



## D3.4 – Innovative toolset

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### Work package / Task:

WP3 - Developing an integrated platform of collaborative tools

T3.3 – Developing new innovative tools for the platform

### Short Description:

This deliverable describes the outputs of WP3 / T3.3: the EO4GEO BoK software platform and its associated tools.

### Keywords:

EO4GEO BoK software platform, BoK tools

Dissemination Level		
PU	Public	x
RE	Restricted to other programme participants (including Commission services and project reviewers)	
CO	Confidential, only for members of the consortium (including EACEA and Commission services and project reviewers)	

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## Executive Summary

In Task 3.3, the EO4GEO BoK software platform and ecosystem of BoK tools were developed. The software platform stores and exposes the BoK for external use, through permalinks and an API, and eases future development by offering default BoK functionality components. The ecosystem of independent yet collaborating tools targets stakeholders in the educational, public and commercial sector. The following tools were developed:

- The Bok Search and Visualization tool (BVS), to visualize, navigate and search the BoK. This tool is for all stakeholder.
- The Curriculum Design Tool (CDT), to create, edit and find EO & GI educational offers. This tool is primarily aimed at the education sector, but can also be used by the public and commercial sector (i.e., to specify training offers).
- The Occupational Profile Tool (OPT), to create, edit and find occupational profiles in the EO & GI fields. This tool is primarily aimed at the public and commercial sector.
- The Job Offer Tool (JOT), to create, edit and find job offers based on eo4geo Occupational Profiles. This tool is primarily aimed at the public and commercial sector, but is also useful for the educational sector (i.e., for training offers, apprenticeship offers, etc.)
- The BoK Annotation Tool (BAT), to annotate external resources with the BoK. This tool is for all stakeholder.
- The BoK Matching Tool (BMT), to compare any BoK annotated resource with respect to knowledge and skills. This tool is for all stakeholder.

In addition, the Living TextBook was adopted to edit and view the BoK.

All tools were developed based on an elaborate requirements engineering phase, with ample input from internal partners and stakeholders in the EO/GI field. Throughout the agile development process, regular input from stakeholders was gathered and taken into account during development. All tools were extensively tested, which included technical and usability tests by the developers, and functional and usability testing by internal partners and external stakeholders.

The work performed under T3.3 completely covers and exceeds the expectations according to the Description of Work (DoW).



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## Acronyms

Acronym	Description
API	Application Programming Interface
BoK	Body of Knowledge
BAT	BoK Annotation Tool
BMT	BoK Matching Tool
BVS	BoK Visualization and search
CDT	Curriculum Design Tool
DoW	Description of Work
EACEA	Education, Audio-visual, Culture and Executive Agency
ECTS	European Credit Transfer and Accumulation System
EO/GI	EO and GI sectors
EQF	European Qualifications Framework
ESCO	European Skills, competences, qualifications and occupations
GDPR	General Data protection regulation
GIN2K	Geographic Information: Need to Know
HTML	HyperText Markup Language
ICT	Information and Communication Technologies
ISCED-F	UNESCO's International Standard Classification of Education: Fields of Education and Training
ISCO	International Standard Classification of Occupations
JOT	Job Offer Tool
OPT	Occupation Profile Tool
RDF	Resource Description Framework
RDFa	Resource Description Framework in attributes
URI	Uniform Resource Identifier



## Glossary

**Body of Knowledge (BoK)** is the complete set of concepts and relations between them, that make up a professional domain, (in this case EO/GI BoK) and the related learning outcomes as defined by the relevant learned society or a professional association.

**European Credit Transfer and Accumulation System (ECTS)** is an European standard to compare academic credits – learning outcomes associated workload - for higher education.

**European Qualifications Framework (EQF)** descriptor is defined by 8 levels of descriptors that indicates at that level the learning outcomes relevant to qualifications in any system of qualifications.

**European Skills, Competences, Qualifications and Occupations (ESCO)** is the multilingual classification of European Skills, Competences, Qualifications and Occupations.

**Geographic Information (GI)** is the data of a geographic location combined with non-spatial information (e.g. statistical data) and their representation as a map.

**Geographic information: Need to Know (GI-N2K)** is a project under the Lifelong Learning Programme Erasmus of the EU that aimed to improve the way in which future GI professionals are prepared for the labour market so that the GI sector in general can evolve in a dynamic and innovative way.

**Information and communication technologies (ICT)** are the infrastructure and components that enable modern computing.

**Permalink** is a permanent URL serving as Universal Resource Identifier (URI)

**Universal Resource Identifier** is a unambiguous identifier for a resource using a common identification scheme. URLs (web addresses) are the most commonly used URIs.

**Zenodo** is a multi-disciplinary open repository maintained by CERN. Datasets, documents and other research materials can be located via the Zenodo search engine. Scholars from any research discipline can upload data in any file format. A digital object identifier (DOI) is automatically assigned to all Zenodo files



## 1. Introduction

### 1.1. EO4GEO project

EO4GEO is an **Erasmus+ Sector Skills Alliance** gathering **25 partners from 13 EU countries**, most of which are part of the **Copernicus Academy Network**. Be they from academia, public or private sector, they are all active in the education and training fields of the space / geospatial sector. The project is also supported by a strong group of Associated Partners mostly consisting of associations or networks active in space/geospatial domain. The project started on January 1st, 2018, upon approval by the EU Education, Audiovisual and Culture Executive Agency (EACEA) and runs over four years.

EO4GEO **aims to help bridging the skills gap in the space/geospatial sector** by creating a strong alliance of players from the sector/community reinforcing the existing ecosystem and **fostering the uptake and integration of space/geospatial data and services**. EO4GEO works in a **multi- and interdisciplinary** way and applies innovative solutions for its education and training actions including: case-based and collaborative learning scenarios; learning-while-doing in a living lab environment; on-the-job training; co-creation of knowledge, skills and competencies; etc.

EO4GEO defines a long-term and sustainable strategy to fill the gap between supply of and demand for space/geospatial education and training taking into account the current and expected technological and non-technological developments in the space/geospatial and related sectors (e.g. ICT). The strategy is implemented by: creating and maintaining an ontology-based Body of Knowledge for the space/geospatial sector based on previous efforts; developing and integrating a dynamic collaborative platform with associated tools; designing and developing a series of curricula and a rich portfolio of training modules directly usable in the context of Copernicus and other relevant programmes and conducting a series of training actions for a selected set of scenario's in three sub-sectors - integrated applications, smart cities and climate change to test and validate the approach. Finally a long-term Action Plan will be developed and endorsed to roll-out and sustain the proposed solutions

For more information on the project please visit <http://www.eo4geo.eu/about-eo4geo/>.



## **1.2. Objectives of the work package**

Work Package 3 (Developing an integrated platform of collaborative tools) essentially foresaw the selection, customization, fine-tuning, development and testing of tools relevant for the project.

This translates in the following specific objectives:

- To identify, assess and select existing platforms and components that can be used/reused and (eventually) integrated;
- To identify the minimal functional and non-functional user requirements the platform(s) should match;
- To discuss and get feedback on the proposed architecture and technical solutions proposed;
- To test and exploit existing platforms and tools, analyse their use/usability and collect input for potential improvement;
- To describe, plan and document the changes that will be made to existing platforms and tools;
- To describe new tools that will be developed;
- To modify and extend coding of existing platforms and tools and to develop new tools;
- To document and provide guidelines for users and to organize acceptance tests.

## **1.3. Objectives of the task – update with respect to DoW**

The objective of Task 3.3 as foreseen in the Document of Work is to develop new innovative tools for the platform. On the other hand, the objective of Task 3.2 as foreseen in the Document of Work is to revise, fine-tune and improve existing platforms and tools. While this distinction between existing and new tools made sense at the time of the proposal, due to various reasons detailed below, it was decided during the execution of the project to re-organize the work into managerially and logically connected/related tools. Concretely, it was decided to group all tools related to Geographic Information (GI) and Earth Observation (EO), together with the learning platform, in Task 3.2; on the other hand, all tools related to the Body of Knowledge were grouped in Task 3.3.

The motivation for this was fourfold: (i) Unforeseen circumstances and decisions made throughout the project caused some tools that were originally foreseen to be re-used to be re-developed. Concretely, due to unsustainability of the existing solution, the BoKWIKI platform was per executive decision replaced by a combination of the EO4GEO BoK software platform (newly





developed by partner UJI) to store, serve and be the main entry point of the BoK, in combination with the Living Textbook (developed/extended by partner ITC) for editing the BoK. Therefore, tools automatically transitioned from Task 3.2 to Task 3.3. (ii) Due to the architectural decision to develop the BoK-related tools as much as possible as re-usable and interacting components, it was logically better to group functionality related to the BoK-related tools under one umbrella. For example, a re-usable component to visualize and browse the BoK was partly extracted from the Curriculum Design Tool (originally T3.2), made available as a new independent tool (originally Task 3.3) and re-used both in the renewed Curriculum Design Tool (originally T3.2), the Occupational Profile and Job Offer tools (both originally T3.3). As illustrated by the example, the original classification between existing and new tools was no longer tenable. (iii) The learning platform, originally foreseen to be reported in D3.4 (Task 3.3), is closely connected to the PROBAA Mission Exploitation Platform, as it interacts with it to provide new, interactive learning material, relevant for Task 4.3, and the case-based scenarios (WP5). It was thus preferable to group both under a single task. (iv) Both for the EO/GI related tools and for the BoK-related tools, there is one project partner that is the main developer of the tools. Therefore, from a project management and software development point of view, it makes sense to group the respective tools under the responsibility of the respected partners, i.e., VITO for EO/GI related tool (now T3.2) and UJI for BoK-related tools (now T3.3).

Despite the re-organization of tools among Task 3.2 and Task 3.3, it needs to be stressed that all foreseen work has been carried out.

As such, Deliverable D3.3 already reported results of T3.2 as described above. This deliverable (D3.4) reports the results of T3.3 as described above. Concretely, this includes the following tools:

- The EO4GEO BoK software platform, to upload, store, serve and expose the BoK for tools and external use
- The Living Textbook, as an editing tool to edit and maintain the BoK
- The BoK Search and Visualization tool, to visualize, navigate and search the BoK.
- The Curriculum Design Tool (CDT), to create, edit and find EO/GI educational offers
- The Occupational Profile Tool (OPT), to create, edit and find occupational profiles in the EO/GI fields
- The Job Offer Tool (JOT), to create, edit and find job offers based on EO4GEO Occupational Profiles
- The BoK Annotation Tool (BAT), to annotate external resources with the BoK



- The BoK Matching Tool (BMT), to compare any BoK annotated resource with respect to knowledge and skills.

## **1.4. Purpose of the document**

In task 3.3, the requirements and use cases of the EO4GEO project, reported in D3.1, were used as a starting point to develop the EO4GEO BoK software platform and the ecosystem of tools built upon the platform. The main purpose of this document is to describe the aforementioned platform and tools, and to provide the location (URL) of the tool and the (documented) software code.

## **1.5. Structure of the document**

This document contains five sections: Introduction (this section), Methodology, EO4GEO BoK software platform, EO4GEO Ecosystem of BoK tools, Discussion and Conclusions. The methodology section discusses the process followed for the development of EO4GEO BoK Platform and associated tools. The EO4GEO BoK software platform section provides an overview of the BoK platform, its components and benefits. The EO4GEO Ecosystem of BoK tools section provides an overview of the EO4GEO BoK tools, both end user tools and auxiliary tools. Finally, a discussion and conclusion section follows.

## **2. Methodology**

The develop the EO4GEO BoK platform and innovative toolset, an elaborated requirement engineering phase was performed, followed by development based on the agile software development methodology. For the first, an initial high level functional and non-functional requirement and use case specification was defined in T3.1 and reported in D3.1. Based on this specification, a further requirement elaboration was performed, and requirement were ordered based on priority. Then, based on these detailed requirements, a non-functional software mockup was created, which was shared with project partners and interested (external) parties, and served as a basis for further discussion. Finally, based on this early feedback, the final requirements specification was defined, which served as the basis for the overall architecture and design.



Software development was performed incrementally, in short iterations (“sprints”), whereby selected high priority requirements were implemented into a working prototype and internally (technically) tested. At regular intervals, intermediate versions were shared with project partners and feedback was gathered, which formed input for next iterations, until stable functionally complete versions were released. All software was documented throughout development. For every tool, a readme file (Readme.md) is provided, which contains a general explanation of the tool, the authors, licence and technical specifications, such as software prerequisites, installation and usage instructions. Furthermore, in the source code, non-straightforward methods are commented, explaining their functionality and essential details. In parallel, usability and functional testing was performed under T3.4, to be reported in D3.5.

### **3. The EO4GEO BoK software platform**

Due to the fact that a BoK editing platform (Living TextBook, an existing artefact from partner ITC – see Section 4.1.2) and a BoK visualization tool (adopted from GIN2K and optimized for EO4GEO by partner UJI, see Section 4.1.1) were available in the project, the project decided to abandon the BoKWIKI platform (<https://gin2k.bigknowledge.net/bokwiki/>), previously used in the GIN2K project. The switch to an own solution entailed a double strategy: 1/ to adopt the Living TextBook for BoK editing and maintenance, 2/ to create the EO4GEO BoK software platform, to store and serve the BoK.

The EO4GEO BoK software platform (<http://www.eo4geo.eu/tools/eo4geo-bok-platform/>) forms the bridge between the knowledge contained in the BoK on one hand, and software applications exploiting it on the other. In essence, the platform stores, serves and is the main entry point for the official release of the BoK. It provides a universal representation of BoK concepts and relations, programmatic access and a set of useful software components ready to be used in software applications based on the BoK.

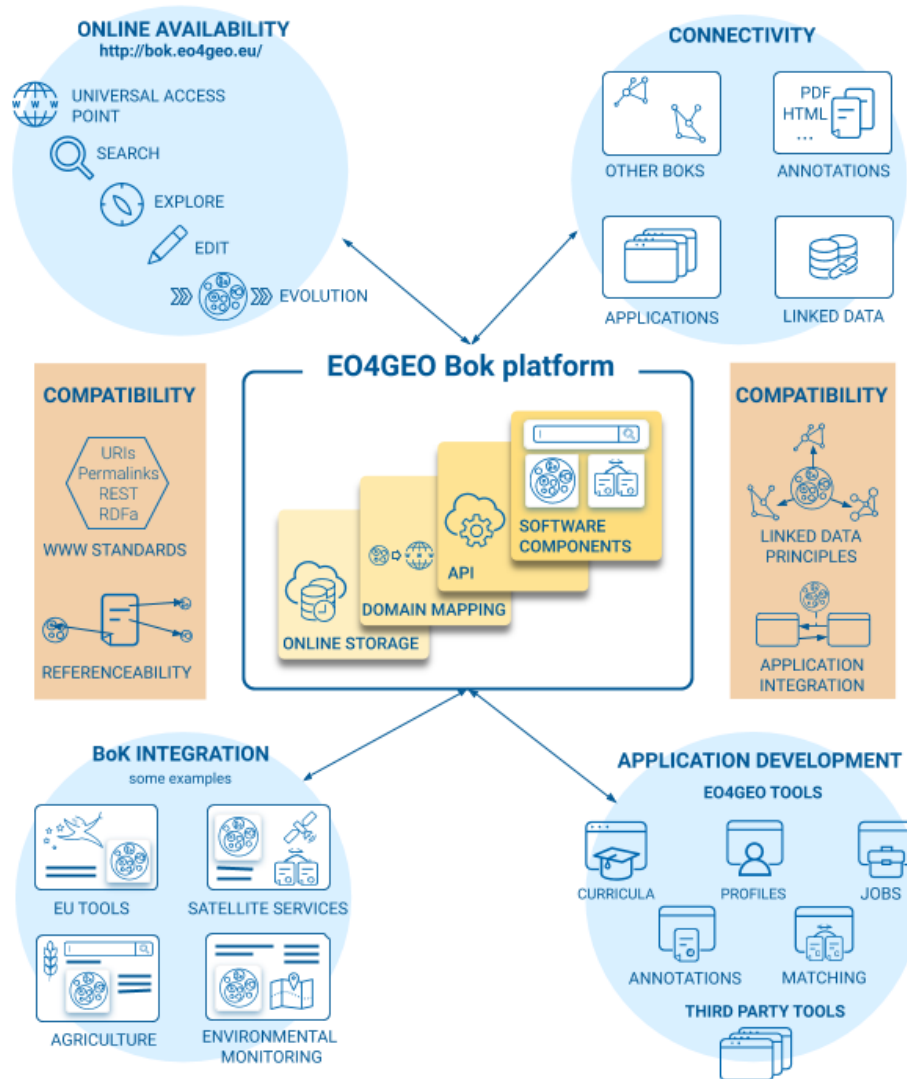


Figure 1 Overview of the EO4GEO BoK software platform

Figure 1 schematically represents the EO4GEO BoK software platform. At the heart of the platform, the Body of Knowledge resides in an online non-relational cloud database. It stores the current (last) version of the BoK, along with all historical versions to ensure backwards compatibility. On top of the database, the domain mapping maps each BoK concept to a Universal Resource Identifier (URI). These URIs – we use permalinks – provide a universal and unique way to identify and refer to BoK concepts and a way to retrieve their description, relationships, skills and other attributes. Next, the Application Programming Interface (API) – implemented as RESTful



services and returning JSON data – provides programmatic access to the concepts (and their URI), relationships and associated attributes. They allow applications to query the Body of Knowledge, and exploit the knowledge contained in it. Finally, the platform offers default software components, ready to be used and integrated in new or existing web-based applications, to provide common BoK functionalities. The platform currently offers a visualization, search and matching component.

The EO4GEO BoK software platform was built with **compatibility and interoperability** in mind. To achieve this, it is based on World Wide Web standards for seamless use and integration with a wide range of existing paradigms and software systems. In the spirit of Linked Data, (http) permalinks are used as URIs for concepts, guaranteeing unique concept identification (referenceability) and retrievability of their description (dereferenceability). Exploiting these permalinks, RDF and RDFa can be used to annotate resources (e.g., pdf files, html files) with BoK concepts. For programmatic access, the API is based on RESTful Web services, ensuring live access from virtually any software application. Finally, the BoK may serve as a common shared vocabulary to enable interaction between and integration of applications.

As mentioned, through the EO4GEO BoK software platform, various applications become possible, which we categorize in four areas. First, the platform provides online availability through a universal access point (<http://bok.eo4geo.eu/>). It serves as the official entry point for the EO4GEO BoK, provides permalinks, and allows users to visualize, navigate, browse and search the BoK using an easy-to-use and compact visualization tool, and explore how the BoK evolved over time through the versioning system. The Living Textbook (see Section 4.1.2), the BoK editing tool, provides another view on the BoK, and allows to export it – after an editing and validation process (see D2.3) – to the BoK software platform. Secondly, through its open online availability and the deployed Web standards, the BoK software platform offers real-time connectivity for a variety of purposes. Through its permalinks, the BoK can be referred to and linked with other BoKs, used for annotating existing resources, or connected to other datasets in the linked data spirit. Through its API, applications dispose of a live connection to the BoK, ensuring to always access and use the latest version of the BoK. Thirdly and fourthly, the API and the default software components allow application development on top of the BoK and integration of BoK-related functionality in existing applications. Within the EO4GEO project, an ecosystem of collaborating tools was developed, which are described in the next section. All of them access the BoK through the API and use it as a shared vocabulary to ensure interoperability and to produce mutually compatible resources. Furthermore, their development is eased by using the default open source software components offered by the EO4GEO BoK platform. The EO4GEO BoK platform is open for use by third party



developers, either to develop novel applications and tools based on the BoK, or to integrate BoK functionality in their existing applications. Documentation the EO4GEO API and links to the default software components to integrate standard BoK functionality in third party applications can be found at <http://www.eo4geo.eu/tools/bok-platform/>.

#### 4. Ecosystem of EO4GEO BoK tools

The EO4GEO ecosystem of tools (Table 1) is a set of collaborative tools which can be used independently or combined, depending on the user' profile and needs. As presented in Figure 2, the tools are all based on the EO4GEO Body of Knowledge and connected to it through the EO4GEO BoK software platform's open RESTful API. We can divide the tools in two sets: BoK Platform tools and BoK end user tools. On the one hand, BoK platform tools are the tools that allow to maintain, visualize and search the BoK. On the other hand, BoK end user' tools aim logically at the main stakeholders that use the BoK, i.e., stakeholders from the educational, public and commercial sector, interested or working in the EO/GI fields.

Table 1 shows the names for all tools, the link to their source code, the Zenodo DOI to unique identify and refer to them, and the link to the online available tool.

*Table 1 – Overview of relevant information of the EO4GEO BoK tools*

No.	Tool Name	Source Code (Github)	DOI link (Zenodo)	Official project link to the tool
1	BoK Search and Visualization (BVS)	<a href="https://github.com/GeoTeclNIT/EO4GEO-BVS">https://github.com/GeoTeclNIT/EO4GEO-BVS</a>	<a href="https://doi.org/10.5281/zenodo.4088135">https://doi.org/10.5281/zenodo.4088135</a>	<a href="https://bok.eo4geo.eu/">https://bok.eo4geo.eu/</a>
2	Occupational Profile Tool (OPT)	<a href="https://github.com/GeoTeclNIT/EO4GEO-OPT">https://github.com/GeoTeclNIT/EO4GEO-OPT</a>	<a href="https://doi.org/10.5281/zenodo.4085217">https://doi.org/10.5281/zenodo.4085217</a>	<a href="http://www.eo4geo.eu/tools/occupational-profile-tool/">http://www.eo4geo.eu/tools/occupational-profile-tool/</a>
3	Job Offer Tool (JOT)	<a href="https://github.com/GeoTeclNIT/EO4GEO-JOT">https://github.com/GeoTeclNIT/EO4GEO-JOT</a>	<a href="https://doi.org/10.5281/zenodo.4088103">https://doi.org/10.5281/zenodo.4088103</a>	<a href="http://www.eo4geo.eu/tools/job-offer-tool/">http://www.eo4geo.eu/tools/job-offer-tool/</a>
4	Curriculum Design Tool (CDT)	<a href="https://github.com/GeoTeclNIT/EO4GEO-CDT">https://github.com/GeoTeclNIT/EO4GEO-CDT</a>	<a href="https://doi.org/10.5281/zenodo.4085224">https://doi.org/10.5281/zenodo.4085224</a>	<a href="http://www.eo4geo.eu/tools/curriculum-design-tool/">http://www.eo4geo.eu/tools/curriculum-design-tool/</a>
5	BoK Matching Tool (BMT)	<a href="https://github.com/GeoTeclNIT/EO4GEO-BMT">https://github.com/GeoTeclNIT/EO4GEO-BMT</a>	<a href="https://doi.org/10.5281/zenodo.4088159">https://doi.org/10.5281/zenodo.4088159</a>	<a href="http://www.eo4geo.eu/tools/bok-matching-tool/">http://www.eo4geo.eu/tools/bok-matching-tool/</a>
6	BoK Annotation Tool (BAT)	<a href="https://github.com/GeoTeclNIT/EO4GEO-BAT">https://github.com/GeoTeclNIT/EO4GEO-BAT</a>	<a href="https://doi.org/10.5281/zenodo.4088153">https://doi.org/10.5281/zenodo.4088153</a>	<a href="http://www.eo4geo.eu/tools/bok-annotation-tool/">http://www.eo4geo.eu/tools/bok-annotation-tool/</a>





	Living TextBook (LTB) (adopted but not developed in EO4GEO)	Currently not available – to be open sourced	-	<a href="http://www.eo4geo.eu/tools/living-textbook/">http://www.eo4geo.eu/tools/living-textbook/</a>
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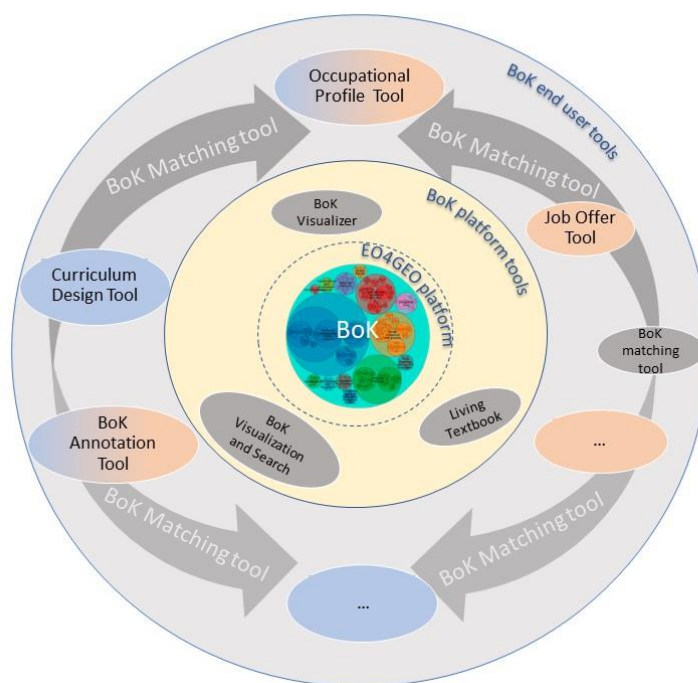


Figure 2. Ecosystem of EO4GEO BoK tools

## 4.1. EO4GEO BoK platform tools

This section gives an overview of the tools that aim to maintain, visualize and search the BoK content, the BoK platform tools, which are in the core of the schema in Figure 2.

The EO4GEO Platform tools, except the Living TextBook, are licensed under MIT License (<https://choosealicense.com/licenses/mit/>)

### 4.1.1. BoK Visualization and Search tool

The **BoK Visualization and Search tool (BVS)** allows to search, navigate and visualize the BoK, using an easy to use and compact graphical and a textual user interface, organized in a hierarchical way according to the BoK's sub/super concept structure. Starting from higher level



concepts, representing areas of knowledge in the field, one can browse down to more detailed concepts. Each concept has a permanent URL to refer to it, a description, relationships (sub/super, similar as, prerequisite of) to other concepts, associated skills, along with some other attributes (contributors, references). Previous versions of each concept can also be browsed, and an advanced search is available to search in concepts and their fields. The BoK Visualization and Search is public, no registration is required.

### BoK Visualization and Search

Copy to Clipboard :

Check the attributes to match with term searched:

Code

Name

Description

Skills / Learning outcomes

Permalink: <https://bok.eo4geo.eu/GIST>

**[GIST] Geographic Information Science and Technology**  
Description:  
Geographic Information Science and Technology  
Subconcepts [14]

- [\[AM\] Analytical Methods](#)
- [\[CF\] Conceptual Foundations](#)
- [\[CV\] Cartography and Visualization](#)
- [\[DA\] Design and Setup of Geographic Information Systems](#)
- [\[DM\] Data Modeling, Storage and Exploitation](#)
- [\[GC\] Geocomputation](#)
- [\[GD\] Geospatial Data](#)
- [\[GS\] GI and Society](#)
- [\[IP\] Image processing and analysis](#)
- [\[OI\] Organizational and Institutional Aspects](#)
- [\[PP\] Physical principles](#)
- [\[PS\] Platforms, sensors and digital imagery](#)
- [\[TA\] Thematic and application domains](#)
- [\[WB\] Web-based GI](#)

**Demonstrable skills [2]**

- Classify the main knowledge domains of GI Science and Earth observation.
- Discuss the synergy between processes in geo-information systems and earth observation systems.

**Contributors [1]**

- [EO4GEO project](#)

**Versioning**

- You are viewing: **version 4.0 (2020/10/21) (Current Bok Version)**
- version 3.0 (2020)
- version 2.0 (2019)
- version 1.0 (2016)

Figure 3 Main view of the BoK Visualization and Search Tool

As mentioned, the BoK software platform provides referenceability and dereferenceability for each BoK concept via its permalink. The BVS dereferences and visualizes a permalink, directly showing the represented concept's content. Furthermore, its versioning system ensures that obsolete concept permalinks are dereferenceable and viewable, an important feature to ensure correct functioning of software applications developed using the BoK software platform and exploiting the BoK.





The software component to visualize and search the BoK, offered by the BoK software platform, is also used in the end user tools, so users are easily familiarized with BoK searching and navigating when using the BoK end user tools.

Copy to Clipboard :

Permalink: <https://bok.eo4geo.eu/AM>

### [AM] Analytical Methods

Status: Completed (GI-N2K)

**Description:**

This knowledge area encompasses a wide variety of operations whose objective is to derive analytical results from geospatial data. Data analysis seeks to understand both first-order (environmental) effects and second-order (interaction) effects. Approaches that are both data-driven (exploration of geospatial data) and model-driven (testing hypotheses and creating models) are included. Data driven techniques derive summary descriptions of data, evoke insights about characteristics of data, contribute to the development of research hypotheses, and lead to the derivation of analytical results. The goal of model driven analysis is to create and test geospatial process models. In general, model-driven analysis is an advanced knowledge area where previous experience with exploratory spatial data analysis would constitute a desired prerequisite. Visual tools for data analysis are covered in Knowledge Area: Cartography and Visualization (CV) and many of the fundamental principles required to ground data analysis techniques are introduced in Knowledge Area: Conceptual Foundations (CF). Image processing techniques are considered in Knowledge Area: Geospatial Data (GD). All of the methods described in this knowledge area are more or less sensitive to data error and uncertainty as covered in Unit GC8 Uncertainty and Unit GD6 Data quality. Mastery of the educational objectives outlined in this knowledge area requires knowledge and skills in mathematics, statistics, and computer programming.




Figure 4 Analytical Methods BoK concept accessed via its permalink

The BVS was available without domain mapping shortly after the beginning of the project, and was first released, together with the domain mapping, on 9th March 2020. Changes done in the several versions can be checked in the release notes in the BVS footer at <http://bok.eo4geo.eu/release-notes>.

#### 4.1.2. The Living TextBook

The **Living Textbook (LTB)** is a web-based tool that was developed (prior to the EO4GEO project) by the University of Twente for modelling and visualizing domain knowledge. In the EO4GEO project, LTB was mainly deployed as collaborative BoK editor for BoK experts to develop and update the BoK, requiring a login to participate. Recently, with the release of version 4.0 of the BoK (28<sup>th</sup> of October 2020), LTB was opened to also allow viewing (in non-editing mode) by the general public, and create learning paths based on the BoK. Its interface combines a concept map with a text-based window containing the description of each concept, including its definition, required skills, external resources, contributors, all of which are editable and can be commented on



– see Figure 5. For the EO4GEO project, some fields have been updated to reflect the BoK, rather than LTB’s original educational setting. Furthermore, relationships between concepts can be defined. At this stage of the BoK development the following relationship types are in place: sub-concept (denotes a parent-child relationship), prerequisite (knowledge of one concept is needed to understand the other), similar as (one concept is similar to another). During the editing process, expert can furthermore use the “proposed relationship” to indicate a potential relationship between concepts, subject for further discussion.

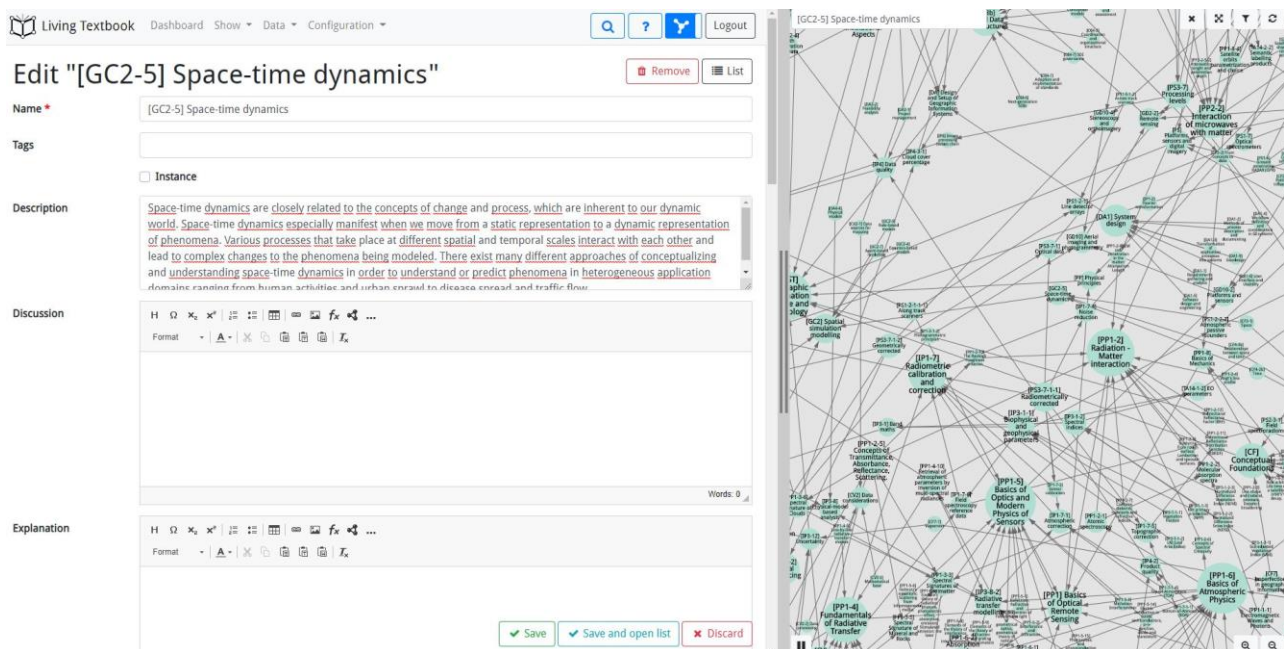


Figure 5 Living TextBook: editing a BoK concept

The LTB is connected to the EO4GEO BoK software platform via its export function. Whenever, according to the WP2 methodology, an update and new version of the BoK is available, the LTB export (JSON format) can be uploaded to the EO4GEO platform using its upload script, which was adapted to understand LTP export. It parses it and saves it in the required format in the BoK platform database, as a new version of the BoK, making it (de)referenceable and be exposed via the API, whereby it is immediately propagated to all (internal and external) tools.

The LTB was developed prior to the EO4GEO project by the Faculty ITC from the University of Twente, and is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives (CC BY-NC-ND) 4.0 license (<https://creativecommons.org/licenses/by-nc-nd/4.0/legalcode>).



## 4.2. **BoK end user tools**

This section gives an overview of the BoK end user tools, which are aimed at main stakeholders: namely academia, the public sector and industry. All of them are built based on the EO4GEO BoK software platform, using its public API to query and exploit the BoK contents, and its default software components to provide common BoK functionality (visualize, navigate, search). All end user tools use single sign-on, a user can login in all the BoK end-user tools using his/her google account or a dedicated EO4GEO account. Once logged in, the user can create or join his/her organization and has access to more advanced functionality.

All BoK end user tools are licensed under GNU General Public License v3.0 (<https://choosealicense.com/licenses/gpl-3.0/>)

### 4.2.1. **Occupational Profile Tool**

The **Occupational Profile Tool (OPT)** allows experts and companies to create and save occupational profiles, which can be characterized as generic, recurring prototypical job descriptions, including the required knowledge and skills to be able to perform them. Profiles use and are linked to the EO4GEO Body of Knowledge (BoK) to univocally describe EO/GI-specific knowledge (i.e., BoK concepts) and (domain specific) skills, available in OPT using the convenient BoK visualization and search components. Occupational profiles furthermore specify transversal skills, for which OPT re-uses the European Skills/Competences and Occupation (ESCO) classification for transversal and cross-sectoral skills, the application domain, for which OPT reuses the UNESCO's International Standard Classification of Education: Fields of Education and Training (ISCED-F), and the level of expertise, for which the European Qualifications Framework (EQF) by the European Centre for the Development of Vocational Training (Cedefop) is used. Custom skills can always be defined.

Occupational Profiles can be set as public - no need to log in to see them - or private – only users from the same organization are able to see or edit them. All listed profiles can be shared as annotated PDF or by link, duplicated to reuse them to create a new occupational profile, edited or deleted.

Non-registered users are able to see the list of (public) occupational profiles (the main view of the OPT), search in it, view a profile (see Figure 6) and share it. Registered users can additionally create, edit and delete their own profiles, and duplicate a profile for further editing.

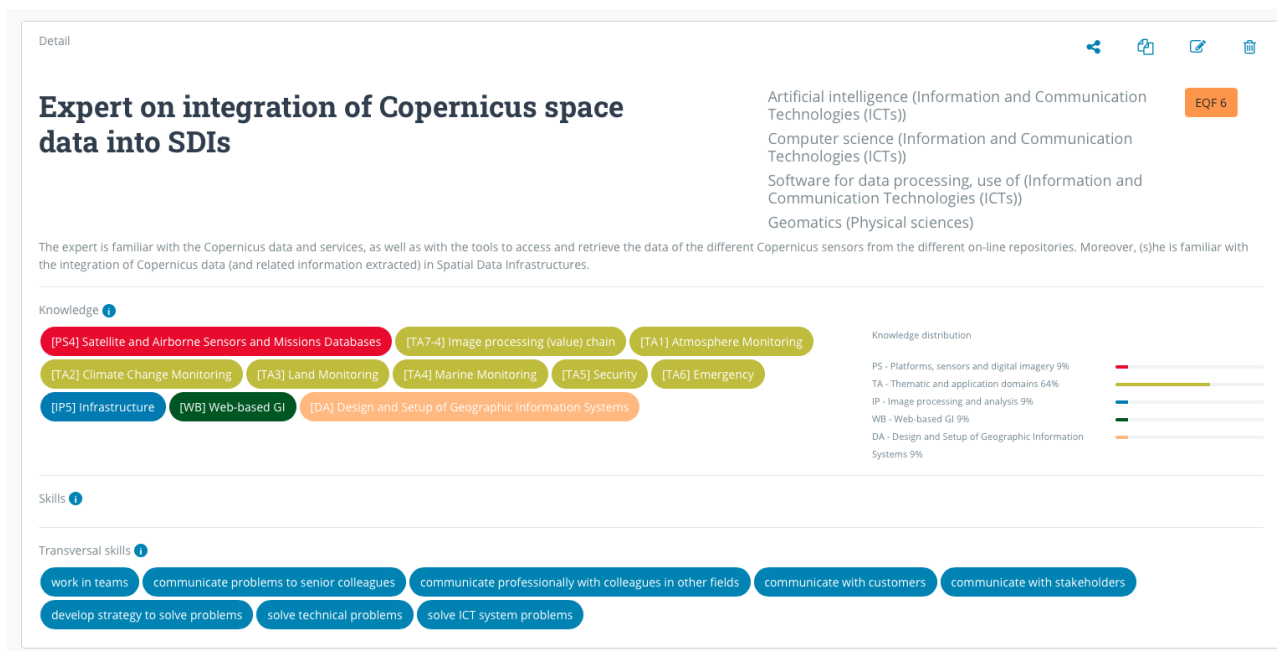


Figure 6 Detail view of an Occupational Profile

The OPT was first released on 5<sup>th</sup> November 2019 and following releases can be checked at <http://www.eo4geo.eu/tools/opt/#/release-notes>

#### 4.2.2. Job Offer Tool

The **Job Offer Tool (JOT)** allows companies to create and save a job offer starting from an occupational profile(s), customizing it and filling in further (concrete) details, or from scratch. As for the occupational profiles, job offers re-use BoK knowledge (concepts) and skills, the ESCO classifications for transversal skills, ISCED-F classification for the applications field and the Cedefop EQF framework for expertise level.

When adding a new job offer one or more occupational profiles can be selected, their information gets combined to obtain a pre-filled job offer, which can be customized by removing or adding knowledge and skills required, and by specifying the particular details related to the job offer. When starting from scratch, all required knowledge, skills and specific information needs to be filled in.

The details of the job offer are as follows: knowledge about datasets required, knowledge about tools required (see Figure 7), languages, location, dedication (full time, half time), type of contract (fixed, temporal, internship, scholarship), annual salary range, motivation letter (yes/no), contact details, additional questions. The datasets can be selected from a list of the EO Handbook



(<http://database.eohandbook.com/data/dataactivity.aspx>) datasets (Committee on Earth Observation Satellites – CEOS), and the tools can be selected from a list which includes both the INSPIRE reference (<https://inspire-reference.jrc.ec.europa.eu/tools>) and the European Space Agency (ESA) Open Source Resources ([http://www.esa.int/Enabling\\_Support/Space\\_Engineering\\_Technology/Radio\\_Frequency\\_Systems/Open\\_Source\\_Software\\_Resources\\_for\\_Space\\_Downstream\\_Applications](http://www.esa.int/Enabling_Support/Space_Engineering_Technology/Radio_Frequency_Systems/Open_Source_Software_Resources_for_Space_Downstream_Applications)). Both values can be also custom in case the desired tool or dataset cannot be found in that list. Note the job offer tool provides support for creating a well-specified job offer in the EO&GI field; it does not support the selection process.

Similar as for the OPT, non-registered users are able to see the list of (public) job offers (the main view of the JOT), search in it, view job offers and share them. Registered users can additionally create, edit and delete their own job offers, and duplicate a job offer for further editing.

The screenshot shows a web interface for creating a job offer. It features a section titled "Specific Information" with a help icon. Below this, there are two main sections: "Knowledge about datasets required" and "Knowledge about tools required", both with help icons. The "Knowledge about datasets required" section has a dropdown menu and three blue buttons with 'x' icons: "Sentinel-2 A", "Sentinel-3 A", and "Meteosat-11". The "Knowledge about tools required" section has a scrollable list with two items: "European Data Portal - Map Viewer" and "European Space Software Repository" (which is highlighted). To the right of this list are three blue buttons with 'x' icons: "ArcGIS Desktop", "Docker Engine", and "European Space Software Repository".

Figure 7 Tools and datasets included in a job offer

The JOT was first released on 26<sup>th</sup> November 2019 and following releases can be checked at <http://www.eo4geo.eu/tools/jot/#/release-notes>

### 4.2.3. Curriculum Design Tool

For the **Curriculum Design Tool (CDT)**, an existing tool originating from the GIN2K project, was redesigned – both architecturally and regarding its look and feel - and extended according to the requirements gathered in EO4GEO.





The CDT allows users to create, edit, save and search in educational offers in the EO/GI field. Therefore, it is mainly addressed to education and training providers. In the main view of the CDT, non-registered users can view all educational offers, which can be filtered according to several criteria and shared. Registered users furthermore have the option to create or duplicate an educational offer, or delete their own offer.

An educational offer can be created at four levels: study program (e.g., for a complete academic degree), module (i.e., a particular grouping of courses, for example by topic or semester), course or lecture. This flexibility to specify and detail an educational offer at different levels of granularity is one of the most demanded requirements, and covers most of the educational offers available in the sector of EO/GI including Vocational Education and Training. When in creation/editing mode, the user is presented with a graphical hierarchical overview of the educational offer on the left, and a textual, editable view of a particular node on the right – see Figure 8. For every node, various common fields are available and some specific depending on the level of granularity of the node (i.e., study program, module, course, lecture). The common fields are: title, description, learning outcomes, transversal skills, knowledge. Examples of specific fields are: prerequisites, bibliography, amount of semesters or nr. of semester, type of lecture (e.g., practical, theory), type of course (e.g., common, specialization, elective), ECTS credits. The BoK is exploited in two ways. Firstly, to specify knowledge or to re-use content of BoK concepts (e.g., use the description of a BoK concept to specify the description of a course, re-use a bibliography from a BoK concept), both by selecting the desired BoK concepts using the BoK visualization component. Secondly, to specify learning outcomes by re-using skills associated the concepts in the BoK.

The CDT furthermore allows several ways of re-use: by duplicating an existing offer (and adapting it to the user's needs) or by importing an existing offer into an offer under design. For instance, a user can import different existing lessons to assemble a new course, be it an introductory or advanced course. And vice versa, the user can also ungroup a full study program to obtain a set of "building blocks", which in turn can be recycled in different study programs.

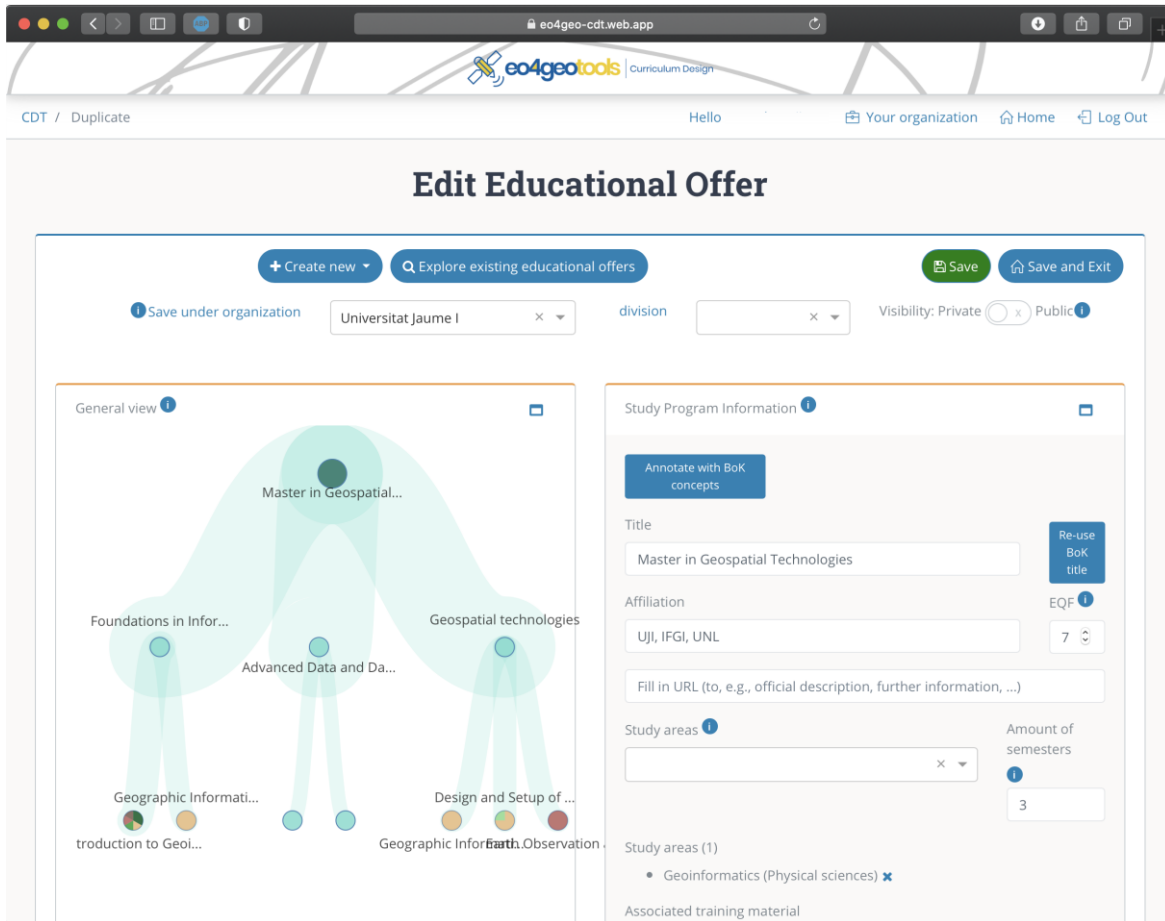


Figure 8 CDT editing view

The CDT prototype was shared on November 2019 and was first released on 3<sup>rd</sup> August 2020. Changes done in the several versions can be checked in the release notes in the CDT footer at <http://www.eo4geo.eu/tools/cdt/#/release-notes>

### 4.3. Auxiliary BoK tools

This section gives an overview of the auxiliary BoK tools, useful for all stakeholders. As the end user tools, all of them are built based on the EO4GEO BoK software platform, using its public API to query and exploit the BoK contents, and its default software components to provide common BoK functionality (visualize, navigate, search). All auxiliary tools use single sign-on, a user can login in all the BoK end-user tools using his/her google account or a dedicated EO4GEO account.

All auxiliary BoK tools are licensed under GNU General Public License v3.0 (<https://choosealicense.com/licenses/gpl-3.0/>), and the default software components can be reused



under the MIT licence (<https://choosealicense.com/licenses/mit/>) and are available to be reused at the eo4geo organization in npm platform (<https://www.npmjs.com/org/eo4geo>).

### 4.3.1. **BoK Annotation Tool**

The **BoK Annotation Tool (BAT)** is an auxiliary tool which allows to annotate (link) external resources (PDF files) with BoK concepts, using the same BoK visualization component as the other tools – see Figure 9. Behind the scenes, the BAT uses the Resource Description Framework (RDF) and the BoK permalinks to semantically describe the annotations. Once annotated, the pdf file can be downloaded, or saved in the BAT if the user is logged in.

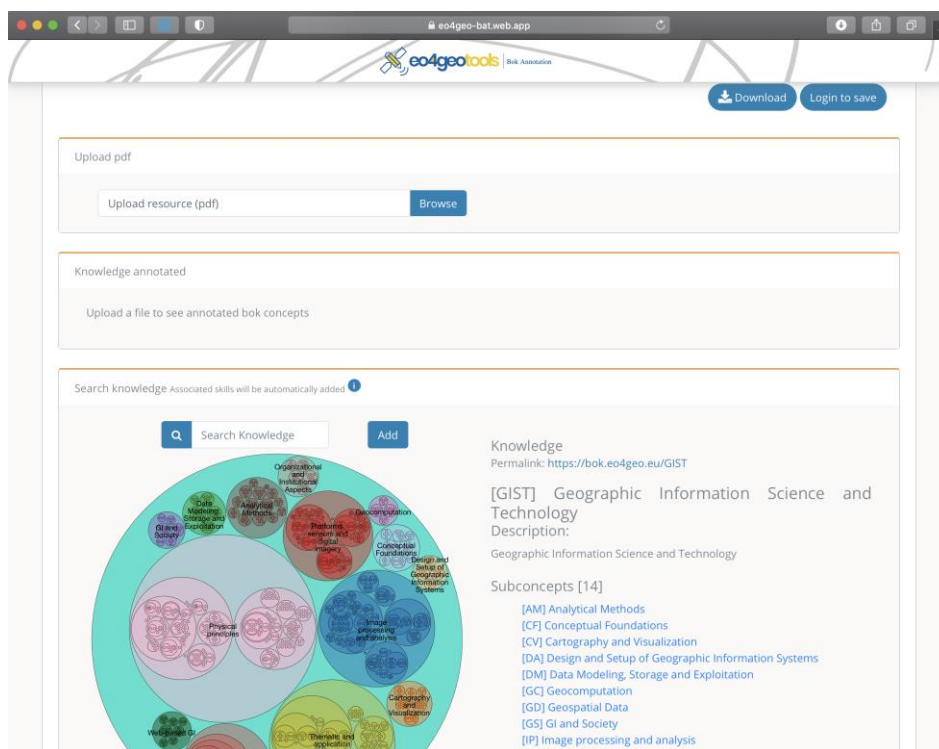


Figure 9 Main view of the BoK Annotation Tool

With the BoK Annotation Tool, we bridge the gap between resources created by the EO4GEO BoK tools and other (external) resources. Now, any resources (pdf file) can be easily annotated and subsequently used/compared with other BoK annotated resources. For example, the BoK Annotation Tool may be useful to annotate already existing training material, a syllabus, a CV (e.g., Europass), a company profile, a conference program, scientific articles, etc.

The BAT was first released on 2<sup>nd</sup> September 2020 and following releases can be checked at <http://www.eo4geo.eu/tools/bat/#/release-notes>





### 4.3.2. BoK Matching Tool

Finally, the **BoK Matching Tool (BMT)** allows to compare two BoK-annotated resources. These are in the first place all resources created with EO4GEO BoK tools (i.e., occupational profiles, job offers, educational offers), which are by default annotated and supported. Secondly, training material, in the form of HTML files (i.e., reveal.js was used) with embedded RDFa annotations, created under WP4 and annotated using the BoK annotation guidelines. Thirdly, any BoK-annotated PDF file annotated with BoK concepts either manually done following EO4GEO BoK annotations guidelines or automatically done with the BoK Annotation Tool (see Section 4.3.1). Lastly, any custom selection of BoK concepts can also be selected for comparison. The matching is made comparing knowledge and skills from the BoK, but also some other fields like EQF level or transversal skills.

The main view of the BMT provides two columns, in which BoK resources (occupational profiles, job offers, educational offers, training material, annotated pdf files, custom selection of BoK concepts) can be selected. Convenient search and filters are provided to easily find the desired resource. Once to BoK resources have been selected, the results of the comparison appear, showing matches and differences, and some basic statistics (e.g., distribution of matching knowledge according to knowledge area) – see Figure

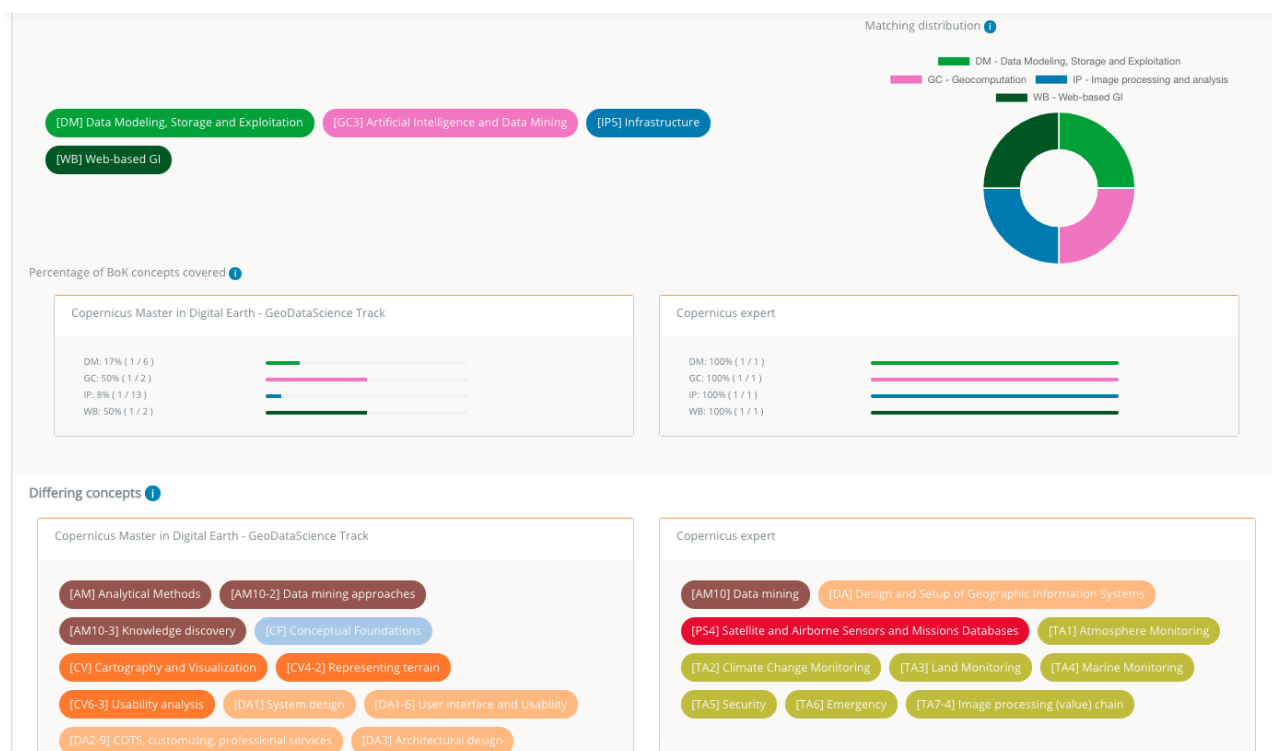


Figure 10 Comparison of two BoK annotated resources



The BMT has a wide range of applications. For instance, a company that created a traineeship offer in the Job Offer Tool can screen educational offers (and institutions behind them) for matching skills and knowledge, in order to find a suitable study program to offer the traineeship. Or, a company that created a job offer can compare curriculum vitae of candidates, annotated with the BAT, to find a match, and understand the strengths and weaknesses of the candidates. In the educational sector, a study program design committee of a university can compare their existing study program with occupational profiles, to discover gaps in their study program, and re-design their program to bridge the gap between offer and demand. A job seeker may compare his annotated CV with educational offers to find a suitable offer to expand his knowledge and skills. In a more academic setting, the BoK Matching Tool can be used to match a paper with an EO/GI conference call for papers, to determine suitability for the conference. These are just some of the potential uses, we are just starting to explore the full potential of the tool.

The BMT was first released on 21<sup>st</sup> July 2020 and following releases can be checked at <http://www.eo4geo.eu/tools/bmt/#/release-notes>

#### **4.4. Tools' usage**

To gather information about the usage of the tools, Google Analytics was configured in the BoK End user tools, BoK auxiliary tools and in the BoK Visualization and Search. These numbers provide a good indicator for the tool's usage, for internal testing and internal use before the public release, by selected associate partners and interested parties during pre-release (October 2020), and by the general public after the public release (end of October 2020).

Figure 11 shows how many unique users visited the [bok.eo4geo.eu](http://bok.eo4geo.eu) per day through the BoK Visualization and Search tool since July 2020. To be noted, the 29<sup>th</sup> October peak is due the publication of the newsletter that announced the public release of the BoK and BoK tools.

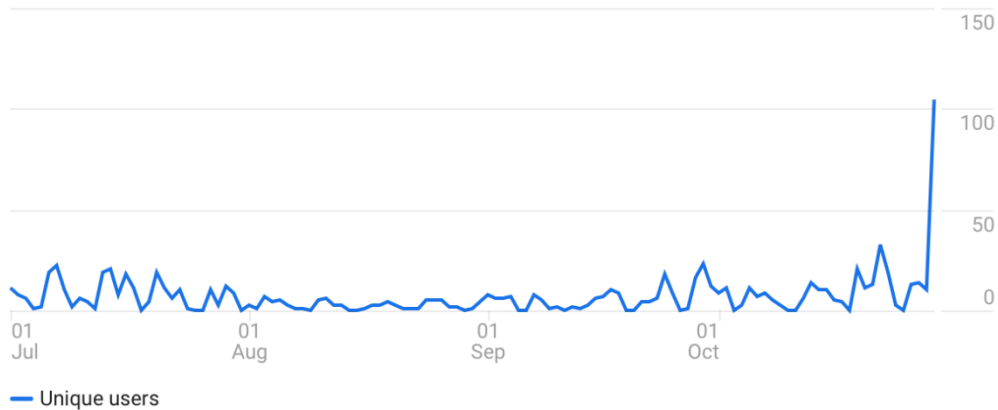


Figure 11 Unique user visits to bok.eo4geo.eu per day

Figure 12 shows the top countries with most unique users since 1<sup>st</sup> July 2020, when we started gathering this type of the data. Note that the high amount of unique users from Spain is due to the fact that the tools were developed by the Spanish partner UJI (i.e., development and testing generated additional hits).

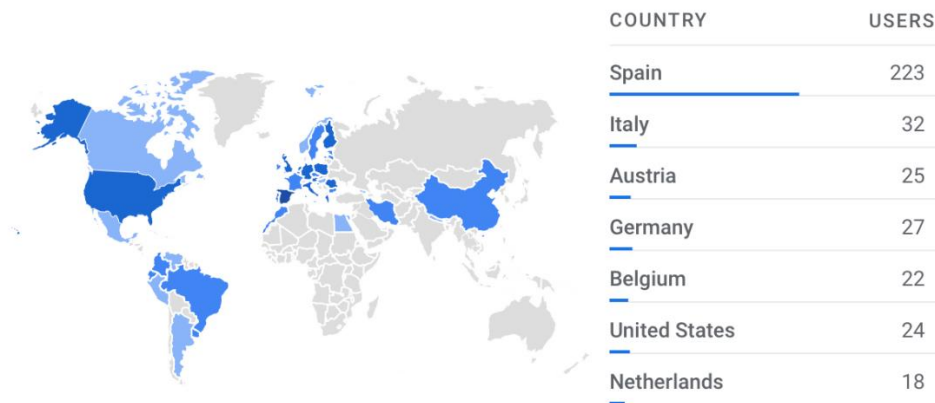


Figure 12 Top countries with most unique users

Figure 13 shows the unique users by day for all BoK end user tools. The BoK end user tools unique users increase as the tools were released (internally) over the time period of 1<sup>st</sup> November 2019 to 29<sup>th</sup> October 2020, and tested and used within the project.

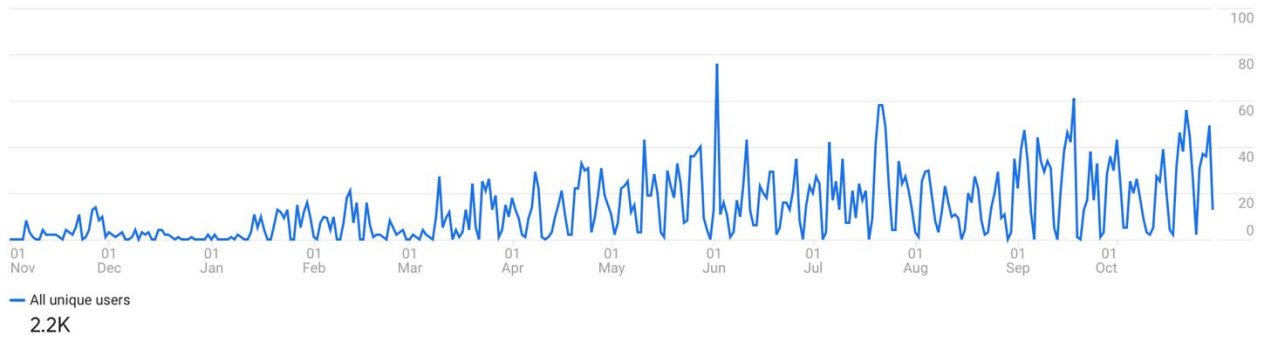


Figure 13 Unique users by day on BoK end user tools

Finally, Figure 14 shows the usage, in terms of unique users per week, for the different end user and auxiliary tools: Curriculum Design Tool, Job Offer Tool, Occupational Profile Tool, BoK Annotation Tool, BoK Matching Tool. We note a higher amount of use of the Curriculum Design Tool, which was extensively used in WP4 (see Section **Errore. L'origine riferimento non è stata trovata.**).

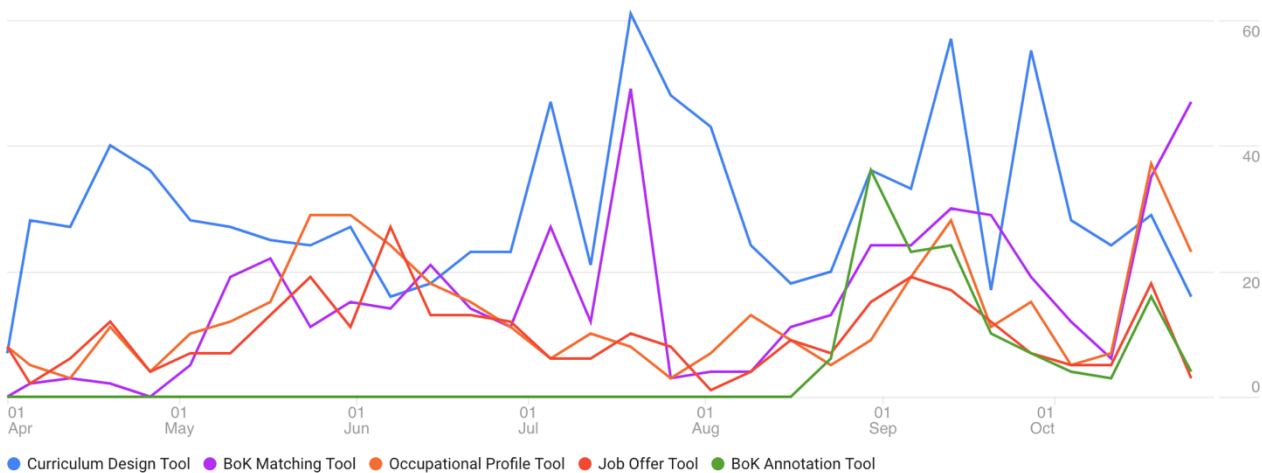


Figure 24 Unique users, per week and by tool

As the Living TextBook is used within the University of Twente as a learning tool, no separate usage statistics for the EO4GEO project could be extracted.



## 5. Conclusions

Task 3.3, covered in this deliverable, set out to design and implement new, innovative tools for the EO/GI domain. According to the slight reorganization of T3.2 and T3.3 (discussed in Section 1.3), the latter task specifically focused on tools for and based on the Body of Knowledge; EO tools and learning platform were covered under T3.2 and reported in D3.3. Accordingly, this deliverable describes the work done under Task 3.3: the development of the EO4GEO BoK software platform and ecosystem of BoK tools. The software platform stores and exposes the BoK for external use, through permalinks and an API, and eases future development by offering default BoK functionality components. In summary, the following tools were developed:

- The Bok Search and Visualization (BVS) tool, to visualize, navigate and search the BoK.
- The Curriculum Design Tool (CDT), to create, edit and find EO & GI educational offers
- The Occupational Profile Tool (OPT), to create, edit and find occupational profiles in the EO & GI fields
- The Job Offer Tool (JOT), to create, edit and find job offers based on eo4geo Occupational Profiles
- The BoK Annotation Tool (BAT), to annotate external resources with the BoK
- The BoK Matching Tool (BMT), to compare any BoK annotated resource with respect to knowledge and skills.

In addition, the Living TextBook was adopted to edit and view the BoK.

In our opinion, the results of T3.3 exceed the expectations.

First of all, a BoK software platform was developed, which stores and serves the BoK, provides an API and default software components. The platform provides domain mapping ([bok.eo4geo.eu](http://bok.eo4geo.eu)) for the BoK, hereby offering permalinks as URIs for the BoK and its concepts. This allows BoK concepts to be referred to be external applications, semantic descriptions to use and link to them, and resource to be annotated with them. The API allows external applications to query and use the BoK, and default components are ready to use BoK functionalities for third party application developers. The BoK software platform is completely open, built using well-known standards, and there allows external application developers to build their own applications on top of the BoK. Such



a software platform was originally not foreseen, as it replaces – together with the Living TextBook editing tool, the BoKWIKI platform, which was originally foreseen to be used as a paid service.

Secondly, the ecosystem of collaborate BoK tools provides 7 tools, of which 6 developed within EO4GEO: the Occupational Profile Tool, the Job Offer Tool and the Curriculum Design Tool (all three suggested in the DoW), and the BoK Visualization and Search tool, the BoK Annotation Tool and the BoK Matching Tool (all three not foreseen in the DoW). Particularly the BoK Matching Tool, which allows to match and compare two BoK resource, has an enormous range of applications. However, the real power of the tools is the fact that they can be used independently, but they are also interoperable and collaborative, which is made possible by using the BoK as a shared, common vocabulary. Through the BoK software platform, new tools can be added to the ecosystem beyond the project's lifetime. We note that a specific learning path tool, suggested in the DoW, was not implemented. However, with the combination of the Living TextBook offering learning paths, and the BoK Matching Tool allowing to match a custom selection of BoK concepts with educational offers, the desired functionality of mapping learning goals to educational offers is met.

Thirdly, the ecosystem of tools has been extensively used within the EO4GEO project. The BoK Visualization and Search tool and the Living TextBook were used in most work packages, to browse and search the BoK; the latter also to edit the BoK (T2.3). In WP4, the Occupational Profile Tool was used to define occupational profiles (T4.1), the Curriculum Design Tool to design EO and related educational offers (T4.2), the BoK annotations were used to annotate training material (T4.3) allowing them to be compared with the BoK Matching Tool, and the Job Offer Tool is used planned to be used to specify mobility offers (T.4.4). The BoK Matching Tool and Curriculum Design Tool are currently being used in WP5, to define case-based scenarios and training actions (T5.3, T5.4 and T5.5)

Fourthly, all these tools have been conceived, designed and implemented with input from project and external partners, through various means (e.g., questionnaires, brainstorming, workshops, ...). Furthermore, through the agile development methodology deployed, regular feedback was gathered and taken into account in the further implementation. All source code is documented and publicly available. In addition, frequent rigorous technical and usability testing, both internal and external, was performed throughout the development cycle, and user guides were developed (note: testing results and user guides are part of T3.4 and to be reported in D3.5). The results are proof of concept tools, which fulfil a certain need in the EO/GI field, be it for the educational, public or commercial sector.