Co-funded by the Erasmus+ Programme of the European Union

EO4GEO – Towards an innovative strategy for skills development and capacity building in the space geo-information sector supporting Copernicus User Uptake

With the support of the Erasmus+ Programme of the European Union Sector Skills Alliances N° 591991-EPP-1-2017-1-IT-EPPKA2-SSA-B

D 1.5 –Skills shortages, gaps and mismatches between supply and (future) demand

Author(s)/Organisation(s):

- Wesley Gruijthuijsen (KU LEUVEN)
- Maria da Saudade De Brito Pontes (KU LEUVEN)
- Glenn Vancauwenberghe (KU LEUVEN)

Work package / Task:

WP1 – Preparing the Space/Geospatial Sector Skills Strategy

T1.4 – Assessing the skills shortages, gaps and mismatches between supply and (future) demand

Short Description:

Integrated analysis of both the demand for and supply of EO/GI skills in Europe, by bringing results and findings of previous and new analyses together, with the goal to identify skills needs and mismatches in the EO/GI sector.

Keywords:

Space/geospatial education and training; supply; demand; trends; skills; shortages; mismatches; occupational profiles.

Dissemination Level		
PU	Public	X
RE	Restricted to other programme participants (including Commission services and project reviewers)	
CO	Confidential	

With the support of the Erasmus+ Programme of the European Union Sector Skills Alliances N° 591991-EPP-1-2017-1-IT-EPPKA2-SSA-B

Revision History:

Revision	Date	Author(s)	Status	Description
0.1	03/12/2018	Wesley Gruijthuijsen	First draft	Draft section on job advertisement analysis
0.2	04/12/2018	M. Saudade Pontes	Add-ons	Review of section on job advertisement analysis
0.3	07/12/2018	M. Saudade Pontes	Add-ons	Delimitation of general structure, chapters and content
0.4	14/12/2018	M. Saudade Pontes	Add-ons	Draft section on Patras workshop
0.5	21/12/2018	Wesley Gruijthuijsen	Add-ons	Draft section on EO4GEO Demand Study and revised section on job advertisement analysis
0.6	21/12/2018	Glenn Vancauwenberghe	Add-ons	Draft section on EO4GEO Supply Study and on trends and challenges
0.7	31/12/2018	Glenn Vancauwenberghe	First final draft	Review and creation of first complete draft (without concluding sections)
0.8	13/01/2019	Wesley Gruijthuijsen	Second draft	Revision of sections based on review
0.9	20/01/2019	Glenn Vancauwenberghe	Third draft	Final revision, complete draft ready for review by QA
0.10	28/01/2019	Wesley Gruijthuijsen	Final draft	Processing of first set of comments from QA review
0.11	29/01/2018	M. Saudade Pontes	Final draft	Processing of second set of comments from QA review
2.0	30/01/2019	Glenn Vancauwenberghe	Final version	Final revision
2.1	01/06/2019	M. Saudade Pontes Glenn Vancauwenberghe	Final version revised	Inclusion of glossary + list of acronyms Revision of chapter 6
2.2	02/11/2019	M. Saudade Pontes	Adustments	Take out workshop proceedings

Table of Contents

List of tables

List of figures

Acronyms

Acronym	Description
BOK	Body of Knowledge
CEDEFOP	European Centre for the Development of Vocational Training
CERTH	Centre for Research and Technology-Hellas
EACEA	Education, Audiovisual and Culture Executive Agency
EARSC	European Association of Remote Sensing Companies
EARSeL	European Association of Remote Sensing Laboratories
ECTS	European Credit Transfer and Accumulation System
ECVET	European credit system for vocational education and training
EO	Earth observation.
EO/GI	Earth observation and geographic information
EQF	European Qualifications Framework
ESA	European Spatial Agency
ESCO	European Skills, Competences, Qualifications and Occupations
ESERO	European Space Education Resource Office
EUMESTAT	European Organisation for the Exploitation of Meteorological Satellites
GEO	Group on Earth observation.
GI	Geographic Information
GI-N2K	Geographic Information: Need to Know
GIS	Geographic Information System
GIS&T	Geographic Information Science & Technology
GIS&T BOK	Geographic Information Science & Technology Body of Knowledge
HEI	Higher Education Institutions
ICT	Information and Communication Technologies
LMSI	Labour Market and Skills Intelligence
LINKVIT	Leveraging INspire Knowledge into Vocational Innovative Training
MOOC	Massive Open Online Courses
NEREUS	Network of European Regions Using Space Technologies
OECD	Organisation for Economic Co-operation and Development

OGC	Open Geospatial Consortium
RUS	Research and User Support
SMEs	Small and Medium-sized Enterprises
TINs	Triangular Irregular Network.
UAV	Unmanned Aerial Vehicle
VET	Vocational and Educational Training
VGI	Volunteered Geographic Information

Glossary

- **Bloom's Taxonomy** is a classification of thinking or cognitive skills, which is often used in the design of educational, training and learning processes, and especially in the definition of learning outcomes. Bloom's Taxonomy consist of six levels of thinking skills, ranged from lower order thinking skills to higher order thinking skills
- **Body of Knowledge** is the complete set of concepts, terms, activities and relations between them, that make up a professional domain, (in this case EO/GI BOK) as defined by the relevant learned society or a professional association.
- **Cartographers** create maps by combining various scientific information depending of the purpose of the map (e.g. topographic, urban, or political maps). They combine the interpretation of mathematical notes and measurements with the aesthetics and visual depiction of the site for developing the maps.
- **ESCO** is the multilingual classification of European Skills, Competences, Qualifications and Occupations. The ESCO classification identifies and categorizes skills, competences, qualifications and occupations relevant for the EU labour market and education and training, and systematically shows the relationships between the different concepts.
- **European Credit Transfer and Accumulation System** is a credit system designed to make it easier for students to move between different countries.
- **Education, Audiovisual and Culture Executive Agency** manages funding for education, culture, audiovisual, sport, citizenship and volunteering.
- **European Centre for the Development of Vocational Training** is one of the EU's decentralised agencies. Founded in 1975 and based in Greece since 1995, it supports

development of European vocational education and training (VET) policies and contributes to their implementation.

- **European Credit System for Vocational Education and Training** have common instruments helping individuals in transfer, recognition and accumulation of their assessed learning outcomes, to achieve a qualification or to take part in lifelong learning.
- **European Qualifications Framework** is a common European reference framework whose purpose is to make qualifications more readable and understandable across different countries and systems.
- **Geographic Information** is the data of a geographic location spatial data, their combination with non-spatial information (e.g. statistical data) and their representation as a map.
- **Geographic information: Need to Know** 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.
- **Geographic information systems specialist** use specialised computer systems, engineering measures, and geological concepts to process land, geographic, and geospatial information into visually detailed digital maps and geomodels of a reservoir.
- **Geographic Information System** is a computerized tool designed for storing, analysing and consulting data where geographic location is an important characteristic or critical to the analysis.
- **Job advertisement analysis** refers to the systematic analysis of real job advertisements to gain insight in skills needs within and across different sectors and occupations.
- **Remote sensing technician** collect airborne data. They utilise equipment aimed for the collection of data and determination of geographical points in order to help in a variety of operations such as land conservation, urban planning, and military operations.
- **Sector Skills Alliance** are designed to tackle skills, aligning vocational education and training (VET) systems with labour market needs. This is done by: (i) modernising VET by adapting to skills needs and integrating work-based learning, (ii) strengthening the exchange of knowledge and best practices, (iii) improving labour market mobility, (iv) increasing the recognition of qualifications. More info.

- **Skill** means the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive or practical skills.
- **Skills deficit** refers to a job market in equilibrium with supply equaling demand, yet both supply and demand are below what they could be.
- **Skills gap** refers to a situation where the demand for skills exceeds supply internally within a firm or organization. The term is also used to refer to a gap in the current education and training system, that is not able to provide people with the necessary skills.
- **Skills mismatch** is the encompassing term which refers to various types of imbalances between the supply of skills and demand for skills.
- **Skills shortage** refers to the situation when supply is less than demand on the skilled job market.
- **Vocational Education and Training** is a key element of lifelong learning systems equipping people with knowledge, know-how, skills and/or competences required in particular occupations or more broadly on the labour market.

1. Introduction

EO4GEO is an **Erasmus+ Sector Skills Alliance** gathering **26 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 sectors. The project is also supported by a strong group of Associated Partners mostly consisting of associations or networks active in space/geospatial ecosystem. 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 will work in a **multi- and interdisciplinary** way and apply 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 will define 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 will be 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/.

1.1. Objectives of this report

The first part of EO4GEO project focused on the preparation of the Space/Geospatial Sector Skills Strategy for the space/geospatial sector. The strategy will be driven by industrial (private sector / EO services companies) needs. It will be a joined effort of the Alliance (Consortium, Associated Partners and broader space/geospatial and education/training communities) and includes the analysis of previous studies on the supply of and demand for education and training in the sector, surveys and studies on the space and geospatial market (uptake), cost-benefit studies and other

relevant materials. The work will also take into account major trends in the space/geospatial market and related markets (e.g. ICT).

As part of the preparation of the skills strategy, this report provides an integrated analysis of both the demand for and supply of GI and EO vocational (and academic) education and training in Europe, by bringing the results and findings of the supply survey (Identifying the supply of GI and EO education and training at the academic and vocational levels), the demand survey (Identifying the current demand for GI and EO skills and occupational profiles) and the trends (Analyzing trends, challenges and opportunities in the GI and EO sector: setting-up a technology and non-technology watch) together. While this analysis will provide valuable insights on GI and EO education and training in Europe, it will also provide direct input to define the GI and EO sector skills strategy and insights for the development and extension of a BoK for GI and EO.

1.2. Structure of the document

This report consists of eight chapters and is structured as follows: After this introductory chapter, the second chapter discusses the approach, results and findings of the EO4GEO Study on the supply of EO/GI training and education. The third chapter present and discusses the EO4GEO Demand Study, which investigates the demand for skills and competencies in the EO/GI job market. The fourth chapter deals with the EO4GEO analysis of trends, challenges and opportunities in the EO/GI sector, another preparatory activity to the development of the space/geospatial sector skills strategy. The fifth chapter introduces the job advertisement analysis that complemented the different previous studies and analyses, and presents the main results and findings of an analysis of existing job advertisements in the EO/GI sector. A discussion of the different presentations during the EO4GEO workshop on skills assessments and skills strategy, organized in Patras in December 2018, is provided in the sixth chapter of the report in a form of findings and conclusions. The seventh chapter of the report brings together the main results and findings of the various studies and analyses, and aims to derive some general lessons on conclusions on skills needs and the skills mismatch in the EO/GI sector. In the eighth and final chapter, the main conclusions are presented.

2. EO4GEO Study on the supply of EO/GI training and education

In this second chapter, the methodology, results and findings of the study on the current supply of EO/GI training and education are presented and discussed. Main element in this study was the EO4GEO Supply Survey, an online survey on the supply of EO and GI education and training. Aim of this survey was to collect information on the existing and planned education and training offer in the EO/GI sector and on the organizations active in this sector. The survey was complemented with other activities, such as a literature review on existing studies on education, training and skills in or related to the EO/GI sector and a systematic web investigation to detect and describe structured training resources available on-line. This chapter provides a summary of the approach and results of the EO4GEO Supply Study and its different components.

2.1. Methodology

2.1.1. Literature review

In preparation of the EO4GEO Supply Survey, a literature review was executed of existing studies on the supply of EO/GI training and education. In total eight relevant studies were identified and further investigated (see Table 1).

Table 1 - Reference studies in the EO/GI sector about supply of EO/GI training

No.	Title	Year	Source	Link
1	A Taxonomy for the EO Services Market: enhancing the perception and performance of the EO service industry	2015	EARSC	Link
2	Analysis of the supply of geospatial education and training Results of the GI-N2K Supply Survey	2014	GIN2K	Link
3	Integrated analysis of the demand for and supply of geospatial education and training	2015	GI-N2K	Link
4	Study to examine the socio-economic impact of Copernicus in the EU	2016	European Commission	Link
5	The Geospatial Industry Magazine	2018	Geospatial World	Link
6	More than counting pixels – perspectives on the importance of remote sensing training in ecology and conservation	2016	German Research Foundation (DFG) / University of Bayreuth	Link
7	EU survey on Earth observation in a global context	2014	GEO	Link

	survey.			
8	Skills for a Digital World	2016	OECD	Link

It was noticed in the EO4GEO Supply Study that some of these studies directly dealt with training and education in the EO and especially GI domain, while other were more general studies in which the need for capacity building and awareness raising in the EO/GI sector was recognized, while many studies also addressed the socio-economic impact of the sector, and of the Copernicus program in particular. A common message across most of the studies was about the strong need to support and increase the existing supply of education and training, especially in areas with high demanding technical capabilities. Addressing the need for help and guidance on how to access and use EO data should be considered as a key element in the Copernicus user uptake process.

2.1.2. EO4GEO Supply Survey

In order to collect data on the current supply of training and education on EO/GI, the EO4GEO Supply Survey was launched in April 2018 in English (and later on also translated to French, for the French speaking countries). The EO4GEO Supply Survey constituted the main component of the project's data collection and analysis activities on the supply of EO/GI training and education. The EO4GEO survey was carried out in EUSurvey. The partners of the EO4GEO consortium were involved in disseminating and promoting the survey, via their own communication channels and networks. The survey invitation was also disseminated via the central EO4GEO communication channels and the already established links with other projects, networks and initiatives.

The EO4GEO Supply survey questionnaire was structured in four sections:

- Section 1: Information about the respondent organization, such as the country of the organization and the type of organization.
- Section 2: Information on the existing EO/GI education and training offer, asking respondents to identify maximum 4 different education and training resources (such as courses, lectures or training modules) and to provide additional information on these resources, such as the type of education/training, a general description, the learning outcomes, the application field(s) covered, duration, EQF level, size in ECTS credits, etc.
- Section 3: Interest in EO4GEO project and its results, aimed at establishing further contact and interaction with the responding organization
- Section 4: Personal contact of the respondent (optional), where respondent had the opportunity to provide his contact details.

The questionnaire consisted of a mix of closed and open questions, allowing the collection of both quantitative and qualitative data on the current supply of EO/GI education and training. For the analysis of the skills mismatch, gaps and shortages in the sector, Section 2 was the most relevant

part of the questionnaire. The results presented and discussed in one EO4GEO report that are based on the data collected until September 2018. Between April and September 2018, the survey was completed by 157 respondents.

2.1.3. Web investigation

In addition to the EO4GEO Supply, information on the current offer of training and education in the areas of EO/GI was also collected via a web investigation, focused on the websites of main stakeholders in the EO/GI domain, including:

1. Copernicus and related organizations
2. European and International Networks
3. Summer Schools organized by Universities and research institutions
4. Comprehensive training packages offered by companies

Through this web investigation, a large amount of additional education and training resources have been identified and further investigated. These training resources were – partly – included in the analysis of the current supply of EO/GI training and education in Europe.

2.2. Results and findings

2.2.1. EO4GEO Supply Survey

The main aim of the EO4GEO Supply Survey was to collect information on the current of training and education in the domain of EO/GI in Europe. Therefore, respondents were asked to provide information on EO/GI training and education resources they were involved in. The term ‘resources’ was used as an overall term referring to a broad set of training and education products, such as courses, modules, lectures, training packages, summer schools and lectures. Based on the data provided by these respondents, 231 different “training and education resources” were identified and included in the analysis. Most of these resources were defines as courses (44%), but also individual lectures (16%), training modules (14%), training packages (14%), summer schools (4%) and webinars (4%) were identified. Among the major application fields covered by these resources were land services (44%), disasters and geohazards (18%), security (14%) and the built environment and human factors (13%). The Copernicus services most used in these resources are the Land (25%), Climate Change (9%) and Emergency Management (9%) services.

The identified training and education resources could be divided into four main categories: courses and lectures at Master level (EQ7, around 59% of the courses identified), courses and lectures at Bachelor level (EQF 5/6, around 27%), vocational training modules and packages (EQF 4, around12%) and other resources, which do not belong to any of the three other categories.

The EO4GEO Supply Study, also includes a qualitative analysis of the scope and content of the training and education resources that were identified and investigated. According to this analysis, there are two main categories in the EO/GI resources as included in the analysis: GI and geomatics courses versus Remote Sensing courses. When focusing on the second category, a further distinction was made between basic resources, advanced resources and domain specific resources:

- **Basic resources**: These resources mainly provide the basic theoretical, methodological and technological principles of RS. Main topics covered in these basic - or introductory - courses refer to the physical principles, platforms, types of sensors, data acquisition techniques, pre-processing, visual interpretation, basic image transformations and basic image classifications.
- **Advanced resources**: Advanced training and education in remote sensing consist of highly specialized resources, often dealing with a particular RS method or technology. Examples of topics addressed in these resources are: advanced techniques, advanced image analysis and calculus, programming and scripting, quality control and data quality, algorithms, etc.
- **Domain specific resources**: These resources, often targeted at professionals or experts, provide introductory knowledge on remote sensing in a specific domain or fields and strongly focus on practical applications and the use of remote sensing data in – decision making – in a particular domain. Examples of such domains are spatial planning, agriculture, urban development, coastal and marine management, mining, fisheries and aquaculture.

2.2.2. Web investigation

While the analysis of the EO4GEO Supply Survey was based on data and information provided by the respondents, i.e. EO/GI educators, teachers and trainers, the web investigation looked at information on EO/GI education and training that is available online. The web investigation covered education and training resources provided by four categories of organizations and initiatives: Copernicus and related organizations, European and International networks, summer schools organized by Universities and research institutions and training packages offered by companies.

Various education and especially training resources are delivered by Copernicus and related organizations. The Copernicus program itself made available around 130 training videos via the official Copernicus YouTube channel, of which 76 are devoted to foster user uptake regarding the use of Copernicus data (with information on how to access and process Copernicus data and how to use the Copernicus Services for specific applications/case studies) and the promotion of the Copernicus Accelerator, the Copernicus Start-up Programme devoted to the involvement of start-ups and entrepreneurs. Another component of the Copernicus training offer are the Copernicus InfoSessions organized in the different Member States, that aim to promote awareness of the many uses of Copernicus data and information. Also various other organizations and initiatives related to Copernicus are active in the development and delivery of training and education

resources on Copernicus. Among these are the European Space Agency (ESA), the Copernicus Research and User Support (RUS), the European Space Education Resource Office (ESERO), and the European Organisation for the Exploitation of Meteorological Satellites (EUMESTAT).

The European Space Agency (ESA) established a training and education portal[1] to provide information about their education activities, and enables access to all the resources produced. ESA provides a large and diverse collection of education resources, including the ESA MOOCs, LearnEO!, various EO Education for Schools resources and training courses (e.g. Dragon Training, Tiger Training, Advanced EO Training). ESA also provides a comprehensive hands-on training service as part of the RUS (Research and User Support for Sentinel Core products) Service, which aims to promote the uptake of Copernicus data and to support the scaling up of R&D activities with Copernicus data. The RUS Training platform provides easy access to face-to-face training sessions, online webinars and e-learning courses. Via the European Space Education Resource Office (ESERO), ESA also aims to support the primary and secondary education community in Europe. ESERO offers a series of national or regional training sessions for both primary and secondary school teachers, as part of continual professional development qualifications. Finally, the European Organisation for the Exploitation of Meteorological Satellites (EUMESTAT), also hosts a Training Library with several online training modules.

The EO4GEO Supply Study also identified and investigated education and training resources provided by European networks and associations in the EO/GI domain, such as the Network of European Regions Using Space Technologies (NEREUS), the European Association of Remote Sensing Laboratories (EARSeL), the International Society for Photogrammetry and Remote Sensing (ISPRS), the Geographical Information System International Group (GISIG), the GI-N2K project, the HatariLabs initiative, and the EO College. NEREUS developed an online tool called the NEREUS e-catalogue[2], an open and up-to-date inventory of training courses performed in the space domain in the NEREUS network regions. The 2017-18 edition, the catalogue contains information on 368 courses provided by European universities. EARSel regularly organizes summer schools and workshops on key topics in the EO/GI domain. ISPRS published a list of Educational Sites, Master Courses and Online Courses. GISIG offers a platform with several training packages developed in the context of different projects, such as LINKVIT, eENVplus, LIFE+IMAGINE and GeoSmartCity. The GI-N2K project has collected and analysed educational offers by programs and curricula in the GI domain, leading to the identification of 570 – ongoing and planned - courses on GIS&T in Europe. HatariLabs, a private consultancy company outside Europe, produced a group of videos called "Working with Sentinel 2 Imagery on QGIS". EO College provides learning materials (mostly presentations) and online courses (MOOCs) on EO related topics, including the MOOC: 'Echoes in Space' - Introduction to Radar remote sensing.

Also several relevant summer schools were identified, such as the Remote Sensing Summer School focused on Agricultural applications of SENTINEL data, the UNIGIS EO4Alps Summer

[1] https://earth.esa.int/web/guest/eo-education-and-training
[2] http://www.nereus-space-training.eu/

School, Climate-KIC InnoSpace Journey summer school and the EO Summer School series. These summer schools, often hosted by universities and organized in collaboration with other research institutes and public – space – agencies, and mainly focus practical training related to very specific scientific fields.

Finally, the supply of education and training on EO/GI related topics also consists of training packages offered by private companies, which often are part of larger user support platforms including comprehensive tutorials, demonstrations and sample data. ESRI, for example, has a catalogue with e-learning resources, including both freely available resources and resources available to their clients. Also Hexagon has a wide Geospatial education program containing many free and on-demand training resources. These enterprises have the type of education and training that focuses on providing skills for real work environment, a type of skills that is less present in the academic curricula.

2.3. Conclusions

The EO4GEO Supply Study aimed to gain insight in the current offer of EO/GI education and training in Europe by identifying existing courses, lectures, workshops and other education and training initiatives in the sector and further investigating the content of the resources. This was done via two main data collection actions: a survey among educators, teachers and other stakeholders involved in the organization and provision of EO/GI education and training, and an online investigation to discover education and training resources on the web and collect additional information on these resources.

The EO4GEO Supply Study was successful in mapping the EO/GI education and training landscape, with the identification of more than 1000 education and training resources. In this way, EO4GEO has composed the largest and most up-to-date repository of education and training resources in the EO/GI domain that is currently available. The main challenge now is to further investigate the content of each of these resources, in order to to better understand which topics they address and which skills they aim to develop.

3. EO4GEO Study on the demand for EO/GI education and training

This third chapter will summarize and discuss the methodology, results and main conclusions of the EO4GEO Demand Study, which explored the current demand of EO/GI skills and occupational profiles. The study consisted of several components, of which the EO4GEO Demand Survey can be considered as the main component. In preparation of the study, an analysis of existing literature was performed, and the survey was complemented with semi-structured interviews with professionals in the EO/GI domain. Moreover, the first results were enriched by organizing a dedicated workshop. In this chapter, a brief discussion and summary is provided of the different components of the study.

3.1. Methodology

3.1.1. EO4GEO Demand Survey

The EO4GEO Survey on demand for EO and GI skills and occupational profiles (EO4GEO Demand Survey for short) was the main component of the larger study on the demand for EO/GI education and training. The objectives of the E04GEO Demand Survey were to better understand the demands of current professional workforce in the EO/GI sector and to highlight skills required in the sector in the future. The survey was made available in English (and later on in French), and carried out via EUSurvey. The distribution of the survey invitation took place through all partners and multiple mailing lists such as the Copernicus network, the AGILE community, social media pages of partners to reach a qualitative and representative number of respondents. The survey was launched in April 2018, and is still open. The current analysis of the survey results is based on the surveys completed until the end of July 2018. In this period, the survey was completed by 176 respondents.

The main distribution area for the survey was Europe, which is reflected in the distribution of respondents across countries. Most respondents originate from Italy (45), Germany (14) and Spain (14). This means the responses are unfortunately not evenly spread throughout the European Union, which can be considered a limitation. It is no surprise that most responses originate from the 13 countries where the EO4GEO Sector Skill Alliance has its partners. In addition the countries of the associated partners are covered. No responses are originating from Cyprus, Estonia, Finland, Ireland, Lithuania and Slovakia. At the same time, it should be stressed that the goal of the survey was not to distinguish the demand between (European) countries.

With regard to the organization type of the respondents, it can be mentioned that the majority (86) can be classified as ‘public institution’ (public body, international organization or international organization of European interest) followed by SMEs and education and training providers. Furthermore, it is interesting to know that most respondents have a rather high level of education. Almost all respondents have a Master’s degree or a doctor’s degree.

The online survey aimed at getting information about both the respondents themselves (in order to get insight in the current workforce), and characteristics of the (needed) workforce. To realize this the survey was structured in two main sections:

- The first section was focused on **information about the organization of respondents**. This included information about the size and type of company/organization, the availability of in-service training, and the most needed EO/GI related skills that employees need to possess. In addition, information was collected about the **expertise of the respondents** themselves. Examples are the level of education, the occupational profile, the (Copernicus application) domains in which their work take place and the most performed tasks.

- The second section was mainly focused on ***the most needed EO/GI related job position/occupational profile*** in the specific organizations and the skills that are relevant and needed to this specific profile, including the educational profile of the needed employees

For collecting information on the required skills for a particular profile in this second section, the survey made use of eight pre-defined EO/GI related skill sets. The respondents needed to indicate the importance of each skill set for the position they consider to be the most needed. For each skill set a list of underlying skills was identified, and respondents were asked the choose the three most relevant skills and the level of expertise that employees need to possess for these specific skills. According to the survey designers, the skill sets can be seen as knowledge areas in the terminology of the BoK. The skill sets are based on both the GIS&T BoK and the BoK designed as part of the GI-N2K project. Some reshuffling has been done to have appropriate labels for the EO/GI related skill sets and to limit the skill sets to eight to prevent an overcomplicated survey. EO related skills were added based on previous studies and EO specialists. Table 2 gives an overview of the skill sets used and the underlying skills for each of them.

Table 2 - Skill sets and underlying skills (Created based on Albrecht et al., 2018

Skill set	Underlying skills
Space/Geospatial Data	Data retrieval from data portals
	Knowledge about nature of multispectral data
	Data models (object, field, network, TINs, etc.)
	Knowledge about sensor platform types (UAV, airplane, satellite), orbits and flight paths
	Extraction, transformation and loading EO/GI data
	Geo-referencing and resampling data
	Ortho-rectification and mosaicking EO data
	Pre-processing of data: calibration and correction (radiometric, topographic etc.)
	Understanding map projections and datums
	Knowledge of metadata, standards and concepts of spatial data infrastructures
	Interpretation of EO/GI data (aerial images, satellite data, VGI,

	trajectories etc.)
	Competence in radar remote sensing
	Evaluation of data quality
Data Capture and management	Planning and collection of field data
	Land surveying and GPS measurements
	Knowledge of different data capture technologies (multispectral sensors, LiDAR, Radar etc.)
	Establishment and usage of a sensor web
	Management of real-time data in a database
	Design, creation and maintenance of a database for EO/GI data
	Usage of data cubes for multidimensional data
	Querying databases in different languages (e.g. SQL)
Organizational and institutional aspects	EO/GI workforce themes (training and education, staff development)
	Adopting standards
	Planning project resources (data costs, product requirements etc.)
	Estimation of budget for EO/GI management
	Balancing costs, risks and benefits
Analytical methods	Application of different image classification methods (e.g. machine learning routines, artificial intelligence for data analysis)
	Usage of analytical operations (e.g. map algebra, overlay)
	Creation of composite indicators
	Application of statistical methods (e.g. spatial statistics for point pattern analysis, geo-statistics for interpolation)
	Application of context specific methods, like object-based image analysis, mathematical morphology, CNNS (convolutional neural networks)or similar
	Analysis of time series data
	Application of data mining approaches (pattern recognition, data classification, big data analysis, knowledge discovery)
	Surface analysis (cost surfaces, visibility analysis)
	Natural language processing
	Mathematical optimization (graph theory, routing, utility networks)
Programming and development	Development of prototypes of new analysis algorithms
	Requirement analysis and identify user needs
	Development of web applications (JavaScript APIs, html5, CSS etc.)
	Realization of applications for mobile devices (e.g. location-based services)
	Integration of sensor data and IoT in applications
	Automation of geo-processing through scripts
	Usage of Jupyter notebooks, Google Earth engine etc.

	Adaptation of EO/GI applications
	Supporting the testing and deployment of new products
	Monitoring software life cycle
EO/GI and Society	Knowledge of space/geospatial policy frameworks (Copernicus, GEO, Inspire , OGC)
	Understanding opportunities/challenges for future markets of EO/GI data exploitation
	Awareness of legal issues (liability privacy, etc.) and data sharing policies
	Running citizen science projects
	Dissemination of space/geospatial information to the public
Computing resources and platforms	Usage of high performance computing resources
	Accessing, analysis and visualization of EO/GI data on cloud infrastructures
	Usage and provision of data as web services (e.g. using OGC web services)
	Administration of web server infrastructures (Linux or Windows servers including map servers)
	Managing of security and privacy issues on platforms
	Application of the MapReduce concept, e.g. implementation in Apache Hadoop
	Managing infrastructure (user support, system revision, database administration)
Visualization and cartography	Data preparation and maps design (considering scale, generalization, symbology etc.)
	Creation of web mapping products
	Design of user interfaces
	Synthesis of EO/GI data
	Analysis and visualization of complex and big data
	Interpretation and evaluation of maps

3.1.2. Complementary interviews

To complement the results of the survey, interviews with representatives from the industrial and public sector were done, in which more focused input was collected on the demand for education and training, mainly focused on EO. More specifically, semi-structured interviews were carried out, through a set of pre-defined topics, and making use of an interview guideline. Questions were indicated as a start for further discussion, but were not necessarily asked to each and every respondent. Three main topics were distinguished for the interviews: 1. Business activities and customers; 2. Task and workflows; and 3. Workforce development.

Concerning the business activities and customers the goal was to get more insight in the business model and organization, the main customers or contracting authorities, and the most frequent

requests related to EO. With regard to tasks and workflows, interviewees were stimulated to talk about the most relevant task for EO-related requests, and to provide insight in workflows and tasks, including the usage and familiarity with Copernicus. Related to workforce development interviewees were asked to discuss and give some information about future drivers and the demand of skills in the organization, including the need for training of employees in specific topics/areas (both in-house, as well as external).

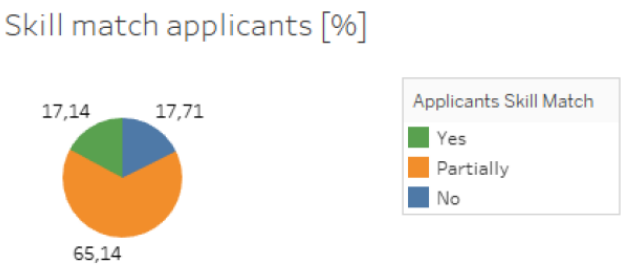
A total of 29 interviews, across 10 different countries, were completed by the EO4GEO partners. Of these 29 interviews, the majority consisted of representatives from SMEs (13), followed by larger companies (8), public bodies (7) and NGOs (1). The profile of the respondents were diverse and varying from CEO's with over 20 years of experience to technicians with less than 5 years of experience. On average the interviewees had 14 years of experience in the EO/GI sector.

3.2. Results and findings

3.2.1. EO4GEO Demand Survey

Since the survey collected both information about the profiles of respondents as well information about the most needed profile, some relevant insight can be gained about the current and future workforce. A first interesting result is related to the question (question 6 in the survey) in which respondents were asked to indicate if job applicants fulfill the required skills. As shown in **Errore. L'origine riferimento non è stata trovata.**, approximately one fifth of the respondents indicated that job applicants fully matched the required skills. In the majority of the cases however, there is only a partial match (65%), while the remaining 17% of the respondents even answered there was no match. This can be seen as a strong indication that there is a mismatch and/or gap between the required skills and the skills possessed by job applicants. In other words, this result points to the relevance of the goal of this deliverable, and of the EO4GEO project in general.

Figure 1 - Skill match of new applicants

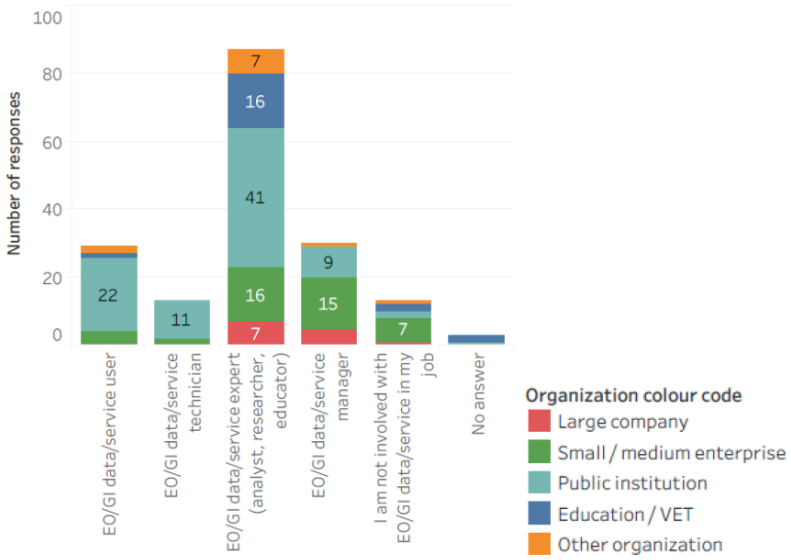


(Albrecht et al., 2018)

Another relevant question in the survey (question 9) focused on the current positon of the survey respondents themselves. This is relevant, because it contributes to the identification of

occupational profiles and their priority in terms of opportunities in the job market. **Figure 2** shows that most of the respondents (87) consider themselves as "*EO/GI data/service expert (analyst, researcher, educator)*" followed by "*EO/GI data/service manager*" (30) and "*EO/GI data/service user"*(29).

Figure 2 - EO/GI related profile of the respondents



(Albrecht et al., 2018

A third relevant question was the open question on the most needed position, which was the first question in the second section of the survey. In the answers to this question, the two most mentioned positions were "GIS Developer" and "Remote Sensing Technician". Among the most mentioned fields of expertise to this question were "GIS", "Remote Sensing", "Software and Application Development", "Data Science", "GIS and Remote Sensing Integration" and "EO". The most common roles or functions were "Developer", "Technician", "Analyst", "Specialist", and "Researcher / Scientist".

After specifying this most needed profile, several questions followed related to this profile. This included questions on the disciplines in which applications for the suggested profile have been trained and on the highest level of education of that profile. Information was also collected on the most importance skills for the profiles. Using the eight pre-defined skills sets (see Table 2), respondents were asked to indicate the three most relevant skills for each skill set and to specify the overall relevance of each skill set. Although the collected information on required skills is related to a particular occupational profile, it gives some insight on skills that are considered to be important. The scores on the overall importance of the skill sets range from 3.6 (on a maximum of 6) to 4.8. The skill set 'Space/Geospatial Data skills" received the highest score, followed by "Visualization and Cartography" and "Analytical Methods". Interesting to notice is that this top 3 is not fully consistent across different types of organizations. Large companies (although it should be mentioned that they account for less than 10 percent of all respondents) rank for example the skill

set “Programming and development” as the most important, while this skill set also scores relatively higher compared to the average for SMEs.

When looking more in-depth into the ranking of the skill sets for specific profiles, it becomes clear that there is a considerable level in variety, even for the same profiles. This can be seen as a first indication of the need for a more common language on skills, positions and occupational profiles in particular.

While the skill set “Space/Geospatial Data” was considered by the respondents to be the most relevant, the survey results also show that this skill set also requires the highest level of expertise. Table 3 shows the average required level per skill set, based on the level of expertise assigned to the specific skills under this skill set. This average level is the highest for the skill set “Space/Geospatial Data”, followed by the skill sets “Analytical methods” and “Visualization and cartography”.

Table 3 - Average required level per skill set (basic=33, intermediate= 66, expert=100)[3]

Skill set	Average level required
Space/Geospatial Data Skills	78.35
Analytical methods	74.84
Visualization and Cartography	74.43
Programming and Development	74.12
Data Capture and management	71.14
EO/GI and society	67.76
Computing resources and platforms	64.36
Organizational and institutional aspects	63.84

(Created based on Albrecht et al., 2018)

When comparing the level of indicated level of expertise for each specific skill across all different skills sets (top 10) (Table 4), the highest level of expertise seems to be required for the skill “Extraction, transformation and loading of EO/GI data”, which is part of the skill set “Space/Geospatial Data”. Other skills under this skill set that – according to the survey respondents – require a high level of expertise are “Interpretation of EO/GI data”, “Geo-referencing

[3] Note: In this table the amount of answers per skill is not taken into account. Respondents were asked to indicate the required level of at least three skills per skill set. In other words, it can be the case that a skill with a high rating (or low rating) was only rated a few times. Furthermore, it should be stressed again that respondents were asked to indicate the importance of a specific skill set (and underlying skills) for **one specific occupational profile**.

and resampling data" and "Evaluation of data quality". The remaining 6 are equally divided between the other three skill sets.

Table 4 - Required level of underlying skills (top 10) (basic=33, intermediate=66, expert=100)[4]

Skill *(overarching skill set)*	Rating
Extraction, transformation and loading EO/GI data *(Space/Geospatial Data Skills)*	82.34
Interpretation and evaluation of maps *(Visualization and Cartography)*	80.64
Interpretation of EO/GI data (aerial images, satellite data, VGIm trajectories etc.) *(Space/Geospatial Data Skills)*	80.04
Automation of geoprocessing through scripts *(Programming and Development)*	78.43
Data preparation and maps design (considering scale, generalization, symbology etc.) *(Visualization and Cartography)*	77.93
Analysis of time series data *(Analytical Methods)*	77.62
Georeferencing and resampling data (Space/Geospatial Data Skills)	77.54
Evaluation of data quality *(Space/Geospatial Data Skills)*	76.88
Design and development of applications (Python, Java, C++ etc.) *(Programming and Development)*	76.04
Usage of analytical operations (e.g. map algebra, overlay) *(Analytical methods)*	75.96

(Created based on Albrecht et al., 2018)

In addition to the sector specific skills, respondents were also asked to indicate transversal and soft skills that are relevant for applicants to possess. The five mentioned skills, which all were mentioned at least 100 times, were: Independent/proactive working attitude; motivated to enter new thematic fields; time management skills; communication skills; and willingness to re-train and/or re-skill.

Based on all the foregoing results and findings, the authors of the report concluded that there is an increased relevance to possess knowledge across the difference skill sets and consequently having expertise in a broad variety of skills. This is also reflected in the demand for applicants with at least a Master's degree. The authors speak about "*a somehow universal expert being seeked for".* Taking into account that at the same time, there was in the majority of cases an indication of at least any kind of partial mismatch between required and possessed skills, a further in-depth

[4] See 4

analysis is needed, in which also the interviews (3.2.2), the supply side (chapter 2) and future trends (chapter 4) are taking into account.

3.2.2. Interviews

In addition to the EO4GEO Demand Survey, and to complement the results and findings of the survey, semi-structured interviews were done with representatives from the EO/GI sector. These interviews focused on three central topics: business activities and customers; tasks and workflows; and workforce development.

Although the business activities of the respondents cover a wide range of activities, most of them were related to the downstream sector of the earth observation value chain. Software development can be seen as an important main business activity, especially for larger companies. They are focused on offering standard product solutions for specific purposes and customers (in both vertical and horizontal markets). Other activities mentioned by larger companies are for example related to data pre-processing, data distribution and consulting (service provision). In contrast to this, small and medium enterprises are mostly active in value-added services and niche markets with specializations in thematic or geographic fields. Product development (e.g. application development, development of products based on satellite data) or consulting are activities which were frequently mentioned. Regarding the public bodies, both institutions connecting up-, mid- and downstream parts of the value chain were interviewed, as well as research institutions focused on specific thematic field.

With regard to tasks, it can be mentioned that duties and tasks are in general more diverse in SMEs, which require consequently a broader, more extensive occupational profile. Tasks include for example data acquisition, processing and analysis, but also the need for transversal tasks and skills, as project management and planning are mentioned. Although the assumption was that the division of task is more fragmented in larger companies, this is not always the case. Some companies put more emphasis on hiring applicants with a broader, less specific, profile and value flexibility and openness in work attitudes. Besides technical skills, interpersonal communication skills are considered important in this regard as well. Regarding changes of tasks and workflows it is mentioned by some respondents that programming and software engineering will become more important, and that certain technological changes will become more profound and that (further) fragmentation of activities is as well underpinned by the use of new methods and technologies.

It is no surprise that the interviewees had a divergent view on workforce development, training and future changes. It is dependent on the size, business model and level of vertical integration of the firm. Nevertheless, also here the further importance of transversal skills in addition to technical skills, is mentioned multiple times. With regard to training, several respondents seem to value especially practice-oriented trainings, while online and on-demand seem to be the preferred methods, in a time-poor context. Both sector-specific as more general topics are mentioned as topics in which training is needed. Examples are project management, social media, general IT skills, programming, databases, Sentinel data processing, Tomographic SAR data and Radar data processing.

3.3. Discussion

The results and findings from the EO4GEO Demand Survey give us an interesting starting point to identify and assess skill gaps, shortages and mismatches. At the same time, the survey (and complementary interviews) also has some limitations that need to be taken into consideration, while additional analysis on the collected data could further strengthen and support the assessment of skill gaps. As an example of this, in the survey a question was asked on the top three EO/GI related skills that are needed in the organization of the respondents. The answers on this – open - question are not analyzed in the report. and are worth it to further explore. Another important aspect, which was already mentioned implicitly, is the fact that respondents were asked to indicate the relevance of certain *skill sets* for a *specific profile,* namely the positon/profile that was indicated as the most needed. A limitation mentioned by the authors themselves is that the survey was mainly distributed by making use of (known) networks of all the partners in the EO/GI market. This can result in a more 'traditional' view in which relatively less newcomers from outside the sector or industry are incorporated. This also means that the group of (potential) users of EO/GI data from other industries are not really represented in the survey. Especially when focused on the uptake of Copernicus, incorporating potential users (and/or awareness raising on the possibilities for potential users) is considered highly relevant.

One of the planned outcomes of the EO4GEO Demand Survey was the description of priority occupational profiles. ESCO, the multilingual classification of European Skills, Competences, Qualifications and Occupations, defines an occupational profile as *"An explanation of the occupation in the form of a description, scope note and definition. Furthermore, they list the knowledge, skills and competences that experts considered relevant terminology for this occupation"* (ESCO, n.d.,a). In ESCO, every occupation concepts consists of a preferred term, alternative terms, an occupational profiles, knowledge, skills and competencies. It should be noticed that the EO4GEO Demand Survey strongly focused on skills and skill sets, and less on knowledge and competencies. Some input on knowledge and competencies was nevertheless gained during a workshop in which sector representatives participated (Aguilar Moreno et al., 2018 (D2.1.)). Although the main focus of the survey was more on technical skills, respondents were also asked to indicate the importance of certain soft skills, a topic that also came to the forefront multiple times during the interviews and workshop. In other words, there is a need for the identification of profiles in which both technical and soft or transversal skills are being stressed.

Although the authors point to difficulties related to the identification of priority profiles (e.g. due to the earlier mentioned heterogeneity across profiles with the same labels entered by respondents), it becomes clear that there the sector is in need of a common language and some standardized (but flexible) overarching priority profiles. Certain results seem to point to the need of a broad (generalist) profile, and although the authors point to the need for a deeper discussion related to the priority profiles, three profiles were proposed (ibid):

1. **EO/GI developer** (master level): The technically oriented master level EO/GI graduate that is proficient in data related skills and has programming and development skills. This profile

requires additional skills in analytical methods, visualization, data capture and management required for the development of EO/GI products and services.

2. **EO/GI data analyst** (master level): The analysis oriented master level EO/GI graduate that is highly proficient in space/geospatial data skills and analytical methods; the profile is complemented by skills in visualization, programming and development and data capture and management.

3. **EO/GI specialist/project manager** (PhD level): Doctor in EO/GI that is highly proficient not only in the technically and analysis oriented skills, but also in other skill sets as EO/GI and society, computing resources and platforms, and organizational and institutional aspects.

The definition of these priority profiles contributes to the broader discussion on (future) skill gaps, shortages and mismatches. It should be noticed that Albrecht et al (2018) have chosen explicitly to define profiles in which EO and GI are integrated. These profiles are slightly contradictory to the survey results, in which only 16 respondents (out of 176 (9%)) name a profile in which EO and GI are combined (in any way). At the same time it should be stressed that an occupation is "*a grouping of jobs involving similar tasks and which require a similar skill set*" (ESCO, n.d.,b). In other words, while a job is restricted to a specific work context (and carried out by one person), occupations group jobs by common characteristics (ibid.). From this perspective a job can belong to multiple occupations, and at the same time occupations can be used as job titles. From this perspective it is interesting to have more insight in the similarities of importance of skill sets (and combination of skill sets) across several profiles (for example as mentioned in the survey).

3.4. Conclusion

The EO4GEO Demand Study aimed to gain insight in the current demand for EO/GI skills and occupational profiles. Therefore, a survey on the need on the demands of current professional workforce in the EO/GI sector and the skills required in the sector in the future was organized, interviews were done with key stakeholders in the public and private EO/GI sector and a workshop was organized to further discuss and complement the first results and findings.

Space/Geospatial Data Skills, Analytical methods, Visualization and Cartography, Programming and Development, Data Capture and management, EO/GI and society, Computing resources and platforms, Organizational and institutional aspects were considered as the main skills sets relevant to the EO/GI sector. In the EO4GEO Demand Survey, the relevance of each of these eight skills sets to job in the EO/GI sector as well as the need for the underlying skills was further explored.

In addition to this, the study also aimed to better understand the different occupational profiles in the sector. Based on the results and views collected during various initiatives, three main profiles were defined: EO/GI developers, EO/GI data analysts and EO/GI specialist and project managers. Also these new profiles provide a new dimension to the discussion on key profiles in the EO/GI sector. Both the defined skill sets and occupational profiles however required further investigation and validation.

4. Trends and challenges in the space/geospatial sector

EO/GI training and education will only be relevant and effective in case it also takes into consideration recent and future trends and challenges related to the domain, since these trends and challenges will determine the future need for knowledge and skills in the domain. Therefore, in addition to the EO4GEO studies on both the supply of and demand for EO/GI training and education, a separate analysis was made of the trends, challenges and opportunities in the GI and EO sector. The analysis covered both technological and non-technological developments, and was not limited to the geospatial domain, but also investigated relevant trends and opportunities in other domains and sectors. This chapter discusses the approach behind the analysis and the main results and findings.

4.1. Methodology

The analysis of trends, challenges and opportunities in the GI and EO sector was based on a combination of various approaches, such as an analysis of relevant documents, contacts with sector experts, and expertise of all consortium partners. An important element in the data collection and analysis was the EO4GEO workshop and meeting in Castellon de la Plana held from 30 May to 1 June 2018. During this event, several bilateral meetings with partners and experts took place, while several experts also presented their own views and ideas on key trends and challenges and a round table discussion was held on the topic of trends and challenges as drivers for the future geospatial applications and having an impact on the professional skills.

This report can be seen as a synthesis of the identification and analysis of relevant trends, challenges and opportunities, and covers the following topics:

- The main actors in the geospatial market, with particular attention to the EO service sector
- Key technology trends, including a description of the model of services, as Info-aaS and Analytics.
- Non-technological trends related to the economy
- Non-technological trends related to communication
- The 2030 Agenda for Sustainable Development
- Approaches for a Technology Watch, i.e. a system to monitor technological trends and support the decision making in the education and academic sector

4.2. Results and findings

The main trends and developments identified in the analysis are summarized in table 5. The table shows a variety of key trends and developments, of which some already have an impact on the EO/GI sector, while others are expected to have such an impact in the – near – future. This impact should be monitored and further explorer, with particular attention to implications for needs for – new – skills in the EO/GI sector and job market. One way to do this, is through putting in place a Trend Watch, an approach that is further investigated and prepared in the report on the trend analysis.

Table 5 - Trends and challenges in the EO/GI sector

Domain / Area	Relevant trends
Technology	Cloud computing
	Big data
	Internet of Things
	Artificial Intelligence
	Blockchain
	Drones
	Augmented Reality
	SmallSats
	CubeSats
	SpaceStream paradigm
Economy	Circular economy
	Financial services
	Geospatial Business Intelligence (GeoBI)
Communication	Citizen Science
	Citizen Observatories
Agenda 2030 for SD	Role of EO in supporting the SDGs, Targets and Indicators,
	Practical examples of EO data usage.
	Contribution of EO data to specific SDGs
	Advantages of EO related to SDG
	EO products supporting SDG Indicators
OGC Geo Tech Trends	Power of Location
	Spatial-Temporal Models
	Big data
	Data Science Analytics
	Spatial Data on the Web
	New Geo Sources
	User Platforms and Networks (HSI)
	Software Development and Patterns

4.3. Conclusion

The assessment of recent and future trends and developments in the EO/GI sector, but also broader societal trends impacting the sector should be seen as a key element in a skills anticipation strategy, in which future skills needs are identified in order to prepare how these skills can be met. It is in this perspective that the EO4GEO assessment of trends and challenges can be seen as an important component of the preparatory activities of the definition of a sector skills strategy. Some of the trends and developments detected in this analysis already emerged in the other preparatory studies, while other trends and developments are new. Detecting and investigating these trends and challenges is an important and valuable exercise, but not an end in itself. In order to be able to anticipate to skills needs, it is essential to better understand and gain insights into the skills that are needed to embrace those trends and developments that will or could be relevant to the EO/GI domain.

5. EO/GI job advertisements analysis

To gain better insight in EO/GI skills and profiles, and especially in the demand for these skills and profiles, an additional analysis was performed as part of the preparation of this deliverable. This analysis focused on existing job advertisements in the domain of earth observation and geo-information. One of the main goals of this job advertisements analysis was to get better understanding of and more insight in the way skills are used in job advertisements and which ones are considered as essential for the EO/GI sector. In terms of skills and skill sets, the existing structure from the demand survey was used as a starting point, to be able to compare, enhance and contrast results. This chapter discusses the methodology, results and conclusions of the job advertisements analysis.

It can be stressed, that the job advertisements analysis is complementary to the demand survey and enhances the view and results regarding the demand side. At the same time, by carrying out the job advertisements analysis it was tried to overcome a limitation from the demand survey in which the focus was only on the skills and skill sets for the most needed profile (as considered by the respondents). We believe that the job advertisements analysis gave us insight in some broader profiles and occupations (including ones which are not necessarily the most needed- but difficult to fulfill). In other words, the job advertisements analysis offers us a complementary snapshot of the demand in the market at a specific moment in time.

5.1. Methodology

5.1.1. Job advertisements as a source and research method

Job advertisements are a rich source of information about skills (and changing skills needs) and increasingly being used in academic studies (Harper, 2010), to get for example more insight in sector-specific requirements or competencies related to a specific occupation (e.g. Copeland, 1997; Clyde, 2002; Kim et al., 2013; Ahsan et al., 2013; Kennan et al., 2008; Sodhi & Son, 2010). Especially in longitudinal studies, they are highly relevant to identify changes in skills needs and to identify (and track) certain skill shortages (Sakethhoo et al., 2002; Copeland, 1997). Furthermore, they are used to get more detailed information about personal transferable skills and differences in the requirement of these skills across several occupations and positions (e.g. Bennet, 2002). By analysing job advertisements, it can also become clear that employers sometimes have problems in defining the positions and role of certain profiles/positions, which can also affect the view of the general public on a certain profile or even a sector (Snyman, 2002). Except for insight in the changing nature of skills, Harper (2010) also points to the relevance of an analysis of job advertisement to inform the design of curricula (e.g. Iyer, 2009, Payne, 2008 in Harper, 2010). Another benefit mentioned is that it provides a snapshot of the current employment market, which

is especially relevant in contexts where job roles are increasingly non-traditional and become less connected to a distinct profile (Harper, 2010).

Also for the analysis of skills and profiles in the EO/GI sector, a job advertisements analysis can be highly relevant, and would be a new and innovative approach to the sector. Benefits of using job adverts as a method are that job advertisements are relatively easily accessible (Viera da Cunha, 2009 & Schlee & Harich, 2010 in Harper, 2010). Furthermore, a database of job adverts can be of practical support to job seekers (Beile & Adams, 2000, Culle, 2000 in Harper, 2010). In the context of EO4GEO the job advertisements analysis and the database can function as a starting point in (developing and) testing the job profile tool. Although the method enables to do a longitudinal comparison and identify trends, and consequently shortages and gaps, this will require a strict methodology and frequent collection of job adverts, which are outside the scope of the EO4GEO project.

Of course, there are also limitations to be identified of an approach focused on job advertisements. A first limitation is that not all jobs are published externally outside the organization. In other words, some data is not available for analysis (Croneis & Henderson, 2000 in Harper, 2010). Nevertheless, there is often a high volume of data available, which can generate difficulties in analyzing the complete dataset. Related to this the analysis can be indicated as time-consuming, while there is a risk of over-saturation (Pickard, 2007 in Harper, 2010). Furthermore, there are issues to be identified related to the content of job adverts. Xu (1996, in Harper) stresses for example that job adverts can be very ambiguous, with a unpredictable quality, which makes it more difficult to analyze. Another factor mentioned is that job adverts cannot necessarily be seen as a current reality, but often reflect a kind of adorable future state and name newly created job roles. In the context of EO4GEO WP1 (with the goal to define new and strengthen existing occupational profiles) this is not a major aspect. Job advertisements can also be influenced by specific legislation, resulting in limited information (e.g. in some cases employers are not allowed to specify the desired years of experience et cetera) (Harper, 2010). A last important aspect which should be mentioned is that job adverts present a biased view of reality. There is no insight in the skills which successful candidates possess in reality and the actual skills which are used in the job itself (ibid.).

5.1.2. Methodology of the EO/GI job advertisements analysis

With the EO/GI job advertisements analysis we aimed to complement the work and results of the demand and supply survey, by having a more in-depth look into the “real” demand and to get a snapshot of the demand on the market in the European Union. The analysis was carried out between 7th and 10th of November, 2018. Based on practical reasons, time constraints and immediate availability of data, LinkedIn was used as a platform from which job advertisements were collected. LinkedIn can be seen as a social media website to build a professional network. They claim to be the “world’s largest professional network with more than 562 million users in more than 200 countries and territories worldwide” (LinkedIN, 2018). LinkedIn was officially launched in May 2003, and is now part of Microsoft.

The use of LinkedIn as a platform, in contrast to a more traditional way of job advertisement platforms can go together with both benefits and drawbacks. In general it can be mentioned that social media is on the rise in terms of its usage for recruitment and job seeking purposes (Duverge, 2017; Joos, 2008). The use of social media can give a potential job seeker higher informational benefits, whereby LinkedIn seems to have the highest impact and benefits (Utz, 2015). Also from the perspective of companies and recruiters LinkedIn offers additional benefits. Duverge (2017) speaks about extensive job posting capabilities, in which it allows recruiters to carry out detailed searches and getting access to full profiles. Although the cost can be high, for recruiters this is considered useful. Nevertheless, and in contrast to common though young graduates are still unprepared for effective job seeking and are often stuck in more traditional ways of looking for a job (Manroop & Richardson, 2013). At the same time, platforms like LinkedIn are going together with some ethical issues, which should be taken into account, when used for recruitment purposes.

Nikolaou (2014) stresses that traditional internal job boards still remain the most used channel for job advertisements. Therefore it can be expected that they present a more complete view, or at least a different and other reality. Others, like Duverge (2017) expect however that LinkedIn will expand in the near future, and will become a “one-stop shop” for business professionals. Partly related to the former drawback, it can be mentioned that LinkedIn is in general less effective for active job-seekers. One of the main advantages of a platform as LinkedIn, is to approach and get in touch with passive candidates. This can probably blur the reality to a large extent (ibid.).

We started are data collection from the occupations as included in ESCO, the multilingual classification of European Skills, Competences, Qualifications and Occupations. The ESCO classification identifies and categorizes skills, competences, qualifications and occupations relevant for the EU labor market and education and training, and systematically shows the relationships between the different concepts. ESCO currently contains three occupations related to the EO/GI domain: geographic information systems specialist; remote sensing technician and cartographer. Each ESCO occupational profile consists of a preferred main term and several other labels for the same occupation. Both the main terms and the other labels were used as search strings to collect job advertisements on LinkedIn. However, we are aware that occupations and occupational profiles are not the same as job titles. An occupation can be seen as a group of jobs involving similar tasks and a similar skill set, while a job is bound to a specific work context (ESCO, n.d.,a). Occupations can be used as job titles, but this is not necessarily the case. Therefore, the use of occupational profiles and alternative labels can be seen as a minor limitation. Next to the labels from ESCO, the two most mentioned “positions/profiles” from the EO4GEO Demand Survey were used as search string, namely ‘GIS Developer’ and ‘Remote Sensing Technician’ were added as search strings. The results for each search string were sorted by newest[5] and only the first 50 results were checked (for practical reasons and time constraints). This is highly relevant in terms of the skills asked, but not necessarily when information is needed

[5] This can be considered as a limitation. Additional work can focus especially on the oldest advertisements, which are probably the most difficult to fulfill (although there are limitations of the chosen platform in this respect, which is the reason we sorted on the most recent ones)

about the skills or profiles which are the most difficult to fill. Further analysis can therefore focus on the adverts which are already online for a long time, although LinkedIN does not give any information about the validity (or active time frame) of job adverts.

Although 38 different search strings were used, only 9 of them gave results, varying from 1 ("GIS Data specialist") to 227 ("remote sensing"). In total 558 job adverts were found, of which 118 were selected. Duplications and not relevant adverts were not included in the analysis. Table 6 gives an overview of the number of found and selected adverts for each search string.

Table 6 - Job adverts found by making use of the search strings

Label/position	Found	Selected
Remote sensing	227	28
GIS specialist	74	17
GIS data specialist	1	1
GIS analyst	46	12
GIS technician	55	14
Cartographer	3	2
Cartographic	36	8
GIS developer	60	20
GIS consultant	56	16
Total	***558***	***118***

For each job adverts, the information considered to be relevant for the analysis, was collected in a database, making use of Excel. More specifically for each job advert the search string was stated, as well as the job title, the company, the sector, the type of company (private, public, non-profit, university), the country, education requirements and the seniority level. Some difficulties were encountered. LinkedIN seems to offer some standard template in which recruiters can indicate for example the seniority and educational level. Although some standardized terms are being used there (e.g. entry, associate, mid-senior level), we noticed some inconsistencies in the usage of these terms, which limits the usability of this information. Except for duplication, we noticed that many job adverts were published by recruitment companies, by using a standardized text. Therefore it was not always clear if there was a duplication, or two single open positions. It happened multiple times, that the same text was used for different advertisements with different labels/profiles (e.g. GIS Specialist, GIS Consultant).

In addition to the basic information mentioned above, also information on the requested skills was collected. Each job advert included information on various skills that were considered to be relevant or essential for the job. For each job advert a maximum of 10 skills were included in the

database. If more skills were indicated in the job adverts, the 10 most important skills were collected. Also in terms of skills, we experienced some difficulties in our data collection. We mentioned already the difficulties respondents had with identifying skills related to answering the surveys. Also in the job adverts, skills are often not used in a proper way. Knowledge, skills and competences were often intermixed and used interchangeable as skills. This was also the case when recruiters placed advertisements according to the exact template of LinkedIN, in which there is one section dedicated to skills. We decided use the information on skills as mentioned in the job adverts, even though in reality the information rather was about knowledge or competences.

After identifying a maximum of 10 skills, we coded each job advertisement, indicating the two most mentioned skill sets. To being able to compare the results with the results for the EO4GEO Demand Survey, we build further on the existing skill sets (see Table 2 -) but made some minor modifications while analyzing the data on the job advertisements. The most important change is the combination of the skill sets 'organizational and institutional aspects" and "EO/GI and society" into "institutional, organizational and society". Furthermore, the name of the skill set "data capture and management" was changed into "data capture" and "Space/Geospatial data" was changed into "pre-processing/modelling of space/geospatial data". Except for name changes in the skill sets, some underlying skills were reshuffled. More specifically, "design, creation and maintenance of a database for EO/GI data" was moved from "data capture" towards "pre-processing/modelling of space/geospatial data", while "usage of data cubes for multidimensional data" and "querying databases in different languages" were moved from data capture towards the skill set "analytical methods". "Usage of GIS" was added to "analytical methods" as well. Table 7 displays the adjusted skill sets, with modifications and improvements based on the job advertisement data.

Table 7 - Adjusted skill sets

Skill sets	Skills
Data capture	Planning and collection of field data
	Land surveying and GPS measurements
	Knowledge of different data capture technologies (multispectral sensors, LiDAR, Radar etc.)
	Establishment and usage of a sensor web
	Management of real-time data in a database
Analytical methods	Application of different image classification methods (e.g. ML, AI for data analysis)
	Usage of analytical operations (e.g. map algebra, overlay)
	Creation of composite indicators
	Application of statistical methods (e.g. spatial statistics for point pattern analysis, geostatistics for interpolation)
	Application of context specific methods, like object-based image analysis, mathematical morphology, CNNS (convolutional neural networks) or similar
	Analysis of time series data

	Application of data mining approaches (pattern recognition, data classification, big data analysis, knowledge discovery)
	Surface analysis (cost surfaces, visibility analysis)
	Natural language processing
	Mathematical optimization (graph theory, routing, utility networks)
	Usage of GIS
	Usage of data cubes for multidimensional data
	Querying databases in different languages
Programming and development	Development of prototypes of new analysis algorithms
	Requirement analysis and identify user needs
	Development of web applications (JavaScript APIs, html5, CSS etc.)
	Design and development of applications (Python, Java, C++ etc.)
	Realization of applications for mobile devices (e.g. location-based services)
	Integration of sensor data and IoT in applications
	Automation of geoprocessing through scripts
	Usage of Jupyter notebooks, Google Earth engine etc.
	Adaptation of EO/GI applications
	Supporting the testing and deployment of new products
	Monitoring software life cycle
Computing resources and platforms	Usage of high performance computing resources
	Accessing, analysis and visualization of EO/GI data on cloud infrastructures
	Usage and provision of data as web services (e.g. using OGC web services)
	Administration of web server infrastructures (Linux or Windows servers including map servers)
	Managing of security and privacy issues on platforms
	Application of the MapReduce concept , e.g. implementation in Apache Hadoop
	Managing infrastructure (user support, system revision, database administration)
Visualization and cartography	Data preparation and maps design (considering scale, generalization, symbology etc.)
	Creation of web mapping products
	Design of user interfaces
	Synthesis of EO/GI data
	Analysis and visualization of complex and big data
	Interpretation and evaluation of maps
Pre-processing/modelling of space/geospatial data	Data retrieval from data portals
	Knowledge about the nature of multispectral data
	Data models (object, field, network, TINs, etc.)
	Modelling of 3D, uncertain and temporal phenomena
	Knowledge about sensor platform types (UAV, airplane, satellite), orbits and flight paths

	Extraction, transformation and loading EO/GI data
	Georeferencing and resampling data
	Orthorectification and mosaicking EO data
	Pre-processing of data: calibration and correction (radiometric, topographic etc.)
	Understanding map projections and datums
	Knowledge of metadata, standards and concepts of spatial data infrastructures
	Interpretation of EO/GI data (aerial images, satellite data, VGI, trajectories etc.)
	Competence in radar remote sensing
	Evaluation of data quality
	Design, creation and maintenance of a database for EO/GI data
Institutional, organizational and society	EO/GI workforce themes (training and education, staff development)
	Adopting standards
	Planning project resources (data costs, product requirements etc.)
	Estimation of budget for EO/GI management
	Balancing costs, risks and benefits
	Knowledge of space/geospatial policy frameworks (Copernicus, GEO, Inspire , OGC)
	Understanding opportunities/challenges for future markets of EO/GI data exploitation
	Awareness of legal issues (liability privacy, etc) and data sharing policies
	Running citizen science projects
	Dissemination of space/geospatial information to the public

5.2. Results & findings

In total 118 job advertisements were included in the analysis. The majority of these advertisements were jobs in the private sector (or 77%). The job advertisement analysis also contained data on jobs in the academic sector (12%), public sector (9%) and non-profit sector (2%). This distribution across sectors, which probably has to do with the chosen platform (LinkedIN), is different from the distribution in the EO4GEO Demand Survey, where most respondents were from the public sector. Figure 3Figure 4 Figure 4 gives an overview of the distribution of the found job advertisements across the different main profiles (which were used as search strings). It can be noticed that almost a quarter of all selected advertisements were found by using the search string “remote sensing”. Almost one fifth of all selected advertisements were found by making use of “GIS Developer”, which was also one of the two most needed profiles evolving from the EO4GEO Demand Survey.

Figure 3 - Distribution of job advertisements across profiles

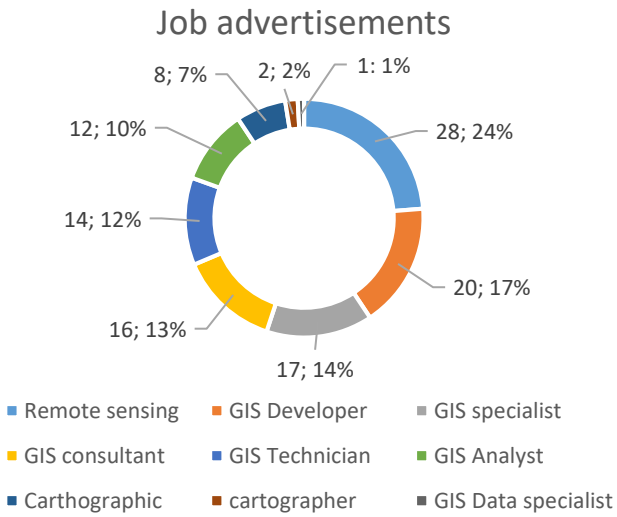
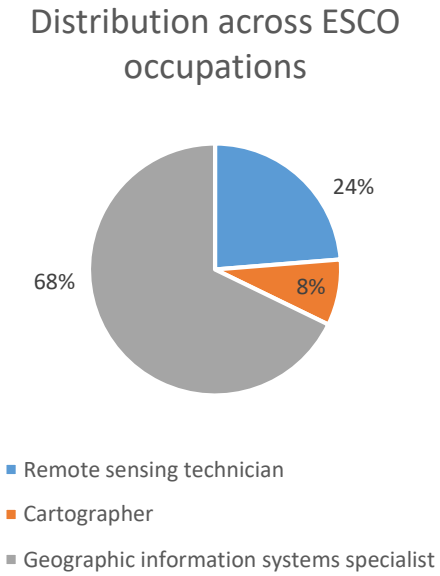


Figure 4 shows the distribution across the three identified ESCO profiles, by grouping the results of all alternative labels per profile. As it can be seen in this figure, almost 70 percent of all job advertisements found are related to the profile of “geographic information systems specialist”, while a quarter is related to “remote sensing technician”. Only a few of the selected job advertisements are related to the ESCO profile of “cartographer”.

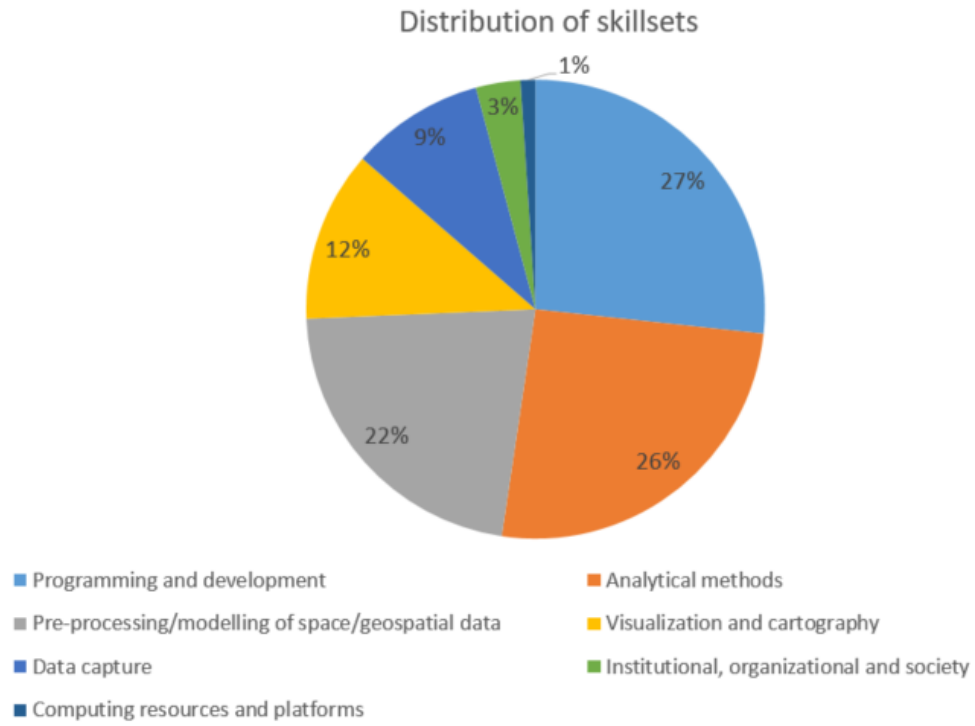
Figure 4 - Distribution of selected advertisements across the three ESCO profiles



For each job advertisement, the two most important skills sets were identified. Some of the job advertisements in the analysis however focused on one single skill set. The two most often required skill sets are “Programming and development” (27%) and “Analytical methods” (26%),

followed by “Pre-processing/modelling of space/geospatial data” (22%) (Figure 5). When compared to the results of the EO4GEO Demand Survey, ‘Visualization and cartography” is not part of the top 3, while “programming and development” was the fourth most important skill set according to the survey. With regard to the latter, some differences were already identified across organization types, whereas large companies and SMEs that participated in the survey seemed to attain a higher importance to this skill set.

Figure 5 - Distribution of skillsets (across all selected advertisements)



When comparing the required skills sets across the three ESCO profiles (Figure 6), it can be noticed that the three most important skill sets for “GIS Specialist” and “Remote sensing technician” are similar, but in a different order of importance. “Analytical methods” are more often attained to the profile of “remote sensing technician”. It is not surprising that the most attained skill set for the cartographer is “visualization and cartography”. At the same time, it should be mentioned that due to the low numbers of job advertisements related to this profile, the number of skill sets appointed to job advertisements with this profile was only 20.

When looking into more detail at the different occupations for the same ESCO profile, some differences across these labels can be noticed. For instance, while the three most important skill sets are the same across for example “GIS Developer” and “GIS Consultant”, the order and weight seems to be different (Figure 7). “Programming and development” as a skill set seems to be mentioned more frequent for the “GIS developer, while for “GIS Consultant” there is a bigger emphasis on “Analytical methods” (although “Programming and development is still the most

frequent classification). In other words, it is open for discussion whether these two labels are indeed the same profile or should be considered as different profiles.

Figure 6 - Distribution of skill sets: GIS Specialist – Remote sensing technician – Cartographer

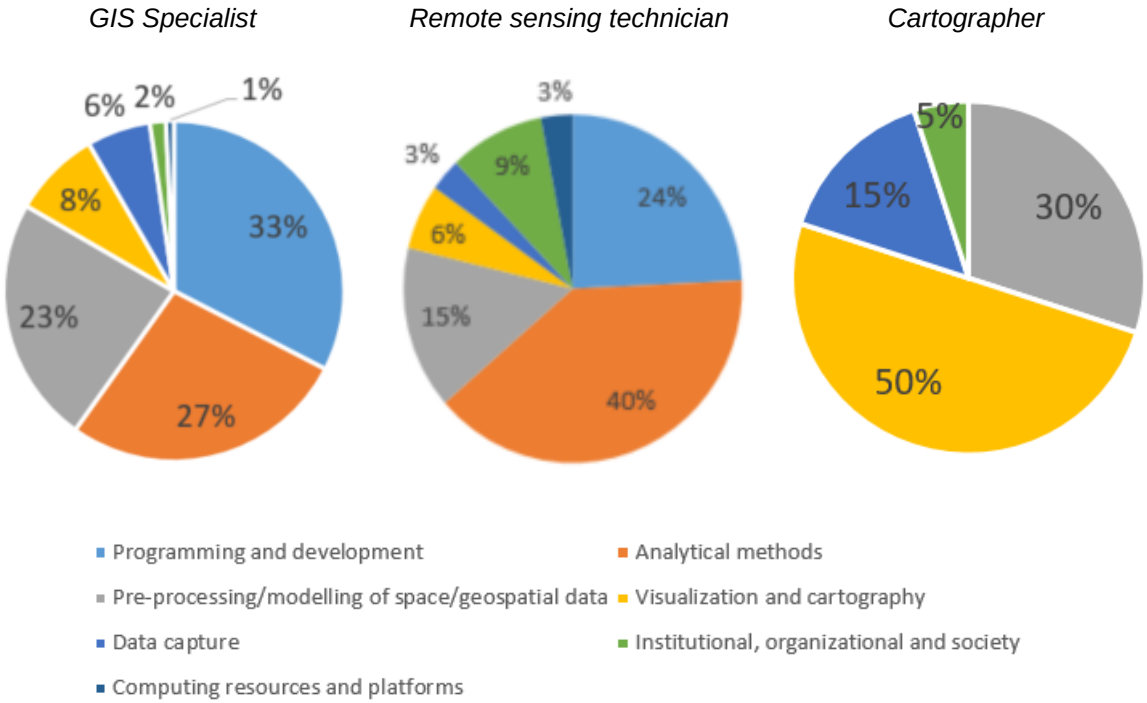
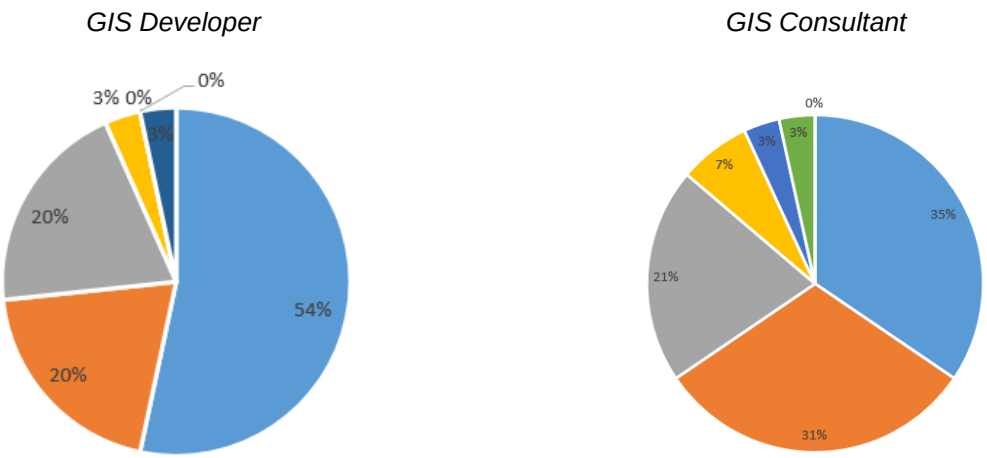
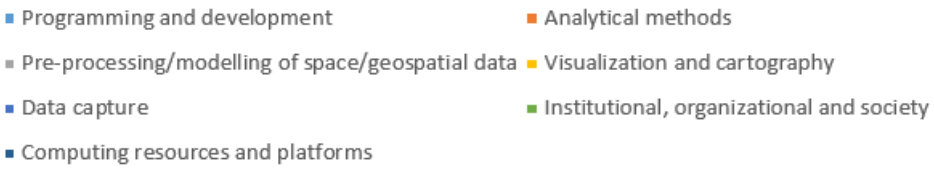


Figure 7 - Distribution of skill sets: GIS Developer versus GIS Consultant





5.3. Conclusion

The EO4GEO Job advertisement analysis aimed to complement the previous EO4GEO studies on EO/GI skills and skills needs by investigating existing job advertisements for jobs in the EO/GI sector. In addition to the most needed profiles (and related skills) resulting from the survey on demand, and the offer in terms of training and education from the supply side, this resulted in a more comprehensive view. Findings from the analysis show some (new) occupational profiles, especially within the ESCO profile of GIS Specialist. Current job advertisements demonstrated the existence of different types of GIS Specialists, of which the profile of GIS Developer is the most prominent in current job advertisements. Related to this, the analysis also points to the importance of skills related to 'Programming and development'. At the same time, skills related to the pre-defined skills sets 'Institutional, Organizational and Society' and especially 'Computing resources and Platforms' seem to be much less relevant in most of the recently published job advertisements.

Together with the results of the EO4GEO Demand Study, the job advertisements analysis provides valuable input to the revision of existing ESCO profiles related to the EO/GI domain. This input consists of new and/or redefined profiles, skills sets and underlying skills.

6. Workshop on assessing the skills shortages, gaps and mismatches between supply and (future) demand

On December 4th 2018, a second workshop focused on assessing the skill shortages, gaps and mismatches between the demand for EO/GI skills and competences and the supply of EO/GI education and training. The workshop consisted of several activities: individual expert presentations, discussions in smaller groups and a panel discussion among different experts. This chapter provides a brief summary and conclusions of this actions.

6.1. Scope and objectives

This workshop was organized for the definition of a Sector Skills Strategy for the space/geospatial sector, and focused on the identification of skills shortages, gaps and mismatches by analyzing the results of the EO4GEO Demand Survey and the EO4GEO Supply survey, which were enriched with new views, findings and opinions. Also future technological and non-technological trends and developments were taken into account and addressed in the workshop. The main goal of this assessment of skills shortages, gaps and mismatches was to provide input to the definition of the Sector Skills Strategy and to the development of a Body of Knowledge (BoK) for EO and GI. The assessment also identified inputs for the preparation of curricula by providing topics that eventually can be covered by the BoK for EO/GI and the VET curricula which will be built also upon this BoK.

The workshop consisted of three main activities:

- A set of presentations from experts in the EO/GI domain and/or experts in the skills assessments and the development of sector skill strategies on the topics of skills assessment, skills shortages and mismatches and the development of sector skill strategies;
- A set of break-out discussions in which participants discussed in smaller groups about one particular topic related to skills assessments and the future sector skills strategy;
- A panel debate among several of the experts who presented their ideas and views on the EO/GI skills assessment and sector skills strategy.

6.2. Conclusions

This second EO4GEO workshop on assessing the skills shortages, gaps and mismatches between supply and (future) demand, consisted of a series of presentations and discussions on the topics of skills assessments and skills strategy. The involvement of both EO/GI domain experts and experts with experience in either the design and/or implementation of skill assessment on the one hand or

the development of sector skill strategies on the other hand contributed to a fruitful exchange of views, experiences, best practices and lessons learned helped to better understand and gain insight in the new dynamics around EO/GI skills and occupational profiles, new trends in the space/geospatial sector and challenges and solutions of similar projects in other sectors.

Several key priorities and challenges of the EO4GEO project were mentioned multiple times during the workshop. Among these priorities and challenges are the need to link the EO4GEO studies and other activities with policy initiatives at national and European level; the importance of recognizing soft skills; the better integration of EO and GI education and training; improving stakeholders' input to the definition of learning outcomes and the emergence of new occupational profiles in the EO/GI sector.

The results and outcomes of the workshop complement the earlier and still ongoing work on mapping the supply of and demand for space/geospatial education and training, and assessing skills shortages, gaps and mismatches between supply and (future) demand. Therefore, the workshop can be seen as an important element in the process of preparing the Sector Skills Strategy for the space/geospatial sector.

7. Assessment of the skills needs and mismatch

Throughout this report the topic of skills assessment and skills mismatch in the EO/GI sector was approached from different perspectives. The EO4GEO Supply Study focused on the current supply of EO/GI education and training, and the skills that are developed and enhanced through different education and training initiatives and activities. The EO4GEO Demand Study looked at the skills and competencies required by professionals in various job roles in the sector. While the Demand Study mainly focused on current skills and occupations, an analysis of key trends, challenges and opportunities was executed to gain insight in how these trends and challenges could bring a need for new skills and occupations for the future EO/GI sector. Complementary to the EO4GEO Demand Study, an analysis was made of existing job advertisements in the domain of earth observation and geo-information, and the skills need and requirements expressed in existing job advertisements. The results of these analyses were further discussed and complemented with new views and insights from experts in EO/GI, skills assessments and skills strategies at the EO4GEO Workshop in Patras. The aim of this chapter is to put to results, insights and conclusions of these different activities together, in order to assess the skills mismatch between the demand for and supply of skills in the EO/GI sector.

7.1. Skills needs and mismatch as central concepts

In the literature and policy debates on gaps and differences between supply of and demand for skills, many similar and related terms are used, often interchangeable and without clear definition or explanation, which leads to confusion over the different terms used. To begin this chapter, a clarification is provided of some key terms used in the debate on skills needs (see McGuinness et al, 2017; and Green, 2016) .

Skills mismatch is the encompassing term which refers to various types of imbalances between the supply of skills and demand for skills (Green, 2016). Imbalance means that there are situations where the supply of skills is less than the demand, but also the opposite – less demand than supply – is possible. Particular concepts are used for each of these situations. When talking about the imbalance between supply and demand, skills mismatch is the preferred term. Also in this report, skills mismatch is used as the central term.

The concepts of skills shortages and skills gaps are used to refer to the situation where the supply of skills is less than the demand for skills. Skills shortage refers to the situation when supply is less than demand on the skilled job market. Key indicator for skills shortages are vacancies for skilled workers that are hard to fill. Skills shortages happen when the demand for people with certain skills is higher than the number of people available with those skills. This does not necessary means that those skills are not provide by the current education and training system. The term skills gap on the other hand, is often used for the situation where demand exceeds supply internally within a firm or

organization. But sometimes the concept of skills gaps is used to refer to a gap in the current education and training system, that is not able to provide people with the necessary skills.

It is important to notice that the evidence collected in various WP1 activities does not directly deal with skills shortages and skills gaps, but rather are about skills needs, and about the mismatch between skills as addressed and developed in EO/GI education and the skills required by the EO/GI job market. For this reason, we prefer the use of these two terms when discussing the results of the EO4GEO studies.

It should however be noticed that also a situation might arise or exist where the supply of skills is greater than demand in the market for skills. As a result, skilled workers might not be able to find an appropriate job, or could be in work but not fully utilize their skills and education in their current workplace. In other words, they could be over-skilled or over-educated. Also in this way, there might be a mismatch between supply and demand for skills.

Finally, also a situation where a balance exists between skills supplied and skills demand, can be sub-optimal (Green, 2016). This is expressed by the term ‘skills deficit”, which refers to a job market in equilibrium with supply equaling demand, yet both supply and demand are below what they could be. In this ‘low-skills equilibrium’, employers have to low ambitions or are too risk averse in their search for skills, while at the same time the skills of workers and job searchers remain too low. When investigating the skills-related problems and challenges in the EO/GI sector, also the existence of a skills deficit should be taken into consideration.

7.2. Occupational profiles

ESCO is the multilingual classification of European Skills, Competences, Qualifications and Occupations. The ESCO classification identifies and categorizes skills, competences, qualifications and occupations relevant for the EU labour market and education and training, and systematically shows the relationships between the different concepts. ***ESCO*** currently contains three occupations related to the EO/GI domain:

- **Geographic information systems specialist:** Geographic information systems specialists use specialised computer systems, engineering measures, and geological concepts to process land, geographic, and geospatial information into visually detailed digital maps and geomodels of a reservoir. They convert technical information like soil density and properties into digital representations of it for the usage of engineers, governments, and stakeholders interested.
- **Remote sensing technician:** Remote sensing technicians collect airborne data. They utilise equipment aimed for the collection of data and determination of geographical points in order to help in a variety of operations such as land conservation, urban planning, and military operations.

- **Cartographer:** Cartographers create maps by combining various scientific information depending of the purpose of the map (e.g. topographic, urban, or political maps). They combine the interpretation of mathematical notes and measurements with the aesthetics and visual depiction of the site for developing the maps. They may also work on developing and improving geographic information systems and may perform scientific research within cartography.

Each ESCO occupational profile consists of a preferred main term and several other labels for the same occupation. Also for the three abovementioned profiles several alternative labels are provided:

- **Geographic information systems specialist:** geographic information systems expert; geographic information systems consultant; GIS specialist; GIS mapping technician; GIS mapping assistant; GIS application specialist; GIS data specialist; geomatics technician; geographic information systems adviser; GIS analyst; GIS technician; specialist in geographic information systems;

- **Remote sensing technician:** remote sensing technologist; remote sensing technology studies scientist; remote sensing technology studies researcher; remote sensing technology studies scholar; remote sensing technology research analyst; remote sensing technology research scientist; remote sensing technology science researcher; remote sensing technology studies analyst; remote sensing technology analyst; remote sensing technology scholar; remote sensing technology studies research analyst; remote sensing technology researcher; remote sensing technology studies research scientist; remote sensing technology scientist;

- **Cartographer:** cartographic draftsperson; cartographers; cartographic scientist; cartographic research analyst; map maker; cartographic analyst; cartographic drafter; cartographic science researcher; cartographic research scientist; cartographic researcher.

Also in the ***EO4GEO Supply Study*** and Survey occupational profiles were addressed, through several of the questions in the survey. To begin, the survey respondents were asked to select the EO/GI related profile that best matches their own position. Respondents could select out of four predefined profiles:

- **EO/GI data/service expert (including analyst, researcher, educator**): selected by around 50% of the respondents, working in various sectors, but most of them in the public sector

- **EO/GI data/service manager:** selected by around 17% of the respondents, mainly working at an SME

- **EO/GI data/service user:** selected by around 16% of the respondents, mainly working in the public sector

- **EO/GI data/service technician:** selected by around 8% of the respondents, mainly working in the public sector

Occupational profiles were also central in the second part of the questionnaire, which aimed to discover the most needed EO/GI related profiles and skills. In the beginning of the questionnaire, respondents were asked to name the one most needed job position or occupational profile in their own organization. Although this was an open question, some examples of possible positions/profiles were provided to the respondent, including GIS Developer and Remote Sensing Technician. Not surprisingly, these two exemplar profiles were the two most often mentioned profiles.

The ***EO4GEO Demand Study*** also included a series of interviews with both industrial and public sector actors in the EO/GI domain, to complement the results and outcomes of the survey. Central topics covered in the interviews were the activities and customers of the organization in the sector, their tasks and workflows, and workforce development. Based on the results of both the interviews and the survey, three main occupational profiles were identified, which already linked occupations with required skills:

- **EO/GI developer (master level):** The technically oriented master level EO/GI graduate that is proficient in data related skills and has programming and development skills. This profile requires additional skills in analytical methods, visualization, data capture and management required for the development of EO/GI products and services.

- **EO/GI data analyst (master level**): The analysis oriented master level EO/GI graduate that is highly proficient in space/geospatial data skills and analytical methods; the profile is complemented by skills in visualization, programming and development and data capture and management.

- **EO/GI specialist / project manager (PhD level):** The PhD level EO/GI graduate that is highly proficient not only in the tasks of the analysis and technically oriented master but also proficient in the skills of EO/GI and society, computing resources and platforms, and organizational and institutional aspects.

The investigation of ***job advertisements*** in the EO/GI domain, also helped in identifying main job profiles currently needed in the EO/GI domain. Based on existing EO/GI related job advertisements, seven main profiles were detected: Remote sensing specialists (24% of the investigated job advertisements), GIS Developer (17%), GIS – Data – Specialist (15%), GIS Consultant (14%), GIS Technician (12%), GIS Analyst (10%) and Cartographer (9%)

The findings from the job advertisement analysis show that

- Cartography and cartographer still is a relevant domain/occupation, but its importance in the current EO/GI job market is relatively limited (less than 10% of all job advertisements)

- Remote sensing (specialist) constitutes the biggest part of the detected job advertisements, with around one fourth of the detected job advertisements

- The remaining job advertisements all deal with a GIS related job or occupation, of which the most often needed are GIS Developers, GIS Specialist and GIS Consultants. This can be seen as an indication of the need to make a clear distinction between different GIS profiles, and move away from the general profile of 'GIS Specialist' as used in ESCO.

The observation that the three occupational profiles as currently included in ESCO no longer cover the skills and occupations currently needed in the EO/GI job market, was also made during the Workshop in Patras, through which the results on the EO/GI skills assessments were discussed. One of the suggested profiles here, was the profile of a 'EO/GI Broker', who should be responsible – and capable for – establishing a link between the current offer of EO services and the demand by users. Another suggestion raised was the need to move away of thinking – and acting – in terms of occupational profiles, but focus more on combinations or 'portfolios' of skills. Especially in the future, work will be organized and execute in work teams, consisting of profiles with different skills combinations.

All things considered, we can conclude that there definitely is a need to revise the occupational profiles as currently defined in ESCO. The various studies and analyses seem to indicate two ways to do this. One way is the development of integrated profiles, covering both EO/GI . Another way, is to especially revise the profile of 'GIS Specialist', and divide this profile in different separate profiles, such as GIS Developer, GIS Analyst and/or GIS Data Specialist. Especially the creation of a 'Developer' related occupational profile, is considered to be essential. The same could also be done for the profile of remote sensing technician (or experts). However, the focus should not be too much on occupational profiles, but rather on skills and particular combinations of skills sets and underlying skills. Occupational profiles should mainly be seen as a way to describe a particular configuration of skills.

7.3. Skills needs

The identification of skills requirements and needs in the EO/GI sector was the central element in the various studies and activities in preparation of the Sector Skills Strategy. Besides looking at the different existing and needed occupational profiles, several types of empirical evidence – and input from stakeholders – was also collected on the skills needs in the sector. Again, the ESCO classification provides a valuable starting point, since skills and competences is one of the three main pillars of this classification (besides occupations and qualifications). If we use the three EO/GI related occupational profiles as basis and map the skills that are defined to be essential or optional to these occupations, we can establish a first list of EO/GI skills. Table 8 provides an overview of the skills listed by ESCO, and how they are linked to each of the three profiles.

Table 8 - Skills needs of the ESCO EO/GI Occupations

	GIS specialist		Remote sensing technician		Cartographer	
	Essential	Optional	Essential	Optional	Essential	Optional
Analyse environmental data		X				

Apply desktop publishing techniques						X
Apply digital mapping	X			X	X	
Apply statistical analysis techniques	X					
Archive scientific documentation						X
Assist scientific research				X		X
Collect data using GPS		X	X			X
Collect geological data		X				
Collect mapping data	X					
Collect mapping data				X	X	
Compile GIS-data	X			X	X	
Conduct field work						X
Conduct land surveys		X				
Conduct quantitative research						X
Conduct research on climate processes				X		
Conduct scholarly research						X
Create cadastral maps				X		
Create GIS reports	X			X	X	
Create strategic maps				X		
Create thematic maps	X			X	X	
Design customised maps						X
Design graphics						X
Develop geological databases		X		X		
Draft legends					X	
Execute analytical mathematical calculations	X		X		X	
Handle geospatial technologies					X	
Identify customer's needs						X
Improve user-friendliness					X	
Interpret geophysical data		X		X		
Keep task records			X			
Operate remote sensing equipment				X		
Operate scientific measuring equipment						X
Operate surveying instruments		X				
Perform image editing		X				
Perform scientific research						X
Perform surveying calculations	X					X
Possess visual literacy			X			
Prepare geological map sections				X		
Prepare visual data		X				
Process collected survey data	X					X
Report analysis results						X
Research remote sensing technologies				X		
Study aerial photos			X			X
Study radar images			X			
Use CAD software		X		X		X
Use digital illustration techniques						X
Use geographic information systems	X		X		X	
Use software for data preservation						X
Use traditional illustration techniques						X
Write work-related reports		X				

Three interesting observations can be made based on this table:

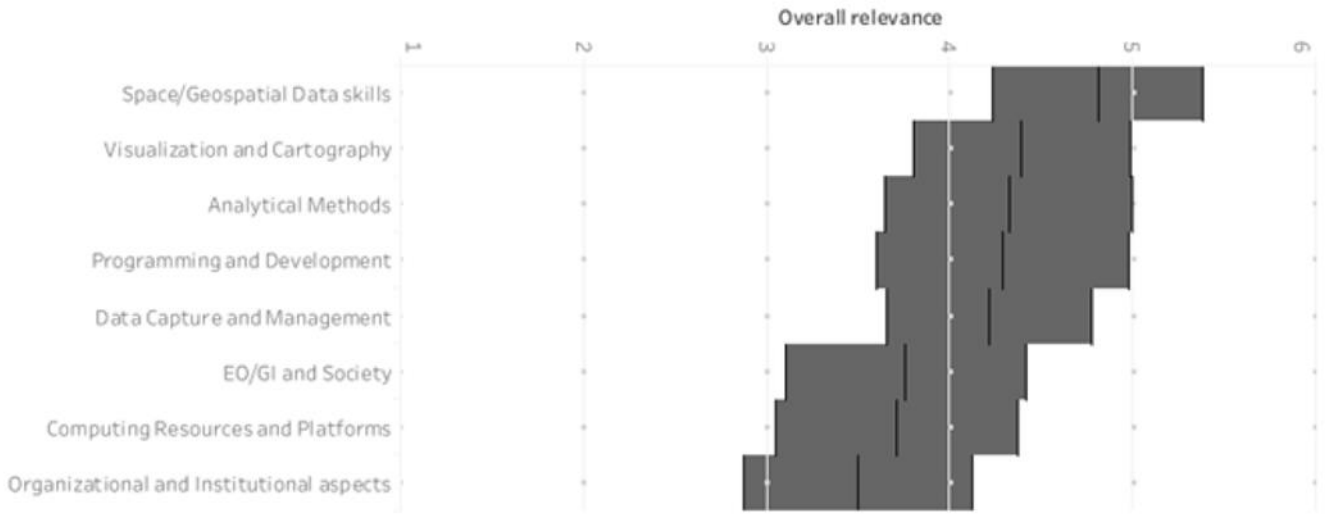
1. There are two skills that are seen as an essential skill for all three occupations: the use of geographic information systems and execute analytical mathematical calculations. In total, there are eight skills that are defined as essential or optional to all three profiles: apply digital mapping, collect data using GPS, compile GIS-data, execute analytical mathematical calculations, create GIS reports, create thematic maps, use digital illustration techniques and use geographic information systems

2. Several skills also are seen as essential to two of the profiles. These include: apply digital mapping, compile GIS data, create GIS reports and create thematic reports. In all four cases, the skills are defined as essential for both GIS specialists and cartographers.

3. The list of identified skills for cartographers is more comprehensive for cartographers (10 essential skills, 20 optional), compared to the skills for GIS specialist (10 essential, 10 optional) and remote sensing technicians (7 essential, 15 optional). Especially interesting to notice is that the list of skills of cartographers also include several more general skills, such as improve user-friendliness, identify customer's needs, design graphics and report analysis results.

In the ***EO4GEO Demand Study***, the need for skills was further investigated in the survey, by asking the respondents to first indicate the relevance of the different skills sets and afterwards also select the most relevant skills within each set. When looking at the scoring of the relevance of the eight pre-defined skills sets, it can be seen that the skill sets 'Space/Geospatial Data skills', 'Visualization and Cartography' and Analytical Methods are considered to be the most relevant sets of skills. This finding is confirmed by looking at the average scoring of the relevance of the individual skills within each of the skill sets (see Table 4 in this report).

Figure 8 - The overall relevance of the EO/GI skill sets, ordered by mean relevance rating



Also at the level of the specific skills, a list of most relevant skills can be made. The exercise made in chapter 3 of this report shows that the five most relevant or essential skills – across all occupational profiles – are the extraction, transformation and loading of EO/GI data, the interpretation and evaluation of maps, the interpretation of EO/GI data, the automation of EO/GI data and data preparation and maps design.

The ***EO4GEO Job advertisement analysis*** investigated the need for skills in the EO/GI sector based on the recently published job advertisements in the sector. All skills needs included in the vacancies were collected and further analyzed. The analysis followed the list of skill sets as used in the EO4GEO Demand Survey. However, during the analysis it was decided to combine the skills sets 'EO/GI and Society' and 'Organizational and Institutional Aspects' into one overarching skills set 'Institutional, Organizational and Society'. It should be noticed that in the job advertisements investigated, very little evidence was found for the need for skills related to Institutional, Organizational and Society. Less than 3% of the detected skills, were related to this skill set of 'Institutional, Organizational and Society'. The skill set 'Computing Resources and Platforms' was even less recognized in existing job advertisements (1% of the skills).

While the skills sets 'Visualization and Cartography' (12%) and 'Data Capture' (9%) clearly were more relevant in current EO/GI job advertisements, especially the three other skills sets were very present in these vacancies. With 27% of the mentioned skills, the skill set 'Programming and development' was the most prominent skills set in the recent vacancies for the EO/GI job market. Also 'Analytical Methods' (26%) and the newly defined skills set 'Pre-processing and modelling of data' (22%) were highly relevant, according to the job advertisements. The Job advertisement Analysis also demonstrated the different composition of skills needs across the three main occupational profiles as defined in ESCO. The profile of 'GIS Specialist' requires a balanced mix of

skills related to 'Programming and Development', 'Analytical Methods' and 'Pre-processing and Modelling of Data'. The key skills set for the profile of 'Remote Sensing Technicians' is 'Analytical Methods', in combination with especially 'Programming and Developing'. Cartographers hardly need competences related to 'Programming and Developing', but have one dominant skills set: Visualization and Cartography. However, the job advertisement analysis also confirmed the existence of different underlying profiles within the profile of 'GIS Specialist'. Many vacancies required a profile of 'GIS Developer', for which the skill set 'Programming and Developing' is dominant. The profile of 'GIS Consultant' required a more balanced combination of the different skill sets, and especially the skills related to 'Analytical Methods', 'Programming and Developing' and 'Pre-processing and Modelling of Data'.

Finally, also the Patras workshop touched more deeply on the issue of skills and skill needs in the EO/GI sector, with several presentations and discussions on this topic. As mentioned before, the importance of 'skills combinations' was repeated several times during this workshop. Also soft skills should not be neglected, many jobs in the EO/GI job market especially require workers to be communicative and to be able to understand and translate user needs. Also 'adaptability' was mentioned in this context, i.e. workers should be able to recognize and react to new – technological – developments. Looking back at the skills as included in ESCO, it is interesting to see how these so-called soft skills were recognized to be important, but only for the profile of cartographer.

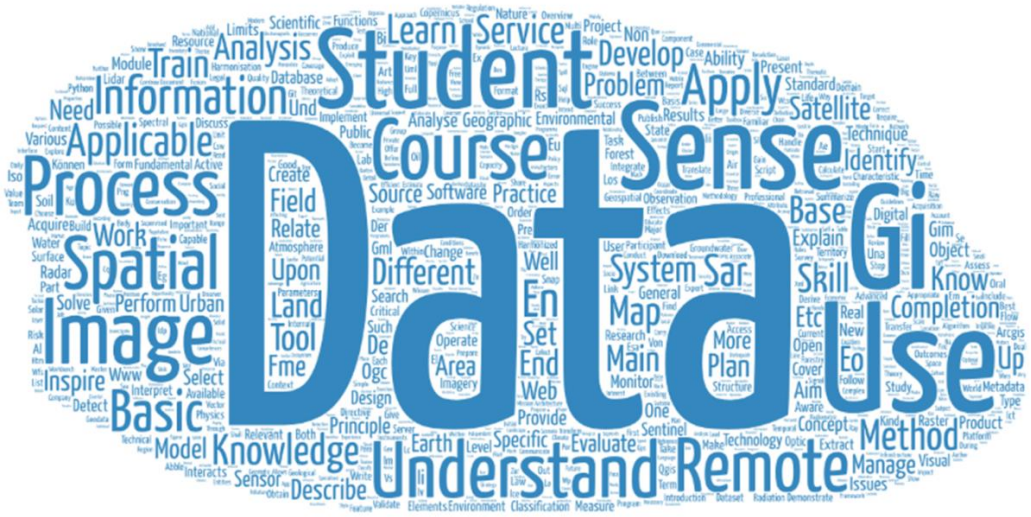
In summary, the results and findings from the various analyses seem to indicate a clear need to revise the skills as currently used in ESCO for describing relevant EO/GI skills. With the definition of several skills sets, the EO4GEO Demand Study delivered an important contribution to the work on defining skills for the EO/GI sector. The use of this list of skills sets in the EO4GEO Demand Survey demonstrated the importance of skills related to space/geospatial data, visualization and cartography and analytical methods. The job vacancy analysis not only proposed a simplification and clarification of the eight skills sets into seven well-defined skills sets, but also explored the presence of these sets into existing job advertisements for EO/GI related jobs. These job advertisements seems to indicate a lower importance of skills related to 'Computing Resources and Platforms' and to 'Institutional, Organizational and Society. Finally, also so-called soft skills should be taking into consideration in thinking and acting about skills for the EO/GI sector. Not only in the definition of occupational profiles as particular 'skills configurations' should soft skills such as communication and commercial skills be included, also EO/GI training and education should address the acquisition and development of these skills.

7.4. Supply of EO/GI Skills

It was the aim of the EO4GEO Supply Study to map and further investigate the current supply of EO/GI training and education in Europe. The Study was successful in doing this, with the identification of more than 1000 education and training resources in Europe, including courses, programs and lectures at Master level and Bachelor level and various types of vocational training

initiatives and actions. The best way to gain insight in the scope and content of these education and training activities is by analyzing their learning outcomes. A first explorative analysis of the content of these resources showed a distinction between GI education and training on one hand, and EO education and training on the other hand. With regard to EO education and training, a further distinction was made between basic, advanced and domain-specific courses and training initiatives.

Figure 9 - Word cloud of concepts in EO/GI learning objectives



A text analysis of the learning outcomes of the different EO/GI education and training resources could contribute to investigate the content of these resources. To illustrate this, figure 15 provides a word cloud of the most often used terms in the learning outcomes as defined for the EO/GI education and training resources. The figure clearly shows the importance of ‘data’ as central concept in these courses, with remote sensing, spatial and GI as related concepts.

Especially interesting to notice is the presence of different verbs, which refer to different levels of Bloom's Taxonomy (e.g. Bloom, 1956). Bloom’s Taxonomy is a classification of thinking or cognitive skills, which is often used in the design of educational, training and learning processes, and especially in the definition of learning outcomes. The idea behind it was to promote higher forms of thinking in education, such as analyzing and evaluation, rather than just remembering things. Bloom’s Taxonomy consist of six levels of thinking skills, ranged from lower order thinking skills to higher order thinking skills. Table 9 shows the six levels, some main verbs associated with them, and the extent to which these verbs are used in the learning outcomes of the EO/GI training and education resources.

Table 9 - EO/GI learning objectives according to Bloom's Taxonomy[6]

Levels of learning	**Active verbs (and number of references in EO/GI)**	**Examples of use in EO/GI**
Remember: *can the student remember information?*	Know (113) Describe (37)	"Know the main components of Geographic Information Systems" "Describe the theory and the technology behind laser scanning and digital photogrammetry"
Understand: *can the student explain concepts?*	Understand (131) Explain (27) Summarize (13)	"Understand the fundamentals of Geographic Information Science" "Explain how digital images are acquired by satellite sensors." "Summarize current theories on RS methods"
Apply: *can the student use information in a new way?*	Use (77) Apply (50) Perform (26) Demonstrate (12)	"Apply the principles of solar radiation transfer in the atmosphere" "Perform a data transformation from a non-harmonized source dataset into an harmonized one"
Analyze: *can the student identify parts and their relationship?*	Analyze (107) Review (6)	"Analyze remote sensing images"" "Critically review and analyze projects that have been conducted using GIS."
Evaluate: *can the student justify a position?*	Evaluate (25)	"Evaluate the possibility of applying GIS in some area" "Critically evaluate proposed remote sensing solutions"
Create: *can the students produce new products, theories or points of view?*	Design (21)	"Design an image process, from starting image to statistical and cartographic results" "Design and implement software to solve simplified although realistic positioning problems"

[6] An interesting initiative in this context is the Taxonomy for the EO Services Market developed by EARS. See: http://earsc.org/eo-information/eo-taxonomy

(Source: data supply survey; Bloom, 1956)

The use of different verbs clearly shows the different levels of learning in the current supply of education and training in the EO/GI domain. The table demonstrates that the current EO/GI education and training clearly targets the different levels of learning, and goes further than just memorizing and remembering. If we however neglect the verbs and look at the different topics mentioned in the learning objectives, we get a better view of the precise content of EO/GI education and training in Europe. While data (263 references in the learning outcomes), remote sensing (113) and GIS (80) are the three most mentioned concepts in the learning outcomes and can be considered as the central topics in EO/GI education, other often mentioned concepts show the importance of sub-topics such as analysis (60 references), processing (61), satellite(s) (42), applications (40), INSPIRE (38), systems (37), techniques (30), and image processing (24). In this way, also an investigation can be made of the extent to which different terms and concepts used for describing skills needs are also included in the learning outcomes of current EO/GI education and training.

However, the data currently available on learning outcomes and the explorative investigation of these learning outcomes so far, does not allow a correct and complete analysis of the content of current EO/GI education and training, and how it matches the skills as required by the EO/GI job market. Our explorative investigation presented in this chapter shows the need to do this, and can be seen as a call for a more systematic mapping of the learning outcomes of different EO/GI education and training resources in Europe. With the identification of more than 1000 different education and training resources, EO4GEO already has developed an important starting point for this analysis. Some information on learning objectives already has been collected, but should be further checked and validated. Some information still is missing and should be collected. Learning objectives are crucial for a good understanding of the scope and content of education and training resources. At the same time, well-defined learning outcomes are essential in the design and implementation of education and training, since they determine the most appropriate learning and teaching activities, and the most effective ways of assessment. Therefore, EO4GEO should support educators, teachers and trainers in the development of good learning objectives.

But prior to the development of learning objectives, agreement should be found on the central topics of EO/GI education and training. These should be derived from the skills as required by the EO/GI sector and job market. In that sense, the analysis of the skills needs should be leading in the design and implementation of EO/GI education and training. However, there already is a large supply of EO/GI education and training in Europe, consisting of various programs and courses at master level and bachelor level, vocational education initiatives and actions, different types of online courses and programs, etc. EO4GEO should reflect on best ways to improve existing education and training, but also to add new elements to the existing education and training offer. Also differences between target groups should be taken into consideration. Education on EO/GI should start at primary and secondary level, and particular actions are needed to address students and teachers at primary and secondary schools. At the level of higher education, not only the difference between bachelor level and master level is relevant, but also between core EO/GI programs and courses, and other programs/courses in which EO/GI is less central but still – potentially – relevant. Capacity building in the EO/GI sector should not only consist of – academic-

education, also vocational training will be an important pillar. With regard to ~~training~~ up-skilling and up-dating on EO/GI, not only workers already active in the EO/GI sector should be addressed, but also workers in other sectors should be recognized as a target group.

8. Conclusions

The first part of the EO4GEO project deals with the preparation of the development of a sector skills strategy for the space/geospatial sector. Several preparatory activities have been undertaken as input to the development of this strategy, including studies of both the demand for and supply of EO/GI education in Europe and an analysis of key trends and challenges in or related to the EO/GI sector. This report provides a discussion and further analysis of the main results and findings of each of these prior studies and analyses, which in the context of preparing these report were complemented with two new activities: a job advertisements analysis in which recent job advertisements for jobs in the EO/GI sector are investigated, and a workshop in Patras on the topic of skills assessment and skills strategies. Also the results and findings of these two activities are presented and discussed in this report. The collection and discussion of the outcomes of these various activities should help us to better understand the skills needs and skills mismatch in the EO/GI sector. In the conclusion of this report, we think it's important to explore and clarify the extent to which we actually are able now to better understand these skills needs and mismatch.

With the definition of several EO/GI skills sets, each composed of several underlying skills, a new way of thinking about skills needs in the EO/GI sector was introduced. In the EO4GEO Demand Survey, an initial list of eight skills sets was defined, and used to investigate the need for EO/GI skills through the EO4GEO Demand Survey. The job vacancy analysis built further on this initial list, proposed some modifications and improvements, and tested the skills sets on existing job advertisements for jobs in the EO/GI sector. In the next stages of the EO4GEO project, the EO/GI skills sets should be further developed, which means agreement should be found on both the main skills sets and the underlying skills.

Actions to better address skills needs and the potential skills mismatch, should not focus too much on occupational profiles. The EO/GI sector and job market is mainly looking for specific combinations or configurations of skills. Identifying the most needed configurations of skills, including both domain specific and more general – soft – skills, will be crucial. Occupational profiles will rather become a way to describe a particular configuration of skills. Some work was already done on exploring and suggesting configurations of skills, the next stages of EO4GEO should lead to the definition of some key profiles as configurations of skills. It can be expected that these configurations will included skills that are at present not sufficiently recognized, such as skills related to programming and development. Although some progress has been made in exploring the skills mismatch in the EO/GI sector, still a lot needs to be done in order to be able to fully understand the EO/GI skills mismatch. EO4GEO has been successful in mapping the EO/GI education and training landscape, with the identification of around thousand different education and training resources. Here, the next step will be the investigation of the learning objectives of these resources, which means information on these learning objectives should be collected first and afterwards analyzed in a structured and systematic manner. The EO/GI Body of Knowledge will be an important tool enabling and supporting this analysis, defining the core concepts in the EO/GI domain. These concepts could be translated into skills demanded by the EO/GI sector as well as into learning objectives addressed by EO/GI education and training. In this way, the EO/GI

Body of Knowledge is crucial for establishing a link between the Supply of and the Demand for EO/GI skills.

References

Aguilar Moreno, E., Hofer, B., Lang, S. (2018) *D1.2.- Workshop on Demand for Space/Geospatial Education and training.* Report prepared in the context of Erasmus+EO4GEO – Towards an Innovative Strategy for Skills Development and Capacity Building in the Space Geoinformation Sector Supporting Copernicus.

Ahsan, K. & Ho, M. & Khan, S. (2013) Recruiting Project Managers: A Comparative Analysis of Competencies and Recruitment Signals From Job Advertisements. *Project management Journal.* 44.5: 36-54

Albrecht, F., d'Oleire Oltmanns, S., Ferber, N., Hofer, B. & Lang, S. (2018) *D1.3.- Demand for space/geospaital education and training and priority occupational profiles.* Report prepared in the context of Erasmus+EO4GEO – Towards an Innovative Strategy for Skills Development and Capacity Building in the Space Geoinformation Sector Supporting Copernicus.

Bennet, R. (2002) Employers' Demands for Personal Transferable Skills in Graduates: a content analysis of 1000 job advertisements and an associated empirical study. *Journal of Vocational Education and Training.* 54.4: 457-476

Bloom, B.S. (1956) *Taxonomy of educational objectives: The classification of educational goals: Handbook I, Cognitive Domain.* New York: Longmans green and company, pp. 207

Clyde, L.A. (2013) An Instructional Role for Librarians: An Overview and Content Analysis of Job Advertisements. *Australian Academic & Research Libraries.* 33.3: 150- 167

Copeland, MS. A.W. (1997) The demand for serials catalogers. An analysis of job advertisements, 1980- 1995. *The serials Librarian. From the printed Page to the Digital Age.* 32. 1-2: 27-37

Duverge, G (2017) *Turning Posts Into Positions: The Rise of Social Media Recruitment.* [Online] https://online.concordia.edu/human-resource-management/social-media-recruitment-growth/ (accessed on 26th of December, 2018)

ESCO (n.d.,a) *Occupations* [Online] https://ec.europa.eu/esco/portal/occupation (accessed on 23rd of December, 2018)

ESCO (n.d.,b) *Occupation* [Online] https://ec.europa.eu/esco/portal/escopedia/Occupation (accessed on 24th of December, 2018)

Green, F. (2016). *Skills Demand, Training and Skills Mismatch: A Review of Key Concepts, Theory and Evidence.* Future of Skills & Lifelong Learning Evidence Review. Foresight, Government Office for Science.

Harper, R. (2010) The collection and analysis of job advertisements: a review of research methodology. *Library and Information Research.* 36.112: 29- 54

Joos, J.G. (2008) Social media: New frontiers in hiring and recruiting. *Employment relations* . 35.1: 51-50

Kennan, M.A., Willard, P., Cecez-Kecmanovic, D., Wilson, C.S. (2008) IS Knowledge and Skills Sought by Employers: A Content Analysis of Australian IS Early Career Online Job Advertisements. *Australasian Journal of Information Systems.* 15.2: 22 pages

Kim, J, Edward, W. & William, M. (2013)Competencies required for digital curation: an analysis of job advertisements. *International Journal of digital curation.* 8.1: 66-83

LinkedIN (2018) *About LinkedIN* [Online] https://about.linkedin.com/ (accessed on 26th of December, 2018)

Manroop, L. & Richardson, J. (2013) Using Social media for Job search: Evidence from Generation Y Job Seekers. *Social media in Human Resources management.* 12: 167-180

McGuinness, S., Pouliakas, K., & Redmond, P. (2018). Skills mismatch: concepts, measurement and policy approaches. *Journal of Economic Surveys*. 0.00: 1-31.

Nikolaou (2014) Social Networking Web sites in Job Search and Employee Recruitment. *International Journal of Selection and Assessment.* 22.2: 179-189

Parez, M. (2013) Linked Into a Job?: The ethical Considerations of Recruiting Through LinkedIn. *Management.* Paper I

Sakethoo, D.D., Covey, A.M., Sunshine, J. & Forman, H.P. (2002) Updated findings from a help wanted index of job advertisements and an analysis of the policy implications: Is the job-market shortage for diagnostic radiologists stabilizing? *American Journal of Roentgenology.* 197: 851-858

Sodhi, M.S. & Son, B.G. (2010) Content analysis of OR job advertisements to infer required skills. *Journal of the Operational Research Society.* 61.9: 1315-1327

Snyman, R. (2001) Do employers really know what they want? An analysis of job advertisements for information and knowledge managers? *ASLIB Proceedings*. 53:7: 273- 281

Utz, S. (2015) Is LinkedIn making you more successful? The informational benefits derived from public social media. *New Media & Society.* 18.11: 243-252

Annexes

Annex 1 – Agenda of the EO4GEO Workshop in Patras

Workshop on assessing the skills shortages, gaps and mismatches between supply and (future) demand

December 4th 2018, from 09.00 to 17.00

	Chair: Danny Vandenbroucke (KU Leuven)
09:00-09:30	*Welcome and Registration*
9:30-13:00	**Workshop on assessing the skills shortages, gaps and mismatches between supply and (future) demand (Morning session)**
9:30-9:45	Welcome and introduction, *Prof. Vassilis Anastassopoulos*, Administrative Board Member of Hellenic Space Agency (University of Patras)
9:45-10:00	Introduction to and objectives of the workshop, *Danny Vandenbroucke* (KU Leuven)
10:00 -10:20	Methodology and results of the skills gaps analysis, *Wesley Gruijthuijsen, Maria Saudade Pontes* (KU Leuven)
10:20 -10:40	Skills shortages in EO sector, *Emanuele Barreca* (DG Grow)
10:40 -11:00	SEnDIng project: Design of VET programmes for Data Science and Internet of Things professionals, *Maria Rigou* (University of Patras)
11:00 -11:30	***Coffee break***
11:30 -11:50	MATES - Maritime Alliance for fostering the European Blue economy through a Marine Technology Skilling Strategy, *George Tsafonias* (CERT)
11.50 - 12.10	Coordinating and integRating state-of-the-art Earth Observation Activities, *Haris Kontoes* (GEO-CRADLE)
12:10 -12:30	Identifying skill needs in fast-changing times: the value of skills intelligence, *Stelina Chatzichristou* (Cedefop) (teleconf.)
12:30 -12:50	Skills for the innovation & development of SME's, *Stelios Bollanos* (Planetek)
10'	Questions on the presentations
Lunch 13:00-14:00	

14:00 - 17:00	**Workshop on assessing the skills shortages, gaps and mismatches between supply and (future) demand (Afternoon session)**
14:00 - 14:10	Breakout Groups introduction *Mónica Miguel-Lago* (EARSC)
14:10 -	Breakout Groups will discuss 2 or 3 questions

15:00	Group 1 (Key skills and competences) - Chaired by *Ilaria D'Auria* (Nereus) Group 2 (Future skills and competences) - Chaired by *Stelios Bollanos* (Planetek) Group 3 (Actions to bridge the gap) - Chaired by *Marc Olijslagers* (KU Leuven)
15'	***Short break (or coffee break)***
15:15 - 15:30	insights from the breakout groups: summaries of the findings for each group (Respective rapporteurs)
15:30 - 16:40	Panel discussion on the blue print project chaired by *Peter Zeil* (SpaSe) • *Maria Rigou* (SEnDIng) • *Haris Kontoes* (GEO-CRADLE) • *Stelina Chatzichristou* (CEDEFOP) • *George Tsafonias* (CERT) • *Emanuele Barreca* (DG Grow)
16:40 - 17:00	Wrap-up: conclusions of the day - *Danny Vandenbroucke* (KU Leuven) and next steps (GISIG)