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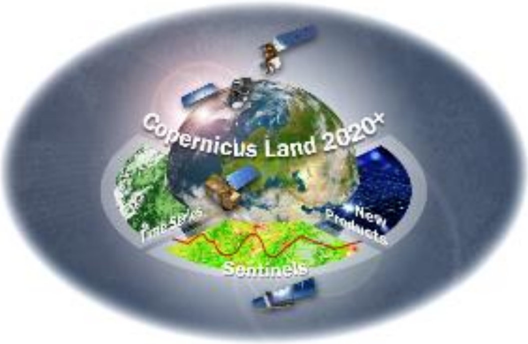
ECoLaSS

Evolution of Copernicus Land Services based on Sentinel data



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Applicable Documents

ID	Document Name / Issue Date
AD01	Horizon 2020 Work Programme 2016 – 2017, 5 iii. Leadership in Enabling and Industrial Technologies – Space. Call: EO-3-2016: Evolution of Copernicus services. Issued: 13.10.2015
AD02	Guidance Document: Research Needs Of Copernicus Operational Services. Final Version issued: 30.10.2015

AD03	Proposal: Evolution of Copernicus Land Services based on Sentinel data. Proposal acronym: ECoLaSS, Proposal number: 730008. Submitted: 03.03.2016
AD04	Grant Agreement – ECoLaSS. Grant Agreement number: 730008 – ECoLaSS – H2020-EO-2016/H2020-EO-2016, Issued: 18.10.2016
AD05	D3.1a – D21.1a - Service Evolution Requirements Report (Issue 1). Issued: 09.08.2017
AD06	D16.2 – D51.1b - Stakeholder Consultation Report (Issue 2). Issued: 20.07.2018
AD07	D17.1 – D52.1a - Report on Candidates for Operational Roll-out (Issue 1). Issued: 21.12.2018

EXECUTIVE SUMMARY

The Horizon 2020 (H2020) project "Evolution of Copernicus Land Services based on Sentinel data" (ECoLaSS) addresses the H2020 Work Programme 5 iii. Leadership in Enabling and Industrial technologies - Space, specifically the Topic EO-3-2016: Evolution of Copernicus services. ECoLaSS is being conducted from 2017–2019 and aims at developing and prototypically demonstrating selected innovative products and methods as candidates for future next-generation operational Copernicus Land Monitoring Service (CLMS) products of the pan-European and Global Components. ECoLaSS assesses the operational readiness of such candidate products and eventually suggests some of these for implementation. This shall enable the key CLMS stakeholders (i.e. mainly the Entrusted European Entities (EEE) EEA and JRC) to take informed decisions on potential procurement as (part of) the next generation of Copernicus Land services from 2020 onwards.

To achieve this goal, ECoLaSS makes full use of dense time series of High-Resolution (HR) Sentinel-2 optical and Sentinel-1 Synthetic Aperture Radar (SAR) data, complemented by Medium-Resolution (MR) Sentinel-3 optical data if needed. Rapidly evolving scientific developments as well as user requirements are continuously analysed in a close stakeholder interaction process, targeting a future pan-European roll-out of new/improved CLMS products, and the potential transferability to global applications.

The ECoLaSS Deliverable D52.1a - Report on Candidates for Operational Roll-out has presented a preliminary assessment of the Copernicus Land Monitoring Service (CLMS) candidate new/improved products which have been selected based on the criteria and procedures specified in WP 52. As next step, a structured process for integration into the CLMS portfolio needs to be investigated and suggested. This is facilitated in WP 53 by the setting-up of the present *Integration Plan into the Copernicus Service Architecture*, which represents one of the main outcomes of ECoLaSS. The current first Issue is provided at the end of the first Reporting Period. Findings are preliminary, and will be consolidated towards the project end in the final Issue of this Deliverable, which will be compiled towards project end, once the consolidated results from the second project phase are available. WP 53 is expected to follow from WP 51 activities and run alongside WP 52, incorporating outcomes of WP 52 when available, but WP 53 activities are expected to run right until the end of the project at T0+36. The integration into the Copernicus service architecture is expected to distinguish two main mechanisms for integrating operational candidate products:

- Products which constitute improvements of existing Copernicus Land products will be easier to integrate, and the related integration strategy will be a matter of assessing mainly whether and how the related improvements can be implemented for the next planned regular update cycle of the products.
- For newly developed products, a careful assessment will need to be undertaken to examine how and when they could be integrated into the then existing Copernicus Land service architecture in terms of availability of respective funds/budget lines, policy relevance and complementarity with other products.

The present Deliverable D53.1 Integration Plan into Copernicus Service Architecture is embedded in the extensive assessment work undertaken in the frame of the project's Task 5 Operationalisation Framework, and primarily aims at providing the basis for informed decisions to be taken by the decision makers on Copernicus, i.e. the EC, the EEEs and the Copernicus User Forum and Copernicus Committee. Furthermore, a high-level concise summary of the ECoLaSS key findings will be presented in the Deliverable D53.2 White Paper on Copernicus Land Evolution.

This present Integration Plan will focus on outlining a roadmap suggestion towards the integration of improved and new products into the Copernicus operational service architecture, with a clear description of the requirements and practical modalities for implementing these products. The consortium acknowledges that funding of the H2020 project in no way commits the Commission or Copernicus service operators to deploy the outcomes from the research in the Copernicus operational services.

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Abbreviations

ARL	Application Readiness Level
BCD	Broadleaved Cover Density
CAP	Common Agricultural Policy
CARL	Communicating and Assessing Readiness Level
CCD	Coniferous Cover Density
CEMS	Copernicus Emergency Management Service
CLC	CORINE Land Cover
CLMS	Copernicus Land Monitoring Services
CORDA	Copernicus Reference Data Access
CORINE	Coordination of Information on the Environment
DIAS	Data and Information Access Service
DLT	Dominant Leaf Type
DLTC	Dominant Leaf Type Change
DSL	Data Score Layer
EC	European Commission
ECoLaSS	Evolution of Copernicus Land Services based on Sentinel data
EEA	European Environment Agency
EEA39	39 member and cooperating countries of the EEA
EEE	Entrusted European Entities
EO	Earth Observation
ESA	European Space Agency
EU	European Union
EU-28	the 28 member states of the European Union
FCC	Forest Cover Change
GFOI	Global Forest Observations Initiative
GIO	GMES Initial Operations
GMES	Global Monitoring for Environment and Security
GRA	Grassland
HRL	High Resolution Layer
IMD	Imperviousness Density
IRS	Indian Remote-Sensing Satellite
ITT	Invitation To Tender
JRC	Joint Research Centre
LPIS	Land Parcel Identification Systems
LUCAS	Land Use/Cover Area frame statistical Survey
NASA	National Aeronautics and Space Administration
RF	Random Forest
S-1	Sentinel-1
S-2	Sentinel-2
S-3	Sentinel-3
SAR	Synthetic Aperture Radar
SDA	Satellite Data Archive
SP	Service Provider
SPOT	Satellite Pour l'Observation de la Terre/Satellite for observation of Earth
TACCC	Transparency, Accuracy, Consistency, Completeness and Comparability
TCCM	Tree Cover Change Mask
TCD	Tree Cover Density
TRL	Technical Readiness Level
WP	Work Package
WPD	Work Package Description

1 Introduction

The ECoLaSS Deliverable D52.1a - Report on Candidates for Operational Roll-out has presented a preliminary assessment of the Copernicus Land Monitoring Service (CLMS) candidate new/improved products which have been selected based on the criteria and procedures specified in WP 52. As next step, a structured process for integration into the CLMS portfolio needs to be investigated and suggested. This is facilitated in WP 53 by the setting-up of the present *Integration Plan into the Copernicus Service Architecture*, which represents one of the main outcomes of ECoLaSS. The current first Issue is provided at the end of the first Reporting Period. Findings are preliminary, and will be consolidated towards the project end in the final Issue of this Deliverable, which will be compiled towards project end, once the consolidated results from the second project phase are available. WP 53 is expected to follow from WP 51 activities and run alongside WP 52, incorporating outcomes of WP 52 when available, but WP 53 activities are expected to run right until the end of the project at T0+36. The integration into the Copernicus service architecture is expected to distinguish two main mechanisms for integrating operational candidate products:

- Products which constitute improvements of existing Copernicus Land products will be easier to integrate, and the related integration strategy will be a matter of assessing mainly whether and how the related improvements can be implemented for the next planned regular update cycle of the products.
- For newly developed products, a careful assessment will need to be undertaken to examine how and when they could be integrated into the then existing Copernicus Land service architecture in terms of availability of respective funds/budget lines, policy relevance and complementarity with other products.

In either case, new products and/or product improvements will need to reach a **Technical Readiness Level (TRL) of at least 7** (cf. section 2.2.1) or a Communicating and Assessing Readiness Levels (CARL) of at least 4-5 (cf. section 2.2.3), which does not only mean that a product definition is mature and a clear methodological path exists to producing it, but also that the infrastructural framework to produce it is secured. This includes notably the availability of **input satellite data**. Another important aspect is related to the availability of required in-situ and other reference data. The progress of the **Copernicus in-situ component** and the related Copernicus Reference Data Access (**CORDA**) are also carefully monitored to ensure relevant data sources are available in time for the integration of these products into the Copernicus Land service architecture.

Under certain circumstances, especially when the infrastructural framework is not yet fully deployed, a **gradual integration** may be envisaged with an initial, **less elaborated** version of the product implemented first and the full product implemented in a next update cycle. For example, an agriculture-related product may be initiated with an annual crop mask product, completed in a next stage by a more detailed identification of main crop types. Considerations related to the innovations' ability for spatially explicit large-scale **geographical coverage** are also taken into account..

The present Deliverable D53.1 Integration Plan into Copernicus Service Architecture is embedded in the extensive assessment work undertaken in the frame of the project's Task 5 Operationalisation Framework, and primarily aims at providing the basis for informed decisions to be taken by the decision makers on Copernicus, i.e. the EC, the EEEs and the Copernicus User Forum and Copernicus Committee. Furthermore, a high-level concise summary of the ECoLaSS key findings will be presented in the Deliverable D53.2 White Paper on Copernicus Land Evolution.

This present Integration Plan will focus on outlining a roadmap suggestion towards the integration of improved and new products into the Copernicus operational service architecture, with a clear description of the requirements and practical modalities for implementing these products. The consortium acknowledges that funding of the H2020 project in no way commits the Commission or Copernicus service operators to deploy the outcomes from the research in the Copernicus operational services.

2 Summary of candidate services for integration

All prototypes have been benchmarked in the report for WP 52. Based on the CLMS evolution requirement priorities, a preliminary list of candidates for operational roll-out has been established based on assessment methodologies detailed in section 2.2. This will be finally consolidated in the second project phase in the course of 2019.

2.1 Service Evolution Requirement priorities

The main focus of the ECoLaSS project is on the pan-European and Global Component aspects of the Copernicus Land Monitoring Service (CLMS), as these are partially closely related, and take into account the respective needs of the key user and stakeholder community. Findings from the Service Evolution Requirements assessment (AD05) and Stakeholders Consultations (AD06) have shown that most of the requirements for evolution of existing services and for next-generation new services could be initially collected for the pan-European CLMS products, i.e., the High Resolution Layers (HRLs) in terms of improvements in information content and timeliness, and CORINE Land Cover (CLC) in terms of development towards CLC+. Requirements for the Global Component were collected from key representatives of the EC's Joint Research Centre (JRC) and other relevant stakeholders, but these are still at a less mature stage of development regarding S-1/S-2 derived thematic products whilst the currently existing Global component portfolio is mainly focused on biophysical products derived from PROBA-V and other Medium-Resolution (MR) EO sensors.

There is generally substantial interest in the use of the High-Resolution Layers and/or a next generation thereof, particularly when equivalent information is not available at national level. But it should be stressed that several users indicated that there is still a lack of awareness about the HRLs, which is hampering their take-up and use. Furthermore, national users showed particularly high interest in products of the Local Copernicus Component, which is clearly related to the higher spatial resolution of the products, better fulfilling the information needs on a regional level and also presumably because these products are thematically closer to those already available locally. There is a general trend towards increased interest in the "raw" Copernicus (Sentinel) satellite data, which was repeatedly mentioned by several users. In terms of specifications, the requirement for shorter update frequencies and change products (incremental updates) was mentioned most often.

Concerning new services, a pan-European Agricultural Service as well as a Phenology Layer were the most frequently recorded responses. A further outcome is a trend towards the desire for more generic or cross-cutting services and products. While it was observed that technical issues and limitations of the CLMS products' (satellite and other) input data, as well as the actual methods for generation of the products are not of major concern to the users, it was also found that (depending on the individual user) the knowledge of specifications of the existing products and metadata is in general rather limited. Requests for obtaining more information on the products and metadata was voiced several times. Additionally, a general requirement for an easier and standardized access to data, products and documentation, on a unified access portal, was repeatedly stated, including the desire for a multi-layer online visualization and/or evaluation tool for the products.

2.2 Evaluation methodologies

Various methodologies exist to assess the maturity, operationality or operational integration capability of a technology. Three are reviewed in this section, in order to facilitate the selection of the ECoLaSS prototypes deemed operational for their integration into the CLMS.

2.2.1 Technology Readiness Levels (TRLs)

The TRL scale was developed in the 70s by NASA to assess the degree of maturity of a technology before integrating it into a broader operational system, and are implemented as an innovation tool policy by the

European Union (EU) (Héder, 2017). The first version of this scale contained 7 levels, and nowadays 9 levels are used, which are detailed in Table 1.

Table 1 - Definition of each TRL

Phase		Level	Description
-	System Test, Launch & Operations	**TRL 9**	Actual system proven in operational environment
System/ Subsystem Development		**TRL 8**	System complete and qualified
	-	**TRL 7**	System prototype demonstration in operational environment
	Technology Demonstration	**TRL 6**	Technology demonstrated in relevant environment
Technology Development		**TRL 5**	Laboratory testing of integrating system validated
	-	**TRL 4**	Technology component or process validated in laboratory
	Research to Prove Feasibility	**TRL 3**	Critical function, experimental proof of concept established
Basic Technology Research		**TRL 2**	Applied Research: technology concept and/or application formulated
	-	**TRL 1**	Basic Research: basic principles are observed and reported

TRL 1: Lowest technology degree of maturity

The scientific research is only starting to be translated into applied research and development. Paper study regarding basic properties of the considered technology can be seen as an example.

TRL 2: Technology concept and/or application formulated

Practical applications are envisioned, even though they remain speculative. Examples are limited to analytic studies and experimentation.

TRL 3: Proof of concept established

Active research and development is launched, with laboratory studies initiated to validate analytical assumptions on separate components of the technology. Those components are not yet integrated or representative.

TRL 4: Testing of prototype component in laboratory

Components of the technology are integrated and combined to check their ability to function together. They are not representative of the eventual final system. Examples are ad hoc elements integrated together in laboratory experiments.

TRL 5: Testing of the integrated system

Components are combined together in a realistic effort to test them in a simulated environment. The prototype is far closer to the eventual system.

TRL 6: Prototype system validated in a relevant environment

The prototype, which is already well beyond the level 5, is tested in a relevant environment – which represents a clear demonstration of the maturity of the technology.

TRL 7: Demonstration of the integrated pilot system

The prototype is close to the planned operational system level, and its design is close to the final system. Tests are carried out in an operational environment. Engineering and/or manufacturing risks are largely removed.

TRL 8: System incorporated in a commercial design

The technology has been proven to work in its final form, and in the expected conditions. This level is usually the end of real system development.

TRL 9: System ready for full scale deployment

The technology has reached its final form for operational deployment. The product or process is ready to be eventually launched commercially and marketed.

The TRL scale provides a valuable tool to unify the understanding of the technology status and to conduct a risk management. However, the "readiness" does not translate exactly the technology maturity, and the evaluation still remains somewhat subjective.

2.2.2 Application Readiness Levels (ARLs)

This scale is an adaption of the TRLs adopted by the National Aeronautics and Space Administration (NASA) to track and manage the progression and deployment of funded projects. It aims at better reflecting the three stages of project research, development and deployment. Each level is detailed in Table 2.

Table 2 - Definition of each ARL

Description	Level	
Phase III: Integration into Partner's System	**ARL 9**	Approved, Operational Deployment and Use in Decision Making: Sustained Use
	ARL 8	Application Completed and Qualified: Functionality Proven
	ARL 7	Application Prototype in Partner's Decision Making: Functionality Demonstrated
Phase II: Development, Testing and Validation	**ARL 6**	Demonstration in Relevant Environment: Potential Demonstrated
	ARL 5	Validation in Relevant Environment: Potential Determined
	ARL 4	Initial Integration and Verification: Prototype and Plan
Phase I: Discovery and Feasibility	**ARL 3**	Proof of Application Concept: Viability Established
	ARL 2	Application Concept: invention
	ARL 1	Basic Research: baseline ideas

For each ARL, a specific list of methods, availability of data and application scale is provided as guidance for evaluation.

ARL 1: Basic Research

- Developed ideas should highlight how specific research results could enhance decision making.
- The baseline support research is identified and documented.

ARL 2: Technology concept and/or application formulated

- Independent application components are formulated and created.
- Decision making activity that will be improved by the application are identified.
- A better characterization of the decision making activity is planned.

ARL 3: PROOF OF APPLICATION CONCEPT

- Each component of the application is tested and independently validated.
- Limitations, mechanisms of the user decision making process are detailed.
- Case of the viability of the application is established.

ARL 4: INITIAL INTEGRATION AND VERIFICATION

- Technical integration issues arising from the combination of system components are worked out.
- Organizational challenges and human process issues are identified and managed.

ARL 5: VALIDATION IN RELEVANT ENVIRONMENT

- The potential of improvement for the decision making activity brought by the application is articulated.
- The combination of system components is evolved in a functioning prototype with realistic supporting elements.

ARL 6: DEMONSTRATION IN RELEVANT ENVIRONMENT

- Prototype application is beta-tested in a simulated operational environment.
- Projected improvements on performance of decision making activity are demonstrated.

ARL 7: APPLICATION PROTOTYPE IN PARTNER'S DECISION MAKING

- Prototype application system is integrated into the end user's operational environment.
- Functionality of the prototype is tested and demonstrated in the decision making activity.

ARL 8: APPLICATION COMPLETED AND QUALIFIED

- The application is finalized and shown to behave as expected in the user environment.
- The application is approved by the user for the decision making activity.
- Training and user documentation can be provided.

ARL 9: APPROVED, OPERATIONAL DEPLOYMENT AND USE IN DECISION MAKING

- The application is sustainably used in the decision making activity.

2.2.3 Communicating and Assessing Readiness Levels (CARLs)

The CARL framework, as detailed in **Table** 3, has been based on TRLs and the concept expanded in the project Global Forest Observations Initiative (GFOI). It aims at prioritising investment in research and development, through a mechanism managing the research and development activities, and facilitating the communication about the contribution of the work to the users.

Table 3 - Details of each CARL

Description	Level	
Operational	CARL 6	Technology successfully and sustainably use in operational environments
	CARL 5	Demonstration in an operational environment
Pre-operational	CARL 4	Demonstration in a larger-scale environment
	CARL 3	Demonstration in a small-scale environment
Research	CARL 2	Analytical and experimental function and/or proof of concept
	CARL 1	Basic principles are observed, and technology concept and/or application formulated

CARL 1: BASIC RESEARCH

- Methods: Development of new methods
- Availability of data: Concept for the data acquisition developed
- Application Scale: Research environment

CARL 2: TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED

- Methods: Demonstrated, validated and scientifically published
- Availability of data: Small-scale data available
- Application Scale: Research environment

CARL 3: PROOF OF APPLICATION CONCEPT

- Methods: The prototype is available and used by groups of experts, the source of uncertainties are known and quantified
- Availability of data: Small-scale data available
- Application Scale: Research environment

CARL 4: INITIAL INTEGRATION AND VERIFICATION

- Methods: The prototype is available and used by groups of experts, the source of uncertainties are known and quantified
- Availability of data: Large scale data available
- Application Scale: Training materials and guidance documents are developed and tested in countries

CARL 5: VALIDATION IN RELEVANT ENVIRONMENT

- Methods: Available to be implemented by countries, meeting the Transparency, Accuracy, Consistency, Completeness and Comparability (TACCC) criteria
- Availability of data: Acquisition is done in consistent and sustainable manner for routine national monitoring
- Application Scale: Active implementation and capacity in mandated country monitoring organizations

CARL 6: DEMONSTRATION IN RELEVANT ENVIRONMENT

- Methods: Available to be implemented by countries, meeting the TACCC criteria
- Availability of data: Acquisition is done in consistent and sustainable manner for routine national monitoring
- Application Scale: Data and methods are used in reporting in countries

Advantages of the CARL scale can be listed as:
- Consistency in the assessment of technology or method status;
- Prioritisation of Research and Development activities;
- Enhancement of communications.

The evaluation can still be qualified as subjective, but the criteria of assessment are clearer than the TRL and ARL scales.

2.3 Evaluation of Phase I prototypes

The prototypes can be assessed following the work done in the report D52.1a Report on Candidates for Operational Roll-out (AD07), specifically the identification of prototypes and the benchmarking evaluation, focusing in particular on the evaluation along the criteria:

- Answering identified needs;
- State of the art and innovation;
- Maturity;
- Adequate Earth Observations (EO) availability;
- Adequate in-situ availability;
- Processing capacity;
- Automation level;
- Roll-out potential;
- Documentation.

The respective evaluation in view of CARLs can be seen in Table 4.

All status layers – Imperviousness Density (IMD), Dominant Leaf Type (DLT), Grassland (GRA) – already present in the CLMS portfolio, have been demonstrated to be operational, hence a CARL level 5 assessment result, since fine-tuning is required to fully integrate the improvements made into the services. However, yearly incremental updates still require further work to reach an active implementation over Europe and can only be evaluated to CARL level 4.

The crop mask status layer benefits from a better evaluation for the availability of in-situ data, since the combination of national Land Parcel Identification Systems (LPIS) and Land Use/Cover Area frame statistical Survey (LUCAS) database facilitate identification of arable lands, however, without every specificity regarding type of culture, hence a rating of 4 for the crop mask and 3 for the crop type layer.

The still evolving specifications for the CORINE Land Cover + (CLC+) prototype cannot allow a clear definition of the source of uncertainties, thus a lower CARL rating of 2.

Time series indicator related layers for crop growth condition and emergence date map rely on data available at small-scale, as demonstrated over the African sites. The prototypes for generic land cover metrics and multi-annual trends and potential change both also lack large-scale in-situ data. They are therefore rated at CARL level 3, except for the Generic Land Cover Metrics, since it has not been delivered in Phase I, due to the absence of a validation process, and therefore is rated at CARL level 2.

Table 4 - Assessment of prototypes following the CARL framework.

	Prototype	CARLs
WP 41 Time series indicator	Crop growth condition	3
	Crop Emergence Date Map	3
	Generic Land Cover Metrics	2
	Multi-annual trends & potential change	3
WP 42 Imperviousness incremental update	**Improved IMD status layer at 10m**	**5**
	Incremental IMD change	**4**
WP 42 Forest incremental update	**Improved DLT status layer at 10m**	**5**
	Incremental forest cover change	**4**
WP 43 Improved Grassland	**Improved Grassland status layer at 10m**	**5**
WP 44 New Agriculture product	**New crop mask status layer at 10m**	**4**
	New crop type status layer at 10m	3
WP 45 New Products	CLC evolution	2

2.4 Candidate services for operational roll-out

Most of the activities during Phase 1 of ECoLaSS have focused on the improvement of existing products and on the development of new products. However, as scheduled, new products are at an earlier stage and further work during phase 2 is required before most of the developments made may be fully considered candidates for full operational roll-out. Therefore, at the current stage of this Integration Plan, only the following products and services could/should be considered:

- WP 42**: Imperviousness incremental update:** (i) improved IMD status layer at 10m; (ii) incremental IMD change 2015-17[1] at 20m
- WP 42**: Forest incremental update:** (i) improved DLT status layer at 10m; (ii) incremental forest cover change 2015-17[1] at 20m
- WP 43: **Improved Grassland:** Improved Grassland status layer at 10m
- WP 44: **New Agricultural product:** (i) New crop mask status layer at 10m; (ii) New crop type status layer at 10m. Specifically the crop type product is subject to still unclear political support from Member States.

Overall, in terms of existing products, evolution steps are suggested with respect to improved temporal and spatial resolution and no changes are envisaged currently with respect to thematic content evolution potential as this will be cassessed during Phase 2. However, the workflow and methodologies have been adapted to take full advantage of the improved Sentinel resolution and characteristics and improve the robustness and reproducibility of the products with less need for manual enhancements. The Imperviousness and Forest layer incremental updates will combine the change of resolution of the status layer from 20 to 10m, taking full advantage of the improved S-2 resolution, whilst it is suggested that the change layer is kept at 20m resolution at the moment to maintain compatibility with the existing 2015 status layer and avoid introducing too many technical changes due to the improved resolution. With respect to the Grassland layer, the main change envisaged is to move from 20 to 10m.

[1] Most of the EO input data used for deriving the HRL status layer products of the reference year 2015 had actually been from the calendar year 2016, since Sentinel-2 data become operationally available only since then. Therefore, the investigated reference year period 2015-17 can actually be considered to be de-facto a 1year period only, i.e. 2016-17.

3 Integration Plan for Candidate Services into the Copernicus Service Architecture

The following sections are organised according to each product selected as candidates for the operational roll-out in the benchmarking phase, as detailed and complemented also in the previous sections of this report.

3.1 Imperviousness

Since the production of the HRL IMD 2006, a time series of imperviousness has been delivered for the reference years 2009 (under the FP7 geoland2 project), 2012 (under the GMES Initial Operations (GIO)), and 2015 (as part of the operational CLMS). For each of these iterations the results contain two products: a status layer for any reference year (e.g. IMD2012), as well as an imperviousness density change layer between reference years (e.g. IMC2009-2012) and based on the already existing imperviousness product for that previous reference year.

3.1.1 Prototype Description and Rationale

The main deliverable, for the years 2006 to 2015, was a raster dataset of continuous degree of soil sealing ranging from 0 – 100 % in full spatial resolution (20 m x 20 m) with the associated metadata. A derived product, a raster dataset of continuous degree of soil sealing ranging from 0 - 100% in aggregated spatial resolution (100 m x 100 m) in European projection was generated.
Several improvements have been tested and prototyped during the first phase of ECoLaSS, and even integrated in the new ITT for the HR Layers of the reference year 2018.

3.1.1.1 Definition of prototype

The main improvements envisaged and tested for the imperviousness product during phase 1 of ECoLaSS was to take full advantage of the S-2 constellation resulting in the following main outcomes:

- Improved more automated and generic workflow combining the S-2 and S-1 data streams although further work is still required to take full advantage of S-1
- Improved temporal frequency with the potential of yearly updates and 10m spatial resolution

The prototypes tested during phase 1 of the project both covered an improved status layer at 10m resolution and an incremental update layer at 20m. The reason for not immediately moving to a 20m resolution are highlighted in D10.1_D35.1a in which a detailed assessment of the changes detected by the new improved S-2 based workflow had shown that nearly 75% of them could be attributed to omissions from the previous period. This was also confirmed as part of the prototype implementation in WP42 with figures of a similar magnitude obtained.

This does not mean that the previous HRL2015 status layer was incorrect, but that the change of resolution from a predominantly Landsat, SPOT and IRS based HRL2015 to an improved 10m S-2 based HRL2017 result in the detection of many previously undetected small urban areas. Therefore, a 10m resolution based incremental update does not make sense at this stage and a 20m layer should avoid in resulting in too many technical changes due to the improved spatial resolution.

Yearly incremental updates should be possible, but will require the combined use of S-1 and S-2 especially in cloud prone areas. In addition, it should be noticed that there is a trade-off between the magnitude of change and the resulting accuracy of the change detection. In other words, the smaller the time interval between updates, the less changes will have occurred and the less accurate the resulting change map will be.

Newly improved status layers at 10m resolution are deemed to have reached a TRL of 8 if based on S-2 only and probably 7 when using S-1 and S-2 in combination, but change layers are more at a TRL of 6-7 considered that there is still much to be improved in terms of accurate and unbiased change detection. This is mainly due to the fact that the magnitude of expected changes is below the accuracy of the status layers for each date within the time interval considered. Therefore, when changes are detected between T1 and T2, these can be:

- Omissions from T1
- Actual changes between T1 and T2
- New commission errors from T2

An iterative procedure was developed to minimise this, but this requires the re-processing of the T1 status layer or at the very least of the imagery used to produce the T1 status layer to ensure consistent changes. It is not possible to re-analyse the entire time series every time a new update is produced, but it is strongly suggested, that at the very least, the specifications of the change layers should include the identification of omission errors from the T1 status layer.

3.1.1.2 Evolution of requirements as foreseen in the HRL 2018 ITT

Specifications for the HRL, in particular the IMP layer, have evolved, as detailed in the ITT for the 2018 reference year HRLs, for the following products:

- The imperviousness status product, with an increased spatial resolution from 20m to 10m;
- A continuation of the imperviousness change layer between 2015 and 2018, at a stable spatial resolution of 20m, in order to smooth the transition.

It should thus be noted that, even before the end of the current Horizon 2020 research efforts are ended, the evolutions tested and prototyped in the project ECoLaSS have been positively deemed operational at a pan-European scale and will be implemented in the new HRLs for the reference year 2018.

It should be further noted that a new component has been added to the requirements of the 2018 ITT: a built-up status layer, at a spatial resolution of 10m, which has also been planned in the project ECoLaSS and will be tested and prototyped in the Phase 2.

3.1.1.3 Service Use cases

The improved spatial resolution should bring the following benefits to users and other Copernicus services:

- The 20m layer often did not have a sufficient level of detail for many users at regional or local level, the 10m layer represent an improvement by a factor of 4 (or even more when considering that 23m or even 30m image data was used as input previously) which should better relate to the level of details that is often required
- It should also be better adapted to determine density classes as part of the local component with a better correspondence to the level of details often required.

The improved temporal resolution is not necessarily required considering the magnitude of change. However, yearly incremental updates will:

- automatically reduce the time required to produce these updates. There was always a requirement to reduce the time needed between the reference year and when the product is actually delivered. Currently, the production time was reduced from nearly 3 years for 2012 to just over one year for 2015 without taking into account the time needed to initiate and finalize the tendering process.
- Be more adapted to a wide range of uses for which the reference year is not necessarily aligned with that of CLMS.

3.1.2 Technical Infrastructure Constraints/Requirements for integration

WP22 and WP35 highlighted that relying solely on S-2 would probably not allow the provision of yearly incremental update for the whole of Europe and that S-1 will also need to be used.

In situ data is mainly needed in terms of provision of topographic reference data and road network for stratification purposes and VHR image data (from the ESA Copernicus SDA) for calibration and validation purposes. The selection of training data for the update of the built-up mask can be extracted from the existing layer for the previous reference year. As such, national reference is not sufficiently easily available at EEA39 level to be used, but this could change if accessibility and homogeneity of available layers is improved in the future.

Currently, the HRL Imperviousness is completely produced using Service Providers' infrastructure. It is understood that for the time being the DIAS infrastructure is mostly targeting downstream applications and is not focusing on the production of core services. Therefore, under the current conditions, core services would be seen as an additional power user. In addition, the producing structure is not yet fully clear and time will be needed to see whether it is adapted for the production of very large areas such as for the pan-European component. It may be envisaged that a separate procurement procedure will be organised to identify a suitable DIAS by EEEs for the implementation of their core service(s), but this is not yet clear.

Finally, there is another argument for which it is perhaps better to wait before the full production can be transferred to the DIAS, which is linked to the lack of fully stabilised S-2 Level 2A products. This means that the production of the Imperviousness layer still relies heavily on the bespoke pre-processing of image data. This increases the storage costs as the S-2 data will need to be duplicated and makes the use of the DIAS infrastructure probably less attractive although this would need to be carefully assessed.

It should be noted that using a DIAS for the production of the HRL for the reference year 2018 was strongly encouraged in the tender. A supplemental step for the SPs should then be to assess the availability of the S-2 Level 2A products before the start of the production and should those products be unavailable or of inadequate quality, a potential dimensioning of a pre-processing phase, as well as a matching storage cost anticipation, would have to be envisioned.

3.1.3 Political Framework, Roadmap and Potential Timing for Integration

The Imperviousness layer was the precursor and first initial implementation for 2006 of what was to become the CLMS pan-European component and the political framework is already well established. The improvements to the imperviousness are directly in the continuity of the existing layer and are already partially implemented as part of the 2018 updates. Further improvements will be tested as part of phase 2 of the project that can be implemented post 2020.

The mechanisms for stakeholder decision and implementation are not expected to be critical as these improvements are already in line with some of the improvements already envisaged as part of the 2018 update.

It is suggested that the 3-year cycle is kept until 2021, with yearly incremental updates implemented gradually with a 2023 update followed by a 2024 and then an onward yearly cycle. A gradual implementation of the yearly incremental update is suggested with potentially a change in the procurement procedures from framework contracts specific to a reference year to multi-annual framework contracts similar to what is already implemented as part of the CLMS Global component or the CEMS.

3.2 Forest

In 2012, the HRL Forest became (initially) operational on pan-European level as part of the GIO phase. Following a 3-years update cycle, forest products for the EEA39 have been updated for the reference year 2015 with an extended product portfolio including first (experimental) change products. In July 2018, the ITT for the second update cycle with reference year 2018 and improved products has been published.

This section is about the specific integration plan for the Forest prototypes produced in phase 1 of ECoLaSS into the Service Architecture of the Copernicus Land Monitoring Service. Therefore, the Prototype Description and Rationale as well as the Technical Infrastructure Constraints/Requirements for integration as well as the Political Framework, suggested roadmap and Potential Timing for Integration are described.

3.2.1 Prototype Description and Rationale

In the following three subsections, information on the Forest prototypes is provided. They focus on the definition of the prototype and the evolution of requirements as foreseen in the ITT 2018, followed by some Service Use Cases.

3.2.1.1 Definition of Prototype

The prototypes for forest are based on the existing HRL2015 Forest product definitions and aim at delivering improved production concepts and enhanced products while considering various user requirements regarding the input EO/ancillary data base applied, the speed of HRL production and enhanced forest data characteristics. In detail, this means that for the production of the prototypes the complete Sentinel-2A+B and Sentinel-1 time series were used by applying an improved level of automation to allow a faster production and thereby shorter monitoring intervals. By the combined use of SAR and optical data it was not only possible to benefit from the multi-sensor characteristics but to additionally overcome the potential regional shortness of the optical time series due to cloud cover. The thematic classification accuracy has been improved by using spatio-temporal features, but also because of the increased spatial resolution from 20m to 10m (in case of the DLT), which is providing much more spatial details in general.

Two prototypes have been developed related to the HRL Forest: an improved DLT status layer at 10m spatial resolution and an incremental update layer at 20m spatial resolution. The automated approach designed for an improved DLT status layer uses spatio-temporal features and a new automated reference sampling approach. The supervised Random Forest (RF) classifier has been selected as classification algorithm for prototype implementation. The approach demonstrated the potential for a highly automatic DLT status layer generation at 10m spatial resolution without manual enhancement, resulting in promising accuracy figures. In addition, the applied classification workflow could be successfully improved, a higher degree of automation could be reached.

A map-to-map change detection approach has been tested in the first project phase for the incremental update layer at 20m spatial resolution to ensure continuity with the precursor HRL 2015 products. The Incremental Update layer or “Forest Cover Change (FCC)” layer compares the HRL2015 and HRL2017 products to detect areas of forest loss. Due to the very short time interval between the two masks (de-facto 2016 vs. 2017, cf. Footnote 1), the layer concentrates on negative changes (loss) only. Due to shortcomings in the 2015 mask and the used Sentinel-2 data, a MMU of 3ha has preliminarily been applied to the final map to allow focusing on forest loss with high reliability. This is expected to significantly decrease in the second project phase.

The improved DLT status layer at 10m has already proven its high level of readiness and has been assessed with a TRL of 7-8 and a CARL of 5, whereas the 20m incremental update layer is currently assessed with a lower level of operational readiness, i.e. a TRL of 5-6 and a CARL of 4.

3.2.1.2 Evolution of requirements as foreseen in the HRL 2018 ITT

The service evolution towards an increased spatial resolution of 10m was part of the ECoLaSS prototype development, and is now a strict requirement for the new HRL2018 Forest status layers. Another aspect that is part of the HRL2018 is the combined use of SAR and optical data, which has been tested in the first project phase of ECoLaSS and which will be implemented in the second phase of ECoLaSS. The multi-temporal approach based on time-features forms another aspect relevant for implementation of the HRL2018.

In case of change products, it should be noted that the 2018 ITT asks for simplified change products at 20m spatial resolution (Dominant Leaf Type Change (DLTC) and Tree Cover Change Mask (TCCM) within a 3-years update cycle), whereas the ECoLaSS prototype is already a step further by assessing an incremental update on annual basis at 20m resolution. For the second project phase, an update based on the 2017/2018 status layers at 10m resolution with an improved MMU is planned.

It should be further noted that some new components have been added to the requirements of the 2018 ITT: aggregated dominant leaf type products at 100m spatial resolution, namely the Broadleaved Cover Density (BCD) and the Coniferous Cover Density (CCD) layer. However, as per their definitions, no significant development work is needed to implement these. Besides, the primary status layers have to be provided together with a series of quality and confidence layers, which are actually only addressed in form of the Data Score Layer (DSL) within ECoLaSS.

3.2.1.3 Service Use Cases

One of the findings of WP 35 (Time Series Consistency) was that it is difficult to reliably identify tree cover changes (both gain and loss) with a yearly update cycle, since (i) the trees' regrowth rates are typically slow and cannot be captured in such short time intervals, and (ii) in "normal" years, the spatial extent of tree cover losses (e.g. due to clear cuts or forest damages) is limited compared to the amount of detectable "technical changes" due to increased spatial resolution and temporal frequency of the EO input data, improved methodologies, etc. Therefore, it is recommended to focus for potential yearly incremental updates on the tree cover extent, i.e. the forest mask which would include primarily rapid (negative) changes. For monitoring the changes in forest characteristics/properties (such as dominant leaf type and tree cover density), the currently practiced 3-yearly update cycle should be maintained. Consequently, the temporal aspect covered by ECoLaSS, considering a yearly incremental update, can be rated as an improvement of the latest forest change product definitions of the HRL 2018 ITT, which are maintaining the current 3-years monitoring interval (2015-2018).

However, with the improved spatial resolution of 10m, much more spatial detail of forest internal structures and leaf type composition will be provided to the users at simultaneously increased geometric and thematic accuracy. Considering the potentially shorter production times, a series of requirements is being addressed, enabling users to valorise the improved 10m products for their specific tasks (e.g. forest monitoring systems at regional level) or applications in the Downstream Sector.

With respect to the Copernicus Land Monitoring Service, the DLT and upcoming TCD products at 10m spatial resolution will provide more reliable information with much more spatial detail. Consequently, they are partially better suited to serve as complementary data source to products of the local component (e.g. LC/LU product of the Riparian Zones by determining specific forest density classes). Moreover, they can provide complementary information on land cover characteristics to other High Resolution Layers and can be generally used to improve their thematic quality (e.g. by a gradual semi-automatic plausibility analysis).

3.2.2 Technical Infrastructure Constraints/Requirements for integration

With the launch and operation of the Sentinel family, together with other established systems such as Landsat, massive EO data sets have become available to the users. In order to cope with these large data volumes, adequate resources (storage and processing units) need to be in place. In the past, these resources have been often provided by the service providers themselves as part of their own IT infrastructure.

However, the ever increasing requirements of the EEEs and the Copernicus user community towards future Copernicus products require the integration of even more EO data plus suitable in-situ data sets. Consequently, respective storage and processing costs need to be properly considered in the budget planning.

Cloud-based storage solutions and processing platforms (e.g. DIASes) are just in place, aiming at providing (highly) automated processing environments for product generation with a satisfactory cost-benefit ratio. Thanks to these solutions, storage capacity issues seem to be things of the past. On the other hand, the assessment of the cost-benefit ratio in terms of storage and processing costs has just started and will need to be followed up in the second project phase.

3.2.3 Political Framework, Roadmap and Potential Timing for Integration

As part of the CLMS pan-European component, the HRL Forest became operational in 2012 and was, alongside the Imperviousness layer, the most mature layer at High Resolution and pan-European level. Lessons learned from the productions 2012 and 2015 have been picked up in the new HRL ITT for the reference year 2018, like several improvements tested and demonstrated by ECoLaSS (except the incremental update) which have already become part of the 2018 update.

After six years of CLMS operationality, the political framework is well established and the mechanisms for stakeholder decision and implementation are not expected to be critical as the ECoLaSS improvements suggested for the HRL Forest are in line with the improvements becoming already part of the 2018 update, and can be conceived as the continuation in the further future.

Even though the Incremental Update as demonstrated in phase 1 of ECoLaSS has not reached its aimed technical excellence yet, further improvements will be tested in phase 2. The future roll-out-potential and benefit is estimated positive and it is assumed that an Incremental Update could be established post 2020.

It is suggested that also for the HRL Forest products, the 3-year cycle is kept until 2021, with yearly incremental updates implemented gradually with a 2023 update followed by a 2024 and then an onward yearly cycle.

3.3 Grassland

In 2015, the first HRL Grassland layer was produced for all EEA39 countries. The product included an operational pan-European grassland map and two expert products: the ploughing indicator and a grass vegetation probability index. In summer 2018, the new HRL2018 ITT was published with improved product requirements and a new change product. Product generation will start in 2019 with a production timeline of 18 months.
The present section describes the specific plan for an integration of the Grassland prototype “improved permanent grassland identification” that was tested and demonstrated in phase 1 of the ECoLaSS project into the operational service architecture of the Copernicus Land Monitoring Service. In the following, the grassland prototype developed is presented and the required technical infrastructure and its constraints for an integration are explained. This is followed by a short analysis of the political framework and potential timing for integration.

3.3.1 Prototype Description and Rationale

In the following subsections, information on the Grassland prototype is provided. The chapter focuses on the definition of the prototype, the evolution of requirements as foreseen in the HRL ITT 2018 and service use cases.

3.3.1.1 Definition of prototype

The ECoLaSS grassland prototype aims at improving the currently used methods and products of the HRL2015 Grassland. For this purpose, the use of EO input data, the data analysis approaches, the automation of processes and the development of new products which are of great interest for users are the subject of the targeted enhancements. Regarding the input data, the required use of complete Sentinel-1 and Sentinel-2 time series has been addressed in order to provide a seamless, spatially complete product with a maximum degree of reduction of data gaps due to cloud cover. Furthermore, the level of automation of the processes and the product accuracy have been significantly increased. A lot of effort has been undertaken to further investigate a more detailed distinction between grassland vs. cropland.
The outcome is an improved status layer with a spatial resolution of 10m derived from specific time features and indices. As data base for this classification both, optical and SAR time series from 2017, and several in-situ data for validation and training purposes were used. Based on the Sentinel-1/2 data, time features for different time steps have been derived and the best fitting ones have been selected as input for the actual classification. The applied algorithm for the subsequent classification is the Random Forest classifier that has been found achieving the most accurate results and offering a high level of automation.

3.3.1.2 Evolution of requirements as foreseen in the HRL 2018 ITT

Since the establishment of an operational HR Grassland layer in 2015, the service and its products have evolved. The changes established with the HRL2018 ITT particularly concern the spatial resolution of the grassland status layer, which has been increased from 20m to 10 m. In parallel, the minimum mapping unit was changed from 1ha to 1 pixel. Both adaptations aim at enhancing the spatial detail of the grassland map in order to support a broader use of the service. A multi-temporal approach based on an integrated optical/SAR-based processing chain using the entire S-1 and S-2 archives instead of a pre-selection of best-suited acquisitions as applied for the HRL2015 approach, will be another important aspect of the HRL Grassland 2018. This shall lead to a complete dataset with improved regional quality and higher reliability. Additionally, new products are requested: a HRL2018 Grassland Change 2015-2018 map, a confidence layer and optionally, a prototype for grassland use intensities. Also products on phenology are of high interest, but not yet required as a delivery.

While the feasibility of a spatial resolution of 10m was already tested and demonstrated in the first phase of the ECoLaSS project, a minimum mapping unit is still applied but foreseen to be reduced from 1 ha to 0.5 ha in the second phase of the project. The ECoLaSS grassland prototype developed in phase 1 was based on complete S-1 and S-2 archives and an integrated classification approach that utilizes time features and an optimized sample selection procedure. The achieved results demonstrated the positive effects of this adapted approach in view of an increased thematic quality of the grassland map and level of automation. Concerning new product requirements, methodologies to derive a change layer (2015-2018 and 2017-2018) and approaches to discriminate between intensively and extensively used grassland will be addressed in ECoLaSS phase 2.

3.3.1.3 Service Use cases

The improved requirements addressed by ECoLaSS are expected to bring the following benefits to users and other Copernicus services:

- With the enhanced 10m spatial resolution and MMU, much more detail in terms of grassland cover and grassland structures will be identified, at increased geometric and thematic accuracy. This facilitates the use of the products and services for Downstream Services;
- Processing of full Sentinel archives raises overall and regional product quality and ensures a higher data reliability. Both aspects increase the capability of including the products and services as a standard in other applications and are expected to facilitate their use in ecosystem accounting as well as EEA/EU assessment work;
- The methodologies applied focus on a higher degree of automation that will lead to shorter production times, as required by the users.

- The change layer addressed in ECoLaSS phase 2 is a first step towards a yearly update that would allow for quantifying areas and changes (losses). However, change detection of grassland is challenging due to the high variability of this land cover class's appearance and the various grassland uses. For this reason, the testing in phase 2 will examine to what extent annual analyses are meaningful, or if trends towards regional changes/losses derived from longer time series are more relevant.
- Separation between extensively and intensively used grassland and related change/conversion of these management classes is a highly relevant information for biodiversity and related environmental goals. Therefore an effort will be made to differentiate these classes. Testing is planned for the Central site and the South-East Demo Site.

3.3.2 Technical Infrastructure Constraints/Requirements for integration

Grassland mapping requires a multi-temporal, multi-sensorial EO data base for adequately portraying this challenging class with high quality. With the Sentinel-1 and -2 archives, the situation has highly improved and a suitable database was established, enabling for the first time a highly automatic grassland mapping and monitoring. Moreover, grassland mapping capabilities of S-1 data were demonstrated in ECoLaSS. Data gaps due to clouds/haze/snow cover therefore should be no longer limiting factors except for mountainous areas, where SAR detection possibilities are limited due to the SAR acquisition geometry.

Concerning in-situ data, the situation could be further improved by making LPIS widely available. This would be an asset for more reliably discriminating grassland from cropland and for a further automation of the processes. Very positive is the expansion of the LUCAS classification scheme regarding grasslands, as grassland types and grassland use classes have been included in the survey. The new data will be tested in phase 2 of the ECoLaSS project for training and validation purposes. In general, CORDA is a good tool for in-situ data search and provision. However, in terms of harmonisation, European data sets are preferred over region-specific or national information.

Concerning data volumes, adequate infrastructure and resources for storage and processing facilities for this massive volume of EO and in-situ data need to be established. Cloud-based storage systems and processing platforms, like e.g. the DIASes, become more and more relevant. It is planned to use these systems for the HRL Grassland 2018 production as they will facilitate the product generation. The cost-benefit ratio however still needs to be assessed and proven.

3.3.3 Political Framework, Roadmap and Potential Timing for Integration

As the precursor product on "Natural Grassland" had been discontinued after the reference year 2012, a new grassland baseline product based on a 7-year time series was established with the HRL2015 Grassland layer. The product's workflows and results were not fully mature at that time and were subsequently improved with a view to the HRL 2018 ITT. Some of these improvements (spatial resolution, MMU, integrated SAR/optic approach, change, etc.) have already been part of ECoLaSS phase 1, demonstrating their feasibility. ECoLaSS developments planned for the second phase of the project will also perfectly fit into the CLMS strategy, as new products required by the HRL2018 will be addressed and further evolved.

In general, there is a demand for faster production and availability of the product (within ≤ 12 months after completed image acquisition) from user side, which will be addressed by a higher degree of automation and the production using cloud-storage systems and processing platforms. However, the 3-year update cycle of the product de facto seems to be kept until 2021. As an annual/more frequent update frequency of the grassland product is nevertheless desired, this will be tested in the frame of ECoLaSS phase 2.

3.4 Crop Mask

The last ECoLaSS prototype to be described in detail in the context of the present Integration Plan into the Copernicus service architecture is the crop mask. In the following sub-chapters, the prototype description and the rationale will be given. Besides that, the potential technical constraints and specific requirements will be named before the focus is laid on the political framework and a suggested timing/roadmap for the integration.

3.4.1 Prototype Description and Rationale

In the following, the details for the crop mask prototype are given. It should be noted that the chapter refers to the prototypes produced for the pan-European sites (West Belgium/France and Central). The crop mask prototype for the Mali site is not considered since the in-situ data sources are completely different and the approach also slightly differs from the one used for the other sites. Nevertheless it is planned to refer to the Mali site in the second issue of this report.

3.4.1.1 Definition of prototype

The Crop Mask is the only completely newly designed prototype that shows all signs of being mature enough at the moment for operationalization in the near future. The prototype has been produced for three different sites; two sites in Europe i.e. Central and West (from which the "West" demo site was further split into a Belgian and French part due to the nature of different time frames of reference data availability), and for the African demo site in Mali.
The crop mask is a binary and completely new product, which is based on both optical and radar input data (S-1/S-2 or only S-2; depending on data availability in the sites). From these input data, time features are derived and classified with the Random Forest Classifier. For the model training as well as for the validation, LPIS and sampling data based on the HRLs 2015 were used. The output is a binary pixel-based crop mask.
At the moment, the TRL of the investigated crop mask is estimated at 6-7, at the same time relating to a CARL of 4. It has been proven that for the Central and both parts of the West site the classification yields promising results.

3.4.1.2 Evolution of requirements as foreseen in the HRL 2018 ITT

Since the prototypes on the agriculture topic are the first products of their kind, there are still many aspects to be clarified before a pan-European layer can be implemented, not the least on political level between the EC and the Member States. Presumably for these reasons, there was no HRL on Agriculture (crop land) included in the HRL 2018 ITT. It is however expected that for a next implementation of the reference year 2021, the necessary boundary conditions may be met.

3.4.1.3 Service Use cases

Based on the User/Stakeholder Requirements assessment in WP 21, the main aspects that should be addressed by a potential future HRL on Agriculture, and a crop mask in particular, are (i) the integration of the complete Sentinel-1 and Sentinel-2 time series in order to benefit from the multi-sensor characteristics, and (ii) a high level of automation for the classification. This has been largely tested and demonstrated in the first ECoLaSS project phase, since the input data for the various prototype implementations made already use of combinations of optical and SAR data. An exception is the French part of the demonstration site West, where only S-2 data were used due to availability issues of reference data for individual years. Another aspect that has already been voiced was to investigate the most useful update cycle for such product. What most of the users/stakeholders seem to desire in this context is a seasonal update cycle.

Regarding the complementarity to other CLMS products, it can be stated that there is no product available yet that has the focus on agricultural areas. The potential to include this thematic focus in the future HRL portfolio in one of the coming updates is clearly there, but there is still a certain lack of specification consolidation on the side of the user community, which needs to be clarified before the actual operationalization can start.

Probably even more than currently existing HR Layers, a potential future HR Agriculture Layer is considered highly relevant for aiding various kinds of farming downstream applications (such as pest and fertiliser control, crop yield estimation, drought monitoring, etc.), CAP monitoring and subsidies control, precision farming, environmental protection efforts, R&D, scientific studies, etc.

3.4.2 Technical Infrastructure Constraints/Requirements for integration

The current full availability of the S-1 and S-2 constellation data is enabling the production of a Crop Mask, applying the methodology tested and demonstrated in the first ECoLaSS project phase. What is rather critical for the implementation of the crop mask is the unequal access/availability of LPIS data. Besides the HRLs as sample basis for the model training, LPIS data are needed as well as a reference, for both training and validation. But unfortunately these data are not equally accessible throughout the EEA39 states. Some countries provide the data set via CORDA, whereas others don’t. Furthermore, the contents of the datasets differ a lot from each other, e.g. the French LPIS data do not contain permanent agricultural classes while the German ones do. This has consequences for the calculation of the crop mask and requires specific adjustments of the workflow and the methods to ensure a somewhat consistent product quality throughout.

3.4.3 Political Framework, Roadmap and Potential Timing for Integration

Unlike the previously described candidate products for integration into the operational environment, certain question marks do exist for the crop mask prototype in terms of the current political support for integrating such product into the CLMS portfolio, either of the pan-European or the global component. Whereas the user requirements assessment undertaken by ECoLaSS clearly underpins the users’ need for a Copernicus crop mask product (as well as for a crop type product), the political support for such decision by the main stakeholders seems currently insecure. The interests of the main involved players, i.e. EC DG Agri, the EEA, the JRC, the EU-28 and EEA-39 member states (via the Copernicus User Forum and the Copernicus Committee), appear not uniform, and the political debate has not yet been concluded.

This is related particularly and primarily to the ongoing political process of the CAP reform, which seems to require further time until a sufficient level of consolidation is reached between the EC and the member states. In the absence of related clear decisions, it appears yet unclear whether a CLMS Agriculture product will be supported – since the delta (or not) to the planned CAP services cannot yet be addressed. Likewise, it is not yet secured whether related budget lines will be made available for such service, although the current draft budget plans for the upcoming Copernicus 2.0 (after 2020) do clearly foresee an increase of Copernicus budget for establishing new services.

If related resources could be secured on political level, it appears that a dedicated European HR “Agriculture” or “Crop” Layer would make sense as part of the next generation of HRL products from the reference year 2021 onwards. This would also allow to realise significant synergies with the HR Grassland Layer, allowing to potentially increase both products’ quality through an integrated production approach. This would make sense, as the biggest challenge for both layers is to mutually distinguish grassland and crop land use, rather than from other land cover classes. A HRL Agriculture would also fit to the current 3-year (and potential future 1-year) update cycle. It seems that in terms of service specifications and use cases, a clear distinction and separation should be envisioned from upcoming CAP-related agricultural EO-based services, since these will most likely be serving different purposes, user communities and time steps.

Global-level agricultural products/services may be conceived with similar specifications, or evolve from a first European-level implementation.

In any case, it will be crucial to further closely observe the developments in the agricultural community and on political level, so that probably in the second project phase of ECoLaSS, a clearer roadmap can be given.

4 Conclusions and Outlook

The present Integration Plan is the ECoLaSS project's first attempt to formulate the operational service implementation perspectives and scenarios of the most promising new and improved CLMS prototype services and products which the ECoLaSS team has been assessing in the course of the first project phase. As such, this report also constitutes the essence and condensed outcome of the various user interaction, testing, developing and prototyping efforts which have been conducted by ECoLaSS. The individual "integration readiness" as well as potential implementation roadmaps for a range of candidate services have been laid out in the previous chapter 3.

Since further developments and prototype demonstrations will be undertaken in the second phase, the findings and suggestions of this first-phase report are to be considered provisional, and will be consolidated in the final, second Issue towards the end of the project in late-2019.

It primarily aims at providing the basis for informed decisions to be taken by the decision makers on Copernicus, i.e. the EC, the EEEs and the Copernicus User Forum and Copernicus Committee. A high-level concise summary of the ECoLaSS key findings will be presented in the Deliverable D53.2 White Paper on Copernicus Land Evolution.

5 References

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