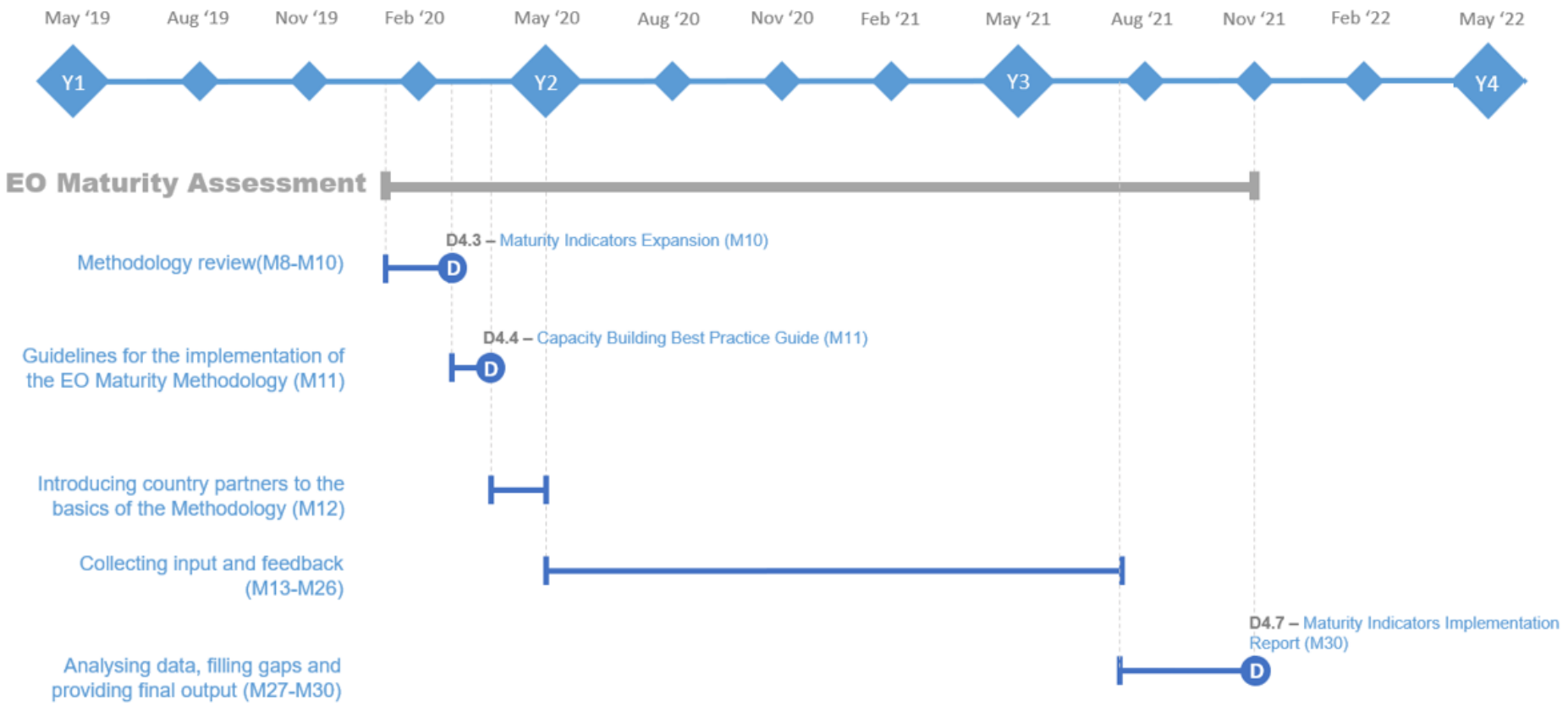


Figure 4-1 Timeline for implementation of EO Maturity Assessment within e-shape

5 CONCLUSIONS AND WAY FORWARD

The **EO Maturity Indicators Methodology** previously developed within the framework of the H2020 GEO-CRADLE project has been deemed successful, but little apt for upscaling. Nonetheless the improved EO Maturity Indicators Methodology, as suggested and analysed in this deliverable, and scheduled to be implemented within e-shape, should be able to overcome such barriers, and provide for a go-to source regarding information on the country's advancement in EO.

With the Methodological study (foreseen to reach conclusion in M30 with *D4.7 – Maturity Indicators Implementation Report*), we aim at providing support to the overall idea of *T4.2* ***Capacity building***, through the conception of an instrument for (self-)assessment and comparison of EO Maturity, with the possibility to easily identify both gaps and the paths towards filling them.

The ongoing feedback we will be receiving in the **implementation phase within e-shape**, will allow to implement any necessary adjustment, as expected from a complex methodology embodied in a living document. Nonetheless, we aim to prove that the methodology, as will be presented to country partners, will be simple enough to be implemented for and by any country, and ideally on a periodical basis by organised ad-hoc bodies within each country.

Further **liaisons are to be sought outside of the project** too, namely in possible liaison with UN-GGIM's Integrated Geospatial Information Framework. We will hence follow closely its development as overlaps may occur and synergies might be identified .

The more countries implement the EO Maturity Indicators Methodology, the more data will be available for validation and improvement, and the more the reputation and credibility of the Methodology will grow.

Of course, it would be easier in a case that an **ad hoc body, or a system of bodies within countries**, take charge, codify and unify the implementation of the methodology. And while this is not happening at the moment, there are no reasons why it should not in the future, nor why we should not in the meantime, and on behalf of the EO community, work towards such a goal by constantly improving the EO Maturity Indicators methodology and bringing it to the highest possible level of quality.

With this principle as our guide **we shall continue to advocate for its widespread exploitation by individual organisations, within projects and, ideally, within mission-driven frameworks**. The latter could be advocated in the context of GEO – guiding principals to conduct the methodology at regular intervals, and in the context of Copernicus Relays, FPA or similar. Moreover, we will strive to raise awareness on its modularity, which in itself could ensure the exploitation of the methodology in specific contexts – see for example the connection with the e-shape pilots and EO penetration in the corresponding sectors, and the potential extrapolation over the full taxonomy of EO sectors and application areas.

6 ANNEXES

6.1 Annex I – EO Maturity level assessment grid

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
Stakeholders Ecosystem	Government and Institutions	1	Governance	Maturity and strength of the governance model at country level	Unspecified governance model.	Formally designated authority.	Formally designated authority, with geospatial departments present in in other ministries as well.	Clear agenda is implemented between authority and ministries-without international involvement and impact.	Clear agenda is implemented between authority and ministries - with international involvement and impact.
		2	Public Service Bodies	Number of entities at national, regional, local level using or producing EO data	Less than 5.	6 - 20	21-50	51- 100	Over 100.
		3	Staff	Employment numbers of people working on EO-tasks in governmental agencies and associated institutions	Less than 25.	26-200	201- 500	501- 1000	Over 1000.
		4	Budget	Volume of annual public investment in EO-related activities (upstream, downstream, mid)	Less than EUR 10 M	EUR 10-50M	EUR 50-100 M	EUR 100-300 M	Over EUR 300 M

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
	Industry	5	Companies (number)	Number of companies active in acquiring and supplying EO data and/or delivering geo-information services/products suitable	No private companies in the EO domain [no companies on EO]	1-5 companies in the country serving any category in the EO value chain [between 1-5 companies]	6-25 companies serving at least 3 categories covering the EO value chain [between 6-25 companies]	26-50 companies serving at least 3 categories covering the EO value chain [between 26-50 companies]	Over 50 companies representing all the categories covering the EO value chain. [> 51 companies]
		6	Companies (scale)	Composition of industry base with regards to company size:(micro <10, small<50, medium <250)	[no comparable]	Micro companies only	Micro and small companies	Micro, small and medium companies [SMEs]	All types of companies spread all over the country. Note: usually the EO companies are the small size ones. They have around 2-10 employees [all types industry]
		7	Companies (employment)	Estimated total employment among industry	Private sector employment up to 10 employees [up to 10 employees]	Private workforce between 10-50 employees. Note: usually the EO companies are the small size ones. They have around 2-10 employees/company [10-50 employees]	Private task force between 51-150 employees [51-150 employees]	Private task force between 151-300 employees [151-300 employees]	Private task force more than 300 employees [>300 employees]
		8	Resellers	Percentage of companies who operate only as resellers of	Only resellers, not companies members of international specialised groups. [only resellers]	Over 60% resellers	Between 60% and 30% and resellers	Between 30% and 10% resellers.	Less then 10% resellers only

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
				international companies					
		9	Sales	Volume of sales (as documented in their annual revenues) by companies incorporated in the country	Less than EUR 1 M	EUR 1-5 M	EUR 5-50 M	EUR 51-100 M	Over EUR 100 M.
	Academia	10	Researchers	Number of researchers working on Earth Observation topics	No significant number of researches in the EO domain [no significant EO staff]	Less than 50 EO researchers	50-250 EO researchers	250-500 EO researchers	> 500 EO researchers
		11	Publications	Number and impact of relevant scientific publications within the last 5 years *(e.g.: indexed in Elsevier's Scopus and Compendex, publications in journals ranked in JRC among the top 30% of journals in the (G)EO field)*	no papers published [no EO publications]	1-25 papers published at department level (from those at least 10 paper citations who have an impact factor)[1-25 papers]	25-100 papers published that will provide some excellence of the research resulting from national projects related to EO funded by Government or other EU funding (from those at least 25 paper citations who have an impact) [25-100 papers]	100-500 scientific papers (+ thesis research) produced by research organizations and universities on innovative topics (from those at least 50 paper citations who have an impact. [100-500 papers]	Over 500 between number of theses and scientific papers produced by research organizations and universities with impact in prestigious magazines or presented in high level conferences; [>500 papers]

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
	Education and Skills	12	University courses	Dedicated or tightly linked to EO courses offered at university level	No specific EO courses.	Sporadic EO dedicated courses within various curricula.	Multiple EO dedicated courses within various curricula with proven impact and peer recognition.	At least one EO dedicated recognised and renowned curriculum.	More than one EO dedicated recognised and renowned curricula.
		13	Training programmes	Training programmes focussed on the development of EO-related skills	No known EO training programmes.	Rare instances of EO training programmes by local and international actors. (e.g. summer schools, seminars)	Sporadic EO training programmes by local actors.	Periodic EO training programmes by local and international actors.	Systematic (i.e. multiple annual) EO training programmes by local and international actors, serving coherent agenda (s)
National infrastructure	Space component	14	Operation of own satellites	If the country itself operates own satellite missions (public and private)	No missions, no technical readiness.	Technical readiness but no EO mission in course	At least one EO mission.	1-5 EO missions	> 5 EO missions
		15	Access to third party missions	Not owned nor operated by the country. Either a satellite operator or 3rd party mission/ including meteo.	No access to other missions [no access missions]	Access to less than 5 third party missions.	Access to 5-10 third party missions.	Access to 11-25 third party missions.	Access to over 25 third party missions.
		16	Ground-based facilities	Number of stations.	No capacity for ground-based control elements of EO spacecraft system [no ground-based capacity]	1 ground station	2-5 ground stations	6-10 ground stations	>11 ground stations

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
	In situ component	17	In situ monitoring networks	Number of in situ networks within the country or providing data to international networks.	0 in situ networks.	Up to 5 in situ networks.	Up to 10 in situ networks.	Up to 20 in situ networks.	Over 20 in situ networks.
	Modelling and computing capacities	18	Modelling	Measuring both number and quality of models (i.e. models for atmospheric modelling, what those are, what is the status).	No modelling capacities	TBD	TBD	TBD	TBD OR internationally renowned/ standardized models have been developed within the country.
		19	Computing	Availability of computing processing capacities (high-performance computers: HPC), assessing who these belong to (i.e. total number of organizations with computing capacities) and how advanced they are.	No HPC [no computing capacities]	One institution with HPC facilities for their executions with multiprocessing systems and large external memory units. [one HPC]	Multiple computing resources for the processing and exploitation of EO data for one or more institutions. [between 2 to 10 modelling capacities]	TBD	TBD
	Data exploitation infrastructure	20	EO Data portals and gateways (data access)	Number of data portals originating from the country.	No data portals.	One generic data portal.	Up to 5 (including thematic ones).	Between 6 and 20 (including thematic ones-some serving different communities).	Over 20 (including thematic ones-some serving different communities).

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
		21	Data handling (incl. data cubes)	Tools for data-handling available through portals in the country	Raw data only. (level 0-1A*)	Capability to query and gather various types of data. (level 0-1B*)	Capability to query and gather various types of data and additional tools to ingest additional data. (level 2*)	Capability to do develop services on the portal. (level 2*)	Capability to do develop services on the portal. (level 2*). Data cubes available as well.
		22	Value-added services exploitation platforms (services/advanced products level)	Number of existing VAS exploitation platforms (access to thematic products or services)	No existing platforms.	Up to 5 existing platforms.	6-15 existing platforms.	16-30 existing platforms.	Over 30 existing platforms.
Uptake	Public Sector Uptake	23	EO for policy making	Exploitation of EO as a policy making and policy monitoring tool	EO not used for policy-making and policy-monitoring.	One public service body using EO data for the monitoring status of policies.	2-5 public service bodies using EO data for the monitoring status of policies.	6-10 public service bodies using EO data for the monitoring status of policies.	Over 10 public service bodies using EO data for the monitoring status of policies. EO explicitly mentioned in legislation.
		24	EO for operational public activities	Use of EO in operational activities of governmental agencies (including local and regional, excl. policy)	EO not used for public operational activities.	At least two public service bodies using EO data for operational activities.	5-10 public service bodies using EO data for operational activities.	11-20 public service bodies using EO data for operational activities.	Over 20 public service bodies using EO data for operational activities.
		25	EO Data Sharing	Level of adoption of data sharing practices	Not adopted.	Intra-ministry.	Inter-ministry.	Data sharing between central and regional.	Between any public and private.

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
	Awareness	26	EO focused events	Occurrence of events allowing both awareness (for general audiences) and networking (for specialised audiences) around EO	No data for organised EO events.	Sporadic EO events without clear link or overall agenda.	EO events organised in a focused way to promote specific agendas.	One renowned (at least regionally) periodic EO event.	More than one renowned (at least regionally) periodic EO events.
	Data Uptake	27	Uptake of Copernicus data (or equivalent)	Volume of Copernicus/Sentinel (or equivalent) number of product downloads per year	Less than 1000 products.	Between 1000 and 10 000 products	Between 10k and 500k products	500k-1 million products	Over 1 million products.
Partnerships	Involvement in GEO	28	Financial Contribution	Financial contribution to GEO or to projects/initiatives which are linked to GEOSS	0	<EUR 1k	EUR 1-25k	EUR 26-100k	Over EUR 100k
		29	GEO Flagships	Involvement in GEO Flagships	No involvement in Flagships.	Involvement in 1 flagship.	Involvement in 2 flagships.	Involvement in 3 flagships.	Involvement in 4 flagships.
		30	GEO Initiatives	Involvement in GEO Initiatives	No involvement in GEO initiatives.	Involvement in 1 or 2 initiatives.	Involvement in 3-8 initiatives.	Involvement in more than 8 initiatives.	Leading at least one initiative (and involvement in at least 3 other initiatives)
		31	Provision of data to GEOSS	Volume and quality of datasets contributed to GEOSS	No provision of data to GEOSS.	Plans for provision of data to GEOSS at country level (plans for sharing metadata brokered directly through the GEODAB)	Provision of one to five metadata types brokered directly through GEODAB [1-5 datasets to GEOSS]	Provision of 5 to 15 metadata types brokered directly through GEODAB [6-15 datasets to GEOSS]	Provision of more than 15 metadata types brokered directly through GEODAB and ideally [provision

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
						[plans for data to GEOSS]			>15 datasets to GEOSS]
	Involvement in Copernicus	32	Financial contribution	Financial contribution to the Copernicus programme	None.	Agreement in place.	EU Member State, not contributing through ESA.	EU Member State, and contributing less than EUR 200 M per year through ESA as well.	EU Member State, and contributing over EUR 200 M per year through ESA as well.
		33	Contribution for Copernicus Services Provision	We look into involvement into Copernicus Services for services provision as carried out by public or private organisations within the specific country.	No organisations from the country is involved in provision to Copernicus service component(s).	Less than 5 companies from the country are involved in provision to Copernicus service component(s).	Over 5 companies from the country are involved in provision to Copernicus service component(s).	Over 5/10? companies from the country are involved in provision to Copernicus service component(s), with a clear focus on one of the components.	At least one company from the country is leading the provision for at least one service component.
		34	Copernicus-related R&D projects	Participation into Copernicus-related R&D projects (*within the past 3 years*)	No projects using data from Copernicus [0 projects using Copernicus data]	1-5 projects using data from Copernicus [1-5 projects using Copernicus data]	6-25 projects using data from Copernicus [6-25 projects using Copernicus data]	26-50 projects using data from Copernicus [25-50 projects using Copernicus data]	Over 50 projects using data from Copernicus. [< 50 projects using Copernicus data]
	Participation in other international efforts	35	Involvement in ESA activities or equivalent	Level of involvement implied by the status of ESA member state or ESA cooperating state, and the information beyond these terms.	No involvement.	Involvement through a general Cooperation Agreement.	European Cooperating State.	ESA Member State contributing less than EUR 500 million/year.	ESA Member State contributing more than EUR 500 million/year.

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
		36	Involvement in SDG Reporting	Exploitation of EO as a tool to support SDG reporting (*within the past 3 years*)	No use of EO in monitoring/reporting of SDG´s [no SDGs actions]	Use of EO in reporting on at least in one SDG´s [1 SDGs action]	Use of EO in reporting on more than one action in SDG´s [2-10 SDGs actions]	Active use of EO for reporting on to different actions in SDG´s [11-25 SDGs actions]	Active use of EO for reporting on different actions in SDG´s in the last 3 years [over 25 SDGs actions]
		37	Involvement in other Global Agenda Initiatives	Exploitation of EO as a tool in relevant Global Agenda initiatives and conventions (other than SDGs)	No national strategy to tackle it.		Use of EO in reporting.		Specific EO mention in consolidated country roadmap.
		38	Involvement in UN Ecosystem activities	Country participation to UN EO-focused programmes and relations with UN institutions (UNITAR, UNOSAT, UN-OOSA, UN-SPIDER, UNEP, etc.).	No membership of UN bodies related to Space activities nor participation in UN activities [no participation UN bodies]	Participation in at least one UN [EO activity (events w/g´s) [at least 1 active participation in UN agency/organisation]	Participation (between 2-5 activities) or plans for links to reference UN sites to focus international efforts, facilitate traceability and enable the establishment of measurement 'best practices' and active participation at one of the UN offices [participation in 2-5 UN agencies/organisations]	Active participation in more than 6 of the UN offices [participation in >6 UN agencies/organisations]	Active participation or membership of more than 6 UN bodies / offices related to space activities: in the last 5 years [participation >6 UN agencies/organisations/10 years]

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
		39	Involvement in Spatial Data Infrastructure Efforts	Involvement with Infrastructure for Spatial Information (INSPIRE or other. Possibly monitoring of n. of reports about the implementation and use of their infrastructures for spatial information)	TBD	TBD	TBD	TBD	TBD
		40	Involvement in Standardisation and Interoperability Efforts	Country participation in other international organisations dealing with interoperability, standards, etc such as OGC	Not following programmes on standardisation processes: compatibility, interoperability, safety, repeatability [no engagement with Standardization discussions]	One public or private organisation participating in one of other international organizations dealing with standardisation, interoperability…etc [one organisation engaged with Standardization discussions]	2-5 public or private organisations in the country have fully implemented and developed technical standards for EO [2-5 organizations engage with Standardization discussions]	6-10 public or private organisations participating in an international organisations dealing with standardization, interoperability…etc [6-10 organizations engage with Standardization discussions]	Over 10 public or private organisations are leading standardisation processes [> 10 organizations engage with Standardization discussions]
	Involvement in International R&D efforts	41	IFIs (World Bank, Regional Development Banks, etc.)	R&D funds from IFIs implemented on the country's territory within the past 3 years	None.	Up to 5 projects, all of them small.(<100k)	Small projects and at least two over EUR 250k.	At least two medium projects (>EUR 1 M) present as well.	At least two big projects (>EUR 3 M) present as well.

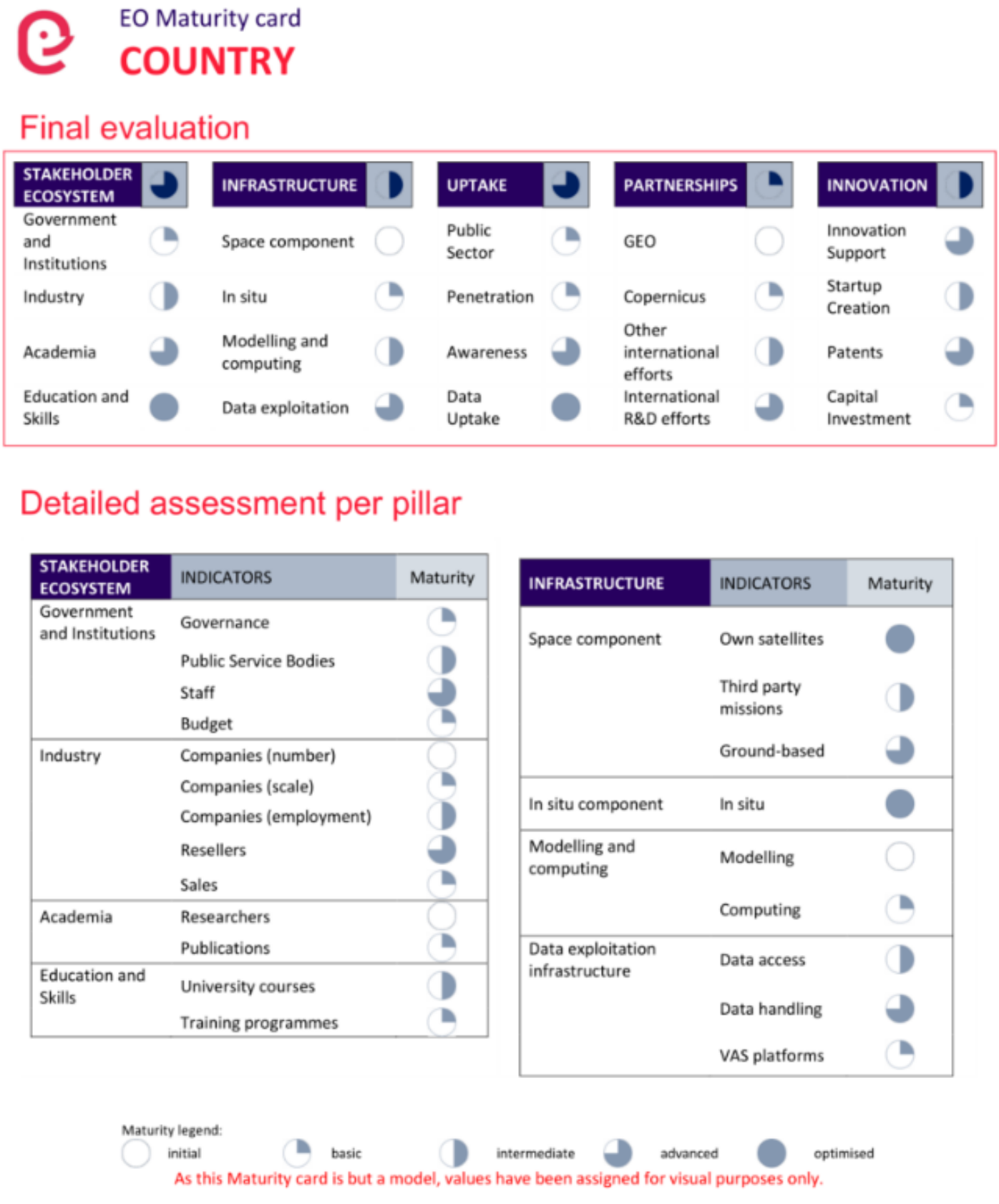
Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
		42	Other funds	Other Projects executed by national actors funded through national or international institutions (other than IFIs) within the past 3 years.	None.	Up to 5 projects, all of them small(<EUR 50k)	Small projects and at least one of them over EUR 100k.	At least two medium projects (>EUR 500k) present as well.	At least two big projects (>EUR 1M) present as well.
Innovation	Innovation Support Mechanisms	43	Clusters or Innovation Hubs	Number of clusters and innovation hubs in a country	No concentration of business activities around EO information [no clusters]	At least one ICT cluster and hubs which could promote innovation and technological development [1 cluster]	2-5 professional cluster and hubs organisations involved in technological transfer and innovation [2-5 clusters]	6-10 clusters and hubs in more than one thematic (EO sector-specific). one cluster with silver impact [6-10 clusters]	Over 10 clusters and hubs in more than one thematic[1] including silver impact and at least one with golden [>10 clusters]
		44	Funding for startups	Amount of available funding for startups	None.	TBD	TBD	TBD	TBD
	Startup Creation	45	Total number of startups	Number of existing startups (*created within the last 3 years*)	0	1-5	6-10	11-20	Over 20
		46	Creation Rate	Creation rate of startups (*for the past year*)	0	1	2-5	6-10	Over 10
		47	Annual Revenue	Average annual revenue of startups	Less than EUR 10k	EUR 10-50k	EUR 51-250k	EUR 251k - 1 M	Over EUR 1 M
	Patents	48	Hardware	Number of patents registered for hardware innovation	No patents registered.	TBD	TBD	TBD	TBD

Pillar	Group of indicators	#	Indicators	Description	0 - initial	1 - basic	2 - intermediate	3 - advanced	4 - optimised
		49	Software	Number of patents registered for software innovation	No patents registered.	TBD	TBD	TBD	TBD
	Capital Investment	50	Venture Funds	Existence of available venture funds	None available.	Less than 3 generic innovation -research related.	4-10 generic innovation -research related.	Over 10 generic innovation -research related.	Over 10 generic innovation - research related. Dedicated EO funds as well.
		51	Capital raised	Amount of investment raised by national players in the space sector	Less than EUR 100k	EUR 100k-1 M	EUR 1-10 M	EUR 10-50 M	Over EUR 100 M

Optional:

Uptake	Penetration		Uptake of EO in key economic sectors [optional]	Operational use of EO in key economic activities within a specific sector (*e.g. agriculture*)	*No uptake.*	*Government uses it for basic activities (Land-cover and land use)*	*Offering access to the private sector via a platform.*	*Prolific use by private sector of the platform.*	*Prolific use by private sector of the platform and building on top of it.*

6.2 Annex II – Proposition for a maturity card for e-shape



EO Maturity card

COUNTRY

Final evaluation

STAKEHOLDER ECOSYSTEM	INFRASTRUCTURE	UPTAKE	PARTNERSHIPS	INNOVATION
Government and Institutions	Space component	Public Sector	GEO	Innovation Support
Industry	In situ	Penetration	Copernicus	Startup Creation
Academia	Modelling and computing	Awareness	Other international efforts	Patents
Education and Skills	Data exploitation	Data Uptake	International R&D efforts	Capital Investment

Detailed assessment per pillar

STAKEHOLDER ECOSYSTEM	INDICATORS	Maturity
Government and Institutions	Governance	
	Public Service Bodies	
	Staff	
	Budget	
Industry	Companies (number)	
	Companies (scale)	
	Companies (employment)	
	Resellers	
	Sales	
Academia	Researchers	
	Publications	
Education and Skills	University courses	
	Training programmes	

INFRASTRUCTURE	INDICATORS	Maturity
Space component	Own satellites	
	Third party missions	
	Ground-based	
In situ component	In situ	
Modelling and computing	Modelling	
	Computing	
Data exploitation infrastructure	Data access	
	Data handling	
	VAS platforms	

Maturity legend: initial · basic · intermediate · advanced · optimised

As this Maturity card is but a model, values have been assigned for visual purposes only.

EO Maturity card
COUNTRY

PARTNERSHIPS	INDICATORS	Maturity
Involvement in GEO	Financial Contribution	
	GEO Flagships	
	GEO Initiatives	
	Provision of data to GEOSS	
Involvement in Copernicus	Financial contribution	
	Copernicus Services Contribution	
	Copernicus-related R&D projects	
Other international efforts	ESA activities or equivalent	
	SDG Reporting	
	Other Global Agenda Initiatives	
	UN Ecosystem activities	
	Spatial Data Infrastructure Efforts	
	Standardisation and Interoperability	
international R&D efforts	EU FPs (or equivalent)	
	Other EU Funding[maybe optional]	
	IFIs	

UPTAKE	INDICATORS	Maturity
Public Sector Uptake	Policy	
	Other governmental activities	
	EO Data Sharing	
Penetration	In key economic sectors [optional]	
Awareness	EO focussed events	
Data Uptake	Copernicus data (or equivalent)	

INNOVATION	INDICATORS	Maturity
Innovation Support	Clusters or Innovation Hubs	
	Funding for startups	
Startup Creation	Total number of startups	
	Creation Rate	
	Annual Revenue	
Patents	Hardware	
	Software	
Capital Investment	Venture Funds	
	Capital raised	

Maturity legend:
initial basic intermediate advanced optimised

As this Maturity card is but a model, values have been assigned for visual purposes only.

EO Maturity card: Sectorial penetration

COUNTRY

Overlook:

AGRICULTURE | HEALTH | ENERGY | ECOSYSTEM | WATER | DISASTERS | CLIMATE

Assessment per sector

SECTOR	INDICATORS	Maturity
AGRICULTURE	Precision agriculture	
	CAP	
	Agri-insurance	
HEALTH	Mercury pollution	
	POPs pollution	
	Urban Health Risks	
ENERGY	Solar	
	Wind	
	Oil&Gas	
	Geothermal	

SECTOR	INDICATORS	Maturity
ECOSYSTEM	Management of protected areas	
	Biodiversity	
WATER	Water quality inland and coastal	
	Floods	
	Monitoring fishing activity	

SECTOR	INDICATORS	Maturity
DISASTERS	Volcanoes	
	Urban disasters	
	Geohazard vulnerability	
	Droughts	
CLIMATE	Carbon and GHG emissions	
	Urban resilience to extreme weather	
	Forestry	
	Hydropower is snow reservoir	
	Seasonal preparedness	

Maturity legend:
initial | basic | intermediate | advanced | optimised

As this Maturity card is but a model, values have been assigned for visual purposes only.

6.3 Annex III – Data Collection under GEO-CRADLE

The GEO-GRADLE collection of data has followed these ten steps as illustrated in the figure below.

1. Indicators collection (1st iteration with country partners);
2. Preparation of country model maturity indicators spreadsheet (one per country);
3. Request for missing data & complementary information (2nd iteration with country partners);
4. Cross check inventory at GEO-CRADLE Networking Platform;
5. Integration of Gap Analysis information;
6. Elaboration of first assessment by level and presentation to country partners to get feedback (3rd iteration with country partners);
7. Request and contact experts in each country (min. 2 and max. 5 experts contacted per country from academia, research, industry & government);
8. Exchange with country experts on the maturity indicators. In some cases, a first assessment (maturity level) was delivered to open discussion and experts commented and provided views;
9. Interpretation of results and average score of the data obtained, media assessment;
10. Elaboration of maturity cards per country.

Figure 6-1 Methodology process steps

Through several iterations with country partners & experts, the data have been collected for each indicator in a single spreadsheet per country before proceeding towards a first maturity level assessment.

Capacities	Pillar	Indicator definition	Sub-indicator	Description	Partner	Government Expert (x,y,z)	Academia Expert (x,y,z)	Industry Expert (x,y,z)	Research Expert (x,y,z)	Gap Analysis	1st assessment Level	Final
Indicator												

Table 6-1 Representing the collection of the data