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Grant Proposal

DiSSCo Prepare Project: Increasing the Implementation Readiness Levels of the European Research Infrastructure

Dimitrios Koureas[‡,§], Laurence Livermore[|], Eva Alonso[‡,§], Wouter Addink[‡,§], Maria Judite Alves[¶], Ana Casino[#], Luís Curral[¤], Henrik Enghoff[«], Michel Guiraud[»], Helen Hardy[|], Jana Hoffmann[ˆ], Salomé Landel[»], Carole Paleco[˅], Mareike Petersen[ˆ], Serge Scory[˅], Vincent S. Smith[¦], Claus Weiland[ʔ,ʕ], Karsten Wesche[¢], Matt Woodburn[|]

‡ Naturalis Biodiversity Center, Leiden, Netherlands
§ Distributed System of Scientific Collections - DiSSCo, Leiden, Netherlands
| The Natural History Museum, London, United Kingdom
¶ Museu Nacional de História Natural e da Ciência, Universidade de Lisboa, Lisboa, Portugal
# Consortium of European Taxonomic Facilities, Brussels, Belgium
¤ Universidade de Lisboa, Lisboa, Portugal
« University of Copenhagen, Copenhagen, Denmark
» Muséum national d'Histoire naturelle, Paris, France
ˆ Museum für Naturkunde Berlin, Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany
˅ Royal Belgian Institute of Natural Sciences, Brussels, Belgium
¦ The Natural History Museum, London, London, United Kingdom
ʔ Senckenberg – Leibniz Institution for Biodiversity and Earth System Research, Frankfurt am Main, Germany
ʕ DiSSCo-D, Frankfurt am Main, Germany
¢ Senckenberg Museum of Natural History Goerlitz, Goerlitz, Germany

Corresponding author: Dimitrios Koureas (dimitris.koureas@naturalis.nl), Laurence Livermore (l.livermore@nhm.ac.uk)

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Abstract

The Distributed System of Scientific Collections (DiSSCo) is a new world-class Research Infrastructure (RI) for Natural Science Collections. The DiSSCo RI aims to create a new business model for one European collection that digitally unifies all European natural science assets under common access, curation, policies and practices that ensure that all

the data is easily Findable, Accessible, Interoperable and Reusable (FAIR principles). DiSSCo represents the largest ever formal agreement between natural history museums, botanic gardens and collection-holding institutions in the world.

DiSSCo entered the European Roadmap for Research Infrastructures in 2018 and launched its main preparatory phase project (DiSSCo Prepare) in 2020. DiSSCo Prepare is the primary vehicle through which DiSSCo reaches the overall maturity necessary for its construction and eventual operation. DiSSCo Prepare raises DiSSCo's implementation readiness level (IRL) across the five dimensions: technical, scientific, data, organisational and financial. Each dimension of implementation readiness is separately addressed by specific Work Packages (WP) with distinct targets, actions and tasks that will deliver DiSSCo's Construction Masterplan. This comprehensive and integrated Masterplan will be the product of the outputs of all of its content related tasks and will be the project's final output. It will serve as the blueprint for construction of the DiSSCo RI, including establishing it as a legal entity.

DiSSCo Prepare builds on the successful completion of DiSSCo's design study, ICEDIG and the outcomes of other DiSSCo-linked projects such as SYNTHESYS+ and MOBILISE.

This paper is an abridged version of the original DiSSCo Prepare grant proposal. It contains the overarching scientific case for DiSSCo Prepare, alongside a description of our major activities.

Keywords

natural science collections, natural history collections, research infrastructure, global natural science, digitisation, data standards, Distributed System of Scientific Collections, DiSSCo, Digital Specimen Architecture, FAIR Data Ecosystem, FAIR digital objects

Context

DiSSCo was first conceived in 2015 as the result of the realisation, by the European Natural Science Collections (NSCs) community within the Consortium of European Taxonomic Facilities (CETAF), that digital transformation of collections and collection practices are fundamental prerequisites for delivering robust and scaled scientific evidence for the natural world. This digital transformation, however, goes above and beyond imaging of the vast amounts of biological and geological specimens and it requires a fundamental shift in how NSCs promote their collections to impact value chains - a shift in the way NSCs produce scientific evidence, conduct science, and eventually deliver impact. In this context, DiSSCo mission was agreed in unleashing the full potential of NSCs by bringing them together in a distributed, interoperable European research infrastructure, making them physically and digitally open, accessible, and usable for all forms of research and innovation.

DiSSCo is currently in its preparatory phase (Fig. 1). At this stage, DiSSCo's community is working hand-in-hand to reach its optimum Implementation Readiness Level (IRL), that is, the required baseline maturity level that will allow DiSSCo to embark on its Implementation Phase (2023-2025). Although some of the infrastructure's concepts are already materialising, DiSSCo is set to deliver a comprehensive Construction Masterplan before embarking on specific implementation actions. The driving force behind these initial steps has a name: DiSSCo Prepare.

Figure 1. doi

Timeline of DiSSCo:

1.Proposal phase (2015-2018),

2.Preparatory Phase (2019-2022),

3.Transition Phase (2023-2024),

4.Construction Phase (2024-2025),

5.Operational (2026-2036).

This paper is an abridged version of the original proposal. It contains the overarching scientific case for DiSSCO Prepare, alongside a description of our major activities. Differences between this paper and the full "Description of Work" include redactions of financial and personal information alongside our risk analysis; inclusion of additional citations that could not be included in the original proposal due to space limitations; minor edits to improve readability; and the inclusion of higher resolution versions of the figures. The abridged proposal is published here to frame the publication of future outputs from DiSSCo Prepare.

Looking ahead, DiSSCo is not only an infrastructure for mass scale data mobilisation but is also a vehicle of change of the way knowledge, expertise and physical assets deliver direct and substantial answers on biodiversity discovery, monitoring, as well as, the sustainable exploitation of our planet's biological and geological assets. In the path of reaching these ambitions it is clear that the vast locked-in knowledge of 1.5 billion objects in European collections can only be fully unlocked through a combined effort of humans and machines tohgether. It is only through a model of "hybrid intelligence" that NSCs can scale up their impact delivery mechanisms to the level that our grand challenges demand. DiSSCo is committed to a path for data innovation and effort consolidation for the community European NSCs.

List of beneficiaries

1. **Naturalis Biodiversity Centre**† (Naturalis) Netherlands
2. **Consortium of European Taxonomic Facilities** (CETAF) Belgium
3. **University of Copenhagen – Natural History Museum of Denmark** (NHMD) Denmark
4. **Senckenberg Gesellschaft für Naturforschung** (SGN) Germany
5. **Helsingin Yliopisto** (Luomus) Finland
6. **Universidade de Lisboa** (ULISBOA) Portugal
7. **Cardiff University** (Cardiff) United Kingdom
8. **Royal Botanic Garden Edinburgh** (RBGE) United Kingdom
9. **University of Tartu** (Tartu), Estonia
10. **Agentschap Plantentuin Meise** (MeiseBG) Belgium
11. **Universitá degli Studi Firenze** (UniFi) Italy
12. **Freie Universitaet Berlin - Botanische Garten und Botanisches Museum Berlin** (BGBM) Germany
13. **Natural History Museum** (NHM) United Kingdom
14. **Museum für Naturkunde Berlin** (MfN) Germany
15. **Muséum National d'Histoire naturelle** (MNHN) France
16. **Institut royal des Sciences naturelles de Belgique** (IRSNB) Belgium
17. **Institut Po Bioraznoobrazie I Ekosistemni Izsledvaniya Balgarska Akademiya Na Naukite** (IBER-BAS) Bulgaria
18. **University of Warsaw** (UW) Poland
19. **Narodni Muzeum** (NM) Czech Republic
20. **Naturhistorisches Museum Wien** (NHMW) Austria
21. **Museo Nacional de Ciencias Naturales** (MNCN-CSIC) Spain
22. **Magyar Termeszettudomanyi Muzeum** (HNHM) Hungary
23. **Centrum Biologie Rastlin a Biodiverzity Slovenskej Akademie Vied** (IBSAS) Slovakia
24. **Naturhistoriska Riksmuseet** (NRM) Sweden
25. **Universitetet i Oslo** (NHM-UIO) Norway
26. **Panepistimio Kritis** (UoC-NHMC) Greece
27. **Musée national d'histoire naturelle Luxembourg** (MHNHL) Luxembourg
28. **Universidade do Porto** (UPORTO) Portugal
29. **Corporation for National Research Initiatives** (CNRI) United States
30. **Global Biodiversity Information Facility** (GBIF) Denmark
31. **Species 2000** (Sp2000) United Kingdom

† The project coordinator.

1. Excellence

1.1 Objectives

1.1.1 The scientific premise

European Natural Science Collections (NSC) are critical infrastructure for meeting the most important challenge humans face over the next decades – mapping a sustainable future for ourselves and the natural systems upon which we depend – and for answering fundamental scientific questions about ecological, evolutionary, and geological processes.

Data derived from European NSCs underpin countless discoveries and innovations, including tens of thousands of scholarly publications and official reports annually (used to support legislative and regulatory processes on land use, societal infrastructure, health, food, security, sustainability and environmental change); inventions and products critical to our economy; databases, maps and descriptions of scientific observations; instructional material for students; and educational material for the public. In the last decades, however, research practice tools have changed dramatically. Digital transformation and instrumentation, remote sensing, rapid identification and molecular approaches allow us to efficiently monitor the changing world and to better understand the causes of those changes (Kelling et al. 2009; Shokralla et al. 2012).

As the volume and diversity of information derived from NSCs are exponentially increasing, so does the need for suitable infrastructures that go further than providing simple access to different data classes. A holistic approach is now required, where cross-linked information effectively underpins the entire research lifecycle and provides open access to mass and precise data (Hardisty and Roberts 2013).

New technologies are providing opportunities to combine the data held in NSCs with other sources on species, genomes, phenotypes, geography, geology and the environment in ways that drive novel, integrative research. Prime examples of this are

1. the compilation of data on the distribution of living species that is held by the Global Biodiversity Information Facility (GBIF),
2. the genetic sequence information that is collated by DNA Data Bank of Japan (DDBJ), European Molecular Biology Laboratory (EMBL), GenBank and the International Barcode of Life (iBOL),
3. the data on morphology held by MorphoBank and TraitBank, and
4. geo-collection data that is held in GeoCASe.

At present, however, the exploitation of these opportunities is severely limited by the low proportion of the collections that is digitally accessible; the lack of a common platform for access to NSC specimen information; incomplete links between major data sources about the natural world; and weak informatics tools to facilitate data exploitation and use. Furthermore, fragmentation of access policies, practices and modes across hundreds of

NSC locations severely impedes reaching the full potential of NSCs as unique global scientific assets.

1.1.2 Europe: a global leader

NSC institutions have always been open for all scientists and form the foundation of bio- and geo-diversity scientific research that studies life on Earth, past and present. Initially, they addressed fundamental questions in systematics, biogeography and geology. While this remains the core mission of NSC institutions, in recent decades European NSCs have taken on even greater significance (David 2017). Many of them have turned their attention to tackling the most important challenge that humans face –the Anthropocene Challenge; mapping a sustainable future for ourselves and the natural system upon which we depend. We live in a key moment for humanity; the global human population is predicted to peak in 2050, a fact that is making the next 30 years unique in the history of our planet's species and our human civilisations. In this context, NSCs are a key resource that can support human decisions for the short- to medium-term with an understanding of the mechanisms that determine the long-term impacts of environmental change.

NSCs, which exist in all the world's countries, are some of the longest established and most mature Research Infrastructures (RI). The scientific need for access to the information derived from the study of those objects has been so big that today we can find publicly accessible scientific collections in more than 500 distinct physical locations across Europe. These collections include large institutions such as the Natural History Museum in London and the Muséum national d'Histoire naturelle in Paris, both established in the 18th century, as well as many medium and smaller sized museums, universities, botanical gardens and research centres, with their associated biological and geological collections and research expertise. Together, European collections hold approximately 1.5 billion ($1.5x10^9$) specimens, accounting for more than 55% of the world's natural science collections. These assets are currently scientifically curated and studied by over 5,000 in-house scientific employees.

1.1.3 A turning point for European natural science collections

In 2018, NSCs entered the Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) as **DiSSCo - the Distributed System of Scientific Collections**. With this, European NSCs reached a tipping point, committing to transforming a fragmented landscape of crucial scientific resources into an integrated, seamless collection providing unified access services to a diverse user base. With 115 organisations across 21 European countries (Fig. 2), **DiSSCo today represents the largest ever formal agreement between organisations of this type, in the world**. These organisations have joined forces to develop and operate as a distributed RI.

The inclusion of DiSSCo in the ESFRI Roadmap followed a series of joint undertakings that improved the ability of the European NSCs to align institutional policies and practices, develop common solutions, and plan collective strategic goals for the future. During the

design (2004–2014) and proposal (2014–2016) phases of DiSSCo, the consortium has taken specific actions towards a more robust collaboration framework.

Figure 2. doi

The DiSSCo partnership across Europe as of March 2019.

Together, NSCs studied the optimal ways through which they can join forces and evaluated the feasibility of their joint endeavours, from a scientific, financial, organisational and technical perspective.

1.1.4 DiSSCo scientific mission

The scientific and technical approach to the DiSSCo mission can be very briefly summarised (Fig. 3). DiSSCo sets the physical objects, the specimens, at the epicentre of the development of a robust, quality ensured and fit for purpose knowledge base for bio- and geo-diversity. This way, DiSSCo aims at putting NSC-derived information at the very core of data-intensive bio- and geodiversity sciences. To achieve this transformation, it is imperative that institutions that hold NSCs not only improve the efficiency of access and scientific reach of their assets, but that they completely change their business model to support a transformative shift in the way NSCs are used across scientific disciplines.

By building the required economies of scale (i.e., the pool of resources to improve overall effectiveness), DiSSCo will significantly improve the role of NSCs in frontier scientific research (Fig. 4). Furthermore, organisations will benefit from being able to understand better, describe and monitor the impact of their collections in different scientific disciplines. Finally, organisations will be able to develop their specialisation strategies within the wider DiSSCo community, and in alignment with national priorities (e.g. Smart Specialisation Strategies), as well as developing and aligning common research and innovation agendas.

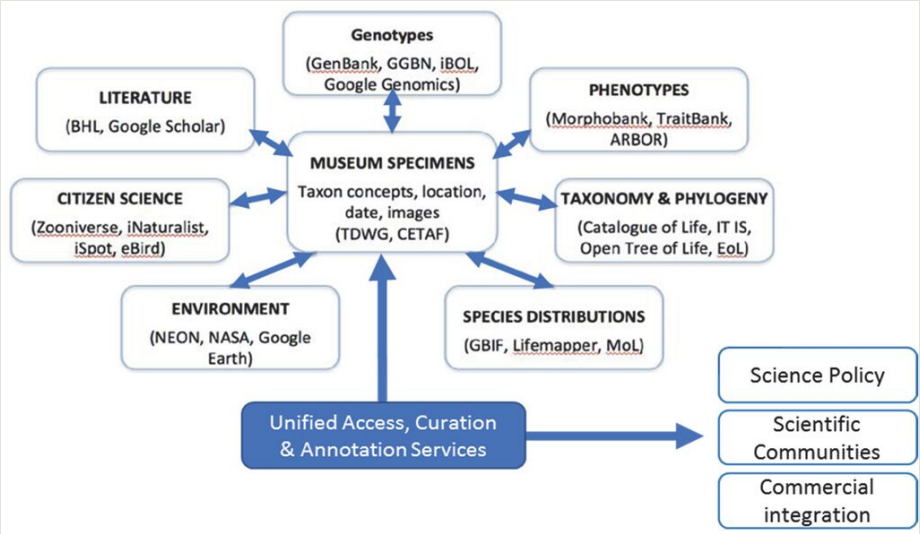

Figure 3. doi

NSC informatics: Key links between specimens and other major data sources and the new approach to building and benefiting from a biodiversity and geodiversity unified collections-based knowledge graph.

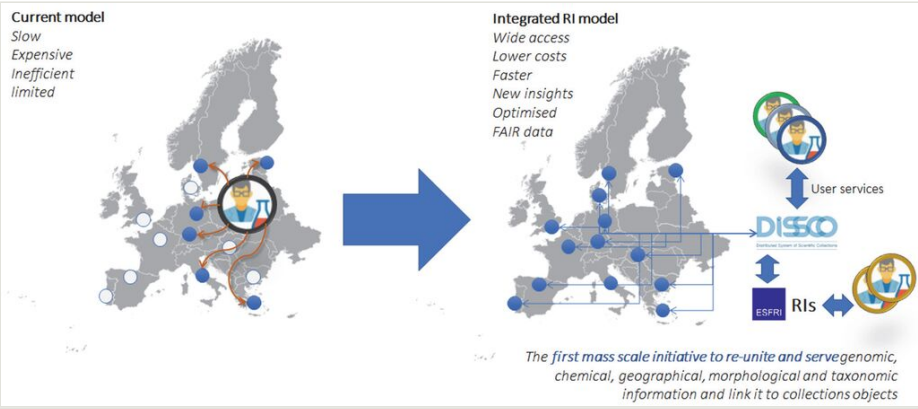

Figure 4. doi

DiSSCo enables the transformation of the way scientists interact and benefit from European NSCs. DiSSCo transforms a slow and inefficient model of access (*left*) into a faster, unified and harmonised system providing rich data services to a variety of users (*right*).

1.1.5 DiSSCo RI service classes

DiSSCo will deploy a comprehensive portfolio of services across three main categories: a) e-Science Services, b) Physical and Remote Access Services and c) Support and Training Services.

e-Science services A one-stop-shop for services providing discovery, access, interpretation and analysis of complex linked data. All e-services will be provided as part of the European Open Science Cloud (EOSC) public offering.

Physical and remote access services Universal, harmonised physical access and digitisation-on-demand services. Physical access is up till today still the main mechanism through which scientists interact with NSCs, but as the digital knowledge base grows, the balance will shift. DiSSCo will continue supporting physical access, balancing requests for physical access with for example digitisation-on-demand or generating new data (e.g., DNA sequences, 3-D or microscopic imaging) that can be associated to the digital specimen objects across the participating DiSSCo facilities.*[1] A suite of e-services will support the process of access provision from both the user and the provider (facility) side.

Support & training services This service pillar focuses on:

- providing a comprehensive user support system for all DiSSCo services and
- enabling more users to embark on data-intensive science research in bio- and geo-diversity.

This will be achieved, by improving digital skills and competencies across the user audiences and supporting career paths for new roles (e.g., digital curators) in the distributed facilities (NSCs).

1.1.6 DiSSCo Prepare project overall aims

DiSSCo Prepare will act as the primary vehicle through which DiSSCo RI will raise its overall maturity and set itself in a position to implement its construction programme. DiSSCo Prepare aims to:

- improve the overall Implementation Readiness Level (IRL) Fig. 5, and
- deliver the DiSSCo Construction Masterplan. A set of specific objectives will support these aims (Table 2).

Table 1.

Definitions of the different dimensions of the overall Implementation Readiness Level (IRL) of DiSSCo.

Dimension	Definition
Scientific Readiness (SR)	Capacity of the RI to respond/adjust to/adjust against current and anticipated user needs.
Data Readiness (DR)	Capacity of the RI data producers and stewards, across the distributed facilities, to serve FAIR and enriched data.
Technological Readiness (TR)	Capacity of the RI to meet the functional requirements of its user audience through comprehensive and sustainable technological solutions.

Dimension	Definition
Financial Readiness (FR)	Capacity of the RI to put in place and implement a comprehensive business model
Organisational Readiness (OR)	Capacity of the RI to set and implement fit-for-purpose governance and management policies as well as strategic and operational plans

Table 2.

Goals and specific objectives of the DiSSCo Prepare project, across the five dimensions of the DiSSCo Implementation Readiness Level.

Project goals	Project specific objectives
Scientific Readiness (SR)	
DiSSCo, like any RI, needs to be in full and constant alignment with the needs of its identified user base. This requires the existence of a practical scientific evaluation framework, which allows the RI to inform decisions around its future scientific programme based on the ever-changing needs of its user base.	a) Construct a service development framework focused on users in NSC related research and research applications; b) Identify the criteria for establishing priority for the digitisation, data generation and enrichment of NSCs; c) Put together a socioeconomic benefits framework for partners and countries; d) Produce a training strategy to address identified needs; e) Design a helpdesk that will provide DiSSCo with the necessary user support services; f) Provide DiSSCo with a human resources policy.
Data Readiness (DR)	
As a distributed data infrastructure, DiSSCo relies on the capacity of the national and institutional nodes to provide and enrich data in a consistent, harmonised manner, compatible with the overall RI manner.	a) Describe the mechanisms and tools to improve digital skills and competencies across facilities; b) Collate, refine and implement best practices for data generation,enrichment and mobilisation at the institutional level; c) Develop secondment and distributed team working practices.
Financial Readiness (FR)	
Before DiSSCo fully embarks on implementation activities, it is necessary to have a robust financial framework in place that enables accurate calculations of costs and contributions. This framework should deliver the trust to secure financial commitments both at a national and European level.	a) Provide DiSSCo with a sound knowledge of its cost structure in order toestimate running costs and costs to be charged to users for digitisation-on demand; b) Draw up the business model for DiSSCo at a national and international level based on governmental and institutional contributions, users' charges and industrial sector contribution through R&D projects.
Technological Readiness (TR)	

Project goals	Project specific objectives
Predominantly operating as a data infrastructure, DiSSCo needs to fully understand the current limitations of technological implementations of existing e-infrastructures and subsequently establish its data architecture as well as the technical specifications of its future services.	a) Build a knowledgebase with structured and validated tools and productsrelevant to the DiSSCo RI; b) Provide a modelling framework and data model covering all requirements from the natural science collections domain in alignment with the broader biodiversity research data domain; c) Provide guidelines for (machine to machine) data enhancement allowing for cross-linking of information and increased interoperability (FAIR); d) Provide construction plans for key services for seamless integration into theoverall technical DiSSCo Architecture; e) Refine the DiSSCo technical architecture for digital specimen data and provide an overall plan for implementation and deployment of this architecture; f) Integrate DiSSCo in the technical landscape of national, European and global biodiversity data providers.
Organisational Readiness (OR)	
To proceed with the set-up of its new legal entity, DiSSCo needs to further set out its overall organisational (governance and management) structures, strategicand operational plan, the involvement of funders and infrastructure siting as well as proceed with harmonisation of policies across its facilities.	a) Provide DiSSCo with a ready–to–implement organisational model at a European and national level; b) Provide DiSSCo with a clear and efficient pathway towards its establishment as a legal entity; c) Provide DiSSCo with a common set of access and management policies; d) Liaise with national governments and external stakeholders to ensure theircommitment, gather their input to enhance DiSSCo, and establish partnership frameworks; e) Develop recommendations to distribute the specialisation towards collections digitisation, generation and enrichment; f) Operate effective communication and dissemination tools to raise awareness and ensure the uptake of project results.

Implementation Readiness Level (IRL) The IRL is here defined as the measure of the ability of the DiSSCo RI to embark on specific implementation actions (construction projects) based on clear and actionable guidelines with minimum risk, and across the scientific, data, financial, technological and organisational dimensions of the infrastructure implementation. These five dimensions, from which the overall IRL is estimated, correspond to the recognised facets of the challenge ahead to improve DiSSCo ability to construct and subsequently operate as a pan-European RI. DiSSCo Prepare will raise the readiness level of the RI across all five dimensions (Fig. 6 and Table 1). Within DiSSCo Prepare, each of the IRL dimensions is separately addressed through specific Work Packages (WP). Under each of the identified dimensions, distinct targets and actions are addressed through the different Tasks in the corresponding WPs. The Project introduces,

for each dimension, a set of measurable, targeted actions. The approach to improving IRL is discussed in section 1.3.

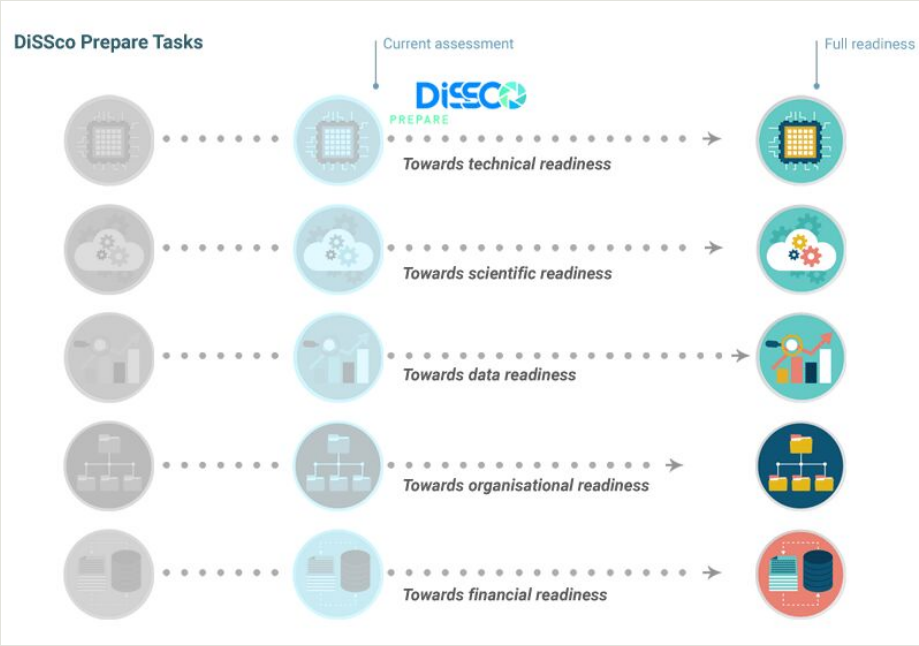

Figure 5. doi

DiSSCo Prepare project overview.

DiSSCo Construction Masterplan Alongside the process of improving the overall IRL of DiSSCo, the DiSSCo Prepare project will deliver a corpus of material to be used during the construction phase. This material will constitute a **comprehensive and actionable 'Construction Masterplan' for DiSSCo RI**. The DiSSCo Construction Masterplan will be considered as the final output of the project and will effectively be used as the organisational, financial and technical guiding framework for the construction of the infrastructure (including establishing the legal entity).

The Construction Masterplan will:

- **ensure that follow-up projects focus only on delivery**,
- **minimise risk for out-of-sync work**,
- **improve the overall programme management efficiency**,
- **reduce the overall costs of implementation and**
- **improve the level of trust by national funders on the capabilities of the RI to reach its operational phase.**

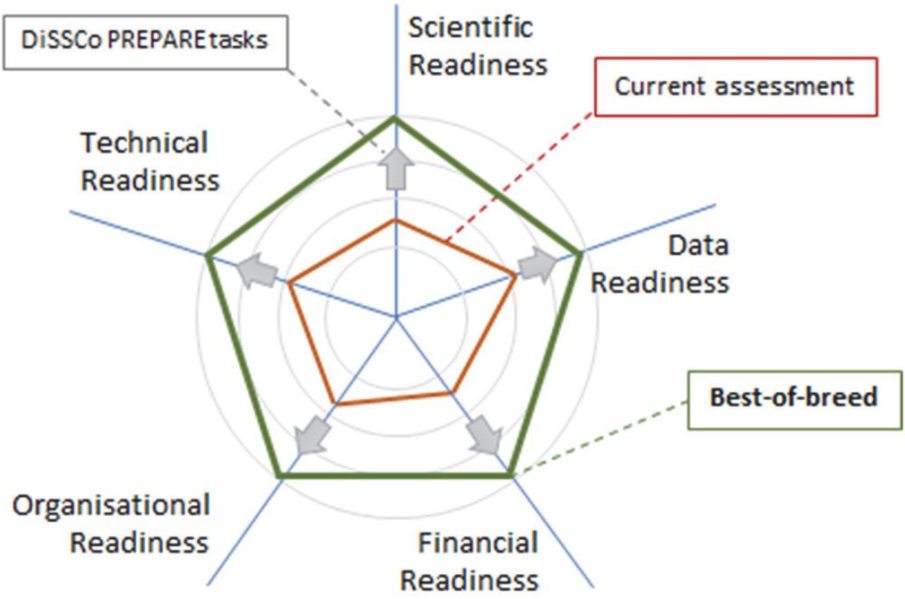

Figure 6. doi

The DiSSCo Prepare approach to improving the overall Implementation Readiness Level of DiSSCo, across the five identified dimensions.

1.2 Relation to the work programme

1.2.1 Ensuring engagement of funders beyond the ESFRI proposal bid

As the DiSSCo RI enters its preparatory phase, it is essential that it stays aligned with the scientific and infrastructure priorities at national level. As a pan-European RI, DiSSCo predicates its sustainability model on national contributions. As such, it is essential that representatives of national funders (science and science infrastructure government departments and ministries) are kept well-informed and consulted on both the strategic and the operational planning of DiSSCo RI. The sooner DiSSCo secures the engagement of national funders in its decision-making processes, the easier it would be to shift from a project-based initiative to a sustainable RI that is well-embedded into national roadmaps for RI. To this end, DiSSCo Prepare will set-up its Funders Forum – FF (described in the management section of the proposal). The FF will hold a key position in the overall governance of DiSSCo Prepare as a consulting body.

1.2.2 Financial Plan and sustainability

DiSSCo facilities are already self-sustainable organisations, some with more than 200 years of consistent operation. Despite their proven sustainable business model, their transformation into a pan-European RI, as an integrated virtual organisation, has additional

requirements and mandates a partial shift in the existing institution-based financial plans. To address this, DiSSCo Prepare dedicates a significant part of its overall effort (See above for Financial and Organisational Readiness dimensions) to deliver a convincing financial plan at European level. **The plan will be based on**:

- **a comprehensive Cost Book of the development and operation of the RI**,
- **cost recovery models and**
- **mid-term and long-term financial projections (modelled multi-tier system for delivering and acknowledging investments).**

1.2.3 Identifying proper governance and management models

DiSSCo has already formal agreements in place at both national and European level. Through detailed Memoranda of Understanding (MoUs), DiSSCo already has, from the bid phase to enter ESFRI, reached agreements with 115 NSCs. These agreements describe the preparatory and operational governance and management procedures. As DiSSCo develops, however, it is imperative to adapt these agreements to the ever-changing landscape and needs of the RI. **DiSSCo Prepare will refine the current governance model, draft rules of participation and rules of procedures and tune managerial practices across the organisational levels of the RI.**

1.2.4 Siting and legal form

DiSSCo, as a distributed RI, relies on the capacity of its distributed facilities to specialise on aspects of the infrastructure operation. This specialisation is essential to ensure their complementary operation at European level. Under the Organisational Readiness WPs, the DiSSCo Prepare project will put forward recommendations for the thematic specialisation of its component facilities. Furthermore, the Project will assess the options for establishing the new DiSSCo legal entity, considering financial, organisational needs, as well as the overall strategy and operational plan of the infrastructure.

1.2.5 Infrastructure architecture and service specifications

As a predominantly data infrastructure, DiSSCo significantly invests in its readiness around data models, its systems architecture and overall technical design. **Driven by the scientific use cases, DiSSCo Prepare will employ a process for developing and validating end-user services.**

1.2.6 Strategic and operational planning

Informed by the current vision and mission statements of DiSSCo, DiSSCo Prepare will undertake an analysis of the environment to better describe how DiSSCo is positioned (currently and in the future) in the wider landscape. Building on an existing RI landscape analysis (Fig. 7), DiSSCo Prepare will, as part of its Construction Masterplan, guide change management and strategic positioning. An operational plan based on that strategic document will be further developed. The DiSSCo strategy document will be based on

simple medium- and long-term mission statements, a solid understanding of the data environment and objective appraisal of its resources.

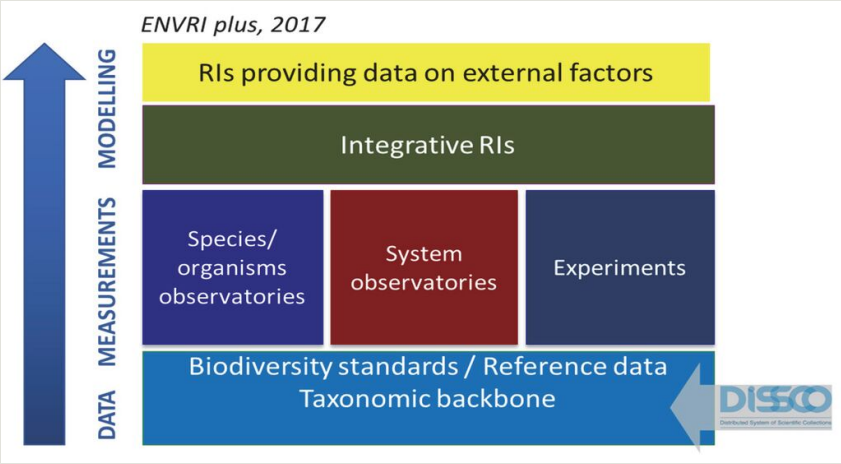

Figure 7. doi

An environmental RIs landscape view based on a single dimension (Data → Modelling) and the foundational role of DiSSCo as provider of reference data (adapted from ENVRI plus project).

1.2.7 Valuing societal and economic benefits

Analysis of the diversity of user communities served by DiSSCo will provide a sound knowledge for defining a framework of development of services tailored to those communities and adjusted to address societal and economic challenges. DiSSCo Prepare will help the RI develop a better understanding of how to evaluate (cost-benefit) everchanging scientific drivers and to translate them into functional requirements for the operation of the RI.

1.3 Concept and methodology; quality of the measures

1.3.1 DiSSCo Prepare approach to the objectives

The project's overall approach can be summarised below:

1. Assess the current state of the art of the RI across the five readiness dimensions (Table 3);
2. Set the targets across the areas of work to ensure a seamless transition to a fully deployed construction plan (see below); and
3. Improve its overall capacity across the five dimensions, reaching the set targets, addressing previous recommendations (including those from ESFRI), while coordinating work across all DiSSCo-linked projects and initiatives (see below).

Table 3.

Assessment summary of the current state of the art across the five DiSSCo IRL dimensions and the projects/initiatives/organisations currently or previously contributing to the current state.

Readiness dimension	**Current assessment summary (progress to date)**	**Currently or previously contributingprojects/ initiatives/organisations(Cf. Table 4)**
Scientific Readiness	**Relatively high maturity** • Extended use cases of DiSSCo collected; • User audiences identified; • Potential user numbers estimated; • Case studies.	GBIF, ICEDIG, SYNTHESYS+, MOBILISE, CETAF, other national projects.
Data Readiness	**Medium maturity** • (Meta)Data standards in use; • Institutional FAIR data portals in place; • Digital curation practices.	GBIF, ICEDIG, SYNTHESYS+, Catalogue ofLife, TDWG, Global Genome Biodiversity Network (GGBN), CETAF, other national projects
Financial Readiness	**Relatively low maturity** • Mass scale digitisation costs estimated; • Procurement needs for e-infrastructure services partly described.	ICEDIG, DiSSCo design study, GBIF, internally funded projects
Technological Readiness	**Medium maturity** • Common (meta)data standards alreadywell adopted in the community; • Data architecture principles established; • Major e-services identified; • Some service functional requirements in place.	ICEDIG, SYNTHESYS+, GBIF, Catalogue of Life, CETAF Information Science &Technology Commission (ISTC), TDWG
Organisational Readiness	**Relatively high maturity** • Interim governance model in place; • Strong institutional-level commitment andengagement; • Political commitment across 11 countries; • Financial commitment currently at aninstitutional level.	DiSSCo national and internally funded projects, DiSSCo design study

Iterative assessment of the DiSSCo IRL

One of the DiSSCo Prepare priorities is to assess the current RI IRL and steer effort towards achieving the desiredtarget values in all the five dimensions (described above). Given the significant previous investments across those dimensions, it is imperative that DiSSCo Prepare focuses more on the aspects of the DiSSCo preparation that are falling behind. As part of its methodology, the project will leverage the results of previous investments and activities across the DiSSCo-linked and DiSSCo-associated projects (Table 4) and international initiatives (e.g. GBIF, iDigBio, Catalogue of Life, ALA, Biodiversity Information Standards (TDWG)).

Table 4.

Currently running DiSSCo-linked and DiSSCo-associated projects with their timelines and key objectives in relation to DiSSCo. All DiSSCo-linked projects are centrally coordinated by the Strategic Alignment of Projects (SAP) group. The SAP group is chaired by the DiSSCo Coordinator.

Acronym	Project title	Timeline	DiSSCo-orientated objectives supported by other projects
ICEDIG	Innovation and consolidation for large scale digitisation of natural heritage	2017-2020	a) Mass scale digitisation and data mobilisation;b) Imaging technologies;c) Citizen Science; d) Data Infrastructure – DiSSCo data models;e) Policy and legal aspects of collections' data mobilisation;f) Design alternatives & Economics.
SYNTHESYS+ synthesys.info	Synthesis of Systematic Resources	2019-2023	g) Digital & Molecular Standards & processes;h) Internationalisation;i) Training;j) Optimisation of Access (physical & virtual);k) Collections on Demand;l) Specimens Data Refinery.
MOBILISE COST Action mobilise-action.eu	Mobilising Data,Policies and Experts in Scientific Collections	2018-2022	m) Current standards assessment and protocols around digitisation; n) Digitisation standards and protocols; o) Data management standards; p) Data archiving requirements and standards;q) Data publication;r) Education & Training / Capacity enhancement.
Catalogue of Life Plus catalogueoflife.org	Towards a clearing house for a common nomenclature and taxonomic names infrastructure	2017-2019	s) Data management standards for species names data;t) Species data enrichment; u) Nomenclature and taxonomic backbone services for geo-biodiversity; v) Shared governance of infrastructure with international parties (Species 2000, Biodiversity Heritage Library (BHL), BoLD, Encyclopedia of Life (EoL), GBIF, LifeWatch).
DiSSCo-associated project			
ENVRI-FAIR envri.eu	Cluster project of all ESFRI environmental RIs	2019-2023	w) Biodiversity Ecosystems subdomain common activities;x) Addressing cross-cutting issues around Data FAIRness.

From science needs to service provision

DiSSCo Prepare takes a user-driven approach in the way it will put together its service development framework. Work across related WPs will support the DiSSCo service development procedure in which user needs inform service functional requirements and subsequently, service technical specifications (Fig. 8). DiSSCo Prepare will aim at operationalising this workflow and embed it into the future Standard Operating Procedures (SOPs) of the RI.

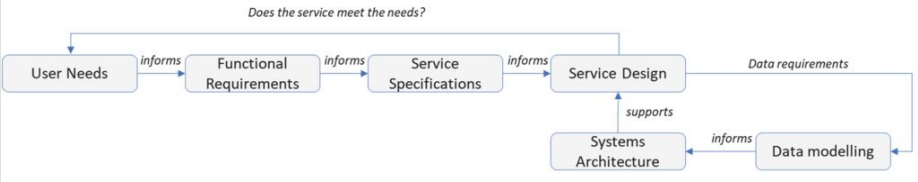

Figure 8. doi

DiSSCo Prepare approach (supported by interdependent Tasks of the work programme) for developing and validating service specifications and design.

Intertwining projects (DiSSCo Programme) – International RIA activities linked to the project

In 2014 (two years before applying for the ESFRI Roadmap), DiSSCo established a pan-European programme to coordinate all the European and nationally co-funded projects. The programme includes currently four DiSSCo linked projects and one DiSSCo-associated one (Table 4), which collectively contribute to the preparation of the RI (Fig. 9).

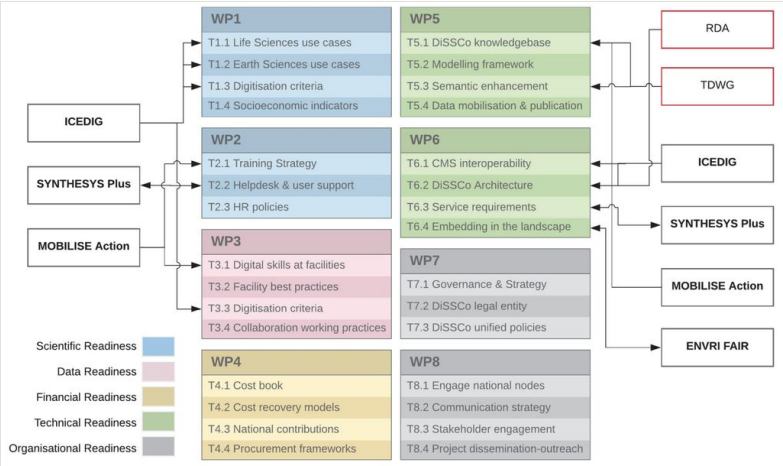

Figure 9. doi

External relationships diagram of DiSSCo Prepare Projects. Arrows indicate complementarity between DiSSCo-linked (ICEDIG, SYNTHESYS+, MOBILISE), DiSSCo-associated (ENVRI FAIR) projects and outputs from international relevant organisations (RDA, TDWG).

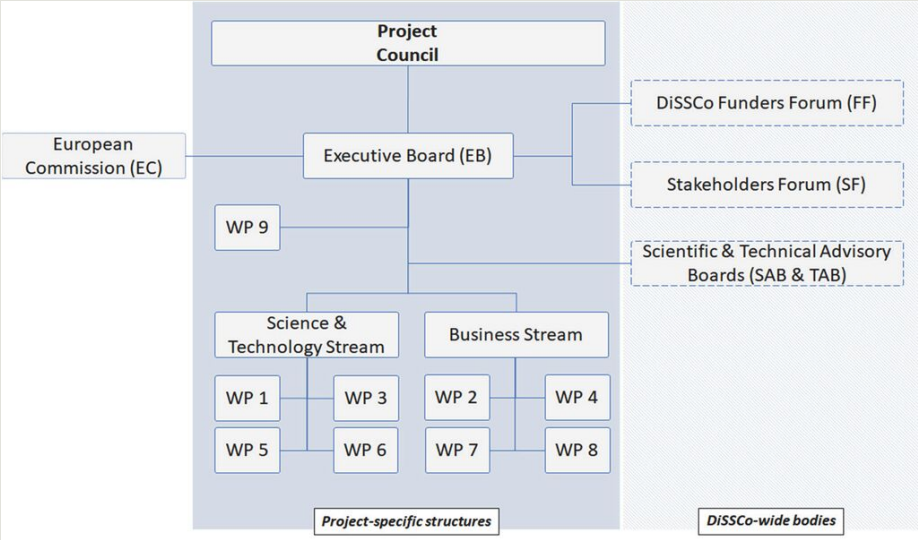

Figure 10. doi

Organisational chart of the DiSSCo Project, showing reporting lines between the project-specific structures, DiSSCo-wide bodies and the European Commission.

DiSSCo Prepare, as the main Preparatory Phase Project of DiSSCo, will take a central role in the project portfolio of the DiSSCo development programme, focusing on bringing together the results of the other projects and on delivering the missing parts across the different implementation dimensions of the new RI. Coordination of the activities across the DiSSCo-linked projects will be essential. Complementarity is ensured by the Strategic Alignment of Projects (SAP) group. The SAP group is chaired by the DiSSCo (Prepare) Coordinator. DiSSCo Prepare will support the operation of the SAP group, which will include the coordinators and WP leaders of DiSSCo-linked projects. The SAP will work towards synchronisation of activities under the DiSSCo Programme. All DiSSCo-linked project coordinators have provided letters of intent (provided at the end of the proposal) for collaboration in DiSSCo Prepare under the coordination of the SAP group.

1.3.2 Methodology & Specific targets

Work programme - Outputs

User needs & socioeconomic impact (WP1)

Contributes to **Scientific Readiness objectives a, b & c** (Table 2). Building on surveys and networking activities already carried out in previous projects (Table 4) and networking activities, this WP will examine the needs of research projects and research application activities (e.g. nature conservation) based on NSCs, and the requirements these needs set for the services to be provided by DiSSCo. This will be done across biological (Task 1.1) and geological (Task 1.2) NSCs. Criteria for prioritisation of digitisation of collections, data linking, generation and enrichment, taking into consideration user needs and (potential)

socioeconomic impact, will be analysed (Task 1.3). Socioeconomic impacts of DiSSCo and DiSSCo-enabled research will be examined with the aim to develop indicators and tracking mechanisms (Task 1.4).

Human Resources, Training & Users Support (WP2)

Contributes to **Scientific Readiness objectives d, e & f.** This WP is divided into three tasks. Task 2.1 will build upon information gathered in previous and current projects and on new information collected by WP3 to deliver a training strategy with distinct channels and modes of accessing training to address the identified needs, of both the data suppliers and the users of DiSSCo. Task 2.2 will build upon the service-specific helpdesk developed under SYNTHESYS+ to design the DiSSCo-wide helpdesk (Smith et al. 2019). Work will involve identification of services and facilities to be offered, a definition of methods of interaction with the user, outlining the mode of operation, and delineation of the necessary support documentation. Task 2.3 will deliver a human resources policy where factors that induce strategic performance in human resources management (HRM) are identified, and key competencies that will guide international recruitment and selection, team-based organisation, performance appraisal and a remuneration system are laid down.

Capacity enhancement (WP3)

Contributes to **all Data Readiness objectives.** WP3 contributes to the preparation of DiSSCo facilities to work towards new institutional roles, and new technical infrastructure requirements, supporting digitisation, exploitation and enrichment of digital collections. This work will provide the capacity enhancement necessary to increase the technical, human and process capacity needed for DiSSCo across institutions. Key outputs cover the formation of key sections of the DiSSCo Construction Masterplan, including a) a summary of recommendations on communication, policy, governance, outreach and organisational structure, and competency frameworks; b) a summary of best practices for data mobilisation at the institutional level to develop the DiSSCo plan for data mobilisation and curation pipelines, which will form key sections of the DiSSCo Preparedness Manual and Toolkit; and finally, c) the development of DiSSCo secondment and distributed team working practices for the technical teams to be adopted within the construction phase of DiSSCo.

Business Framework (WP4)

Contributes to **all Financial Readiness objectives.** To fulfil the objectives, WP4 is divided into four tasks. Task 4.1 will set up the set of parameters which describe all the activities in DiSSCo. These parameters must be useable and informative regardless of the institution or country size of the institution or the country. Task 4.1 is subdivided into subtasks which tackle the different areas of application: running costs, capital expenditure and IT infrastructure. D4.1 is the Cost Book of running DiSSCo. Task 4.2 will be built on Task 4.1 to select and combine Cost Book parameters to establish the cost structure to charge users for digitisation-on-demand or data enrichment provided by DiSSCo and other services identified in WP1. D4.2 is a Cost Book sheet for services. Task 4.3 will produce

the most suitable model for national contributions to DiSSCo. D4.3 is the survey of current models for RI. Task 4.4 will set up the financial relationships between DiSSCo industrial partners. D4.4 is the roadmap for partnerships projects.

Common Resources and Standards (WP5)

Contributes to **Technological Readiness objectives a, b & c.** The WP5 aims to achieve the technical readiness for organisations by identifying, developing, and providing services and best practices for DiSSCo. This aim is achieved by incorporating profound experience in, e.g. data standards, modelling platforms, and service infrastructures in accordance with outputs from leading initiatives and consortia outside the DiSSCo RI. The objectives of WP5 are divided into four tasks and produces five corresponding Deliverables: D5.1 DiSSCo Knowledgebase for technical development, D5.2 DiSSCo Modelling Framework, D5.3 DiSSCo Digital Specimen Object Specifications, D5.4 A best practice guide for semantic enhancement and improvement of semantic interoperability, and D5.5 Construction plans for the improvement of technical infrastructure in the areas of geo-collection data and taxonomic services.

Technical Architecture & Services provision (WP6)

Contributes to **Technological Readiness objectives d, e & f.** WP6 is responsible for the design of the DiSSCo technical architecture and the development of an implementation plan. The WP activities are divided into four tasks, which aim at reaching a series of corresponding and culminate in four discrete Deliverables. Task 6.1 focuses on including the harmonisation of the collection management systems (CMS) of the partner organisations, resulting in a CMS integration plan into the DiSSCo RI (D6.1) that provides the harmonisation and migration plan for the integration of the CMS into the DiSSCo RI. Within Task 6.2 the designs of the core architecture centred on the DiSSCo knowledge graph is prepared, and D6.2 supplies the implementation and construction plan for the DiSSCo core architecture (D6.2). Task 6.3 complements the efforts in Task 6.2 focusing on the interoperability with end-user services, leading to D6.3, which delivers a generalised set of API specifications for interaction with the DiSSCo Architecture (D6.3). Task 6.4 links the activities of WP6 to the European and global technology landscape and implements the DiSSCo data management plan, ensuring ENVRI FAIR compliance ofDiSSCo services (D6.4).

Governance, Policy & Legal frameworks (WP7)

Contributes to **Organisational Readiness objectives a, b & c.** WP7 aims at achieving the Organisational Readiness for which the work is divided into three tasks leading to three Deliverables. Task 7.1 will combine and analyse outputs of previous projects to provide (Task 7.1) a ready–to–implement organisational model for governance structure and function (D7.1). Within Task 7.2 a SWOT analysis will be performed to provide a draft status and by-laws implementation plan to establish DiSSCo as a legal entity (D7.2). Task 7.3 will focus on comparing current access and management policies to prepare an assessment tool and direction map to the implementation of DiSSCo policies (D7.3). The

representatives of the national consortia will be consulted (under Task 8.1) at key moments of the elaboration of the final documents. WP7 also focuses on developing a clear case on the best option for the establishment of DiSSCo as a legal entity. Task 7.3 focuses on delivering a common set of access and management policies. For Tasks 7.1 and 7.3, information available either in documents prepared for the submission file to ESFRI or as outcomes of ongoing projects will be improved and refined. For Task 7.2, a SWOT analysis of the possible options will be performed and then resulting in preparation of drafts statutes, by-laws and an implementation plan will be prepared. D7.1 Detailed plan for governance structure and function, and participation framework, Strategic positioning and operational plans. D7.2 Draft statutes and by-laws; implementation plan, D7.3 Assessment tools and direction map to the implementation of common DiSSCo policies.

Stakeholder engagement & Communication Strategy (WP8)

Contributes to **Organisational Readiness objectives d, e & f.** To put the project partners in a position to fulfil the objectives mentioned above and advocate on behalf of DiSSCo, showcasing its relevance and urgency, WP8 will provide communication channels (Task 8.2) and strategic mechanisms (Task 8.4). To facilitate, the communication plan (D8.1) will lay out tools and key messages for the consortium to use. To allow further targeted communication activity, the landscape around DiSSCo needs to engage decision makers, with national nodes acting as an interface to their national governments (Task 8.1), and the wider domain to investigate synergies and opportunities (Task 8.3). The former will be accompanied by a specialisation strategy (D8.2) to inform prioritisation objectives in countries and institution to carry out once DiSSCo moves to the construction phase. The latter will specifically strengthen the links with industry and other RIs by exploring future relationships and procedures for collaboration and procurement resulting in Partnership Best Practices (D8.3), a framework for alignment and cooperation

2. Impact

2.1 Expected impacts

2.1.1 Improving technological capacity and effectiveness of the infrastructure

The effectiveness of the infrastructure to be designed by DiSSCo Prepare relies on three pillars: readiness of the community at different levels (Fig. 6), comprehensive and coherent design of the RI and its implementation phases, and commitment towards implementation and further sustainability. Successfully balancing activities between facility-level, national-level and European-level investments will be critical to operating a unified RI. Although digitisation and data enrichment programmes will be undertaken at the institutional and national level (following the corresponding national strategies), individual physical facilities will be supplemented by a Europeanwide, coordinated endeavour that will gather best practices, to lead technological improvements and to foster breakthrough enhancements

for all participating facilities. Getting a more comprehensive view on the DiSSCo technological knowledgebase and its gaps, will allow for more targeted future investments (WP5). These investments can then be distributed across DiSSCo facilities, based on an agreed upon facility specialisation framework (WP7) and a better understanding of the services such technological investments can support (WP1, WP6).

Besides the investments across the DiSSCo facilities, DiSSCo Prepare will investigate the opportunities for targeted industrial participation. By engaging Technology Transfer offices (TTOs) and Technology Licensing Offices (TLOs) (WP8) and by better defining the frameworks of such collaborations (e.g. pre-commercial procurement – WP4) with the industry, DiSSCo Prepare will strive for a integrated and balanced approach to improving its technological capacity.

2.1.2 Keeping abreast with of ever-changing scientific needs

Uncertainty is a variable that needs to be minimised in the DiSSCo model design. To that end, a risk management plan, including monitoring tools, mitigation measures, and progress indicators, will be developed under WP9. Still, flexibility and resilience will be key aspects of the DiSSCo RI that will need to develop mechanisms to cope with a) differences among participating entities (e.g. size, coverage, involvement level, scientific relevance); b) evolution of scientific research (e.g. new forms of metadata to be added to the digital specimen), and c) ever-growing technological support (e.g. in imaging, data capture). These three aspects need to be encompassed and the RI will offer the required adaptation mechanisms as to be able to integrate new advances in any of those aspects (developed under WP1). The SAB and the TAB, as advisory fora, will play an instrumental role in anticipating potential new paths for science and technology, and of advising and guiding the RI executive board to integrate those changes in the DiSSCo development.

2.1.3 Building on existing investments and leveraging cross-infrastructures collaboration

infrastructure initiatives at the national level. To provide efficient coordination among all participating partners while ensuring required harmonisation and efficiencies in the organic system of collections to be established under DiSSCo, it will be necessary that certain common policies and technology solutions are coordinated by the coordination hub, are endorsed nationally and finally are implemented at institutional level. To that end, corresponding decisions will be transferred to the central DiSSCo coordination hub, but driven by DiSSCo national implementations. Those essentially will concern prioritisation of digitisation actions at a European scale, and a framework for the establishment of specialisation strategies and distribution of knowledge enhancement across institutions. Nevertheless, the hosting, curation, enrichment and provision of data and the creation of a collective digital objects collection will remain responsibilities of each institution, who will take institutional and national infrastructure responsibility and devote its resources to meet the requirements derived from the DiSSCo common framework. It is crucial that national roadmaps include DiSSCo as a reference and give priority to collections in order to

guarantee provision of resources to the national task force (and its constituting facilities) so it can meet its commitments towards the RI and participate actively in the further development of DiSSCo. DiSSCo will be financed by national investments of which a part will be designated to the DiSSCo coordination hub. The coordination hub will provide all the member institutes and national infrastructure initiatives with mechanisms and tools that will facilitate their integration into the pan-European initiative.

2.1.4 Paving the way for a fully FAIR infrastructure

FAIR Data is at the core of the DiSSCo RI. The RI that seeks to move from a collection of fragmented and isolated databases to a well-structured, harmonised and overall-improved mechanism to showcase NSC data digitally delivered and publicly offered to science and society. DiSSCo Prepare will intensively work on architecture and plans to make the collections catalogued and properly indexed data, easily findable on a common platform (the European Collection Objects Index - ECOI), thereby facilitating a sole entry point to search for reliable enriched data coming from the different distributed partner institutions and national infrastructures, that are properly catalogued and indexed. Although national investments will drive the digitisation of data, DiSSCo can provide efficiencies in sharedmass digitisation approaches and support access technologies. Physical specimens will remain of the property of the respective institutions that will be responsible for curating, enriching and delivering it as the digital objects created from them to the common infrastructure. Therefore, access to the reference data is ensured both, at the physical collections collection level through individual institutions and at the DiSSCo RI in its digital format. Interoperability in DiSSCo will be achieved by identifying common references, shared applicable standards and vocabularies, harmonised policies and connecting APIs that will create a system of systems of specimen-related information. Finally, Reusability of the data will rely on the provision of unique, persistent and stable identifiers, together with tracking mechanisms for the provenance of the data, accurate annotation systems and rigorous quality control means. Altogether, the FAIR principles will act to furnish the data provided through DiSSCo with the precision and reliability that is required for further analysis by other users. Through the “Technical readiness” WP5 & WP6, DiSSCo Prepare will establish a robust framework of standards and workflows to facilitate seamless integration of all data. Alongside this, WP6 will contribute as well to DiSSCo “Technical readiness” by designing the supporting architecture for data integration and service provision, to integrate the data and to provide the necessary services, based on the DiSSCo knowledgebase that will collect, combine and harmonise the different Collection Management Systems (CMSs) usedby the partners.

2.1.5 Better EOSC integration

As a data-intensive RI and service provider, DiSSCo will integrate its e-services into the EOSC by means of two mechanisms: directly, by supplying a robust business case based on a continuous solutions-driven development of tailored services and tools to address users’ needs, and indirectly, by clustering of services with the majorenvironmental-related RIs (via ENVRI-FAIR project). The DiSSCo catalogue of services will be provided ready-to

fit to be embedded to the EOSC-Hub. To that end, synchronisation and alignment to Open Science goals and FAIR principles will drive the design of DiSSCo outcomes (WP5) and the architecture to support them (WP6).

Moreover, DiSSCo Prepare will continue to work closely with the EOSC partners, particularly its newly formed EOSC Executive Board, and will build on top of existing data platforms as EGI and EUDAT, to i) safeguardalignment and to ensure that DiSSCo services can be seamlessly integrated into the EOSC service catalogue, and b)translate DiSSCo e-infrastructure needs into functional requirements of EOSC-provided cloud services.

2.1.6 Early involvement of national-level RI funders

Early involvement of national funders (through the Funder Forum operation – described in Section 1.2), primarily consisting of the government ministries, will a) ensure the right level of engagement of with national representatives and understanding of the specificities of the community practices specificities, and b) enable DiSSCo to effectively adjust driven by national and international priorities, as they are expressed through national RI roadmaps or national Smart Specialisation Strategies. By the end of the project national funders will be able to take informed decisions on their future financial commitment to DiSSCo, based on the scientific and societal impact, technological viability and operational efficiencies of the RI.

2.1.7 Establishing clear rules of participation

Rules of participation are critical for seamless operation of distributed RIs. Partners will need to know the scope and extent of their participation, the type and level of the contribution expected, and how the mechanisms for decision making will be established and executed. The Governance Model to be established under WP7 will describe the framework for action, with clear duties and rights for each partner and also for any other related party, whatever their function and their role will be in terms of implementing the digitisation process and delivering the derived products and services to the community. Transparency is imperative at all levels and in any respect. Governmental participation and support need to be rooted in mutually trusted mechanisms that ensure an equal playing field. On their side, individual institutions and national DiSSCo-related infrastructure initiatives will be called to carry out the same exercise of deploying clear rules of joint participation at a national level by identifying the DiSSCo National Node (NN) that will facilitate a positioning of all involved institutions in each country, when so needed, while keeping the necessary decision rights in each entity. Overall, the DiSSCo governance model will strive for the needed integral coordination between de-centralised and centralised decisions throughout at all levels of the organisation.

2.1.8 A simple and convincing financial and business model

DiSSCo RI will be based on the instrumental Cost Book that WP4 will develop. An external consultant (University of Paris-Faculty of Economics) will provide an expert assessment on

how to identify essential financial parameters and key types of costs, including fixed and variable, direct and indirect, structural and running costs, for the coordination hub but also for the participation of the distributed facilities. All together the project will underpin the development of the reference Cost Book that will apply to the infrastructure activity as well as to the definition of the business model necessary for creating and delivering DiSSCo services. Such a model will include unified and structured tools for the cost calculation of DiSSCo outputs: the services cost sheets. To sustain the deployment of services as demanded by the different communities of users and practitioners, DiSSCo Prepare will develop commercial procurement frameworks for industrial participation, with a straightforward indication of cost-benefit models for contracting with private partners on a competitiveness basis. The Cost Book should provide a framework for investments at various levels, including at the institutional, national, and international level. On top of the overall Cost Book, proper and feasible mechanisms of monitoring, deviation control, and adjustments application will be identified to facilitate control and transparency towards the financial partners. For them, a clear, objective and trustful mechanism of participation will be developed that will ensure their active involvement and facilitate them with tools to visualise their investments returns. Altogether, this will facilitate the partners acting jointly under a common model, based on the shared values of fairness and transparency. It is expected that the Cost Book and the business model will also be informed by approaches in other RIs.

2.1.9 Gender balance and geographic inclusiveness

DiSSCo Prepare considers gender equality across from two perspectives. Gender balance in the managing and advisory teams of the project will be ensured by the inclusion of corresponding recommendations by the Project Council in the rules of participation of the managing and advisory boards of the project. Furthermore, DiSSCo Prepare not only looks into the need to invite or select team members based in a gender-balanced manner but predominantly develop the capacity enhancement strategies (through WP2) which would specifically enable women to better access managerial and leadership positions in the DiSSCo RI. Rules of procedure and rules of participation will also be developed (WP7) in a way that not only ensures equality, but also create an empowering environment for supporting gender and cultural diversity.

A geographic balance within the DiSSCo community has been sought from its beginning, seeking active involvement across all DiSSCo member countries. In addition to the current 21 countries (including seven from Southern and Eastern Europe) directly participating in DiSSCo, the RI invests in reaching out to new members and in filling existing geographic gaps. DiSSCo Prepare will specifically, during its course, target current candidate member countries, including Ireland, Switzerland, Malta and Israel, whilst investigating potential for newpartnerships in the Balkans.

2.1.10 Intellectual Property (IP) and ethical issues

The DiSSCo RI will follow the INSPIRE Directive to ensure proper transboundary context by implementing specific rules concerning data specifications, network services, data and service sharing and monitoring and reporting. Efforts will be dedicated to identifying IP issues at all stages of DiSSCo deployment and in all levels of interest, from individuals to institutions and overarching organisations. In the same line, the protection of personal data according to the EU's General Data Protection Regulation (GDPR) will be secured throughout all actions and activities planned. Ethics is a guiding principle for DiSSCo and it supports Responsible Research and Innovation (RRI) and upholds to European ethical standards. It recognises that research is intrinsically ethically driven by the search for evidence and the avoidance of errors. DiSSCo, as a RI focused on open access to scientific outcomes and aiming to boost knowledge transfer anchored on the provision of digital assets, is underpinned by research carried out at publicly funded institutions, thus ensuring national ethical standards will also feed into the development of DiSSCo outcomes and use of DiSSCo resources. Data usage agreements for DiSSCo will include robust ethics clauses to ensure ethical use of data by diverse end-users; these will be developed during DiSSCo Prepare through broad discussions in the partnership and beyond and will incorporate both national and international aspects. Adaptations for compliance will be described and structured, and WPs 7 and 8 will work closely together to build the supporting legal and ethical framework. All DiSSCo Prepare project outcomes (including reports, publications, technical specifications and code) will be by default open access/open source. The project will (mandated by its Data Management Plan - output of WP9) make use of open access journals and repositories (See Section 2.2.1) and its open DiSSCo Git repository to make all outcomes public.

2.1.11 Capacity enhancement and Human Resources

Human resources are instrumental in achieving DiSSCo Prepare objectives as a project and in ensuring the successful implementation of DiSSCo RI at large. Acknowledging the challenge inherent in upgrading the organisations' institutional workforces in a fast technologically transforming landscape, DiSSCo Prepare will devote specific effort to the preparation of DiSSCo facilities and their staff to acquire the skills and competencies needed to enable them to optimally use DiSSCo when addressing digitisation, exploitation and enrichment of digital collections. WP3 will provide support to enhance technical, human and process capacity needed to follow DiSSCo requirements. Equally important to the effective and efficient implementation of DiSSCo is to furnish the infrastructure with the best possible managerial team. To that end, DiSSCo Prepare will support the training of DiSSCo RI executive managers and will seek appropriate certification ('Certificate of Excellence in Management of RIs' provided by Bicocca-University of Milano). Moreover, DiSSCo Prepare will draft the necessary Human Resources (HR) policies (under WP2) that will support an inclusive and balanced approach in acquiring and retaining expertise and ensuring gender balance. Altogether, the DiSSCo executive bodies (structured under the governance models to be described by WP7) will help to upgrade the skills and

competencies of personnel at each participating institution, by providing necessary advice for capacity enhancement (to be developed under WP2).

2.1.12 International coordination

The scientific mission of DiSSCo goes beyond political borders. Despite being born as a European RI, DiSSCo has been conceived as an initiative that unites a previously fragmented international landscape. Building strong global partnerships is essential to enable the much-needed international coordination across regional and national investments in NSCs. Working together with initiatives such as iDigBio in the USA (letter of intent for collaboration provided) and ALA in Australia is pivotal. Connections with global organisations as GBIF (project partner), Catalogue of Life/Species 2000 (project partner), the Research Data Alliance (RDA), and other thematically focused ones like TDWG and GGBN, will also help build a global alliance around biodiversity and geodiversity data infrastructures.*[2] While the relationships with all those players are already in place, a better and more effective coordination mechanism for international cooperation in NSCs will be developed, to overcome the challenges of an increasingly crowded and complex landscape. It is expected that DiSSCo Prepare (through activities in WP8 and WP9) and in collaboration with similar tasks in SYNTHESYS+ and MOBILISE COST Action will improve DiSSCo ability to develop a policy framework for joint international progress towards an NSC data commons.

2.2 Measures to maximise impact

2.2.1 Dissemination and exploitation of results

Addressing long-term engagement of users and open access to results

The dissemination and exploitation plan for DiSSCo Prepare (under WP8) will: a) reach out to the broadest possible range of users and practitioners in the bio- and geodiversity realm, b) ensure sustainable access to those results (by communicating them not only through DiSSCo, but also through CETAF and linked institutional sites), and c) spread the national engagement messages through the extensive networks of CETAF and DiSSCo, and their related stakeholders. To this end, it will be essential to establish mutually beneficial relationships between them and DiSSCo. The industry will benefit from participating in the construction process of the RI and its components, policymakers from having a sustainable source of reliable geo- and biodiversity data, and the public at large, from cutting edge technology working more effectively to protect the environment and tackle societal challenges.

A crucial role will be played by the CETAF Working Groups (specifically those dealing with regulations, digitization, collections management and bioinformatics) acting as an interface for reaching the involved community and ensuring a permanent bottom-up perspective by both, their involvement in the definition of needs, gaps and bottlenecks as well as the possible solutions to overcome those challenging areas and the uptake of the expected

results. In parallel, the DiSSCo National Nodes (NNs) will be instrumental to engage decision makers further and disseminate results at national and international level, acting as a liaison with the administrative and governmental top levels, down to the broadest user base. These Nodes will receive clear guidance, under WP8, on establishing national-level engagement plans aligned to national priorities.

DiSSCo Prepare will ensure engagement with other related infrastructures in the environmental domain (in all subdomains) as well as in other scientifically adjacent RI domains (such as the cultural heritage sector). Through the DiSSCo Prepare dissemination plan they will be provided with relevant updated information and updated of the progress made in the preparation of DiSSCo.

Dissemination will anchor on open access to DiSSCo Prepare outputs. The standard dissemination procedure will start with the provision of publications through articles and other published materials, in open access journals such as Research Ideas and Outcomes (RIO) and the European Journal of Taxonomy (EJT). Similarly, dissemination ofresearch data as well as the source code of software developed within the project will be uploaded into openly accessible repositories (e.g. Zenodo, GitHub), equipped with suitable licences, and will follow the formalisedguidelines of the Data Management Plan of the project, including requirements for FAIR data.

2.2.2 Communication activities

For DiSSCo Prepare communication and dissemination it will be instrumental to reach effectively the diversity of user communities tackled in DiSSCo Prepare. To achieve this goal, it will be necessary to identify targeted messaging, encapsulated in visual materials and tailored campaigns and to communicate those through the most impactful channels.

Communicating the aims and expectations of the DiSSCo RI throughout the involved actors and users will imply:

- fostering the participation in actions under the ESFRI umbrella within the environmental domain and beyond to give visibility to DiSSCo and contribute significantly to enhance connectivity among all European RIs;
- developing extensive networking activities and establishing a permanent dialogue with stakeholders – especially those that are usually less engaged – like the general public and industry by establishing discussion fora, digesting the innovation potential of collaborative work and identifying the messages to stimulate shared actions;
- achieving alignment through DiSSCo SAP (Strategic Alignment of Projects group) and implementing synchronisation groups among all DiSSCo-related projects (ICEDIG as design study, SYNTHESYS+ for facilitating virtual and physical access, ENVRI-FAIR for services clustering, CETAF WGs for community-rooted mechanisms and MOBILISE for networking), to unify criteria, identify complementarity under different thematic streams that cross-cut all relevant projects and initiatives;

- raising awareness of the usefulness of tools created by DiSSCo prepare to societal progress and to that end, to support informed decision making by policy makers by stimulating permanent flow of information with governmental representatives and acknowledging sensitivity to cultural differences and national specificities; and
- intensifying the interaction with the user base to maximise involvement and acceptance of the DiSSCo RI asit progresses.

Communication will use all available channels (Table 5) and will deploy focused, simple though strong shared messages across all partners in different formats (publications, press releases, brochures, posters, images, videos, etc.) to reach out to the maximum number of actors involved along the DiSSCo value chain. The plan will reach out from custodians of the physical objects (in Europe and beyond), to the facilitators of the research system and users of its results on different levels (funding agencies, technology suppliers, industry, policy makers etc.), as well as the people who organise the work (e.g., museums, NGOs, citizen scientists, scientific organisations etc.). To that end, the Communication Plan (under WP8) will identify a complete package of communication tools and means. Messages will be tailored accordingly to the diverse nature of the related parties to the project. The participation of all involved actors in general, and the WP leaders, will be instrumental for the communication of DiSSCo Prepare achievements. The Communication Plan will equally tackle all information channelling dimensions to develop clearand measurable metrics for assessing the reach and success of the project's communication actions.

Table 5.

List of targeted audiences, messages and channels used for the Communication plan of DiSSCo Prepare.

Targeted audience	Message(s)	Content	Channel(s)
Scientific community	Benefits from integrated virtual access to unified collections data. Scientific advances possible by providing accessibility to collections worldwide for a multidisciplinary approach and thus enabling new forms of research.	Examples of collaborative work for facilitating discoveries	Twitter Campaigns, Open access to outputs, dissco.eu
Citizen Science	Contribution to scientific development	Use cases showing co-creation of science	Instagram
Policy makers	Delivering updated, simplified reliable information for informed decision-making	Presentation of tools (Dashboards)	Press releases, dissco.eu
Public, NGOs	Using cutting edge technology to unlock the knowledge stored in collections to protect the environmen	Examples of how collection knowledge supported tackling societal challenges	Campaigns, Videos, Social media, dissco.eu

Targeted audience	Message(s)	Content	Channel(s)
Industry	Potential breakthrough innovation by stimulating partnering and services procurement agreements	Technology and service needs for constructing and running DiSSCo	Discussion fora, round tables, fair booths
Related Research Infrastructures	Mapping resources and impacts on a multilateral flow to find and exploit synergies and cluster services	Present already identified complementarities (e.g. longterm data storage) to showcase potential shared interests	Workshops
Collection Managers	Improved Collection Management through harmonised policies and guidelines	Examples for coordinated implementation (e.g. CETAF ABS Code of Conduct)	Training and benchmarking seminars / webinars, dissco.eu

2.2.3 Concretely engaging stakeholders

DiSSCo is designed to run in close coordination with other parties. Several layers of collaboration have been identified and the relevant stakeholders, with whom to improve relationships, have been identified. This includes:

a) related RIs (in the environmental domain, eLTER, Danubius, LifeWatch and others such as DARIAH, e-RIHS and ELIXIR);

b) international initiatives, either b1) global organisations, as GBIF and Research Data Alliance (RDA), b2) parallel RIs in other regions, such as ALA and iDigBio, or b3) thematic organisations, e.g., Catalogue of Life, TDWG and GGBN;

c) overarching fora and organisations, such as Convention on Biological Diversity (CBD), Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and OECD; and

d) industrial partners, with which draft commercial procurement frameworks will be prepared for d1) technological infrastructure provisions, such as EGI or EUDAT, and d2) provision of intermediate services to DiSSCo.

DiSSCo service provision is predicated on the ability to form reliable operational and strategic partnerships with:

- e-Infrastructure providers (e.g., to procure cloud services),
- industrial partners, and
- international initiatives in the space of bio- and geo-diversity information mobilisation and management.

During DiSSCo Prepare, a wide Stakeholders Forum (SF) will be established, and recurrent repeat activities will ensure permanent stakeholders' engagement, going beyond

their assessment and advice roles. The SF will provide critical feedback to the overall decision-making process of the Project across the readiness dimensions of the infrastructure. A furtherbreakdown of the SF into thematic areas will allow a more focused approach to specific issues addressing current needs as well as to anticipating future needs derived from breakthrough advances in technology and science discoveries. The SF will operate under the responsibility of WP8 and be facilitated by WP9.

2.2.4 Partner inclusiveness and openness

For a distributed RI like DiSSCo, collection-holding partners constitute the pillars on top upon which NSCs expertise and collaboration can be mobilised and enhanced. The DiSSCo facilities are the institutions which ensembled together at the national level to ensure a critical mass of research-performing organisations that are working on a collaborative basis for the enrichment and optimal use of the collections at the three different layers of action; institutional, national and European levels. Institutions from the same country will be supported in forming National Task Forces, based on either formal or informal consortia. This will enable them to unify their needs and contributions while allowing them to voice their priorities in alignment with national roadmaps for science and technology, or national Smart Specialisation Strategies. Rules of participation and corresponding statutes (to be described under WP7) will define the process for selection of and support to national facilities. Principles of open, participatory representation, inclusiveness and complementarity are the foundation for the governance model. Special attention will be given to attracting southern and eastern European countries to participate in DiSSCo since barriers currently prevent them from achieving the required level of readiness. Training and capacity enhancement activities will be developed with a focus on institutions in these countries to provide them with the necessary basis from which to develop the required level of readiness to fully participate in DiSSCo RI. These activities will build on top of those of the COST Action MOBILISE that specifically aims to reduce such barriers.

2.2.5 Key advisory boards

DiSSCo Prepare will count on two key advisory boards for support with essential external advice and guidance to critical elements from a scientific (Scientific Advisory Board - SAB) and infrastructure (Technical Advisory Board-TAB) perspective. The advisory boards will act as consultants to inform, assess and propose action to the DiSSCo Prepare Executive Board (EB). In each of their fields of expertise, the advisory boards will be formed with international experts who will play a key role in highlighting issues to consider, tabling risks to mitigate, or identifying specific new challenges to address. They will ensure that both areas – technological infrastructure and scientific coverage – are aligned and developed coherently. With the support of WP9 the advisory boards will meet as independent bodies periodically, either physically or virtually. They will also be invited to participate in the DiSSCo Prepare governing bodies. They will report directly to the EB that will be committed to providing them with the necessary administrative, logistic and economic support (including travel costs), as needed. The DiSSCo Prepare Scientific (SAB) and

Technical Advisory Boards (TAB) will evolve to become permanent advisory boards embedded in the DiSSCo governance model like the Funders Forum (further refined under WP7).

2.2.6 Addressing ESFRI recommendations

During the evaluation of the DiSSCo Proposal, the coordination team received remarks about the areas where DiSSCo needs to invest to improve its overall maturity towards implementation and operation. DiSSCo Prepare is specifically addressing these remarks as follows:

"*The proposal tends to focus very heavily on Bio-collections and therefore the support to the Geo-community should be more elaborated.*"

DiSSCo Prepare is taking an inclusive approach to the challenges of mobilising NSC information that encompasses all types of scientific collections in the participating facilities. To specifically address the concerns expressed around geological collections, DiSSCo Prepare will increase focus on tasks that target geological collections. These tasks focus on a) improving the scientific case and better describing the opportunities around geological collections (Task 1.2), and b) better understanding the technical (e.g. metadata standards, community services) specificities around the mobilisation and publication of geological collections information (Task 5.4).

"*DiSSCo should better describe the services under Scientific Excellence: For example, how will the infrastructure actually benefit sectors from health to social science*."

The identification of functional requirements of DiSSCo end-user services is put at the centre of the DiSSCo Prepare Project. Through a process that is described in Fig. 8, the Project specifically focuses on the critical path between (ever-changing) user needs and service specification. Services for a variety of new user communities form part of the SYNTHESYS+ activity, and DiSSCo Prepare will build on the results from this work to further refine benefits for societally relevant sectors. Benefits from increased access to NSC information via the RI will be quantified through use cases built throughout DiSSCo Prepare in WP1.

"*Improvements needed in HR policies and Finances*"

The DiSSCo ESFRI proposal scored lower than the rest of the assessment areas for HR policies and Finances than for the rest of the assessment areas. To remedy this, DiSSCo Prepare dedicates WP2 to HR policies and training, and WP4 towards describing in a more precise way the overall business and financial models of the new RI.

3. Implementation

3.1 Work plan – Work packages and deliverables

DiSSCo Prepare consists of nine work packages. The overall structure of the work plan is summarised in Fig. 11 and Fig. 9.

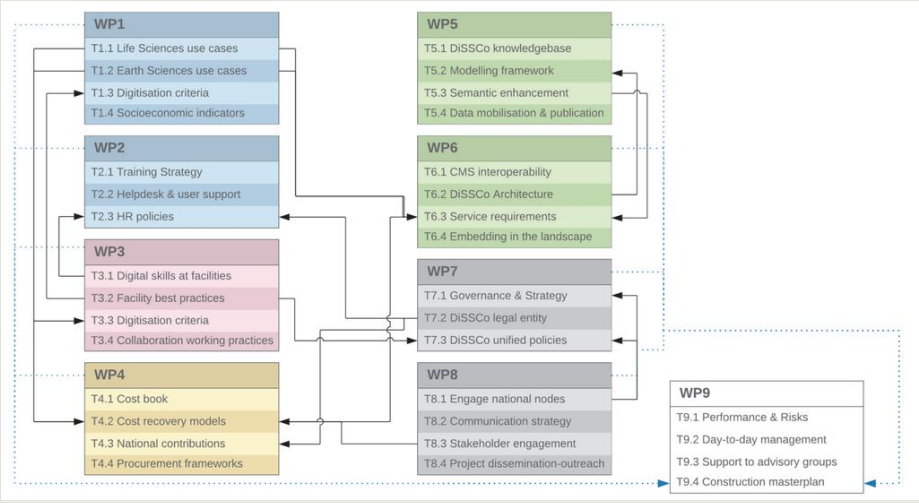

Figure 11. doi

Project Tasks relationships diagram of DiSSCo Prepare. Solid lines show interdependencies between Tasks in the work programme (direction of the arrow indicates end-to-end dependency. For instance, Task 4.2 has an end-to-end dependency on Task 1.1). Dotted lines indicate how the flow of outputs from WPs to the DiSSCo Construction Masterplan (Task 9.4).

Work Package 1 - User needs & socioeconomic impact

Building on surveys already carried out in previous European and international projects and on extensive previous networking activities, this work package will examine the needs of research projects and research application activities (e.g., nature conservation, agriculture) based on NSCs. Requirements from these user needs that determine the services necessary for broad uptake of DiSSCo will be key to future success. Criteria for prioritisation of digitisation of collections, taking into consideration user needs and (potential) socioeconomic impact, will be analysed. Socioeconomic impacts of DiSSCo and of DiSSCo-enabled research will be analysed with the aim to developindicators and tracking mechanisms.

Objectives

- To construct a service development framework focused on users in natural science collections-related research and research application (Task 1.1, Task 1.2)

- To identify criteria for establishing a priority for the digitisation of natural science collections (Task 1.3)
- To define a socioeconomic benefits framework for partners and countries (Task 1.4).

Description of work

Task 1.1 Analyse life sciences use cases and user stories

This task builds on existing compilations of DiSSCo-relevant use cases and user stories including, but not limited to that described in the DiSSCo Design Study Report, and the one in the recently opened DiSSCo User Stories Survey 2018. The results of these studies will be analysed, and a synthesis presented, with special emphasis on:

- the functional demands such use cases will put on DiSSCo and its services
- their socioeconomic importance (in relation to the societal challenges highlighted in H2020)

When necessary, the analysis will be supplemented by targeted user surveys to fill detected major gaps. There will be particularly close collaboration with Task 1.2.

Task 1.2 Analyse Earth sciences use cases and user stories

Same as Task 1.1, but for earth sciences. Focus on collections of fossils, rocks, sediment structures, minerals, and extra-terrestrial material (meteorites). As earth scientific collections are important, among others, for the better understanding of past and future hazards and disaster events (Tilley et al. 2019), this task will also focus on use cases from this domain. Particularly close collaboration with Task 1.1.

Task 1.3 Establish relevant criteria to identify a prioritisation model for digitisation

Based on the analysis of previous studies, relevant criteria will be identified and developed into a basic model for the prioritisation of digitisation of objects held in NSCs. Criteria to be considered include scientific relevance, user needs, socioeconomic impact, specialisation, technical feasibility and cost. Particularly close collaboration with WP3, especially Task 3.2 which will synergistically inform the identification of criteria and the formulation of the model to establish priorities.

Task 1.4 Develop indicators of socioeconomic impact

A set of socioeconomic impact indicators will be identified to measure how DiSSCo activities impact:

- future digitisation of collections,
- impact research performance and
- economy at local, national and European levels.

The socioeconomic impacts of a RI like DiSSCo, as well as the research and research application activities based on it, are not easily or directly valorised in monetary terms; indicators in use for the cultural sector will be comparatively explored. In the context of environmental grand challenges, this WP will develop indicators of direct socio-economic impacts such as job creation, technology innovation and more efficient use of existing resources, as well as the impact that DiSSCo based research can have on areas like agriculture, forestry, conservation, bioeconomy, risk management, education and citizen science and broad public engagement.

Work Package 2 - Human resources, training & user support

This work package will provide the resources to ensure that the DiSSCo community has the appropriate skills andcompetencies to use and manage the infrastructure and manage all aspects of the project efficiently. Theinfrastructure needs to be and is properly framed by a human resources policy, enhancing the managerial andleadership capacity and will ensure that this is in place for the new infrastructure. We also want to provide a dynamicchannel of communication within the DiSSCo community will be provided, oriented towards offering informationand supporting to the user in need to use of the DiSSCo services and facilities.

Objectives

- To create a training strategy with distinct channels and modes of accessing training provision that addressesthe identified needs for both data suppliers and end-users (Task 2.1).
- To design a Helpdesk and user support services that will provide the necessary information on the use ofthe infrastructure (Task 2.2).
- To develop a Human Resources Policy that ensures that RI-related human resources have the appropriate skills and abilities and are used able effectively and efficiently to accomplish DiSSCo objectives effectively and efficiently (Task 2.3).

Description of work

Task 2.1 Training Strategy

This task will build upon information already gathered in previously and currently running projects, in addition to implementing and in as well as new information collected by Task 3.1, to develop a training strategy with distinct channels and modes of accessing training to address the identified needs. Personnel capacity building will consider both the side of the data suppliers (collection managers, data digitisers, museum technicians, etc.) and the side of the users of DiSSCo (researchers, policy makers, students, environmental Agencies, NGOs, etc.).

The work will include reviewing existing best practices for training delivery and creation of materials, and organisational structures to support it. The training scheme will refine and complement existing training programmes organised within the DiSSCo community (see Table 4 - objectives. d, i and r; CETAF DEST (Distributed School of Taxonomy) and

BIOTALENT EC-funded project) and consider both academic and continuous professional training. This task will further develop the recommendations produced by the DiSSCo Design Project ICEDIG and elaborate, among others, paths to integrate bioinformatics-related topics into formal education, while formalising collaborative actions with e.g. academia, professional associations and providers of vocational training, etc. Training programmes will be built on the 'train the trainer' principle, creating a strong network of trainers, able to provide support to their local (institutionally and nationally) communities. Additionally, diversity based on aspects such as educational resources, cultural differences and policies and regulations applicable, will be equally considered.

Specific activities will include:

- compilation of needs for skills/competencies;
- identification of training providers/platforms;
- landscape analysis of best practices for training delivery; and
- integration of all training strategy elements, to jointly provide a final report with a recommendation for setting up the DiSSCo Training Strategy.

Work Package 3 - Capacity enhancement

A critical factor in the success of DiSSCo will be the capacity enhancement necessary to scale up our digital operations. This requires organisational change, documenting digitisation best practices and technical frameworks for building capacity with third parties that have competencies critical to the success of DiSSCo. These need to beoperable across organisations of very different sizes and levels of existing digital capacity. Mindful of this, WP3 will develop a framework that allows organisations of any scale to enhance the capacity of their digital activities supporting DiSSCo, which will be flexible enough to become a series of living documents that can be modified asnew technologies and approaches are developed. To support this, we will use a series of digital tools (e.g., wiki-based handbooks and web resources like Protocols.io) alongside short and visually appealing publications to openly document our work and facilitate reuse of materials.

Objectives

WP3 supports the Data Readiness dimension which forms one of the five dimensions within the DiSSCo Prepare IRL. Through WP3 we will support actions to prepare DiSSCo facilities to work towards new institutional roles, and new technical infrastructure requirements, supporting digitisation, exploitation and enrichment of digitalcollections. WP3 provides support to enhance technical, human and process capacity needed by DiSSCo across institutions.

The aims of this WP are to:

- Describe the mechanisms and tools to improve digital skills and competencies across facilities;
- Collate, refine and implement best practices for data mobilisation at the institutional level to develop the DiSSCo plan for data mobilisation and curation pipelines;

- Develop secondment and distributed team working practices.

WP3 will draw upon actions of WPs 2, 5 and 6, as well as the portfolio of DiSSCo-linked projects (ICEDIG, SYNTHESYS+ and MOBILISE COST Action – Table 4 *objectives e, j, q*). We will work together with through the digital teams present within DiSSCo facilities to sustainably gather benchmarking data on current practices, resources and expertise. With these groups, we will make a series of recommendations to senior institutional management on how to achieve the necessary enhancements of digital capacity. This will lead to a series of outputs such as competency frameworks and operational manuals containing standard operating procedures. Each output will be scaled to different sizes and types of organisation within the DiSSCo consortium, as these dictate the degree of specialisation possible. In many cases, there will be a need for hybrid roles encompassing a mixture of digital skills and competencies by a single individual, especially in smaller organisations. Aspects of this WP are strongly linked to the scientific and Organisational Readiness dimensions of DiSSCo Prepare.

Description of work

Task 3.1 Improve digital skills and competencies across DiSSCo facilities

This task and subtasks seek to identify the current capacity and processes (e.g. skills communication, leadership, governance, mentoring) necessary to enhance digital capacity by supporting organisational change. Results will feed into training requirements described in WP2. Task 3.1 is broken into a series of subtasks:

Subtasks:

3.1.1 Current capacity: Bring together outputs from prior digital capacity surveys (e.g. CETAF, SYNTHESYS, ICEDIG and the DiSSCo Design study); identify digital roles and competencies within this data; explore platforms/approaches to sustainably automate the long-term collection of these data across DiSSCo facilities (e.g. institutional websites and use of LinkedIn); make recommendations on how to improve the machine readability of these data sources (e.g. via controlled vocabularies to classify skills); and prototype a system with initial data that demonstrates this semi-automated approach to monitoring digital skills capacity.

3.1.2 Organisational change: Make recommendations based on best practices related to the processes necessary to support the organisational change required to enhance digital capacity at partner institutions. This concerns communication, policy, governance, outreach and organisational structure. Digital activities are cross-cutting, often spanning whole organisations and stretch traditional operational practices. Working with institutions that have built digital teams within their organisations and using baseline data from the capacity surveys, we will produce custom recommendations for each DiSSCo partner identifying their present capacity and maturity to support DiSSCo activities as well as potential gaps. This will be delivered through a series of institutional digital dashboards that can be updated to reflect changes in institutional digital capacity.

3.1.3 Digital competence framework: Embedding and sustaining a programme of digital change requires an effective framework to develop and measure competencies. This digital framework will build on existing frameworks, enabling staff to demonstrate their digital abilities by providing evidence of their achievements to identify areas for personal development, and support opportunities for promotion and career progression. This work will be embedded in a digital platform and take into account different sized organisations. Digital and data competencies will be the main focus, but this sub-task will also take account of other competencies relevant to DiSSCo delivery, including the management and leadership of people and projects; and working with collections.

Task 3.2 Collate, refine and implement best practices for data mobilisation at the institutional level to develop the DiSSCo plan for data mobilisation and curation pipelines

How do you best prepare collections for digitisation, digitise them, curate the associated data, publish this information and measure the outputs? What are the options and rationale for different types and sizes of collections, when should this be outsourced and what different project management approaches are most appropriate in this range of circumstances? This task seeks to address these questions, describing and refining best practices and building on a substantial investment from prior and current projects (MOBILISE COST Action, ICEDIG; SYNTHESYS+ - Table 4) and feeding these into DiSSCo Prepare WP8). Consolidating what is known into a community-edited manual (supported by WP5), and other relevant platforms, WP3 will streamline the reuse and implementation of these procedures and enhance digitisation capacity across the DiSSCo collection-holding organisations.

Subtasks:

3.2.1 Standard Operating Procedures for digitisation (SOPs): This subtask will publish SOPs for major collection types, documenting digitisation workflows that include information on when different scales of operation demand different modes of digitisation. This will also cover entry point digitisation (i.e. for the acquisition and digitisation of new collections), as well as the digitisation of pre-existing collections. Many of these workflows have been well established through related projects but are poorly documented. This subtask will take into account the contrasting scales and needs of day-to-day databasing operations including targeted research focussed digitisation, ‘on demand’ digitisation and major institutional digitisation programmes.

3.2.2 Standardised Extract Transform and Load (ETL) procedures: Handling metadata and images during digitisation involves many transformations, as information is modified and held in various temporary (staging) environments, before reaching the institutional collection management systems (CMS) and being made accessible through public portals. This subtask will document best practices for these processes, where necessary including the computational workflows required to support data transformations.

3.2.3 Pre-Digitisation Curation: Many NSCs are not digitisation-ready, and in some cases, the curation necessary to support digitisation is a much bigger bottleneck to the digitisation process than the act of digitisation. This subtask will develop a checklist of requirements that ensure a collection is fit for digitisation. We will outline the steps necessary to improve digitisation readiness, including estimates of required resources that take into account the different scales and speed of operation typically encountered among DiSSCo facilities.

3.2.4 Digitisation Monitoring: Ongoing and prospective digitisation activities will be highly distributed across the DiSSCo consortium. To monitor digitisation pipelines, a set of digitisation measures and dashboards will be needed. This subtask will put in place the framework for these, supporting delivery of a set of agreed key performance indicators (KPIs) for digitisation. This will allow the progress of digitisation to be monitored across the consortium.

Task 3.3 Develop DiSSCo secondment and distributed team working practices

Implementing the vision for DiSSCo requires improving the staff capacity and spread of expertise across partner institutions. This challenge is most acute in technical, engineering and project management areas where specialist staff are fundamental to delivering core parts of the DiSSCo Programme. The most rapid approach to building capacity is the temporary transfer of staff or the formation of dedicated cross-institutional distributed teams. This is key to sharing of best practices and develop trust across the consortium.

Subtasks:

3.3.1 Staff secondment procedures: Building on Task 3.1 which identifies the critical skills needed to support DiSSCo activities, we will develop a formal staff secondment procedure that balances the needs of the donor and host institutions across different sizes and types of organisations. Secondments might range from short term placements where staff with specialist skills undertake projects with a host to deliver pre-agreed technical outcomes; through to longer-term (up to one-year) staff transfers to deliver programme-level capacity improvements. Examples of the latter include the construction of institutional digital teams or implementation of major pieces of DiSSCo technical infrastructure. A major barrier to the implementation of a secondment programme is the loss of capacity from the donating organisation. This subtask will develop secondment models and procedures that account for this, providing reciprocal benefits to all stakeholders, as well as deliver pilot placements with DiSSCo facilities. Example models to explore include the creation of a central secondment fund across DiSSCo, routes for the host institute to pay, and route for the donor institute to pay. We will identify best practices at complementary infrastructures that take into account the diversity of countries as well as the size and type of organisation that are part of the DiSSCo consortium.

3.3.2 Distributed teamwork practices: As a highly decentralised RI, DiSSCo will need to develop crossinstitutional teams adopting work practices where individual staff are intensively working collectively on common tasks. This subtask will identify the work

practices and supporting tools necessary to achieve this. We will make recommendations on the procedures and systems necessary by examining best practices from other research communities (e.g. physics, astronomy, molecular biology and environmental science communities), highlighting which different project management approaches and procedures (e.g., PRINCE2, agile, daily stand-ups) are most appropriate. We will begin to create, shape and train the technical development and architecture team. These include roles supporting 'DevOps', back/front end developers and product management as part of WP5 and WP6. The subtask will highlight the communication infrastructure necessary to deliver effective distributed team working for construction and operations of DiSSCo.

Work Package 4 - Business framework

The DiSSCo Cost Book will provide the financial elements to serve both internal and external purposes. DiSSCo operations must incorporate knowledge about the operating costs of maintaining the IT infrastructure and the associated services. It must also be able to evaluate the cost of the service portfolio it provides in order to charge the appropriate costs to its users.

The core service of DiSSCo is access to information within two main areas: access to existing digitised information and digitisation-on-demand.

Cost of access to existing digitised information depends on choices made for storing data, which controls data mobilisation speed. DiSSCo governance should be able to prioritise sets of collection data requiring fast access based on users' needs and relevant impact assessments, as identified in WP1.

Cost of digitisation-on-demand depends heavily on resources for access to physical specimens. DiSSCo operations should incorporate knowledge about the cost of accessing, hence digitisation, specimens for each member, and possibly for each scientific collection department. At the DiSSCo level, it will be able to propose to the users a programme of digitisation that will create the set of data it needs.

The parameters which will be developed will also serve as performance indicators for DiSSCo business operations. The digitisation-on-demand process must be as thorough and fast as possible; therefore, the speed of access is a key element. Based on access speed, DiSSCo business operations should be able to establish priorities with respect to current trends of users' interests. Establishing the cost book faces several challenges due to the diversity in DiSSCo members; different sizes, organisations, methods of accounting, making it difficult to identify the cost of DiSSCo activity which is generally a fraction of the DiSSCo members activities. WP4 aims at delivering the DiSSCo cost book in a way that is as much as possible independent of institution size and countries and that covers all aspects of funding, including the design of a sustainable business model. For this purpose, WP4 will be divided into four tasks.

Description of work

Task 4.1 Cost Book for DiSSCo

Subtasks:

4.1.1 Develop a set of indicators for estimating the cost of running the infrastructure and providing services. The indicators will have to be compatible and useable for all DiSSCo NN members. Based on FR-NN experience, an accurate yet simple method will be based on assessing the cost of the whole activity of DiSSCo member institutions. Therefore, conservation, access and infrastructure (e.g. equipment maintenance, building maintenance and administration) running costs will have to be accounted for to ensure DiSSCo activities can fully recover their costs. In order to allow comparisons across countries and institutions, the time effort any staff time and the level of experience/salary of all staff will be incorporated. We will run workshops with the NNs to set out and review the indicators, and review and incorporate previous work on staff costs/experience from EUColComp, SYNTHESYS 3 and ICEDIG (Table 4 – *objective a*).

EuColComp is engaged in mapping all the activities occurring in any natural history museum and resulted in a competency framework for those responsible for the collections. This set of competencies can be used in common job descriptions across European NSCs.

During SYNTHESYS 3, a set of key performance indicators were developed to assess the activity in natural history museums: access and uses, digitisation, collections management and conservation, research and scientific activities, which can all be connected to resources.

As a design study, ICEDIG (Table 4 – *objectives a, b*) is currently surveying the digitisation methods and looking at the most efficient ones for 2D and 3D imaging.

4.1.2: Survey of costs and best practices for commissioning/decommissioning collections infrastructure. In addition to costs incurred in building IT infrastructures, we will survey the NNs and other non-European museums to gather the cost of collection renovation projects in the last 10-15 years, as renovation projects aim, at least partly, at improving the conditions of physical access and therefore can be used by DiSSCo in setting up priorities, and possibly, including some of the costs in the service charges. We will include the costs of conservation and re-curation of collections, physical storage provision, and new buildings and supporting infrastructure. Any lessons learned and best practices will be summarised. Changes to collections infrastructure will be expressed as capital expenditure indicators in the cost book.

Subtask 4.1.3: Costs of IT infrastructure and long-term preservation of data. This subtask will work closely together with WP6 to develop indicators on the running costs of the associated DiSSCo IT infrastructure both for the consortium and for individual institutions. This includes software tools and services, physical infrastructure and long-term data preservation.

Task 4.2 Cost model for charging services

This task will build on the user stories and case studies compiled in WP1 (Tasks 1.1 and 1.2) and user needs to be identified in Task 8.3. In conjunction with the service needs provisionally identified during the proposal stage of DiSSCo, Task 4.2 will identify and fully cost the range of services to be provided by the DiSSCo RI. These services support both the institutional data contributors as well as the external user community (e.g. researchers and citizen scientists). Task 4.2 will develop a technical framework to measure these costs and collate this data from selected DiSSCo facilities. Services that need to be costed, broadly fall into the following categories:

- Data mobilisation (i.e. physical digitisation across a range of collection types and service providers)
- Data processing activities (i.e. cleaning and preparation to make the data fit for use)
- Data access and exploitation (i.e. the actions required to supply data to users and track its impact)

In addition to these data services, DiSSCo will incur running costs fundamental to the provision of common services core to the operation of the DiSSCo RI. Examples include:

- Running the DiSSCo helpdesk (i.e. operating 1st - 3rd line support across for the DiSSCo facilities)
- Training provision (i.e. providing access to training services across all partners)
- Common communication services (i.e. provision of IT services necessary for facilitating the efficient operation of the DiSSCo community)
- Common human resource services (e.g. the costs of secondment procedures)

Task 4.2 will develop detailed costings for the provisioning of these services at reference institutions that represent the diversity, geographic spread and size of those present across the consortium. As part of this task, we will seek agreement on the platform to store these data, as well as the security and privacy arrangements that govern access to this information. These will be developed in conjunction with WP9 that covers the ethical aspects of DiSSCo development and the technical subcontractor aiding the development of the DiSSCo Cost Book (with Task 4.1).

A technical subcontracted partner will help to identify users and market niches. It will then explore with potential users their needs and will identify the key elements to propose or to implement into services in order to fulfil these needs and ensure that offer matches demand. The technical partner will run some pilot/experimental project to assess the cost for services. These pilots will lead to a full business model with project marketing including the range of offers and prices, and communication strategies. The technical partner will liaise with WP1.

Task 4.3 National contributions to the DiSSCo RI

Develop the most suitable model for national contributions based on the existing ESFRI landscape and ERICs; for this task, WP4 will link with WP7 regarding legal requirements and DiSSCo Prepare WP8 for the specialisation graph. This task will especially focus on the national funding mechanisms by assessing the functioning of other existing infrastructures already legally established. Integrating the lessons learned will be essential to determine the contribution model of DiSSCo. In coordination with WP7 and WP8 it will be important to consult the funding mechanisms in the different DiSSCo countries to seek a globally endorsed model for the implementation and consolidation phases. The NNs will play an important relay and advocacy role towards the national funding bodies and ministries.

Task 4.4 Pre-commercial procurement financial structure

The objectives of this task are to address the business model based on DiSSCo as an R&D platform that will both answer the needs of running the infrastructure and will support the development of tools and services reaching outside the DiSSCo remit. The financial structure and the relationships with industrial partners will aim to improve maintenance (e.g. internal IT maintenance) and improving services to users.

In practice, we will work together with the technical partner, an expert in writing financial business plans. Under the supervision of the task leader and with the input from external experts the technical partner will write up the business plan. This plan will include the needs listed according to potential financial return, a revenue stream based on identified types of partnerships and the requirements for implementation (feasibility, resources, competencies).

The output will be a roadmap showing the priorities for implementation of the financial model for Pre-Commercial Procurement based on targeted users, partnerships, R&D activities and fundraising opportunities.

Work Package 5 - Common resources & standards

WP5 aims to achieve the technical readiness of DiSSCo facilities by identifying, developing, and providing services and best practices for DiSSCo. This will be realised by making use of outputs (e.g. data standards, modelling platforms and service infrastructures) by leading initiatives and international organisations (RDA, TDWG, CETAF, etc.).

Objectives:

- Building a knowledgebase with structured and validated information about existing data standards, persistent identifiers and further products (e.g. software) relevant to the DiSSCo RI
- Developing a modelling framework and data model covering all requirements from the natural history domain

- Providing guidelines and resources for data enhancement allowing for cross-linking of information from various institutions and increase the overall data interoperability
- Providing Construction plans for the improvement of key services for seamless integration into the overall technical DiSSCo Architecture

Task 5.1 DiSSCo Knowledgebase for technical development

DiSSCo Prepare will build on profound technical knowledge from various sources and initiatives. In order to allow for efficient knowledge and technology transfer for partners building the DiSSCo technical backbone, a central and freely-accessible DiSSCo knowledgebase will be designed and implemented. The knowledgebase will provide (1) structured technical documentation of identified DiSSCo technical building blocks, such as web services, PID systems, controlled vocabularies, ontologies and data standards for bio- and geo-collection objects, collection descriptions, digital assets standards as well as domain specific software products for quality assurance and monitoring, (2) an assessment of their technical readiness for DiSSCo, as well as (3) specifications on their relevance for the overall DiSSCo technical infrastructure and the DiSSCo data model. This will be achieved together with international community (data) standards organisations (TDWG, GGBN).

Task 5.2 DiSSCo modelling framework and data model

The interoperability of DiSSCo RI software components and services highly depends on the availability of an agreed data model covering all aspects of specimen-related information, for example, specimen and observational data, taxon names, DNA sequences, and publications. The existing landscape, of bio- and geodiversity data formats and standards, is heterogeneous and modelling approaches are hindered by current use of different modelling workflows for similar or identical data domains, incomplete version histories, insufficiently documented concepts, and the lack of machine-readable links to related data definitions. The DiSSCo Modelling Framework will provide modelling capabilities for required groundworks in order to shape DiSSCo Digital Specimen Object Specifications (DSOS).

Specific use cases range from semantic annotation of collection-related research data to general semantically annotated DiSSCo APIs. Based on an existing technical platform (e.g. WikiData) and existing standards and data formats developed by the community (e.g. DwC, ABCD, CDM), the modelling framework will provide a mechanism for agreeing and documenting a core set of “DiSSCo data elements”. The Platform will provide persistent ID for each concept, relations to elements in existing standards, as well as an API for machine-readable access to the data model.

The main objectives of this task are

1. a compilation of target resource (information) types, e.g., taxon names, publications, DNA sequences,
2. an analysis of existing data standards (e.g., DwC, ABCD, GGBN, Audubon core) according to their matching capability with the required resource types,

3. identification of data standards forming the basis for the DSOS,
4. definition of specifications and technical implementation of the required modelling capabilities, e.g., WikiBase, and
5. an alignment of identified standards for building the DiSSCo-specific applications for digital objects.

Task 5.3 Semantic enhancement and interoperability

Semantic enhancement of existing textual collection information by linking to (external) authority files or other semantic resources is a key effort to improve discoverability, comparability, data quality and linkage of the digital objects. Furthermore, enabling semantic interoperability of collection data will facilitate a new generation of applications processing and connecting this information to the rapidly growing globally linked open data graph.

The main objective of this tasks is the provision of construction plans for required basic components and best practice documentation for enriching activities at the collection level, starting with priority concepts such as taxa, persons (collectors) and geographic features.

Building on preliminary works of the CETAF ISTC as well as the OpenUp! project, this task will instigate a broad campaign for semantic enrichment activities in all DiSSCo member organisations and ensure that related activities are aligned with data management processes in CETAF member organisations.

Task 5.4 Modernising technical infrastructure for science data mobilisation and publication

The modernisation of key services, especially of services for data currently underdeveloped in the DiSSCo community, is of great importance for the overall improvement of the technical readiness level from the DiSSCo RI. This task is focusing on construction plans for the improvement of technical infrastructure in the identified key areas of geo-collection data and taxonomic services. Geo-collection data are highly underrepresented in terms of available services for data mobilisation and publication. Thus, these services need special consideration in order to significantly increase DiSSCo technical readiness in the earth scientific domain. In addition, the harmonisation of life science taxonomic checklist services (e.g., Catalogue of Life) needs construction plans for the integration into DiSSCo architecture in order to exploit their full value as a taxonomic backbone.

This task will focus on the investigation of existing tools and provide necessary plans for seamless integration intothe overall DiSSCo technical architecture.

Work Package 6 - Technical architecture & service provision

The main objective of WP6 is to bring the design of the DiSSCo technical architecture to the required maturity to provide a comprehensive implementation plan.Major elements for the technical preparation and readiness of DiSSCo are:

- the interoperability with scientific data in collection management systems (CMS) of the partner organisations (6.1);
- the evaluation of the core Digital Object architecture and adding further detail to achieve the maturity needed for future implementation of the DiSSCo Knowledge Graph (6.2);
- Detailing the planned provision of FAIR end-user services and their required capabilities based on the DiSSCo use cases collected in ICEDIG (6.3);
- Development of a roadmap for integration in the European and global technical infrastructure landscape (6.4) and interoperability with FAIR services provided by the cluster of environmental RIs (ENVRI) in the European Open Science Cloud (EOSC).

Task 6.1 CMS systems interoperability and harmonisation

Establishing specifications and agreements for local DiSSCo facilities to achieve interoperability of scientific data managed in these systems to transform the currently isolated datasets into one unified European collection, building on experience from established systems for data communication (e.g. GFBio, GBIF) and software development communities (e.g., DINA). The task will include prototyping of APIs that are required to provide bi-directional interfaces for achieving the linkages between the data in the facilities through the DiSSCo Knowledge Graph.

Task 6.2 Evaluation of the DiSSCo Architecture

Evaluating and testing the DiSSCo Architecture recommendations provided by the ICEDIG project to add further detail, resulting in an implementation and construction plan for the core DiSSCo technical infrastructure. The infrastructure will be prototyped to model DiSSCo operational capabilities and implement the core virtualisation infrastructure, supported by bi-directional interfaces from/to the DiSSCo facilities as specified in Task 6.1. The infrastructure will need to serve digital specimen and their related data for the DiSSCo scientific use cases as collected in ICEDIG. Required hardware infrastructure for storage and computing will be described as well as integration with EOSC. The task will include the following activities:

Prototyping the DiSSCo Digital Architecture and creating a demonstrator.

- Demonstration of Machine Learning algorithms integration to serve use cases for knowledge discovery and annotation of digital specimen data. To prototype, demonstrate and describe how to integrate these with the DiSSCo Knowledge Graph to serve data relationship discovery and exploration, semantic interoperability, and data governance.

- Workflows and technical instructions that enable collaborative FAIR data curation and annotation, including machine-added annotations/metadata. Working in close collaboration with WP5, this activity will 1) refine the use cases for bio-/geodata annotations (including scholarly and citizen science applications), 2) explore technical solutions currently implemented across DiSSCo facilities; and 3) measure their compliance with the W3C annotations standards and FAIR principles, with a particular focus on interoperability. This builds on the data standards activities in ICEDIG, SYNTHESYS+ and the MOBILISE COST Action (Table 4 – *objectives d, g, h, m, o*).

Task 6.3 Technical interface requirements of the end-user services

This task aims at further defining the collection of technical services and capabilities offered by DiSSCo to serve the use cases collected from end-users in the ICEDIG project (including individual researchers, other RIs and citizen scientists) and user needs, to be defined in WP1. In addition, it will describe how these need to interact with the DiSSCo core technical architecture. Interactions with external services like virtual research environments for data aggregation, machine learning, analysis and visualisation (like the VAT tool within the GFBio Data Federation) tools will also be defined. The task will make use of other outputs from WP5 & WP6, and results from WP1. FAIRness maturity requirements for the services will be calculated in the context of WP11 in the ENVRI-FAIR project. The task will also assess the maturity of the European Loan and Visits System (ELViS), to be developed under SYNTHESYS+ (Table 4 – *objective j*), focussing on the adaptations needed for integration with the core DiSSCo architecture.

Task 6.4 Embedding DiSSCo in the technical landscape

Subtasks:

6.4.1. Embedding DiSSCo in the European and global technical landscape National efforts and projects (projects (e.g. German GFBio and DCOLL proposal, US iDigBio, French RECOLNAT infrastructure) will be inventoried and a roadmap will be developed to align these with the DiSSCo Construction Masterplan. The Construction plan will also be adapted to international developments in e.g. EOSC, GEOSS, GBIF, EMBL-EBI, ENVRI-RIs, iDigBio, and new recommendations developed in the Research Data Alliance.

6.4.2. Representation of DiSSCo in relevant technical committees and standardisation, e.g. bodies, initiatives, organisations or relevant technical working groups for DiSSCo (e.g. TDWG, ELIXIR, RDA).

6.4.3. Bring the DiSSCo Data Management Plan (DMP) to maturity including embedded relevant principles and policies with respect to FAIR data policies.

The subtask will assess and update the DMP defined in the ICEDIG project. It will adapt the DMP to the latest developments with respect to FAIR data policies and European rules and best practises for data management.

Measurements will be performed, in collaboration with ENVRI-FAIR and the Go-FAIR (Biodiversity Implementation Network) to evaluate current and anticipated DiSSCo compliance with the FAIR data principles.

6.4.4. Enable FAIR data and compliant services, and integration in the EOSC service catalogue. This subtask will develop and adopt measurements and indicators in collaboration with ENVRI-FAIR and the Go-Fair initiative to measure compliance of data and services with the FAIR data principles. The task will also describe how the DiSSCo services will be added to the ENVRI part of the EOSC catalogue of services.

Work Package 7 - Governance, policy & legal frameworks

WP7 contributes to the Organisational Readiness of DiSSCo by producing reference material for the legal framework in which DiSSCo will operate, and for its governance and the common policies that will apply to its operation (i.e., access to physical and virtual collections, data policy).

WP7 will build upon information already gathered in previously and currently running projects, in a strong relationship with the key decision makers of the institutions and organisations involved in DiSSCo. In order to streamline the interactions with the stakeholders, new information will be collected, as needed, by WP8 (Task 8.2). WP7 will collate, analyse, and synthesise the information, and produce documents that will be submitted to the stakeholders through the streams set up by WP8.

Objectives:

- Refine the governance model, strategy and operational planning
- Pave the way towards establishing DiSSCo as a legal entity
- Develop a minimum corpus of policy material needed to be adopted at the institutional level to enable the operation of the infrastructure. This should include data and access policies.
- Develop implementation/adoption scenarios in relation to national/European legislation frameworks and requirements

Task 7.1 Refinement of the governance model, Strategy and Operational planning

Although already partially developed the DiSSCo governance model will have to be further refined and the feasibility of its implementation analysed. The roles of the various bodies will be defined (including practical aspects like number of members) and translated into Terms-of-reference. A wide DiSSCo partner consultation will be carried out to ensure acceptability, endorsement and commitment of the partnership, building on top of the existing MoUs. Based on the current mission and vision, resource limitations, and the landscape analysis, this task will articulate a mid- and longer-term strategy for DiSSCo and develop an operational planning in support of this strategy. The strategy will be put forward to the DiSSCo General Assembly.

Task 7.2 Towards the creation of a legal entity

With this task, we will prepare the necessary steps to establish DiSSCo as a legal entity in order for the RI to deliverits services in the most efficient way. The following actions will be performed in sequence:

- Detailed analysis of the legal entity models, including a SWOT analysis, and their suitability for achieving DiSSCo objectives in agreement with its governance model. The result of the analysis will be presented and discussed with the various national contact entities (*cf.* WP8), in order to reach a consensus on the best choice.
- Draft statutes and by-laws will be prepared, according to the legal entity model that appears to be the most appropriate.
- Planning for the creation of the legal entity.

Task 7.3 Develop and establish DiSSCo policies

The main objective of this task is to provide all institutions in the DiSSCo RI with a "direction map", identifying a series of targets and possible pathways to reach them, in order to have their policies align with a common set of principles and rules that support DiSSCo services. Assessment tools will also be provided to help institutions identify the most crucial issues. This task will look at the key concepts underlying the following policies:

1. Physical access policies (which are now rather homogeneous and mature thanks to the SYNTHESYS projects)
2. Data policies and digital access policies (access to and use of the products of the digitisation processes); and
3. Collection curation policies.

With the completion of this task DiSSCo Prepare will provide:

- A map of legislation, policies and policy components that are relevant to physical/digital access and digital collections. This can act as a policy self-assessment tool for DiSSCo facilities and help to identify gaps in and develop institutional policy documentation, reducing the requirement for local resource and expertise.
- Improvement of discoverability and interoperability of policy documentation across DiSSCo facilities, so institutions can reuse relevant parts of existing documents for drafting policy documentation.
- Mapping of common DiSSCo policies into the framework to support the alignment process.

The different regulatory levels will be addressed by the map, through several case studies. This work will largely be based on and benefit from the ongoing efforts in ICEDIG (Table 4 – *objective e*) and from the contribution of the various national contact entities (*cf.* WP8). Interaction and coordination with the "FAIR Policy Working Group" set up in the frame of the H2020 ENVRI FAIR (Table 4 – *objective w*) will also be established.

Work Package 8 - Stakeholder engagement & communication strategy

By providing the proper channels (Task 8.1) and strategic mechanisms (Task 8.4), the DiSSCo facilities will be put in a position to advocate on behalf of DiSSCo, showcasing its relevance and time-sensitivity to selected targeted audiences. To achieve this, the landscape around DiSSCo needs to be engaged along two streams: with decision makers and national nodes (Task 8.1), and the wider domain to investigate synergies and collaboration opportunities (Task 8.3).

Task 8.1 DiSSCo national nodes engagement

National Smart Specialisation and institution-level strategies inform prioritisation objectives in each DiSSCo member country. Gathering the state-of-the-art nationally will provide the basis for the construction of an overall strategic map that is necessary for DiSSCo activities distribution and operation. Equally important will be to establish a follow-up mechanism to ensure alignment and harmonisation with national RI roadmap processes and relevant foreseen developments (e.g., national contributions/nodes for EOSC, participation in cluster services development, etc.). This means close relations with all national nodes to channel the engagement of governments (whichever the level might be for each country). Out of these activities, a granular thematic specialisation planranging from national to institutional levels will be produced.

For this to be effective, apart from the participating partners' involvement, each national node will receive 2 PMs that will go to the institution representing the node (to have due legal partnership). The national nodes will be asked to deliver a few very concrete results within this task:

- Identify contact points within their relevant ministerial structures and function as an information junction between them and DiSSCo on a regular basis, as required.
- Channel their relevant institutional strategies and policies to CETAF as a basis for tasks Task 8.2 and Task 7.3.
- Validate the resume of the policies corpus (and their translations, if necessary) developed under WP7, and ensure its widest dissemination nationally.
- Provide feedback for outputs and participate in surveys.
- Stay informed on the development of the project as well as DiSSCo and participate in project meetings where necessary.

Task 8.2 External Communication Strategy

The strategy aims to set out a concise communication plan, employing a four-layered approach for targeting relevant audiences, as developed under the ICEDIG project:

- direct contributors in the broader network of collection holders;
- complementary stakeholders and initiatives (including international initiatives/RIs such as iDigBio, CRIA, ALA, GBIF, in the environmental and digital domains);
- related third parties (users platforms, e.g. EOSC); and

- societal bodies (including governmental representatives and funding agencies at regional, national, European, and international scale, ESFRI delegates, media and the general public).

Based on this strategy, several external communication tools will be developed and operated. These include a logo and graphic charter (developed under WP9), the project website (which will be hosted as part of the DiSSCo website – dissco.eu) as well as social media channels. All project partners commit to feeding any newsworthy content into these channels and to engage with their respective communication and press teams. The strategy will establish clear messages to use in joint communication campaigns. These will inform potential users of the capacities and benefits of DiSSCo. Among others, socioeconomic impact, the scientific dimension, and innovation push factors will be integrated into the communication strategy.

The activities will include an engagement mechanism to facilitate promoting the project activities towards stakeholders and potential users of the RI. Tools that will be used include dialogue with the community, open consultations to related institutions and associations, and workshops.

Task 8.3 DiSSCo stakeholder engagement

Built on the work performed by DiSSCo-related initiatives, Task 8.3 will strengthen the linkages and build strategic partnership frameworks with the relevant external stakeholders and communities. The goal of these engagement activities is to identify synergies, coordinate actions and joint services development. Alongside target audiencesidentified in Task 8.1, this activity will specifically address three axes:

- legal: from private (IT partners and other industrial actors) to public (e.g., academia, citizen science);
- field of reference: domain specific to related entities (e.g., Biodiversity Heritage Library-BHL, Open Access publishers as well as RDA and ECSA), and
- geographical spread: from European to global international coverage.

This task will look at procedures for DiSSCo external collaboration and tendering, both collectively and individually. DiSSCo facilities will partner and contract with third parties to obtain, e.g. computing capacity and to deliver, collections management, digitisation, training or publishing, etc. This task will set out procedures and procurement frameworks, to ensure consistent practice and maximise successful outcomes across the consortium. It will also consider the wide variety of potential partners and contractors, from businesses of all sizes, to publicly or philanthropically funded organisations, social enterprises and research organisations.

The output of this task will be a framework for alignment and cooperation and a set of best practices for partnerships to act with partners as described above, but with other relevant European RIs and initiatives included (towards EOSC, but also ERA, ESFRI, Europeana, EuroGEOSS, in addition to eLTER, LifeWatch, E-RIHS through the clustering ENVRI FAIR project, etc.).

Task 8.4 Dissemination, Outreach and Advocacy

In the future, DiSSCo will need enough support from national governments to work efficiently. This requires functioning communication channels, which will be established under T8.2, and continuous advocacy work. Task 8.4 will develop and implement a strategic plan to address governmental agencies (members of parliament, ministries, ESFRI delegates, etc.) on a national and European level.

Participation in the relevant, influential fora along the science policy interface will be organised within this task to increase DiSSCo visibility and acknowledgement. National scientific agencies, as well as international bodies (e.g. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Consortium of Scientific Partners on Biodiversity to the Convention on Biological Diversity (CSP to the CBD)), will be regularly contacted and updated on progress. Over time, these fora and their components have the potential to become new end-users for the DiSSCo RI, and so will collaborate with WP1 in supporting this transition.

Advocacy and outreach also will cover parts of the dissemination activities of the DiSSCo Prepare project to ensure the uptake of the results.

Work Package 9 - Project Management

WP9 will set up the governance and management structure, necessary bodies, and collect all documents necessary for producing the DiSSCo Construction Masterplan. This WP produces the descriptions of the targeted governance and management structures and establishes the governance bodies. WP9 facilitates the work and meetings of all DiSSCo bodies. The WP is split into four tasks that focus on the following key project-wide objectives:

- Set-up and operate the key project governance and management bodies, ensure quality and invoke necessary mitigation actions against identified risks;
- Ensure seamless day-to-day implementation of the project, providing the right platforms for technical management technical platforms, financial management and overall administration of the project;
- Support the operation of the critical advisory boards of DiSSCo, including the stakeholders and Funders Forum, Scientific and Technical Advisory boards;
- Bring together the outputs of the project to deliver the DiSSCo Construction Masterplan and initiate theprocess for the establishment of the new DiSSCo legal entity.

Task 9.1 Governance, Performance and Risk management

The main objective of this task is to support the operation and communication of the key governance and management structures of the project. Specifically, this task will focus on:

- Internal procedures (statutes) of the General Assembly and Executive Board;

- Evaluation of the quality and fitness for the purpose of the project outputs (milestones and Deliverables), using internal or external (as needed) review panels;
- Risk monitoring and initiation of risk mitigation actions;
- Proposals for amending the Consortium or Grant Agreement, as needed.

The responsibility of this task lies with the Executive Board of the project. The Project Coordinator will ensure due procedures are followed according to the Consortium Agreement.

Task 9.2 Day-to-Day management

This task is focusing on the day-to-day management of the project. Specifically:

- Set-up and operation of the project online management platform;
- Support for the operation (administration and logistics) of the project's governance and management bodies, including the Project Council and Executive Board);
- Internal communication with partners on contractual responsibilities and evaluation of progress against upcoming milestones and Deliverables;
- Communication with the European Commission;
- Financial administration of the project.

This task will be undertaken by the DiSSCo Prepare project manager in collaboration with the project administration team.

Task 9.3 Operation of Advisory Groups

The main objective of this Task is to provide administrative and logistical support to the operation of the key advisory and stakeholders groups of the DiSSCo RI as well as within the project.

Specifically, during the task, we will:

- Set-up, draft the rules of procedure and provide administrative support to the Scientific and Technical Advisory Boards (SAB & TAB) of DiSSCo;
- Set-up, draft the rules of procedure and provide administrative support to the SF;
- Provide administrative support to the DiSSCo Prepare management structures, including the Project Council and Executive Board.

Task 9.4 Compilation of DiSSCo Construction Master Plan

The objective of this Task is to bring together the outputs of all the content-related Tasks across the project in order to create an integrated Construction masterplan for DiSSCo.

The Construction Masterplan will have the form of a structured and indexed corpus of material, and act as 'blueprints' for the subsequent construction phase of DiSSCo. Furthermore, the task will initiate (following recommendations from WP7) the process for establishing the new DiSSCo legal entity.

3.2 Management structure and procedures

3.2.1 Overall project governance structure

The project governance structure follows the principle ‘as simple as possible, as complex as necessary’. It recognises the minimum number of distinct bodies that will operate as project-specific structures, and benefits from the operation of DiSSCo-wide advisory bodies, which will be incorporated into its management (Fig. 10).

3.2.2 Decision-making, stakeholder and advisory bodies

Project-specific structures

Project Council - The Project Council is the ultimate decision-making body for the project. The Council is comprised of one representative from each of the consortium beneficiaries. The Project Coordinator chairs the Council. The Project Manager and Stream Coordinators participate with no voting rights and facilitate the work of the Council. The Council physically meets at least once a year. Detailed rules of procedure will be established during the Consortium Agreement negotiations.

Executive Board (EB) - The EB is the main executive branch of the project and responsible for the implementation of the Grant Agreement and General Assembly decisions. The EB is comprised of the Project Coordinator, Project Manager, Stream Coordinators and the Project administration team. The EB works daily, in the context of the tasks described in WP9, to ensure the smooth implementation of the project.

Work Streams - To ensure better coordination of thematically related work, the WPs are grouped in two streams of work with a Stream coordinator appointed to each. The Science & Technology Stream coordinator overlooks the work undertaken by WPs 1, 3, 5 and 6. The Business Stream coordinator overlooks the work undertaken by WPs 2, 4, 7 and 8. Both stream coordinators report to the EB.

DiSSCo-wide bodies participating in DiSSCo Prepare Project governance/ management

Stakeholders Forum (SF) - The SF interacts with the EB and, it constitutes a critical body in the implementation of the project, providing an external view to the project from a technical, organisational and financial perspective. The SF will convene at least twice a year to discuss relevant milestones and provide guidance on ongoing and future tasks as needed. The SF is chaired by the Project Coordinator, who participates ex officio.

Funders Forum (FF) - The FF directly interacts with the project’s Council. Recommendations and reports from the FF are presented for action to the Council. The communication between FF and the Project Council is facilitated by the EB. The FF convenes once per year co-located with the Council meeting. The FF directly elects the FF chair.

Technical Advisory Board (TAB) and Scientific Advisory Board (SAB) - The TAB & SAB operate to provide direct consultation services to the EB. The EB will nominate membership of these Boards and approved by the Project Council.

Strategic Alignment of Projects (SAP) - The SAP provides the mechanism through which the DiSSCo-linked projects are kept synchronised. The SAP will be supported by DiSSCo Prepare and will convene on a regular basis to support the coordination of activities at WP and Task level across the DiSSCo-linked projects.

3.2.3 Management procedures

Project Management (WP9)

DiSSCo Prepare is a relatively complex project, which requires not only good synchronisation across the Tasks and activities in its work programme but also an efficient way to take a birds-eye view on linked activities across all the DiSSCo-linked and DiSSCo-associated projects. To this end, this WP dedicates significant effort in supporting the crucial advisory boards (SF, FF, TAB, SAB) and the Strategic Alignment of Projects (SAP) group (Task 9.3). Further recognising the increased risks from operating within a constantly moving landscape, it dedicates significant effort to risk management (Task 9.1) and employs dedicated tools, such as the Responsibility Assignment Matrix (RAM), to safeguard the quality and relevance of the project outputs. Furthermore, WP9 will collate the outputs of all the DiSSCo Prepare activities, harmonise them and structure them into a final product (DiSSCo Construction Masterplan), which will be delivered to the DiSSCo management to guide next steps in construction and operation of the infrastructure. Finally, WP9 will dedicate resources (dedicated project manager, administration team and cloud-based tools) to ensure seamless day-to-day project management.

Quality control of DiSSCo Prepare outputs

In order to ensure the quality of the Deliverables and improve the efficiency of the quality control process, the Council will allocate certain responsibilities to individuals (with explicit project functions), Governing Bodies and Consortium Partners, according to the model presented in the Responsibility Assignment Matrix (RAM) (Table 6).

Table 6.

The DiSSCo Responsibility Assignment Matrix (RAM) facilitates clear accountability and quality control pipelines in the project.

Role	Milestone	Deliverable
Project Coordinator	Informed	Suggest
Project Manager	Suggest	Informed
Technical / Scientific Advisory Board	Informed	Suggest
Executive Board	Suggest	Control

Role	Milestone	Deliverable
WP Leader	Control	Accountable
Task Leader	Perform/Accountable	Perform
Task Partner	Perform	Perform
Council	Informed	Suggest

Governance and decision-making processes

The implementation of the work plan is ensured by the Council and supported by the EB and through implementation of the RAM. The Project Manager (assisted by the administration team) will monitor the timely delivery of DiSSCo Prepare outputs, inform the accountable partners of potential time drifts in the work plan, propose mitigation actions and report any deviations to the EB and the Council. In case of severe (risk of missing deliverable deadlines) deviations from the work plan timescale, the Project Manager will ask for a written justification that will be presented to the EB. The EB will examine the justification report and recommend course of actions in the context of the Grant and Consortium Agreements provisions.

The ultimate decision-making body of the project is the Project Council. The Council operates in the context of the Grant and Consortium Agreements.

DiSSCo Prepare makes extensive use of DiSSCo-wide advisory bodies, including the SF and FF, as well as the TAB and SAB. The role of the Advisory Boards in the evaluation and quality control of the project milestones and Deliverables is described in the RAM. The responsibility of engaging the corresponding Advisory Board for the evaluation lies with the EB.

Mode of collaboration

The project consortium will make use of the DiSSCo Project Management Platform (dissco.org). The Project Manager and the administration team will formally monitor the progress of the project, collect outputs and handle consortium-wide communications. A specific PERT (Programme Evaluation Review Technique) chart will be implemented on top of the GANTT chart provided in the proposal. Both tools will act to ensure effective progress and achievement of objectives, as well as to implement correction and alignment measures. Both online and physical meetings to be held during the project (Table 7):

Online meetings will be agreed for all structures and bodies of the project, including WPs, Streams, EB and Advisory Boards. Minutes of the meetings will be made available consortium-wide (and when applicable publicly) through the DiSSCo project management platform (dissco.org) or the DiSSCo public website (dissco.eu).

Physical meetings will be held according to the following schedule and where possible co-located with activities of the other DiSSCo-linked projects or European relevant events, to minimise associated financial and environmental impact.

Table 7.
List of online and physical meetings schedule for the project duration.

Meeting type	Description	Planning
All-hands meetings	Provides opportunity for work-intensive meetings. Will include physical meetings of: EB, Project Council and WPs	Yearly (physical meeting)
Executive Board (EB) meeting	EB meets to review progress of the work implementation, review risks and invoke mitigation procedures, and prepare the agendas for Project Council meetings	Online meeting every three months
Work Package (WP) Streams meetings	Coordination meetings of all WP leaders in the Science & Technology Stream and the Business Stream	Online working meetings every month
Funders Forum, Stakeholders Forum, SAB and TAB	Provides opportunity for wide consultation across the project and evaluation of the current Implementation Readiness Level across all dimensions	Mostly online every three (SAB, TAB) or six months (FF, SF)
Roundtables	Work-intensive thematic meetings targeting issues relevant to one of the Dimensions of Readiness	Five for the duration of the project (one per IRL dimension)
Workshops	Provide opportunities for detailed analysis of specific topics	Planned by different WPs in response to their needs

Project Data Management Plan

The project's Data Management Plan (DMP) will be finalised in month 3 of the project (D9.2) and will include policies on the publication, storage, persistence and accessibility of all data (content and process) produced or handled by the project partners and in accordance to the practices of open science. Any personal data will be handled in accordance with GDPR. The project's DMP should not be confused with the RI overall DMP, which is in detail developed as part of WP5 and WP6 and builds on the work performed under the DiSSCo-linked project ICEDIG.

3.3 Consortium as a whole

3.3.1 Overview of Consortium

The consortium is built on the following key premises:

1. Bring together partners with the expertise and experience to undertake the tasks in the project's Work Programme, ensuring geographical balance to the extent where possible;
2. Allow DiSSCo facilities across all 21 DiSSCo countries to i) keep abreast with the project developments, and b) support them in liaising with national funders;

3. Identify any missing expertise in the current DiSSCo consortium and invite technical partners to join the consortium, filling any expertise gaps; and
4. Keep close to global developments, by inviting international organisations to join the consortium as associated partners.

The above approach in building the DiSSCo Prepare consortium balances between optimum engagement of the key DiSSCo stakeholders and retaining the right expertise in relation to the programme execution.

3.3.2 Core beneficiaries

The core beneficiaries undertake most of the work described in the nine WPs of DiSSCo Prepare. As WP and task leading organisations they provide oversight to the execution of the programme and coordinate contributions by other partners as needed. The 14 core beneficiaries are DiSSCo facilities (natural science collection organisations) with the significant expertise in the fields relevant to the topics they address. Additionally, the underlying natural science collections network (CETAF) participates, ensuring efficient engagement and communication across internal (DiSSCo) and external (Policy, Industry and other RIs) stakeholders. Naturalis (the spearheading national organisation from the country that leads DiSSCo) coordinates the project. The core beneficiaries include the seven largest natural science museums in Europe (NHM, MNHN, Naturalis, IRSNB, NHMD, SGN and MfN). Finally, the coordinating organisations of the DiSSCo-linked projects (NHM for SYNTHESYS+ and Luomus for ICEDIG) participate to ensure better coordination between DiSSCo Prepare and those projects.

In-kind contributions of core beneficiaries

All core beneficiaries contribute in-kind an average of 21% of the total project personnel effort. This in-kind contribution shows the level of commitment of the DiSSCo facilities to the project and the highlights the importance of the outputs for DiSSCo.

3.3.3 DiSSCo National Nodes (NNs)

The DiSSCo partnership consists of 115 organisations across 21 European countries. DiSSCo Prepare involves, in the project, formally appointed representative organisations (through previously signed national MoUs) of each national consortium (National Nodes - NN) across all the 21 countries. These organisations represent the NN and ensure that the project keeps abreast with ongoing national developments and requirements. They also undertake key activities around the engagement of national funders and stakeholders. The participation of the NN representing organisations is described in WP8 (Task 8.1). All NNs participate in the Project Council and the decision-making processes of the project.

3.3.4 Technical Partners

Technical Partners fill critical expertise gaps in the project consortium. DiSSCo Prepare has an expert partner contributing to the Technical Readiness (WP5 & WP6) (Cardiff

University) and a partner contributing to the Financial Readiness (WP4) which will be subcontracted by the project to perform tasks related to the development of the Cost Book and financial models of DiSSCo. Furthermore, to better address the critical issues around the need for a DiSSCo-wide taxonomic backbone, Species 2000 (issuer of Catalogue of Life) is coming on board in Task 5.4.

3.3.5 International Partners

The partners play a pivotal role in enabling international coordination and providing expertise on project outputs. GBIF (major international biodiversity data aggregator) will provide expert opinion on outputs of the technological readiness WPs, while CNRI (US-based no-profit organisation, also supporting the digital objects initiative) will be essential for assessing the work of WP6. Collaboration with other key regional initiatives such as iDigBio is ensured through the provided letters of intent for collaboration.

3.4 Resources to be committed (budget)

The project has a total cost of € 4,868,518.37, of which the EU's contribution was €3,999,383.01. See Cordis project information for more details.

Participant resources based on staff effort are summarised in Table 8.

Table 8.
Summary of staff effort (WP leads underlined and bold).

Participant no.	Short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total person months
1 (coordinator)	Naturalis	4	0	0	0	6	14	8	6	**33**	**71**
2	CETAF	2	9	0	5	0	0	6	**10.5**	6	**38.5**
3	NHMD	**9**	0	0	0	0	0	0	2	2	**13**
4	SGN	0	0	3	4	5	**24**	0	0	2	**38**
5	Luomus	6	0	7	0	0	6	6	4	0	**29**
6	ULISBOA	4	**13**	5	0	0	0	0	4	2	**28**
7	Cardiff	0	0	0	0	1	10	0	0	0	**11**
8	RBGE	1.5	0	3	0	4	5	0	0	0	**13.5**
9	Tartu	5	0	3	0	3	3	0	2	0	**16**
10	MeiseBG	4	0	4.5	14	6	6.5	2.5	1	0	**38.5**
11	UniFi	2	6	0	0	0	0	0	2	2	**12**
12	BGBM	1.5	0	0	0	15	2	0	1	0	**19.5**
13	NHM	4.5	2	**15**	7	10	3	7	6.5	2	**57**

Participant no.	Short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total person months
14	MfN	5	6	7	0	15	9	0	1	2	**45**
15	MNHN	1.5	1	0	23	0	2	8	5	2	**42.5**
16	IRSNB	1	0	3	10	0	0	9	4	2	**29**
17	IBER-BAS	0	0	0	0	0	0	0	2	0	**2**
18	UW	0	0	0	0	0	0	0	2	0	**2**
19	NM	2	0	0	0	0	0	0	2	0	**4**
20	NHMW	0	0	0	0	0	0	0	2	0	**2**
21	MNCN-CSIC	0	0	0	0	0	0	0	2	0	**2**
22	HNHM	0	0	0	0	0	0	0	2	0	**2**
23	IBSAS	0	0	0	0	0	0	0	2	0	**2**
24	NRM	0	0	0	0	0	0	0	2	0	**2**
25	NHM-UIO	0	4	0	0	0	0	0	2	0	**6**
26	UoC-NHMC	0	0	0	0	0	0	0	2	0	**2**
27	MHNHL	0	0	0	0	0	0	0	2	0	**2**
28	UPORTO	0	0	0	0	0	0	0	2		**2**
29	CNRI	0	0	0	0	0	1.5	0	0	0	**1.5**
30	GBIF	0	0	0	0	1	1	0	0	0	**2**
31	Sp2000	0	0	0	0	2	0	0	0	0	**2**
Total		**53**	**41**	**50.5**	**63**	**68**	**87**	**46.5**	**74**	**55**	**537**

Glossary and list of abbreviations

CETAF - Consortium of European Taxonomic Facilities (https://cetaf.org/)

CMS - collection management systems

DDBJ - DNA Data Bank of Japan

ECOI - European Collection Objects Index

EMBL - European Molecular Biology Laboratory (https://www.embl.org/)

EOSC - European Open Science Cloud (https://eosc-portal.eu/)

ESFRI - European Strategy Forum on Research Infrastructures

FF - Funders Forum (described in the management section of the proposal)

GBIF - Global Biodiversity Information Facility

GDPR - General Data Protection Regulation

HRM - human resources management

iBOL - International Barcode of Life

IRL - Implementation Readiness Level

MOBILISE Cost Action - “Mobilising Data, Experts and Policies in Scientific Collections” see Cost Action CA17106 and https://www.mobilise-action.eu/

MoU - Memoranda of Understanding

NN - National Node (formerly referred to as National Task Force (NTF))

NSC - Natural Science Collections

SAB - Scientific Advisory Board

SAP - Strategic Alignment of Projects

SOPs - Standard Operating Procedures

SYNTHESYS+ - Synthesis of systematic resources project - see Cordis Project #823827 and Smith et al. 2019

TAB - Technical Advisory Board

TLOs - Technology Licensing Offices

TTOs - Technology Transfer Offices

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Naturalis Biodiversity Center, Darwinweg 2, 2333 CR Leiden, Netherlands

Author contributions

Original proposal authors:

- **Wouter Addink**: [Whole Proposal - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Eva Alonso**: [WP9 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Judite Alves**: [WP2 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Ana Casino**: [WP8 - Author, WP2 T2.1. Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Luís Curral**: [WP2, T2.3 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Henrik Enghoff**: [WP1 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Michel Guiraud**: [WP4 - Author] Conceptualization, Funding Aquisition, Supervision, Writing – Review & Editing
- **Helen Hardy**: [WP3 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Jana Hoffmann**: [WP5 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Dimitris Koureas**: [Whole Proposal - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Salome Landel**: [WP4 - Author] Conceptualization, Funding Aquisition, Supervision, Visualization, Writing – Review & Editing
- **Laurence Livermore**: [WP3 - Author, WP4 T4.2 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Carole Paleco**: [WP7 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Mareike Petersen**: [WP5 - Author] Conceptualization, Funding Aquisition, Supervision, Visualization, Writing – Original Draft, Writing – Review & Editing
- **Serge Scory**: [WP7 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Vincent Smith**: [WP3 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing, Writing – Review & Editing
- **Claus Weiland**: [WP6 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing
- **Karsten Wesche**: [WP6 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing

- **Matt Woodburn**: [WP3 - Author, WP7 T7.3 - Author] Conceptualization, Funding Aquisition, Writing – Original Draft, Writing – Review & Editing

Transfer and editing of abridged proposal: Dimitris Koureas, Laurence Livermore, Eva Alonso, Wouter Addink, and Ana Casino.

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Conflicts of interest

The authors have declared that no competing interests exist.

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Endnotes

*1 DiSSCo facilities are here defined as NSC organisations, which have signed the formal agreement for participation to DiSSCo. These currently include 115 European natural history museums, botanical gardens and collection-holding universities across 21 countries.

*2 The SYNTHESYS+ DiSSCo-linked project already contributes to this global alliance through targeted networking activities under the coordination of GBIF, CETAF, and GGBN.