



Improving Digital Capability - Case Studies & Analysis

DiSSCo Prepare WP3 – Milestone 3.1

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Abstract

A critical factor in the success of the Distributed System of Scientific Collections (DiSSCo) will be the capacity enhancement necessary to scale up our digital operations, from leadership and infrastructure competency to digitisation capability and beyond. Task 3.1 in Work Package 3 seeks to address this in both human and organisational terms: analysing case studies and examples in this report, as a first step towards developing the tools or dashboards for development of individual digital competencies and to measure and raise institutional digital maturity. This is needed to underpin new DiSSCo services and support the required digital transformation to deliver and use DiSSCo outcomes. Our approaches need to be sufficiently flexible to be used by organisations of very varied size and scope, including the option to obtain or develop capacity via third parties.

WP3 draws upon the portfolio of other DiSSCo-linked projects (ICEDIG, SYNTHESYS+ and MOBILISE COST Action), as well as providing insights that are essential to other DiSSCo work packages, including WP 2, 5, 6, and 7. This report analyses the relevant outputs of the previous projects in this context. It also examines case studies and best practice in competency frameworks and in organisational digital transformation, from within and beyond the natural science collections sector. The conclusions of this report will inform Milestone 3.2, a prototype dashboard or tool(s), which will then be developed further into the full digital and data competencies framework for individuals and institutions envisaged under this Task (July 2021). This document also brings forward aspects of Milestone 3.3 of this task, by delivering case studies - as identified under Next Steps, however, further analyses of key and additional examples will be required.

Key words

**COMPETENCY, COMPETENCIES, CAPABILITY,
DIGITAL, LEADERSHIP**



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01 INTRODUCTION

1.1 Introduction

This report seeks to identify a range of case studies and best practices in relation to supporting the development of individual competency and organisational capacity. It looks at these through the lens of what is likely to be needed for DiSSCo, and makes suggestions for next steps towards developing tools or dashboards and informing requirements for training, secondments and distributed working.

The authors represent collections-holding institutions of various sizes with a variety of current approaches towards recruitment; performance management; personal development and institutional roles and skills/capacity. In many cases, these processes are governed by Human Resources teams, and may use approaches not specifically adapted to the natural science collections sector. While meetings have been held with HR teams in London and Berlin for this report, further and more systematic engagement with HR departments across DiSSCo will be necessary to identify a suitable approach to competences and roles that can adapt to different organisational contexts - there is a key interdependency here with DiSSCo Work Package 2 on Human Resources policies. We have analysed previous work in the DiSSCo-linked projects to identify vocabularies and insights relevant to competencies, roles and capabilities. Without undertaking a full academic literature review, we have carried out desk-based research and group discussion to identify key features of a competency framework and a range of case studies, both from within our individual Institutions; across the sector (where the main previous effort of this kind was the EU Collections Competencies Project of 2014); and from outside our sector where there are examples relevant to our needs and challenges.

1.2 DiSSCo needs

Why does DiSSCo need a focus on individual and institutional capabilities, and the tools and practices that help to source, develop and sustain these? Within the consortium at the current DiSSCo Preparatory phase there are already a wide variety of organisations, of different sizes, types and taking different approaches to everything from digitisation priorities to team structure. This is even more the case as DiSSCo research infrastructure evolves towards its operational phase, when common policies and shared frameworks will be in place, and as the consortium expands outwards via the National Nodes, embracing an even wider span of European collections. We do not believe that there are 'one size fits all' answers to DiSSCo challenges, but conversely a degree of alignment and standardisation is essential to effective data mobilisation. In this respect all institutions can benefit from sharing best practices and lessons learned.

The DiSSCo services will be far-reaching, including the [European Loans & Visits System](#) (ELViS - already developing) and the Specimen Data Refinery automation approaches [1], with transformational impact not only on research users but on all of the institutions providing data. Organisations will need not only to continue and extend their digitisation efforts, but to connect to the infrastructure and to develop new processes and standards to support digitisation as a service. This change should not be underestimated, with impact across collections management practices, policies and organisational structures, as well as the wider standards and structures that underpin effective and FAIR data mobilisation.

In relation to DiSSCo progress, there are a few ‘clusters’ of capabilities that seem particularly relevant. These are explored in more detail throughout this report, looking across the work of previous DiSSCo-linked projects, sector examples and beyond. In summary:

Leadership competencies, such as strategic thinking and planning, coordination, communication and building capability in others and across an organisation are vital. Without these, no aspect of DiSSCo is likely to achieve its potential. These skills are required within organisations to effect transformational change, and across institutions to secure funding and steer DiSSCo initiatives.

Programme, project, planning/operational and organisational skills including financial management, other resource management, risk management and similar are likewise fundamental to the day to day operations of DiSSCo-linked projects and to the delivery of organisational initiatives such as digitisation in the most efficient and effective ways.

Specialist capabilities and corporate service type functions will be required by DiSSCo for particular areas, such as legal, procurement, human resources, and particular aspects of technology. These may be needed by the DiSSCo hub (central team) or sometimes by the individual organisations and nodes. These may sometimes be contracted, but may also sometimes be found in-house or seconded as they are integral to the running of institutions. Many of the teams providing these capabilities have not been engaged with the DiSSCo aims and projects as yet, but will need to be involved in future stages if these are to succeed.

Digital and data capabilities have been identified throughout as key - for digitisation and particularly for effective, consistent and impactful data mobilisation and discovery via the future DiSSCo infrastructure.

Wider technology and infrastructure capabilities are also relevant - without the right storage, computing and development capacity for example, data will have nowhere to land or will not be preserved effectively for the future, and interfaces will not meet user needs.

02 INSIGHTS FROM DiSSCo-LINKED PROJECTS

2.1 ICEDIG and SYNTHESYS

There has been extensive work in the prior DiSSCo-linked projects and through CETAF (the Consortium of European Taxonomic Facilities – www.cetaf.org) looking at, for example, workflows and approaches to digitisation; costs; progress among the consortium members; training and capability. This work provides key context for this Task.

2.1.1 Cost drivers

The Costbook of the Digitisation Infrastructure of DiSSCo [2], produced as part of the ICEDIG design study (Innovation and Consolidation for large scale Digitisation of natural heritage – www.icedig.eu), notes that staffing costs are the key component of digitisation costs in all cases, and also the key driver of variation. Time spent is also a key parameter of cost. This highlights the importance of identifying the competences needed for successful digitisation and data mobilisation initiatives, and of using these insights in hiring, performance management and promotion to ensure appropriately skilled and incentivised teams who are able to work as cost-effectively as possible. Staff experience level is also a key cost driver in relation to transcription, and in the comparative costs of staff vs volunteer or crowdsourced transcription which typically requires extensive quality assurance [3].

2.2.2 Capability and training

ICEDIG undertook a number of surveys and exercises to look at digital capacity across the consortium members. Primarily, these focused on institutional capability such as the presence of dedicated digitisation teams and the types of objects that can be digitised [4]. The ICEDIG Policy analysis, available as a dashboard [5], is similarly focused on institutional policies but suggests areas likely to be important for a competence framework. This tool uses three broad categories - Collections, IT and data management, with subheadings leading to collections of policies. Under Collections, for example, subcategories are 'Collections care, development and scope'; 'Collections access and information'; and 'Digitisation strategy and prioritisation'. This structure is not dissimilar to some of those used in existing competency frameworks, and an alignment of those frameworks with policies and compliance requirements is likely to help in ensuring that competencies are relevant and useful to collections-holding organisations, albeit that these policy data were collected from only six institutions in the first instance.

Collectively, the outputs of ICEDIG and SYNTHESYS also illustrate some of the challenges for individuals and organisations in gaining and maintaining digital competence. There is a continued development of technologies and techniques relevant to the collections context, including software automation such as Optical Character Recognition and Natural Language Processing [6], and innovation in imaging [7]. In addition, processes and demand evolves - the SYNTHESYS+ Virtual Access programme (www.synthesys.info), for example, recognises the increasing need for digitisation on demand / as a service, and the provision of digital services to internal and external users is likely to draw on somewhat different skills than mass digitisation driven by institutional priorities.

One of the potential solutions to this proposed for DiSSCo is to use Centres of Excellence for aspects of digitisation - effectively as concentrations of competence that are available to help others, whether through training or through offering digitisation services [8]. Roles as part of Centres of

Excellence are therefore likely to require higher levels of certain competencies, and to be a place for others to build competencies to bring back to their own roles and institutions.

The Conceptual design blueprint for the DiSSCo digitization infrastructure [9](henceforth ‘the Blueprint’) summarises much of the work referred to above, and makes recommendations for its implementation through DiSSCo. The Blueprint notes the importance of increased alignment in a range of areas, including policies, digital prioritisation, and techniques; and also makes reference to the various areas of leadership, including technical, financial and strategic, required to accomplish this. Fig. 1 from the Blueprint, reproduced below, shows the balance of factors at work, illustrating why a competency framework for DiSSCo cannot focus solely on digital and technology aspects, but must embrace wider dimensions of leadership and collections management as well. This is also illustrated by the case study of Luomus in this report, showing the vast range of factors that contribute to organisational digital transformation.



Fig. 1 [9] [section 1.3]

Recommendation 35 in the Blueprint is that design and development of core software components for DiSSCo should begin no later than early 2021, to allow a soft start to operations in 2024. These core DiSSCo services can only operate when the DiSSCo institutions also undergo a digital transformation to have the technology, people and processes in place for these services. Therefore, this transformation should also start in 2021. Initial discussion of enabling roles for this transformation has already identified a need for moderators, to manage e.g. user roles and institutional metadata, as well as leaders for the digital transformation.

Chapter 5 of the Blueprint covers Culture, skills and capacity building, noting that: *‘Technical advances outstrip the ability of social structures to adapt to changes. Personnel involved in collections to be digitized must be part of the process of change and must become enthusiastic and engaged; especially since collection agents are a large set of end-users of both the eventual DiSSCo research infrastructure and the data produced and stored within.’*

A competence framework can be part of engaging people, allowing them to understand the requirements of their role(s), and have agency in developing themselves. The Blueprint however records the results of a 2018 survey which received 143 responses from relevant institutions, and found that:

‘One third (36%) of digitization staff receive on-the-job training. Within this already small group, half of them only receive training initially at the beginning of their digitization activities without follow up or additional training to stay up to date. Only a minority (10%) receive training multiple times per year....

These results suggest that many staff employed to perform digitization tasks are not adequately trained to do so.’

Work package 2 of SYNTHESYS+ was established to support the community in acquiring digital and data skills and competencies, enabling individuals to navigate collections information effectively as well as optimising overall access and use of collections data, with a catalogue of training modules due to be finalised in 2021. DiSSCo Prepare WP2 will continue and build on this work. A workshop was held in January 2020, to examine existing training modules across Natural History Institutions, start to construct the catalogue and identify key gaps. Key training areas were identified and have continued to be developed as follows:

- Specimen - including curation, digitisation and research skills;
- Data - including data curation; standards & interoperability; processing and software skills;
- Policy and legislation;
- Citizen Science; and
- Text and media e.g. knowledge transfer via exhibition and communications

Key gaps and needs identified include training in new or emerging platforms such as ELViS; training in aspects of policy e.g. access and benefits sharing; and aspects of data mobilisation such as use of GeoCASE.

It is imperative that a competency framework, which acts as a tool for individuals as well as for institutions, is supported by training and opportunities that allow individuals to develop their skills. For institutions, use of a competency framework as a reference point in hiring, performance management, personal development and progression can ensure that gaps in skills and competencies are recognised and acted upon, supporting planned training provision and training delivery for both individual and organisational benefit.

2.2.3 Functional units

While the Blueprint does not make specific recommendations about competency frameworks, Chapter 5.3.1 recognises that many staff surveyed already identify with multiple roles as part of a digital processes, and recommends adjusting from roles to the concept of functional units: *‘A functional unit (in the sense of organising competencies) is a collection of competencies needed to perform specific tasks within the different steps of the digitization process. We believe this approach can allow a more fluid distribution of tasks among digitization personnel’* (see fig. 2 below). This would allow for individuals to fulfil more of the aspects of a functional unit in a smaller organisation or team, and perhaps be more specialised in larger organisations. Survey respondents supported this approach, and this is clearly relevant to the application of any DiSSCo competency framework in practice, supporting the principle that it is better to take a broader approach to competency definition, supplemented as relevant by job or role descriptions and by well-defined individual objectives in each relevant period. Functional units were not examined in relation to grades or levels of competency development, and this area requires further consideration.

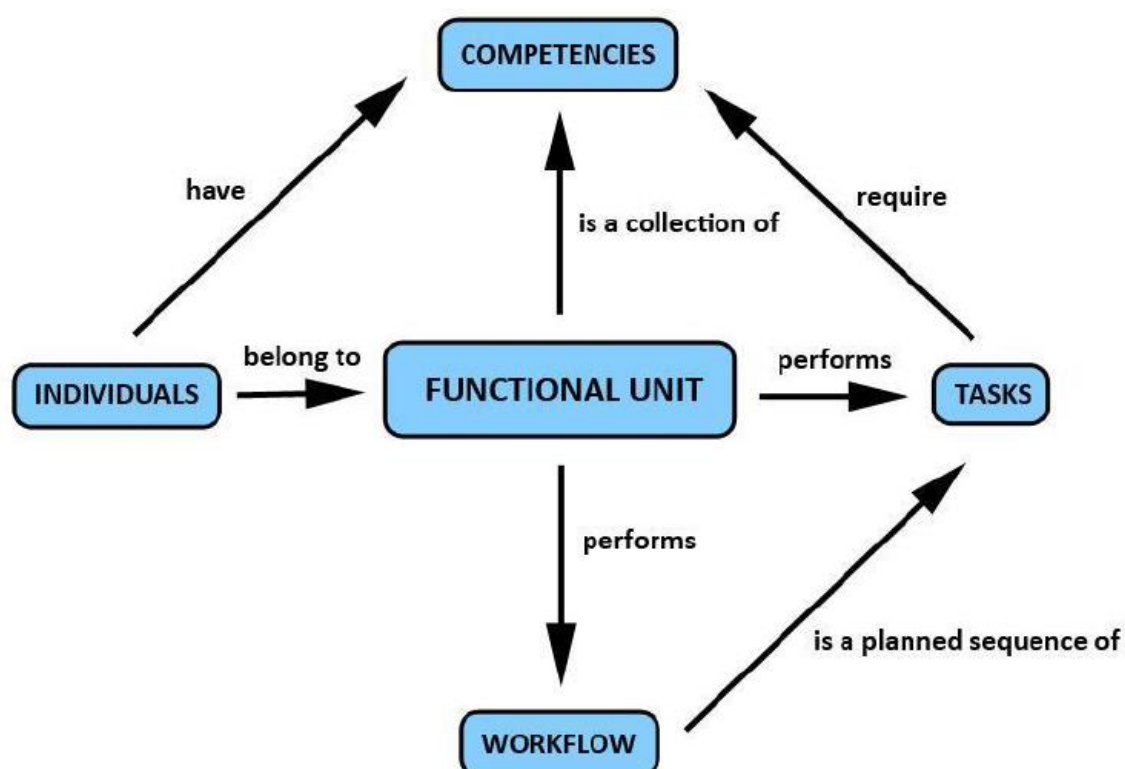


Fig. 2 - ICEDIG MS49 schematic of how functional units relate to other elements

This functional unit approach was based on the survey conducted and reported as ICEDIG Task 8.1 Milestone 48 and 49 (not currently published). This survey was based around roles as the constituents of functional units. The roles used (respondents could select multiple roles) were:

- Head of the physical collections
- Head of the digital collections
- Collection curator
- Collection technician
- Digitisation officer specialised in image capture
- Digitisation officer specialised in (meta)data capture
- Digitisation officer (other than the options above)
- Curator of digital data and database input
- Researcher performing research on collections
- Researcher using digitised data
- Other - additional roles defined by respondents.

The survey had 188 complete responses from individuals across European Research Performing Organisations and a few responses from beyond the EU. As well as identifying the deficiencies in training mentioned above, this survey was also used to define the relationships between stages of digitisation, functional units, tasks and competencies, summarised below. The distinction between roles, tasks and competencies in relation to this and to fig.2 above will need further consideration going forward.

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| Stage 1: Pre-digitisation |
| <p>1.1 Functional unit - collections curation Includes diverse tasks from rehousing to strategic development of collections and managing staff.</p> |
| <p>Competencies:</p> <ul style="list-style-type: none"> • Management and leadership skills, strategic planning and direction • Experience in general collection curation, management and handling of collection specimens • Supporting and promoting (interdisciplinary) research on collections • High/detailed level of subject matter expertise in particular collections e.g. taxonomy; collections history and similar, and part of a network of similar experts |
| <p>1.2 Functional unit - collections management Includes tasks such as collections organisation and storage, quality management and pest management.</p> |
| <p>Competencies:</p> <ul style="list-style-type: none"> • Experience in the general collection management and handling of collection specimens. • Preparing, organising and maintaining collection items to be preserved |
| <p>1.3. Preparing collections, part of collections or a selection of specimens to be digitised This section has a shorter description and does not list competencies, but mentions for instance preparing data such as taxonomic lists.</p> |
| Stage 2: Digitisation |
| <p>2.1. Extraction and transportation of specimens or containers from collection storage for digitisation and back</p> |
| <p>Competencies:</p> <ul style="list-style-type: none"> • Experience in the handling of delicate and valuable collection items |
| <p>2.2. Preparing specimens to be digitised Including e.g. tasks of label removal, positioning items and adding barcodes or similar</p> |
| <p>Competencies:</p> <ul style="list-style-type: none"> • Similar to unit 1.2 and 2.1 for general handling of collections • Experience in the handling of fragile, valuable or unstable specimens i.e. rusted pins or those with verdigris • Additional skills needed to create and manage identifiers for an automated system |
| <p>2.3. Digitisation Including image capture and data capture stages.</p> |
| <p>Competencies:</p> <ul style="list-style-type: none"> • Excellent knowledge of the digitisation set-up, technical knowledge of the equipment and its use • Good technical background regarding the used technology and materials • Basic problem-solving skills when a (minor) technical issue occurs • Database input skills |

| |
|--|
| <ul style="list-style-type: none"> • Deciphering (old) manual handwriting • Transcribing written data and enter them into a database • Working knowledge of OCR techniques for printed text • IT knowledge on databasing and CMSs • Knowledge and skills to create and manage identifiers for an automated system |
| Stage 3: Post-digitisation |
| 3.1. Curating digital collections, record management and quality control Including e.g. image processing, geo-referencing, transfer of data between systems etc |
| Competencies: <ul style="list-style-type: none"> • Advanced computer skills • image processing experience • database processing and maintenance |
| 3.2. Operating the online data portal website Including aspects of specifying, procuring, installing, operating, maintaining, supporting, migrating etc specialised IT systems and services |
| Competencies: <ul style="list-style-type: none"> • ICT specialist, database expert, website/platform operator |
| Stage 4: Functional units transcending digitisation stages |
| Competencies are not listed but tasks/skills include ICT support; process optimisation; researcher interaction; advanced areas such as machine learning; administration; biodiversity informatics and data architecture. |

Table 1: Summary of units and competencies relating to digitisation from ICEDIG Work Package 8

From this analysis, it is clear that the understanding of more technical competencies was lower than that of collections competencies, with much less detailed descriptions given - this is not surprising given the primary areas of expertise among ICEDIG consortium members. In both cases, the competencies stated include a combination of skills, experiences and to some extent behaviours, and as noted above there is overlap across the language of roles, competencies and tasks. Further consideration of this is in Discussion and next steps below.

2.2 MOBILISE COST Action

The objectives of the MOBILISE COST Action (EU COST Action CA17106 *Mobilising Data, Experts and Policies in Scientific Collections* – www.mobilise-action.eu) cover research coordination and capacity-building, fostering a cooperative network in Europe to support excellent research activities; facilitate knowledge and technology transfer around natural science collections; and prepare the ground for a future pan-European Distributed System of Scientific Collections (DiSSCo).

Objective 5 of MOBILISE is to facilitate the implementation of common standards and of newly developed techniques by training and education. A primary need was identified around digitisation and data mobilisation, particularly for those working with collections in smaller institutions. Training set up to support this was oversubscribed, confirming the appetite. Two Training Schools on

“Digitisation and Data Management Challenges in Small Collections” have been organised, and another is scheduled for June 2021. The objective of these is to support institutions to be able to develop their own Institutional Digitisation Strategy & Plan, with training primarily covering data quality, data cleaning and data visualisation using relevant tools. While MOBILISE is ongoing and therefore full analysis of these initiatives is not yet available, feedback questionnaires to trainees suggest that the majority found the experience useful, making moderate gains in knowledge, skill and competence, but would in addition prefer more practical exercises to consolidate this learning.

The MOBILISE Action have also organised three calls for Short-term Scientific Missions (STSMs), focusing on early career scientists, collection and data managers, collection curators and stewards from smaller institutions and those in countries that do not have extensive facilities and/or well-developed policies for data mobilisation, digitisation of biodiversity collections, data practices and curation. Analysis of the MOBILISE initiatives when they are complete will be a useful input to inform DiSSCo work around training and capability building going forward.

03 COMPETENCY FRAMEWORKS FOR INDIVIDUALS

3.1 What is a Competency Framework?

A competency (or competence) framework is a model that sets out the competencies - usually skills and behaviours - that are the key requirements for individuals working in an organisation or sector/profession. It usually sets these out at various levels (whether something akin to 'high / medium / low' or specifically linked to job grades or roles), stating what good or excellent looks like, and sometimes also giving examples of what would be seen if the competency was lacking or negative.

Frameworks can be very broad - for example the entire UK Civil Service (from Tax Inspectors to policy makers, diplomatic staff or front line job centre workers) operated for many years under a single competency framework based on broad competencies such as 'strategic thinking' (see case study below). Alternatively, they can go deeper into the requirements of a particular organisation or profession, for example including more about technical requirements.

Typically, competency frameworks are used (or intended to be used) as part of key Human Resources processes, including:

1. Recruitment - for example listing the competencies relevant to a role as part of the job description, and testing these via competency based interviewing, where candidates are asked for specific examples when they have demonstrated these competencies;
2. Performance management, including appraisal, and reward / progression - for example using the competency framework as a tool for individuals and managers to discuss behaviour, progress, strengths and development areas and as part of determining promotions or similar; and
3. Individual career development and planning - e.g. understanding what is expected to reach a particular level or role, and undertaking work that will give the opportunity to develop and demonstrate those competencies at the required level.

The extent to which competency frameworks are available, are used, and are effective, varies considerably depending on the organisation or sector, but the most successful frameworks are likely to be those that align and are embedded in these key processes, so that they incentivise the behaviours that the organisation needs and values - driving success in outcomes - and avoid incentivising others. They are also key to ensuring that behaviours are considered alongside delivery - i.e. individuals are assessed not only on what they deliver but on how they go about it.

Competency frameworks are intended to be used alongside other tools and documentation in a sector or organisation - they are not a substitute for, for instance, individual job descriptions; individual objectives for a particular period; training and development plans; or organisational policies, strategies and procedures.

While a key focus for DiSSCo are digital and data-related competencies relevant to the development and running of the future DiSSCo infrastructure and how institutions work with this, as noted above there are a range of other competencies that are critical to the success of DiSSCo and highly relevant to all the sizes and types of organisations within it - so our analysis includes consideration of the management and leadership of people and projects, and the wide range of competencies relevant to working with collections.

While competencies themselves can be quite varied, depending on the organisational or sectoral context, most frameworks require a sense of levels to which to apply these. Across DiSSCo, we cannot apply a single set of 'grades' as these vary across member and stakeholder institutions. It is useful therefore to consider the five stages introduced by Dreyfus and Dreyfus [10], which offer a more generic way of looking at competence levels based on e.g. degrees of complexity and experience. The five stages are:

1. Novice - following rules or procedures under monitoring/guidance
2. Competence - a degree of experience has led to recognition of patterns or situations which can be associated with relevant actions
3. Proficiency (or practitioner) - able to look at the whole situation in relation to larger or longer-term goals, determine relative importance, and apply this to future situations
4. Expertise - experience gives an intuitive understanding of appropriate action in different situations, connected to understanding of the bigger picture
5. Mastery - conscious effort is no longer required in performance, something has successfully become instinctive/intuitive to a high level of performance.

While these levels may not be directly usable in an organisational context, adapted vocabularies based on similar approaches are used. NHM London, for example, while using institutional grades for competence levels in the Science directorate, associates these grades via a cumulative 'Expectations' framework to the following short descriptions (other key associated vocabulary from the more detailed expectations is given in brackets - most junior level first):

- Assist and follow (support, assistance, trainee, occasionally contributing to e.g. outreach or other activities)
- Enable and apply (regular contributions)
- Acts on own initiative (senior, expert, lead, management, regular contributions, may represent Museum)
- Responsibility. Advises and guides. Consultant. (principal, established, international and/or major area or project/programme lead, strategic, regularly represents Museum officially)
- Accountability. External leadership and influence. Advisor. (established, internationally regarded leader, vision, initiative, strategy, leads change, advises and develops others).

Similar concepts can be found in many frameworks (including EU DigComp 2.1 as outlined below), where levels represent increasing degrees of expertise, applied to increasingly complex situations or spheres of influence, with increasing independence in decision making and accordingly greater responsibility and accountability for outcomes.

In order to be relevant to all types and sizes of organisations in DiSSCo (and more broadly to future DiSSCo users and partners as relevant), it is likely that a DiSSCo competency framework and tool(s) need to look at broad skills and behaviours, rather than at detailed technical knowledge relevant to specific roles and tasks, and apply these across generic levels such as those set out above. This is perhaps the hardest balance for every competency framework to achieve - to be sufficiently general to be approachable and usable, but sufficiently specific to add value in specific institutions and roles.

A DiSSCo competency framework should support both individuals and organisations - i.e. it should help individuals to understand what might be expected and what good looks like in different contexts/levels, to aid their own development and career planning; and should also provide a tool that organisations can, if they wish, adopt and build into their wider HR processes. Some DiSSCo

members already have competency frameworks of their own, and we will seek to ensure that the best features of these are represented in any shared framework to encourage take-up.

3.2 Collections sector case study – the EU Collections Competencies project (EUColComp)

EUColComp (<http://eucolcomp.myspecies.info/>) was a two-year (to 2015) Leonardo da Vinci Transfer of Innovation project, funded under the European Commission Lifelong Learning Programme (LLP). Eleven institutions from eight European countries worked together to support a consistent understanding of professional standards of Collections care and management across the EU, thereby supporting the career development of curators or collections care professionals, enabling better mobility between EU Museums and other collections-based organisations and providing transparency within institutions. While the project had a strong focus on Natural History Collections, using a collections competency framework from NHM London as the key source, it was intended from the outset to develop a vocabulary that would be transferable to other collection holding institutions in the cultural heritage sector. The specific aim of the project was to transfer a set of universal competencies for collections management to institutions across the EU to help organisations to a) identify the competencies required for particular roles; b) identify individuals' levels of competence; and c) identify the vocational and educational training (VET) needed to address missing/weak competencies.

The project delivered a common multilingual (English, French, German, Spanish, Dutch, Italian and Czech) competency framework (CF) linked to a curriculum of training opportunities. The CF was supported by multi-language guidance and is available on the EUColComp website [11], to guide personal development of staff responsible for natural history collections and assist managers to address skill and knowledge gaps. In late 2015 when producing the final project report, the project partners stated that the EUColComp framework was being adopted as a basis for job descriptions and staff development in three partner institutions, while another was using it to ensure research staff were competent to work with collections, and a fifth as a basis for a national framework.

The EUColComp framework is a matrix of 96 competencies covering a broad range of the work of those with responsibility for natural history collections, which are mapped to four levels of expertise. The four levels represent increasing degrees of expertise, applied to increasingly complex situations or spheres of influence, and are entitled: Early stage career / training level (Level A); Established Professional (Level B); Mid -Career/Professional/Manager (Level C); Senior Manager/Expert (Level D). This is broadly in line with the five stages of competence levels identified by Dreyfus and Dreyfus discussed above. The generic stages of 'Expertise' and 'Mastery' both apply to the level of Senior Manager/Expert in the EUColComp framework. For each competency at each level, the framework generically describes the expected way of approaching relevant tasks, i.e. an individual who is involved with digital curation at the level of an established professional should be able to use collections management systems/databases, to perform complex queries about holdings, to use reporting system for the specific needs of the end user and to generate bespoke views of data for their own needs (e.g. csv, excel, word). This is therefore a very detailed framework, unlike some of the more high-level examples discussed - which can be a benefit in terms of relevance to a specific field such as collections, but can also make it more daunting and challenging for individuals to navigate and use.

The competencies are grouped into seven fields relevant to collection-based institutions. Each field was then subdivided into areas, which group individual competencies. The following list gives an interpreted summary of the field and areas of competencies:

1. Collections Management, Conservation and Care
 - a. Collections Growth & Development
 - b. Collections Policies and Procedures
 - c. Collections Organisation
 - d. Collections Care and Conservation
2. Access to Collections
 - a. User Needs
 - b. Research Loans
 - c. Destructive and Invasive Sampling
 - d. Visitors to the Collections
 - e. Enquiries
3. Digital Curation
 - a. Data entry
 - b. Query and Reporting
 - c. Data Validation and Enhancement
 - d. Mass Digitisation
 - e. Workflows and Process Management
 - f. Manage Collections Data
 - g. Database Management
 - h. Collections Management System
4. Scholarship
 - a. Systematic and Taxonomic Principles and identification skills
 - b. Domain-specific knowledge
 - c. Assessment Skills
 - d. Funding
 - e. Conferences, Meetings and Workshops
 - f. Communication with the Media
 - g. Training and Education
 - h. Refereeing
 - i. Editorship
 - j. In-House Staff Development
5. Exhibition, Outreach, Corporate Activities
 - a. Exhibitions
 - b. Public Outreach
 - c. Consultancy and Income Generation
 - d. Information Technology
 - e. Health & Safety
6. General Management
 - a. Resource Management
 - b. People Management
 - c. Problem Solving and Decision Making
 - d. Change Management (Flexibility)
 - e. Meetings
 - f. Strategic Analysis and Planning
 - g. Learning and Development
 - h. Training and Mentoring
 - i. Record Keeping

7. Human Remains - NB this forms part of the NHM London framework that served as a template for EUColComp, but is perhaps too specific to be broadly applicable in a wider structure.

The EUColComp framework seems to cover most areas relevant to the DiSSCo infrastructure, including those identified in ICEDIG MS49 (see table 1 in this report). However, a more thorough analysis would be necessary to identify any potential gaps, especially in the field of digital curation, where NHM London have since added additional sections to the framework on which EUColComp is based (see below). Unfortunately the results of EUColComp have never been properly published and are not widely known within the DiSSCo community. At MfN Berlin, the department for collection development uses the EUColComp framework as a management tool for staff development and recruiting procedures. Also, the HR department of MfN refers to this for the evaluation of job descriptions in the context of recruiting procedures - however it must be stressed that national collective labour law does not necessarily overlap neatly with the categories in this framework, and will take precedence where relevant. The NHM London still uses an updated version of the collections competency framework from which EUColComp originated, but without any explicit reference to EUColComp, or any means to align updates or changes between versions. An intrinsic part of allowing for any competency framework for DiSSCo to be sustainable must be to have a clear mechanism for updates and dissemination of these.

Further work is needed to verify the extent to which the former EUColComp partners and other DiSSCo partner institutions make use of this or other competency frameworks. It has been suggested by EUColComp to consider the following points for measuring the effectiveness of competency frameworks:

- number of collections-related posts that have been defined using the competency set;
- number of staff who have had a competency profile drawn up;
- the success of the training curriculum developed and taken up by collections staff;
- number of staff with a learning plan developed using the Competency Framework and the learning curriculum;
- number of staff/institutions taking up training opportunities in response to the new curriculum; and
- number of staff moving between institutions and countries in the consortium.

In the first instance, however, it is necessary to see whether the framework is being used in any of these ways. An assessment of the actual use of the EUColComp framework five years after the end of the project would be highly relevant to ensuring that lessons are learned to inform the outputs of this DiSSCo task, providing for future sustainability and understanding the mechanisms for the institutional implementation of a competency framework as an important management tool.

3.3 The NHM London Science Competency Framework

As mentioned above, the NHM London Science Directorate does continue to use the competency framework on which EUColComp was based. There was an extensive exercise to update this framework over 2018-20, and it remains a 'living document' that is expected to evolve - it is not published at present except internally on the NHM Intranet. This framework is regularly applied to progression and promotion processes within NHM Science, and sometimes to the creation of job descriptions, which then inform the competencies explored during recruitment (e.g. in competency-based interviews), although it is also common for job descriptions to include additional skills and experiences that do not directly map to the framework and are specific to each role. While the

review of the framework did cut back on areas e.g. instances of duplication, anecdotal evidence suggests that staff continue to find the level of detail somewhat daunting.

Compared to the EUColComp framework outlined above, there are now additional categories relating to specific Library and Archives competencies and to Data Management (with a particular focus on the Collections Management System). The Digital area has also been extensively updated to reflect a wider scope of roles and skills including software engineers, developers and data architects, and has been re-titled 'Digitisation and Informatics'. The competence areas within this redrafted section are now:

1. Data analysis & use - includes analysis, presentation, data policies, governance, data problem solving, data quality and data linkage;
2. Data architecture & standards - includes translating business requirements into data architecture, data modelling, and data standards;
3. Operations & service delivery - includes asset management, delivery of services and workflows, reporting, continuous improvement, and user focus;
4. Project management, business analysis and digital leadership - includes project management, communication, enterprise and business architecture and digital leadership;
5. Software development - includes capacity management, design, programming and build, service support and development process optimisation.

One immediately obvious change here is the absence of explicit 'digitisation' competencies - the competencies required of the digitisation team are captured here for example under Operations & service delivery (which includes delivering digitisation workflows); Data analysis & use (e.g. troubleshooting and ensuring data quality) and across the wider competency framework in terms of, for example, collections handling. While this approach will continue to be tested and refined in practice, it may provide a useful example for DiSSCo in terms of trying to identify the actual behaviours and skills that are most relevant, rather than to try to create 'competencies' that are role-specific - the latter tends to lead to a longer and more unwieldy framework, which incorporates not only key behaviours and skills but aspects such as knowledge of particular systems or adherence to particular policies. These aspects arguably should sit elsewhere in the ecosystem of HR and wider processes, e.g. a job description or role profile may capture the key policies to be applied in that work area.

There is no wider competency framework in consistent use across the rest of the NHM, although other frameworks do exist including one focused on management and leadership competencies. The management sections of the Science framework were broadly aligned to this, although specific vocabulary has diverged over time. The NHM HR team plan to introduce a single, high-level competency framework, focusing on key behaviours and aligned with the Museum values, within the next few years, but work on this has not yet begun and it is not clear how it will interact with the detailed Science framework.

3.4 Luomus technical staff framework

The Finnish Museum of Natural History, Luomus, has a framework of job requirements for technical staff. This covers knowledge, skills and responsibilities for the following roles and levels:

- Museum Technician (level 5),
- Senior Museum Technician (level 6),
- IT Specialist (level 8), and

- Digitisation Manager (level 9).

Descriptions are given for each of typical problem-solving and organisation skills; interaction skills; key responsibilities at the broad level (e.g. ‘extensive reporting responsibilities’); and knowledge, which mentions for example relevant qualifications. Like other frameworks discussed here, the level of autonomy and complexity rises at each level. This is a relatively short document, and has the benefit of combining key behaviours and skills such as communication with other elements relevant to particular roles and levels in the technical work area. More details of the organisational framework at Luomus and in Lisbon can be found in the next chapter and at Annex A & B.

3.5 Open Science frameworks

Open science is a key pillar of DiSSCo, with open and FAIR data mobilisation enabling the research infrastructure. The Open Science Skills Working Group Report July 2017 [12] discusses Open Science skills in a research environment, grouping these into four categories, which may be relevant at different levels in different roles:

- Skills and expertise necessary for open access publishing
- Skills and expertise regarding research data, data production, management, analysis/use/reuse, dissemination and a change of paradigm from “protected data by default” to “open data by default”, respecting legal, and other constraints.
- Skills and expertise to act in and beyond one’s own scholarly and disciplinary community (including research management, legal and ethical awareness).
- Skills and expertise resulting from a general and broad concept of citizen science, where researchers interact with the general public to enhance the impact of science and research.

These are all relevant skills in the DiSSCo environment, perhaps particularly the second area around open data. This includes data science skills or data literacy in the round, from data collation and handling large datasets, to use of taxonomies and metadata creation and management. The survey found that training across these areas was felt by researchers to be lacking, despite activities from bodies such as OpenAIRE, SPARC Europe and others. The survey report mentions a need for the creation of an Open Science Competence Catalogue, building on existing approaches but noting gaps relating to open science across existing policies and frameworks.

Within the secretariat and projects of the European Open Science Cloud (EOSC), work is currently taking place across three Task Forces on the minimal EOSC skill set, organizational models for competence centres (centres for e.g. training & coordination) and national digital skills strategies [13]. This is similar to the work of DiSSCo work packages 2 and 3, across training and capacity building, and we will continue to examine the outcomes of this work. Fig.3 below shows the users and roles identified as relevant in this context; broad areas of activity such as research; and how these relate to EOSC.

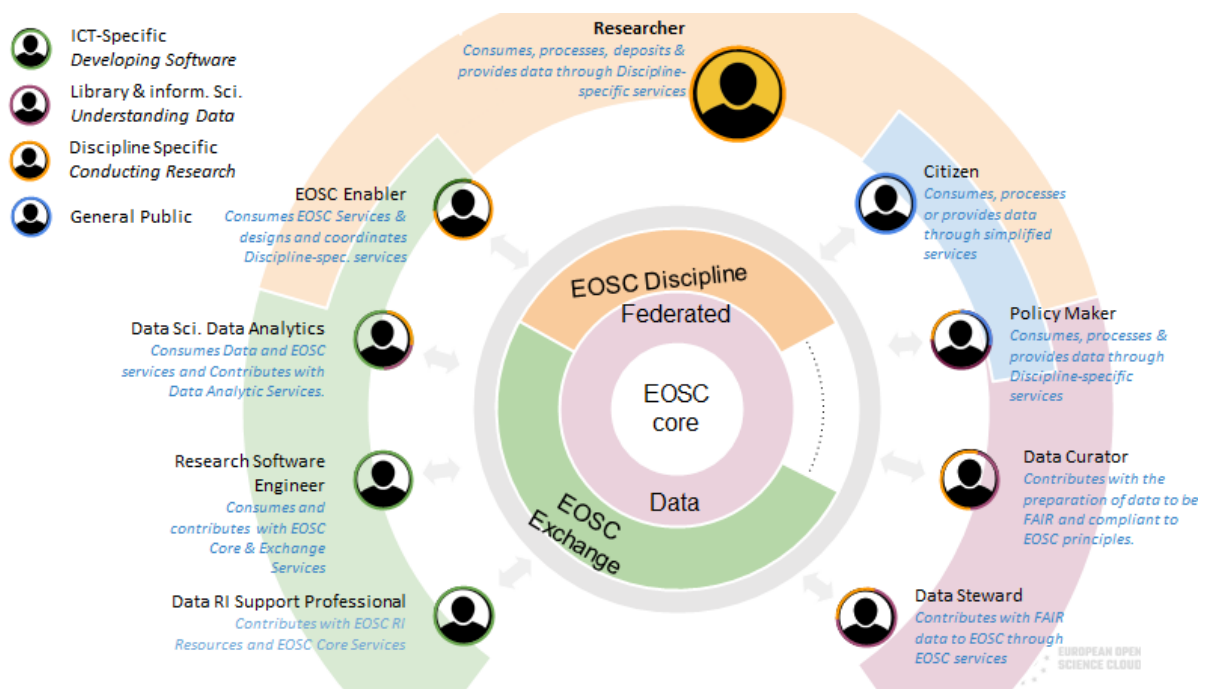


Fig.3 EOSC skills landscape

3.6 EU Citizen & learning frameworks

The EU Key Competences for Lifelong Learning [14] is a general competence framework for citizens, intended as a reference point for educators. While this is by definition a very high-level framework, it includes digital competence as one of eight fundamental learning competencies. Knowledge under the digital competence includes ‘a critical approach to the validity, reliability and impact of information and data’, alongside an attitude of curious but ethical and critical learning, and skills which encompass ‘the ability to use, access, filter, evaluate, create, program and share digital content... manage and protect information, content, data, and digital identities, as well as recognise and effectively engage with software, devices, artificial intelligence or robots’.

The EU DigComp 2.1 (2017) framework [15] is similarly a high-level framework for citizens, but captures the digital area in more detail, using five key areas all of which have relevance to DiSSCo needs:

- Information and data literacy - ability to search and retrieve data; evaluate it, and organise / manage data in a structured digital environment;
- Communication and collaboration - including managing digital identity, and using digital technologies inclusively for communication and collaboration;
- Digital content creation - including integration with existing bodies of knowledge, understanding licences & copyright, and programming;
- Safety - including hardware, software, data privacy and environmental impacts; and
- Problem solving - including selecting digital tools, identifying competence gaps, and creativity / innovation in processes and products.

This framework is then further developed across eight ‘proficiency levels’, building on an original three levels (foundation, intermediate and advanced) in DigComp 1.0. Each of the eight levels is intended to represent a step up across all three of cognitive challenge (knowledge), complexity of the tasks handled (skill), and autonomy in carrying out the tasks (attitude). Autonomy also includes the

ability to support others in carrying out tasks at the higher levels. A table of keywords associated with the eight levels and these three dimensions is below. Detailed examples are given, but are primarily relevant to the citizen context e.g. jobseeking so are not discussed further here. The levels from five upward are particularly relevant to the professional context and to the kinds of digital competencies that are likely to be needed in DiSSCo. Levels seven and eight are considered to be specialised levels, at which people are capable of creating solutions to complex problems with limited definition; integrating knowledge to contribute to professional practice; guiding others; and proposing new ideas and processes. This is a useful example of a framework that is high level and can be visualised easily on one or few pages, while also offering detail and examples for individuals to dig down into.

| Levels in DigComp 1.0 | Levels in DigComp 2.1 | Complexity of tasks | Autonomy | Cognitive domain |
|-----------------------|-----------------------|--|--|------------------|
| Foundation | 1 | Simple tasks | With guidance | Remembering |
| | 2 | Simple tasks | Autonomy and with guidance where needed | Remembering |
| Intermediate | 3 | Well-defined and routine tasks, and straightforward problems | On my own | Understanding |
| | 4 | Tasks, and well-defined and non-routine problems | Independent and according to my needs | Understanding |
| Advanced | 5 | Different tasks and problems | Guiding others | Applying |
| | 6 | Most appropriate tasks | Able to adapt to others in a complex context | Evaluating |
| Highly specialised | 7 | Resolve complex problems with limited solutions | Integrate to contribute to the professional practice and to guide others | Creating |
| | 8 | Resolve complex problems with many interacting factors | Propose new ideas and processes to the field | Creating |

Fig. 4 Table of competency levels from DigComp 2.1 [15]

3.7 Data stewardship

The 'Towards FAIR Data Steward as a profession for the Lifesciences' project has examined three types of data stewardship - policy, research, and infrastructure - based on interaction with particular stakeholders and recognising that one person may perform more than one of these roles, part of a role, and/or interface between these domains [16]. Eight key areas have been defined relevant to these data stewardship roles. These are described both as competencies and as responsibilities, and seem at least in part to be closer to the latter - they are policy/strategy; compliance; alignment with FAIR data principles; service provision (e.g. user support); infrastructure (e.g. defining what data infrastructure will meet policy aims); knowledge management; network (e.g. of internal and external stakeholders); and data archiving.

While levels of proficiency are not determined in this framework, examples are given of tasks; knowledge/skills; and learning outcomes i.e. what the person will be able to do after successfully completing training for each role. As these describe specific roles including tasks in some detail, but at a set level, they appear to have more in common with job descriptions or role profiles than competency frameworks - however as data stewardship is key within DiSSCo they are likely still to be a useful reference point.

3.8 External case study – the UK Civil Service

The UK Civil Service competency framework [17] is a high level description of the skills and behaviours expected from civil servants. The latest version was in full use from 2012-2017, across all of the central UK Civil Service i.e. all the main departments of government, including a vast range of jobs from tax inspectors and policy advisers to technology roles. The framework was used in advertising jobs and assessing candidates (e.g. in competency-based applications and interviews); in promotions; and in objective setting and appraisal / performance management, particularly around behaviours and personal development e.g. by identifying competencies relevant to a role and gaps for reaching more senior levels. It is still used by some of these bodies, but many now use broader 'success profiles' for hiring - these are outlined in more detail below.

The original framework is designed to be understood and visualised easily at the top level, and allow individuals then to drill down to the examples and details relevant to their grade and the competencies for their role. It covers 10 competencies, divided into three groups as follows:

Setting direction (linked to the leadership quality of being **inspiring**)

- Seeing the big picture
- Changing and improving
- Making effective decisions

Engaging people (linked to the leadership quality of being **confident**)

- Leading and communicating
- Collaborating and partnering
- Building capability for all

Producing results (linked to the leadership quality of being **empowering**)

- Achieving commercial outcomes
- Delivering value for money
- Managing a quality service
- Delivering at pace

For each competency, the framework gives a description of what it means in practice and 3-6 examples of effective and ineffective behaviours at each level/grade. The grades are cumulative i.e. someone more senior is still expected to display the positive aspects identified at more junior levels.

While this framework successfully covered the range of activities in the Civil Service at a high level, more recently Success Profiles [18] have been developed for a broader perspective in hiring. A summary of Success Profiles is at Figure 1 below.

What are the elements of the Success Profile?

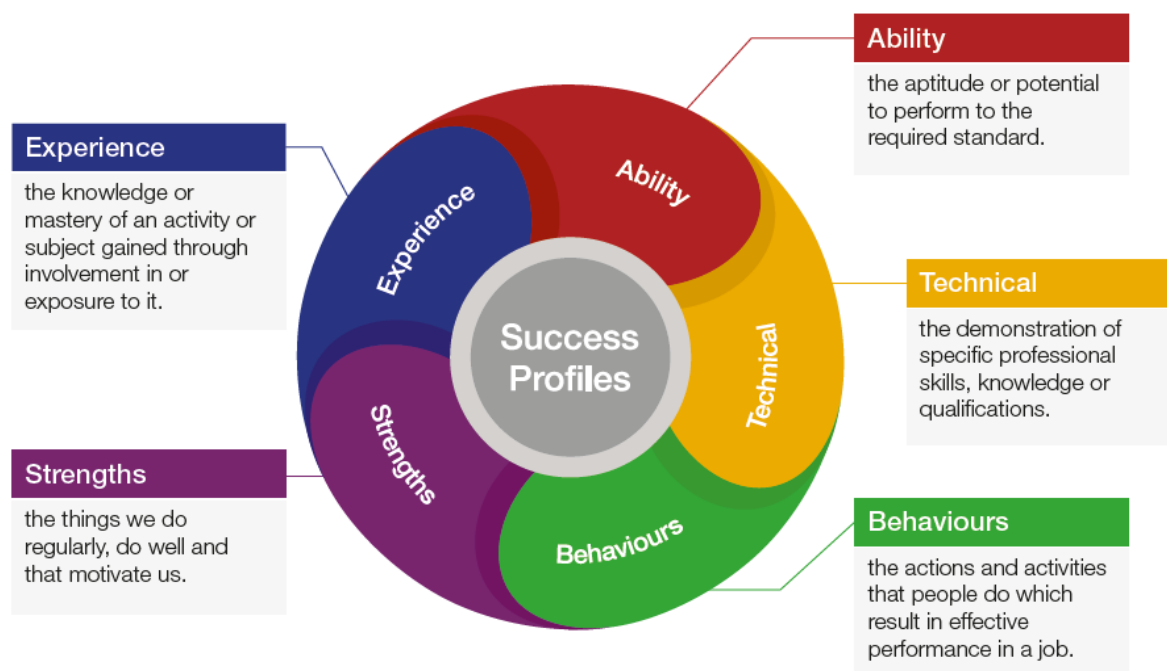


Fig. 1: UK Civil Service Success Profiles for recruitment - overview

The 'Behaviours' aspect of the Success Profiles uses the same competencies as the original competency framework above, with minor changes - the two competencies about finances and value for money are removed (these were always relevant only to a more limited number of roles with financial management aspects, and are arguably not behaviours), and those on building capability, partnering etc are slightly renamed.

For the other elements in a Success Profile:

Experience would usually be assessed by CV, interview etc;

Ability is measured where relevant by psychometric, verbal and numerical tests;

Technical and professional knowledge builds on specific frameworks for the various Civil Service Professions (there are more than 20 of these, the digital profession is explored in more detail below), and may include qualifications or other examples or tests of specialised knowledge; and

Strengths are assessed by interviews or e.g. simulated exercises, covering the elements of performance (carrying something out to a high level of proficiency), engagement (being motivated by this), and use (carrying out the activity regularly/often). Strengths are not the same as technical proficiency or experience - they are closer to demonstrations of skills or qualities. The 'dictionary' of strengths available as part of the Success Profiles framework, includes for example problem solving, negotiation, learning and authenticity.

The technical/professional area is likely to be relevant to individual competence or capability in the context of DiSSCo. Professions in the Civil Service include a Digital, Data and Technology profession with its own capability framework [19]. This framework describes the job roles in the Digital, Data and Technology (DDaT) profession and provides details of the skills needed to work at each role level. It consists of six job families:

- Data - including data analyst, data engineer, data scientist and performance analyst;
- IT Operations - including application operations engineer, end user computing engineer, and manager roles for areas including business relationships, change & release, infrastructure operations, incidents, IT services, service desk and service transition;
- Product & delivery - including business analyst, delivery manager, product manager, programme delivery manager and service owner;
- Quality assurance testing - including QAT analyst, test engineer and test manager;
- Technical - including data architect, DevOps engineer, frontend developer, software developer, infrastructure engineer, and network, software, technical and security architects; and
- User-centred design - including content designer, content strategist, graphic designer, interaction designer, service designer, technical writer and user researcher.

As well as being a very comprehensive reference point for technical and digital roles, which may be helpful for DiSSCo where many of these roles are not yet available or widely understood, each of the roles listed above also has a role description and short descriptions of relevant skills across relevant levels, which vary somewhat but follow the broad pattern: trainee (or associate)... (add role title); junior...; role title itself such as 'user researcher' (could be generalised as 'practioner'); senior...; lead (or principal)...; and head of...

Overall, the UK Civil Service case study is useful in the DiSSCo context for two main reasons: first, it offers a competence framework which struck a balance between being simple at the highest level but having detail of positive and negative behaviours across many grades; and second, the newer ecosystem of success frameworks and professions offers a potential model of how a behaviour-focused competency framework can fit into a more detailed set of processes and standardised descriptions to inform both individuals and organisations in their capability development and HR processes.

3.8 Other competency framework examples outside the collections sector

There are a very wide range of competency frameworks available across multiple sectors. The most relevant for DiSSCo are likely to be those that cover digital and technical areas, such as the Skills Framework for the Information Age (SFIA) [20], which is available in multiple languages and aims to describe the skills and competencies required by professionals in roles involved in information and communication technologies, digital transformation and software engineering. As with other frameworks, this uses seven levels of competency or responsibility, which in this case are a useful generic list:

- Follow (most junior)
- Assist
- Apply
- Enable
- Ensure / advise
- Initiate / influence
- Set strategy / inspire / mobilise.

These levels are characterised by increases in the generic attributes of autonomy, influence, complexity, knowledge, and business skills. Beyond this, the framework goes into very extensive detail, with SFIA 7 covering 102 'skills', each with a description against the levels and attributes above. The website offers an A-Z list of skills, as well as alternative ways to browse such as focused views considered most relevant to particular professional disciplines. For example, it is possible to view digital transformation skills 'at a glance', with lists of skills and levels under the headings: Digital strategy, innovation and investments; Digital culture, skills and capabilities; Digital and data transformation, change and governance; and Digital technology enablers [21]. Each skill can then be selected to see further information. This is an extremely comprehensive resource, which may be helpful when looking at the potential breadth of roles and skills relevant to DiSSCo, but is likely to include areas of detail beyond what is accessible or required for the DiSSCo context.

04 INSTITUTIONAL DIGITAL CAPABILITY & MATURITY

4.1 What is organisational digital transformation and digital maturity?

In addition to individual competencies relevant to the DiSSCo vision and services, member institutions will need to be able to develop and transform across the board to make full use of these services by coordinating infrastructures; managing data creation and mobilisation at scale and as a service (on demand); and offering leadership within their national nodes and beyond. Individual competency development sits within a broader institutional framework, in which once again the emphasis is not only on digital but on all the factors that surround that in terms of creating an organisational culture and outcomes. This is illustrated in the detailed case study of Helsinki's Luomus (see below and Annex A), which draws out how change has been impacted by a vast landscape of factors, including political and internal & external policy; communications; governance; outreach and organisational structures. Digital maturity is therefore part of a wider maturity around change management and organisational culture and process.

4.2 Case study – organisational change at Luomus

The Finnish Museum of Natural History, Luomus, has gone through a quite substantial change during the past ten years regarding digitalisation, with major cultural and organisational changes. Luomus has been, however, in a very fortunate position, because its aspiration to make its collections accessible to the wider community through digitisation has been in line with the goal of Finnish society to promote open science and open data in the public sector. Strong support has also come from the strategy of Helsinki University, which endorses open science. This favourable operating environment has acted as a firm foundation, which has facilitated the implementation of the changes.

The driving force behind bringing about the change has been the clear and strong vision from senior management. In Luomus, the vision of open data and open science has been promoted for years through continuous interaction with staff through different modes and channels of communication. The importance of this communication can't be overemphasised!

As part of its quality management and goal-driven strategic development, Luomus draft policy documents to guide the museum's operational sectors. These policy documents emphasize the importance of the accessibility of the collections, hence strongly supporting digitisation and open data. All policy papers have been prepared in close collaboration with the staff, helping to ensure that they are applied effectively in practice.

Luomus has made changes to its organisational structure within existing resources by reallocating them more appropriately, as well as applying for external funding. Although many changes can be made with the available resources, significant improvements to level up digitalisation often require external funding. To support and help its member institutions in obtaining that funding it is desirable that DiSSCo provide e.g. guidelines and information on funding opportunities for its members, and support in making the funding case e.g. strong examples of the benefits and impact of open digital collections.

Luomus's case study represents an example of the breadth of factors that influence organisational digital transformation and maturity. Luomus is a reasonably large organisation, which has allowed these quite extensive measures to be used. The situation may be very different in some of the smaller DiSSCo institutions where resources are more scarce, or in organisations of any size where the support of the political and leadership environment is lacking. The DiSSCo Blueprint [ref chapter] recommendations for national or regional centres for large scale digitisation; outsourced digitisation services; training and capacity building for in-house digitisation; and Centres of Excellence are all likely to be key in managing this variation of circumstances.

The main factors that have helped successfully implement digital transformation at Luomus can be summarised as follows:

1. Strong support from the open data policy implemented in the EU and especially on the national level.
2. Clear vision from management.
3. Strong staff engagement in the process of creating the guiding documents endorsing open science e.g. in policies and implementation plans.
4. Solid process of setting concrete goals, with line of sight from university's strategy → institution level → unit level → team level → personal level.
5. Reshuffling the pre-existing resources in new ways, with a new unit focusing on different aspects of digitalisation and new teams specialising in digitisation, ICT and species information.
6. External funding for some additional personnel, investments in digitisation equipment for increased speed and wider scope of workflows, and the establishment of the Finnish Biodiversity Info Facility (FinBIF - <https://laji.fi/en>) as a repository for FAIR data dissemination.
7. An effective collection management system, Kotka, that is well suited to our institution's needs.
8. Suitable training for the staff.

The full Luomus case study is available at Annex A.

4.3 Digital transformation in other collections institutions

It is likely that all institutions, whether larger or smaller, will have a landscape of equal complexity to Luomus in achieving digital transformation, and of course there is no single 'right' way to achieve this, although it can be useful to look at where similarities and differences arise.

At the NHM London, for example, similarly to at Luomus, the Digital Collections Programme was fully centralised as a Programme after the first two years (having previously relied on distributed curatorial projects) and has created a centralised digitiser team, where previously digitisers tended to be hired relatively short term for particular projects. This enables digitisers to be trained across multiple workflows, providing them with greater job satisfaction and opportunities, as well as maximising flexibility to respond to opportunities (e.g. philanthropic donations to digitise particular collections) and to offer services such as a pilot service to image digital loans for entomology. Centralisation has also enabled consistent data to be gathered about digitisation time and cost, with regular time recording by the team at each workflow stage. A key limiting factor at the NHM London, however, is that specific public funding for digitisation has not yet been secured, and collections data are not currently an explicit part of public sector open data strategy, unlike in Finland. In addition, although there is a centralised digitiser team for mass digitisation, a wide span of other teams and staff are involved in data entry and imaging, including curators; a specialised Data Management

Team for the collections management system; a substantial Imaging and Analysis Centre who offer more specialised imaging facilities such as CT scanning; and a photography unit who work mainly for public-facing communications but also take images for Science. The NHM Digital Collections Programme has worked for a number of years across the institutional boundary between Science (Informatics team) and Technology Solutions - this has led to complexity in managing resources and funding at times, but has also been a strength in building necessary relationships with technology specialists e.g. around data storage.

In Lisbon, the National Museum of Natural History and Science (MNHNC) is part of Lisbon University. The Collections & Heritage division are currently considering the creation of a Digital Data and Objects group to address digitisation needs, and creating new job roles/functions around this such as Database management. As with Luomus, being part of key national infrastructure - in this case the Portuguese E-Infrastructure for Information and Research on Biodiversity (PORBIOTA) has been instrumental in digitisation, giving MNHNC the resources to start digitising the natural history collections. Digitisation is carried out in-house, and is currently distributed across curatorial teams which is affecting consistency e.g. of data storage - this is why a central team is under consideration, as well as a central digitisation plan. A fuller description including the current dashboard of collections roles is at Annex B.

4.4 Digital maturity reports and tools

In 2020, Europeana commissioned a report by Culture24 into how to support the digital transformation agenda across galleries, libraries, archives and museums (GLAMs) [22]. This report offers a range of definitions of digital transformation, digital maturity, digital literacy and digital skills, noting that these concepts can be quite broad, but that the idea of change, often quite substantial change, is key, making this more about humans and about strategic leadership than about technologies. As well as leaders, this report identifies the importance of ‘agents of change’, individuals or small groups in any position or level in an organisation who display digital and/or change leadership, often by doing something differently in their own sphere of influence. This concept is important within DiSSCo - many of those involved are already agents of change within their own organisation, and identification of other key change agents is likely to be key to moving forward. The report notes that people who are able to connect and ‘translate’ between different colleagues and teams often make good change agents. Organisationally, it is important to be able to value and nurture such people, and this is something where competency frameworks and HR policies and practices can play a role, for example by consciously valuing and rewarding these behaviours, and by creating space for personal development and innovation.

In the UK, the Digital Culture Compass [23] was launched in February 2020 (commissioned by Arts Council England) as a toolkit for arts and heritage organisations. This offers a Charter - a short set of best practice values for digital transformation that emphasises aspects such as ethics and inclusivity; understanding staff and user needs; and being flexible and adaptable. It also offers a Tracker too (free registration is required but available to anyone), to help organisations assess their current digital progress and set goals. The tracker divides organisational activity into twelve areas:

- Strategy and governance - which sits across all the other areas;
- ‘Core’ areas of
 - Programme (refers here mainly to the public programme of Museums, but could be used more broadly)
 - Places & spaces
 - Collections
 - Talent and sector development

- Fundraising & development
- Enterprise (e.g. sale of consultancy services);
- 'Support' areas of
 - Marketing & communications
 - Research & innovation
 - HR
 - IT
 - Finance & operations.

Those using the Tracker can select which areas are relevant for them, and mark others as not applicable. The Tracker allows organisations to self-assess all relevant areas across five maturity levels: Initial; Managed; Integrated; Optimising and Transforming. These can be seen as similar to the progress or seniority levels found in many individual competency frameworks discussed above, but in the organisation context. In relation to each area, criteria and guidance are offered to assess whether each of the five levels is fully achieved, partially achieved or not met within the organisation. For example, the criterion for the 'Managed' level is that within the relevant area 'we plan and periodically review the digital elements in this activity, and they are appropriate for our organisation', but the guidance notes that this planning might be siloed and not yet fully strategic.

The Tracker explicitly states that organisations should not aim for 100% in everything, but should prioritise areas for improvement to a suitable target level. This tool provides an interesting insight into organisational digital maturity indices, and could act as an example for the development of a similar approach tailored to the context of natural science collections. Similar tools and models are available commercially, for example Deloitte offer a Digital Maturity Model [24] which covers areas of customer, strategy, technology, operations, and organisation & culture; with criteria across these again to enable organisations to assess and make prioritised improvements.

05 FINDING CAPABILITY DATA

5.1 Skills of individuals

There are two dimensions to examining data about individual skills and competence - first, the vocabulary used across the competency frameworks discussed above; in job descriptions and role profiles used to recruit personnel; in publications describing key areas such as digitisation workflows; and in the personal experience of those involved in this task. In its simplest form, capturing these vocabularies and using visualisation such as word clouds will enable identification of keywords and common terms across these sources, suggestion directions for the next stages of work. It will also be necessary to examine the possibility of creating controlled vocabularies based on these sources, for example to ensure more structured and machine-readable data about competencies, skills and roles within the future DiSSCo platforms and services.

As an example, a review of publications, practitioner experience and job descriptions related to mass digitisation at the Botanic Garden Meise has been used to construct a list of possible skills and competencies grouped under job titles. This will vary in other institutions and analysis of the sources outlined throughout this paper will be used to refine this across digitisation and wider competence areas, however it illustrates the diversity of roles and skills even in the mass digitisation area.

| | | |
|---|---|---|
| <p>Project manager Coordination Evaluation Monitoring Leadership Budget management Problem analysis/solving People management Writing e.g. protocols & reports Tendering/procurement if outsourcing Technical skill e.g. setting up imaging infrastructure and imaging process</p> | <p>Curator Coordination Evaluation Monitoring Leadership Problem solving Analytic skills Management skills Taxonomic knowledge Logistics Collection handling Communications</p> | <p>Imaging and specimen moving (digitiser / operator / photographer / technician) Collection handling Problem solving Meticulous & comfortable with repetitive tasks Technical knowledge (to set up and run imaging process e.g. camera, lighting, software)</p> |
| <p>Quality control (images) Technical knowledge of photography, software and image processing Meticulous and comfortable with repetitive tasks</p> | <p>Transcription manager Preparation of protocols Quality control Reporting Tendering / procurement if outsourcing Collections knowledge Taxonomic knowledge</p> | <p>Transcriber Meticulous & comfortable with repetitive tasks Able to decipher (old) handwriting Geo-referencing Collections knowledge Taxonomic knowledge</p> |

| | | |
|---|--|---|
| <p>Quality Control (Data) Meticulous and comfortable with repetitive tasks Able to decipher (old) handwriting Geo-referencing Collections knowledge Taxonomic knowledge</p> | <p>Database manager Knowledge of collection management system Data cleaning Data migration Technical knowledge e.g. of relational databases Data export/import Data standards</p> | <p>Bio-informatician Online data publication Programming/scripting Problem solving Technical knowledge of: Code control systems Workflow automation Data extraction Data standards Barcoding Digital identifiers Image processing and automation e.g. optical character recognition</p> |
| <p>IT specialist Development (particularly scripting) Expertise in: Image preservation Software Standards Automation including semi-automated quality control</p> | <p>Web developer Programming Technical knowledge e.g. open source PHP framework SQL and PostgreSQL Javascript Linux webserver configuration Backup and recovery systems</p> | |

Second, there is the question of data about the specific current skills of individuals - for example how DiSSCo colleagues could find experts in particular areas. We will investigate two key sources of information on this, ORCID (Open Researcher & Contributor ID - <https://info.orcid.org/what-is-orcid/>) and LinkedIn. ORCID provides a self-administered, persistent digital identifier for researchers, and ORCID profiles can provide a basic scientific biography of anyone who is registered, including educational level, funding, affiliations and publications. Information is only available about those who are registered, and the quality of their data is only as good and as up to date as they choose to provide, however if the user has opted-in the publication list is automatically updated. LinkedIn is another self-administered platform that gives details of employment, education, qualifications and self-declared specialisms. Again, the data are limited to what people choose to share, however, it has a broader userbase than ORCID, which may mean it holds complementary data. LinkedIn also enables connections to endorse people for particular skills e.g. strategy or stakeholder management. Both ORCID and LinkedIn have public APIs that allow machine access to the basic data. By using these APIs, we may examine the profiles of people working in collections. For example, their job titles, the qualifications etc. Much of the information is only available as free, unstructured text so a certain level of text mining may be required. We can also investigate other possible sources of information, such as Researchgate and Web of Science ResearcherID and Publons.

5.2 Skills within organisations

It may be more straightforward to identify 'clusters' of capability in organisations than to find expertise in individuals. Several sources of information on organisations have been mentioned in the

previous sections, including the dashboards, surveys and reports created through the DiSSCo-linked projects. Various other sources of organisational information exist online, such as the GBIF Registry of Scientific Collections; Index Herbariorum and institutional websites. These resources, however, tend to describe the collections better than they reveal the skills and knowledge of the staff, and are variable in coverage and in frequency of updates. In the context of DiSSCo, we may need to know specific capabilities of institutions so that we can evaluate the opportunities for outsourcing, distributed working and secondment. Currently, these data are somewhat patchy, dispersed and often unstructured, and further work is needed to examine whether and how they can be made more findable and usable. The DiSSCo services are likely to offer opportunities to improve on these data, both in terms of platforms and because offering services such as digitisation on demand will require good and up to date information, although once again perhaps most focused on collections.

06 DISCUSSION & NEXT STEPS

6.1 Discussion

The sources examined in this report show that a competency framework has several dimensions:

- the competencies themselves - which may be limited to behaviours or high level skills such as ‘communication’, or may go wider into areas of knowledge, skills, experiences and qualifications;
- The levels at which the competencies are applied, or how they develop across levels, which as a minimum tend to include three levels, but can also extend to every grade of an organisation with seven-eight levels being quite common; and
- The generic attributes or expectations which define those levels i.e. how they increase - typically including increasing autonomy, complexity and cognitive burden with increasing seniority.

Importantly, competency frameworks do not stand alone - those that work form part of an ecosystem which may also include job descriptions, role profiles or descriptions of ‘professions’; individual objectives for each period (typically the appraisal year); and laws and processes governing recruitment, performance management, reward, progression and promotion. In considering how best to manage competency and capability for DiSSCo, we need to consider whether a new competency framework and associated tool(s) is required, or whether any of the existing frameworks could be applied or tailored to the DiSSCo context. Good framework examples strike a balance between detail and accessibility, for example by offering one- or few-page summary views which then act as a ‘menu’ to direct individuals to the relevant levels of detail for their level and/or role. We also need to consider to what extent DiSSCo can or should provide standardised examples of the other elements, such as descriptions of ‘digitiser’ roles or other key technical roles.

Sources of data on individual skills and specialisms are available, for instance profiles maintained by individuals about themselves such as those on LinkedIn, and the research profiles associated with ORCID IDs, however these typically contain unstructured, self-chosen data and cannot be relied upon to be accurate or up to date.

In relation to organisational digital transformation and digital maturity it is clear that a very wide range of factors are influential, from the broadest political and funding context, to institutional leadership, communications and organisational structures, and of course funding and resources. While there are fewer organisational digital maturity indices and tools available than their are individual competency frameworks, examples do exist and could be developed for the DiSSCo context, helping institutions to identify their priorities for transformation and steps to achieve these. This may also help to distinguish between shorter and longer-term needs and priorities, both for institutions and potentially at the higher DiSSCo national and international levels.

6.2 Next steps

In relation to individual competencies, our next steps will include further examination of competency framework examples, particularly those not in English and/or from beyond the EU (e.g. USA & Australia) that we have not yet been able to review, and more recent developments such as the emerging outputs of the EOSC task forces and the terms4FAIRskills initiative (<https://terms4fairskills.github.io/>). We will also conduct a fuller review of frameworks currently in use among the DiSSCo members, including reviewing whether EUColComp is in use among the

original project partners or more widely, and why (or why not). Any significant conclusions of this work will be reported as further case studies and analysis as part of Milestone 3.3 of this task.

We will review, so far as possible, the extensive vocabularies identified in the many existing examples of competency frameworks, looking for key aspects in the language and examining these through the lens of DiSSCo needs to identify those competencies or categories that seem most relevant.

We will consider behavioural insights relevant to how individuals may be persuaded to keep their own data up to date, including incentives such as professional recognition or opportunity, and work with ELViS to consider how individual and organisational data will be represented and maintained in the DiSSCo infrastructure, whether through linkage to existing sources and / or through the development of new user interfaces for the DiSSCo environment. We will also seek any evidence about the needs of individual users of competency frameworks, or identify gaps in our understanding of these needs.

The development of prototype dashboards or tools to support individual competence and organisation digital maturity (Milestone 3.2 of this task) will not be straightforward, given some of the big questions raised in the discussion about the potential use of existing frameworks - however the additional analyses detailed above, alongside discussions with DiSSCo members about the areas they believe would be most useful, will indicate directions which can be tested in this prototype stage. At this point, it is not possible to define what would be included in one or more dashboards or tools - for example these might include a competency framework in a format that facilitates navigation; a tool to help navigate existing competency frameworks; a tool with key categories and resources that might be used to align or enrich institutional competency frameworks; a tool for institutions to self-assess digital maturity against their strategic need; and tools to identify where best practices or clusters of particular skills can be found, feeding into task 3.3 around secondments and distributed team working practices.

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Organisational Change in Finnish Museum of Natural History, Luomus Case study

Introduction

Luomus has gone through a quite substantial change during the past ten years regarding the digitalisation. It has affected the whole organisation and in the following chapters, the background, main aspects and changes have been described.

Policy

EU and national level

The background for the opening up the natural history collections in Luomus through digitisation lies deep in the open data policy implemented in EU and national level. There are many programmes launched by the Finnish administration that support and promote open data initiatives. For example, The Finnish Open Data Programme 2013–2015 was launched to accelerate and coordinate the opening of the public sector data resources. This programme acted as a strong support for the establishing the Finnish Biodiversity Information Facility, FinBIF, <https://laji.fi/en>.

- Examples:
 - EU policy
 - On 20 June 2019, the European Parliament and the Council adopted the objectives of open data processing (1024/2019 / EU) with the harmonization and streamlining of regulation and opening processes for the opening of public sector information resources. The aim of the project is to implement the directive nationally.
 - Finnish programmes
 - The principle of publicity is already enshrined in the Constitution in Finland, according to which all documents and other recordings of authorities are public, unless their publicity is restricted elsewhere in legislation due to necessary reasons. Also the data must be in a sufficiently structured form to be able to be identified, retrieved and combined mechanically.
 - Guidelines for open data have been made in several contexts since 2011: e.g. The Finnish Open Data Programme 2013–2015.
 - National implementation of the Open Data Directive

Institutional level

Luomus drafts as part of its quality management and goal-driven strategic development policy documents to guide its operational sectors. The purpose of such policies is to define the content and procedures of the Museum's activities and therefore guide and inform the personnel. The General Collections Policy serves this goal by determining the key guidelines, followed by the collection-specific policies. They describe each collection's current status of curation and specify the measures required for their development and preservation. Guidelines concerning the targeting and practices

of amassment, destructive research, loans and deaccessioning are central for ensuring the preservation of the collection. These policy documents emphasize that the scientific and perceived value of the Luomus collections is ultimately dependent on their accessibility, hence strongly support the digitisation and open data. All policy papers have been prepared in close collaboration with the staff.

- Different policy documents in Luomus:
 - o General Collection Policy, <https://riojournal.com/article/58167/>
 - o Invertebrate Collection Policy
 - o Herbarium Policy, <https://riojournal.com/article/60470/>
 - o Living Collections Policy, <https://riojournal.com/article/60450/>
 - o Genetic Resources Collection Policy
 - o Luomus Digital Data Policy and FinBIF Data Policy
 - Principles relating to digitisation and digital resources are separately specified in these documents (soon published).

Governance

The (Finnish) Universities Act: Section 72. Finnish Museum of Natural History Operating in connection with the University of Helsinki is the Finnish Museum of Natural History. The Museum is responsible for the preservation, accumulation and exhibition of the national natural history collections and for research and education relating to them.

The ongoing reform of the (Finnish) Nature Conservation Act is drafted so that it will mention also that Luomus coordinates the Finnish Biodiversity Information Facility (FinBIF), which is responsible on collecting and sharing species information nationally.

Strategy of the University

- o Open science shows up strongly in the university strategy (both 2017-2020 and 2021-2024) <http://strategia.helsinki.fi/en/1/#development-areas3> and in the materials and services of the University.

**Open Science at the University of Helsinki:
Guidelines and support services** ^

- [Strategic plan of the University of Helsinki](#)
- [Principles of open publishing](#)
- [Research data policy](#)
- [Open science on the University's external pages](#)
- [Open access guide for researchers](#)
- [Data support services](#)

Luomus Implementation Plan 2021-2024 of the strategy (including staff development plan) accepted by the rector of the University includes e.g. the following actions:

- Make selective and prioritised investment in and promote shared use of Luomus' RI
 - Adopt new digitisation technologies to diversify digital research services, in particular CT scanning.
 - Continue developing FinBIF – 1) internal services; 2) national services cross-sectorally; 3) international networking (sharing best practices) – focusing on further strengthening its all-encompassing service model.

- Focus on the active collection development and digitisation
 - Adopt new digitisation technologies to diversify digital research services, in particular CT scanning.
 - Triple the rate of specimen digitisation by 2025 (to 1 M specs. / yr.) through utilizing outcomes of the ICEDIG design study.
 - As part of the digitisation programme, prepare up-to-date catalogues of Luomus' collections, providing crude listings of taxa and numbers of specimens, and share these openly.

The Annual (qualitative and quantitative) goals based on the Implementation Plan are agreed at different levels with increasing level of details

- Unit level
- Team level
- personal level

The processes, development and transfer of knowledge are supported by strong participation to DiSSCO development processes and international networks

- projects (DiSSCo Prepare, Synthesys, Mobilise)
- related working groups
- congresses, networks (e.g. TDWG, CETAF, GGBN)

Communication

Big cultural change is needed in addition to organisational change. The background comes from the aim and principle of open science and open data, which has been promoted for years through continuous interaction with staff through different modes and channels of communication e.g.:

- Participatory and interactive planning of the Implementation plan.
- Discussion with the supervisors on annual goals at different levels.
- Documentation: Policies, workplans, guidelines, instructions
- Meetings on development and workflows of digitisation processes (e.g. Team meetings, meetings of Scientific Managers (Curators) and technical staff (Coordinators and (Senior) Museum Technicians).
- 1:1 meetings.
- Courses

- Internal electronic notice board Museoinfo.

MUSEOINFO

Must know

- 16.11: Rehtori tapaa (virtuaalisesti) Luomuksen henkilöstön / The Rector to meet Luomus' staff (virtually) (4)
- 12.11: Muutos Luomuksen HR-timissä (1)
- 9.11: Virtuaalipikkujoulu / Virtual Christmas party maanantaina / Monday 7.12. 14.30 – 15.30 (3)
- 5.11: Computer and other IT related purchases at the end of the year (0)
- 21.10: Administrative services at Luomus (2)
- 16.10: Kari Lahdesta yksikönjohtaja / Kari Lahti promoted to Unit Director (5)
- 16.10: Uusin koronavaiheita / The most recent corona communications (15)
- 15.10: Flu vaccine 2020 (3)
- 15.10: Influenssarokotukset 2020 (2)

Should know

- 18.11: Luonnontieteellisen museon lastausreitit vapaaksi 18.11. ja 24.11.2020 (2)
- 10.11: Remember Open Access of your publications! (0)
- 10.11: Introduction to Open Science – lectures 13th & 20th November (0)
- 6.11: Luomus Botany Twitter Account launched (5)
- 5.11: Library services support open science and research (0)
- 4.11: Lajiluettelo 2020 – Checklist 2020 (0)
- 3.11: Creative Commons -webinaarillenne ja julkaisuinnon arvioinnin Moodle-kurssi (0)
- 2.11: Luonnontieteellisen museon lastauspaikka tyhjäksi autoista 4.-5.11.2020 (0)
- 30.10: Botanicum 4/2020 (0)
- 27.10: Iris ai at Helsinki workshop 5th November 1 pm (0)
- 26.10: Research Data Management basics Oct 29th 2 pm (0)
- 23.10: Tuholajistorjunta Luonnontiet. museossa ma 9.11. klo 15.30 / Pest control in the Natural History Museum on Mon. 9.11. at 15.30 (0)
- 22.10: Memo / muisto: Institution Meeting 19th October 2020 / Laitoskokous 19.10.2020 (0)
- 20.10: Quality in UH and Luomus (slides) (0)
- 20.10: UH's Africa program launched: Luomus' research well-represented (1)
- 19.10: Helsingin kaupungin lääkintöalan KOTÄän / Heaman of the staff an

Nice to know

- 18.11: "Cradle of Mankind" – can you help to transcribe African vertebrate fossil specimen cards into a database? (0)
- 16.11: Keittolounaat ajalle 17-20.11.2020 (0)
- 12.11: Luomus Seminar 10 am Nov. 18: Björn Kröger (0)
- 12.11: Ilmastohätätilä ja kriisinhallinta -paneelikeskustelu (0)
- 11.11: An introduction to open science webinar (2)
- 11.11: Kiitos mustamisesta merkkipäivänään! (2)
- 10.11: Keittolounaat ajalla 10-13.11 (0)
- 10.11: Seminar under the "Current topics in Ecological Change Research"-series. (0)
- 8.11: Luomus Seminar, Nov 11. 10 am in Teams: Jyrki Muona (1)
- 3.11: ForBio Annual Meeting – Virtual 2020 – registration DL 8.11. (0)

Uusimmat uutiset

- Arkisto (kaikki uutiset)

Viimeksi kommentoidut

- Rehtori tapaa (virtuaalisesti) Luomuksen henkilös...
- Luonnontieteellisen museon lastausreitit vapaaksi ...
- Luomus Seminar, Nov 11. 10 am in Teams: Jyrki Muon...
- Virtuaalipikkujoulu / Virtual Christmas party maan...
- Luomus Botany Twitter Account launched

Pikalinkit / Resources

- IT Help / IT-ohjeita
- Annual report 2017-2018 / Vuosikertomus
- Visual identity / Luomus-ilme (logo) (wiki)
- Strategic documents (wiki)

Luomuksen tiedotteet ja uutiset

- 18.11: "Cradle of Mankind" – can you help to transcribe African vertebrate fossil specimen cards into a database?
- 16.11: "Cradle of Mankind" – auta tutkijoita fossiilinäytteiden tietojen digitoimisissa

- Positive feedback on achievements and development of digitisation is shared constantly on Museoinfo, social media channels, and meetings as well as face to face.

Luomus Zoology @luomus_zoology · 26. lokak.
Another day of taking pictures. Digitizing and databasing larger Thai moths from a recently donated collection. This is an Antherea, a relative of the silk moth @luomus @lajitieto @HILIFE_helsinki @GBIF #OpenData

Jere Kahanpää @JKahanpaa · 26. lokak.
Tänään(kin) töissä perhosten kuvausta. Tässä Antherea -suvunkehräjäjä Thaimaasta. @luomus_zoology #biodiversity #Thailand #Saturniidae

Aino Juslén @ainojuslen · 16. marrask.
Such a beauty! Excellent that the publication links directly to @lajitieto @luomus specimen id, one of our #opendata #openscience goals. #ResearchInfrastructure @HILIFE_helsinki @LifeSciHelsinki @heisinkiuni

Pasi Silhonen @pasi_silhonen · 16. marrask.
Species descriptions are the essence of biodiversity research: name links all data and literature together! New Sacada pyralid moth on Evolutionary Systematics evolyst.pensoft.net/article/59893/... #OpenAccess @pasi_silhonen @luomus_zoology

Leif Schulman @Leif_Sch · 4t
Mitämitä? Eihän tässä @lajitieto @luomus #AvoinData kasvussa pysy perässä: ei mennyt viikkoakaan edellisestä lkm-twiitistäni, ja jo paukkui 38M 🤖🤖🤖 Kiitos @mikkohei13 tiedosta, että rajan rikkoi iso #intu-havaintolataus @iNaturalistFin.

LAJI.FI
SUOMEN LAJITIEOKESKUS
FINLANDS ARTDATACENTER
FINNISH BIODIVERSITY INFO FACILITY

38 012 679 havaintoa
39 383 lajia

Leif Schulman @Leif_Sch · 12. marrask.
Koskaan ei ole liian myöhäinen syksy #laji-havaintojen tekemiseen & tallentamiseen - @lajitieto-keskuksen datamassa ihan kohta 38 miljoonaa! Jaksaa, jaksaa! painaa, painaa! Kuka puhkoo seuraavan miljoonan? @luomus @helsinkiuni kiittää jokaisesta 🤖sesta!

Outreach

Much of the outreach has been done through the social media; FinBIF/Zoology/Botany twitter, facebook and via specific projects e.g. Synthesys +, ICEDIG, DiSSCo Prepare and some national projects. The use of our own public attractions; botanic garden, natural history museum have been underutilized so far. The main reason for this is that Luomus has suffered quite substantial budget cuts, which affected most severely the public engagement activity.

Organisational structure

Luomus currently digitise only in-house, in the past there has been some outsourced digitisation to contractors such as Digitalium for off-site digitisation of herbarium sheets. At the beginning the

digitisation was done independently in every collection team. This led to the situation for example where there were multiple different databases, excels etc. where the data was stored. It made finding and using the data extremely difficult. It became apparent that more organized way of doing digitisation was needed.

The main changes have been done with the pre-existing resources by reshuffling them more efficiently. For example, a new unit, Biodiversity Informatics Unit (BIU) has been established with new teams (explained below, see Table 1.). Start of Digitisation team made mobile employee reallocation possible. Team members can be moved to the collections that have been prioritized. They are not restricted to a specific collection as was the situation before. However, it has not been entirely possible to bring about the change with existing resources alone. We have also succeeded in obtaining external funding (both national and EU). This has enabled investments in physical infra (see Table 2). The equipment is, in turn, essential for the acceleration of digitisation rate. We have also been able to establish some new job positions in digitisation e.g. Digitisation Manager, Digitisation Coordinator and CT- scanner Senior Museum Technician.

Enablers for more effective, fast and comprehensive digitisation and open access data.

- Kotka development
 - Kotka is an in house developed collection management system (CMS). Its development began ca. 2012 and is still ongoing because it is being developed by applying agile software practices.
 - Developed in close collaboration with the collection managers and curators i.e. personnel working with the collections and having the best knowledge what is needed from the CMS.
 - Essential for an effective collection management and digitisation is a well-developed and working CMS.
- Establishing the FinBIF, <https://laji.fi/en>
 - Essential for the mobilisation and accessibility of open data.
 - Follows FAIR (Findable, Accessible, Interoperable, Reusable) principles.
 - ICT Team, own in house developers
 - Is responsible for the development and maintenance of the information systems of Luomus and FinBIF.
 - Species Information Team – interaction!
 - Team acts as the link between FinBIF and the other units and teams within Luomus, also towards external stakeholders.
 - They e.g. design the services needed for the management of biodiversity information.
 - Digitisation Team
 - Established in 2019.
 - Team consists (in 2020) 8 full-time members and 10 part-time members. Part-time members also work in other teams within the Zoology and Botany units and most full-time members are with external funding.
 - Institution wide: enables better coordination e.g. of allocating resources, in developing more efficient workflows, implementing policies, better communication.
 - All three teams work in close interaction with each other.

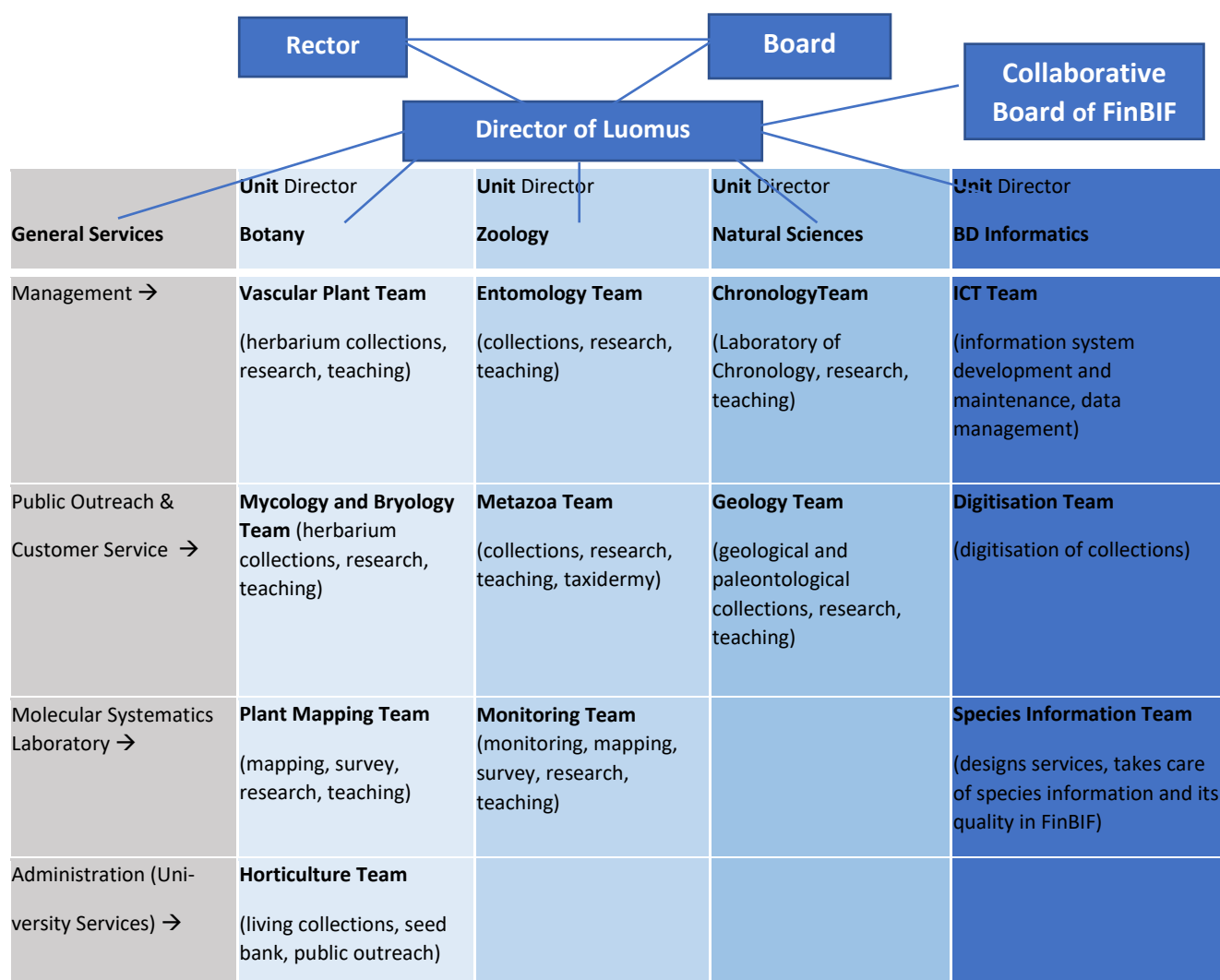
Digital Capacity building

Luomus personnel is divided into two broad categories: technical and research staff. Almost everyone among technical staff is involved in varying degree in digitisation in their daily duties, and even some of the research personnel takes part in digitisation in some way. Digitisation is done mainly by long-term staff, especially by the Senior Museum Technicians who also have other duties as curators of the collections. The content of their daily work has changed quite substantially over recent years. Their duties consisted previously mainly of traditional collection work e.g. arranging the collections, specimen curation, identifying specimens. There have been slight challenges in this change and they have been tackled with the actions described in the previous chapters.

Most Senior Museum Technicians have a university degree, usually in biology. Many employees have a nature hobbyist background.

- Training:
 - **New:** at the beginning the basic training: handling of the specimens, use of the CMS and other relevant systems, use of basic imaging equipment, introduction to the guidelines related to digitisation, basic knowledge of data basing. Usually the more advanced knowledge for e.g. georeferencing and use of specialized imaging equipment is gathered later through peer guidance.
 - **Long term:** the new tasks have entered to the daily work little by little. Much of the training has occurred learning by doing method by peers who have the required skill. Staff is encouraged to participate to the relevant available courses, seminars and conferences.
 - Examples:
 - The focus of training arranged in connection with BIU has been on capacity building of technical personnel and staff scientists who develop the Unit's services. Institutional wide staff training has been provided in digitisation methodologies and workflows, and in using IT solutions for data management e.g. the Species Information Team organizes training courses on the use of Kotka (CMS) for both beginners and more experienced regularly. There has also been a semi regular "Kotka clinic", where anyone with questions, problems with Kotka can go to get personal help and support.
 - The BIU has also invested in training for its staff offered by external parties, such as courses in process and project management, programming, machine learning, advanced software use, global RI development, and legal questions in data management.
 - Participation in the COST Action MOBILISE through which international visitors have been received for, and the staff offered, so-called Short-Term Scientific Missions, i.e., training visits to learn about RI service development and technologies.
 - Participation to conferences e.g. Biodiversity next, have acted as a very good motivator. These events enables people to see the bigger picture behind the digitisation.
 - General courses: The University offers a wide range of courses and they are available to all.

- Job descriptions/requirements of some key digitisation personnel
 - Senior Museum Technician
 - The work requires precision, diligence, patience and perseverance. The task requires good skills in information technology. Knowledge of the species and knowledge of the various sample handling techniques and information systems involved in the collection work is an advantage. The work requires the maintenance and development of independent material management and processing skills and interaction skills. The use of foreign languages is needed in cooperation with international scientific loans. A typical level of education is a university degree, although there is no education that directly prepares for the task, but achieving a sufficient level of skills requires voluntary familiarization as well as work experience in the field.
 - Digitisation Coordinator (in Insect team)
 - The digitising coordinator is responsible for organizing and overseeing the imaging and data basing of insects specimens at the museum. Typical tasks involve work process design and documentation, shift scheduling, equipment maintenance and troubleshooting. He does also participate in curating and maintaining the created data, and in the actual imaging & data entry as needed.
 - In addition to digitizing-related tasks, he also maintains the Diptera collections of Luomus (ca. 500.000 specimens) and participates in teaching, PR and daily operations at the museum as needed.
 - Senior curator (research staff)
 - Maintenance, expansion and enhancement of the scientific vertebrate collections and related databases, together with other team members.
 - Supervision of the technical staff regarding these collection sections, particularly managing the chain of acquisition, preparation and cataloguing

Table 1. Organisation Chart of Luomus

Digitisation equipment in Luomus

- Investments for physical infra are essential for the acceleration of digitisation
 - Conveyor belt digitisation line for insects (90 000 specimens per year)
 - Conveyor belt digitisation line for herbarium sheets (140 000 specimens per year)
 - Macrophotography setup (camera, stand & lighting)
 - Herbarium imaging setup (camera, stand & lighting)
 - Image stacking photographic equipment
 - Herbarium scanner
 - Flatbed scanner
 - Manual microscope
 - 3D surface scanner
 - Micro CT Scanner (planned in 2021)

ANNEX B

Museu Nacional de História Natural e da Ciência

University of Lisbon

The Museu Nacional de História Natural e da Ciência (MNHNC) dates back to 1768 and it was definitely installed in its current premises in 1858. Even though it is a national museum, the MUHNAC is also an academic museum that belongs to the “Universidade de Lisboa” (ULisboa), having a privileged link with higher education institutions, which promotes a close cooperation and the use of natural history collections for higher education and research. Since 2015, it manages the collections of the Institute for Tropical Research (IICT), which was then incorporated in the ULisboa. The MNHNC is part of two National Scientific Infrastructures:

1) The Portuguese Research Infrastructure for Scientific Collections - PRISC gathers scientific collections on botany, zoology, anthropology, geology and palaeontology, totalling c. 3.335 million specimens

2) The Portuguese E-Infrastructure for Information and Research on Biodiversity - PORBIOTA

The Museum is a data provider for GBIF (<https://www.gbif.org/publisher/315127e0-d7bb-11db-9885-b8a03c50a862>; <https://www.gbif.org/publisher/9fdb5a90-a5a6-11dd-8d5f-b8a03c50a862>). We have also published data on international botanical digital repositories such as, e.g., ca. 7640 type specimens of plants of LISU and LISC herbaria in JSTOR:

https://plants.jstor.org/search?filter=free_text&so=ps_group_by_genus_species+asc&Query=RepositoryCode%3ALISU

https://plants.jstor.org/search?filter=free_text&so=ps_group_by_genus_species+asc&Query=RepositoryCode%3ALISC).

Governance, Organisation, Collections Policy, Strategy, Digitisation:

Being a part of the University of Lisbon and its structure, the MNHNC depends entirely on the university and its Rector. The organisational structure of the MNHNC is currently the one you can see in Figure 1.

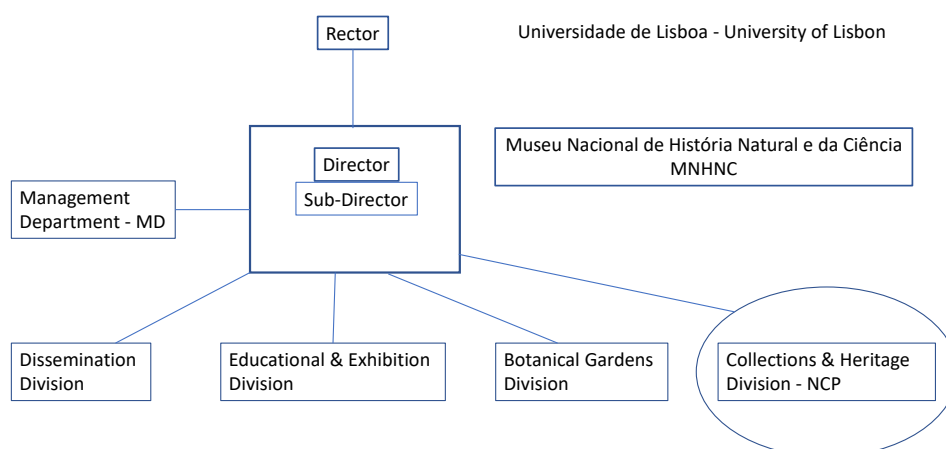


Figure 1 - Organisational structure of the MNHNC.

Here we focus essentially on the structure and functioning of the Collections and Heritage Division (NCP). The Heritage and Collection Division is responsible for the implementation of the management heritage and collections policy, namely:

- a) to manage, preserve, enhance and make accessible the heritage and collections, ensuring their study, interpretation and dissemination;
- b) to ensure the integrity and security of the heritage and collections;
- c) to plan and manage the reserves, laboratories, equipment and materials;
- d) to support the enhancement and conservation of the cultural heritage of the University of Lisbon.

As the structure of the museum has been under renovation, the organization of the NCP is still under construction (Figure 2).

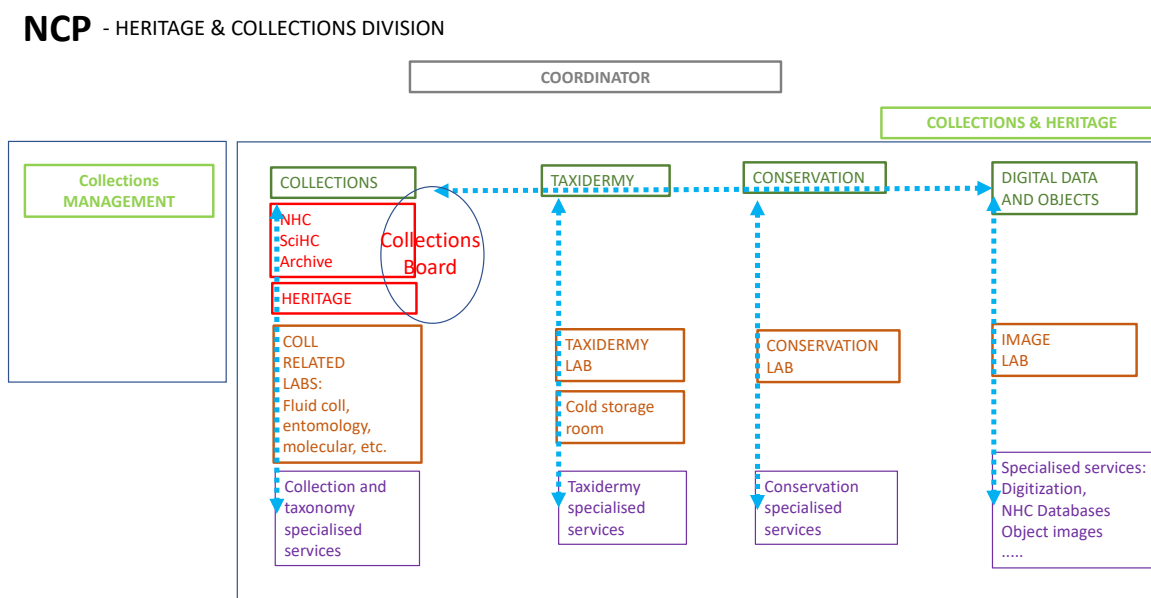


Figure 2- Organization of the Heritage & Collections Division (under renovation)

The MNHNC has several “types” of scientific collections. In this document we discuss only the roles associated with the natural history collections.

The “Digital Data and Objects” Group does not yet actually exist, but it is being considered to create, as a result of the current needs associated with the collections and data digitization process. The MNHNC needs now to define the skills and competences needed for the functions associated with the digitisation of collections, both in capturing images and obtaining the information associated with the various collections.

At the MNHNC the roles associated with the NHC collections are:

Curator, Guardian (for collection without curator), Technical Assistant, Conservator and Taxidermist. The functions and responsibilities are briefly described in the dashboard presented in Figure 3. The MNHNC is considering adding other collections functions, as is also described in the dashboard

presented in Figure 3, as is the case of Specialist Consultant, Database Manager and Technical Manager.

Without having assigned all the jobs the care of collections requests, some of the functions are performed by professors, researchers and duly qualified technicians of the University of Lisbon and other national universities. These include curators and assistant curators. As a consequence, a Collections Board was created to provide a forum for discussion and advice on collection-related issues.

As the MNHNC manages, since 2015, the collections of the Institute for Tropical Research (IICT), which was then incorporated in the ULisboa, a new Collections Policy is now being prepared and adapted to the entry of these collections and will be released soon.

Conscious that digital access to natural history collections is an effective way to distribute scientific information worldwide, and that online collections are useful tools not only in research for experts but also for public education, we have been intensifying the digitization and online access to our natural history collections.

Being part the Portuguese E-Infrastructure for Information and Research on Biodiversity - PORBIOTA gave the MNHNC the resources (especially human resources) to start digitizing the natural history collections.

The MNHNC collections digitisation is made only in-house. It is currently running independently in some collection teams, depending directly on the curators.

As this is leading to a situation where there are multiple different databases, excels etc. where the data is being stored. Its becoming evident that a more organized and general way of doing digitisation was needed. The MNHNC is now studying a system to store all the digitized information. The complexity comes with the many different kinds of scientific collections the MNHNC holds. The MNHNC needs to define a collections digitisation plan.

A new Group of work, the “Digital Data and Objects” Group (referred above), needs to be established with new teams. The MNHNC needs now to define the skills and competences needed for the functions associated with the digitisation of collections data and image.

This team would not be restricted to a specific collection and will work with all type of collections.

| DRAFT - WORKING VERSION | universal to the various collections | | per collection | | universal to the various collections | | Databases Manager | | | | |
|---|--------------------------------------|--|--|--|---|--|--|---------------------------------------|--|--|--|
| | Museum direction | Collections Board | Curator | Assistant Curator | Guardian | Specialist Consultant | | Technical Manager | Technical Assistant | Conservator | Taxidermist |
| General Functions | | Body for discussion and coordination of activities linked to collections | The curators are responsible for the collections in their charge, namely, incorporation, cataloguing, preservation, loans, study, etc. | To support the activity of the curator in its various components, but it has no decision-making responsibility | Takes responsibility for the preservation of and access to collections, objects or in deposit, of libraries | National or international specialists who contribute to the valorisation of a particular collection specifically with regard to identification and cataloguing | Coordinate and follow up management procedures for the various collections | Ensure routine tasks for collections. | Ensures the conditions for the preservation and conservation of the objects/specimens of the various collections | Ensures the conservation, preparation and assembly of objects/specimens from the various collections | Manages the standardisation, maintenance and operation of databases and the publication of data on dedicated platforms |
| Level of autonomy | | | | work supervised by the curator | work in cooperation with the Board of Collections | work in collaboration with the curator | | work supervised by the curator | | | |
| Scientific/administrative management activities | | X | X | X | X | X | X | X | X | X | X |
| Expansion | | | X | X | X | X | X | X | X | X | X |
| Valorisation | | | X | X | X | X | X | X | X | X | X |
| Conservation | | X | X | X | X | X | X | X | X | X | X |
| Accessibility | | | | | | | | | | | |
| Dissemination | | | | | | | | | | | |

