Geographical Information Management and Applications

GIMA

Master of Science Thesis

User-Centered Design of a Scientific Geographic Information Infrastructure for the Balearic Islands University

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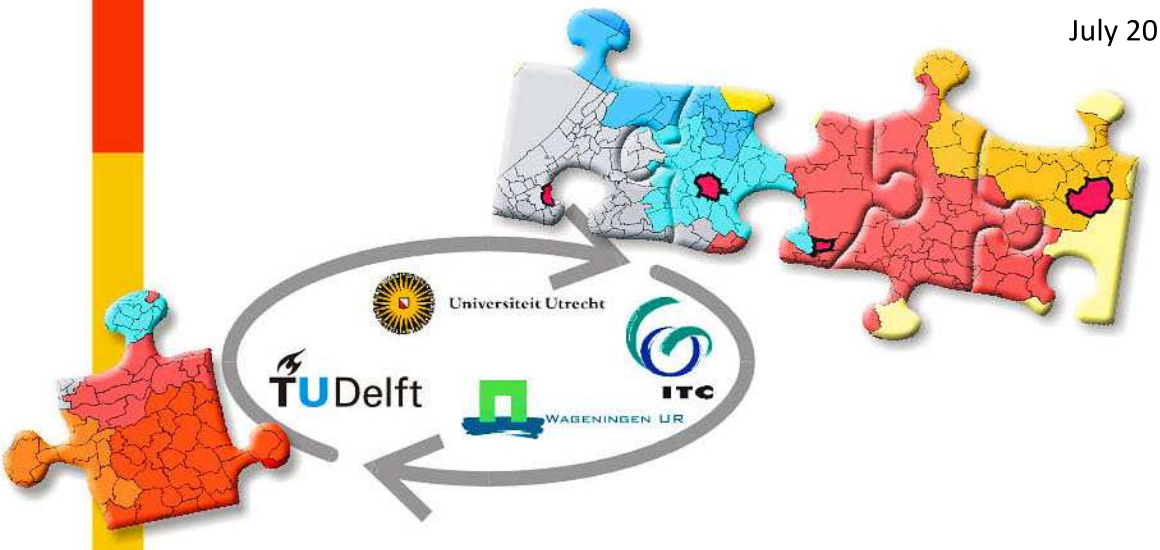

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Title: User-Centred Design of a Scientific Geographical Information Infrastructure for the Balearic Islands University

Master of Science in Geographical Information Management and Applications (GIMA MSc)

Utrecht University (UU), Technical University of Delft (TUD), Wageningen University and Research Centre (WUR), and Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente (UT); in collaboration with the Balearic Islands University (UIB).

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“We are all very ignorant. What happens is that we all not ignore the same things”
Albert Einstein

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This is the result from a long and difficult journey through scientific knowledge management, distributed GIS, and user needs. This thesis represents a long period of research, mental efforts, hard work and perseverance, with good days and nights of progress, and much more others of uncertainty and doubt. However, in the end, once finished, the best reward is the simple self-proud for being able to overcome such difficulties.

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Llorenç J. Guasp Giner

Contents

List of figures

List of tables

Summary

Research and education are two activities closely related to the management of scientific knowledge. To support the increasing difficulty to manage information, many initiatives have tried to come out with solutions. Since most part of the knowledge may be somehow related to space, Scientific Geographical Information Infrastructures (ScGIIs) are created to support research and educational activities, and disseminate its results into society for further reuse or investigation.

Stakeholders, but specially users, are the main actors in the use of such infrastructures. Therefore, this study takes the User-Centred Design (UCD) methodology, which tries to discover the potential demand and requirements for a product, before generating a supply, which may otherwise not be adapted to the user needs. This research focuses over the first phase of the UCD, consisting into a requirements analysis.

Since at present the Balearic Islands University (UIB) (Spain) is developing a ScGII for the own university. This research takes that example as a case study to investigate how users and stakeholders can collaborate in the design and development of a ScGII.

To do so, the research does a deep study over the critical aspects that should be approach to define a ScGII, which are mainly their components: stakeholders, technology, geospatial information, standards, organizational framework and finances. Then it goes through a long list of other existing ScGIIs and systems that serve the same function, like GI repositories or geospatial grids. When focusing over the case study, the research studies the socio-economic context of the Balearic Islands Society and state-of-affairs within the UIB's ScGII project.

This research takes the survey as a main methodology to approach the requirements analysis study over students, teachers and researchers, who are intended to be the users of this infrastructure. To sharpen and increase the liability of the prospective survey's questionnaire, a group of experts' advices about considered aspects and topics.

The existence of very different stakeholders with diverse interests requires generating adapted survey models in base to the tasks that can be carried out with ScGIIs. The execution of these surveys is preceded by brief explanations in base to the Joint Analysis Design (JAD) methodology.

Results are analyzed statistically, and conveyed into a deliverable report that explains carefully how all ScGII components should be set up to respond to user requirements. These ideas are also taken into account to design a graphical mock-up of the prospective UIB's ScGII user interface prototype.

Key words: Scientific Geographical Information Infrastructure (ScGII), Distributed GIS, User-Centred Design (UCD), requirements analysis, conceptual prototyping, spatially related knowledge, science.

List of abbreviations and acronyms

AGILE	Association of Geographic Information Laboratories in Europe
ANEP	National Agency of Evaluation and Prospective [*Agencia Nacional de Evaluación y Prospectiva*]
ArcIMS	ArcGIS Internet Mapping Service
CEDAI	Download Centre IMEDEA [*Centro de Descarga IMEDEA*]
CI	Cyberinfrastructure
CNIG	National Centre of Geo-Information [*Centro Nacional de la Información Geográfica*]
CRE	Economic Research Centre [*Centre de Recerca Econòmica*]
CSIC	Centro Superior de investigaciones científicas. Spain
CSW	Catalogue Service Web
DB	Data Base
DRIHM	Distributed Research Infrastructure for Hydro-Meteorology
EC	European Community
ECWP	Enhanced Compression Wavelet Protocol
ESA	European Spatial Agency
e-SciDR	e-Science Digital Repositories
GCI	Geographical Cyber-Infrastructure
GDI-NRW	Geospatial Data Infrastructure for North-Rhine Westphalia
GDP	Gross Domestic Product
GeoRSS	Geospatial Rich Site Summary
GI	Geographic Information
GII	Geographical Information Infrastructure
GIS	Geographical Information System
G-POD	Grid Processing on Demand
GPS	Global Positioning System
GPW	Geo-Processing Workflow (service)
GSDI	Global Spatial Data Infrastructure
ICT	Information and Communication Technologies
IDE	Acronym for SDI in Catalan and Spanish [*Infrastructura de Dades xviiispacial sor Infraestructura de Datos Espaciales*]
IDE*Ci*-UIB	Scientific Spatial Data Infrastructure for the Balearic Islands University [*Infrastructura de Dades Espacials Científica de la Universitat de les Illes Balears*]
IDEE	Spanish GII [*Infraestructura de Datos Espaciales de España*]
IDEIB	Balearic Islands GII [*Infrastructura de Dades Espacials de les Illes Balears*]
IDEMallorca	Mallorca's GII [*Infrastructura de Dades Espacials de Mallorca*]
IDEMenorca	Menorca's GII [*Infrastructura de Dades Espacials de Menorca*]
IDEO	Oceanographic GII [*Infraestructura de Datos Espaciales Oceanográfica*]
IDE-ULPGC	Spatial Data Infrastructure for the University of Las Palmas de Gran Canaria [*Infraestructura de Datos Espaciales de la Universidad de las Palmas de Gran Canaria*]
IEO	National Oceanographic Insitute [*Instituto Español de Oceanografía*]
IGN	National Geographical Institute of Spain [*Instituto Geográfico Nacional*]
IGN	National Geographic Instiute [*Instituto Geográfico Nacional*]
II	Information Infrastructure
IMEDEA	Mediterranean Institute of Advanced Studies
IMI	Innovation Municipal Institute of Palma
INSPIRE	Infrastructure for Spatial Information in the European Community
IPR	Intellectual Property Rights
ISDM	Information System Development Methodology
ISO	International Organization for Standardization
JAD	Joint Analysis Design
KM	Knowledge Management
KML	Keyhole Mark-up Language
KMZ	Keyhole Mark-up Language Zipped files
LBS	Location-Based Service

NRC	National Research Council
NUTS	Nomenclature of Territorial Units for Statistics
OBSAM	Socio-environmental Observatory of Menorca [*Obsevatori Socio-ambiental de Menorca*]
OGC	Open Geospatial Consortium
OLC	Organic Life Cycle
OODA loop	Observe – Orient – Decide – Act loop
OWS	OGC Web Services
PyWPS	Python Web Processing Service
R&D	Research and Development
RS	Remote Sensing
SDI	Spatial Data Infrastructure
SIB-ESS-C	Siberian Earth Science System Cluster
SOA	Service Oriented Architecture
SOCIB	Balearic Islands Coastal Observing and Forecasting System [Sistema d'Observacions Costaneres de les Illes Balears]
SOS	Sensor Observation Service
SSIGT	GIS and RS Service [*Servei de Sistemes d'Informació Geogràfica i Teledetecció*]
SWOT	Strenghts, Weaknesses, Opportunities and Threats
UAB	Autonomous University of Barcelona [*Universitat Autònoma de Barcelona*]
UCD	User-Centred Design
UIB	Balearic Islands University. [*Universitat de les Illes Balears*]
ULPGC	Las Palmas de Gran Canaria University [*Universidad de Las Palmas de Gran Canaria*]
VPN	Virtual Private Network
VRC	Virtual Research Community
WCPS	Web Coverage Processing Service
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WPS	Web Processing Service
XML	X-tended Mark-up Language

1. Introduction

1.1. Research background

1.1.1. Introduction

The management of information and knowledge, that serves science for education and research, is a determining activity to increase its efficiency and performance. Different media in Information and Communication Technologies (ICT) serve the purpose of supporting this activity. Geographical Information Infrastructures (GII) are the most common type of media to distribute and share geospatial information between users and providers. This kind of infrastructures has been used already to support these activities, but they do not necessarily fulfil the users' expectations, and, therefore, their aim does not complete all possible potentialities. This chapter introduces these topics by setting out the weaknesses and threats of education and research in the cycle of knowledge, and presents a methodology to study the viability and potential capabilities for a Scientific GII based on stakeholder values.

1.1.2. Scientific Knowledge Management, ICT and e-Science

The preservation and maintenance of existing knowledge, and the documentation of new discoveries and breakthroughs, have permitted a universal recognition of science by intellects and professionals worldwide (Gottschalk-Mazouz, 2008). Moreover, the management of scientific knowledge has helped to increase the productivity and performance of scientists, institutions, organizations and enterprises (Abresch, et. al., 2008; Wallace, 2007).

At present, different authors agree on the fact that in Research and Development (R&D), the accumulation, management and utilization of intellectual resources improves the performance of organisations (Cash, et. al., 2003) and its efficiency to innovate (Ensign, 2009), becoming an strategic factor for decision-making (Cribb and Sari, 2010).

Regardless the importance of scientific knowledge in the society, its accessibility was never as open as nowadays. For centuries, the management of scientific knowledge was carried out by libraries in universities where most of the intellects could meet (Bowker, 2002). Meanwhile, most people were not able to access this knowledge by any means (Bowker, 2002).

The advances in ICT in the last decades have implicated a great change in the capacity to share information and knowledge. Special emphasis has to be put on the generalization of the internet, which has become the major network to disseminate information faster and easier than in any previous age in history, enabling immediate exchanges of information (Diaz, et. al., 2011; Jennex, et. al., 2008).

For science, breakthroughs in ICT have represented a great step forward. They have multiplied exponentially the possibilities to exchange and distribute knowledge to and between large communities, and to the general public worldwide. Nowadays, scientific information and knowledge are not belonging to individuals or small groups anymore (Gottschalk-Mazouz, 2008). This openness also gives the possibility to have more people participating in it, sharing their expertise, and consequently expanding the capacities to enlarge knowledge. Moreover, this greater accessibility represents that all this wisdom can also be transferred to society, where it can make profit when being applied to many other activities (Cribb and Sari, 2010). Actually, this is the main argument behind the concept of “Open Science”, a hot topic that creates controversies between all stakeholders that have to deal with it (Bowker, 2002; van Loenen, 2006).

Another major impact of the introduction of ICT on science has been the way in which this activity is carried out. E-Research, understood as the performance of scientific activity aided by Information Technologies (Yang, et al., 2011), has been possible thanks to the development of science support systems, shaped into Information Infrastructures (II). They have enhanced the capability to search, access, acquire, manage, process and produce information and knowledge, increasing the productivity and efficiency of researchers and students. The product of their activities is known as e-Science.

The expansion of these activities has been made possible due to technological advances, which have permitted an increase of the complexity of operations from simple data or information transfers, like shared directories or databases (Cribb and Sari, 2010) to highly complex computational operations in distributed environments, like Scientific Grids (Deelman, et. al., 2009; Cossu, et. al., 2010).

The setting of science into the distributed environment of the internet marks the beginning of e-Science as a revolution in the way in which research is understood and performed (Yang, et. al., 2011). It also gives new opportunities to improve the relationships between scientific disciplines, which have helped to fill in the gaps that grow between the different branches of science. Moreover, the virtual environment has permitted creating Virtual Organizations or Virtual Research Communities (VRC), which work together for a common objective, no matter their physical location (Andronico, et. al., 2011).

1.1.3. Threats and opportunities for science performance

The application of ICT in science has had some impacts. Some of them are positive but some others may be threatening because of their future evolution. Therefore, they have to be recognized, analyzed and approached in order to keep a good track on the evolution and performance of science.

a) In the first place, more efficiency and effectiveness in information processing (Ackerman, et. al., 2003) and an increasing number of people working in the R&D sector, has increased the production of scientific knowledge and information (Ackerman, et. al., 2003; Berástegui, et al., 2011). Actually, it is said that nowadays scientific knowledge expands faster than in any other past period in history (Cribb and Sari, 2002), doubling its size every 5 years (Cribb and Sari, 2010). Day after day, this fact causes more difficulties to manage all existing contents, and this has repercussions on its posterior use for further investigation (Watson, et. al., 2010) or for the application to other activities in society (Cribb and Sari, 2010). For instance, Cribb and Sari (2010) cite that more than half of the scientific papers are never read except by their editors, or that 90% of published papers are never cited by other scientists.

b) In the second place, having more information to consult enlarges the fields to do research in, but also complicates the task to define the state of affairs (Guasp, et. al., 2011) and the definition of what is uncertain or unknown in a discipline or in trans-disciplinary studies. In this sense, minding the gap becomes a difficult task (Finnegan, 2005), especially if there are multiple spots or Cyber-Infrastructures that offer diverse amounts of information (Andronico, et al., 2011; e-SciDR, 2008). As a consequence, innovation becomes progressively difficult.

c) Nevertheless, the existence of information or knowledge of a certain research field does not necessarily mean that there is actual access to these contents. inaccessibility to information may be owing to the fact that authors do not share their work, publications, etc (Bowker, 2002); or may be due to the restriction of use and access, regulated by accessibility policies (Cho, 2005) or the aim of selling results in exchange for economical benefits (Finnegan, 2005). All these restrictions to access are protected by copyrights and accessibility policies.

d) Accessibility comes defined by the aims of information creators. If they are a private enterprise, it is normal that they want to get benefits from it. On the other hand, public organizations like universities, research institutions or administrations should logically share their findings and results publicly or at least with the same organization community (Courant, et al., 2010).

In any of the cases described before, what used to be published are the results of an investigation through a paper, a conference proceeding or a simple report. The problem is that with this basis researchers or students cannot reproduce or improve results, because information, data and methodology are not always shown or provided (Bowker, 2002), reducing the capability to take profit of these findings (Watson, et al., 2010).

This protectionism over information may be caused by the reticence to share ideas to keep the leadership over certain research topics. For this reason, great amounts of produced scientific information may rest stored by individuals, when they could be used for further investigation while being shared (Guasp, et al., 2011). Unfortunately, protectionism over scientific production slows down the potentialities to reproduce scientific discoveries (Cribb and Sari, 2010; Courant, et al., 2010; Watson, et al., 2010).

All these problems could be identified within the *Knowledge Transfer Cycle* (see Figure 1). This cycle explains how scientific knowledge follows a continuous sequence to evolve and grow passing by students' and researchers' hands. This evolution is marked by the acquisition of knowledge, the learning process absorbing new ideas, and from it creating new findings and results to be published. From here the cycle starts all over again with new contributions. Echeverri and Abels (2008) explain the sequence of this cycle and comment on how important ICT is with respect to the aim of fostering information to close the cycle between dissemination and acquisition. They also remark the importance of knowledge producers (scholars), knowledge publishers and libraries as main characters that empower the continuity of this system (Echeverri and Abels, 2008).

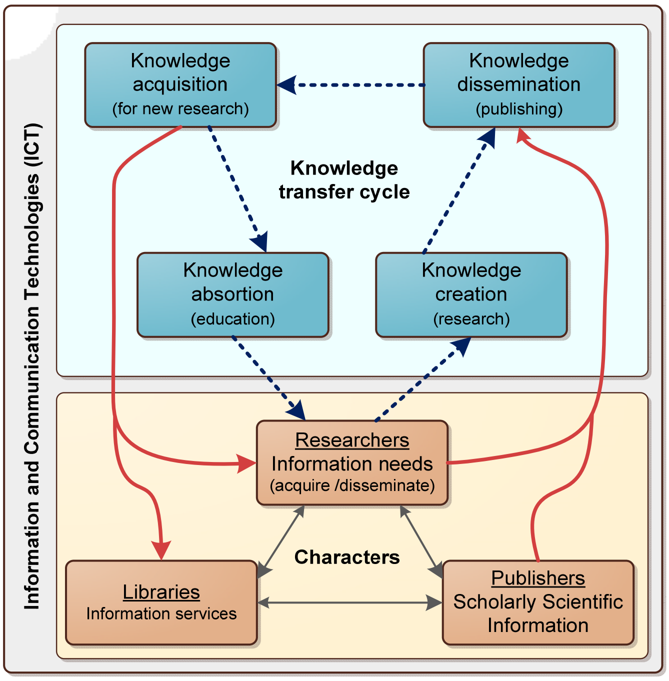


Figure 1: The Knowledge transfer cycle.
Source: Own design based on Echeverri and Abels, 2008, p. 149

e) Finally there is another point that strongly conditions the performance of science: the adaptability of ICT media to user and stakeholders' needs. The generalization of media to share scientific information has not reached all its possibilities yet. The case is that often technological capabilities are higher than the user's skills in using these tools with their maximum potential, creating a *breach* between possibilities and real facts (Bowker, 2002; Logan and Stokes, 2004).

Thus, the design and development of ICT media for scientific dissemination may be approached from two different points of view: the techno-centric and the socio-technical approach (Revee and Petch, 1999). Disequilibrium between the concern of factors from social and technological approaches may represent a fail or success in the long term, depending on the actual result when carrying out the activities that that type of media is intended to achieve (Logan and Stokes, 2004). In relation to this idea, Bowker (2002) remarks the importance of social and organizational factors when setting the technical features of infrastructures for science in order to get all potential possibilities to generate an efficient and effective system, capable to speed up research and publication cycles (Figure 1).

Actually, this is what Logan and Stokes (2004) define as the technology paradox, which states that "*the more complex and sophisticated the technology, the more important are the human issues of attitude, cooperation and motivation, as well as the training, education and learning of all members of the organization*" (Logan and Stokes, 2004, p. 3). Consequently, this factor induces the so called productivity paradox where a higher technological advance does not mean a higher productivity if the user community cannot reach that level of complexity to take a full profit of it (Logan and Stokes, 2004).

1.1.4. The geospatial factor in scientific knowledge and its dissemination

When dealing with scientific knowledge, the majority of generic infrastructures or media focus on finding answers to the “why”, explaining what are the reasons to explain a behaviour, event, etc. (Cribb and Sari, 2010). They may also look at the “what”, “who”, “when” (Cribb and Sari, 2010), but very often they do not approach the “where” with enough value (Jennex, 2008; NRC, 2006).

It is widely recognized that more than 80% of scientific information has a spatial correlation (Shekhar and Xiong, 2008; Pick, 2005). Therefore, any scientific discipline related to space can be studied from the point of view of Geographical Information Sciences, where it can be set on space, related to its spatial context, analyzed and represented. This set of extra activities may give an additional value over information (Williamson, et al., 2003), enriching its content and complexity (Guasp, et al., 2011; NRC, 2006).

The study of sciences through geographical space has been mainly carried out by the Earth Sciences discipline, which relates all its activities with the territory. In this way, *spatial thinking* serves as a study approach, where space is the base for placing, representing and reasoning about problems to find a solution based on geographical variables (NRC, 2006). However this approach can be applied to many other study fields to enhance results and their relation to related disciplines promoting collaboration.

Geographical Information Systems (GIS), but also Computer-Aided Design (CAD)[1] systems, are the best tools to carry out formal studies from the approach of spatial thinking. Therefore they have served as a base to realize studies in a very wide range of scientific disciplines, as well as in many professional activities.

Then, as there are infrastructures to manage and disseminate generic information, Geospatial Cyber-Infrastructures (GCI) (Yang, et al., 2010), serve the purpose of dealing with geographical information (GI). To do so, they combine diverse technological resources to provide GI to users, based on standards, information policies and organizational features (Yang, et al., 2010; Shekar and Xiong, 2008).

Nowadays, the distribution of GI within and between organizations is very widespread, from the highest research institutions with high computation capabilities, like GeoGrid (URL 55), to the most popular web resources like Google Maps (URL 11). Between them, GIIs, also known as Spatial Data Infrastructures (SDI), are the most generalized types of GCI, more accessible to the general public than other systems (Fu and Sun, 2010).

In the field of science, different types of GII have been developed mainly by research institutions, universities, national administrations or private or independent organisations. In a way, they could be considered as a differentiated type of GIIs, due to their distinct aim to distribute scientific geospatial data, information and knowledge between people working in research and education and following the principles of e-Science (Yang, et al., 2010). Different authors (Guasp, et al., 2011; Tintoré, et al., 2006) refer to them as *Scientific Geographical Information Infrastructures* (ScGII).

[1] It is important to point out that just CAD projects working with georeferenced information are applicable to spatial thinking. Examples can be found in architecture, topography, etc.

1.1.5. The user: the prime component

GIIs are defined by their components that permit the transference of GI to users by means of a technological framework, standards and accessibility policies (van Loenen, 2006). Nevertheless, users and providers are who actually create flux of GI with certain demand and supply respectively. These agents are the stakeholders and they are the ones who should lead the development of the GII to ensure its future success (Brox, et al., 2002).

Therefore, a User-Centred Design (UCD) methodology may serve as a main way to develop GIIs (Brox, et al., 2002) and specifically ScGIIs, in order to adapt to users', providers' and external partners' prospects, fulfilling their needs for a better performance in the long term.

1.1.6. The study case

Taking all these ideas in mind, at present the GIS and RS Service (SSIGT) at the Balearic Islands University (UIB) in Mallorca (Spain) is setting up the basis to build up a ScGII to support research and education within the university community, and spread the scientific production into the society (Guasp, et al., 2011; Tintoré, et al., 2006).

The so called IDECi-UIB (Scientific Geographical Information Infrastructure for the Balearic Islands University) has been selected as a study case for this research due to its primary development stage, in which there is only a clear vision, and some practical experimental practices. Those advancements were already presented and evaluated by Europe-wide professionals in a short paper at the AGILE Conference 2011. The publication of that article represented a second reason in the decision of taking this case as an example to work within this research theme. It is attached in Annex 1.

Besides, not enough attention was invested in the socio-technical features (Revee and Petch, 1999) like user requirements (Poore, 2011; Schneider, et. al, 2011).

At this evolving stage, shaping a sharper profile on how this ScGII should be according to potentially involved stakeholders it s is still an undone task. A study over these factors should ensure a better project's feasibility and stability in the long term, enabling users to find what they are looking for (Poore, 2011; Courage and Baxter, 2005; Hsu, et. al., 2011), and defining who are the potential external partners, and how they can collaborate into the infrastructure.

It is also important to mention that the IDECi-UIB has evolved during the progress of this Master Thesis. At the very beginning in November 2011, there were just some practices in map viewers and geoservices trials, and at the end (July 2012) there is already an essential prototype working with most basic tools. Anyway, it is not yet available to users and there is no significant content. Thus, if it would have to be fit into a Deming Cycle the project would be placed between the planning and development phases (Figure 2).

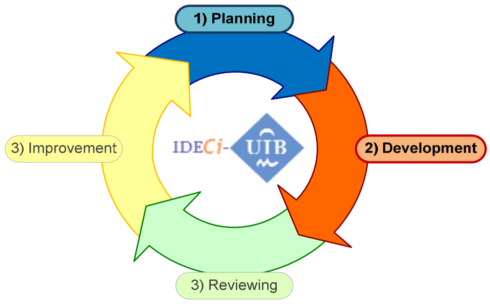


Figure 2: Denim cycle representing the IDECi-UIB building process stages

This context represents an opportunity for this research, which pretends to apply the UCD methodology over this real study case of ScGII, to prove whether this methodology can provide useful information to the prospective ScGII design and development.

Then, the innovation aimed at consists on approaching the GII assessment from a different point of view. While most of GII assessment studies are made to analyze what effect or impact they have had over the society and the economy, through socio-economic impact assessments (van Loenen and Zevenbergen, 2010), this approach wants to assess GII (and specifically ScGII) user needs before developing the infrastructure, involving real stakeholders.

The innovative points over other research studies are basically two:

- ✓ Apply the UCD methodology on potential stakeholders using real users, providers, developers and other possible partners, instead of just considering stakeholder representatives' views (Hansen, et al., 2011; Brox, et al., 2002)
- ✓ Contribute to the stronger conceptualization of the Scientific GII concept, trying to find consensus between existing approaches using stakeholders' views.

1.2.Goal and objectives

1.2.1. Main goal

The main aim of this research project is to:

Develop a body of knowledge to determine what should be the contents, structure, user interface, tools and applications of and for the Scientific Geographical Information Infrastructure of the Balearic Islands University, based on a user requirement analysis and resulting into the design of a conceptual prototype.

The results of this research will serve ScGII developers who will have to design a new infrastructure. In principle, this research fills the existing gap between user requirements and developers' ideas on what a ScGII should be, how it should work, or what organizational aspects should change, in order to respond to user needs.

1.2.2. Research questions

In order to accomplish the main aim of this study, four main research questions have been formulated. Actually, their structure and order has the clear purpose of responding: firstly to the definition of a ScGII and its potential capabilities; and secondly to the steps described in the UCD methodology. The research focuses on the requirement analysis and on the prototyping, without carrying out a usability analysis.

1- What features define Scientific GIIs?

a) What are the potential differences with generic GIIs?

b) What existing examples of ScGIIs are already there? Are there other ScGIIs for which the UCD methodology has already been applied? What kind of requirement analysis did the developers do? Did they involve representatives of real users?

c) What are the possible capabilities of a ScGII?

d) What are the potential benefits of a ScGII? And of uploading research projects into a ScGII?

2- What is a ScGII intended to contain based on stakeholders' needs?

a) Who are the potential stakeholders for a ScGII?

b) What contents, tools and applications should a ScGII comprise to fulfil stakeholder needs?

c) To what extent do existing generic GII contents and tools fulfil research and educational stakeholder needs?

d) Are existing educational and research GIIs fully covering stakeholders' demands?

e) To what extent can knowledge of the stakeholders' demands improve GII's efficiency and effectiveness?

f) What tools or contents can stakeholders use to interact with GII providers?

3- What are the critical points to improve the IDECi-UIB?

a) In what measure should current ScGII components be adapted to suit better user requirements?

b) What kinds of GI contents or tools are mostly needed to cover user requirements?

c) What are the existing user interfaces in other GIIs that offer best services to users? In what aspects? Which one adapts better to a ScGII according to UIB's ScGII stakeholders?

4- How do we meet stakeholders' requirements into a prototype?

a) What are the most important concepts when designing a prototype of a ScGII? How can they be applied to be most effective?

b) What distributed environments better suit the user requirements when building a ScGII?

c) Can user requirements be met with the available hard- and software?

d) What are the aspects that the newly designed prototype covers and the initial sketch at the SSIGT does not? Is the new approach giving better results?

1.3.Research set up

One of the strongest features in this research is the focus on the user as the main character who will make full use of this infrastructure. Therefore, the UCD-methodology has been taken as a central pathway which conduces and structures the whole study.

Revee and Petch (1999), describe that before starting with the development of a new information system, it is convenient to know about the critical ideas, the organization's internal structure, and the external context of what has been done by other organizations. Therefore, before gathering user requirements, it is important to settle the theoretical basis of what is possible, what has been done, or what issues are more critical than others. Chapter 2 starts with analyzing the meaning of ScGIIs and their components. Since ScGIIs are quite rare types of infrastructures, the most significant examples are compared with other information systems that also support science activities like grids and GI repositories. This is explained in Chapter 3.

Chapter 4 sets the methodological basis of the UCD method, and constructs an own model to carry out the UIB's study case with the requirements analysis and conceptual prototyping. Chapter 5 continues with a description of the study case, setting the context where the ScGII will be set up. It also puts emphasis on defining the population samples that will be used to carry out the requirements analysis.

Chapter 6 focuses on how the requirements analysis test was designed and executed within the UIB community, with special advice from expert panel members. Next, Chapter 7 closes the requirements analysis phase evaluating the tests' results by statistical means. Chapter 8 is aimed to project these results into a conceptual prototype; all requirements which can be graphically fit into a diagram are presented into a user interface mock-up, and the rest are reported and discussed. Finally Chapter 9 concludes the research project exposing the conclusion, discussion and recommendations.

2. Theoretical framework: Foundations for a Scientific GII

2.1. Introduction

The intention of this chapter is to explain the theoretical basis of ScGIIs. By doing this, the chapter sets how all GII components should be adapted to face the problems of scientific activity described in the last chapter. This is going to serve as a theoretical framework for the coming chapters and sections, showing what the ideal ScGII should be like. In practice, the components may need certain adaptation to every case study, especially when referring to the social context, like the organizational framework, or the users' activity.

2.2. Basis for a Scientific Geo-Information Infrastructure

2.2.1. Introduction

Information Infrastructures, also known as Global Information Infrastructures, represent all the virtual platforms that use ICT to transmit, manage and process information of any kind to improve the performance of a certain task or activity (Cambridge Dictionary, URL 1). Yet, they are more than a physical construct involving technical and social factors (van Loenen, 2006).

Between those, GII grew as a differentiated type of infrastructure due to the spatial contents that they embrace. The nature of spatial information is very complex and different enough to require specific technical features, which would not be necessary with non-spatial information (Shekhar and Xiong, 2008). Still, authors like de Man (2007) criticize that non-spatial infrastructures may be, some day, absorbed by generic IIs as they keep gaining complexity and functionalities.

The multi-dimensional and changing nature of GIIs is a greatly discussed topic between experts (Crompvoets, et. al., 2008; van Loenen, 2006; de Man, 2011; Williamson, et. al., 2003). That brings us to the difficulty of defining what a GII is conceived as, or what are the differences are between GIIs and other types of Information Infrastructures (Crompvoets, et. al., 2008).

In general, GIIs have the aim of facilitating the share and exchange of GI between stakeholders within or between communities (Grus, et. al., 2011) by means of an underlying framework composed of technological resources, enabled by standards and regulated by accessibility policies (Crompvoets, et. al., 2008). The interrelation between these components should constantly change in order to adapt to the stakeholders' demands (van Loenen, 2006). In summary, GII components can be identified as: stakeholders, geographical information, technology, policies and standards (Williamson, et. al., 2003). Van Loenen (2006) also mentions the organizational framework and finances as necessary pieces for the GII puzzle (Figure 3).

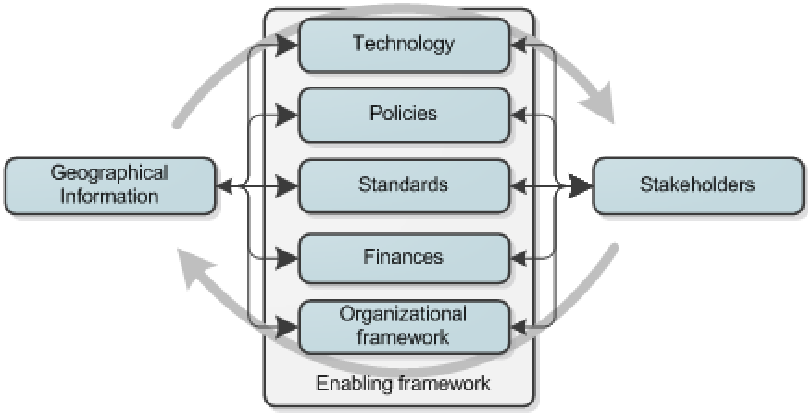


Figure 3: GII Components

Source: Own design, March 2012. Based on Crompvoets, et al., 2008, van Loenen, 2006, and Williamson, et al., 2003

Generally, the main role of GII initiatives is to achieve better outcomes in all that refers to GI use and management, by creating a collaborative environment where users and providers can easily cooperate and exchange geospatial information in a cost-efficient and cost-effective way (van Loenen, 2006). These measures should increment an organization's capabilities to reach its goals (van Loenen, 2006).

In this way, GIIs serve as a practical instrument to save costs in time and budget when having to acquire, store, manage and utilize GI (Rajabifard, et al., 2003). The use of a central spot to store information avoids duplication, enables its reutilization and its rapid delivery (van Loenen, 2006). Moreover, it also helps to maintain, catalogue and preserve GI, looking for its quality (spatial and temporal) and keeping it up to date (Rajabidard, et al., 2003).

GIIs are applied to a wide range of fields in society. Administrations with regional GIIs, are the most common uses, although other purposes may be filled, like the application of GII advantages to scientific activity in research and education.

2.2.2. Definition of Scientific Geographical Information Infrastructure

Information Infrastructures dedicated to spatially-related sciences are not a really new concept. Already in 1998, the U.S. Vice-President Al Gore envisioned the creation of *Digital Earth*: a multi-resolution, three-dimensional Earth representation where geospatial information from worldwide could be represented, helping to realize relationships between the physical and the human aspects of Earth (Craglia, et al., 2008; Fu and Sun, 2010). This framework would permit the reunion of all this spatial data, information and knowledge, which could be used for a wide variety of purposes like decision-making in government, in research, etc. (Craglia, et al., 2008; Shekhar and Xiong, 2008). Actually, similar practices like Google Earth (Google, 2004) or Virtual Earth (Microsoft, 2005) were made following these ideologies (Craglia, et. al, 2008).

From then on, these types of systems have been spread, reaching a wide diversity of activities and applications. Among them, it has also reached the field of science (Fu and Sun, 2010). In the same way, the grade of complexity and capabilities from one system to another has evolved differently depending on every organization activity. That diversity can vary from Geospatial Grids, -one of the most advanced e-research systems, which interconnects a large amount of clustered computers to solve a single operation (Fu and Sun, 2010)- to the most simple systems like GI repositories. The heterogenic nature of scientific activities and the required systems has complicated the conceptualization of GIIs for science.

Authors like Yang, et al. (2010) or Sieber et al., (2011) qualify GIIs dedicated to science as Geospatial Cyber-Infrastructures (GCI). Shekhar and Xiong (2008) or Poore (2011), define them as Cyber-Infrastructures for Spatial Data Integration, associating them with high-performance systems like Geospatial Grids. Others, like Granell, et al. (2006), relate e-Science with the GII concept. Yang et al. (2010) define ScGII's as "*the combination of technological resources to support the collection, management, and utilization of geospatial data, information and knowledge for multiple science domains"* (Yang, et al., 2010, p. 265) between partnering stakeholders. They also state that ScGII are the media that use geospatial principles and GI to transform science performance within and across science domains in research, development and education (Yang, et al., 2010).

The ScGII definition (Yang, et al., 2010) does not differ much from the concept of generic GIIs from authors like Grus, et al. (2011), Crompvoets et al. (2008), van Loenen (2006) or Williamson, et al. (2003). The main difference between them is that ScGII emphasize the technological part of this II type, and GIIs try to emphasize the rest of the components, that may be more social (Sieber, et al., 2011) and the harmonization between them. However, this study prefers to keep the term "GII" for its multi-dimensional view (de Man, 2011) and the term "ScGII" for its main aim on transferring scientific spatially related knowledge (Guasp, et al., 2011).

One of the stronger identity features in ScGIIs is that they can approach all unknown or uncertain hypotheses or problems with a spatial relation using spatial analysis as a main way to solve such problems (NRC, 2006). Actually, this is the purpose of spatial analysis in GIS: it tries to simplify the reality into models to analyze them and create hypothetical scenarios applicable to real life (Heywood, et al., 2006). These can also be conceptualized into theory to create trends, models or paradigms for certain scientific disciplines. In the same way, the scientific method also has this common pathway: it abstracts facts from reality to create a hypothesis, that after tries to be demonstrated by testing (Cambridge Dictionary, URL 1).

Spatial thinking represents the *'routes'* of GIS. This approach sets the space as the main base of any study, trying to find relationships between spatial features, by analyzing their geospatial position and properties (NRC, 2006). Spatial thinking is composed of three main elements: concepts of space, tools of representation, and processes of reasoning (NRC, 2006). It is evident then, that GIS represents the means to put in practice spatial thinking, and in the same way, ScGIIs would be the way in which this concept can be spread and distributed within the society.

Bearing in mind all exposed ideas, this could be a proper definition of ScGII:

A Scientific Geographical Information Infrastructure (ScGII) is defined as the combination of technological and social components that support the collection, use and management of geodata, geospatial information, and spatially related scientific knowledge in a multi-disciplinary environment of different partnering stakeholders.

2.2.3. GII classifications and hierarchies

GIIs are classified according to their function, and, normally, their hierarchy is a reflection of existing hierarchies between organizations (van Loenen, 2006):

- Regional and Corporate GIIs can be fitted into a pyramidal structure (Figure 4*a*) responding to a top-down hierarchy, with executive, managerial and operational levels respectively (Revee and Petch, 1999). Regional GIIs only manage information of their own region. In other words, they take a vertical or regional approach to analyze the territory. Besides, Corporate GIIs are at the base of Regional GIIs because they organizations work as GI producers, although they may work at other levels too (Revee and Petch, 1999; van Loenen, 2006).

- ScGIIs' hierarchy it is not so clear. Universities, research centers or other entities working in the sector may not follow this common structure, because they do not have such a strict hierarchy in between. They may work independently or without a clear agreement with other organizations from the same field (Revee and Petch, 1999). Consequently, they may take responsibility for all tasks at all levels, which in other cases would correspond to several entities or bodies (Revee and Petch, 1999). In this way, the "Greek Temple" (Revee and Petch, 1999) organizational model (Figure 4b) is better adapted to the case of ScGIIs than the pyramidal. Yet, it is not clear which infrastructures or organizations could be placed at the top of this Greek temple. Possibly, they will be defined in future if ScGIIs start to be widely used, as it has happened in regional GIIs with INSPIRE (URL 2) or GSDI (URL 3) initiatives.

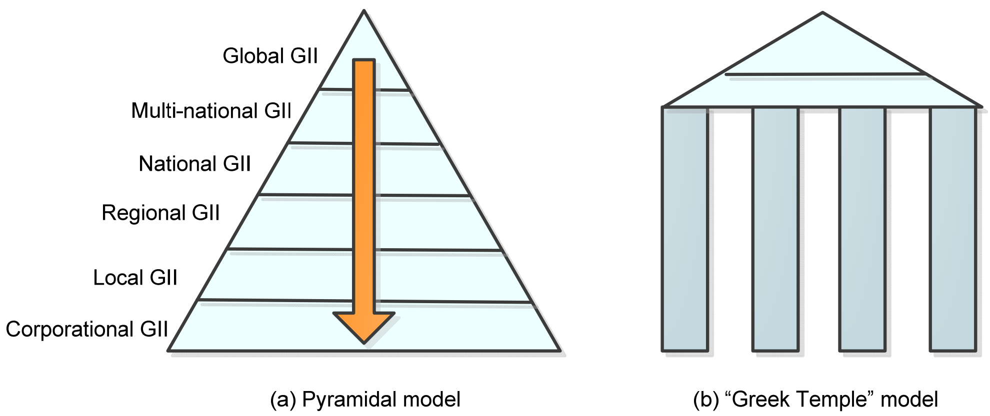


Figure 4: Models of organizational hierarchy
Source: based on Revee and Petch, 1999, p. 156

2.3. ScGII Components

ScGIIs are meant to find solutions to the threats that condition the performance of the scientific activities with spatial correlation in research and education. As pointed out in section 1.1.3, there are several human and technological difficulties that threaten the productivity, efficiency and effectiveness of science support systems like ScGIIs.

As already mentioned in section 1.1.4, GIIs are mainly defined by their components and the relationships established in between (van Loenen, 2006). Therefore, the depiction and differentiation of ScGIIs must also be defined by its components. The coming sections make a deep analysis of all factors that should be considered in a ScGII design. At the end of every component description there is a set of responses to threats in science performance. They summarize the involvement of every component into the points described in section 1.1.3.

Yet, every study case is different and consequently user needs may change (Courage and Baxter, 2005). Therefore, a proper requirement analysis, as the first stage in a User-Centred Design methodology should give a more accurate approximation about what users really want.

2.3.1. Data, information and knowledge

Geo-information represents one of the most important components for a GII. It is the object which is shared, exchanged and distributed among users and providers, and therefore, what gives sense to GIIs.

One of the biggest differences between generic and scientific GIIs is the type of information they serve. In general administrations' GIIs serve descriptive GI from the region they manage (Brox, et al., 2002).

In science, descriptive information is necessary to serve as an input for prospective studies (Heywood, et al., 2006). As shown in Figure 5, raw or descriptive geodata represent a basic input for research projects based on, or supported by GIS (*x* in Figure 5). Whether it is descriptive GI coming from administrations (through GIIs), whether it is data gathered on first hand, usually other information sources are also needed to complete the research content. Non-geographical information focused on methodologies, other case studies, statistics... serve as a support to enrich data and information content, transforming it into knowledge by means of analysis and reasoning *(y)***.**

This research process ends up into outputs like publications, reports, etc *(z)*. However, these results, characterized by their added value on richer contents, may be also seen as inputs for other investigations or studies (Watson, et al., 2010, Guasp, et al., 2011). These sets of spatially related scientific knowledge are the second group of served information by the ScGII.

It is clear then, that ScGIIs need two types of information to provide the best support to R&D and education: firstly with descriptive GI *(a)* working as input data; and secondly with spatially related research studies *(b),* interesting for their content, methodological approach, results and conclusions.

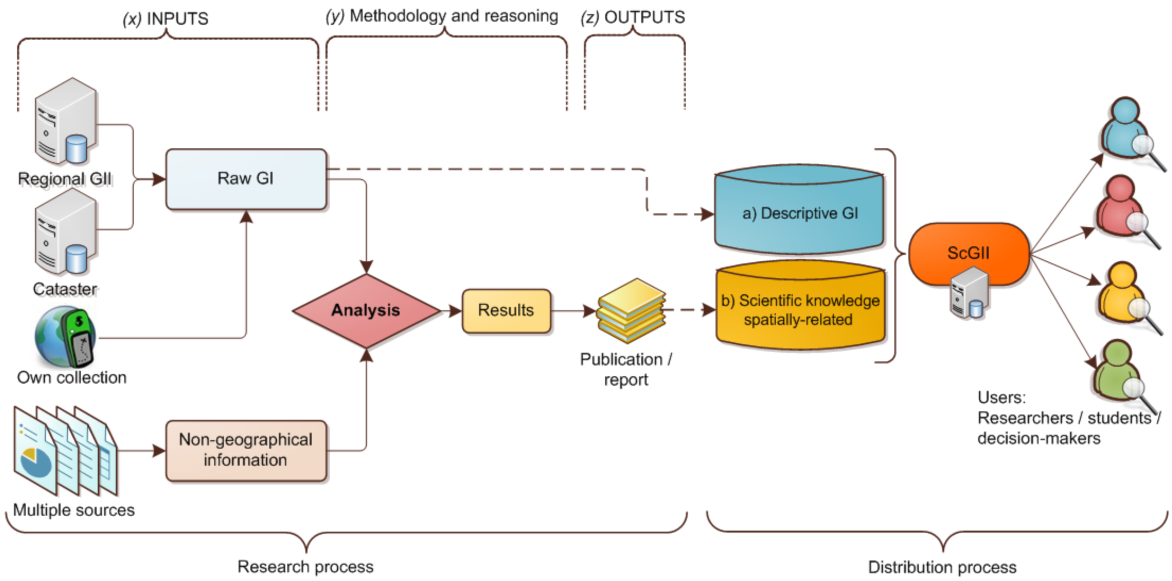


Figure 5: Enrichment process from Geo-data to spatially-related knowledge

There are a set of features in ScGIIs concerning to its contents, that need to be pointed out and explained separately. They are: the inclusion of spatial analysis tools (section 2.3.1.1), the distinction between geospatial information types (section 2.3.1.2), and the management of these contents from a managerial point of view (section 2.3.1.3):

2.3.1.1. The key content in ScGIIs: methodologies for geoprocessing

What perhaps is more innovative than serving scientific knowledge is the capability to provide precise methodological approaches in research (Bose and Frew, 2008; Baranski, 2006; Giuliani, et al, 2011; Roberts, et al., 2010). That means that ScGII users could make use of geoprocessing methodologies from other researches without having to start all over from scratch (Granell, et. al., 2006; Roberts, et al., 2010), or trying to find a proper methodology to face that problem (Roberts, et al., 2010).

This fact is technologically possible thanks to geoprocessing services (OGC, URL 4; Schut, 2007), which enable the use of operational tools in a web service environment (Giuliani, et. al., 2011). Since most study scenarios cannot be approached with simple geoprocessing tools, workflows are necessary (Giuliani, et al., 2011; Guasp, et. al., 2011). Such tools enable the customization of parameters to adapt them to every study case (Guasp, et al., 2011). ArcGIS software enables the generation of models based on predefined tools or by means of Python scripts (Esri, URL 5; Guasp, et al., 2011), which can be written with open-source software, being compatible with other programming languages like MATLAB or C/C++ (Roberts, et al. 2010). Nevertheless, users may have considerable troubles when having to deal with such technical requirements due to their lack of skills in ICT and programming languages (Roberts, et al., 2010).

2.3.1.2. The shift from spatial data to spatially-related knowledge

It might be stated that ScGIIs provide a way to serve spatially related knowledge instead of just geodata or geo-information. Knowledge is divided into explicit and tacit knowledge (Anklam, 2002). ScGIIs should be capable to distribute explicit knowledge composed by all contents able to be stored, manipulated, indexed, shared and re-used (Anklam, 2002). Tacit knowledge is something more abstract, representing experience and the know-how

(Anklam, 2002). This content might be also included, but would need from farther research, and it is not approached in this study.

It has been demonstrated that the sum of different media enhances the user's comprehension (Clark and Mayer, 2008). Communicating knowledge represents approaching a set of contents from different points of view to clarify an issue or a topic (Hong, et al., 2011). In this way, the more information is given, the higher is the precision and the better should be the comprehension. On the other hand, it is also true that media matters much, because every type of media serves a purpose in communicating in certain way (Liu, 2008). Therefore the combination of GI, methodologies and associated media like text, statistics, models, recordings or interactive animations (Cartwright, et al., 2007) should help to provide a better understanding about study cases or themes (Guasp, et al., 2011).

In this direction, ScGIIs represent an opportunity to merge the great abstractive capacity of maps to represent geographic phenomena over space (Kraak and Ormeling, 2010), with the complementarity of multimedia and hypermedia, enriching contents and linking them to extra information (Cartwright, et al., 2007). In consequence, the capability to interact and navigate through all these resources enhances the communication capabilities (Cartwright, et al., 2007).

Figure 6 provides an overview of the content enrichment from SDIs to ScGIIs, with the shift from "data" to "knowledge". In this context, assuming that information is data with meaning and context added (Heywood, et al., 2006; Kebele, 2010), knowledge is the next step in complexity. It is clear that GIIs share geo-information (Chen, et al., 2008). The difference between information sharing and knowledge sharing is that the sharing of information does not necessarily lead to the generation of new knowledge, whereas knowledge sharing does (Chen, et al., 2008). Therefore, ScGIIs are qualified as GIIs and not knowledge infrastructures, because even distributing GI and spatially-related knowledge, they do not necessarily imply the generation of new knowledge.

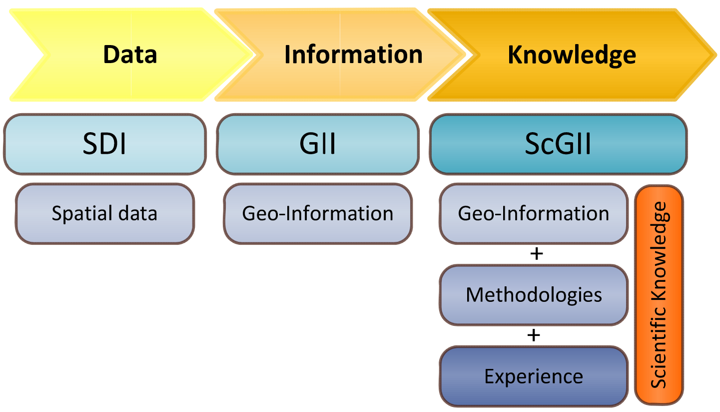


Figure 6: Shifts from data to knowledge on types of GIIs

2.3.1.3. *Metadata, a requirement for information retrieval*

Obviously, as any other II, a ScGII needs a catalogue to manage and retrieve its contents within the system (Giuliani, et al., 2011). Generally, the better structured information is, the more the structure can be exploited to browse, manage and interconnect these contents with other information (Gilliland, 2008). Metadata serves as a base to structure contents by describing their content, context, and structure (Gilliland, 2008). This set of descriptions ensures cataloguing, classification and indexing (Gilliland, 2008).

ISO 19115:2003 defines metadata standards in geographic information (OGC, URL 4; INSPIRE, 2010). In order to ensure interoperability and access, ScGIIs should also use this standard to generate their metadata. Geodatasets can be described relatively easily. However, geoprocessing tools may represent a threat because they are not yet a common tool in GIIs (Baranski, 2006; Goodchild, et al., 2009). Still, the INSPIRE directive contains references to these types of resources (INSPIRE, 2010).

2.3.1.4. Responses to the threats of science performance

The ScGII concept concerning to geographic data, information and knowledge solves some of the threats of science performance described in section 1.1.3.

In the first place, if information and spatially-related knowledge are catalogued and structured into a ScGII, the problems related to search and retrieval should be diminished, due to the existence of a transparent information inventory. Still, the searching/finding problems in semantics between the system and the user could represent a threat that needs further research (Giuliani, et al., 2011) Moreover, the uncertainty when establishing the state of affairs in a research field should be reduced.

In second place, the access to GI, methodologies and results should increase notably. The inclusion of all these contents into the system should not be an obstacle for extra production in R&D and education. Still, the accessibility policies may restrict the access to these contents.

2.3.2. Stakeholders

Undoubtedly, the human component is one of the main elements of any GII. It is formed by the people who use and interact with the infrastructure (Brox, et al., 2002), giving constant dynamism to and between the other components (van Loenen, 2006). Stakeholders do not only refer to the (final) users who directly benefit from the framework. Providers, developers or other indirectly interested partners, who have interests in being involved in such an initiative, are included as well (van Loenen, 2006).

From a socio-technical point of view stakeholders -but specially users- are the actual centre of interest for building a GII (Revee and Pech, 1999; Williamson, et al., 2003). Truly, stakeholders are the interested parties in the infrastructure development, so they must define what their requirements and demands are when having to use the new system (Maguire and Bevan, 2002). Therefore, a User-Centered Design (UCD) methodology is required to take care of these needs to design and build up the framework basis (Brox et al., 2002).

In national or regional GIIs, stakeholders may represent the whole GI market (Brox, et al., 2002). Nevertheless, in sectorial infrastructures like a ScGII, the potential public is more limited (de Man, 2011; Brox, et al., 2002). Still, the field of science is quite broad when thinking over all the activities that may take profit from its results, like for instance, decision-making for government (Yawson, et al., 2011).

Moreover, the differences between groups working with scientific knowledge management may be very broad depending on their activities, as well as their levels of skills in GISciences (Ensign, 2009). Based on this criterion, stakeholder profiles may vary strongly, complicating the establishment of a system that is able to suit everybody's needs (Heywood, et al., 2006).

Universities represent one of the most important centres of scientific knowledge production, management and distribution (Cribb and Sari, 2002). In them, the major activities that recruit many individuals are education and research (Cribb and Sari, 2002). Both have the common objective of gathering new or existing information to learn or find new discoveries.

In a ScGII for a university community, students, researchers and professors form the groups of final users. Other interested third parties (stakeholders) could be external public or private organizations from the research or educational environment. While in national or regional GIIs potential users often belong to the administrative community, the scientific community does not necessarily follow the same rules. Science is universal and therefore the physical location of stakeholders working in an e-infrastructure should not matter at all (Andronico, et al., 2011).

Cultural and educational influences are an important aspect that should be taken into account when designing a ScGII. The level of skills of users and their cultural background strongly limit their capabilities to perform certain operations (Courage and Baxter, 2005). It might be assumed that a ScGII is already made for users with a high educational and cultural level. Nevertheless, IIs necessarily involve skills and experience in ICT, which might not be the case in certain research or educational user profiles. Therefore, the technical features should be adapted to facilitate the access to and use by non-expert users (Cartwright, et al., 2007). Skills on spoken languages are also vital to ensure a good communication within the GII and the organization. Nowadays, English is the universal language of science (Drubin and Kellog, 2012), and should therefore be the main language used in ScGIIs.

ScGIIs may be used for different activities. Next sections describe what influences they could have in research (section 2.3.2.1), education (section 2.3.2.2) and decision-making in governance (section 2.3.2.3)

2.3.2.1. The e-research environment

The rise of ICT in science is a fact that conditions the way in which people work (Andronico et al., 2011). More than ever nowadays the research community needs to share and exchange information in order to increase their production and their efficiency by means of e-research infrastructures.

Different sources (Andronico, et al., 2011; Bowker, 2002; NRC, 2006; Shekhar and Xiong, 2008) confirm that collaboration is the best way to perform research. Actually, working in research groups is widely accepted in universities and research centers worldwide. Minding the gap of knowledge, when carrying out an investigation, is easier when involved people take care of common topics from different points of view. Collaborative intelligence is the concept that points out how important it is to exchange information, methodologies and ideas when different partners are involved in a common research (Singletary, 2011).

Weaknesses and strengths of partners' skills and experiences are complemented to build new knowledge and to innovate (Singletary, 2011).

Actually, so-called collaborative organizations perform better and are the success of today's organization types (Logan, 2004). Rather than competing, they collaborate to improve results and increase productivity. These organizations have clear values and objectives that are known and assimilated by every partner. They have a clear trust climate, full access to all managed knowledge within the organization, decentralization of decision-making and a minimum set of hierarchical structures, promoting democratic management and consensus when having to take decisions (Logan, 2004).

Virtual Research Communities (VRC) or Virtual Research Environments are the result of collaborating and sharing in a virtual environment to perform research (Andronico, et al., 2011; Candela and Pagano, 2010; Chen, et al., 2009). They are partnerships composed of professionals from multiple disciplines who work together in a common topic, no matter their physical location. VRC's are especially common in scientific grids, where the exchange of information and the super-computation capabilities are especially high. Yet, research communities may be settled in the same spatial location. They are then known as territorial communities which may also have virtual relationships to work in research (Chen, et al., 2009).

Dealing with space in research may have great implications. *Geocollaboration* deals with establishing a research community over a geographical area for problem solving, decision-making, planning, exploration, etc. (Shekhar and Xiong, 2008). In this way, a research environment can be settled over an area, and researchers from multiple disciplines can work together to solve study cases.

ScGIIs can potentially involve these types of relationships and working methods. ScGII organizations can potentially be collaborative organizations, facilitating the incorporation of such characteristics within the infrastructure. The consolidation of virtual research groups within ScGII can be made as shown in Figure 7. It *depicts: ScGII r*esearch groups are capable to access, manage, analyze and publish spatially-related knowledge. They can use open access GI from external partners or other GI and contents from other fellow groups.

The gathering, organization, and consolidation of all these contents would help to create a complex repository for scientific spatially-related knowledge. These collaborative tasks would help to eliminate gaps and uncertainties, avoiding the proliferation of information islands. These actions would favour the expansion in research within and between disciplines and the opening up of these contents for learning or consultation (Courant, et al., 2010).

The open access to published GI will depend on every community's will to share their outcomes; to be opened up just within the community or freely accessible to anyone.

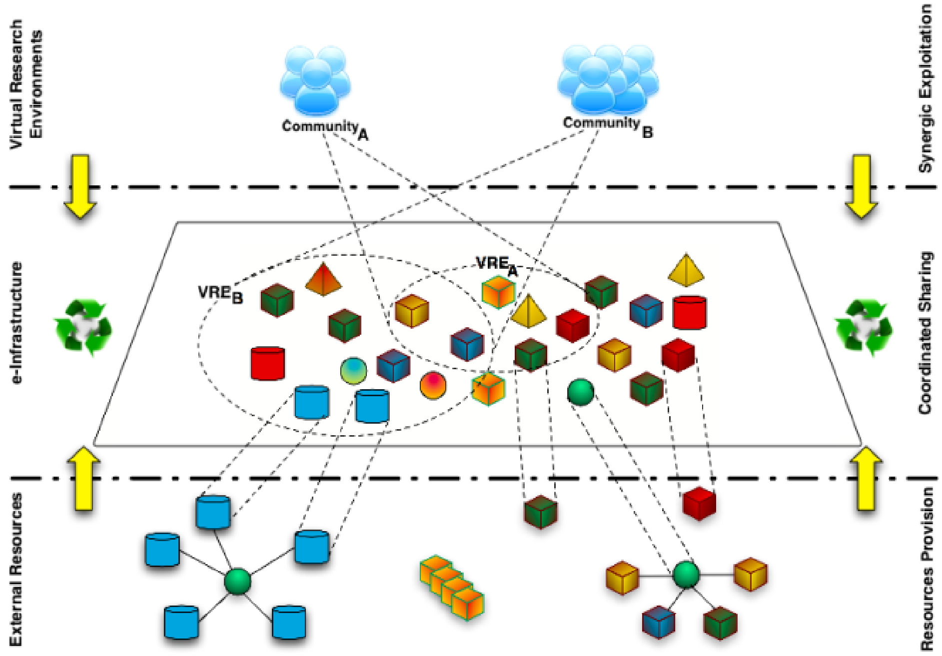


Figure 7: Building virtual research environments through e-Infrastructures.
Source: Candela and Pagano, 2010, p. 228.

The amount of research groups depends on every organization building the ScGII. Nevertheless, the increase of collaboration partners means more savings on GI distribution and maintenance, and consequently, an important rise of the system's efficiency (Willianson, et al., 2003).

Besides the possibilities for exchanging GI and knowledge in its explicit shape, there is also the possibility to establish direct relationships between users. When referring to research, an interesting view would be to use the participation of fellow researchers to validate or review other research projects uploaded to the catalogue (Haug, 2009). The peer-review process made by experts –or generic users- in the own research field or neighbouring fields really helps to validate the quality, veracity and legitimacy of these results and methodologies (Cash, et al., 2003; Courant, et al., 2010; Haug, 2009).

This link between peers enhances contents quality but also reinforces the capacity to criticize other's work with constructive arguments (Abdul-Rahman and Hailes, 2000; Haug, 2009). That fact helps to build prestige, trust and academic impact on one's own work among fellows, in the same way as a citation is constructing certain renown between authors (Ensign, 2009; Nightingale and Marshall, 2012). This is another reason why users may trust the ScGII as a way of self promotion (Ensign, 2009; Nightingale and Marshall, 2012). Moreover, the capability of ScGIIs supporting all contents in a research project permits a deeper and multi-view evaluation. Necessarily, this review could be much deeper than in generic scientific papers, where only a summary of the whole project is evaluated (Nightingale and Marshall, 2012).

Yet, collaboration in virtual environments has a higher dependence on humans than on technological factors. In this way, the real convincement of collaboration and exchange rises from stakeholders rather than thanks to technological tools and resources (Crompvoets, et al., 2008; Wallace, 2007).

2.3.2.2. Support to education

In the construction of a ScGII, the education community represents an important group of potential users who can make use of stored GI and knowledge. On the one hand, teachers and professors have a potential tool to instruct students with map viewers or other web applications. Moreover, GIS is an appropriate educational tool that helps creating spatial thinking skills, and is a very powerful tool to solve real life situations in society or environment (Iaaly, et al., 2011). On the other hand, a ScGII serves as a spatially-related information repository (Al-Daihani, 2011).

Cartography can serve as an added value to enrich contents and support arguments in projects, essays, theses, etc. (Kraak and Ormeling, 2010) in earth sciences or in any other spatially related discipline.

There are examples of multimedia cartography resources focused on education at different levels: from the simplest quizzes based on maps, like Didactalia maps (URL 6), to more advanced environments with higher complexity and contents, like the map viewer of National Geographic Education (URL 7).

2.3.2.3. E-Science supporting decision-making

Government and decision-making are activities directly related to the reconnaissance of the territory (Williamson, et al., 2003). This is a parallelism with earth sciences and all other disciplines that are, in some way, spatially related. Very often, scientific information is ignored by governments, as a result of failure in communication (Schaal, 2008), when it could serve as a way to manage fairly the society and the environment (Cribb and Sari, 2010).

Therefore, ScGIIs may work as a link between the administration and the research sector, providing spatially related knowledge to policy makers. In this way, advice to decision-makers is enhanced, and the society disposes of a tool to view prospective projects or changes in, for instance, urban planning. Instances are the Danish Cataster (URL 8) (Hansen, et al., 2011), the Bavarian GII (URL 9) (Stoessel, 2006), or MetroGIS (URL 10) (Georgiadou, et al., 2006) in the US.

2.3.2.4.Responses to the threats of science performance

ScGII stakeholders and their roles also deal with the threats of science performance. Firstly, the increase of interactivity between partnering groups improves exchange, collaboration and quality by peer-reviewing in the scientific field. Those factors empower the science sector’s efficiency and effectiveness and its applications to other sectors like decision making or education.

Secondly, stakeholders represent the intervening actors in the use of a ScGII. Therefore, it is important to focus on them because their skills and abilities hardly condition the system’s contents and capabilities. In this way, focusing on stakeholders helps to solve the breach between system capabilities and user needs.

All components explained up to this point represented on one side the stakeholders, behaving as users and providers; and on the other the GI, behaving as the message or the exchanged information in a communication. Crompvoets, et al. (2008) refer to stakeholders and GI as the two components that create the need for that communication. To do so, they need an *'enabling platform'* which refers to the rest of the components: technology, policies, standards, (Crompvoets, et al., 2008), organizational framework and finances (van Loenen, 2006).

2.3.3. Technology

GII technology is shaped by a set of methodologies and standardized protocols based on ICT (Fu and Sun, 2010). Technology embraces all the physical elements that enable the communication and the transference of GI between stakeholders (Crompvoets, et al., 2008; Fu and Sun, 2010; Van Loenen, 2006). Actually, it is considered as one of the leading components in GIIs, because it determines what theoretical ideas are practically feasible with ICT means (Delgado, et al., 2008).

Yet, there are barriers on technological implementation. They reside in two main influencing factors, which are critical for the GII success: on the one hand, the GII developer team has to have the technological resources and technical capabilities to build the infrastructure (Zhong-Ren et al., 2003); and on the other hand, users have to have enough skills and experience in GIS and technology to take the maximum profit from the system (Brox and Pires, 2004; Haklay and Zafiri, 2008; Zhong-Ren et al., 2003). Nevertheless, first of all it is important to gather user requirements and to make sure that all system needs are covered.

2.3.3.1. GII technical elements

GIIs are composed of a set of software, middleware and hardware resources that work closely inter-related to serve GI from providers to users (Fu and Sun, 2010). Generally, GIIs require a set of elements to fulfil the basic needs of GI storage, management, search, retrieval, visualization, operation and acquisition (Mansourian, et al., 2011). Normally, they work in a distributed environment through the internet, connecting user and server sides into desktop clients. Nevertheless, in a near future GIIs pretend to be totally distributed systems, enabling full operability in a web-based environment without the need of any GIS software (Yang, et al., 2010; Zhong-Ren et al., 2003).

There are some critical features for the implementation of a GII that must be taken into account to determine the nature of the infrastructure (Zhong-Ren et al., 2003): the system's architecture (section 2.3.3.1.1), the interoperability capabilities (section 2.3.3.1.2), and the usability of the system (section 2.3.3.1.3).

2.3.3.1.1. System's architecture: SOA vs. grid structures

E-Science infrastructures have wide differences in their technological construction depending on who they are made for (Foster and Kesselman, 2004). The main structural differences reside in the network architecture design. Up to the present there are two main architecture systems (Giuliani, et al., 2011; Zhong-Ren et al., 2003) (*Figure 8*): *(a)* a Service Oriented Architecture (SOA) which connects a single server with many thin clients (One to Many - 1:M); and *(b)* the Grid Architecture, which connects multiple users in between, all acting as heavy clients (Many to Many- M:M) (Zhong-Ren et al., 2003).

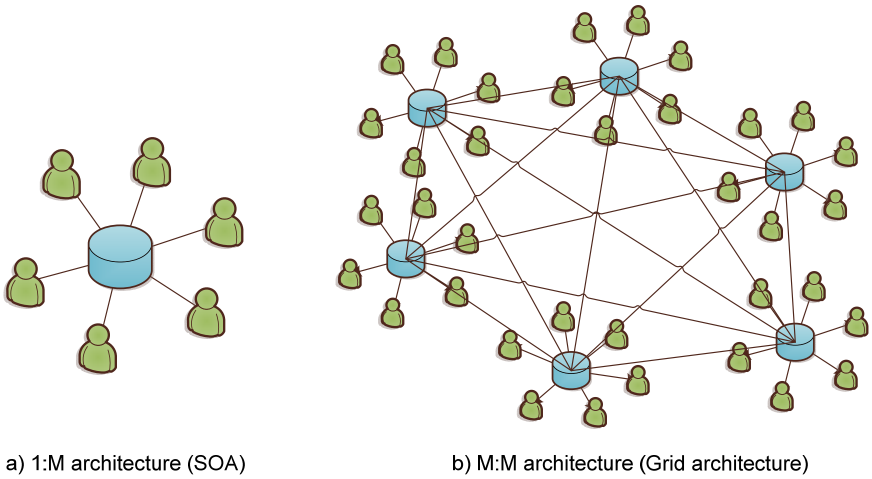


Figure 8: Complexity in Information Infrastructures' architecture
Source: Own design, based on Zhong-Ren et al., 2003, page 9

While most GIIs are structured as SOA, scientific grids often use cloud architecture to work in a truly distributed environment, where collaboration, sharing and interaction is fully possible. Actually, grids represent the best example in the practice of e-Research and e-Science (e-SciDR, 2008). Grid computing involves intensive computation and the use of immense datasets, which with the coordination of different nodes allow complex operations that, cannot be processed with stand-alone computers (Foster, et al., 2002; Giuliani, et al., 2011). Examples of this type of infrastructure can be found in national or international research organizations and partnering fellowships between different research groups (Andronico, et al., 2011; e-SciDR, 2008). Yet, the use of grid computing is limited because it requires complex middleware, and is not easily accessible by the majority of researchers (Fu and Sun, 2010). In a way, those resources are not very easy to use for non-expert professionals in IT (Deng and Di, 2009).

Architecture is the technological base of GIIs (Zhong-Ren et al., 2003). Generally, developers take a technology-centred approach to provide a system that is able to work in a short time frame, using ad-hoc and simple technological resources (Zhong-Ren et al., 2003). The problem, in this case, is whether these implementations match with user needs in practice.

Ideally, the chosen architecture should be dynamic, enabling a change from a simple to a complex framework when needed, without having to re-structure the whole system from scratch (Zhong-Ren et al., 2003).

2.3.3.1.2. Interoperability capabilities

Interoperability is defined as "*the capability of components or systems to exchange information with other components or systems or to perform in multiple environments*" (Esri, URL 5). In a GII, technical elements need to be as much interoperable as possible to reach the maximum amount of users and enable the maximum amount of operations and functionalities. To do so, standards help creating a common pattern to ensure that all systems are compatible (Mansourian, et al., 2011). Different initiatives in the ICT and GIS sectors try to encompass standardization to enable full compatibility, but, still, this process is very difficult and complex.

The most important problems are the compatibility of geoservices in GIS or CAD programs, the compatibility of data formats, the geoprocessing capabilities (Zhong-Ren et al., 2003) and the capacities of GIIs to perform all GIS functions in a really distributed environment without the use of any GIS/CAD desktop software (Guan, et al., 2012; Zhong-Ren et al., 2003). These problems considerably decrease the performance capacity of GIIs (Béjar, et al., 2009).

2.3.3.1.3. System utility and usability

Apart from being interoperable and having a proper structure, a GII must be useful and easily usable by any user from the own community (Shekhar and Xiong, 2008; van Elzakker and Wealands, 2007). In the first place, utility "*implies whether the system can perform the function(s) required by the users to achieve their goals"* (van Elzakker and Wealands, 2007, p. 492). In the second place, usability entails the concepts of system effectiveness, efficiency and satisfaction by addressing the accuracy and completeness to fulfil tasks, the user-friendliness to use the interface and obtain geospatial resources (Bonifatti, et al., 1996; Shekhar and Xiong, 2008) and the satisfaction in the use of the system respectively (van Elzakker and Wealands, 2007).

In a way, these are the technical factors that facilitate the rapprochement from the most complex side of technology to the human and social side of GIIs. Instances of this are the great capabilities offered by a web application like Google Maps (URL 11) to edit and share GI, or all the geospatial systems for children or high-school pupils like Maps 4 kids (URL 12), or the already cited interactive map maker of National Geographic Education (URL 7), which facilitate enormously the use of multimedia cartography.

2.3.3.2. Potential technical capabilities of a ScGII

When dealing with higher education and research, the technological resources have to move towards a more advanced environment. Yet, they have to keep utility and usability as main referents to permit any community user a proper use of the infrastructure. The potential technical features of a ScGII should be applied to its basic elements (Grill and Schneider, 2009): the GI repository *(a),* the metadata catalogue *(b),* the visualization system *(c)*; and the geoportal (Figure 9):

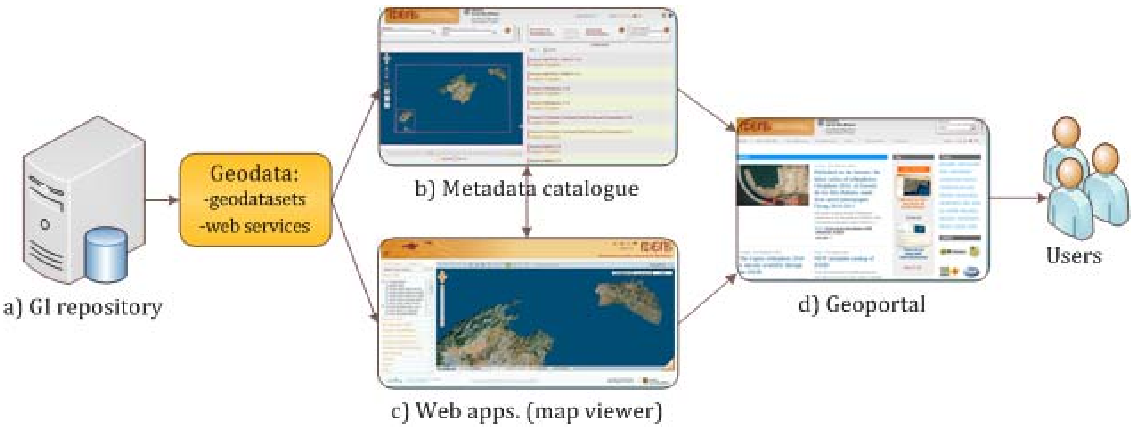


Figure 9: Basic technological elements in a GII

Source: Own design based on the Balearic Islands GII (IDEIB) (http://www.ideib.cat/)

a) The GI repository: should be structured by information types (separating spatial from non-spatial information) and by information origin (research projects or descriptive

GI). Also, depending on the nature of geodatasets (format) or the software used to manage the database, structures may vary. Contents should include:

- **Geodatasets** for download

- **Geoservices**: composed by GI and geoprocessing methodologies. A ScGII should incorporate the maximum variety of geoservices to increase accessibility, but specially strengthen the use of geoprocessing tools as the special tools of e-Science infrastructures (Baranski, 2006; Deelman, et al, 2009).

b) The metadata catalogue: should be transparent to any user to ensure total discoverability of existing resources. This is not meaning that access should be totally open; policy restrictions should take care of that issue (Section 2.3.4). Catalogues can be centralized or distributed (Fu and Sun, 2010). Distributed catalogues enable the access to external partnering GII catalogues. That means that they have greater accessibility to more information sources from a unique spot.

c) Web applications: mainly composed of map viewers (Fu and Sun, 2010). These may serve as a way to visualize and perform simple operations on research project results (Tintoré, et al., 2006) or together with descriptive geo-information layers. There is a possibility of incorporating Location-Based Services (LBS), serving real time information to users (Shekhar and Xiong, 2008).

d) The Geoportal: should offer a simple and self-explanatory interface where the user can easily find all contents in the fewest clicks, and serve ready to use information, shortening the needed time to perform an operation (Deng and Di, 2009). It should give information about the organization, and the ScGII in itself. Besides, it should also include support materials, up-to-date news, links to related GIIs, and other possible sources of interest for the user community (Koshkarev, et al., 2008).

2.3.3.3. *Responses to the threats of science performance*

Technology represents one of the components that deal with more adaptation problems when having to adapt to user needs. Despite being the component that has enabled the great advance of science in the last decades (Andronico, et al., 2011; Cribb and Sari, 2002), it still misses some points, especially in the relation with users. Nevertheless, when identified, system weaknesses can be easily corrected and customized.

Scientific knowledge management may appear as a threatening topic when having to deal with enormous amounts of contents. Therefore, ScGIIs should try to improve the search, index and retrieval options in its catalogue (Shekhar and Xiong, 2008). To do so, advances in semantics may help users to find what they are looking for (Abresch, et al., 2008).

When dealing with the establishment of collaborative environments, and a proper system performance, ScGII technology should adapt to enable information exchange, clearly defining:

1) which structure should be applied among users (architecture)
2) In which ways should users communicate (interoperability)

3) How the system should be to result as usable and useful as possible (usability and utility)

2.3.4. Policies

Sharing information and knowledge requires policies and regulations, determining who owns these contents, and what are its permitted uses (Cribb and Sari, 2010; van Loenen, 2006). In GIIs the existence of policies enables GI owners and providers to determine who can make use of what, how it can be used, and how it can be distributed (Cho, 2005).

Generally, GIIs have four groups of user types: the public sector, decision-makers, scientists and commercial users (Cho, 2005). Depending on their interests, these stakeholders' groups may have different requirements when providing/accessing GI (Cho, 2005). Likewise, GIIs also have their own regulations according to their aims for information distribution (van Loenen, 2006).

Janssen (2008) analyzes GII policies and legal issues from three different approaches: compliance (section 2.3.4.1), coherence (section 2.3.4.2), and quality (section 2.3.4.3). These study views may also be applied to the ScGII concept construction:

2.3.4.1. Compliance

Compliance refers to the laws and policies that lie behind an organization or initiative, and must be obeyed by participants to achieve certain aims or objectives (Oxford Dictionary, URL 13). GIIs follow the same rule (Janssen, 2008): all participating stakeholders must follow the regulations regarding GI access, dissemination and use (Cho, 2005), predefined by underlying rules of their political context (van Loenen, 2006).

One of the main aims from ScGIIs consists on the dissemination and transfer of spatially related scientific knowledge into society. Then, all law rules emitted by the political entities in an international or national context regarding to R&D should be followed and applied to the ScGII to support the initiative's aim (Janssen, 2008). In the case of a ScGII built in Spain, the policy rules should comply with the Spanish legislation in *Science Technology and Innovation* (Law 14/2011, BOE), the Spanish legislation in Geo-Information Infrastructures and Services (LISIGE) (Law 14/2010, BOE), the European Commission law in R&D (EU, No. 1906/2006) and the European Union Charter of Fundamental Rights (EU, 2010, Article 179).

2.3.4.2. Coherence

Underlying rules directly related to the ScGII's aims should be coherent with GI policies defined by stakeholders (Janssen, 2008). This means that policies from both sides should not contradict each other (Janssen, 2008), otherwise these policies would result into a constraint of these GIIs to reach their full potential, offering more contents in their catalogues than really accessible information sets. This is the case of some national or regional GIIs, which offer GI sets which are not accessible in any way, except by purchasing. An instance of this case may be seen in the Balearic Islands GII (IDEIB, URL 14).

Laws and regulations can be focused on multiple factors like information, GII coordination, software, standards, etc. (Janssen, 2008). Yet, the greatest focus is usually on information because it is the actual exchanged object that may suffer from misuse.

There are four factors that influence users and providers when having to define accessibility regulations with respect to the GI they offer (Figure 10): Intellectual Property Rights (IPR), privacy, security and liability (Janssen, 2008).

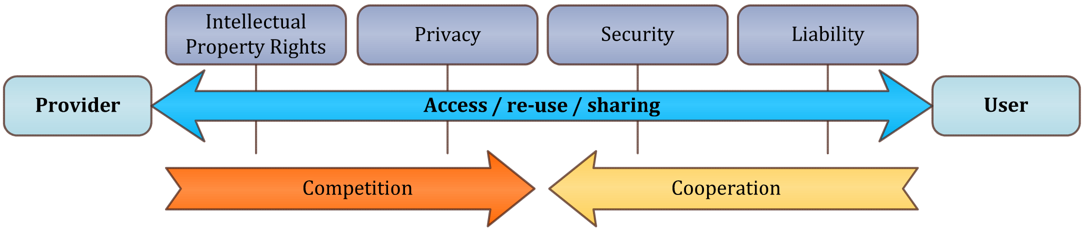


Figure 10: Legislation affecting GIIs
Source: Own design, April 2012, based on Jansen, 2008 p. 262

- **Intellectual Property Rights (IPR)** refer to the assignment of a protection legal standing over an invention or novel practical application that gives advantages to the holder over others (Cho, 2005; OECD, URL 15). IPRs are formalized through patents, copyrights and trademarks, and give exclusivity over the product for its use (Cho, 2005) and potential economical and social benefits (OECD, URL 14).

In the field of science this factor is especially important. When dealing with the dissemination of scientific products, IPRs are a primary element to state the author of the innovative product, and the ways in which it can be distributed (Crib and Sari, 2002). The level of restriction will depend on every holder. However, the more restrictive IPRs are, the more difficult it is to share contents and to carry on a good management of scientific knowledge for its posterior dissemination (Crib and Sari, 2002).

- **Privacy** is also totally necessary in GIIs. It represents the agreement between individuals and organizations to keep confidentiality over shared information (OECD, URL 15). Privacy must respect IPRs apart from other private information.

- **Security** refers to the technological means that enable keeping the privacy into an infrastructure, protecting it from misuse or external intruders. Security may be applied in many GII elements, like the databases (Abresch, et al., 2008), the metadata catalogue, the web applications or the geoportal (Geonetwork, URL 16). They must be adequately customized in order to obey to the stated sharing rules for every type of user.

- **Liability** refers to the legal responsibility that a GII must have towards all the distributed information (Oxford Dictionary, 13), respecting the intellectual property of providers. In this way, the GII should ensure security and privacy to providers, to create enough trust and induce them to share their products (Abdul-Rahman and Hailes, 2000; Ensign, 2009; van Loenen, 2006).

The existing relationships between stakeholders strongly condition the definition of these factors (Janssen, 2008). Either stakeholders aim to compete (confronting each other), either they aim to cooperate. Depending on this, the possibilities for enabling better exchange rules to access re-use and share GI change dramatically (Janssen, 2008). In the field of science, cooperation should be the leading trend, enhancing relationships among researchers, developers or students to permit the access to a wider range of data, information and knowledge (Abdul-Rahman and Hailes, 2000).

In the ScGII IPRs, privacy, security and liability are especially determining factors to ensure the trust of GI providers, especially if they are aiming to share research publications and novel discoveries. Researchers may be reticent to share their findings with the user community. Therefore, the GII organization must make sure that all the coherence factors are perfectly accomplished. Moreover, since the ScGII tries to be an open gateway for science into a community, GII managers should negotiate access conditions with providers to reach the maximum accessibility capabilities for a wider amount of users.

2.3.4.3. Quality

Quality analyzes whether the legal basis of a GII meet the infrastructure's goals (Janssen, 2008). In this way, *the quality of the legal framework will increase as it gets closer to reaching these goals* (Janssen, 2008, p. 267).

Disseminating and sharing scientific production are among the main goals of a ScGII. In this sense, the more open the access is, the more intensive can be the collaboration, and, as a consequence, the higher the production. Ideally, results from scientific research should be totally open. in this way, the whole society could make profit of it when applying it to real life situations (Cribb and Sari, 2010). In this respect, there are authors like Murray and Stern (2007) who question whether the application of IPRs is really positive for scientific production, or whether it results in an action to "privatize" scientific commons and limits the growth of scientific production.

In any case, property rights over discoveries and research findings are a reality. ScGIIs should negotiate policies with providers (researchers) to agree on a wider openness to guarantee that a maximum amount of users can indeed access and use the maximum amount of contents.

2.3.4.4. Responses to the threats of science performance

In ScGIIs, policies and legislation have great importance. Intellectual property has a special relevance in the sector of science because it is the element that defines who is the legal owner of a certain idea, and limits its uses and applications (Cribb and Sari, 2010; Janssen, 2008). In this way, if IPRs are restrictive, spatially-related scientific production cannot be properly exchanged (Murray and Stern, 2007). Therefore, in ScGIIs IPRs and policies may even be more determining than in generic GIIs.

A ScGII should guarantee that all contents can be seen in the metadata catalogue, although they may not fully be available for use. This measure enables researchers to find out whether a certain topic has already been studied or whether it still is an uncertain or unknown issue. ScGIIs must respect IPRs and privacy over contents, ensure system security and be confident towards users and providers (Janssen, 2008). As explained, ScGII goals should match with underlying laws and the providers' accessibility policies (Janssen, 2008). Yet, to guarantee a maximum amount of accessible contents, GII managers should convince providers, especially researchers, that enabling access to their research products works as a way of self-promotion, curriculum construct and common benefit through collaboration in the long term. Misuse or illegal utilization of these materials is a risk that every individual should be conscious about. In case of interfering with law restrictions, the owner of an IPR is free to denounce the offender, who will have to deal with justice (Global Legal Resources, URL 17). Therefore, having clear legislation and policies helps to avoid possible bias in the inadequate use of protected contents.

Obviously, scientific products and all related contents may have an economical cost. Every administration sets its rules about R&D publication. For instance, the European Union reveals that all administrations or public research centres and universities research results should enable open access (European Commission, URL 18). In case of collecting contents from private providers, GII managers should agree on the economical costs to gather that information. If the ScGII is part of a public entity like a university or research centre, most contents from other public entities should not require any fee.

2.3.5. Standards

Standardization is a basic element to allow communication. The International Organization of Standardization (ISO) defines standards as "*the documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics to ensure that materials, products, processes, and services are fit for their purpose*" (Kemp, 2008, p. 446). Likewise, geospatial open standards refer to the set of rules and protocols agreed in consensus between participating stakeholders (Kemp, 2008), that need to be established to enable geospatial systems' interoperability to use and transfer geospatial information (Michaelis and Ames, 2008; van Loenen, 2006).

Different organizations from the GIS sector work to standardize technological means to permit the exchange of geospatial information, which in general is rather heterogenic. Amongst others, the global Open Geospatial Consortium (OGC) and the Infrastructure for Spatial Information in Europe (INSPIRE) in the European Union, work to establish rules and permit interoperability (INSPIRE, URL 2; OGC, URL 4).

In science, standardization also represents a critical issue. Since exchanging information and collaboration are necessary to produce new knowledge, the ways in which this information is shared are relevant. Actually, e-Research infrastructures like grids or ScGIIs rely on standards to collaborate, exchange heterogeneous information and perform complex computations between highly interdisciplinary users (Anselin, 2012; Giuliani, et al., 2011; Yue, et al., 2011).

Geospatial standards are applied to the hardware, middleware and software (Hanselth, et al. 1996; van Loenen, 2006). They are applied to data formats (Kemp, 2008), geographic coordinate systems and projections (INSPIRE, URL 2; OGC, URL 4), thematic classifications (INSPIRE, URL 2), database structures, geospatial web services (OGC, URL 4), metadata profiles and catalogues (OGC, URL 4), GIS programs etc. Likewise, all other ICT means require standards, especially the ones that work in a distributed environment. Instances may be programming languages like Java, Python or C/C++ (Giuliani, et al, 2011) or the WWW environment, managed by the World Wide Web Consortium (W3C, URL 19).

Still, standardization has not reached perfection yet. Several standards serve common purposes, but, for different reasons, not all organizations or enterprises want to use the same standards. This creates problems when having to combine standards to perform tasks. In this way, there are the *de facto* standards, set by important software firms like Esri or AutoDesk (Kemp, 2008);

and the *de jure* standards, set by law (Kemp, 2008). This duality is spread in most of the fields that require standardization and are fully applied in GIIs.

Next sections explain the implication of standards in data formats (section 2.3.5.1), metadata standards (section 2.3.5.2) geoservices (section 2.3.5.3), and the compatibility between geoservices and GIS / CAD programs (section 2.3.5.4).

2.3.5.1. Data formats

Data and database formats need total interoperability into a GII. The most relevant geodata formats in the GIS sector have their origin in enterprises. Therefore, they may present compatibility problems with other systems or programs (Kemp, 2008). This is the case of formats like shape (.shp), layer (.lyr), geodatabase (.gdb), SDE, e00 from Esri; .kml from Google Earth; .dgn and .dxf from Autodesk; or .img from Erdas Imagine (Kemp, 2008). Others like GML are recognized by the OGC, but their use is not very generalized yet. Therefore, considering the users' abilities with GIS, ScGIIs should serve the most used formats and not necessarily the *de jure* standards. In any case, access to conversion libraries like GDAL (URL 20) or FME (URL 21) would enable interoperability from other existing formats to the standards, and the other way around.

2.3.5.2. Metadata standards

Metadata sets follow specifications from different organizations in order to be retrievable in catalogues. The ISO19115:2003 specification describes how geospatial metadata should be (ISO, URL 22). However, international organizations in different places in the world have created their own metadata templates. Instances are the OGC with the ISO19139 and ISO19110:2005 templates, the Dublin Core template, or the Federeal Geographic Data Committee (FGDC, URL 23) template in the US (Geonetwork, URL 16). In Europe, the INSPIRE initiative adapts to the OGC metadata standards (INSPIRE, 2010)

2.3.5.3. Geoservices

Geoservices require a very strict standardization to be fully interoperable. Therefore, the OGC has created standard models to ensure their compatibility in multiple software platforms (Mansourian, et al., 2011); the so called OGC Web Services (OWS). In parallel, private companies have also created their own geoservice types for their software products. The list of existing geoservices is long, but they concentrate on performing 4 main tasks:

- <u>Search and retrieval</u>: They serve as a technology to publish and search geospatial metadata by means of a geospatial catalogue on the Web (Fu and Sun, 2010). The Catalog Service for the Web (CSW) from the OGC is the most relevant. Examples of the CSW are *Geonetwork* and *eXcat* (GDSC, URL 24).

- <u>Visualization</u>: They enable the visualization of a cartographic layer in a GIS in an image format. Web Map Service (WMS) from the OGC is the most popular one in its category and among all other geoservices (Fu and Sun, 2010; Shekhar and Xiong, 2008). Its capabilities are quite limited because it just enables visualization and query, but it does not permit any legend consultation, customization, processing or exporting (Fu and Sun, 2010; Shekhar and Xiong, 2008) although is very easy to use and does not report errors

(Fu and Sun, 2010). WMS serve for raster and vector indifferently. Base maps in various GIS program like ArcGIS (Esri, URL 25) or Google Earth (Google, URL 26) have a similar performance, but do not admit query. Another service in this category is ArcIMS from Esri (GIS Dictionary, URL 27), although is already quite old-fashioned.

- Operation: This category refers to all services that do have interactive capabilities between the server and the user. They enable queries, updating, deleting, exporting and customization (Fu and Sun, 2010). Basically they work as datasets with the difference that they are acquired by a URL address. The OGC Web Services (OWS) of this type are: *Web Feature Services* (WFS) for vector format; *Web Coverage Services* (WCS) for raster format (OGC, URL 4). Transactional services enable service edition (WFS-T and WCS-T). KML services have been adopted from Google into the OGC and also enable these functions but only work with feature data (OGC, URL 4). GeoRSS services work in web application environments, like map viewers, permitting queries to RSS feeds, to consult up-to-date information, for instance in public services (Fu and Sun, 2010). An example is the Global Incident Map (URL 28).

- Processing: These services enable geoprocessing operations through the Web in a GIS. They enable using and customizing geoprocessing tools that do not need to be on the user's computer (Guasp, et al., 2011), using own data or other geoservices like WFS or WCS (Baumann, 2010). The operations can perform spatial, thematic, temporal and metadata processing (OGC, 2007).

  These types of services are quite rare yet, but they grow as a trending topic in science because they permit operating (Brauner, et al., 2009; Meng, et al., 2010), rather than just visualizing or querying like in most GIIs nowadays (Giuliani, et al., 2011). The OGC has developed Web Processing Services (WPS) for vector processing (Schut, 2007), Web Coverage Processing Services (WCPS) for raster processing (Baumann, 2007), and Geo-Processing Workflow (GPW) dedicated to join WPS into workflows to enhance geoprocessing capabilities (Meng, et al., 2010). Several initiatives, like 52ºNorth URL 29), Degree (URL 30), ZOO (URL 31) or PyWPS (URL 32) have made their own implementations, which follow the OGC specifications.

2.3.5.4. GIS software vs. geoservices

Geoservices are very useful means to transfer geospatial information. Nevertheless, they are intrinsically related with GIS and CAD software programs, which work as clients. Therefore, software capabilities are a limiting factor in the use of geoservices.

There are great differences between GIS and CAD programs regarding their capabilities and user-friendliness. Normally, commercial programs incorporate a wide array of capabilities and are rather easy to use. On the other hand, Open Source software may be simple or complex, but the user-friendliness is often lower. As a consequence, users with little experience in GIS or ICT may not be able to use these programs. The compatibility of programs with different Operating Systems may also be an issue. Table 1 summarizes the software capabilities with geoservice types. The cells in green represent compatibility; if there is a plug-in needed it is also indicated. WCPS and GPW are OGC standards, although they are not compatible with many GIS or CAD programs yet, because they still pass by a trial and development phase. ECWP, ArcIMS and GeoRSS are not OGC standards but may be useful too.

	WMS	WFS	WCS	WPS	KML	WCPS*	GPW*	ECWP (Erdas)	ArcIMS (Esri)	GeoRSS
ArcGIS				From v.10.1		?	?			
ERDAS Imagine						?	?			
GRASS GIS				+plug-in (PyWPS)		?	?			
Quantum GIS				+plug-in (PyWPS)		?	?			
uDig				+plug-in (52ºNorth)		?	?			
Google Earth						?	?			
GvSIG						?	?			
AutoCAD						?	?			
Microstation						?	?			
Open Jump GIS						?	?			
MapWindow GIS				+plug-in		?	?			
Miramon						?	?			

Cells filled in green mean compatibility; empty cells mean no-compatibility; cells with a question mark (?) mean unknown compatibility. WCPS and GPW are OWS in a trial and development phase

Table 1: GIS software compatibility with geoservices

Sources: ERDAS, URL 33; Esri, URL 5; IDESF, URL 34; PyWPS, URL 32; uDig, URL 35 and OGC, URL 4

2.3.5.5. Responses to the threats of science performance

Standards are basic to ensure interoperability in geospatial systems. While in generic GIIs distributed resources might not be so determinant, in e-Research infrastructures the need to collaborate in VRC requires the widest amount of Web GIS resources (Anselin, 2012; Deelman, et al., 2009; Deng and Di, 2009)

In the first place, standards help to catalogue and classify information enabling a faster retrieval for any user by means of CSW (Fu and Sun, 2010) and metadata standards. The infrastructure should make use of a distributed catalogue, permitting the retrieval of external catalogues, and consequently increasing the discoverability and accessibility to other information sources (Fu and Sun, 2010). In relation to metadata standards, ScGIIs should stick to a unique metadata profile for their own catalogue, following the rules of underlying ruling bodies like the OGC or INSPIRE. In this way, all information obeys to the same pattern, it ensures that all descriptive information for every dataset is clear, and states accessibility policies that permit or restrict the access depending on the user rights.

In the second place, it is important to share GI in standard formats. However, is important to remember that not always the *de jure* standards are the most used. A ScGII should serve geospatial information in the formats that users normally work with. And we should also be conscious about the GIS/CAD software they work with, because this factor strongly conditions their activity at work.

Currently, GIIs usually implement just the geoservices that comply with the OGC and INSPIRE rules (OGC, URL 4). Yet, there are other types of geoservices that also work efficiently, are widely used, and may have applications in the field of science. A ScGII should serve OGC geoservices, but to be even more interoperable it could also incorporate other types of geoservices like ArcIMS or ArcGIS Service.

In the third place, geoservices serve as a way to distribute information in a variety of ways to perform different tasks, all applicable to the scientific activity. Yet, user experience and skills may not reach enough level to work with those advanced techniques (Li, et al., 2010). As a consequence, ScGIIs should just implement the types of services that users know how to use. Nevertheless, advice about other geoservices and their opportunities may be given to support their implementation in the long term.

In the fourth place, in relation to GII policies, geoservices may serve as a way to enable or restrict the use of information in certain ways (Grill and Schneider, 2009). This enables the owner to decide what have to be the distribution means for his product (Grill and Schneider, 2009).

2.3.6. Organizational framework and finances

These two components represent the last features that characterize any GII. When applying it to ScGIIs, there are no great differences, because both factors are relevant to every study case:

- On the one hand, human, organizational and technological resources are different among organizations. This fact conditions their capacity to develop and maintain social and technological features for a GII (van Loenen, 2006). Therefore, the organizational framework can be analyzed but not generalized out of a context.
- On the other hand, finances are also determined by the organizational environment, and, as a consequence, the funding of a ScGII totally depends on the organization's capacity to invest own capital, or find external funding for the initiative.

From the users' perspective, organizational and financial aspects are determining factors to maintain a GII over time. Nevertheless, users do not have any competence to influence them.

2.4. Conclusion

This chapter discussed about the theoretical background of ScGIIs, and set the potential adaptations for every component to the activities dealing with science. So far, could be seen what the critical and sensitive factors are, to build up a ScGII. This chapter made evident that except from organizational and financial matters, which are case applied, the construction of ScGIIs mainly depend on the customisation of main GII components, which are stakeholders, GI, technology, standards and policies. From them, the ones that need from a greater change are stakeholders and contents (GI); the enabling platform should also adapt, making emphasis on accessibility policies, which seem to be the most threatening factor into the scientific community.

This chapter has set up the base for the coming parts of this research. It solved the first research question stating what ScGIIs are and in what aspects they are differentiated from generic GIIs. It also explained its possibilities and potential benefits. Nevertheless, not all questions were responded; current examples of ScGIIs and geospatial systems dealing with science are explained in the next chapter.

3. Geospatial systems dealing with Science

3.1. Introduction

As already mentioned, many research, development and educational organizations have created their own Cyber-Infrastructures or simpler systems to deal with geospatial data, information and knowledge (Giuliani, et al., 2011). The system's complexity may vary enormously from case to case, depending on user needs and developers building capacity. At the same time, the media to distribute geospatial information within a community may vary, although the final objectives are similar.

This section presents three types of existing distributed systems that serve the aim of sharing geospatial data, information and knowledge to enhance scientific transference and production. They are: GI repositories, Scientific GIIs, and Geospatial Grids. In order to be able to compare them, a set of factors with respect to their capabilities to perform tasks in search and retrieval, editing and visualization are presented.

3.2. GI repositories

Maybe simple but pretty effective, GI repositories permit searching and retrieving geospatial information from a remote server for direct use in GIS or CAD software. GI repositories are used in research and education centres as a simple way to share contents within a community. The structure is based on a direct connection between the server and the users using a shared folder. The technological means can be based on a File Transfer Protocol (FTP) or on a Virtual Protected Network (VPN) connection.

From the users' point of view, getting connected is pretty simple; it just requires access to the FTP address in the Web browser, or the download of VPN software that enables connecting with the data server. The access is just authorized if the user has the credentials to use these datasets responsibly, complying with data access and use policies. No standards in data formats are required, although they should correspond with those most used by users.

3.2.1. Utrecht University GI repository

The Geosciences Faculty at Utrecht University (The Netherlands) uses a GI repository to share geospatial information with students, professors, and researchers (Utrecht University, URL 36). This is made possible by means of formal agreements between the user and the University to use these datasets just for educational or research purposes (Zeilmans, M., 2012, Private communication). This type of infrastructure to share information (not necessarily geospatial) is also common in other universities. This is the case in the universities of Delft (URL 37) or Edinburgh (URL 38)

- *Search and retrieval*: Users just need to access the network with their University ID number and password to enter the shared folder. In it, a search can be made by folder directories, structured by region, GI provider and year. The inconvenience is that the inexistence of metadata and a cataloguing system may make finding some contents difficult.

- *Editing and visualization*: GI repositories give direct access to geodatasets. Therefore, the user can download the information for his own needs directly into a GIS or CAD software. To facilitate visualization, some layers dispose of a layer file (.lyr); however, their use is only possible with Esri software.

3.3.Scientific GIIs

Geographical Information Infrastructures for Science are not very common. Yet, there are several initiatives that work to distribute research and educational resources based on geospatial information and spatially related knowledge. They work mainly for three activities: research, education or decision-making, although very often a unique infrastructure can serve many purposes simultaneously.

Table 2 summarizes the capabilities and features of some relevant examples of ScGIIs at the present time [May 2012]:

ScGIIs		Search and retrieval				Editing and processing		Visualization
		Full access directed to:	Contents	open access capabilities	Restricted capabilities (need for credentials)	Web-based capabilities	To use with GIS software	Map viewer capabilities
University initiatives	**IDE-ULPGC (URL 39)** (ULPGC) *(Schorn et al., 2011)*	Restricted to U. Researchers	-Research projects' GI + extra docs.	-Consult all contents in the catalogue and external GIIs (CSW) -Use geoservices -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*None*	-*Geoservices*: WMS, WFS -*GI download*: KML	-View published GI -Use base-maps -Make queries -Create and save pinpoints
	WorldMap (URL 40) (U. Harvard) *(Guan, et al., 2012)*	U. Researchers, professors and students	-Thematic GI -Research projects' GI + extra docs.	-Consult all contents in the catalogue -Publish GI and metadata -Use geoservices -Download GI -Use the map viewer	Fully open to anyone	Create maps with map viewer using: -Own GI (upload) -WorldMap OWS -External WMS -Scanned maps to georeference	-*Geoservices*: WMS, WFS -*GI download*: KML	-View published GI -Use base-maps (2D-3D) -Make queries -Use Street View -Combine with YouTube and Picasa
	SIB-ESS-C (URL 41) (U. Jena) *(Gerlach, 2007)*	Restricted to U. Researchers	-MODIS GI -Research projects' GI	-Consult all contents in the catalogue and external GIIs -Use geoservices -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	-Perform and view geoprocessing	-*Geoservices*: WMS, WFS. WCS, WPS -*GI download*: KML	-View published GI -Use base-maps -Make queries -Perform geoprocessing
	IDEUnivers (URL 42) (dif. universities in Spain, Italy, and Greece) *(Barea, et al., 2011)*	Restricted to U. Researchers	-Research projects' GI	-Consult all contents in the catalogue -Use geoservices -Download GI -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*(Unavailable)*	-*Geoservices*: WMS, WFS -*GI download*	*(Unavailable)*

ScGIIs		Search and retrieval				Editing and processing		Visualization
		Full access directed to:	Contents	open access capabilities	Restricted capabilities (need for credentials)	Web-based capabilities	To use with GIS software	Map viewer capabilities
Research Institutions initiatives	**CEDAI** (URL 43) (IMEDEA) *(IMEDEA, 2011)*	Just researchers	-Research projects' GI	-Consult all contents in the catalogue and external GIIs (under construction) -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*(under construction)*	-*Geoservices*: WMS -*GI download* (under construction)	*(under construction)*
	Casa Montero Project (URL 44) (CSIC) (Fraguas, et al., 2009)	Open	-Research projects' GI	-Consult all contents in the catalogue -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*None*	No accessible resources	-View published GI -Use base-maps -Make queries
	IDEO (URL 45) (IEO)	Just researchers	-Research projects' GI	Unknown *(under construction)*	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*(under construction)*	*(under construction)*	-View Thematic GI -Use base-maps -Make queries *(under construction)*
	IDAMAR (IHPT) *(Bessa, 2009; Chumbinho et al., 2003)*	Just researchers	-Research projects' GI	Unknown *(under construction)*	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*(under construction)*	*(under construction)*	*(under construction)*
	SHARE Geonetwork (URL 46) (EvK2-CNR) *(EvK2CNR, 2011)*	Just researchers	-Research projects' GI	-Consult all contents in the catalogue -Use the map viewer	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	*None*	-*Geoservices*: WMS -*GI download KML*	-View published GI -Use base-maps -Make queries
Governmental initiatives	**Geoscience Australia** (URL 47) (Australian Gov.)	Just researchers and decision-makers	-Thematic GI -Research projects' GI + extra docs.	-Consult all contents in the catalogue -Use geoservices -Download GI -Use the map viewer -Access extra contents	-Publish GI, metadata and extra contents -Publish geoservices -Establish access policies -Download GI	Access to related projects with web-based resources (Multimedia, 2D-3D map viewers, etc). i e. World Wind app.	-*Geoservices*: WMS -*GI download and purchase*	*None*

Table 2: ScGIIs per functionalities and types

3.3.1. University initiatives

Although they are not common, several universities work to develop and maintain their own GIIs to disseminate their spatially-related research into their research communities, and serve GI for educational purposes to professors and students.

The examples listed in Table 2 are:

- Gran Canaria University (Canary Islands Spain), with the **IDE-ULPGC** (URL 39)
- Harvard University (Massachussetts, U.S.) with **WorldMap** (URL 40)
- Jena University (Germany) with the **Siberian Earth Science System Cluster (SIB-ESS-C)** (URL 41)
- Catalan, Greek and Italian Universities (Catalonia, Spain; Milano and Emilia-Romagna, Italy; and Aegean Islands, Greece) with the **IDEUnivers** (URL 42)

With respect to their functionalities and features (Table 2), the following remarks can be made:

- **Search and retrieval**: Generally university initiatives disseminate information for their communities. Accessibility policies are very important, especially for researchers, and therefore even if the catalogue is freely accessible to everyone, the access to GI and extra contents keeps restricted to external visitors. This is the case for the IDE-ULPGC (Schorn et al., 2010) and IDEUnivers (Barea, et al., 2011). SIB-ESS-C and WorldMap do permit the access to GI and other results. The IDE-ULPGC, and the IDEUnivers catalogues give access to external repositories (Barea, et al., 2011);

  The contents of the IDE-ULPGC, SIB-ESS-C and IDEUnivers are directed to research users: permitting the publication of GI, and related contents, and related metadata; and giving access to other published projects. ScGIIs that also support education, like WorldMap, also give access to thematic GI and open access information.

- **Editing and processing**: ScGIIs foster the possibilities to produce geo-information over the simplicity of other GIIs that just work for visualization and dissemination. Good examples in this direction are WorldMap and SIB-ESS-C. While WorldMap is more interactive and easy to use, directed to low and highly skilled users, SIB-ESS-C is more specific and technical, and requires higher skills in GISciences. Geoprocessing tools need more understanding; SIB-ESS-C enables web-based geoprocessing with WPS, but it does not give the possibility to download results. WorldMap permits creating your own maps like in a fully distributed GIS: uploading layers, using your own or external WMS, digitizing features, or even including scanned maps, which can be easily georeferenced by the system.

  Other systems are not so interactive, but still provide tools to work in GIS desktop environments like geoservices or downloadable files. With more or less restriction, all ScGIIs serve WMS and WFS services, and more specific ones like SIB-ESS-C provide WCS and WPS.

- **Visualization**: Generally, map viewers do not differ from other GIIs in their capabilities. Some permit saving features over the map (IDE-ULPGC), viewing information in 3D, Street View or multimedia sources (WorldMap). Others like SIB-ESS-C enable geoprocessing in the viewer.

3.3.2. Research institutions initiatives

Public institutions or private enterprises from the research field also bet for ScGIIs when having to distribute their production. Their aim is to share contents between partners and collaborators, especially if they are not working in a common location.

The examples listed in Table 2 are:

- IMEDEA (Balearic Islands, Spain), with the **CEDAI** (URL 43) (Marine and coastal research)
- CSIC (Madrid, Spain), with **Casa Montero Project** (URL 44) (Archeological research)
- IEO (Spain), with **IDEO** (URL 45) (Oceanographic research)
- IHPT (Portugal), with **IDAMAR** (Oceanographic research)
- EvK2-CNR (Italy), with **SHARE Geonetwork** (URL 46) (Mountain areas research)

Their functionalities are similar to the university's GIIs, although they are more technical and not so user-friendly on their interface. Most of them are made by public organizations, apart from the SHARE Geonetwork, which is made by an independent and non-profit organization.

- *Search and retrieval*: These infrastructures are rather restricted to external visitors, despite the fact that their catalogue is open for consultation. Registered users can access, view and download GI and extra contents. However, accessibility policies may limit the access to just certain users (IMEDEA, 2011). None of these examples have distributed catalogues. All these ScGIIs enable researchers to upload their research results' GI, extra contents, links and metadata documentation.

- *Editing and processing*: Despite being for higher performance, research institutions did not reach enough level in ScGIIs in processing capabilities. None of these systems has Web-based capabilities to process GI or create digital cartography. Yet, these infrastructures serve geoservices: WMS in most of the cases, and WFS and WCS in the Casa Montero Project (Fraguas 2009). Generally, they also offer downloadable GI (Barea, et al., 2011; EcK2CNR, 2011; IMEDEA, 2011).

- *Visualization*: All these ScGIIs have map viewers to visualize published with thematic GI in a common place. Options of these map viewers are not different from generic map viewers.

3.3.3. Governmental initiatives

Governments may also bet for disseminating science to promote R&D and education, but also use this information for decision-making. Despite the fact that many nations use GISciences to improve decision-making, not so often their initiatives are focused on creating an infrastructure to serve this information.

However, the Australian Government is doing it with **Geoscience Australia** (URL 47). It serves thematic and research GI, research results, extra documentation, GIS software, etc. to the society in a quite open environment. Still, the use is restricted to researchers and decision-makers. The portal enables searching through a catalogue, accessing WMS services and downloading GI. Some Web-based applications like World Wind are also accessible. However, there is no map viewer to visualize all GI.

So far, all commented infrastructures are working and accessible at the present [May 2012] or they are documented in literature as GIIs in development. For instance, this is the case of IDAMAR which does not have Web access yet (Bessa, 2009); IDEO or CEDAI which are in development, and are not yet able to fulfil all the functions detailed in literature (IEO, URL 48; IMEDEA, 2011). Others seem to have quitted, like the IDEUnivers project, which lasted from 2010 until 2011, but literature confirms that there is still some activity (Barea, et al., 2011).

3.4.Geospatial Grids

When dealing with research in distributed environments, grids are the most advanced tools to manage and compute information enabling the performance of very complex operations (Pnjat, et. al., 2010). They are defined as systems of software and hardware that allow a coordinated data, information and knowledge sharing in a secure environment, which is not centrally controlled. These shared resources can vary from databases (spatial or non-spatially related), geoprocessing capabilities, software services or applications (Shekhar and Xiong, 2008; Cossu, et. al., 2010). Grid users' work in Virtual Research Communities (VRC) spread in different research centres or universities (Shekhar and Xiong, 2008; GEON, URL 49). These infrastructures may be so limited that is even difficult to know about their activity.

Examples are found at:

- Indiana and California Universities (US), with **QuakeSim grid** (Seismic research) (URL 50)
- National Science Foundation (NSF, URL 51), (US), with the **GEON grid** (Environmental Sc.) research) (URL 49)
- European Spatial Agency (ESA – URL 52), (European Union), with the **G-POD** (RS and environmental science research) (URL 53)
- National Institute of Advanced Industrial Science and Technology (AIST – URL 54), (Japan), with the **GeoGrid** (Environmental science research) (URL 55)
- European Comission (EC), with the Distributed Research Infrastructure for Hydro-Meteorology (DRHIM) (URL 56)

The capabilities of geospatial grids can be compared to the functions of ScGIIs. Table 3 summarizes how a set of geospatial grids facilitates functions:

- *Search and retrieval*: The restriction of geospatial grids is superior to any ScGII; most of them only give access to partners. In some cases even the catalogue is not freely accessible (DRIHM, G-POD or GeoGrid). Yet there are exceptions like GEON or QuakeSim, who do share their production, even permitting the free access to contents for consultation and download.

- *Editing and processing*: These are the most characteristic features of grids. They are capable to perform complex geoprocessing simulations in various dimensions (GEON), time series (QuakeSim), generate automatic WMS services (GeoGrid), work with LBS (QuakeSim), and a wide range of complex operations.

- *Visualization*: Generally, grid map viewers are not much different from generic map viewer applications in GIIs. Yet, their restricted access does not permit knowing much about them.

Scientific Geospatial Grids	Search and retrieval				Editing and processing		Visualization
	Full access directed to:	Contents	open access capabilities	Restricted access to: (need for credentials)	Web-based capabilities	To use with GIS software	Map viewer capabilities
QuakeSim (URL 50) (Indiana and California Universities) *(Pierce, et. al., 2008)*	Just researchers	-Raw data -Research projects' GI -Geoprocessing tools -Publications	-Consult the catalogue -Use processing tools (some) -download software	-Raw data -Research projects' GI -Publications -Information sources -Publish GI and metadata -Geoprocessing tools	-Generate dynamic maps of earthquakes -Generate time series -Calculate seismic variables -Run complex simulation models	-*Geoservices*: WMS, WFS -*GI download*: KML, GPS	-View published GI -Make queries -Use LBS on seismic data
GEON Grid (URL 49) (NSF) *(Gerlach, 2007; Shekhar and Xiong, 2008)*	Just researchers	-Thematic GI -Research projects' GI -Geoprocessing tools working on 2D, 3D and 4D dimensions -Publications + extra docs.	-Consult the catalogue -Download GI -Use processing tools (some)	-Raw data -Research projects' GI -Publications -Information sources -Publish GI and metadata -Geoprocessing tools	-Run complex simulation models -Create customized digital maps with grid contents	-*Geoservices*: WMS -*GI download*: Shp	-View published GI -Make queries -Use LBS
DRIHM (URL 56) (European Universities) *(Schiffers, et al., 2011)*	Just researchers	-Raw data -Research projects' GI -Geoprocessing tools	*None*	-Raw data -Research projects' GI -Publications -Information sources -Publish GI and metadata -Geoprocessing tools	-Run complex simulation models on hydro-meteorology	-*Geoservices*: OGC Services -*GI download*	Unknown (not accessible)
G-POD (URL 53) (ESA, Europe) *(Löscher, et. al., 2008)*	Just researchers	-Raw data: Satellite imagery -Research projects' GI -Geoprocessing tools	*None*	-Consult the catalogue (OGC) -Raw data -Publish GI and metadata -Geoprocessing tools	-Create customized digital maps with grid contents	-*Geoservices*: -*GI download*:	-View published GI -Make queries -Consult satellite imagery
GeoGrid (URL 55) (AIST, Japan)	Just researchers	-Raw data -Satellite imagery -Thematic GI -Research projects' GI -Geoprocessing tools	-Use processing applications (some) -download GI	-Raw data -Research projects' GI -Publications -Information sources -Publish GI and metadata -Geoprocessing tools	-Run simulation models of: Geology, Natural hazards, environmental models, etc.	-*Geoservices*: WMS -*GI download*: Shp, KML	Unknown (not accessible)

Table 3: Functionalities of Geospatial Grids

3.5.Conclusion

This chapter went through existing geospatial information systems that support scientific activities, from the simplest GI repositories, to the most complex geospatial grids, passing by ScGIIs. That served to create a general overview of system capabilities, pros and cons of certain types of solutions, processes, etc. This information was collected as an external investigation to set up the state of affairs in terms of ScGIIs.

This chapter complemented chapter 2 arguments regarding to ScGII capabilities and existing examples of geospatial systems that deal with science. In this way, concluded with the first research question related to ScGII definition.

The description of these geospatial systems is also considered when setting the requirements analysis study in section 6.1. These systems are taken as use cases, to demonstrate to users, the possible capabilities of ScGIIs.

4. User-Centred Design methodology for ScGII development

4.1.Introduction

This chapter describes the general methodology of this research project. After a deep study on the critical topics and ideas to analyze, a concise description on how this project is carried out is necessary. Therefore, Chapter 4 goes through the User-Centred Design methodology (UCD) passing by all its phases, with special emphasis over the Requirements Analysis. Moreover it explains how other secondary methodologies are also considered to improve users' involvement into the ScGII design.

4.2.The User-Centred Design (UCD) methodology

The design and development of a GII, and in general, an Information System (IS) or software, is a tricky challenge for developers, due to the complex nature of these infrastructures, and all the factors and relationships that need to be established around them (Alexander, et al., 2009). The appropriate set up of these factors is what ensures a proper performance it the long term (Revee and Petch, 1999). The methodologies to serve these purposes are Information System Development Methodologies (ISDM), which consist of "a *set of philosophies, phases, procedures, rules, techniques, tools, documentation, management, and training for developers of Information Systems"* (Revee and Petch, 1999, p. 46).

Generally, the implementation of a new IS comes when senior managers in an organization realize the need for an improvement, that will somehow reinforce the organization's activity (Revee and Petch, 1999). In such cases, the decisions and the choices on what is necessary for the organization are made in a top-down direction. The advantage of the top-down awareness is that senior managers can direct funds and the needed organizational changes to promote the new implementation (Revee and Petch, 1999). However, this model does not consider that decisions may not be approached well enough to fulfil its purposes. Moreover, users and external parties may not optimally benefit from these implementations in such a way (Revee and Petch, 1999; Courage and Baxter, 2005). The problem arises when the system developer's ideas on user needs do not match with the real demands, and thus create an inadequate system with a lack of efficiency and effectiveness (Alexander, et al., 2009; Courage and Baxter, 2005; Wilson, 2009)

What matters in these cases, is the infrastructure's design approach (Revee and Petch, 1999) (Figure 11):

- **The techno-centric design approach** represents the traditional methodology that sets its bases on serving a product for itself, no matter its real need. In other words, relying on the premise that most recent is best (Revee and Petch, 1999), and that the demand can be made out of a new supply. Therefore, this approach is highly based on the technological push of new advances. They are carried out by IT developers, who decide what should be included, based only on what other organizations are currently doing (Revee and Petch, 1999).

- **The socio-technical design approach** is the opposite methodology. It tries to create the necessary supply to an existing demand. Thus, it focuses on stakeholders as the main piece of the product's design puzzle (Revee and Petch, 1999), adapting the infrastructure to the specific needs of that community. This represents a more democratic decision-making on the product's design, and guarantees more success in the long term, avoiding an unnecessary waste of resources like: time, budget, ideas, personal effort, etc. (Courage and Baxter, 2005; Hsu, et al. 2010; Yawson, et al, 2011).

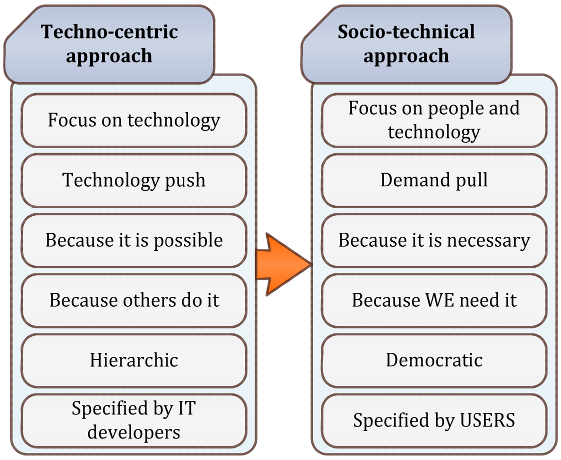


Figure 11: IS design approaches: techno-centric to socio-technical computing
Source: Adapted from Revee and Petch, 1999

The User-Centred Design (UCD) or Human-Centred Design methodology stands out as the leading procedure to follow socio-technical approaches. It is defined as the methodology that focuses on end users and other stakeholders, to collect and analyze their requirements to promote usability, and enhance the product's effectiveness, efficiency, and satisfaction of its use (Bullinger, et al., 2010; Courage and Baxter, 2005).

The UCD methodology is composed of three phases:

1) **The requirement analysis** tries to discover what users want and need before designing the product (Alexander, et al., 2007; Courage and Baxter, 2005)

2) **The prototyping phase** consists of implementing these user requirements into an operative system (Buxton, 2007; Revee and Petch, 1999)

3) **The usability analysis** lies on proving the validity of the prototype with users. This trial takes users as samples to demonstrate in what measure the product implementation fits expected requirements in the first phase of the UCD methodology (Garrett, 2011).

Definitely, the most important feature of this methodology is the inclusion of user views into the design perspective (Bullinger, et al., 2010). As a consequence, users get importance in deciding on the shape and contents of the final product, resulting in a more democratic decision-making. Nevertheless, it does not mean that decisions are taken only in a bottom-up direction; organization managers should find the equilibrium between both approaches to construct a best practice scenario, as close as possible to user needs.

Democratic decision-making with the UCD methodology is easily depicted by Buxton (2007) with the overlapping funnels in the products' design process (Figure 12). This model sets: the elaboration process and the reduction process. The first one consists on providing users with a set of possibilities to fulfil similar tasks; the second one asks potential users to decide on them based on their abilities and needs (Buxton, 2007). This reduction helps analysts to shape and sharpen how the product should be in order to match with user needs (Buxton, 2007). Then it is the developer's task to reach that set of requirements by means of a prototype (Buxton, 2007). The main point of this approach is that without this process of elaboration to reduction, there would be just one path to follow (Buxton, 2007), and, consequently, the developers' perspective would be seriously limited (Courage and Baxter, 2005).

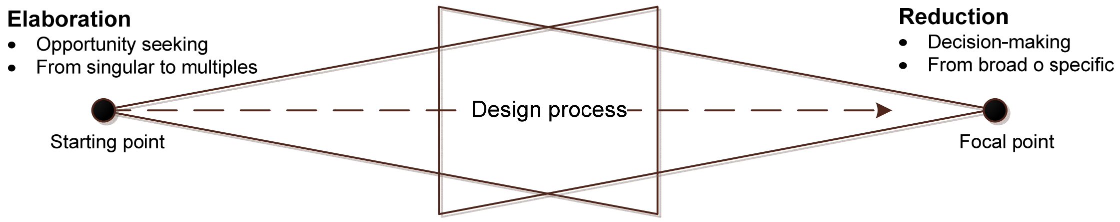


Figure 12: Overlapping funnels in the design process
Source: Buxton, 2007, p. 144

4.3. User-Centred Design applied to ScGII development

GIIs are systems where the application of the UCD methodology fits especially well, due to their complex and dynamic nature (Williamson, et al., 2003). Like other types of Information Infrastructures, GII users and stakeholders are the main characters, and therefore the shaping of the whole system has to be based on their needs (Brox, et al., 2002).

Up to the present not many GIIs have been developed by applying a sound UCD yet (at least there are no public reports on it). However, positive examples are the Geospatial Data Infrastructure of North-Rhein Westphalia (GDI-NRW; URL 57) (Brox, et al., 2002) or the Danish Cadaster GII (Hansen, et al., 2011; URL 8). So far, there is no evidence that any ScGII has ever used this methodology for its design. Some systems comparable to GIIs, like geospatial grids, are based on the application of the UCD method. An example is the Distributed Research Infrastructure for Hydro-Meteorology (DRIHM) (URL 56), which was designed and constructed based on a requirement analysis, using researchers views (in the role of users), and computer science technicians (acting as developers); moreover, the criteria of experts was also considered (Schiffers, et al., 2011). In any case, grids and GIIs still have notorious differences in capacities, stakeholders' context, functions, etc. In consequence, the application of UCD method to ScGIIs is still a research line that might have certain innovative values.

4.3.1. The breach between technological and social components in GIIs

From a managerial point of view, the duality between technical and non-technical factors in GII development (de Man, 2011; Grus, et al., 2011) entails a threat for its design and implementation. On the one hand (Figure 13*a*), technological resources and technical capabilities (1) rule what possibilities are technically feasible, or what could be achieved with existing resources. The resources' cost-effectiveness has to be taken into account when dealing with a GII's efficiency and effectiveness, in such a way that given resources have to have high usability but, at the same time, be feasible enough for the organization (van Loenen and

Zevenbergen, 2010). On the other hand, user needs (2) determine what is necessary for the GII, according to users' skills and experience with GIS, GIIs, ICT and potential benefits (Brox and Pires, 2004; Haklay and Zafiri, 2008; Zhong-Ren et al., 2003). The field lying in between meets needs and possibilities from both sides defining how the GII should be.

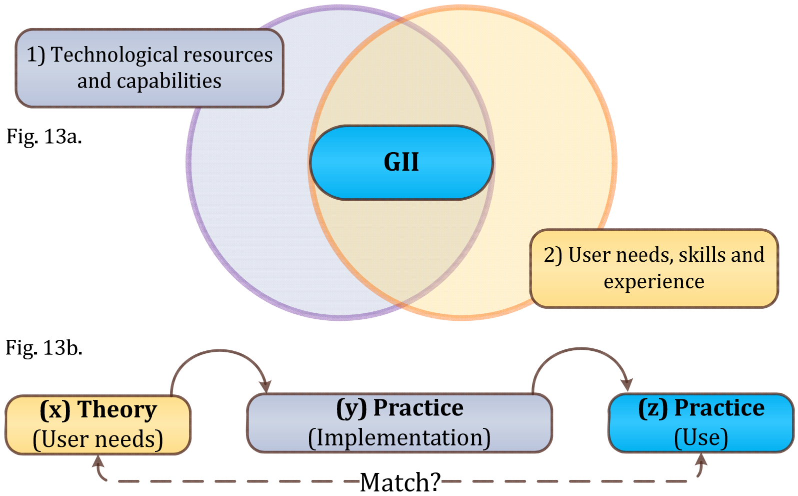


Figure 13 a, and 13 b: Critical factors in design and implementation
Source: Own design, April 2012, based on Alexander, et al., 2009; Zhong-Ren et al., 2003

In this way, the UCD methodology serves as a perfect framework that permits meeting these two views. This is because it investigates the social side of GII with user needs, but also focuses on technological resources trying to match both ingredients into a solid and stable system (Alexander, et al., 2009). *Figure 13b* describes how the GII design and implementation must evolve from a theoretical approach with user needs (x), passing by an implementation process with prototyping (y), to finally end with the infrastructure's practice, with a usability analysis (z). This process permits checking whether the theoretical view and the practical approach meet a good balance, achieving the optimal GII practice (Alexander, et al., 2009; Fu and Sun, 2010; Haklay and Zafiri, 2008; Bonifatti, et al., 1996).

In the end, the designed GII should find the precise structure, interface, contents and tools that are required by users. The Long tail theory (Figure 14) reflects this idea: This curve represents the relation between popularity and specificity of GIS products (Fu and Sun, 2010). According to this graph, GIS products are divided between a head, representing the mass market, more popular and accessible but using simpler functions, or lower diversity of products; and a tail, representing the niche markets focussed on professional communities that look for a wider list of products with less popularity but much more functionality (Fu and Sun, 2010). Between these extremes, the characteristics of products change significantly depending on the type of public that will make use of them. The challenge consists on finding the precise point or segment of the curve to suit the GII.

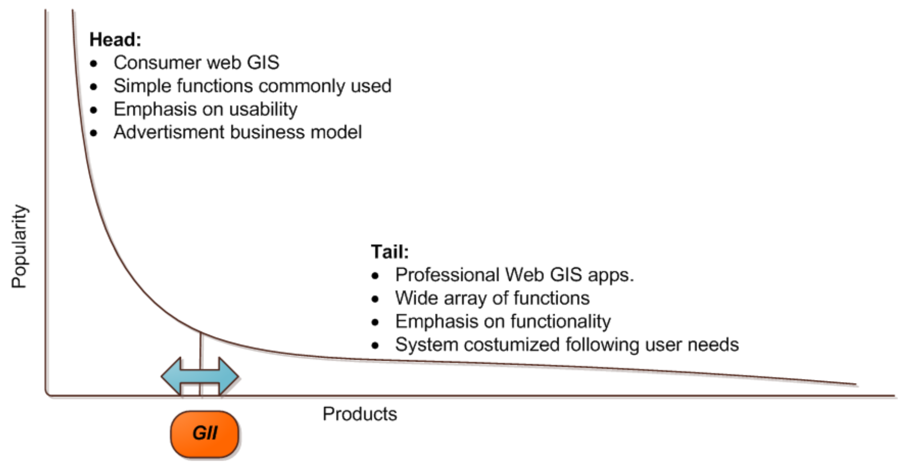


Figure 14: Long tail theory applied to ScGII suitability
Source: own design based on Fu and Sun, 2010, p. 21

4.3.2. The Organic Cycle of Life applied to GII development

The UCD method can be easily fitted into the Organic Cycle of Life (OCL) structure (Revee and Petch, 1999). Both methodologies have an iterative nature when carrying out cyclic activities to improve the product. These are shaped into a spiral; the completion of every cycle represents the end of a phase. This model may incorporate the so-called Deming Cycle phases of planning – development – review - improvement (Moen and Norman, 2011). The models depicted below show this methodology for the techno-centric approach (Figure 15) and the socio-technical approach, where the UCD methodology is applied (Figure 16).

The difference between both models is that in the techno-centric model, the infrastructure is ready much earlier, but yet when it comes to review and improvement, the expenses and efforts on redesigning and changing errors which do not meet user requirements may be very costly or even represent a waste of effort.

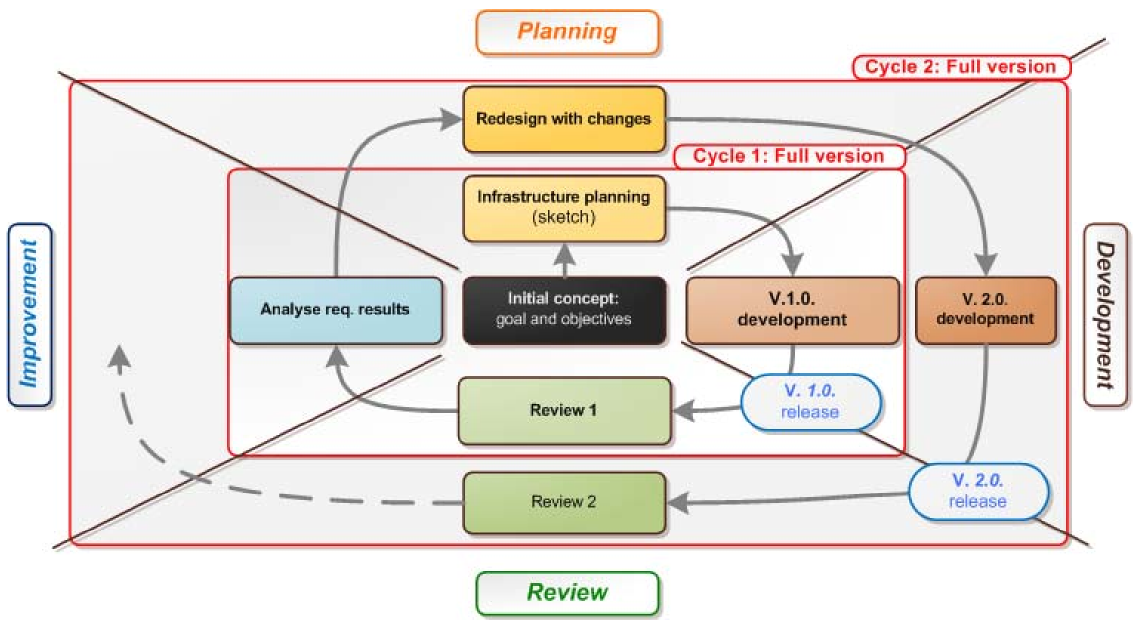


Figure 15: Spiral development model approached from the techno-centric view
Source: own design based on Revee and Petch, 1999 and Courage and Baxter, 2005

The UCD model (Figure 16) is longer, because it incorporates two more cycles: an initial one with the requirements analysis, and a second one with the prototype development, and then the usability analysis. This process results in a more stable system that reduces risks that may threaten the system's success in the long term, and gives a stronger implication and acceptance of the user towards the system (Courage and Baxter, 2005). However, its management requires more dedication and coordination due to its complexity and the involvement of different groups of stakeholders (Courage and Baxter, 2005; Revee and Petch, 1999).

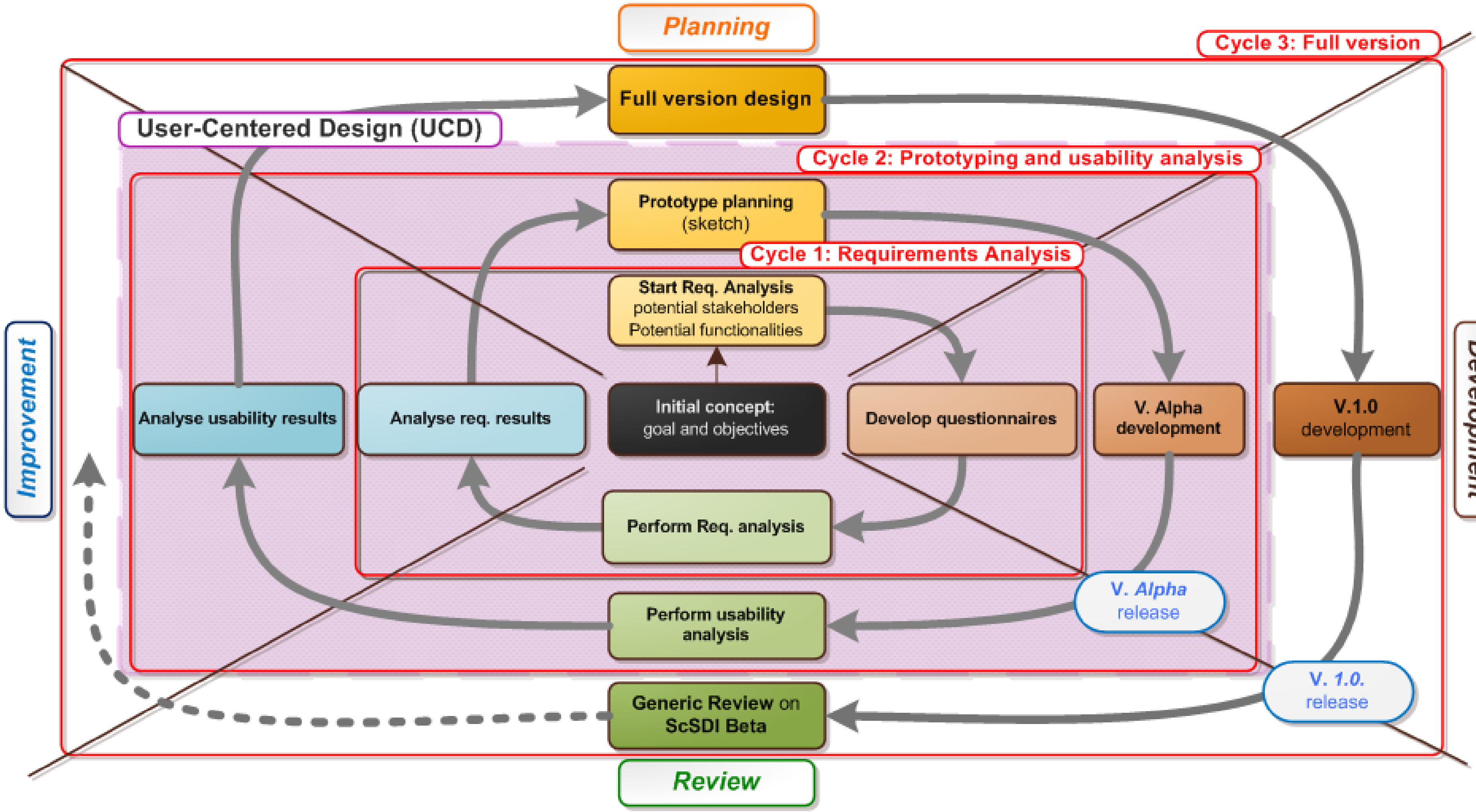


Figure 16: Spiral development approached from the socio-technical view

Source: own design based on Revee and Petch, 1999 and Courage and Baxter, 2005

4.4. Study case methodology

This research aims to implement the UCD methodology to support the design of the ScGII at the Balearic Islands University (UIB). Nevertheless, as stated in Chapter 1, this study just focuses on the requirements analysis and the prototyping phases, omitting the usability analysis. Figure 17 depict a general view of all steps in this case study. The following sections describe this general overview

4.4.1. Theoretical basis

Before asking what is necessary for users in the requirements analysis, it is good to know what is potentially possible in GIIs. Therefore, it is important to create a body of knowledge with a deep understanding about:

- **Critical topics to analyze**: The definition of ScGIIs resides on their components (van Loenen, 2006). Therefore, a deep analysis of all of them provides a good understanding of the critical issues that need to be dealt with. This objective has already been approached Chapter 2 when defining ScGIIs (section 2.2), and defining its components (section 2.3).

- **External investigation**: It is necessary to evaluate how other ScGIIs work to know about their objectives, capabilities, contents, or structure. This analysis helps to set out the prospective system's capacities (Revee and Petch, 1999). However, since the user's view is the prime component, this external investigation serves to state examples, which need to be assessed by users (Alexander, et al., 2009). The decision upon their convenience/inconvenience is taken in the next phases. These issues have been approached in Chapter 3, where different geospatial systems were analyzed.

- **Internal investigation**: When using the UCD methodology, the organizational context becomes determinant. Basically it sets the circumstances in which the ScGII is built. These study case conditions require an adaptation of the other theoretical approach ingredients to compound a proper base for the requirements analysis and the coming design phases (Courage and Baxter, 2005). These issues are approached in Chapter 5, where UIB study case is broadly explained: setting out the UIB's ScGII state-of-affairs (section 5.2 and 5.3), and the organizational and socio-economical contexts (sections 5.2.1.1 and 5.4 respectively).

4.4.2. The Requirements Analysis

Once theoretic concepts have been applied to the UIB study case, the Requirements Analysis can be started. It is composed of two parts: the design and the execution:

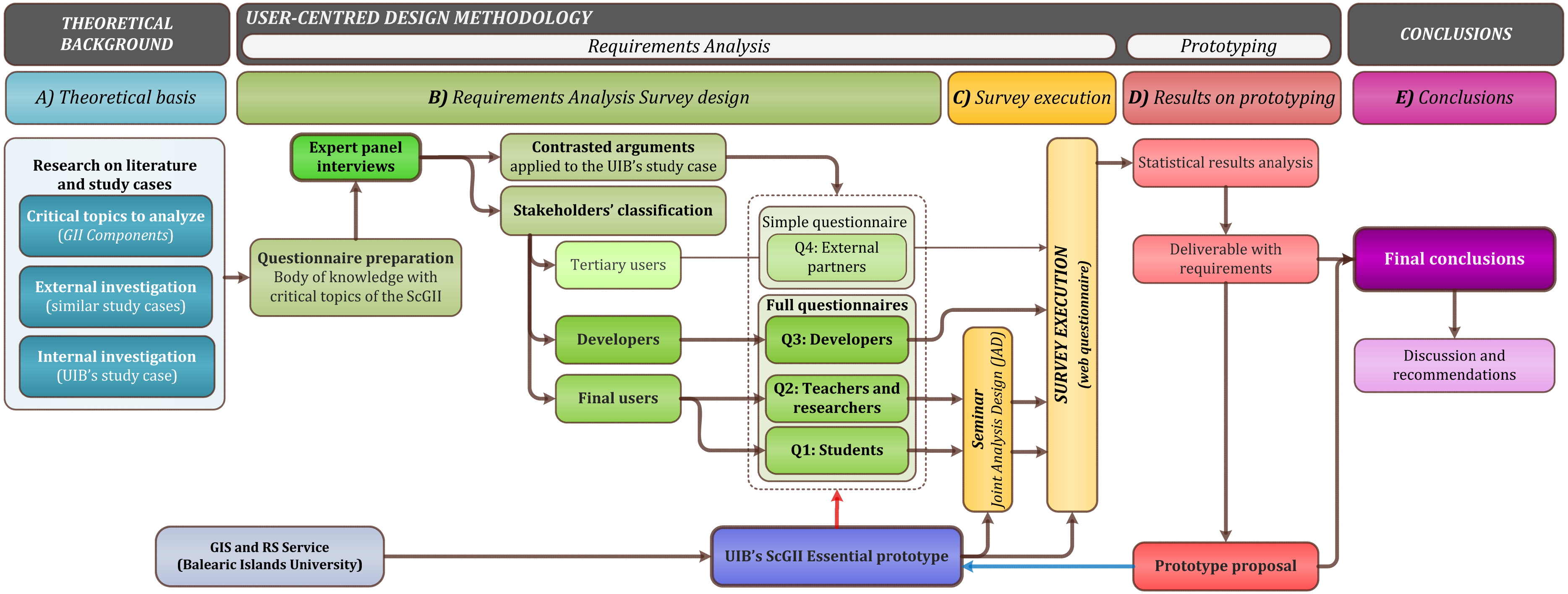


Figure 17: Methodological structure of the whole research
Source: Own design, April 2012

4.3.4.1. Requirements Analysis design

Gathering user requirements is complex and requires a solid methodological base. One of the innovations of this study consists on gathering real user views on the potential ScGII. National or Regional GIIs are directed to the whole society, while ScGIIs are directed to a narrower sector of the population. Taking these ideas in mind, collecting ScGII user needs requires from gathering a large amount of responses, which should be representative over the potential ScGII users' community.

Courage and Baxter (2005) point out different techniques to discover requirements, like: interviews, surveys, wants and needs analysis, card sorting, group task analysis, focus groups, and field studies.

Between all, the survey is the most appropriate technique for the present study case. This technique allows formulating a unique and structured list of predefined questions to large groups of participants (Alexander, et al., 2009; Courage and Baxter, 2005). While open questions might have a wide variety of responses with similar meaning, surveys permit predefining multiple-choice questions, where qualitative responses can be treated quantitatively. That permits analyzing results from a quantitative point of view, with statistical methods (Cassidy, 2006). Such results enable responses comparison, and a totally objective choice over predefined options (Alexander, et al., 2009; Courage and Baxter, 2005). This is a critical point to carry out the study case on ScGIIs, because choices must be made over presented possibilities to define the most chosen option based on user views. In addition, the test can be easily taken to a large amount of participants almost simultaneously. Distributing the test via web enhances its dissemination and speeds up its posterior collection (Courage and Baxter, 2005). The present research uses Lime Survey software to execute the survey in a web-based format.

Nevertheless, this method has some limitations that should be considered when analyzing results. In the first place, closed questions limit participants' responses to the view of the survey editor on what options could be considered (Courage and Baxter, 2006). This may lead to two threats: first, the closeness of this type of analysis limits the users' communication towards analyzers; and, secondly, the analyzers view when designing the questionnaire may not be complex enough to cover all aspects from all points of view (Cassidy, 2006).

4.3.4.1.1. Expert panel review:

Therefore, in order to avoid possible bias in the survey, it is useful to first ask advice from an expert panel (Haug, 2009). A group of experts in GIS and GIIs may reinforce the analysts' ideas on what should be asked to users. This step avoids certain subjectivity or a unique point of view when setting up the Requirement Analysis. They serve as a reference to validate and improve the contents and approaches of the Requirements Analysis (Haug, 2009). Apart from survey contents, in this study experts were also asked to assess a proposed stakeholder classification based on their roles towards the infrastructure.

The chosen methodology to gather expert views was the interview. With this technique, the interviewer steers an open and structured list of questions that the interviewee is asked to respond to. However the conversation is open and flexible. In this way, the discussion can be focused on one topic or another depending on the initiatives of the interviewers as well as interviewees (Alexander, et al., 2009). This methodology collects qualitative information, which may be difficult to process. Nevertheless, since the expert panel can be formed with a small number of members, this does not represent a problem.

4.3.4.1.2. Questionnaires

After exchanging ideas with experts, arguments needed to be fit into web questionnaires. Three different questionnaires were made, reflecting the stakeholders' classification in: users, users and providers, and external partners. This classification was made depending on their role (Maguire and Bevan, 2002) into the ScGII. The decision on creating three questionnaires was based on literature and later approved by experts' advice.

As already presented at the beginning of this research, before carrying out the requirements analysis, the SSIGT (UIB) developed an essential ScGII prototype with basic functions and contents (IDECi-UIB, URL 58). Its purpose resided on illustrating the system capabilities to potential users (Revee and Petch, 1999).

This prototype was used as a base to explain the most basic system capabilities, which use to be in most GIIs. Moreover, other administrative and scientific GIIs were used as examples to let subjects think about possible system requirements. More information about the prototype and its capabilities is provided in sections 5.2 and 5.3

4.3.4.2. Requirements Analysis execution

When the questionnaire is ready, the Requirements Analysis can be finally executed. This point may seem easy, but the problem is that users do not always know what they want (Heywood, et al., 2006). Only when potential users have criteria and choices, they are able to take decisions. Therefore, guidance on potential system capabilities is a good way to create awareness among users. In this way, based on their knowledge and experience, potential users may decide on their interests.

This is what the *Joint Analysis Design (JAD)* methodology tries to achieve. It consists of organizing workshops or seminars to assess potential users on how the system could work or what it could contain (Davidson, 1999). This methodology is widely applied in socio-technical IS development methodologies (Chiu, 2005; Yatco, et al., 1999), together with User-Centred Design (Holloway, 2007).

Eaton et al. (2007) describe 5 phases in the JAD methodology, which help to increase the understanding and confidence of users towards the new product, in this case the ScGII (*Figure 18*). Like in this research (*Figure 17*), UCD and JAD methods have approximately the same stages: awareness rising, analysis preparation, analysis execution, results evaluation and reporting (through the prototype). The JAD then, represents a good tool to increase the confidence and understanding of users who are not familiar with GIIs and GIS. This extra step in the UCD should improve the quality of the responses and the interest for the new infrastructure.

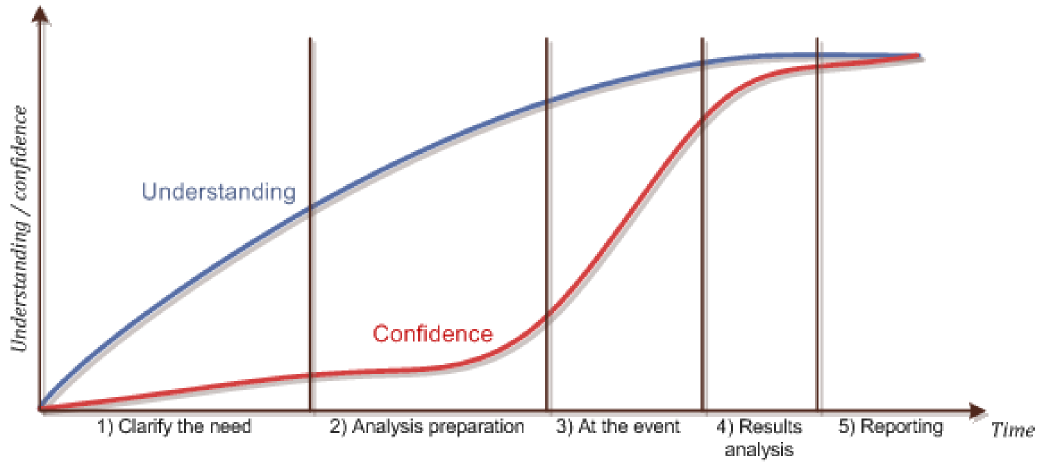


Figure 18: JAD methodology phases
Source: Adapted from Eaton, et al., 2007, p. 4

The added value of JAD lies in orienting potential users. The *Boyd's cycle or OODA loop* (Observe-Orient-Decide-Act) is a closely related method and may also be applied to the UCD method (Holloway, 2007). Basically it could be fitted in between the phases of Requirements Analysis and Prototyping (*Figure 19*): "Observation" would correspond to internal and external investigation; "Orientation" to workshop sessions with potential users; "Decide" to analysis results; and finally "Act" to the application of user requirements into a prototype.

Orientation workshops vary in their content depending on the participants' role within the ScGII. Following Figure 17, two different types of workshops will be carried out: one for "simple" users (students) and another one for users who may also act as providers (researchers and/or professors). There will not be any informative workshop for external partners; they are just informed about the conditions of the new infrastructure.

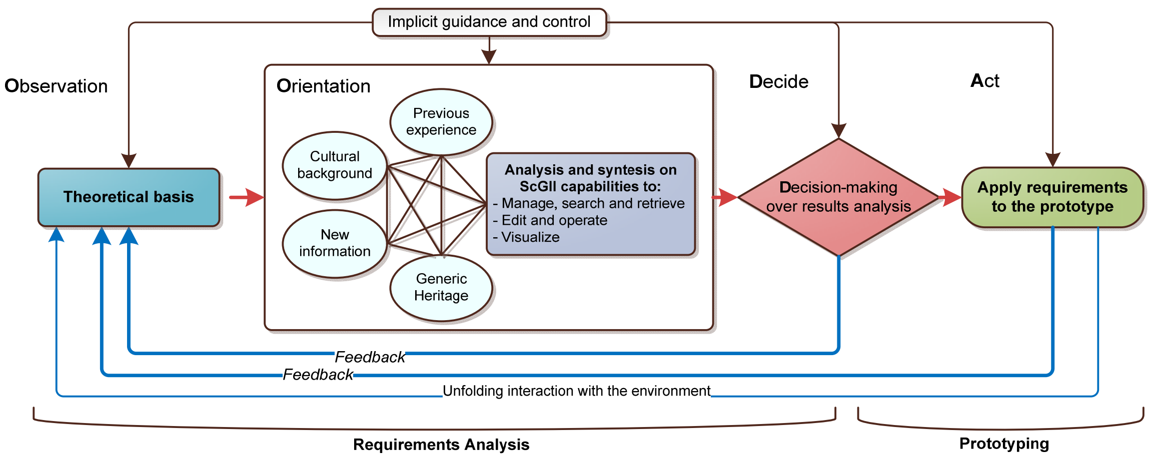


Figure 19: JAD methodology applied to UCD for ScGII design
Source: Adapted from Brehmer, 2005, p. 4

After the informative session, potential users need to complete the survey. In principle there is not a fixed amount of samples to validate the results. The bigger the sample, more significant it is. Courage and Baxter (2005) point out that there should be a sample of about 20 to 30 participants per user type to have significant (quantitative) results.

4.4.3. Prototyping

The Requirements Analysis results represent the users' ideas about the ScGII. Yet, opinions about what is most necessary or wanted may not coincide in a unique argument. Therefore, at this point scientists opt for creating so-called "personas". They are fictional characters constructed by the common view of real user groups (Garrett, 2011; Maguire and Bevan, 2002). Personas facilitate the tasks of analysts and developers when they have to design prototypes.

The problem of Requirements Analysis is that users just give their views on needs corresponding with their skills and experience. However, they do not necessarily know the importance of certain components and structures, which are critical to make the system work (Alexander, et al., 2009). Consequently, when requirements are listed, the advice from an Expert Panel may represent a way to validate what components are more necessary than others, or which ones should be implemented in the first place.

This results in a list of requirements ordered by importance or prevalence (Alexander, et al., 2009), which represents one of the main practical results of this research. At this point, enhancements of the initial prototype and technical limitations to implementation must be evaluated. As a final result, this research presents a prototype design, combining all user requirements (Revee and Petch, 1999).

4.4.4. Conclusions, discussion and recommendations

The study concludes with a summary on how research questions were responded and completed through the research. Next, there is a discussion about issues influencing the research results. The case study appropriateness section assesses whether the UIB's study case suited all expectations and possibilities. Finally, general and case specific recommendations were presented; they show which points should be taken into account if the research was continued.

4.5. Conclusion

This chapter went through the methodological aspects of the UCD methodology, and applied them to the design and development of the UIB's ScGII, making special emphasis over the requirements analysis phase. Although it is not covering any research question itself, it served as a way to discover and discuss the options, which will be approached in coming chapters about the requirements analysis design and execution, and the posterior results analysis to construct a conceptual prototype proposal for the IDECi-UIB.

5. The UIB's ScGII study case: Context and state of affairs

5.1. Introduction

A basic need before starting with the requirements analysis design and execution consists on setting the study case internal and external contexts (Revee and Petch, 1999). Therefore this chapter focuses in setting the state of affairs of the UIB's ScGII, the context within the UIB, and the context into the Balearic Islands society, doing special emphasis over the geo-information sector.

Although the IDECi-UIB is already a reality, it is still in the very beginning of its development, just in a designing phase. Up to the present there is only an essential prototype accomplishing some basic operations, however it was not even given to users for its real use. Therefore, this research is very profitable in two ways: firstly it results appropriate for this research because it puts in practice the proposed UCD methodology, and tries to fit the potential capabilities of geospatial systems dealing with science. Secondly, it is also helpful for the IDECi-UIB and the developing team, because it states how the infrastructure should be set up to be most effective and efficient for prospective users.

5.2. The IDECi-UIB: state of affairs and development

The IDECi-UIB (Scientific Geographic Information Infrastructure for the Balearic Islands University) was born in 2010 as an initiative to support research and education within the UIB community (Guasp, et al., 2011).

All this activity has been carried out by the GIS and RS Service (SSIGT), department working within the same University. The SSIGT's objectives consist on supporting research, education activities, and scientific transference towards the Balearic Islands society, in all that concerns to GISciences (SSIGT, URL 59). Therefore the implementation of a ScGII supposes a great advance to enhance and extend the use of geospatial information in all possible scientific fields, promote collaboration and extend the uses of scientific GI in other activities in society, like decision-making or collaboration with the geospatial private sector.

To do so, the IDECi-UIB pretends to become a spot to: access thematic and descriptive GI to start new educational or research projects, and be a portal to publish and distribute research projects with geospatial information produced by own researchers at the UIB. Furthermore it may also include other types of associated information, like text documents, statistics, hypermedia or multimedia files (Guasp, et al., 2011).

All these ideas have been shaped over this time and at the present [June 2012], the IDECi-UIB has been developed enough to implement the first essential prototype with a minimum set of GI resources. Yet, the work behind the scene has been much wider and complex. All GII components still need to be structured and interrelated to enable a good system performance.

Therefore the UCD methodology can still play an important role when defining and strengthening all these components and relationships in between. So far, it is important to have a general overview onto seven GII components on UIB's study case, to have a base to evaluate them properly in the requirements analysis phase.

5.2.1. The IDECi-UIB per components

5.2.1.1. Organizational framework at the SSIGT

The SSIGT is a small department composed by a team of three people. They are uncharged to manage and provide all GI used and generated at the UIB. Moreover, they also collaborate in research projects and other assigned tasks in all that refer to cartographic production (SSIGT, URL 59). Generally, this university service works as the GI intermediary between producers and providers in the regional and national administration and other institutions, generally public rather than private. Being such a small group of people, the amount of activities they can perform is limited; therefore the GII development is rather slow.

Nevertheless, the SSIGT has enough software, hardware and facilities to develop and maintain a GII. There is a large and powerful server able to manage and distribute great amounts of geospatial information by different means: geo-services, downloads, etc.

5.2.1.2. Geographic Information

The infrastructure's information contents are currently in development. Several databases are already prepared to be distributed, but the lack of metadata or the need to ask it to other organizations did not permit to publish it yet. Furthermore, it is not yet clear whether this ScGII is going to serve non-spatial information. By now, the information bases are split between:

- **Thematic and descriptive GI**, provided by administrations or other institutions with an agreement with the UIB, or GI sources that provide open access to GI like CORINE Land Cover.

- **Scientific GI + Associated information**, provided by UIB researchers who want to publish their research project's cartography. There are neither projects nor associated contents yet. It is expected to start with this after the completion of this requirements study and have a large collection in a medium-long term (Guasp, et al., 2011). There is a great interest over the possibility to generate geoprocessing tools. Yet, this option will depend on providers will and skills to create and work with this type of services.

Figure 20 summarizes the structure in which GI is intended to be collected, and stored to be distributed afterwards. Initially providers (UIB researchers and external GI producers) sign a data transfer agreement with the SSIGT, where all accessibility policies are detailed. Then, these contents are stored and managed within the SSIGT GI repository. Subsequently, these contents are treated considering legal statements, established standards, and human, technological and financial resources. They are finally published through the IDECi-UIB (Guasp, et al., 2011).

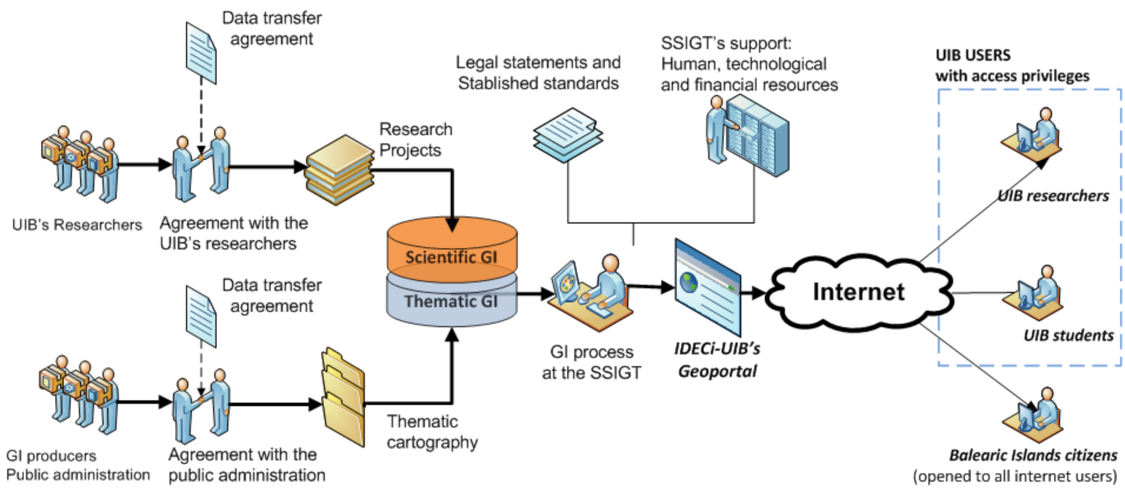


Figure 20: IDECi-UIB geo-information distribution workflow
Source: Guasp, et al., 2011

5.2.1.3. *Stakeholders*

The IDECi-UIB is aimed to serve and support the UIB research and educative communities. Therefore, all potential users are within the university community. The SSIGT takes the administrator and developer role. Other stakeholders like providers or other partner types may be from: administration bodies, research organizations, private businesses, etc. Over time, relationships among stakeholders may change; that will depend on the role taken by each partner within the ScGII.

Figure 21 depicts the current idea on user's hierarchy in relation to GI accessibility. Depending on users' activities, they will have broader or narrower access to certain contents. The SSIGT, as administrator, works at the top, accessing and managing all contents. In second place, researchers and teachers have access to their research project and all thematic/descriptive GI. In third place students, and the University community in general, will have access to most thematic/descriptive GI. Finally, part of the IDECi-UIB contents could be open to anyone; however, these contents are not defined yet. External partners may also have some kind of special access, which is not defined yet. Future agreements should agree on that point.

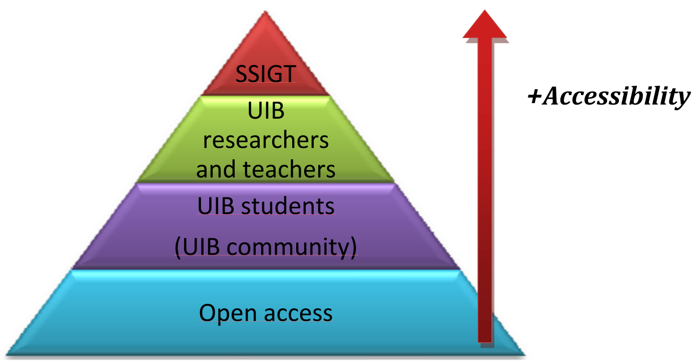


Figure 21: IDECi-UIB's users' hierarchy per accessibility

5.2.1.4. *Technology*

To the present, the IDECi-UIB works with the Service Oriented Architecture (SOA). There is a central server containing GI, which distributes its contents by different means like geoservices (WMS), a map viewer, and a download service (Guasp, et al., 2011). These resources are managed by a centralized metadata catalogue which already work linked to the GI repository. All these resources may be tested in the IDECi-UIB prototype (URL 58).

5.2.1.5. Policies

Accessibility policies represent a determining issue in ScGIIs (Watson, et al., 2010). Therefore the IDECi-UIB must comply with providers' policies in GI distribution. It must be stated who can access what information and for what purpose. This is an issue that still needs to be approached at the SSIGT. By now, only thematic/descriptive GI is accessible by the UIB members (Balearic Islands Government, 2008). This agreement was signed between the Balearic Islands Government and the UIB in 2008 to give free access to official GI for research and teaching purposes (Balearic Islands Government, 2008). Nevertheless, it is not clear whether students can directly access GI to use it for educational purposes.

Referring to research projects, there are no policy statements yet. However the SSIGT created GI agreements to agree on: research projects cession, and map viewers and geo-services generation and publication. In short term, clear laws and policies should be officially stated at the IDECi-UIB within the UIB framework.

5.2.1.6. Standards

Openness and interoperability should be guaranteed in a ScGII, in order to ensure the dissemination of heterogeneous geo-information (Giuliani, et al., 2011), and the access for any user. The IDECi-UIB is structured from its very beginning under OGC and INSPIRE specifications (Guasp, et al., 2011), adapting the whole system's structure, data and metadata to these structural requirements.

Main standards refer to:

- **Geo-Information**: All GI work with ETRS89 (INSPIRE, URL 2) in the European area, and in WGS84 in the rest of the world. It is structured with the standard thematic classification (INSPIRE, 2008). Moreover all served geo-services work with OGC standards: WMS. Yet there is also a service which is not opened: ArcGIS Service.

- **Metadata**: also complies with standards. The metadata model for geo-information ISO19139/119, recognized by the OGC has been taken as a template due to its multilingual feature.

5.2.1.7. Finances

The IDECi-UIB project does not have any special fund by any European or Spanish institution. In principle, the resources that make it work are paid by the own UIB, and maintained by the SSIGT personnel (Balearic Islands Government, 2008). With these resources, this ScGII progresses depending on developers and managers capacities to improve the system or invest on it.

5.3. The essential prototype capabilities

Essential prototyping is useful when designing, developing or improving IS (Revee and Petch, 1999). At the present, the UIB's ScGII has an operative essential prototype, that consists on a basic structure and a minimum set of contents. This initial ScGII has been used for the requirements analysis execution, as a usable example. It needs from some description before it is being analyzed and improved into the requirements analysis and posterior prototyping.

5.3.1. Geoportal

The SSIGT, as ScGII developer, has enabled a link into its website to embed the IDECi-UIB geoportal. From this site, all ScGII can be accessed, either through the GI catalogue, either through a direct access in the initial geoportal site; this is the case of the *UIB Campus* map viewer (

Figure 22). In addition, other secondary contents are accessible; for instance GII's information and external links to other GIIs or institutions. By now, the site is only accessible in Catalan, although the Catalogue has been adapted to Spanish and English too.

5.3.2. Catalogue

The catalogue is mounted over Geonetwork catalogue application (Geonetwork, URL 16) (*Figure 23*). It permits searching GI by means of its metadata records. By now only the UIB's campus layers have been added. They are served into a WMS, download service (zip file), and map viewer application.

A part from contents, the catalogue is accessible with open and restricted access. There is a user's hierarchy made up from different user profiles and groups of users. In future, this option may be used to restrict the access to certain contents.

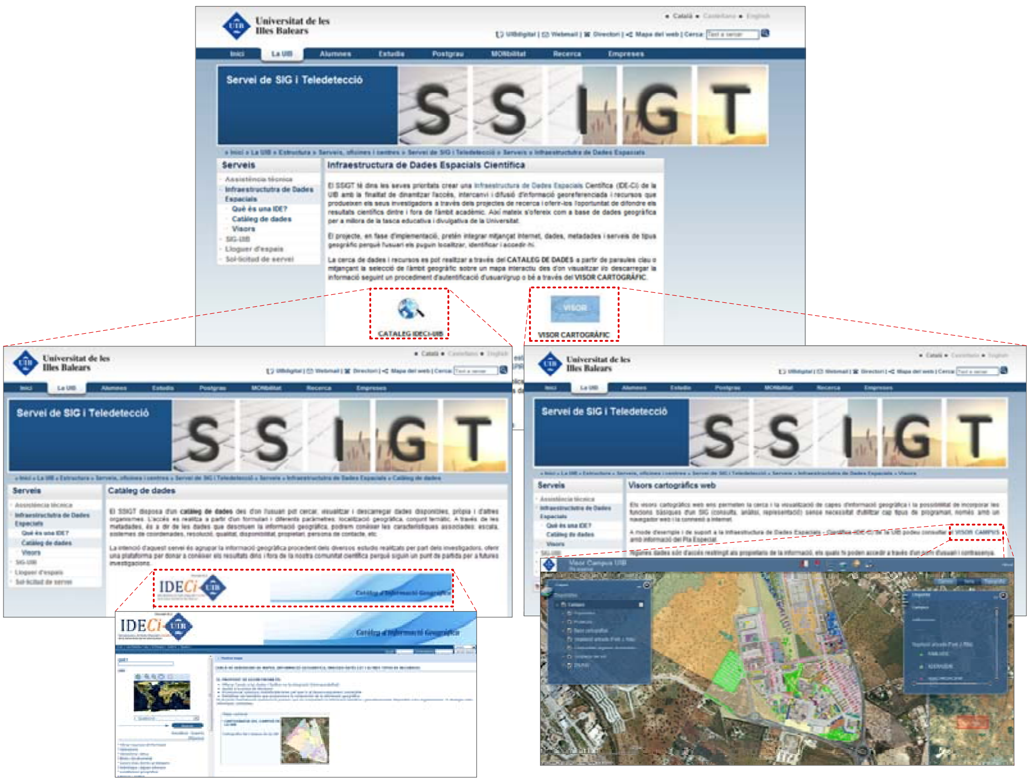


Figure 22: IDECi-UIB geoportal interface

Source: http://ssigt.uib.cat/serveis/IDE/ (Online 12.06.12)

Figure 23: IDECi-UIB metadata catalogue layout
Source: http://ssigt.uib.cat/serveis/IDE/ (Online 12.06.12)

5.3.3. Map viewer

The map viewer has been developed with Esri software (URL 5) (*Figure 24*). It offers most generic tools like: navigation (1), legend (4), scale (10), location map (9), layers (5), base maps (8); a section for bookmarked places (2), and address search (3). Moreover it offers a drawing tool (6) and an option to print (7). Yet, it lacks querying and geoprocessing tools, amongst others possible options. By now its contents are protected by a user name and password.

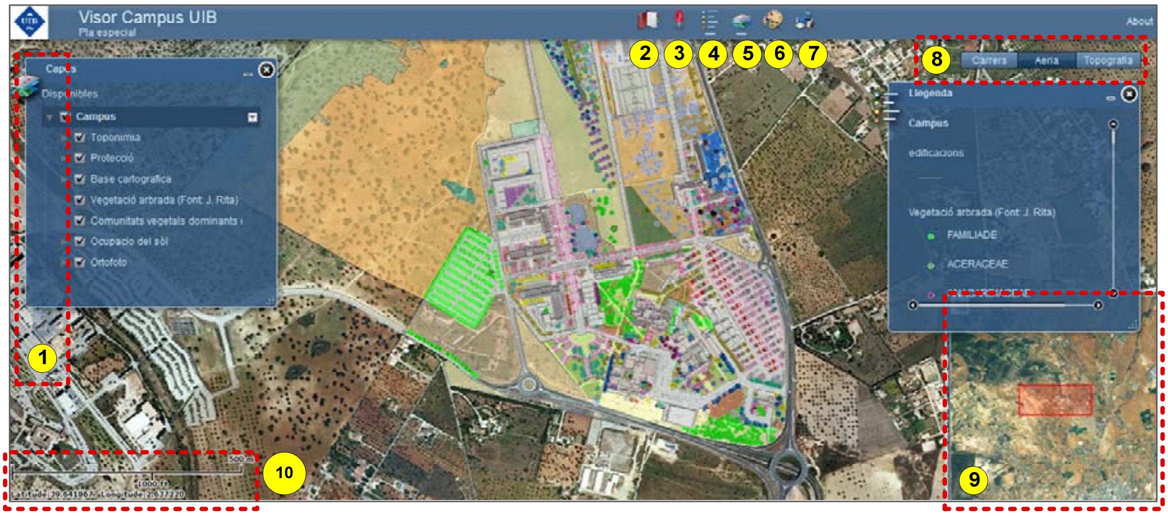


Figure 24: IDECi-UIB map viewer interface
Source: online at http://ftpssigt.uib.es/campus/ (12.06.12)

5.4. Context of the Geo-information sector at the Balearic Islands

To understand the context where the IDECi-UIB is built, it is necessary to have a reference over the current socio-economical conditions. Due to differences between administrative levels in Europe, this section has considered the NUTS levels as equivalences within the EU (Eurostat, URL 60).

The Balearic Islands Autonomous Community is composed by the islands of Mallorca, Menorca, Ibiza and Formentera. Altogether they sum a total population of 1.102.564 inhabitants [2010]

(CRE, URL 61); however the 78'8% of them are concentrated in Mallorca, and from them more than the 50% live in Palma and its metropolitan area (CRE, URL 61).

In what refers to economy [2010], tourism and the services sector take about the 81'9%, while other activities like industry (8'3%) or construction (9'8%) are just a minority. The R&D sector just takes the 0'47%. The agrarian sector has a so small value that is not even counted. Those values were derived from the non-agrarian GDP from 2010 (CRE, URL 61).

In addition, the economical crisis (2008-2012?) has strongly affected all economical sectors, with special effect onto the construction sector, and all the activities that were depending on it. An example of this recession can be seen when observing the GDP; for instance all sectors activity fell between a 0'7 and a 2'3% between 2010-2011 (CRE, URL 61) Public administrations has also suffered a strong recession and reduced their expenses in certain sectors; normally the ones they thought unnecessary.

The geo-information sector at the Balearic Islands is rather small. There is no acknowledgement about its size, and there is no evidence about any study covering that area. Therefore, this research has taken literature research and expert panel members' views (described in section 6.2.1) to clarify who is working on this sector. Nevertheless, no precise quantities or percentages are provided due to the imprecision of this information.

5.4.1. The public sector

Organizations working with geospatial information at the Balearic Islands are mainly depending directly or indirectly over public administration bodies. Most of them work for the Autonomous Community Government (NUTS 2), the Island Councils or the local administrations (NUTS 4). Their activity consists on generating descriptive GI, for urban or land planning and management, or for commercial purposes (IMI, URL 62; SITIBSA, URL 63). Their activity with spatial analysis is rather low (Guaita, F., 2012).

Most of these organizations are also related to regional or local GII initiatives. They all follow the INSPIRE directive, and therefore they are structured hierarchically depending on their administrative level (INSPIRE, URL 2). Figure 25 details how European and Spanish GIIs, INSPIRE and IDEE (URL 64) respectively, embrace the regional and local GII initiatives at the Balearic Islands:

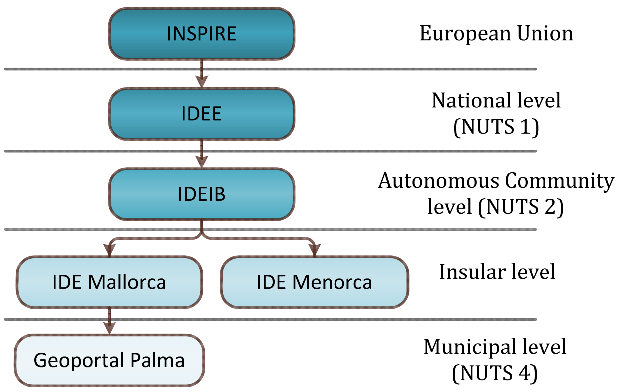


Figure 25: Hierarchical structure of GIIs at the Balearic Islands

The next list identifies the main public organizations that work extensively with geo-information, and details whether they are related with regional GIIs, and which is their development level:

- **Territorial Information Service for the Balearic Islands (SITIBSA)** (URL 63): is the governmental agency entrusted for reference cartography in the Balearic Islands region (NUTS 2). It is one of the main GI producers in the regional and local GIS market. Moreover, it is the manager of the regional GII at the Balearic Islands
  - **The IDEIB (URL 14):** is the main Regional GII at the Balearic Islands, and to the present, the most developed. It embraces all GI from lower levels produced by administrative bodies. This initiative started in 2007 (Black, 2010), but compared to other Spanish or European GIIs still needs to develop on many aspects, like GI download, types of services, etc. (Black, 2010).
- **Mallorca's Insular Council** (URL 65): has different roles in government but is specially entrusted for land and urban planning, environment and historical heritage. It has a GIS section entrusted to generate and manage all GI needed for these activities.
  - **The IDE Mallorca** (URL 66): includes the Mallorca's Insular Council GI. The initiative started in 2008 (Black, 2010), but still needs an important development since there is no metadata catalogue yet.
- **Menorca's Insular Council** (URL 67): follows the same structure as the Mallorcan Council.
  - **The IDE Menorca** (URL 68): includes the Menorca's Insular Council GI. The initative also started in 2008, but it is less developed than the IDE Mallorca (Black, 2010).
- **Innovation Municipal Institute of Palma (IMI)** (URL 62): is a municipal agency depending on Palma's municipality (NUTS 4). Its function consists on generating and managing urban topographic and cadastral information.
  - **Palma's Geoportal** (URL 69), includes IMI's GI. The initiative was born in 2011, and it is the least developed; just with a map viewer and a home page.

A part from public administrations, there are other organizations which are also public, but develop other activities:

- **The GIS and RS Service (SSIGT, UIB)** (URL 59) supports education and research activities at the University. It also develops own research projects. Further information is provided in section 5.2.1.
- **Mediterranean Institute of advanced Studies (IMEDEA)** (URL 70): Depending on the Superior Council of Scientific Research (CSIC) and the UIB, this institution focuses on coastal and oceanographic research. As mentioned in section 3.3.2, they are already working on an own ScGII, the CEDAI (URL 43).
- **Balearic Islands Coastal Observing and Forecasting System (SOCIB)**: Is an organization that depends on the Spanish Government, and also works in coastal and oceanographic research. They carry out advanced studies in spatial analysis with LBS. They are accessible through web applications in their portal (URL 71)

- **Socio-environmental Observatory of Menorca (OBSAM) (URL 72)**: It is an organization that depends on Menorca's Council. Its function is to investigate environmental and social aspects on the island of Menorca. It produces a significant amount of GI, which is highly interesting for research purposes in earth sciences. Part of this GI is also disseminated by the IDE Menorca.

- **National Oceanographic Institute (IEO)** (URL 48): is a research body from the Spanish government and is doing oceanographic research. It is GI producer and has already collaborated with the UIB in research projects with GIS (Ruiz, M., 2012, Private communication).

5.4.2. The private sector

The business sector in geo-information is really reduced at the Balearic Islands. Until 2007 it was in an incipient phase, mostly depending on public administrations. Now with the economical crisis, the activity has ceased almost completely. Nevertheless two private businesses and an NGO are mentioned:

- **ESTOP** (URL 73): It is a local business dedicated to topography and geotechnical studies, GIS, photogrammetry, aerial photography, and environmental studies
- **GAAT** (URL 74) is a local consultancy which works with GIS on urban planning, environmental impact assessment, and urbanism.
- **GOB** (URL 75): is a regional NGO working on nature defence. They produce local and regional GI besides other reports and publications about ecology, environmental impact assessment, etc.

5.5. The Balearic Islands University context

5.5.1. General statistics

The UIB is the unique University at the Balearic Islands Region. At the present, there are 18.259 people [Course 2011-2012] (SEQUA, 2012). This population includes: Administration personnel, Research and Teaching personnel, and students. *Figure 26* describes these populations in percentages.

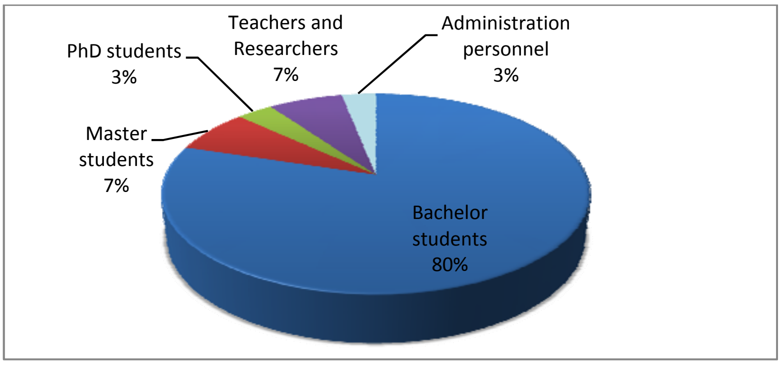


Figure 26: Balearic Islands University community structure in 2011-2012
Source: from SEQUA statistics, 2011-2012.

This University is mostly placed in Palma's Campus (Mallorca), although there are some faculties in the other islands. Being small also means that the list of available degrees is limited, especially in what refers to postgraduate courses. Research groups and institutions aren't very large either (UIB, URL 76).

5.5.2. The ScGII requirements analysis population scope

Concerning to studies and research fields that may be somehow spatially-related, it is difficult to make a choice over what studies may be potential users for the ScGII. Certainly, main studies related to GISciences are Geography, and some studies from Earth Sciences (Biology and Physics), Social and Juridical Sciences (Journalism, Economy or Tourism), Engineering and Architecture (Computer Sciences, Construction Engineering and Agriculture Engineering), Arts and Humanities (History and History of Art) (UIB, URL 76).

The 80% of Science fields are spatially-related (Shekhar and Xiong, 2008); however individuals, in this case students or researchers, may not be aware that they constantly work with geospatial information and associated technologies (Williamson, et al., 2003, p. 10). These acknowledgements complicate choosing which should be the potential users at the IDECi-UIB.

Therefore, this research decided to focus just over the scientific disciplines that are closer to have potential users, because they already work directly with it. Here there is a difference between the activities that are actually carried out:

- **In education**: only the studies that formally work on GIS and RS, compulsorily or optionally, are considered as potential users (UIB Geography Study program, URL 76). The rest are left out, because their profiles do not respond to any understanding on applications and methodologies on GISciences.

  Here must be remarked the difference between graduate (Bachelor) and postgraduate studies (Master and PhD), in all that refers to education on GIS. Only in grade courses there is the specification about who take GIS courses; however it is not so clear between master and PhD programs (UIB, URL 76).

  - Bachelor programs: Only Geography has GIS and RS as compulsory subjects. Other studies with option to take GIS are: Agriculture Engineering and History of Art [Course 2011-2012] (UIB Geography Study program, URL 76). Yet in past study programs, this course was available for Biology students. Allegedly, next year [2012-2013] GIS will be available again in this degree. This research then, considers Geography, History of Art, and Agriculture Engineering students. Biology students are also taken into account because perhaps they took GIS courses in the past, or they may take them in future. All these groups then are considered as the valid sample of this Requirements Analysis study (Table 4). Nevertheless, skilled users are more prone to make use of it. Then from bachelor degrees, geography students would represent the most potential users (1'53%) (Soft orange), and the rest would be less potential (7'41%) (orange).

Bachelor degrees taking GIS as a subject:	Total bachelor students	% bachelor students (14574 people)
Geography	**223**	**1,53**
History of art	235	1,61
Agriculture Engineering	169	1,16
Biology	453	3,11
TOTAL	**1080**	**7,41**

Table 4: Potential users from bachelor programs
Source: Own calculations, SEQUA Statistics, UIB, course 2011-2012

- Master and PhD programs: There is no specification about GIS courses in postgraduate programs, especially in PhD programs (UIB, URL 76). Only the Postgraduate course in GIS that takes place at the SSIGT can guarantee courses in GIScience methodologies and applications (SSIGT, URL 59). Master programs from Geography and Tourism do use GIS techniques for some of their subjects.

  Those facts complicate the set of a precise number of potential users for the ScGII. Then the sample has been taken around people working in the Earth and Social Sciences field, where there are more possibilities to gather participants with knowledge and experience on GIS, IT and GIIs. Yet, participants from other disciplines are also taken to check their profile and appropriateness to be ScGII users. These statistics refer to most approximate scope of samples between Master and PhD programs (Table 5 and Table 6):

Master degrees using GIS:	**Total students**	**% master students** (1300 people)
Master in Geographical Information Technologies	**12**	**0,92**
Master in Coastal Area Analysis, Planning and Management	21	1,62
Master in Tourism Management and Planning	27	2,08
TOTAL	**60**	**4,62**

Table 5: Potential users from Master degree programs
Source: Own calculations, SEQUA Statistics, UIB, course 2011-2012

PhD programs using GIS *(estimated**)*	**total students**	**% PhD students** (600 people)
PhD in Geography	**26**	**4,33**
PhD in Plant Biology	13	2,17
PhD in Marine Ecology	15	2,50
PhD in Tourism Economics and Environment	6	1,00
PhD in Computer Sciences	19	3,17
PhD in History of Art	30	5,00
PhD in History	13	2,17
TOTAL	**96**	**16,00**

Table 6: Potenital users from PhD degree programs
Source: Own calculations, SEQUA statistics, UIB, Course 2011-2012

In both tables most potential users (soft orange) are a limited number of people, while the total counts with the rest of students who may need from a ScGII (orange). In average, the final amount of users may be even lower than the most potential estimation, because not all "most potential" users are actually real users. Table 7 summarizes results over the total of students. It is estimated that the 1'79% of all students could use the ScGII frequently, and the 8'48% would be less likely from using it.

Potential users for the ScGII	**Most potential**	**% most potential over students total**	**Potential**	**% potential over students total**
Bachelor students	223	1,53	1080	7,41
Master students	12	0,08	60	0,41
PhD students	26	0,18	96	0,66
TOTAL	261	**1,79**	1236	**8,48**

Table 7: Students by most potential and potential users over the total
Source: Own calculations, SEQUA statistics, UIB, Course 2011-2012

- **In teaching and research:** Despite Earth and Social Sciences are the disciplines that are spatially-related, the use of GISciences are not really spread into education and research. Many teachers and researchers still work using analogue cartography, having very limited knowledge about GIS. Others, use advanced techniques closely related to GISciences, but are not aware to be working with geospatial information. Therefore, setting an amount of potential users is rather imprecise and difficult. Table 8 shows the departments where samples are taken. Looking to current values, potential users may move between the 3’3% (most potential) to the 39’85% (other potential fields). Yet, these values do not mean that everyone knows equally about GIS. It is difficult to precise who may know enough to be a potential ScGII user.

Department	**Total Researchers / professors**	**% over the total** (1227)
Biology	72	5,87
Art and history	53	4,32
Mathematics and Computer Sc.	107	8,72
Earth Sciences	**40**	**3,26**
Applied Economy	78	6,36
Physics	92	7,50
Chemistry	47	3,83
TOTAL	**489**	**39,85**

Table 8: Teachers and Researchers potential interested over the ScGII
Source: Own calculations, based on SEQUA Statistics, UIB, Course 2011-2012

Table 9 summarizes all data referring to potential users at the UIB. Based on this data (SEQUA, 2012), potential users would represent between the 1’7% and the 9’75% of the UIB Community, neglecting the Administrative personnel (570 people – 3%). However, reality may represent different values.

In any case, this study has decided to take the widest sample (bold text) because even being wider, and maybe less likely to have favourable values, it is really important to include people from many disciplines, following the ScGII principles stated in Chapter 2.

User type	Most potential	% most potential over the total	**Potential**	**% potential over the total**
Students	261	1,48	**1236**	6,99
Researchers / Teachers	40	0,23	**489**	2,76
TOTAL	301	**1,70**	**1725**	**9,75**

Table 9: Potential users total at the UIB
Source: Own calculations, SEQUA Statistics, UIB, Course 2011-2012

5.6. Conclusion

This chapter explained the state of affairs at the UIB, and the geo-information sector at the Balearic Islands region. This is important to set the context of the future IDECi-UIB, and all the stakeholders and organizations that may take part, or be somehow involved in this initiative. It also set the basic components of the current ScGII prototype capabilities, which are taken as a base in next chapters with the requirements analysis.

The presented statistics are the base to start with the requirements analysis. They were shown and discussed here as part of the university context. However, they are also provided in chapter 6 when stating who is going to take the requirements analysis test.

On what refers to the research questions, this chapter settled who the potential users and stakeholders may be, and who is going take the test within the UIB. Chapter 6 uses these values to construct a final list of potential stakeholders to complete the research question on what the requirements are, based on who is intended to use the infrastructure.

6. Requirements Analysis for the UIB's ScGII

6.1. Introduction

This chapter explains the design and execution of the requirements analysis for the UIB's ScGII case study. In a way, it is the central part of this thesis, because it sets up the critical points that will determine the generation of results, and will also have an important effect over conclusions. This initial phase of the UCD method must be split in two main parts: design and execution.

The present chapter also follows this structure: the first part describes how the requirements analysis was designed, based on literature research, and on experts opinion. The second part describes how the questionnaire was executed to generate the results that are analyzed in Chapter 7.

6.2. The requirements analysis design

As explained in methodology (section 4.4), before starting with the requirements analysis design it is important to know what issues need to be approached, and who are the potential stakeholders which may be involved into this initiative (Brox et al., 2002). Once this list is set, the study can be designed according to their activities and functions in the ScGII.

6.2.1. Expert panel interviews design and execution

The requirements analysis mainly follows a qualitative approach (Courage and Baxter, 2005). In order to avoid possible bias in the contents, and chosen stakeholders, it is convenient to ask the advice an Expert Panel (Haug, 2009). That will avoid certain subjectivity or a unique point of view when setting up the analysis. The panel is composed by highly skilled and experienced professionals in GIS, GIIs and Science (Haug, 2009), that are also acknowledged about the socio-economical context of Spain and the Balearic Islands.

In this way, three experts were interviewed individually through an open interview, where all theoretical topics from this research about education and research support systems were discussed deeply. Interviewees were selected in relation to the study case context: they are important characters in the Spanish and Balearic regions with respect to issues related to GIIs and research. They are:

- **Antonio Rodríguez Pascual** (Madrid) IDEE developer and head of the National Geographical Institute of Spain (IGN – URL 77). Recorded on 31st May 2012 by Skype.

- **Joan Vallespir** (Mallorca) GIS professional, has worked at SITIBSA (Balearic Agency in digital cartography), IMEDEA (Med. Research Centre), JRC (Joint Research Centre) (Italy), IEO (Spanish Oceanographic Centre). Interview recorded on 1st June 2012 in Sa Pobla, Mallorca in a face to face meeting.

- **Francesc Guaita Mas** (Palma) IDE Mallorca developer and head section at the Mallorcan Council's GIS department. Has worked as collaborator at the UIB and has experience in the private sector too. Recorded on 1st June 2012 at the UIB, Palma, Mallorca, in a face to face meeting.

6.2.1.1. Interviews edition

Interviews' questionnaires were edited approaching three main points:

- **The Requirements Analysis questionnaire approach**: As explained next in section 6.2.3, the requirements analysis questionnaire is structured differently depending on the user role towards the ScGII. In this part, experts had to provide an advice on whether they thought the division in tasks to carry out with the ScGII, was more appropriate than the classical analysis through GII components.

- **The analysis over the research and education communities at the Balearic Islands to implement a ScGII**: This part consisted on analyzing strengths, weaknesses, opportunities and threats from the Balearic and Spanish contexts, where the IDECi-UIB is build on. This was summarized into a SWOT diagram, partly answered by my criteria, and later reviewed and completed by experts.

- **The ScGII characterization in relation to its components**: Finally, this part analyzed the main ScGII components (explained in section 2.3): geo-information, stakeholders, technology, standards and policies; and how they should be adapted to adapt to the scientific sector needs.

6.2.1.2. Interviews execution and outcomes

Interviews were carried out individually, in face to face sessions preferably, or by videoconference. Each of them took between 1:20 h and 2:00h, depending on the speech direction, and the appearance of unexpected questions. The used language was English in most of the cases, although one of them was carried out in Catalan due to the lack of skills to communicate fluently in English, and the great importance of this expert into the Balearic Islands geo-information sector. Interviews' recordings are in Annex 2, in audio format (MP3) into the CD attached to this document.

Advices and recommendations provided by experts were included into the potential stakeholders' identification, and the requirements analysis questionnaire. Moreover they are used to justify certain decisions in this chapter, into the results analysis, and on prototyping. They are included in explicit cites indicating the interviewee and the minute in which they can be found.

The SWOT analysis over the IDECi-UIB study case was especially helpful to identify strong and weak points that should be approach by the study. Table 10 already incorporates all comments and advices from expert panel members. More information about the expert panel is provided in Annex 2.

Strengths	Weaknesses
• Initiative to create a ScGII for the UIB • Small research community easy to manage • Existence of a GIS department. It is not necessary to create it ad hoc; they have personnel, software and hardware • Existence of different regional GII nodes at the Balearic Islands. The IDECi-UIB may become another node offering unique contents like scientific GI and tools.	• Limited use of GIS in research • Lack of connexion between entities to share information and knowledge • Lack of collaboration between research departments and between the UIB and external partners. • Worries for information transference policies, Intellectual Property Rights, privacy and security. • Lack of connection with the Computer Science researchers to develop the ScGII • Researchers' reticence to share GI. They assume that Information is power, while it is more intelligent to share and collaborate to produce more. • Restrictive policies from the Balearic Islands administration on GI distribution

Opportunities	Threats
• Large amount of existing GI in public organisations that could easily be shared. • Amount of GI from research projects to be shared. • Potential involvement from external partners (private or public) into the GII: education, research, decision-making, etc. • Become a node into a network of other ScGIIs in the regional/national/international context • Define the role of academia into society through the ScGII, when transferring spatially related scientific knowledge into society. • If the IDECi-UIB starts opening GI access, other regional GIIs may also change their accessibility policies to be more opened	• Limited knowledge of potential users and stakeholders on GIS capabilities and applications • Level of knowledge and use of ICT resources • Unknown level of interest to finance the project • High difficulty to implement INSPIRE complying with all its requirements. IDEIB developers could help to this process. • The digital gap in users' skills to use the system may become a problem for system's success. • Lack of academic policies at the UIB forcing researchers to publish and provide access to their results.

Table 10: SWOT analysis over the IDECi-UIB study case context

6.2.2. Stakeholders identification

For setting up a list of ScGII participants requires a clear idea on what the ScGII aims are. Expert panel members agree on the fact that the UIB ScGII should be widely open to the society:

"A GII needs to be opened to the world, and taking into account, on the one hand, people requirements inside the university and, on the other hand, also the requirements from people outside university and reach both targets"(Rodríguez-Pascual, A. 2012, 8:40)

"I don't think a GII has to spend resources on people who don't want to share information. It could be an internal GII, […] but the type of GII we are talking, everything should be public […] "but data into a system just for internal viewing, I do not see it" (Vallespir, J., 2012, 1:05:22)

Bearing in mind that this ScGII is intended to be as open as possible to the society, "*the requirements analysis should gather potential user needs from both inside and outside the university*" (Rodríguez-Pascual, A. 2012, 8:55). This study has first of all focussed on internal potential users and has considered external organizations as external partners who may act as providers or collaborators in the future. In the long term, these organizations may change their role towards the ScGII, from simple providers or observers, to active users; all depends in their implication level.

Chapter 2 mentioned the different activities the ScGII could be applied to, like, for instance, decision-making for governance. Experts agree in this aspect (section 6.2.1). Nevertheless, in this study the focus is only on the research and education activities. Working over other activities would imply working in very different directions, which may complicate the study.

"Would be interesting that external organizations could have access to certain data produced by the UIB; […] it could be used as a support element in decision-making" (Guaita, F., 2012, 1:19:20-1:20:34)

"Decision-makers are very interested in GI coming from the university, it is supposed that administration doesn't have experts, so they usually go to university for advice" (Vallespir, J., 2012, 24:30)

This research has addressed several groups of stakeholders who are intended to play different roles in the ScGII. They are divided per activities in the UIB and roles within the ScGII. They are also split by roles (Courage and Baxter, 2005; Van Loenen, 2006) depending on their interactivity with the ScGII.

Figure 27 shows all considered stakeholders. The closer they are to the core, the greater is the potential activity with the infrastructure. In this way, it can be easily differenced how UIB members (students, teachers and researchers, and developers) are main characters in this research, and are the target groups for the requirements analysis.

Meanwhile external stakeholders just have a secondary role, and are treated differently into the research. External stakeholders are included into a second circle with broken lines. That means that the ScGII could easily incorporate other stakeholders, even if they are not from the same administrative level, since ScGIIs are not necessarily bind to administration bodies. The icons appearing in transparent and broken lines did not respond or did not complete the required questionnaires.

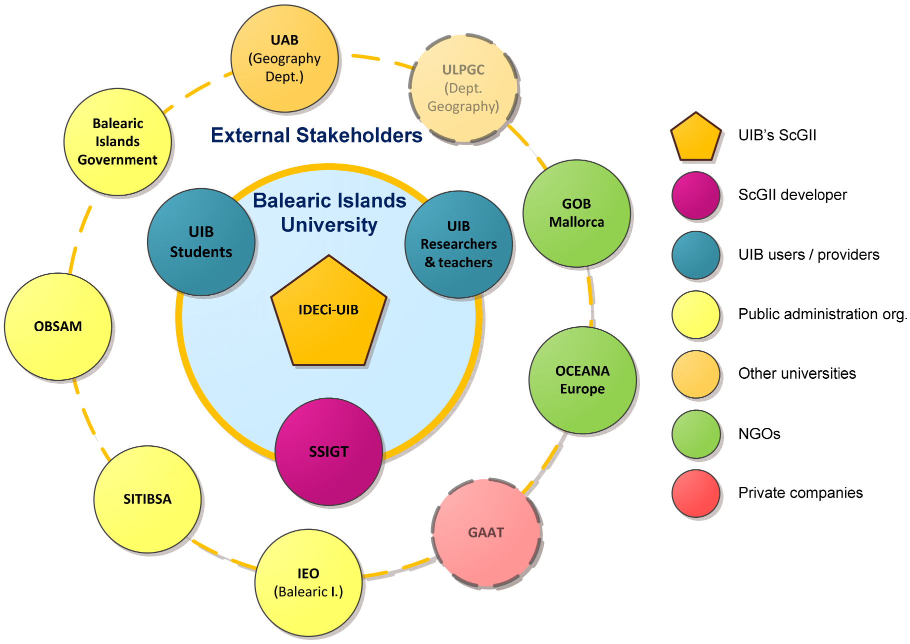


Figure 27: Potential stakeholders for the UIB's ScGII

Stakeholders may be divided in three groups depending on their role towards the ScGII. Here there is a clear differentiation between: users, developers and external stakeholders.

- **Users:** In a first stage, this ScGII is meant to offer direct services in the UIB (SSIGT, URL 59). Therefore, only users within the University have been considered for the study.
    - UIB students need GI to work with in GIS courses but also in other subjects somehow related to space. The ScGII may represent a good source of GI for their direct use. As a consequence, they act as users.
    - UIB teachers and researchers may need GI as a source for research and education activities. Furthermore, they may also want to publish GI from their own researches in the ScGII, which they then use as a means of dissemination. Therefore, they act as users and providers.
- **Developers**: The SSIGT members are also considered as main participants within the university. However, they work as a GII developers. Their task consists of developing and maintaining the system. The interviewed experts also qualify them as providers or intermediaries who permit publishing GI resources in the infrastructure (Guaita, 2012; Vallespir, 2012).
- **External partners** are also invited to collaborate within the ScGII. Some may take part as simple observers, as providers, or even as potential users in the future. The present study considered organizations of different types, as advised by the experts.

"I think there should be some kind of pay-back towards the society and the private businesses. They should have the opportunity to establish agreements with the university, to take advantage of research results. If they are two independent worlds, there is no way to generate economic activity" (Guaita, F., 2012, 1:25:30-1:26:01)

Mainly public administrations have been listed, although independent and private organizations were also taken into account.

- **Administrative bodies and organizations**

    - Balearic Islands Government, Ministry of mobility and land planning. This government organism is responsible for all the official cartography generated by the Balearic Islands Government. They support the development of a ScGII at the UIB, in which they just act as observers.

  The organizations listed below were already described in section 5.4.1:

    - SITIBSA (URL 63)
    - OBSAM (URL 72)
    - IEO (URL 48)

- **Other universities** could be good partners to share GI as superior research and teaching bodies but also to establish collaboration relationships. In this research two different Spanish Universities were approached; both with strong geography departments and who have widely applied GIS in their activities:
    - Autonomous University of Barcelona (UAB): responsible for the generation of *Miramon* GIS software (URL 78)

    - Las Palmas de Gran Canaria University (ULPGC): very active on GIS and GIIs with its ScGII: the *IDE-ULPGC* (URL 39)(see Table 2 in section 3.3)

- **Non-governmental organizations (NGOs)** are also potential stakeholders for the ScGII. As GI producers they may collaborate with the university to share information and co-operate in other ways (Vallespir, J., 2012, 18:40).

    - GOB Mallorca (URL 75): It was already described in section 5.4.2.

    - OCEANA Europe (URL 79): is an international NGO that works on marine protection. They have important amounts of GI about oceanography, which may be used for research or education.

- **Private companies** are a key stakeholder according to the experts consulted (Guaita, 2012; Rodríguez-Pascual, 2012; Vallespir, 2012). They may set up promising projects between the public and the private sides by means of spin-offs (Rodríguez-Pascual, 2012). Nevertheless, as mentioned in section 5.4.2, the private market in geoinformation at the Balearic Islands is very limited. This study just considered the view from one company, the GAAT (URL 74), because it was thought to be representative enough. Moreover, there were other organizational obstacles explained in section 9.2.

6.2.3. Questionnaire development

As mentioned before in section 6.2.2 (Figure 27), there is a set of target groups that are aimed to take the requirements analysis questionnaire. These groups have different functions into the IDECi-UIB, and are assigned to a set of tasks, that can be executed with the ScGII. In consequence, they take different questionnaire models. This research set out 3 different online questionnaires in accordance with these 3 groups of students (1), teachers and researchers (2), and developers (3).

All these questionnaires follow a common structure: they are divided in two main parts. In first place, the determination of the user profile, to know about the abilities and experience of the user (section 6.2.3.1). In second place, the main part of the test embraces a set of tasks that help to determine user requirements (section 6.2.3.2). All questionnaire models

6.2.3.1. User profile determination

First of all, the requirements analysis survey needs to gather some information about the user. Basically, users may have different reactions towards ScGIIs. Therefore, it is fundamental to collect information about their profiles (van Elzakker and Wealands, 2007). There is a set of aspects that needs to be closely analyzed to have a reference on the user's view (Brox and Pires, 2004; Courage and Baxter, 2005; van Elzakker and Wealands, 2007). The three main aspects, explained below, serve to create a definition of the user, that will later be used as a means to interpret the results and to give a more realistic analysis of the user needs (Courage and Baxter, 2005; van Elzakker and Wealands, 2007):

1- General profile: This section gathers information about the age group, language skills and activities at the university.

2- Skills and experience with GIS: users may vary from most basic users, who just consult maps with map viewers, to really advanced GI professionals, who apply GIS techniques to a wide variety of activities (van Elzakker and Wealands, 2007). The differences between these users relate to their familiarity with GIS theory, methodologies and applications (Kraak and Ormeling, 2010). As a consequence, the user abilities in GIS will strongly condition their performance with ScGIIs. Therefore, this part of the survey asks about how frequent users use GIS, what tasks they carry out, what GIS courses they took and how they apply their skills to other fields in teaching, research or learning.

3- Skills and experience with GIIs: Although being widely known within the GIS sector, GIIs are still an innovative tool not everyone knows about yet. Therefore, asking whether potential users know what GIIs are is important to evaluate their responses to the questionnaire. In that respect, it is also useful to ask them about the GIIs and their tools they use most, and whether they have used other geospatial web applications like Google Maps or Bing Maps, which have a wide use and can eventually perform operations really similar to GIIs. That helps to guess whether a low grade in GIIs use is related to users' abilities with GI resources, or it is more a matter about the difficulty in using the user interface and GI resources that require high technical abilities.

6.2.3.2. Requirement analysis survey structure and contents

GII components analysis is the most common approach to evaluate GIIs (van Loenen, 2006). Nevertheless, this approach is not familiar to common people who never studied or worked directly with GIIs. The high complexity and specificity of GII issues makes the contact with potential users difficult. Knowledge about GIIs requires expertise in GIS, ICT and aspects of

GI management, policies, organizational frameworks, etc. Therefore, an alternative approach is required.

Various authors (Alexander et al., 2009; Courage and Baxter, 2005) advise to approach users with use cases or scenarios, in which users need to fulfil tasks. These use cases are taken from other types of GIIs, ScGIIs, web map applications, etc., which may serve as real examples of feasible options for the prospective ScGII. Most of them were already presented in Chapters 2 and 3 about theoretical background and practical cases. These examples support users to choose their preferences (Alexander, et al., 2009). Use cases are accompanied by explanations to improve the participant's understanding about pros and cons of each choice. For more information refer to Section 6.3.

GIIs can fulfil different sets of tasks depending on who makes use of them. As explained in Section 6.2.2, the ScGII is embraced by diverse stakeholders with different roles in the infrastructure. In each case, a role signifies a set of sub-tasks that should be achieved to reach an objective.

Geographical Information Systems (GIS) enclose a set of activities that can be applied to the requirements analysis for a ScGII as well. GISs are defined as *"the set of tools for collecting, storing, retrieving, transforming and displaying spatial data with a particular set of purposes"* (Heywood, et al., 2006, p. 18) This set of activities can be executed with GIS software, but also with GIIs resources. In this way, these activities can also be taken as tasks that the user could fulfil when using the ScGII.

Figure 28 explains how these ideas are brought into a model where GII components are translated into tasks, which can be realized within the infrastructure. Every sub-task is related to a GII component. They are consciously ordered by: technological means (1), Geographical Information (2), standards (3) and accessibility policies (4). Stakeholders are not mentioned, because they are already taken into account in the GII roles, when the stakeholder is assigned to a set of tasks.

There are three stakeholder profiles (target groups):

- **User**: This profile responds to the need of accessing GI (Grill and Schneider, 2009). This activity may vary from a simple query to a GI download or a geoprocessing activity. In any case, the activity always starts from a GI collection or gathering, which is made by "searching" for data in GIIs. The subsequent tasks may pass by manipulation, analysis and visualization or presentation. This chain of tasks may be done in sequence, or may be carried out just performing some of the activities (Vallespir, J., 2012, 4:32). Among these tasks, accessibility policies are not cited because users should not care about them; "they just need to know what they can access to" (Vallespir, j., 2012, 6:35). Below, these tasks are explained in more detail and related to GII components:
    - Task 1: Search. When looking for GI it is important to consider which technological means is the best to gather information. To do so, it is also important to consider its qualities. This part offers several options in search and retrieval methods. Next, the

user has to respond to the types of information he/she would like to find in the ScGII, including GI, geoprocessing methods and associated contents.

- Tasks 2 and 3: Manipulation and Analysis. These tasks are stuck together because of their great resemblance. They may be carried out in a distributed environment through the GII, although they often need the support from desktop GIS software. The set of questions is highly related to technology and standards for all that regards to interoperability and web services usability. This point intends to discover whether users prefer to work, or would be able to work, in a distributed environment, or whether they rather prefer to work with geoservices in their GIS or CAD software. Defining user capacities in software use, and skills to work with ICT media like geoservices reveals whether the prospective system should incorporate simple resources, like a GI download service or WMS services, or it should implement advanced tools like download services (WFS/WCS) or geoprocessing services (WPS).

- Task 4: Visualization. This task is focused on optimizing the performance of web applications like map viewers and geoprocessing applications. Based on the current version of the IDECi-UIB map viewer, and tools used in other GII map viewers, users must evaluate which of them suit better suit their needs.

- **Provider**: This profile responds to the desire or duty to publish GI in the infrastructure. This activity may be assigned to providers who may also act as users (in this case, teachers and researchers), and to external partners who may also participate in the ScGII project. Nevertheless, external partners are not target groups and therefore they do not respond to the online questionnaire, due to their low integration into the IDECi-UIB (Rodríguez-Pascual, A., 2012, 41:52).

  - Task 5 and 6: Publishing and visualization. These tasks are stick together since they have a common aim: distributing GI. They respond to the tasks of GI management and visualization, if map viewers are developed. At this point, questions are focused on types of information to be published, and the preferred media to do so. Critical points are the accessibility policies; providers are asked to tell what GI resources they would publish, and who could access them. That determines the openness of the infrastructure, and, in a way, the opportunities to have a successful project (Guaita, F., 2012, 43:32; Vallespir, J., 2012, 57:40).

- **System manager**: The profile of the personnel that manages the interactivity between users and providers, and keeps the system working for its best performance on the server side. There is a set of sub-tasks (Task 7) which should be carried out constantly and simultaneously, like publishing GI, managing and maintaining the infrastructure, and keep developing and improving the system. At this point it is very important to grasp whether the developer's views match join with the users' and providers' views.

Apart from GIS tasks, there is another element that needs analysis and does not appear in Figure 28. The user interface is necessary for all GIIs with a geoportal access (Rodríguez-Pascual, et al., 2009). It is a common element for all GII stakeholders but it is not related to any task within the infrastructure. Therefore in questionnaires was referred as Task 0. The questions regarding the user interface focus on comparing interfaces from use cases with different formats. Evaluating on user interfaces is rather qualitative. Users are asked to evaluate geoportals' usability, and the accessibility of available tools.

6.2.3.3. *Questionnaire technicalities*

The three profiles described in the previous section 6.2.2 correspond to roles in the GII, although stakeholders may take on one or more of these roles. Next target groups are assigned to participating stakeholders:

a) Students: They just act as users of the infrastructure. Therefore, they are only asked to complete the first part of the test, corresponding to user profile, user interface analysis and tasks 1, 2, 3 and 4. All in all, they have to respond to 30 questions, which should just take about 15 minutes time to respond.

b) Teachers and researchers: They act as users and providers. Hence, next to the user questions, they also have to respond to tasks 5 and 6 on publishing. That results in a total of 41 questions, which could be answered in about 20 minutes.

All the questions from these tests are configured to be single or multiple-choice, to limit and simplify the participants' responses (Courage and Baxter, 2005). Some of them are subordinated to others, in the way that certain responses give access to a particular other question.

c) Developers: The SSIGT members are asked to respond to a different test consisting of 21 questions that comprise three parts: user profile, user interface analysis, and system maintenance and management (Task 7). Their questions are more open and qualitative and vary from single and multiple choice questions, to free text, or single choice with comments questions.

The tests were transformed into anonymous web questionnaires to facilitate the survey execution, and the posterior statistical evaluation (see section 7.2). The survey was edited with Lime Survey software (URL 80). All the survey versions are provided in Annex 3.

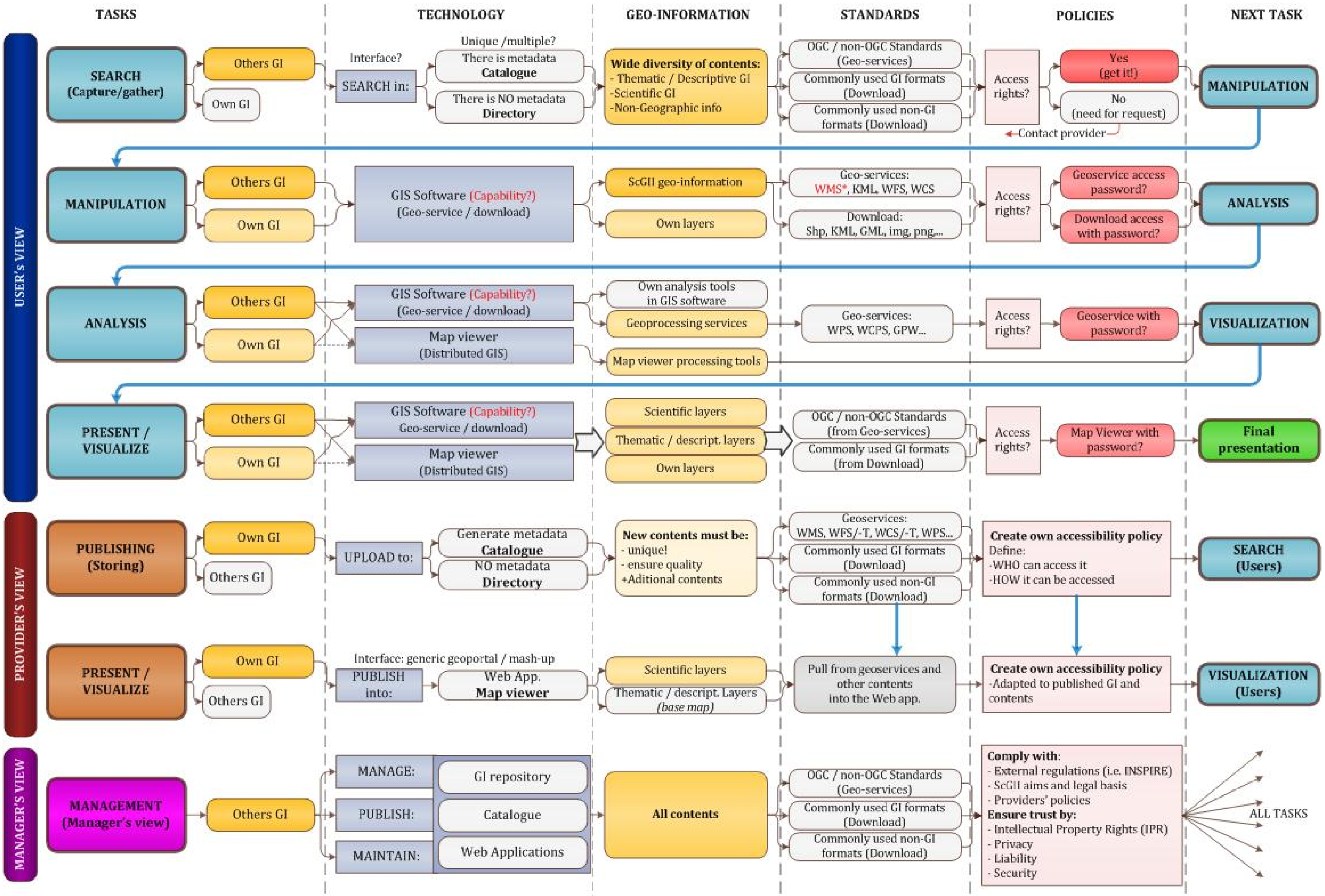


Figure 28: GIS tasks related to GII components

6.3. Survey execution

The requirements analysis survey execution was planned to be made in-class to students and to teachers and researchers. To do so, presentations were prepared to explain the survey contents and provide some guidance to participants (Eaton, et al., 2007; Holloway, 2007). The questionnaire may appear to be rather technical for people who do not relate to the GIS sector. Therefore, explanations were provided between test tasks to avoid misunderstandings and concept errors, and, if needed, responses were given to questions posed by participants. These explanations were supported with 2 different presentations attached in Annex 4. They were only made in Catalan since English is not necessarily understood by the test participants.

Most of the students were tested following the planned methodology with 3 sessions of 7, 21 and 9 participants each. Other 5 students were questioned after an individual personal meeting. The rest of the students (24 participants) could not be met personally. To solve this issue, a blog site was created, including the needed information to complete the questionnaire. A video with the recorded presentation about the user's profile represented the main part of it. With a length of 13 minutes the video guides the user through an introduction, and then through all the user tasks. It was just recorded in Catalan because that is the official communication language at the UIB. The site is in Catalan and English available at: http://blog-scgii.blogspot.com.es/.

Other 8 participants did take the test but did not complete it. They must be considered in the sample, however since the test is anonymous it cannot be known whether they were in-class students or participants who were not met personally.

Meetings with teachers and researchers did not happen as planned. Individual personal meetings had to be made to most of them. That required a separate explanatory session per participant. In these conditions participants had a more personal treat, but, meanwhile, the explanations made to each of them, could have been slightly different. These variations may have had some influence on the test responses. Test responses leaded to 33 responses, in which 7 were not valid.

ScGII developers were directly asked to respond to the questionnaire with no explanatory session. It was assumed that they do know enough about GIIs and the possibilities that could be applied to it. The SSIGT team is just composed by 3 people, and they all responded to the whole test.

6.4. Conclusion

This chapter has gone through all the conditions and methodologies that served to create the requirements analysis surveys, and after that to execute it. This is a culminating point in the research; once the information is collected there is only the need to analyze the results and come out with user needs, which will provide the necessary background to propose a prototype model.

In what refers to research questions, this chapter solved who could be the potential users and stakeholders at the IDECi-UIB. Next, it also set out the methodology to define the user needs, and the critical points to improve the current UIB's ScGII prototype, responding to the second and third research question. These results will be finally given in Chapter 7.

7. Requirements analysis results

7.1. Introduction

Now that the requirements survey has been executed and all data collected, it is necessary to process this information by different statistical means to provide the input for the next phase of the UCD methodology: prototyping. This chapter aims to analyze the requirements analysis results is structured in two main parts: the first one is intended to generate statistics from the collected data, to interpret them and to generate personas.

7.2. Statistical analysis of the results

7.2.1. Population representation

Table 11 shows the response to the requirements analysis surveys. From the two surveyed groups of potential users, the study got a total of 74 student samples and 33 teacher samples. Yet, a total of 15 people did not complete all the questions, and, therefore, their responses were rejected. So, the total amounts of considered responses were 66 students and 26 teachers and researchers.

	Total responses	Not completed	Completed responses
Students	74	8	**66**
Teachers / researchers	33	7	**26**

Table 11: Requirements analysis responses summary

These samples represent the responses from the UIB students, teachers and researchers that were discussed in section 5.4. These populations are basic to explain the results. Both samples represent approximately a 5.3% of the populations of both groups of users (Table 12). That would seem a coincidence, but it has a methodological explanation: student samples were collected in the first place, and professors and researchers samples were collected afterwards. Considering that the students' proportion of the total population was around 5.3%, samples of teachers and professors were collected until the same amount of samples was reached.

	Total population	Sampled population	% sample
Students	1236	66	5,34
Teachers and researchers	489	26	5,32

Table 12: Representation of the sample population

None of the results analyses merge the values from both user types, because they have different roles in the ScGII; mixing them would make no sense. As a consequence, no weighting calculations were applied to those values.

7.2.2. User profiles

7.2.2.1. User profile analysis

As mentioned in section 6.2.3.1, user skills and experiences in GIS, GIIs and ICT are critical to evaluate user needs. These are the main criteria that have been established to create personas among the two groups of users. The interviewed experts recommended creating 3 to 5 groups also based on user skills and use of cartography in their daily work:

*"You can classify users by the level of competence; for example: basic users, advanced users, developers, geomatic engineers, etc. […] define four or five groups" (*Rodríguez-Pascual*, A., 2012, 48:25)*

" I would create three types of users the first one who may just have the map as a support next to their text, then GIS user, who uses GIS programs, developer user, who designs and develops the system" (Vallespir, J., 2012, 25:58)

"There is a very big difference from using a map viewer to working with geoprocessing; […] you can differentiate between a map user and a GIS user" (Vallespir, J., 2012, 30:47)

Creating personas helps to simplify results creating just a few fictional users that represent a whole users' group that follow a common pattern in skills and experience (Courage and Baxter, 2005) with GIS and GIIs.

Therefore this study generated 4 personas in each target group (students and teachers/researchers). This division was based on the GIS courses they have taken. This is the only premise in the questionnaire that certainly guarantees an ability level in GIS. For people who have not been trained in GIS, and just use GIS indirectly for visualization, there is a fourth group: the map user. The experts emphasize that many users may suffer from the digital gap; because they are not trained enough or they are reluctant to work with IT (Rodríguez, A., 2012, 40:01; Guaita, F., 2012, 1:16:23). In principle, these kinds of users are put into the "map user" group, because despite working in cartography and spatial thinking, they did not bet for GIS use yet. Nevertheless, there may be some self-learners who may fall into this group when they have more skills than expected.

Table 13 summarizes these criteria and sets what types of courses should be taken by users to be placed in one group or another.

	GIS courses	Tasks when working with GI
1) Map user	-None	-Visualization task
2) Basic GIS user	- Basic GIS (Bachelor) -Non-university GIS courses	--
3) Intermediate GIS user	- Intermediate GIS (Bachelor) - Advanced GIS (Bachelor) -Remote Sensing (Bachelor)	--
4) Advanced GIS user	-Postgraduate in GIS -Master in GIS	--

Table 13: Criteria to split users into groups to create personas

The division of students, and teachers and professors in groups was successful in most of the cases (Table 14). The threat in both groups is the short amount of advanced GIS users. The number of teacher groups had to be reduced to three due to the lack of intermediate users. The unique user from the intermediate level was assigned to the basic level, because his/her responses were closer to a lower level than to an advanced.

	Map user	Basic GIS user	Intermediate GIS user	Advanced GIS user	Total
Students	5	32	24	4	66
Teachers and researchers	9	12	--	5	26

Table 14: User types divided in personas

7.2.2.2. Skills and experience in GIS

Once all users are categorized into their profiles it is interesting to look in both groups of samples to find differences in the level of skills (Figure 29 and Figure 30). While in both groups 50% of samples have a basic knowledge in GIS, students seem to be more prepared to use GIS, with a higher percentage of people with an intermediate level (37%). Meanwhile, teachers and researchers seem to have more extreme results with a large amount of people with no training in GIS (about 35%) and also a larger proportion of advanced GIS users (19%).

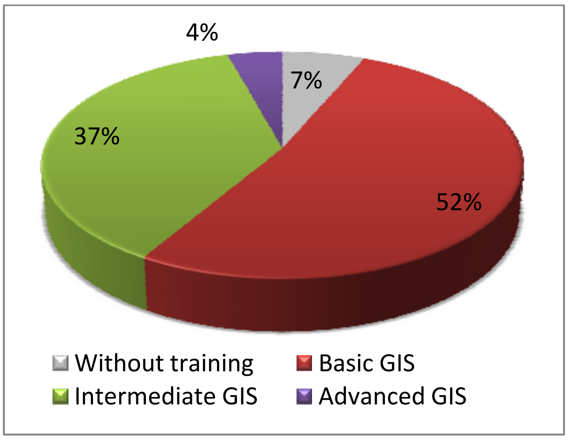


Figure 29: Students by training

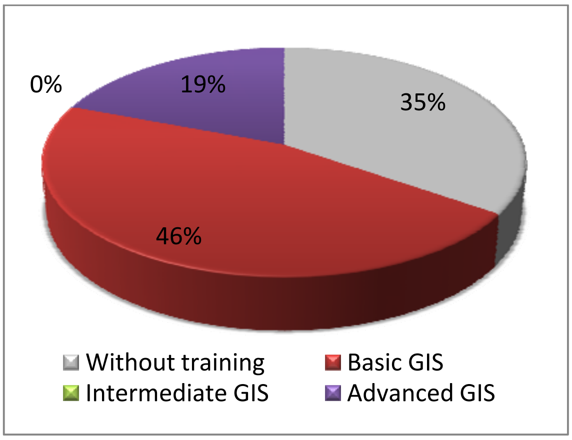


Figure 30: Teachers and professors by training

But training in GIS is not the only factor that affects its real use in education and research. The real application of GIS out of training is what enables the user to solidify his skills (NRC, 2006). Figure 31 for instance, shows the amount of students that use GIS in different studies: colours symbolize the amount of subjects (*x axis*, from 0 to 10 subjects), per amount of people (*y axis*). It is evident that Geography is the degree that uses more GIS by far; in most of the cases in 2, 3 or 4 subjects, and in some cases in 10. Yet, there are still cases of people who never use GIS (white). In other studies the use of GIS are minorities or just inexistent; instances are Biology with none subjects, or Agriculture Engineering with only 1 subject.

That may be a matter depending on students' will, although teachers also have part of this responsibility. Teachers should instil students to apply GIS resources in their daily work (NRC, 2006). This is not a fact among the taken samples (*Figure 32*): results affirm that teachers mostly use GIS in the Geography degree, but in other study programs its use is rather low.

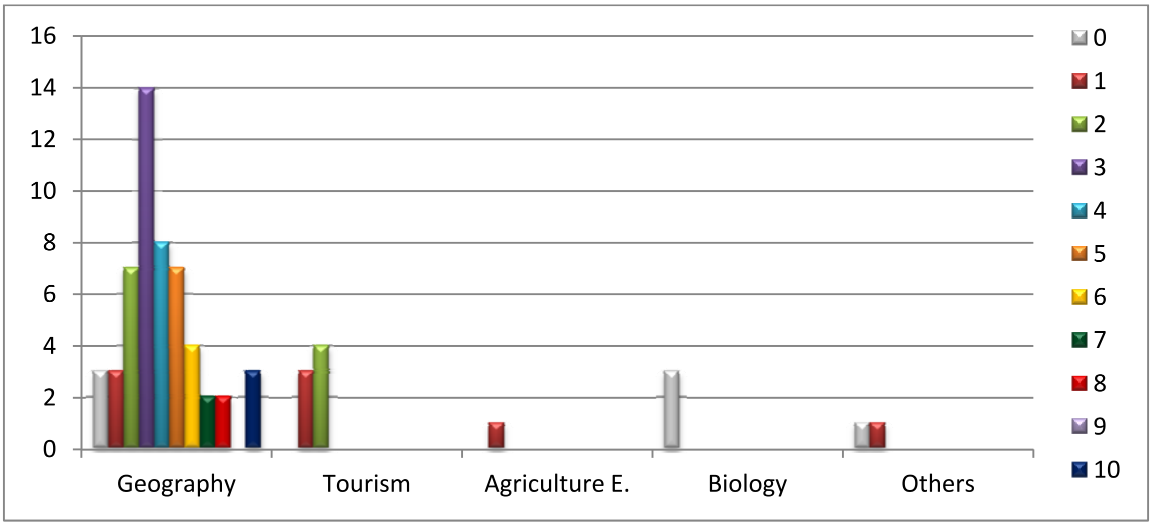


Figure 31: Subjects with compulsory or voluntary use of GIS techniques (students)
Colours: amount of subjects using GIS / y axis: amount of people

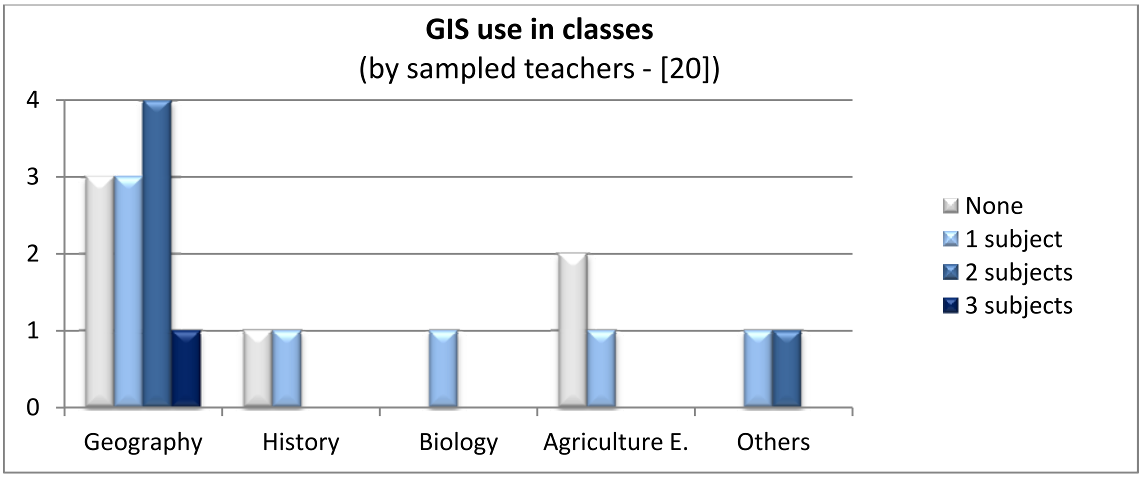


Figure 32: Digital cartography used in classes (teachers)

Skills in GIS do limit the amount of tasks users can actually carry out at work. In Figure 33 and Figure 34 the results from students and teachers and researchers can be compared. Values demonstrate that students, who have had more courses in GIS can carry out a greater variety of tasks, while teachers and researchers carry out a smaller variety of activities and focus on visualization and map generation.

These graphics demonstrate how sampled students were rather young (20-25 years old). Those are bachelor and part of the master students. Older students are also spread in most of the tasks, apart from advanced analysis and RS.

The use of GIS and ICT may be also a generational fact among the population, especially in the group of teachers and researchers. GIS tools have become popular in the last 15-20 years, and GIIs even later, in the last 5 to 10 years (Fu and Sun, 2010). That also generates difficulties for older people who did not have the opportunity to learn GIS when they were studying; and later on did not see the need for using it.

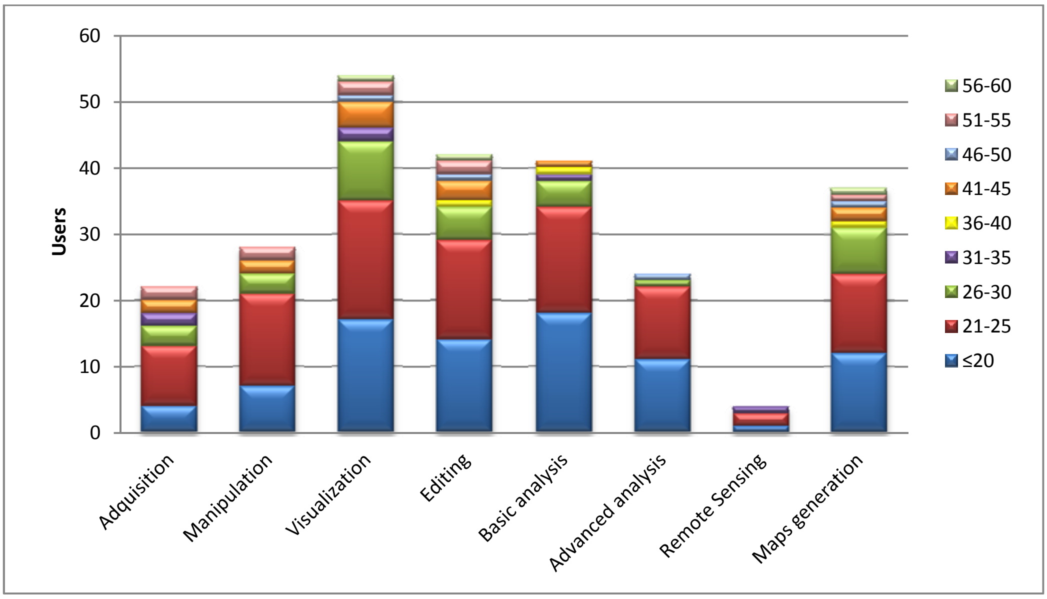


Figure 33: GIS tasks per age group (students)
(in absolute values)

This fact is reflected in Figure 34, where it can be appreciated that younger personnel, from 26-40 years old, executes most of the tasks in GIS, while older professors from 55 to more than 60 years old, limit their activities to visualization, maps generation, or even do not respond to the question.

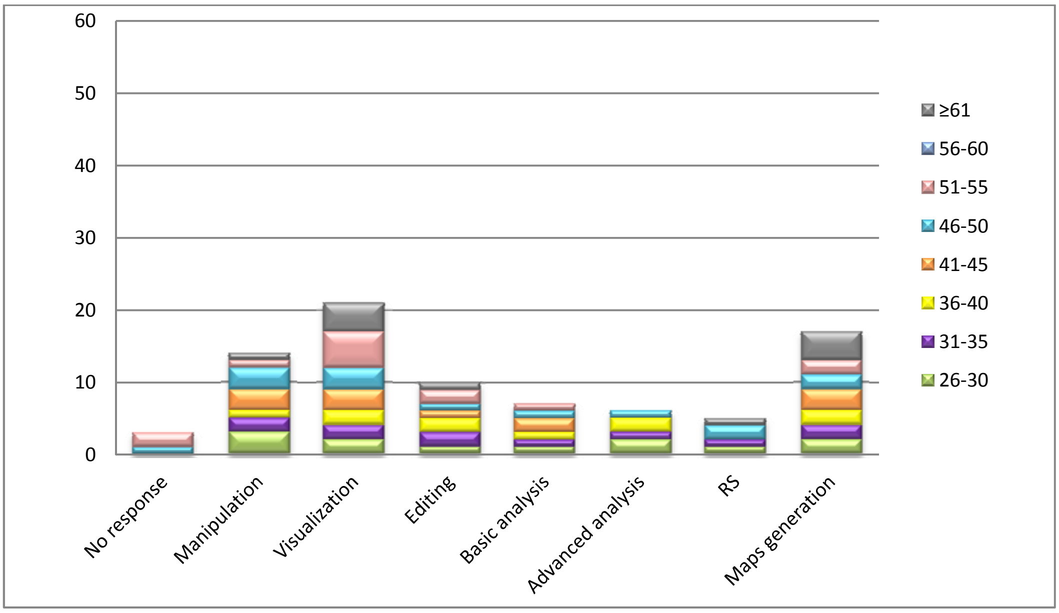


Figure 34: GIS tasks per age group (teachers and researchers)
(in absolute values)

7.2.2.3. Skills and experience in GIIs

The use of GIIs among UIB users is different from the work carried out with GIS software. Although not everybody knows about what GIIs are, most of the sampled population did use or work at some point with them. 89% of the students and 73% of teachers and researchers knew what GIIs are before they took the survey.

Yet, there are different trends between very basic and advanced users. These trends are really clear when looking at the GIS and GIIs use frequency graphs (Figure 37 and Figure 38). In both cases the habits of the users are clear: while map users never or occasionally use GIS software, they make use of GIIs more frequently. When we go to more advanced degrees, users start using GIS software more and more and GIIs are used less, because they just act as information sources.

To support this argumentation, we should know about the most used functions in GIIs. Figure 35 and Figure 36 show how most basic users focus their attention on map viewers, and as more advanced they get, the more GII resources they use. It is notable how downloading GI and using geo-services are less used tools. Nevertheless in general, users prioritize downloading geodata to the use of services. The catalogue is a tool rather unknown or not used by basic users, while it becomes one of the main ones for advanced users.

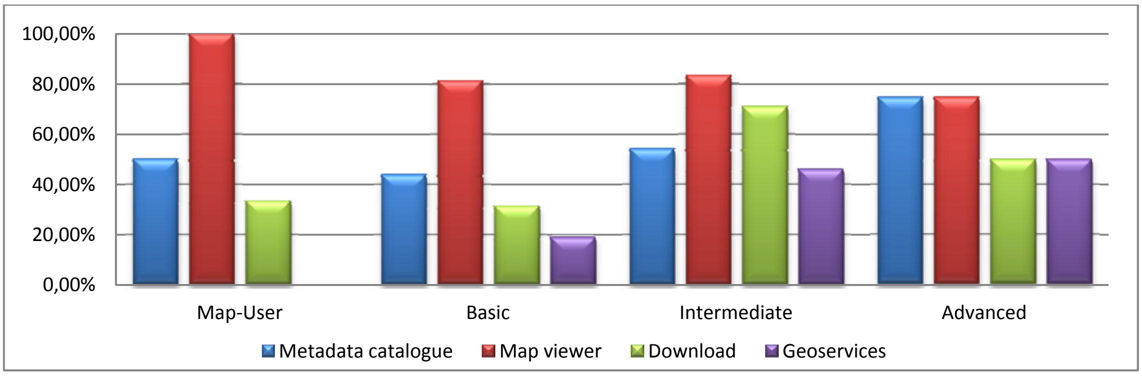


Figure 35: GIIs tools use per user type (students)

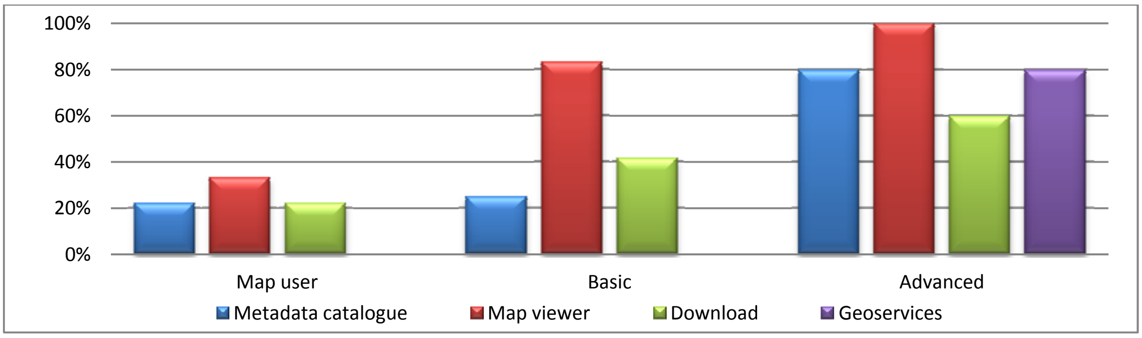
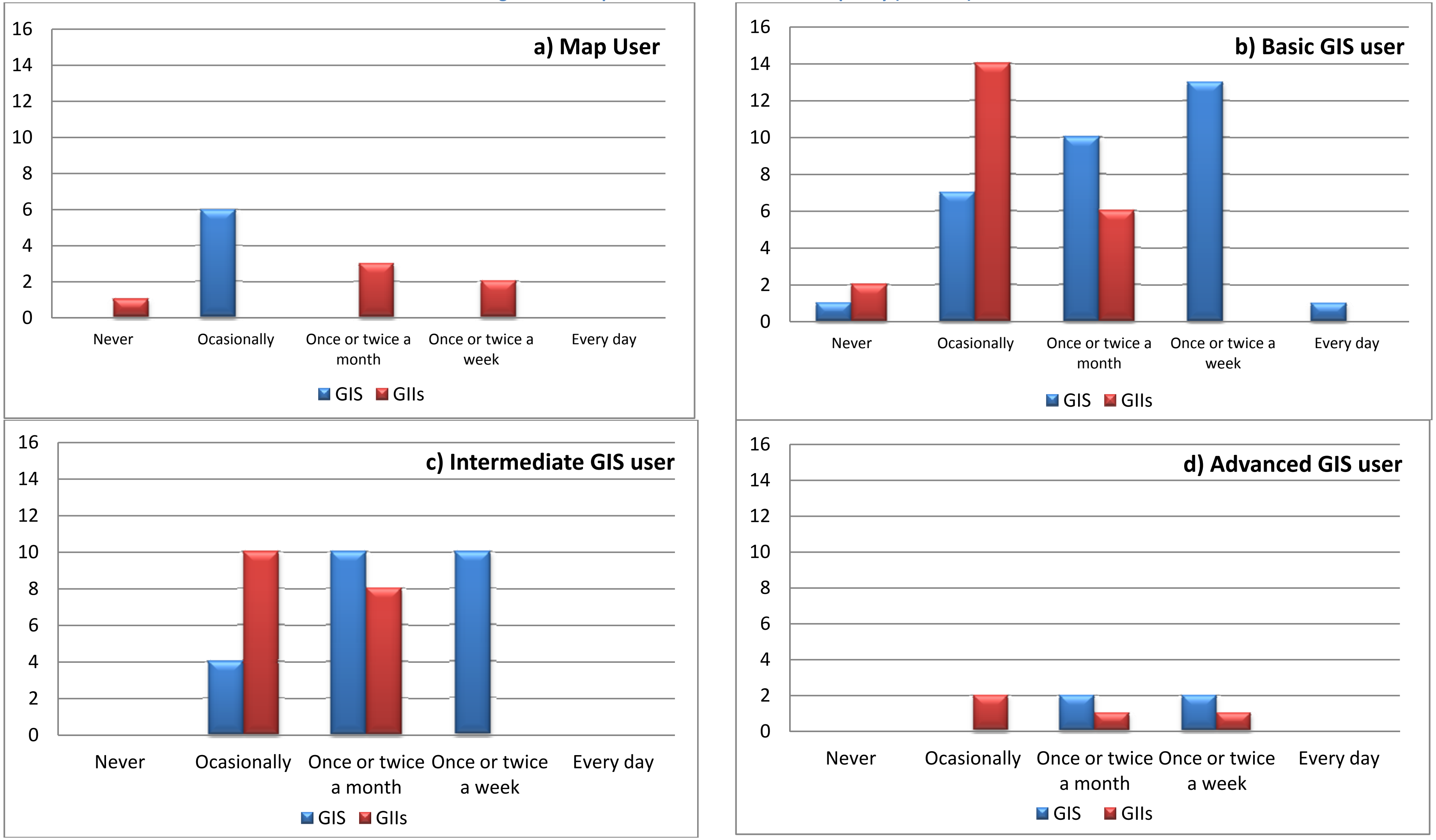
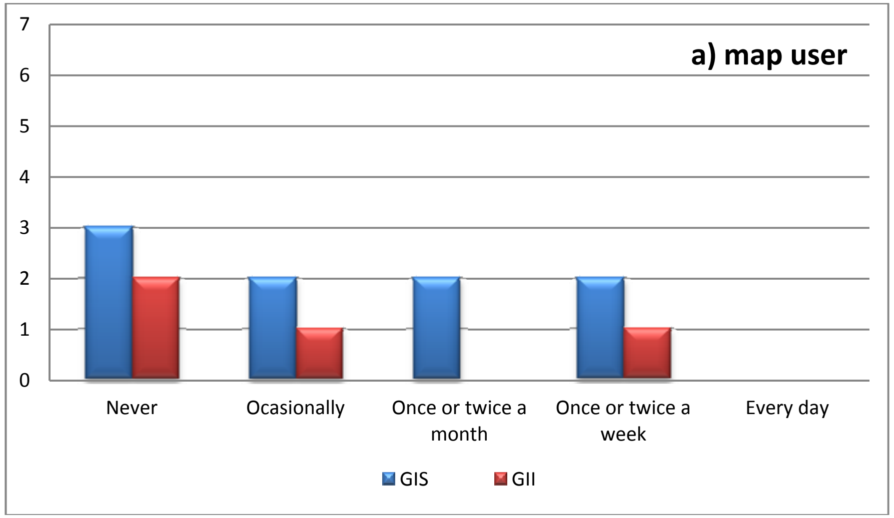
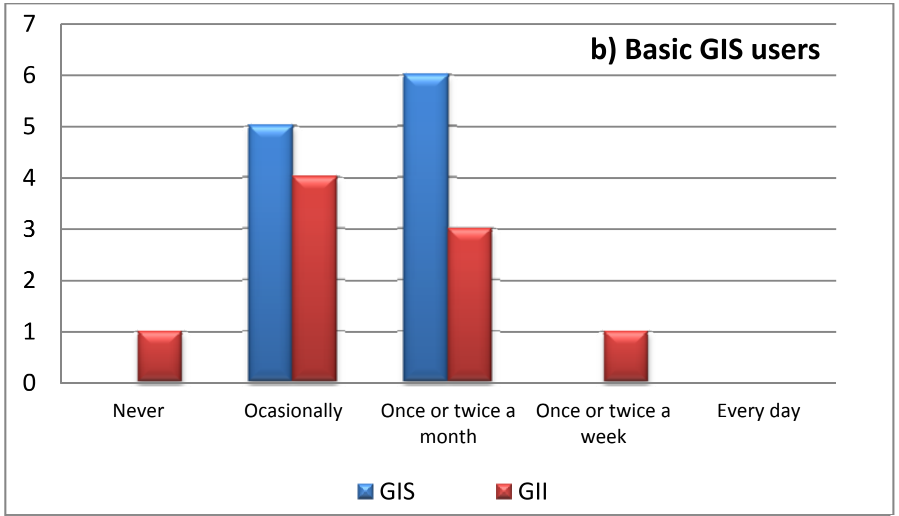


Figure 36: GIIs tools use per user type (teachers/researchers)

Figure 37: Comparison in GIS and GIIs use frequency (students)







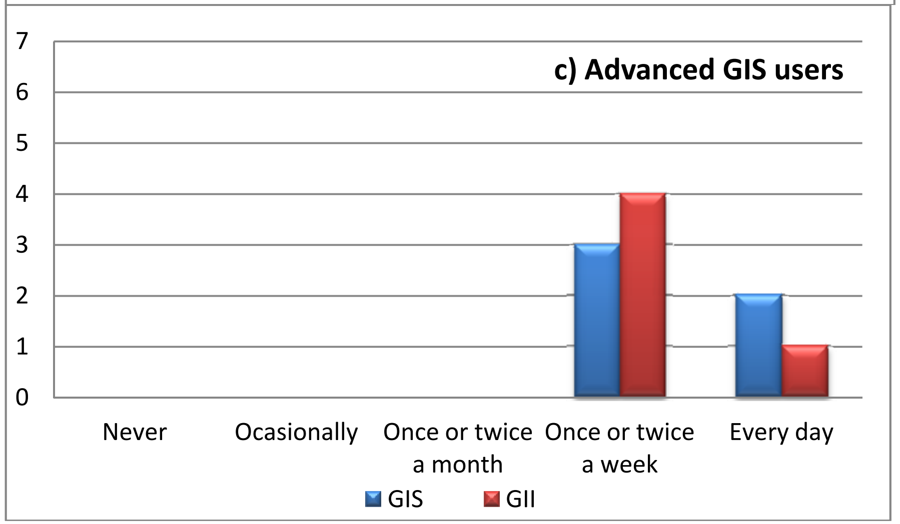


Figure 38: Comparison in GIS and GIIs use frequency (teachers and researchers)

User profile questions have demonstrated the level of knowledge in GIS and GIIs and the use made of these types of resources. The low level in the use of certain tools need not be the users' fault only. The system's adaptability to the ways users are working matters very much. To remark this issue, users were asked whether they make use of popular web map applications like Google Maps or Bing Maps. Responses were positive for 100% of the students, and for 85% of the teachers and researchers. Figure 39 and Figure 40 show how different tools with a complicated technological background are used by many users, even by map users and basic GIS users.

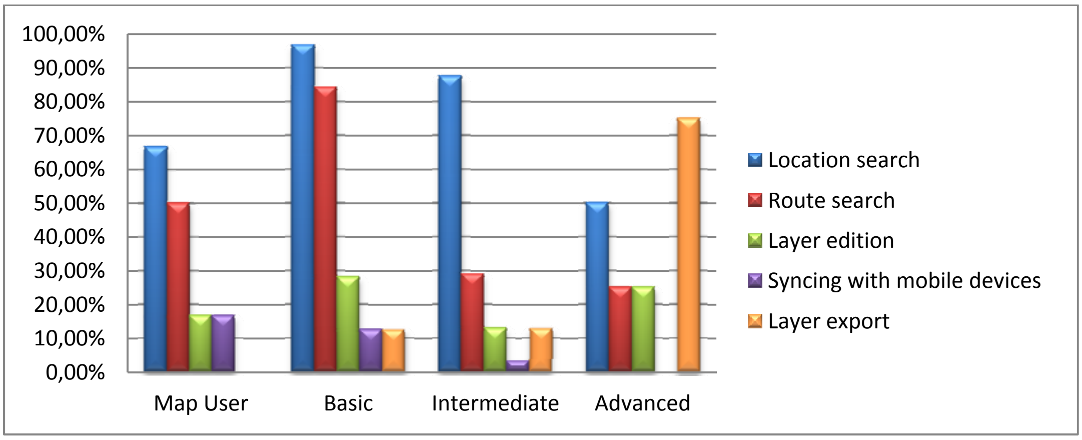


Figure 39: Use of Google Maps / Bing Maps functions by students

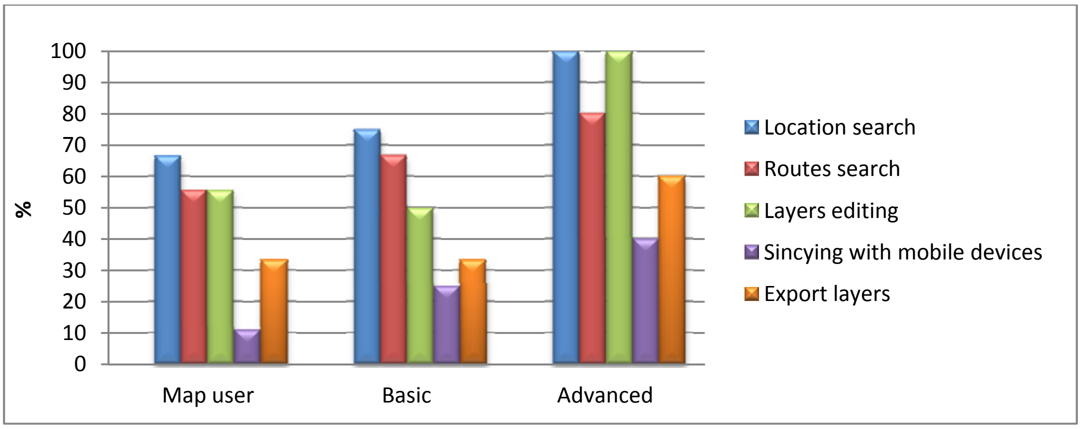


Figure 40: Use of Google Maps / Bing Maps functions by teachers/researchers

This is the case from the route or location searching tool. Actually, they are geoprocessing tools that calculate the shortest path in time between two points, or an address from a database, to serve it easily. Synchronization between desktop and mobile devices is also a great advance; it is real distributed GIS.

So, while geo-services have a very limited use in existing GIIs, systems like Google Maps (URL 11) or Bing Maps (URL 81) that also work with geoservices are able to supply a really great demand (Nivala, et al., 2008); up to 80% between basic, intermediate and advanced students of this research. Usability is the key point for this type of systems, and Google Maps or Bing Maps systems have really created interfaces and developed the necessary technological means in which very complex tools can be used easily by anyone (Nivala, et al., 2008). Evidently, the nature of information provided not always points to activities like learning or research, and these tools are used for private purposes. In any case, what matters is the capacity of users to make use of such tools. Therefore, it would be convenient to apply similar schemes into ScGIIs to make the system more usable.

7.2.2.4. Interface analysis and structure

Bonifatti et al. (1996) defend that user interfaces should be designed in the first instance from a non technical perspective, from the user point of view. Precisely this part of the analysis tries to sharpen the type of geoportal's interface that is most convenient for the UIB's ScGII. The interviewed experts advised to set a generic geoportal as a home page and to maybe create more specialized interfaces for research projects or secondary sections (Rodríguez-Pascual, A., 2012, 1:07:11; Vallespir, J., 2012, 47:30).

The requirements analysis survey showed a set of five geoportals with different interfaces and the respondents had to evaluate which of them were more clear and accessible considering interface features, like icons position, size, and structure (Rodríguez-Pascual, et al., 2009; Nivala, et al., 2008). These geoportals were the IDEIB (URL 14) and the IDEE (URL 72) from the Spanish and the Balearic Islands administrations, the SIB-ESS-C and the IDE-ULPGC (both ScGIIs analyzed in section 3.3) and the already existing IDECi-UIB prototype (URL 58). An overview of these user interfaces is provided in Figure 22 with the IDECi-UIB interface, and Figure 41 with the rest of examples.

IDEIB Geoportal

IDEE Geoportal

IDE-ULPGC Geoportal

SIB-ESS-C Geoportal

Figure 41: GII Geoportal interfaces selected to perform the user interface analysis

Source: IDEIB (URL 14), IDEE (URL 82), IDE-ULPGC (URL 39), SIB-ESS-C (URL 41), IDECi-UIB (URL 58)

The evaluation of user interfaces consisted on grading each the tools and resources of each GII interface. Since these decisions are rather qualitative and subjective, a Likert scale (1-10, low-high), and a normalization method were applied.

The Likert scale is a psychometric response scale to obtain the preferences of participants, and to know the grade of agreement or disagreement with a statement (Bertram, 2009), in our case the grade of agreement with the accessibility to a tool, or its usability in a specific geoportal. The responses are qualitative and depend on the participant's opinion. Common statistic measures like the mean cannot be applied over these values (Ginard, 2011); instead, non-parametric statistics need to be applied.

To normalize the results this study used the "classification per scalar degrees" method (Gómez Orea, 2002). In this way, the weighted value (V) that a participant (i) assigns to the element (e) is obtained with this expression:

$$V_{ei} = \frac{E_{ei}}{\sum_{e=1}^{n} E_{ei}}$$

Where Eei is the value of the scale that the participant assigns to the element e. The final weighted value results from the expression:

$$V_e = \frac{\sum_{i=1}^{m} V_{ei}}{\sum_{i=1}^{m} \sum_{e=1}^{n} V_{ei}}$$

Table 15 shows the results of these calculations, where a unique value is provided for each example. Higher percentages show more preferred examples. Since finding, using or accessing each GII resource like the metadata catalogue or the map viewer may be evaluated with different criteria by the same participant, calculations were made separately for every GII resource. This means that users' calculations just took in account complete responses, refusing incomplete qualifications.

					Students
	IDEIB	IDEE	SIB-ESS-C	IDE-ULPGC	IDECi-UIB
Metadata Catalogue	**26%**	22%	13%	16%	22%
Map Viewer	**26%**	22%	16%	16%	21%
Geoservices	**24%**	22%	16%	17%	20%
Download Serv.	17%	**35%**	16%	12%	20%
					Teachers and researchers
	IDEIB	IDEE	SIB-ESS-C	IDE-ULPGC	IDECi-UIB
Metadata catalogue	**25%**	24%	15%	14%	22%
Map viewer	23%	**24%**	19%	14%	20%
Geoservices	**24%**	22%	19%	18%	17%
Download Serv.	14%	**42%**	11%	10%	23%

Table 15: User interface analysis

Results show a clear preference for the IDEIB and the IDEE in both groups (in orange), and, on the third place, the IDECi-UIB geoportal (in pale orange). This may be explained by the fact that the IDEIB and IDEE are the most familiar GIIs for the users (IDEIB: 80.3% of students, 53% of teachers and researchers; IDEE: 15% of students; 23% of teachers and researchers). Habits and familiarity with the site may have influenced the users' responses (Flavian, et al., 2006).

Secondary sections of the geoportals were also assessed with a ranking, asking to order by preference 5 types of sections from the highest to the lowest (Table 16). To evaluate that, no examples were given, since most GIIs already incorporate these options. Of the 5 possibilities only the first three were considered as the most relevant. The evaluation demonstrated that the most important sections for users are the informative section about the GII and the support section. On the third place there are the links to other GIIs and the news section. The feedback post-box was put in the last place. This point is very comprehensive, because when users have to choose, they prefer a practical resource to solve their needs than a resource that results more useful for developers, who try to shape a GII according to user proposals.

			Students
	Ranking 1	Ranking 2	Ranking 3
Support section	38%	**35%**	8%
Informative section about the GII	**39%**	20%	12%
News (blog/website)	6%	17%	30%
Feedback postbox	3%	6%	17%
Links	14%	21%	33%
			Teachers and researchers
	Ranking 1	Ranking 2	Ranking 3
Support section	**38%**	**42%**	15%
Informative section about the GII	**31%**	**27%**	12%
News (blog/website)	4%	12%	**38%**
Feedback postbox	4%	0%	8%
Links	19%	19%	**19%**

Table 16: Secondary GII sections classification

Language is also a very important matter to ensure the accessibility of geoportals (Rodríguez, et al., 2009). Users were questioned about their spoken languages (Table 17), and in both cases the languages that were mastered most were Spanish and Catalan, English ended up in the third place. These responses were also normalized using the classification per scalar degrees (Gómez Orea, 2002) since the scale (1-5) was also qualitative.

	English	Catalan	Spanish	German	French
Students	**20%**	**29%**	**32%**	8%	11%
Teachers and researchers	**21%**	**27%**	**30%**	7%	14%

Table 17: Language qualifications

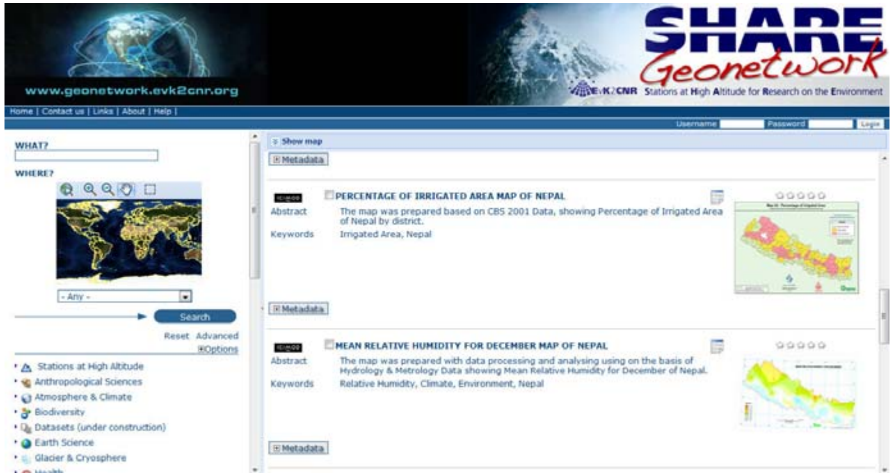
7.2.2.5. Task 1: GI search

As mentioned in section 6.2.3, GI search is the first task that is realized when accessing a GII. At this point it is very relevant to know what searching method is preferred by the users. Therefore they were asked to respond between three use cases: the SHARE Geonetwork catalogue (URL 46), the SSIGT's GI download service (URL 82), and Landscope mash-up (URL 83) (Figure 42). Table 18 shows how the catalogue was the most valued system, followed by the folder directory structure. The mash-up structure came in the third place, maybe because of ignorance regarding these types of systems.

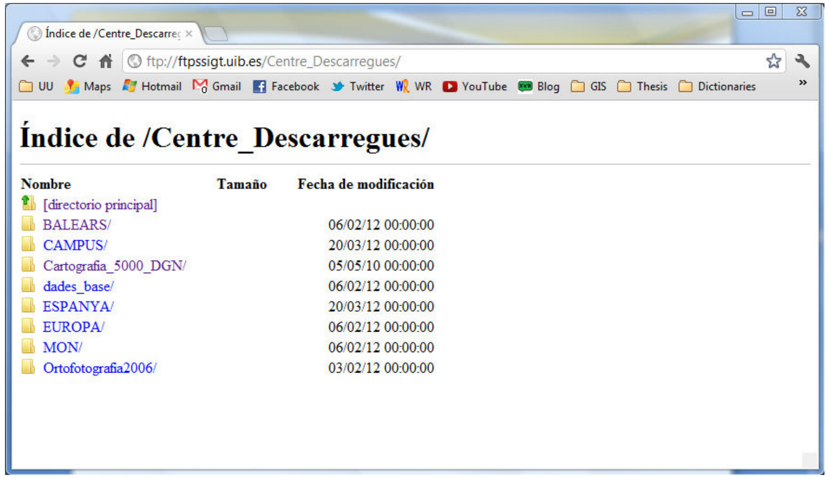
Searching method - Students			
	1st place	2nd place	3rd place
Catalogue	**53%**	30%	17%
Directory	30%	**41%**	29%
Mash-up	17%	29%	**55%**
Searching method – Teachers and researchers			
	1st place	2nd place	3rd place
Catalogue	38%	50%	12%
Directory	42%	19%	38%
Mash-up	19%	31%	50%

Table 18: Results on searching methods preference

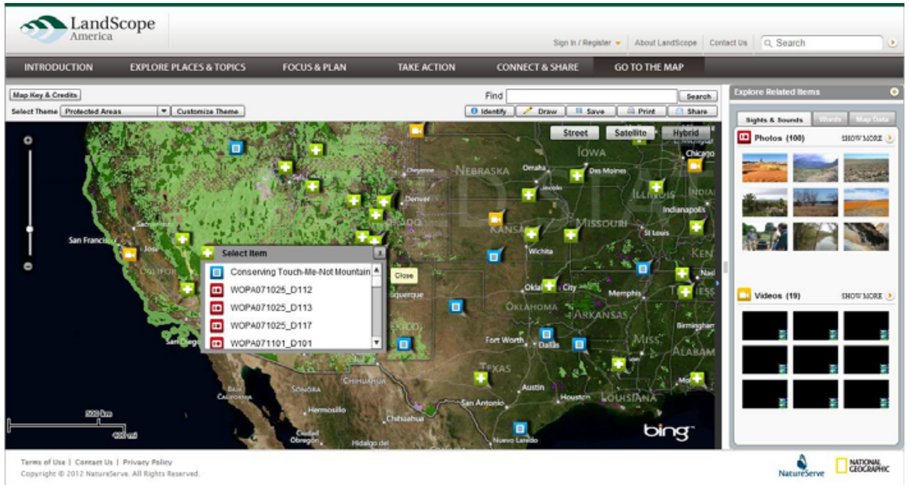
Users also found it very interesting to have the possibility to access other catalogues with a CSW service, based on the example of the IDE-ULPGC's catalogue (Figure 42d). 92% of the students and 84% of the teachers and researchers gave a positive value to this option.



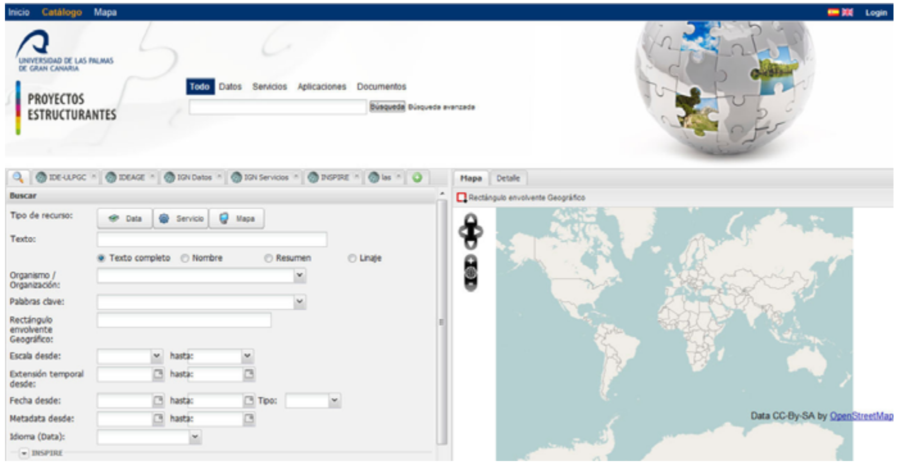
(a) SHARE Geonetwork catalogue



(b) Directory structure. FTP service from the SSIGT (UIB)



(c) Landscope mash-up



(d) IDE-ULPGC catalogue, with option to search in other catalogues (CSW)

Figure 42: GI search use cases

Source: SHARE Geonetwork: URL 46; IDE-ULPGC, URL 39; FTP SSIGT directory, URL 82; Landscope maps, URL 83

Regarding the searched contents, students and researchers have very different interests. Students are interested in more or less all thematic classes, because they may use it in any subject. Teachers and researchers just prefer specific topics from their study field to research or teach on. These geodatasets should mainly cover the Balearic Islands region, with Spain, the Mediterranean Basin, and the world in the second place (Table 19). Most users also find important the availability of temporal series (100% of the students, 85% of the teachers and researchers).

	Students (66)	**Teachers and researchers** (26)
Balearic Islands	**80,30 %**	**96,15 %**
Spain	56,06 %	34,62 %
Mediterranean Basin	34,85 %	61,54 %
Europe	39,39 %	30,77 %
Other continents	21,21 %	42,31 %
World	50,00 %	34,62 %

Table 19: Study area interests

Non-spatial contents would be also appreciated (Table 20). Within a ranking of different material types, students qualify statistics as the most interesting type (57%) followed by multimedia (33%) and text documents (31%) and finally hypermedia (37%). Teachers and researchers also consider that statistics are the most important documents, followed by text documents and multimedia files.

In fact, also the interviewed experts remarked the importance of these associated contents:

"It would be absurd having a very complex system for geographic data without considering non-geographical information" (Guaita, F., 2012, 81:00:23)

			Students
	Ranking 1	Ranking 2	Ranking 3
Statistics	**57%**	24%	10%
Text documents	27%	**31%**	22%
Multimedia	8%	**33%**	31%
Hypermedia	8%	12%	**37%**
			Teachers and researchers
	Ranking 1	Ranking 2	Ranking 3
Statistics	**38%**	23%	19%
Text documents	35%	**35%**	8%
Multimedia	4%	19%	**42%**
Hypermedia	12%	12%	19%

Table 20: Ranking of potential non-geographical contents

7.2.2.6. Tasks 2 and 3: GI manipulation and analysis

Most of the times, manipulating and analyzing GI still requires GIS software. So far, distributed GIS systems are not developed enough to permit working online without the need of a desktop computer (Fu and Sun, 2010; Zhong-Ren et al., 2003); interoperability and usability are still two issues that need to be strongly improved. Therefore, the questionnaire asked about the most used GIS programs among users to know which standards in geoservices and files should be used in the ScGII.

Figure 43 shows the most used GIS programs of the two user groups. Generally, there are four main programs which are used most: Google Earth, ArcGIS, GvSIG and Miramon. Other GIS programs like Quantum GIS or uDig, or CAD programs like AutoCAD or Microstation, do not have a very extensive use.

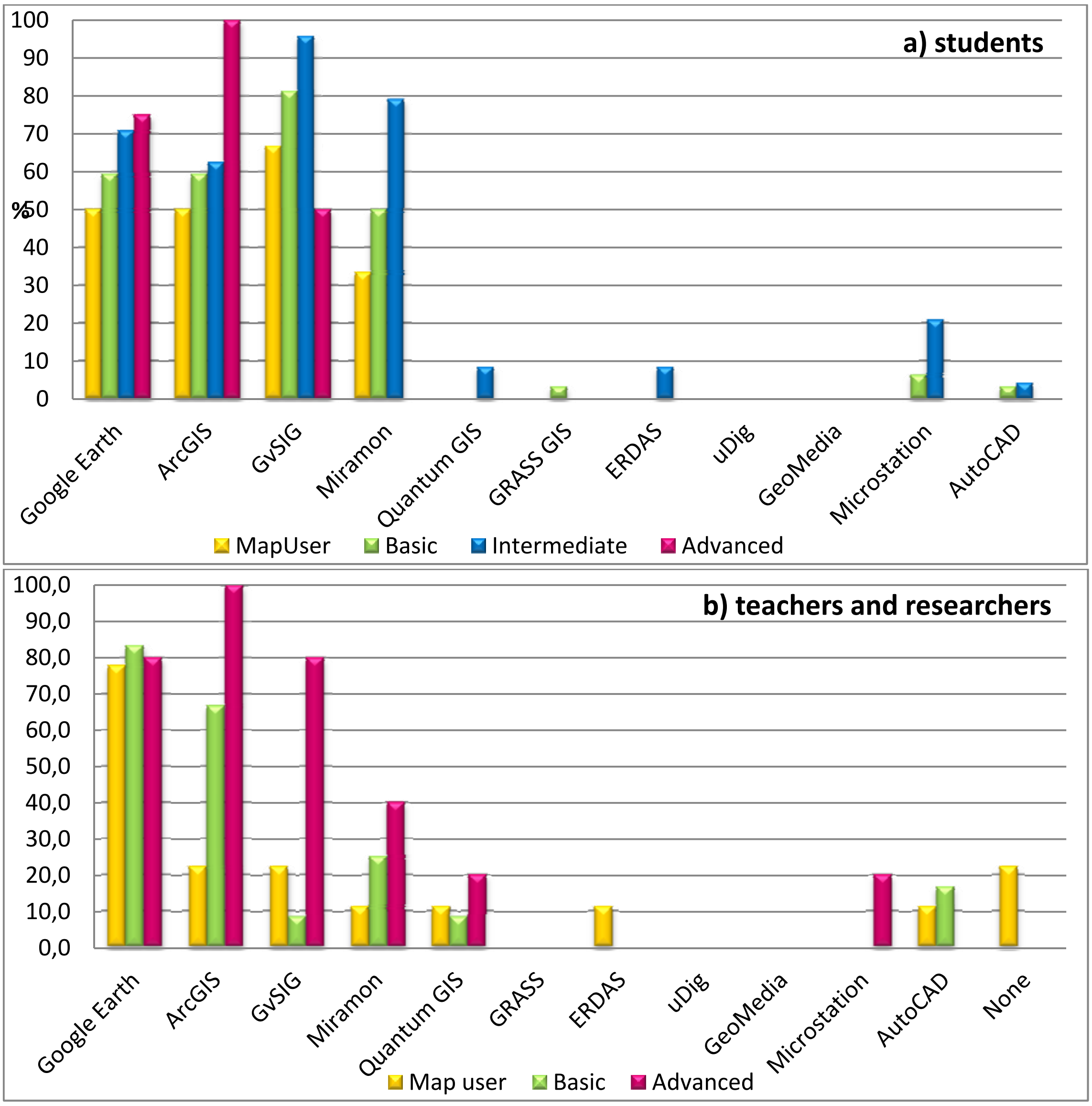


Figure 43: Used GIS/CAD softwares per user type (in %)

Referring to the use of GIS/CAD software, respondents were also asked about whether they prefer using downloaded GI or geoservices (Table 21). Responses favour downloaded GI more (with the 42-45% of the participants), and, in the second place the people who prefer combining both types.

	Students	Teachers and researchers
Downloaded GI	**45%**	**42%**
Geoservices	6%	4%
Combine both	42%	35%
No response	6%	19%

Table 21: Preference with the use of downloaded GI vs. geoservices

The use of geoservices is not really widespread in the user community (*Figure 44*). Around 50 to 60% of the participants never use services or they do not know what services are. The rest opts more for visualization services like WMS. Manipulation and download (WFS/WCS), and geoprocessing services (WPS), are minor options. The sum of percentages is not 100 because there are people who use various types of geoservices. The responses to this question are not very reliable, especially those by students. It is very doubtful that only 7 students (11%) make use of geoprocessing services. Very probably they got confused or did not pay enough attention to the question.

No more questions were posed in relation to GI analysis. Geoprocessing services are still very experimental. Yet they can be used through web applications, like, for instance, map viewers. Therefore, this question was added in Task 3.

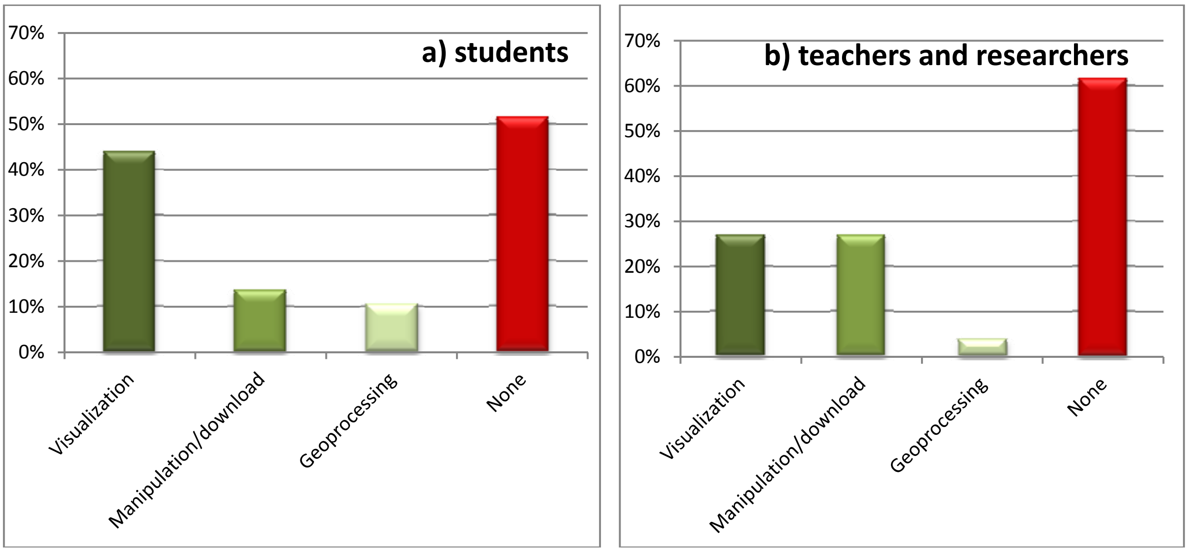


Figure 44: Use of geoservices per user group

7.2.2.7. *Task 4: Visualization*

Visualization in GIIs is mainly carried out by map viewers. These web applications have a wide range of possible tools that may be added to consult, visualize and print simple maps (Rodríguez, et al., 2009). This part of the survey aimed at finding out which of these tools were most important for users based on the current the IDECi-UIB map viewer application tools and contents (URL 84).

In this part of the questionnaire there was a methodological error which could not be corrected in time for the student group. They had to respond whether they would want to add, improve, maintain or eliminate a list of tools in the existing IDECi-UIB map viewer. The problem was that at some point users responded illogically, or they interpreted the question differently. Therefore, the responses were difficult to analyze. The corrections applied were:

Inexistent tools (red shading in Table 21):

- Add + improve = **Add**
- Maintain + eliminate = **Keep out**

Existing tools (green shading in Table 21):

- Add + improve = **improve**
- **Maintain**
- **Eliminate**

These calculations resulted in the percentages shown in Table 22. The results are difficult to interpret because it is hard to assess how important these items are for users. In any case it is possible to appreciate that existing tools have similar values on maintaining and improving, while missing tools get a higher value to be added.

%	3D map viewer	Research proj. layers	Thematic layers	Insert external WMS	Navigation and query tools	Analysis tools	Print
Add/Improve	**75,76**	56,06	**72,73**	**80,30**	54,55	**71,21**	53,03
Maintain	24,24	43,94	27,27	19,70	45,45	28,79	45,45
Eliminate	...	0,00	...	...	0,00	...	1,52

Table 22: Map viewer responses analysis (students)

The approach was adjusted when surveying the group teachers and researchers (Table 23). A Likert scale (1-10) was applied to identify the most important tools for users. After normalizing values (Gomez Orea, 2002), it came out that users weigh all tools very similarly with a value that moves from 10 to 14%. In any case, most valued tools are the inclusion of research projects layers, thematic and descriptive layers, basic tools for query and navigation and the option to print out the map on paper.

Map viewer tools	%
3D visualization	10
View research projects GI	13
View thematic layers	13
Insert external WMS layers	12
Basic navigation and query tools	13
Analysis tools (geoprocessing)	12
Drawing tools	12
Print	14

Table 23: Map viewer responses analysis (teachers and researchers)

7.2.3. Providers profile

Teachers and researchers may also act as scientific layers providers. This part tried to analyze to what extent they would supply the ScGII, and with which contents and accessibility restrictions.

7.2.3.1. Task 5: Publishing

Teachers and researchers practising digital cartography and GIS mostly come from earth (35%) and social (23%) sciences; the rest comes from multiple disciplines like history or agriculture engineering (Figure 45).

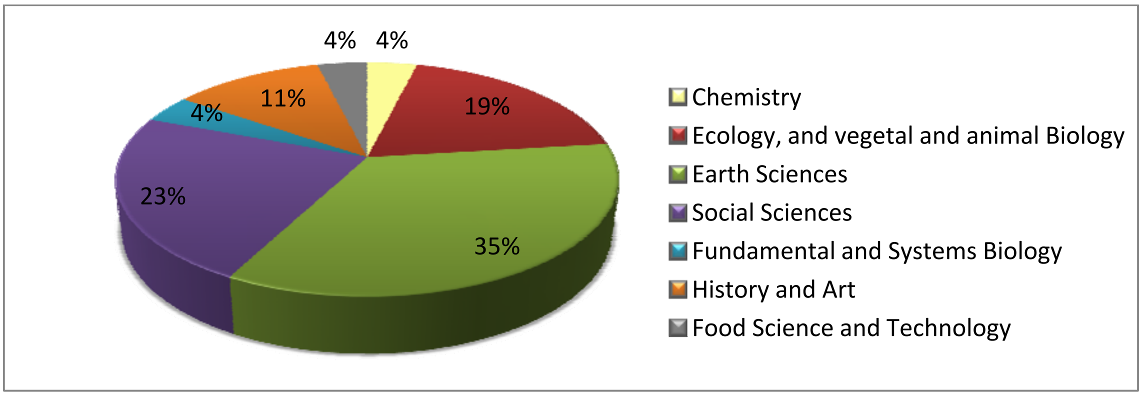


Figure 45: Research fields per themes

Of the total, 88% of the researchers would agree with publishing GI in the ScGII. Others did not want to participate or provide information (4%) and another 4% did not respond. While the demand for thematic classification was more or less homogeneous in all demanded GI types, the supply of research projects is rather heterogeneous; every researcher publishes information on very specific topics, like environmental impact, the tertiary sector, society and population and hydrology (Figure 46). From the taken sample (5% of the total population approximately), about 64 projects would be published in the ScGII. The spatial coverage of these researches mostly focuses on the Balearic Islands (83%), Spain (22%) and other continents out of Europe (26%).

Researchers also pointed out that they could publish non-geographical contents, especially text documents (74%) and statistics (52%).

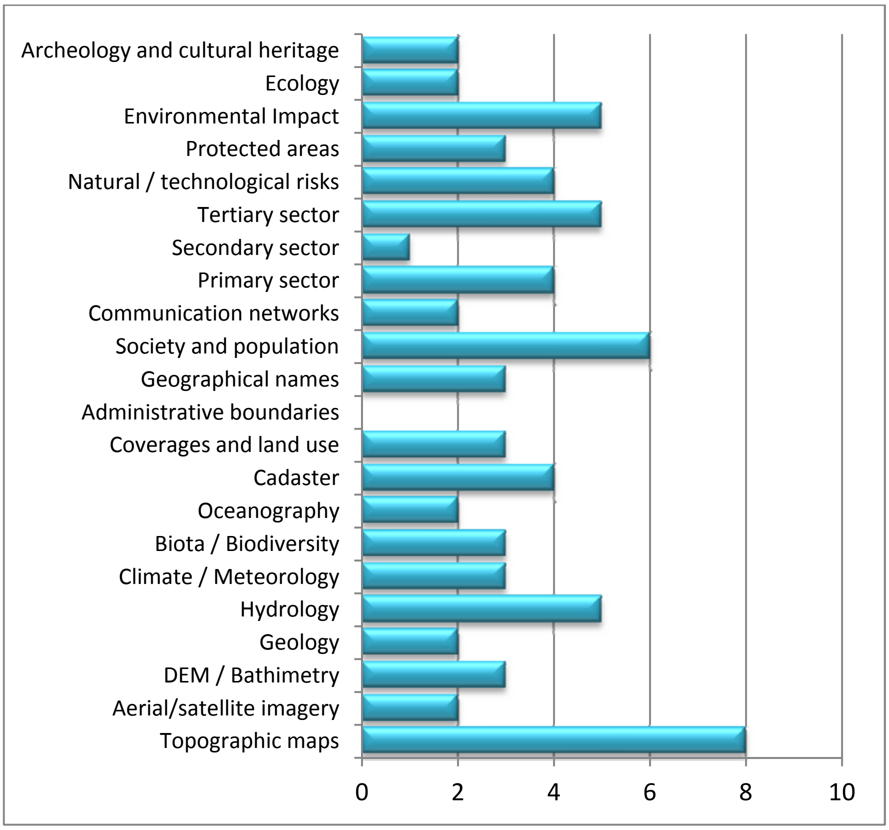


Figure 46: Thematic classification of Research projects that could be published
Project themes (y) per amount of projects (y) in absolute values

A key point in the publication of research projects are the accessibility policies. Therefore, providers were questioned on which accessibility policies they would apply to the published GI resources (Figure 47). In principle, most of them would let their researches open, especially through map viewers. Yet, in some cases there are also restrictions by researchers who would just want to give access to their own research group, taking special care with downloadable GI and associated materials. It is important to remark that none of the researchers would restrict the access to map viewers.

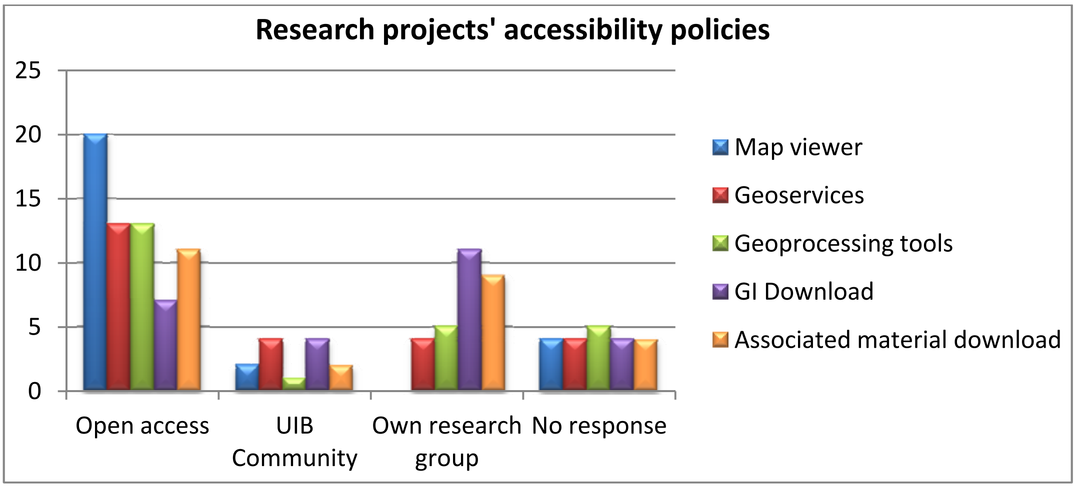


Figure 47 Preferred accessibility policies for research projects

Geo-collaboration between researchers is an activity that should be promoted by the own ScGII. The interviewed experts advise that collaboration should be implicit when the GII starts working (Rodríguez, A., 2012; Vallespir, J., 2012). Still, some communication channels could be established to improve the dissemination of scientific information (Table 24). 54% of the researchers preferred a website or blog instead of a wiki space or a mash-up.

	Ranking 1	Ranking 2	Ranking 3
Mash-up	35%	31%	35%
Web site / blog	**54%**	15%	31%
Wiki space	12%	**54%**	35%

Table 24: Best media to disseminate research results

In addition, they qualified the map viewers as the best means for GI dissemination (50%); better than the metadata catalogue (27%), the mash-up (19%) and the file directory (4%).

7.2.4. Developers

The SSIGT developers' team was also questioned as one of the main stakeholder groups. The responses were rather qualitative and just need mere interpretation. They are compared to the user views, in order to check whether they match.

Two of the three SSIGT members are also researchers in Geography. Therefore they also responded to the teachers and researchers questionnaire.

7.2.4.1. *User interface and structure*

In the ranking of secondary sections, the developers' team prioritize the informative section (1st), followed by the support section (2nd), the third place is not clear among participants. The feedback post-box was not a priority, while perhaps it would be important that using the UCD method, users' view would be more relevant (Figure 24).

According to the developers the IDECi-UIB should be inside the SSIGT website. Although there is no total agreement on it, 2/3 of the team agree on including a direct access to the map viewers and the GI catalogue. The same proportion of the team agrees that to make the system simpler and more usable, there should not be intermediate pages between the home page and the contents, like in the present prototype (Figure 22, page 64).

In the ranking of secondary sections, the developers team prioritizes the informative section (1st), followed by the support section (2nd). The third place is not clear among participants. The feedback post-box was not considered a priority, while perhaps it would be important that using the UCD method, users' view would be more relevant for developers (Table 25). In any case that tool was neither appreciated for potential users.

	R1	R2	R3
Support section	0	66%	33%
Informative section about the GII	100%	0	33%
News (Blog/website)	0	33%	0
Feedback postbox	0	0	0
Links	0	0	33%

Table 25: Secondary sections priority (developers)

7.2.4.2. *Visualization*

The developers' views on the current map viewer are quite positive, although they think that tools can still be improved (Table 26). The methodology of this question follows the same model as in the student survey (section 7.2.4.2). Therefore, the results are difficult to interpret. In any case, it appears that the 3D visualization does not seem to be so necessary, while the inclusion of other tools like: geoprocessing functions or the insertion of external WMS layers are basic. There is also agreement about the inclusion of thematic layers to set a context into the geographical space.

	3D visualization	Research Proj. layers	Thematic layers	Insert external WMS	Navigation and query tools	Analysis tools	Drawing tools	Print
Improve	33%	**100%**	**100%**	**100%**	**100%**	**100%**	**67%**	**67%**
Maintain	0%	0%	0%	0%	0%	0%	33%	33%
Eliminate	**67%**	0%	0%	0%	0%	0%	0%	0%

Table 26: Map viewer tools priorities over developers

7.2.4.3. *Management, publication and maintenance*

In relation to technology, the developers agree that the infrastructure should be preferably constructed with open source software, like Geoserver (URL 85) or Geonetwork (URL 16). On the other hand, the SSIGT has an Esri license and the developers think it would be wise to take profit of this software as a pay off.

With regards to information management, the developers think that providers should be able to publish contents by themselves. In their opinion, that would enhance the providers' trust and would simplify the dependency on the SSIGT.

On the other hand, none of the interviewed experts supports this view. In their opinion, the publishing process requires support from the developers' side, because "*usually providers do not have enough technical background to manage the limited resources from the GI repository*" (Guaita, F., 2012, 8:35)

Security is a very important issue to protect certain contents. The SSIGT members advised that it would be necessary to establish a password for all restricted contents. To improve usability, certain users advised that would be very practical to access the GII with the university ID code and the secret password. Nevertheless, developers are opposed to that due to organizational politics within the UIB.

Accessibility policies are the last issue that needs special attention. Users and providers already gave their opinion on what they want to access and provide. According to the arguments given in section 2.3.4 about policies and compliance, GIIs should comply with the providers' policies and underlying organizations. In the second term, users also desired to have access to thematic and research GI contents. This is not matching with the ideas of the developers, who aim to restrict open access and student access to research projects and associated contents, giving just full rights to teachers and researchers. However, there is not full agreement on what should be done (Table 27 and Table 28).

Access tp descriptive GI	Geo-services	Download	Both
Open Access	0%	0%	100%
Bachelor students	0%	0%	100%
Postgraduate students	0%	0%	100%
Teachers and researchers	0%	0%	100%
research projects	Geo-services	Download	Both
Open Access	66%	0%	33%
Bachelor students	66%	0%	33%
Postgraduate students	66%	0%	33%
Teachers and researchers	0%	0%	100%

Table 27: Accessibility policies from developers' view 1

Associated contents	consult on screen	Download
Open Access	66%	33%
Bachelor students	66%	33%
Postgraduate students	33%	66%
Teachers and researchers	0	100%

Table 28: Accessibility policies from developers' view 2

7.2.5. External partners

In this study potential external partners were contacted just to find out whether they would collaborate in the ScGII project, and which issues they found most important. Annex 5 shows the used questionnaires to contact to those organizations. Table 29 summarizes their responses. Shading colours correspond with organization types already classified in Figure 27 (section 6.2.2).

A total of 9 organizations responded to the collaboration request. Two organizations (in grey) did not send back a completed questionnaire. In general, the expectations with respect to collaboration and scientific GI and spatially-related knowledge are quite positive. On the one hand, many organizations pretend to disseminate contents that may be useful for the UIB, or might be beneficial for both sides. On the other hand, research organizations, external universities and NGO's are willing to establish collaboration relationships.

In future, these connections may become stronger, so that some of these providers or observers could become users, expanding the possibilities to share spatially-related scientific knowledge. Guaita, F., (2012) ensures that "*if the IDECi-UIB project is successful, other ScGIIs could establish bonds with this one*" (49:50), to create some kind of ScGII network.

	Organization type	Production sector (INE classification*)	Activities when working with GI	Which GIIs are you using?	Willing to collaborate with the IDECi-UIB? How?
Balearic I. Gov. *Ministry of mobility and planning*	*Government organism*	*-Public administration and defence*	*Activity carried out by SITIBSA*	--	--
SITIBSA	*Public administration*	*-Public administration and defence*	*-GI production* *-Support to decision-making* *-Topography and geodesy* *-Aerial imagery production* *-GI dissemination and distribution services IDEIB*	*-IDEIB* *-IDEMallorca* *-IDEMenorca* *-IDEE*	*-Disseminate own contents / technologies*
OBSAM	*Public administration*	*-Agriculture, cattle, fisheries and forestry* *-Information and communications* *-Public administration and defence*	*-GI production* *-Support to decision-making* *-Environmental consultancy* *-Remote Sensing*	*-IDEMenorca*	*-Disseminate own contents / technologies* *-Collaborate in research projects*
IEO - Balearic I.	*Public administration*	*-Agriculture, cattle, fisheries and forestry* *-Extractive industries*	*-GI production* *-Support to decision-making* *-Environmental consultancy* *-Remote Sensing*	*-IDEIB*	*-Collaborate in research projects*
Autonomous University of Barcelona (UAB) - *Geography Dept.*	*Public University*	*Education*	*-GI production* *-Support to decision-making* *-Support to education and research*	*-IDEE* *-IDEC (Catalonia)*	*-Collaborate in research projects*
Las Palmas University (ULPGC)	*Public University*	*Education*	*No response*	*No response*	*No response*
GOB	*NGO*	*-Information and communications*	*-GI production* *-Support to decision-making*	*-IDEIB* *-IDEMallorca*	*-Disseminate own contents*
OCEANA Europe *Sciences Department*	*NGO*	*-Agriculture, cattle, fisheries and forestry* *-Energy supply*	*-GI production* *-Support to decision-making* *-Environmental, territorial consultancy*	*- IDEIB* *- IDEE* *- IDEO* *...*	*-Disseminate own contents / technologies* *-Collaborate in research projects* *-Exchange information and knowledge*
GAAT	*Private company*	*Administrative activities and auxiliary services*	*Environmental consultancy*	*No response*	*No response*

Table 29: Summary of the external partners' collaboration profile

7.3. Conclusion

This chapter has served to end with the requirements analysis. It has synthesized the survey results to construct personas. A part from users, this chapter also went into developers' and external partners' view. After all, GIIs are constructed by and for people, and therefore they need to be developed out of mutual agreements and collaboration.

Chapter 7 concluded with the research question 3. In this way, requirements analysis results have made clear the contents, tools and structure of the IDECi-UIB according to user needs. However, results from the UCD methodology should not be extrapolated to other ScGIIs, since stakeholders are an interdependent component with its socio-economical context.

Furthermore, results revealed what the critical points to improve the IDECi-UIB system are (Research question 3). Nevertheless, results do not speak by themselves, and therefore chapter 8 translates these statistical values into a real outcome for the requirements analysis, considering experts' views and literature. These are the foundations to construct a conceptualized model of the IDECi-UIB prototype.

8. Conceptual prototyping

8.1. Introduction

Past chapters have gone through the requirements analysis to set the basic needs for the UIB's ScGII. Many aspects have been set out by different stakeholders who influence the system's working order. This part summarizes all these results to serve ScGII developers to continue with this work and properly implement all recommendations and requests made by potential users. Once again these needs are structured per GII components. These results are contrasted with the SWOT analysis completed by expert panel members in the interviews (in section 6.2.1.2). The final result is a prototype mock-up and a set of recommendations that cannot be explained graphically.

8.2. Requirements analysis outcomes

8.2.1. Stakeholders

The responses from this requirements analysis survey prove the convenience of a ScGII at the UIB. This assumption is more notorious in certain user groups than in others. Results demonstrate that most skilled and experienced users are more prone to use GII resources, particularly the most specific contents or the ones that require more technical skills, like geoservices.

Students represent the largest potential amount of users, with 1236 people, in which 261 are most skilled in spatial thinking and GIS. The survey has demonstrated that they require descriptive and thematic GI in temporal series for educational purposes. Moreover, they also would like to access research projects' GI and extra contents. In general, geography students know about GIS and GIIs, but students from other degrees do not know much about it, whereas it could be very useful for their studies and prospective professions. Therefore if the IDECi-UIB provides GI, other students, teachers and researchers from other studies could potentially apply GIS to support their activities.

On average, the GIS and GII skills of teachers and researchers are lower than those of the students. But still there are highly experienced users, and people with very basic skills, no skills or not much interest to participate in the initiative.

The interviewed experts advised that education and training are fundamental to ensure the success of the GII, since it is an information source for rather skilled people. It also seems that users who use IT daily, but do not work with GI, are more likely to use GIIs than people that who work with spatial information but are not skilled in informatics (Guaita, F., 2012, private communication) (Table 30).

"-It is very important to consider education and training. It's necessary to convince people over the GII ideas; I think it is really a new paradigm" (Rodríguez, A. 2012, 32:20)

	No IT	*+IT*
No Geo-Information	*OUT OF SCOPE*	*POTENTIAL USERS*
+Geo-Information	*HIGH DIFFICULTY*	***MOST POTENTIAL USERS***

Table 30: user skills related to potential GII use.
Source: Guaita, F., 2012, private communication

The unbalanced distribution of unskilled people over the total means that, initially, only very basic tools should be supplied, until the level of the users grows up. Perhaps, some advanced tools could be implemented to show new GII users the possibilities of this tool.

8.2.2. Geo-information, tools and extra contents

Results show that there is a common interest in geospatial information. Providing supply to all demanded issues is a matter for the ScGII managers. The main interest of the Balearic Islands region requires de direct involvement of local public administrations, and, if possible, private enterprises or NGOs with GI to share.

Moreover, users are very interested in non-geographical additional contents, which may complement the accessed information. A weak point for this ScGII are geoprocessing tools. The use of spatial analysis in GIS and in GIIs is rather low from the providers' (researchers) and the users' side. On the one hand, that means that it will be difficult to create analysis tools; and on the other hand, if they are created they will not be used very much.

Nevertheless, users were asked about searching for routes in Google Maps and most of them (approximately 80%) did work with this tool at some point. Actually, this is a geoprocessing tool. That means that if they do not use any geoprocessing tool, this is due to the great difficulty that these tools require in most GIIs. In this sense, it would be convenient to add geoprocessing tools into map viewers, or create web applications just for geoprocessing to facilitate the human to machine interactions (Feng, et al., 2011). Usability and utility play a determining role in the usage of these tools.

8.2.3. Technology

8.2.3.1. Architecture

According to all interviewed experts the ScGII has to be structured based on a Service Oriented Architecture (SOA). All GIIs work in this way and technological means are also designed to work in this way. In addition, users and developers are already familiar with this structure.

8.2.3.2. Searching method

Users have pointed out their desire to establish a geo-information catalogue as a main engine to search for GI. It is true that many people have chosen the file directory for data searching, but if this would be applied, this would just be a distributed GIS within the UIB with no opportunity to publish anything outwards.

The GI catalogue has to be able to search GI in other catalogues. That means that it is necessary to create a CSW (Catalogue Service Web) connection in this resource, so that simultaneous searches can be made. Yet, the interviewed experts do not advise to create a distributed catalogue; they better prefer to develop a centralized catalogue harvesting other metadata into the own catalogue:

"-In the case of the university, it is good to have a centralized node, or maybe some nodes depending on departments, this is up to the manager. It depends on the technology, on the infrastructure they have, it depends on political relationships" (Vallespir, J., 2012, 41:05)

These requirements can be implemented in the present catalogue working with Geonetwork software (Geonetwork, URL 16).

8.2.3.3. Web applications

The present map viewer application already covers many of the possible tools. Generally, users miss the inclusion of thematic layers and the lack of very basic tools like spatial query. Meanwhile, researchers say that they may provide geoprocessing tools. A part, the majority of them also sees the map viewer as the best tool to disseminate their project information.

A feasible solution to overcome the difficulty of accessing geoprocessing services with GIS programs consists on embedding these services into web applications. Then, with a user interface, users could easily access these tools with no need to know much about ITC or GIS.

In addition any provider wanted to set a password to access map viewers to present research projects. Therefore it is recommended to remove passwords to enter into these applications.

8.2.4. Standards

8.2.4.1. INSPIRE implementation

With the aim of being fully interoperable, the IDECi-UIB pretends to use OGC and INSPIRE standards (SSIGT,URL 59). However, the interviewed experts pointed at the difficulty to implement INSPIRE specifications, because they are very sensitive to changes, and if applied, every single detail needs to comply with its requirements. Moreover, these requirements will keep changing until 2019, when the INSPIRE program will be totally implemented. That could mean that the infrastructure needs rebuilding if it does not comply with requirements anymore (Rodríguez A., 2012; Guaita, F., 2012). Therefore, the interviewed experts consider the INSPIRE implementation more as a threat than as an advantage for the ScGII (Rodríguez A., 2012; Guaita, F., 2012).

8.2.4.2. Geodata and geoservices

ScGII contents for download, and geoservices should all be compatible with the most used GIS and CAD programs. Then interoperability would be totally assured to heavy clients. Table 31 summarizes the most used programs in the UIB user community against the geodata and geo-services they can operate with. The results row (in blue) indicates precisely which standards should be used according to user needs and technical restrictions. Geodata formats are mostly de facto standards, while geo-services are preferred to be “de jure”, because they are open and not commercial (Vallespir, J., 2012).

Geoprocessing services are not included as services by now because there is no demand from the user side, neither the capacity to work with them from the heavy client side. Then it is recommendable to publish them into web applications where users do know how to operate them.

The interviewed experts advise that other geoservices that are in development at present, like Sensor Observation Services (SOS) (OGC, URL 86) could be very useful for research as a means to acquire GI in real time (Rodríguez, A., 2012; Vallespir, J., 2012).

From a technical point of view on GI download, it is also recommended (Guaita, F., 2012) to serve static GI, (that does not change through time (i.e. Digital Elevation Models)) in downloadable files, and just keep WFS and WCS as means to serve dynamic GI (that changes constantly). This measure facilitates the access to GI for basic users, avoiding possible problems of service/software incompatibility (Guaita, F., 2012).

	Geodata types		**Geo-service types**		
	Vector	Raster	Visualization services	Manipulation / download serv.	Geoprocessing services
Google Earth	**KML**	**GIF, TIFF, PNG, JPEG**	**WMS, KML**	--	--
ArcGIS	**SHP, KML,** GDB, **DGN,** DWG, **GML**	**GIF, TIFF, GeoTIFF, PNG, JPEG**, ASCII, IMG, **BMP**	**WMS, KML,** ArcIMS, ArcGIS Server	**WFS, WCS**	WPS (from v.10.1 on)
GvSIG	**SHP, GML,**	**GIF, TIFF, PNG, JPEG**	**WMS**, ArcIMS	**WFS, WCS**	--
Miramon	**SHP**, KML, **DGN, GML,** GPX	**GIF, TIFF, GeoTIFF, PNG, JPEG, BMP**	**WMS**, WMTS	**WFS, WCS**	--
Microstation	**SHP, KML, DGN,** DWG,	**--**	**WMS**	**--**	--
RESULTS	**SHP, KML, GML, DGN**	**GIF, TIFF, PNG, JPEG**	**WMS**	**WFS, WCS**	None

Table 31: GIS software compatibility with geodata and geoservices types
Source: own edition June 2012, based on: ArcGIS, URL **4**; GvSIG, URL 87; Microstation, URL 88; Miramon, URL 78; Google Earth, URL 26; and OGC, URL **4**

8.2.4.3. Metadata

Standards on metadata should guarantee the availability of multiple languages to interpret GI contents. Since English is the language of science, it should be present in metadata records. In addition, one or two local languages, like Catalan or Spanish, should also be included.

8.2.5. Policies

Accessibility policies are a determinant topic for the IDECi-UIB. As mentioned in section 7.2.3, researchers are rather reticent to publish their results because they are afraid of plagiarism. On the other hand, many also say that they would publish all their results openly.

To convince as many researchers as possible to publish their GI into the infrastructure, a convenient strategy would be to permit a certain grade of access restriction. This action would familiarize them with the system so that they can learn about its advantages. That could work creating research channels between researchers as a means of geo-collaboration. Meanwhile, these contents are available in the catalogue and at least others can know about the present research lines (Guaita, F., 2012; Vallespir, J, 2012).

System security measures may represent a tool to support complying with Intellectual Property Rights. For instance, geoprocessing applications could work as a "black box" in which there is an input and an output, but there is no way to know about the followed procedure (Guaita, f., 2012).

In future, this ScGII should progressively try to open its contents, working as a means to communicate and apply scientific discoveries in society (Rodríguez, A., 2012; Vallespir, J., 2012).

In any case, if there is not a law requirement for researchers to publish their results, it is difficult to achieve that they open their publications to the UIB and the society in general (Guaita, F., 2012; Rodríguez, A., 2012; Vallespir, J., 2012). A strategy to cover this weakness would be to set by law, that once a public fund is given for research, its results must be published openly. This regulation might be in an institutional (UIB) or administration level.

At this point it is important to remark that developers should not restrict users' access if providers intend to serve their information openly. The infrastructure should be as open as possible, and managers should just act as mere intermediaries.

8.2.6. Organizational framework and finances

Users do not have competence over organizational frameworks. Yet, user preferences can be limited by these relationships. For instance, the interviewed experts strongly recommend involving Information Technologies colleagues to work on the technical side of the infrastructure, together with SSIGT developers. They could work to improve issues like: interface usability, utility, system security, GI repository administration, etc. (Guaita, F., 2012; Rodríguez, A., 2012).

In the second place, the IDECI-UIB should be involved as another node in the current Balearic Islands GII network, together with IDEIB, IDE Mallorca and IDE Menorca. The personnel from these nodes could also collaborate to develop the UIB's ScGII (Rodríguez, A., 2012).

Those strategies would favour the use of GIIs and strengthen the added value of "scientific information" in the IDECi-UIB. That indirectly would affect users positively, and would give more applications to spatially-related scientific knowledge.

8.3. Prototype mock-up

User interface design is a very important part of the requirements analysis for ScGII for two reasons: it gives a solution based on requirements analysis results, and it also proposes a system structure or methodology to continue with the system's development process (Wood, 1998). However, this point of the design process has a critical factor: the impasse between the user requirements and ideal design for these needs. That means that even knowing what users want, achieving it is not necessarily an easy task, and although there is criteria to generate an effective GII design, creativity is a highly involved factor.

Design prototyping (Revee and Petch, 1999) serves to generate a prototype out of user requirements. The problem is that this task may be time-consuming to finally be not adequate to users' use (Jenkins, 2009) in the next UCD phase of usability analysis. Therefore, a scratch (Buxton, 2009), or better, a mock-up (Jenkins, 2009) may serve to set out a practical "scenario" (Alexander, et al., 2009), or a graphical overview of the requirements application, with the advantage that changes can be applied easily without having to restructure the whole system.

For this research on the IDECi-UIB case, a mock-up was designed for its geoportal, serving all requirements posted above. It is structured in principal and secondary sections. Sections are ordered per importance hierarchy from left to right; boxes in grey mean other pages with extra contents.

The geoportal's home page (*Figure 48*) has a very simple interface with big buttons and pictures that easily show the most important contents (Jenkins, 2009). The upper banner with the site logo serves as a direct access to go back to the home page. Tabs in dark turquoise are the principal sections, and tabs in clearer turquoise the secondary sections. They are ordered in priority from left to right, and keep their position in the entire site to ensure its access at any time (Jenkins, 2009). Moreover, a search window lets users browse into the web structure. The map viewer is remarked more than the rest of the resources. Links to other GIIs, the UIB, the SSIGT and other interesting pages like Open Street Maps appear at the bottom part. These GIIs are also ordered in users' preference from left to right. They are presented in the centre where it can be seen easily. The design of this interface has been reviewed by *28 motivos*, a private company working on web development and design in Palma (URL 89). This mock-up already incorporates their advices.

Figure 48: Home page mock-up

The web map applications section has been emphasized for its extended use by potential users. *Figure 49* shows the window dedicated to web map applications. It is divided into two parts: map viewers and spatial analysis tools (geoprocessing applications). To enter the viewers, the user needs to click on the map; if (s)he clicks on "+info" there is a link going to the project's website. This is made this way because researchers choose the map viewer as the best means to disseminate their GI, and the website to advertise their publications. After clicking on "more" the user accesses other research project map viewers. Map viewers would not require a password, while spatial analysis tools would need it, depending on the provider's decision.

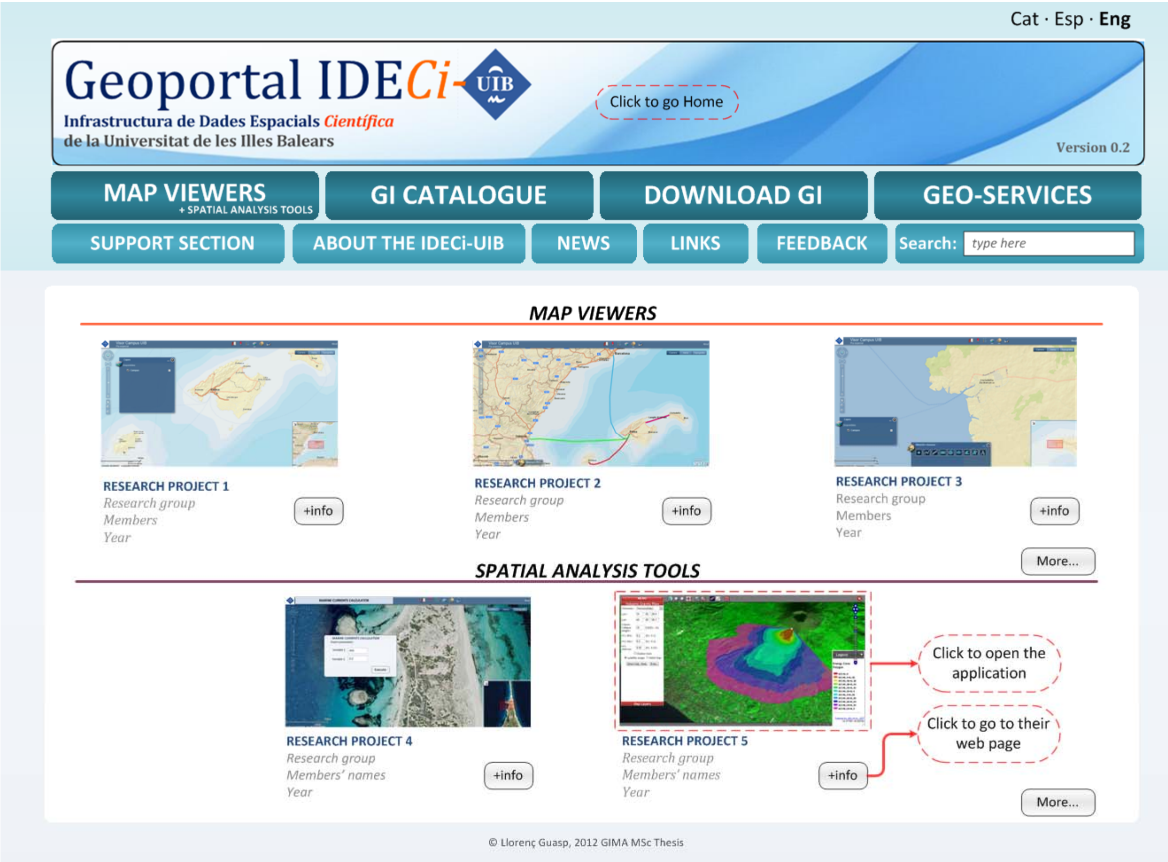


Figure 49: Map viewers and geoprocessing tools page mock-up
Source: Own design, June 2012 using GeoGrid (URL 55) and IDECi-UIB (URL 58)

The GI catalogue could stay very similar to how it is nowadays. *Figure 50* shows how it could look like. To give integrity to the geoportal; it could be inserted within the same interface. Another necessary detail would be the inclusion of GI accessibility policies (Rodríguez, A., 2012).

Figure 50: Geo-Information catalogue page mock-up.
Source: Own design, June 2012, using IDECi-UIB (URL 58)

Users consider it very necessary to have access to downloadable data for their further work with GIS or CAD programs. The structure set out in Figure 51 shows a clear interface that separates GI by types in descriptive and thematic GI and research projects GI. The first one is classified with the INSPIRE thematic categories division (INSPIRE, 2008), and the second one by ANEP research areas (URL 89).

Downloading should be very simple, just to click on the project's name. Then, a pop-up window should appear offering download in the most common formats (section 8.2.4). A user name and password would be required to access the transaction.

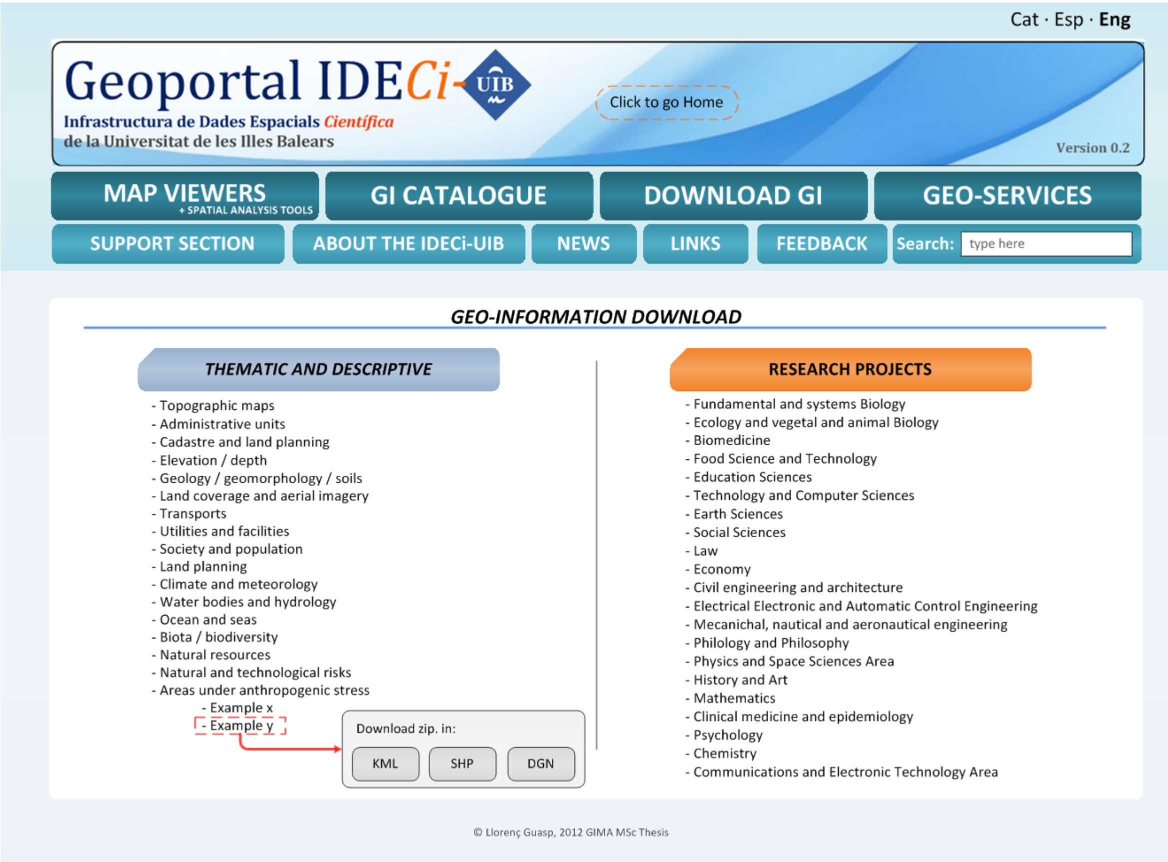


Figure 51: Download service page mock-up

Access to geo-services may also be improved by creating a directory just with URL addresses, as other GIIs do (*Figure 52*). Services could be searched by type, research area or thematic classification. Only the ones with free access and use would be provided on this site, the rest would have to be searched from the catalogue.

Figure 52: Geo-Services directory page mock-up

Help and support is the main secondary section according to users (*Figure 53*). It is organized in tabs, which facilitate the searching between the different ScGII tools, and avoids having to scroll up and down on the page. This section incorporates mainly text, videos demonstrating how to work with certain tools, and links to other supporting materials.

Figure 53: Support section page mock-up

The Informative section about the IDECI-UIB (About) (Figure 54) is set in the second place. It explains the theoretical background of the infrastructure by means of its objectives, developing team, and GII components. They are also organized in tabs.

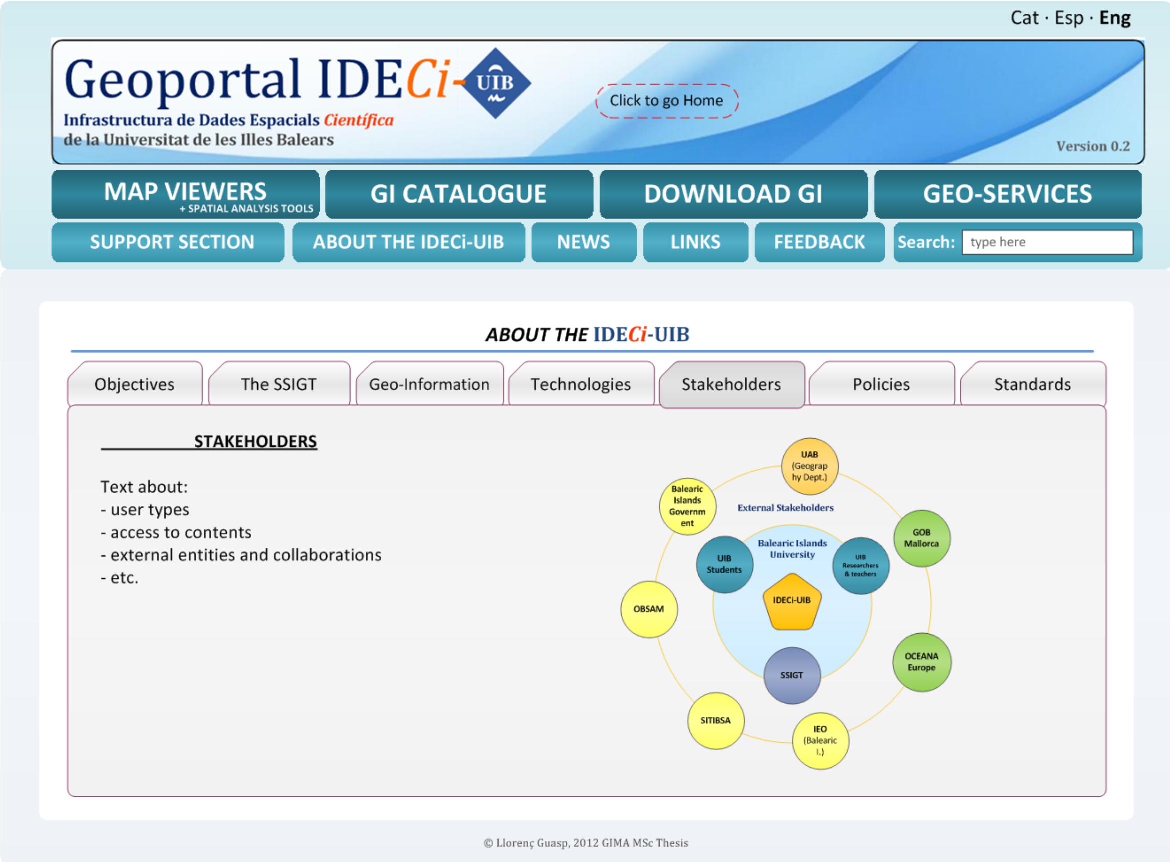


Figure 54: Informative section about the ScGII mock-up

The last two sections, news (*Figure 55*) and feedback (*Figure 56*) are very simple but still necessary. The news section is structured by date, with a title and subtitle. To get more information about it, the user just has to click on a title and then a new window is opened. The feedback section provides a space to comment on extra needs or missing points. Users just have to write in it and click on "send". The information should be received by managers, for instance in an email.

Figure 55: News section mock-up

Figure 56: Feedback box page mock-up

8.4. Conclusion

This chapter has concluded with the requirements analysis outcomes and proposed a conceptual prototype for the study case of the IDECi-UIB. These outcomes were the result from mixing users, developers, and interviewed experts with literature and reasoning. Yet, the threat about prototyping is that user needs are not necessarily achieved with the prototype, because subjectivity in decision-making is still quite involved. Thus, the usability analysis intends to analyze whether user needs are properly achieved. In any case, this is out of the scope of this research.

Research question 4 about how user needs should meet into a prototype, was successfully approached and responded throughout this chapter. In first place all stakeholders' requests were suited into ScGII components in contrast with theory (Chapter 2). All requirements with a graphical aspect were incorporated into the prototype mock-up. In comparison with the anterior IDECi-UIB geoportal prototype, the new conceptual prototype results more clear and adapted to user demands. Moreover, experts ensure that with available resources these theoretical outputs could become a reality (Vallespir, J., 2012).

9. Conclusion, discussion and recommendations

9.1. Conclusion

At the beginning of this research a main aim and four research questions were stated. They served to plan the structure and contents throughout the study. Next, these research questions are exposed and responded to according to the ideas, methodologies and results gathered through the study.

1- *What features define a Scientific Geographical Information Infrastructure?*

ScGIIs are aimed to support the scientific community for all the activities that are directly related with its work, which are mainly research and education. In this way, the infrastructure has to have two main objectives:

- In the first place, it has to serve as a source of geo-information for students, teachers and researchers to support their daily activity with GIS.
- In the second place, it has to work as a spot to distribute spatially-related scientific knowledge to the own scientific community and the rest of society.

In this way, the ScGII becomes a tool to concentrate scientific GI, analytical geo-processes, and other complementary information. When distributed with GIS technologies, these contents can have application in many study fields, and be a possibility for multi-disciplinary studies. By doing this, it may be expected that ScGIIs enhance collaboration between research groups and communities. This is intended to stimulate the use of GISciences in the research and educational sector. Moreover, when opened outwards, sharing this information can give an opportunity to other activities that also work with geospatial information, like decision-making or private business collaboration.

To serve these aims, the ScGII has to adapt itself in shape and features, mostly through the set-up of its components. In it, the main differences with administrative GIIs reside in the provided contents, and the public who is intending to use them. Contents include spatially-related scientific knowledge coming from research projects. Users are the other difference: the ScGII focuses on research and education activities, and, therefore, its demand is reduced to a more specific community with tasks that vary from the simplest query on a map viewer, to very complex operations in spatial modelling. The rest of the components enabling this information transaction also need to be adapted according to user and provider demands, but always restricted by technical limitations.

Although the concept of ScGII is not really clear or recognized by the scientific community, there are many examples of Information Infrastructures that work to distribute geospatial information. Among them, GIIs are the most common tools, although other systems like GI repositories or geospatial grids, also serve the needs of the scientific sector. Among the most acknowledged ScGIIs there are the IDE-ULPGC (Las Palmas University, Spain), the SIB-ESS-C

(Jena University, Germany) or WorldMap (Harvard University, US). They were deeply analyzed per type in Chapter 3.

So far, there is no clear evidence about any ScGII developed on the basis of a UCD methodology. Only administrative GIIs, like the GDI-NRW (Brox, et al., 2002) and the Danish Cadastre GII (Hansen, et al., 2011), applied UCD, but only with the help of user representatives, and not real users. The DRIHM geospatial grid (Schiffers, et al, 2011) did also apply the UCD method with the help of real users and developers, and asked for experts' advice (Schiffers, et al., 2011). Yet, DRIHM is a geospatial grid (super-computation information infrastructure) and, therefore, its components and its usage change substantially when compared to GIIs. As a consequence, the use of this methodological approach for ScGIIs may be considered as innovative.

2- What is a ScGII intended to contain based on stakeholders' needs?

When applying the UCD methodology to ScGII design and development, every case study becomes unique. Every community of users has a different context, and, consequently, a distinct set of requirements. Yet, there is a common methodology, and a common set of conclusions that could be applied to any generic ScGII.

When following the UCD methodology is basic to have a clear idea on who are the users and stakeholders. These may be very different from case to case. To do so, it is recommendable to follow the advice from experienced people in the academic sector, GIS, ICT, GIIs, and acknowledged about the socio-economical context where the ScGII is built.

Potential stakeholders for a ScGII would normally be the members of the educational and research community, which may act in different ways depending on their interests. At this point, it is also fundamental to consider the project aim; depending on that factor users could be restricted to a closed community, or be any interested person in scientific matters.

In case users were restricted to the scientific and/or educational community, partners from other sectors could also be involved into the ScGII. In any case, they would not be directly involved into the UCD methodology because they do not have a user role; they may behave as providers, observers or developers.

The IDECi-UIB study case took the advice from an expert panel, which helped in sharpening the requirements analysis contents and the target groups aiming to take the requirements survey. The IDECi-UIB project managers predefined two user groups:

- **UIB students**: It is assumed that the students that have more skills in GIS, and use "spatial thinking" as a way to approach studies, are potential users for the prospective ScGII. Those students are mainly geography students, although there are some from other degrees like biology or agricultural engineering. This research has demonstrated that their knowledge and skills in GIS and GIIs are between basic and medium, based on the GIS courses they have taken. In the ScGII they have the user role, because they are only allowed to gather information from it.

- **Teachers and researchers** represent the group of users that enable the scientific component of this ScGII. Basically they work as users, but also as providers of research projects that contain GI, geoprocessing models and additional non-spatial information. It was difficult to assess which teachers and researchers were working with GIS and GIIs. Their skills level was extremely diverse; from the ones that never used GIIs or map viewers to highly experienced GIS operators.

Developers were also questioned to know about their preferences and the organizational limitations and conditions. They do not enter into the UCD method but need to be considered to generate a reliable proposal on how the IDECi-UIB could work. This is also applicable to any generic ScGII study case.

With respect to external partners, ScGIIs should not worry about administrative boundaries, like national or regional GIIs do. Science does not have territorial barriers; all depends on the organization's management capacity, and the will to establish relationships with other bodies like research organizations, Universities, private enterprises, etc. with no matter on their location.

The IDECi-UIB considered mostly organizations from the Balearic Islands Region, however also organizations from other regions, like the Autonomous University of Barcelona, in Catalonia, Las Palmas University, in the Canary Islands, or OCEANA Europe.

The IDECi-UIB requirements analysis was executed on the basis of the tasks that users could fulfil with a GIS: search or GI gathering, data management, manipulation, analysis and visualization. These tasks were related to the roles that stakeholders could play in a ScGII: as users (students), providers (teachers and researchers) or system managers (the SSIGT team).

In a way, the UCD method worked as a tool to settle the users' demand of geospatial products in relation with the providers' supply. As a consequence, this methodology might be seen as a medium to interact with providers and agree on a mutual benefit.

Nevertheless, the results of the application of the UCD method do not necessarily end up in a more innovative system. The case study demonstrated that everything depends on user experience and skills: a good background represents a good result. Indeed it is better to have an appropriate system for all case study users. Later on, the system can be improved with new versions to become more innovative.

In addition, with this method the system's efficiency and effectiveness are strongly reinforced, because developers can make sure that all provided contents and resources (map viewers, services, etc) will be used, and their development will not have been a waste of budget, time or efforts.

Normally, scientific contents are not provided by any national or regional GII. In the Balearic Islands community, regional GII nodes only provide thematic and descriptive information that normally are very general. In addition, they do not give the possibility to download GI for further use with GIS programs. They focus on offering visualization services (WMS) and map viewers. Yet, the Spanish GII does serve more information by more means, being more interoperable. However, the types of contents are not yet adequate to researchers' needs.

It is difficult to determine whether other ScGIIs are successful within their communities. Since the contexts in relationships between stakeholders are unknown, the only way to know about their success is by finding out whether they are still active. Unsuccessful GIIs cease their activity soon. Nevertheless, this might not be because users are unsatisfied. This is the case with the IDE-ULGPC or the IDEUnivers: both ScGIIs were started, but, due to organizational or political decisions, their activity had a considerable decrease.

Finally, it is important to remark that the UCD methodology works as a helpful procedure to merge technical and the human parts of GIIs. Both of them need to be perfectly understood in order to match the social needs or preferences with the technical limitations and opportunities.

3- What are the critical points to improve the IDECi-UIB?

The Requirements Analysis results served to point out the strong and weak points of the ScGII. Nevertheless, interviews with experts gave a great background and ensured that all approached issues in the survey were making sense.

User requirements' results analysis demanded a rather simple system, enabling access to visualize and download a wide amount of GI (thematic and scientific) mostly covering the Balearic Islands region apart from other GI from other regions in the world. The most demanded tools were map viewers, downloadable GI in files, and WMS services. Meanwhile, more advanced tools like geoprocessing tools were left behind. Users demonstrated that they are only capable of using analysis tools with web applications. Therefore, it was recommended to include this type of tool through an application.

The study demonstrated that technical components did not require a major adaptation into the ScGII: standards and technology are structured almost equally as in other administrative GIIs. In this sense, only matters concerning security differed. Human components like stakeholders, organizational framework or policies were the most affected factors by the "scientific" characterization. Special emphasis should be given to accessibility policies. They represent a key point in ScGIIs. Complying with them is necessary to ensure providers' trust. Scientists are usually reticent to share geo-information and need a guarantee that their information is safe, with an strict control on who is accessing it, and for what purpose. On the other hand, accessibility policies may have quite a negative impact on the ScGII because this restriction might not let open access to any scientific content, diminishing the possibility to distribute these contents and to use this information for other researches, activities or purposes.

The user interface is another topic that needed special attention. After the advice from experts on defining a generic GII interface, the results of the Requirements Analysis also revealed that the most user-friendly, or at least the most familiar interface, was indeed the generic geoportal interface used by most GIIs.

4- How do we meet Stakeholders' requirements into a prototype model?

The results in the form of personas served very well as models to design the prototype model. Since the prototype design just consisted of a user interface mock-up, other requirements could not be shown materially and had to be expressed in words.

The most important issues in the prototype design were the enhancement of usability and utility based on user requirements. To do so, user needs were taken, and approached as simply as possible from the users' point of view. What mattered was to construct a simple and rational structure where primary contents could easily be found, and secondary sections would be kept aside, but are still easily accessible. This model was designed such that users could find a rapid and intuitive way to carry out their tasks. An instance of this is that it is preferred to let users download the files instead of accessing them with WFS or similar; the process is simpler and the result is the same. The prototype design also helped to make the interface more friendly and with a better feeling.

When the essential IDECi-UIB prototype is compared with the new version based onto the requirements analysis outcomes, system capabilities do not change much; what changes is the way in which contents are accessed. Most important remarks are: the important suppression of text or the elimination of many access barriers, like log in passwords. Restricted contents should only be accessible from the catalogue. In this way only allowed people would access them; the rest would just be able to consult the metadata. There is also an increase of section types and direct accesses to most relevant contents.

Behind the user interface scene, the prototype should be structured into a common SOA system, following the pattern client-provider. A centralized catalogue would be the best solution, but still the capacity to access other catalogues through CSW would be much appreciated. The importance of policies is maintained in the new prototype. Therefore, these accessibility conditions should be easily accessible to know about the use conditions.

This research did not do a real implementation of the prototype. However, the analysis results were positive regarding the SSIGT technical resources. With the present soft- and hardware resources the SSIGT would not have problems to implement user needs. Maybe the greatest problem would reside into the developers' ability to apply these requirements. To do so, it would be of great interest to establish contact with ICT faculty members, who could lend a hand to improve the system capabilities.

9.2. Discussion

After going through the results and conclusions of this research, it is important to now discuss certain issues that did condition the application of the UCD methodology. Results and derived conclusions are influenced by these issues. The main issues can be summarized as follows:

- *The IDECi-UIB is an institutional project from the SSIGT and therefore this research had to adapt to stated rules and limitations*

  From the beginning of this research was clearly stated that the IDECi-UIB is an institutional project from the SSIGT (UIB). That influenced the research performance and consequently its contents and outcomes. Decisions taken by the SSIGT managers limited the amount of contacted stakeholders, and required the development of an essential prototype. These organizational limitations affected time management, and created a strong dependence over the institutional project development.

- *The methodology slightly changed during the research due to the development of a prototype by the SSIGT development team before carrying out the requirements analysis.*

  When this research was set out and started [September 2011], the UIB's ScGII project was just an idea. Although there were some services and map viewers, there was no catalogue or geoportal. Then, in principle, the requirements analysis was going to be executed *before* the generation of a prototype. Nevertheless, in February 2012 the SSIGT developers decided to construct the prototype before my requirements analysis execution. This fact delayed the execution of the requirements analysis. Eventually, the effect of this change somehow helped the research, because when executing the requirements analysis, potential users had a real example to refer to.

- *The requirements analysis was only carried out among UIB community members.*

  The IDECi-UIB initially just aims to support the own university community and its activities. This restriction had a great influence when setting the requirements analysis conditions. If only university members have to use this ScGII, only they should participate in the requirements survey.

  However, other external stakeholders' views should be taken into account too. Actually, GIIs act in a wider context than just the users' community. They are influenced by a set of organizational relationships that condition their activity. In this way, the present study did consider these potential external partners, but just through a simple questionnaire asking for their interest in collaborating with the ScGII. Then, in future, relationships with these public and private organizations might be strengthened to enlarge the ScGII applications, and, in consequence, the intervening actors.

- *Why were only research and higher education considered as activities for the ScGII when other possibilities could be also investigated?*

  Apart from research and higher education, ScGIIs could be applied to other activities too. This research did not consider the possibility to include decision-making or collaboration with private enterprises in the study case. The main reason for that was the limited time and scope of this study, which had to focus on predefined objectives. Besides, it was difficult to contact administrative bodies commissioned with decision-making within the present conditions of economical crisis and regional government restructuring.

- *Benefits and limitations to use the survey as a main technique to carry out the requirements analysis.*

  A requirements survey among potential ScGII user needs that participants understand what is offered and possible within a rather technical and specific range of opportunities. Even when explained carefully with an easy vocabulary, it seemed that in some cases there were conceptual confusions, because some responses are implausible, or not complete. Participants' skills in GIS, GIIs and ICT highly conditioned the ability to respond to the questionnaire with ease. For participants with low or null skills in GIS, the questionnaire could be found difficult or not of interest.

  In addition, the survey required quite some time to be responded to: 15 minutes for students (users) and 20 minutes for teachers and researchers (users + providers). That might be a reason for why certain responses are not complete. When analyzing the results these empty values were rejected and only valid responses were considered.

  Obviously, the Requirements survey could have covered more aspects of the prospective infrastructure. However, that would mean a longer time need for responding and that was not recommended due to the limited patience and disposition of participants.

- *Requirements survey sample size and results*

  Gathering a representative sample was a determining issue when carrying out the Requirements survey. The sample represented approximately 5% of the total potential population fixed by different criteria in section 5.5.2. This amount was substantial enough to create personas, and trends in GIS and GIIs use among them. However, some user groups could be larger, improving the liability of each profile.

  If the requirements survey would have gathered more samples, the results may have been different. But that was not possible due to limitations in time and other organizational aspects within the UIB.

9.3. Case study appropriateness

As explained in chapter 5.4, the UIB is a rather small organism with limited resources and personnel. As a consequence, there are not many offered studies or research lines. The low application of GIS in education and research, and the ignorance of its possibilities by students, teachers and researchers, limits its views towards a ScGII in the university community.

These limited skills have a very high influence on the outcomes of the Requirements Analysis, since results are based on potential user responses. Considering all the system capabilities, and other social opportunities that a ScGII may permit, these limited working skills ended up in a limited infrastructure, not much different from administrative GIIs.

Therefore, it is debatable whether the UIB case study was the most appropriate scenario to carry out this research. Very possibly, it would have been more appropriate to perform it in an environment where GISciences are a widely spread tool. Then, the ScGII could have been designed with all its possibilities and advantages.

9.4. Recommendations

This study went through the complex world of GIIs, and got deeply involved in many topics. Nevertheless, it could continue with new research lines, or just continue following the UCD methodology and complete all its phases. I conclude with the most important recommendations for further research:

1) The UCD methodology should be completed until its last phase. To do so, the prototype should be really built and put into practice with users. Only after the usability analysis it can be guaranteed that the system works fine enough to satisfy user needs.

2) The UCD cycle needs to keep evolving constantly, so that the infrastructure's evolution keeps fulfilling user requirements. Moreover, all requirements that could not be implemented instantaneously should be dealt with and applied as soon as possible.

3) The communication with external partners was rather limited and hypothetical. When constructing the ScGII, developers should worry about establishing real binds with them, if possible by legal means. At that point it should be clear what are the roles and compromises in these relationships.

4) The UCD methodology and the Requirements Analysis are good tools to generate a better system, although they have a limited effect. Stakeholders and the relationships in between change in time. As a consequence, needs may change too. Therefore, it is recommended to continuously question users whether the system fulfils their needs.

5) The Requirements Analysis helps to generate a better system, although it is limited because stakeholders are dynamic: they also change and consequently does their role towards the ScGII.

6) Another limitation of the Requirements Analysis is that users just give their view on needs corresponding with their skills and experience. However they do not necessarily know the importance of certain components and structures, which are critical to make the system work (Alexander, et al., 2009). Consequently, when requirements are listed, the advice from the Expert Panel could represent a good way to validate what components are more necessary than others, or which ones should be implemented in the first place. This should result in a list of requirements ordered by importance or prevalence (Alexander, et al., 2009). That list would represent a very reliable source for ScGII developers.

10.References

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ANNEXES

ANNEX 1: Building a Scientific SDI node for the Balearic Islands University

This thesis was set out based on a short paper presented in the 12th AGILE conference held in Utrecht University in April 2011. The paper is attached in the next page as a document that proved the validity of the ScGIIs arguments.

Building the IDECi-UIB: the Scientific Spatial Data Infrastructure Node for the Balearic Islands University

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ABSTRACT

Technical and methodological enhancements in Information Technologies (IT) and Geographical Information Systems (GIS) has permitted the growth in Spatial Data Infrastructures (SDI) performance. In this way, their uses and applications have grown very rapidly. In the scientific and educational working fields, different institutions and organisations have bet for its use enforcing information exchange that allows researchers to improve their studies as well as give a better dissemination within the scientific community. Therefore, the GIS and Remote Sensing Service (SSIGT) at the Balearic Islands University (UIB) has decided to build and launch its own SDI to serve scientific Geo-Information (GI) throughout the Balearic Islands society focussing on the university community. By these means it intends to boost the development of research and education focusing on the field of spatial information. This article tries to explain the background ideas that form the basic concept of the scientific SDI related to the concepts of e-Science and e-Research. Finally, it explains how these ideas are taken into practice into the new University Scientific SDI.

INTRODUCTION

The technological advance of these last decades has had a very positive influence in GIS. This advancement has been reflected with the appearance of different geo-spatial cyber-infrastructures that serve geo-information increasing accessibility and availability to restricted user communities or to everyone from anywhere with internet access (Yang, et. Al, 2010).

These platforms, known as Spatial Data Infrastructures (SDI) work as portals to access to geo-databases for visualization or download (through geoservices) and web applications like viewers. They can also serve to disseminate geoprocessing tools or even data in real time through LBS[1] (Peng, et al. 2003). It is demonstrated that the rise of the SDIs has favoured the expansion of GIS applications and by those means, it is considered as a strategic advantage to many businesses, administrations or other public institutions (Williamson, et al. 2003).

Science is also continuously evolving. Research produces every day more information and therefore the difficulties to manage these amounts of information increase dramatically. In line with this, publications and discoveries once produced are stored, but if they are not accessed by anyone they rest stored when they could be used for further investigation (Watson, et al., 2010).

The IDECi-UIB wants to give response to all those questions. Thus, the aim of this article will show what the ideals of this SDI are and how it is build in order to respond to all these needs.

SCIENTIFIC GRIDS AND SDI: KEY TOOLS FOR E-RESEARCH

In the last ten years different organisations worldwide have had the need to find a system to store and catalogue produced scientific information. This has been done in order to save and retrieve it's information for research, enhancing the capacity to find new discoveries (e-SciDR, 2008), following

[1] LBS refer to Location-Based Services defined as "*wireless, mobile, and mostly handheld devices that use wireless communications to deliver information that conveys a geographical reference through location-determination technologies such as GPS or Wi-Fi to calculate a specific latitude and longitude of the device*" (Shekhar, et al. (dir.), 2007, p. 623)

the ideals to create an e-Science network with *Scientific Grids*[2]. After some initiatives in the UK, the European Union created in 2006 the e-SciDR (e-Science Digital Repositories) Program to promote the creation of a scientific grid in Europe. *"It is formed by different nodes working as inter-connected scientific information suppliers"* (Shekhar, and Xiong, 2008, p.419).

These networks work on any kind of scientific discipline. In GISciences *Scientific Geospatial Grids* connect different nodes that offer distributed GI through the net to share and exchange it among the scientific community (Shekhar and Xiong, 2008). There are several examples in the international context like the GEON Grid, focused on Earth Science Investigation, made between different universities in the US (GEON, 2011) or the Earth System Grid working in a global context with atmospheric research (ESG, 2011). Focussing in the Spanish territory scientific grids are neither so common nor developed; however some projects have been done in this direction: The CESGA[3] has developed a Scientific Grid with extensions on GIS issues (CESGA, 2011). Others like the CSIC[4] is also collaborating on a joined effort with the University of Valencia to create a Grid in Oceanography that involves GIS a part of working on an own Scientific Grid for the CSIC (Gómez, 2010).

Definitely, Scientific Geospatial Grids are not really a new concept, but nevertheless they are rare and not necessarily related to educational purposes. As cited before (e-SciDR, 2008) some organisations work with GI, and others apply the grid concept to Geosciences and GIS (Giuliani, et al. 2011) but a network with the application of GI in every research project belonging to any scientific discipline is something not so common.

So far, grids are made of interconnected nodes that work as GI providers (Shekhar and Xiong, 2008) and permit information sharing in between. Therefore it is easy to understand that nodes work in a lower hierarchical level, also providing information to the corresponding users. In the field of GISciences a *Scientific Geospatial Grid* might be created interconnecting nodes that share a common aim: the support to e-research based on GI. From here Scientific SDI nodes are derived (*Figure 1*).

Like the generic ones, Scientific SDIs work to disseminate GI focussing on the placement of scientific research projects in space, giving an added value to information exploiting the relationship between the studied features and the territory, making evidence of the surrounding geographic context.

The relation between Scientific SDI nodes and Scientific Geospatial Grids might grow if they achieve enough stability and confidence. Actually, it is expected that geospatial grids are going to be increasingly important in the comming years (Shekhar, and Xiong, 2008) due to *the accumulation of digitized data, information and Knowledge (DIK), of which 80% are geospatially related* (Shekhar, and Xiong, 2008, p.423). Therefore the Scientific SDI grows as an strong concept to develop.

[2] **Scientific Grid** refers to a specific kind of network that interconnects different nodes with the aim of producing science to exchange and share information enhancing the support systems for research and the production of e-Science. Moreover, *it takes a leading role since it addresses issues related to access provisioning, coordinated resource sharing, usage and security policies, etc* (Bosin, et al. 2011).

[3] **CESGA**: stands for "*Centro de Supercomputación de Galícia"* (Galician Supercomputation Centre) (CESGA, 2011)

[4] **CSIC**: stands for "*Consejo Superior de Investigaciones Científicas"* (Spanish National Research Council) (CSIC, 2010)

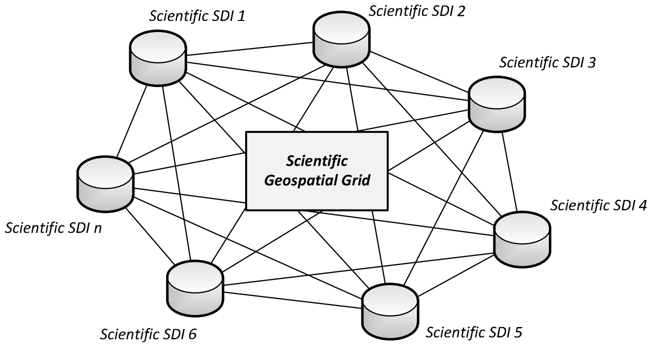

Figure 1*:* Conceptual idea for the Scientific SDIs and the Scientific Geospatial Grid.
Own production in January 2011.

THE CASE OF THE IDECI-UIB: A GATEWAY FOR SCIENCE

Keeping all these ideas in mind, the GIS and Remote Sensing Service (SSIGT) from the Balearic Islands University (UIB) has started developing its own Scientific SDI node: the IDECi-UIB[5]. In it, GI will be accessible for UIB users but also for the whole Balearic Islands community and therefore for everyone, becoming a semi-open platform. In this platform geo-information, understanding it as thematic geo-data, geoprocessing models and project results will be available for visualization and download. Nevertheless, it is considered semi-opened because only some of the contents are fully available to any user on the internet, and the rest are restricted to research members. This is going to promote a progressive growth in the use of GIS in education, research and a better geographic knowledge for Balearic citizens about their territory.

The website overview

Figure 2 shows the IDECi-UIB website. In it, users can find a Geo-information Catalogue to access geodata and services through metadata; a window to access a collection of visors on thematic datasets with the possibility to download data selecting by location; In third place, the section for e-Research gives access to Research projects (restricted access) that incorporate geotools, data and results and a section for Volunteered Geographical Information (Haklay, 2010) known as *Geoforum*, consisting in a site where users can upload self-collected geo-data. A part from that, secondary sections like information about the IDECi-UIB, the SSIGT Service, SDI documentation, news or links are provided.

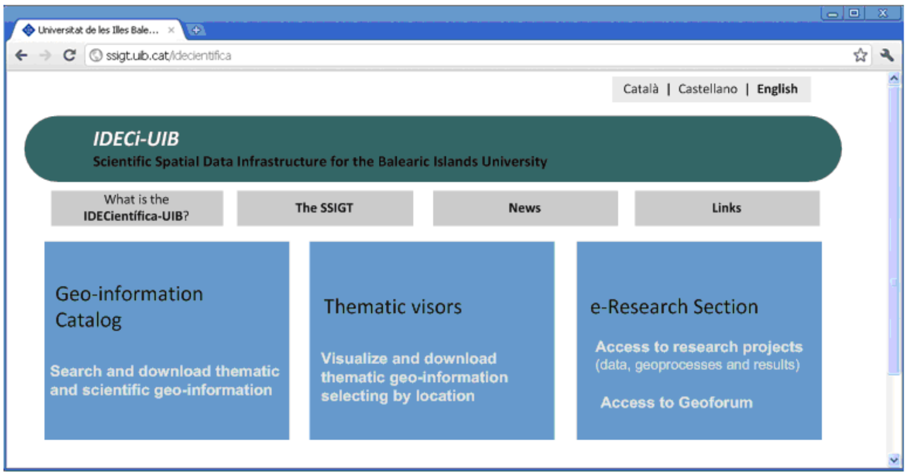

Figure 2*:* Previsualization on the *IDECi-UIB*'s website.
Own production, January 2011.

[5] IDECi-UIB stands for *"Infrastructura de Dades Espacials Científica de la Universitat de les Illes Balears"* (in catalan). The English translation would be: *Scientific Spatial Data Infrastructure for the Balearic Islands University*

Infrastructure needs: storage, access, retrieval and information sharing

In order to make the site accessible to the widest public, the SDI is being designed to be opened. Ideally an interoperable service should use standard communication methods to exchange heterogeneous data without caring about file or database formats or operating systems (Giuliani, et al., 2011). The IDECi-UIB indeed uses OGC standards to catalogue data and geoservices with proper metadata[6], and fulfils the minimum requirements made by the Spanish Legislation in GI (CNIG, 2006). Finally it is also adapted to the INSPIRE Programme to be compatible with all other European SDIs. This is made by instances like the use of its GI thematic classification or with the use of ETRS89 standardized projection (INSPIRE, 2011).

So far, one of the main goals of the IDECi-UIB is to compile the maximum amount of scientific projects created by the Balearic Islands University that have an spatial component from any scientific discipline to place it in the geoportal: permitting a permanent access to any user with permission and storing it within a catalogue to ensure safety and retrieval (Watson, et al. 2010). The continuous storage of research projects into it will mean a big collection of spatial-based projects available for e-research in a medium-long term, ensuring its use for further investigation.

Moreover, the added value for researchers will be that they will have a gateway where others can access to their projects for visualisation, download or even collaboration, improving the research capacity and creating a space where all knowledge related with spatial information can be found.

A part from the e-research side there is the option to access to thematic data that can be used for own projects development. These geodatasets are catalogued and archived in a database, and by different means (in archives or services WMS, WFS or WCS), they will be accessible through viewers and geoservices. Data comes through external providers, mainly public administrations.

Figure 3 shows how the SSIGT works only as a GI service between the university users, serving GI from the external providers and investigators through the geoportal considering human, financial and technological resources and established standards and policy statements.

A necessary key development item to achieve such a GI Library is security. Researchers are sensitive to the safety of their produced information, and therefore they want a precise guaranty that it is only accessed by the desired users (Watson, et al. 2010). These conditions are met through data transfer agreements with each researcher that gives a totally open or more restricted access depending on their level of access privileges (Figures 3). In any case, everyone will have access to metadata to be able to know what is available at the IDECi-UIB.

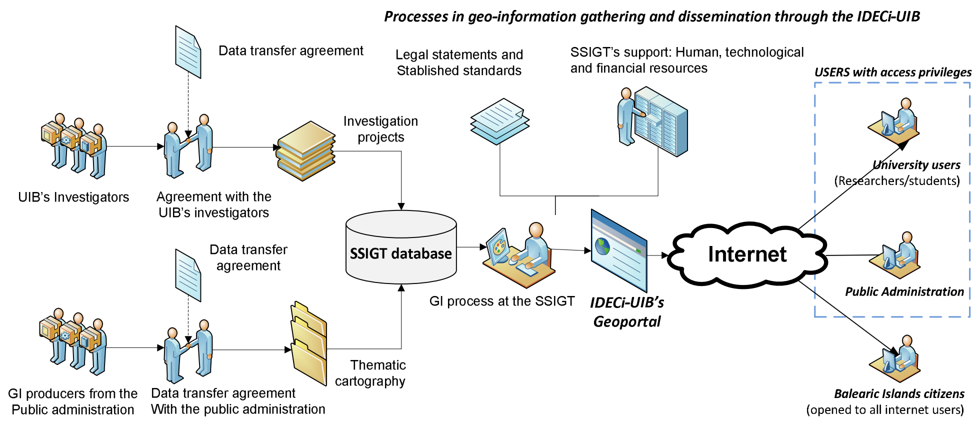

Figure 3: Processes of Geo-Information gathering and dissemination through the IDECi-UIB. Own production, January 2011.

[6] Metadata files within the SDI are structured following the ISO 19115 and ISO 19131 standards as the OGC defines.

Serving more than geo-data: towards distributed GIS

A part from the most popular OGC geoservices like Mapping Services (WMS) and the not so extended geoservices with possibilities on download like the Web Feature services (WFS) for vector information and the Web Coverage Services (WCS) for rasters (Giulani, et al. 2011) other services will permit to offer more than geo-data.

Web Processing Services (WPS) are rather new OGC standards (Schut, 2007) that permit the use of geoprocessing tools in a web service environment (Giuliani, et al., 2011). This technologic advance included in the IDECi-UIB permits the enclosure of the methods used to create the investigation projects provided at the SDI. WPS allow *the publication of reusable and interoperable software tools to allow other researchers, managers, and conservation practitioners to repeat analyses without reengineering them from scratch, to integrate them into larger scientific and management workflows, and ultimately to leverage them in an operational context*" (Roberts, et al. 2010, p. 1197). These complex analysis operations will be available for users even if they don't have such software capacities (Giuliani, et al., 2011). Additionally, other metadata for geoprocessing services will have to be made, explaining in detail what parameters and data is required to give a proper result in operations.

Since most of scenarios in study cases are not able to be approached with simple operations, workflows are necessary (Giuliani, et al., 2011). These workflows models allow users to change parameters, so it is possible to re-process and download data that will extract the information they need using that model. The performance of these services will be achieved through ESRI software. Therefore WPS will be limited to models created with ArcGIS Desktop Model Builder or through Python scripts (ESRI, 2010). Nevertheless there is the option to upload models made with Python which can be written freely in open-source software and are even compatible with other programming languages like C/C++ or MATLAB (Roberts, et al. 2010). However investigators may require a notable notion on programming languages that they may not have (Roberts, et al. 2010).

This technical advance gives a step forward towards a platform working in distributed GIS, where users do not require any specific GIS software and can freely work through the internet browser (Peng, et al. 2003); a part gives an added value providing geo-data but also methods and however it is just an approximation that must be improved in the future.

Geoforum, an option for open e-research

The implication of users in this Scientific SDI is notable counting the amount of investigators that work as GI providers. However, not only investigators are able to collect scientific information. Considering the existence of mobile and wireless GIS devices, other people with enough background and ability could collect GI that might be interesting to study.

Thus, the IDECi-UIB will make this system available to permit the open upload of scientific geo-data or associated GI to the SDI. Instances of this might be GPS samples of endangered species in remote areas, location of services with related attributes or videos and pictures. This system will work as Figure 4 and 5 depict: a first data upload through a FTP[7] connection by users will point to the SSIGT server; that information will be evaluated and catalogued to be included in the database for further studies or thematic layers development, which later on will be added to the SDI.

[7] **FTP** stands for File Transfer Protocol; it serves as a protocol to copy files from a host through the Internet (Internetsoft Corporation, 2004)

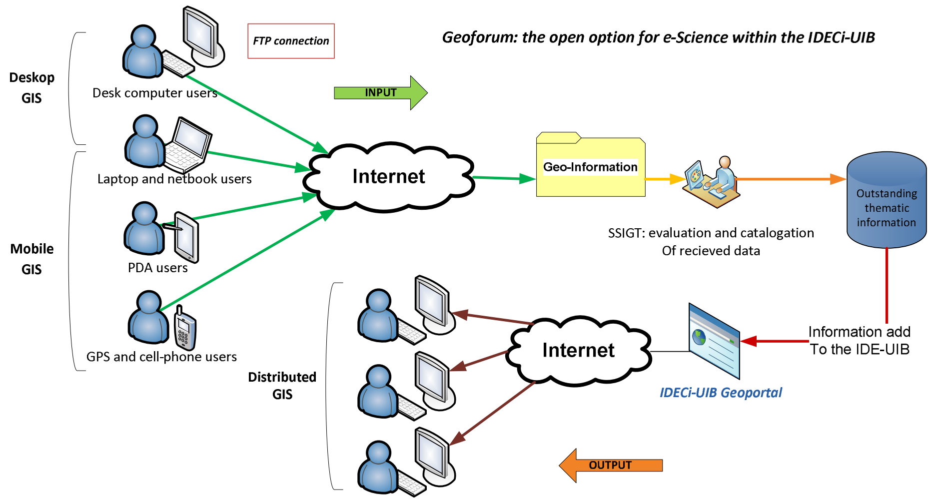

Figure 4: Working system of Geoforum: the open option for e-Science into the IDECi-UIB. Own production, December 2010.

Network architecture design

The enclosure of all these services and applications needs a clear structure to support a proper system performance. At the present two main system architectures are available: the Service-Oriented Architecture (SOA) and the Cloud Architecture. From those, the most innovative and promising one for distributed GIS and a scientific grids is cloud architecture (Watson, et al. 2010; Giuliani et al, 2011). The problem comes with the needed expertise on GI management skills that most researchers do not have. Since they will interact in the SDI, it is convenient to have an independent responsible team to manage with the infrastructural changes and reviews, data management or security. On the other hand, Cloud Architecture is quite unfamiliar with the SDI development team. Therefore, the more common standard and tested SOA has been selected as architectural model, reducing difficulties when building the system. Future structural changes may happen when users are ready for such a change in possibilities and responsibilities.

SOA "*provides the framework and rules for service description, discovery, interaction and execution*" (Giuliani, et al., 2011, p. 293), and therefore can include all SDI services and applications. This architecture defines a centralized infrastructure where all data is provided from a central server and clients (users) tend to have a lower responsibility grade (Peng, et al. 2006).

System architecture

The database at the SSIGT server works as central data repository for all existing GI sources in the IDECi-UIB. However, not all users access by the same way due to different accessibility and action roles.

The system structure depicted is clearly explained in Figure 5. The SSIGT Database is the central source of Geo-Information divided in three main blocks: the Thematic Information Block where the descriptive layers are stored and catalogued per theme; the Scientific Information Block where all research projects are stored (including data, geoprocessing models and resulting layers); and finally the Associated Geo-Information Block, which includes information related to space like multimedia files (pictures, videos…), scientific project reports (related to the research projects), amongst others.

However, information blocks are not static. Since scientific research is based on the production of new information, resulting layers from investigation projects can become thematic layers (Tintoré and Ruiz, 2007). That means that at some point part of these Scientific Block layers will pass to the Thematic Block. That will be made by the SSIGT managers who will decide which layers should be moved. It is symbolized in Figure 5 with an orange arrow.

This GI can be accessed using the IDECi-UIB Geoportal through the Internet or through a direct link into the DB using the server's IP address. The Geoportal access, the most common, is based on the creation of geo-services through ArcGIS Server. Between those services some have an opened access and others are restricted to specific users. Due to the thematic data openness the SSIGT will give free access to the most of these datasets. However for scientific GI accessibility will be much more restricted: only researchers and users allowed to have access to these projects will have the possibility to view, process or download that GI. For that reason every project will need the proper user name and password to access it.

As explained before (Figure 1), the IDECi-UIB geoportal gives access to GI through three main sites, all of them working directly or indirectly with services. Thematic Viewers are applications that pull WMS or WPS to show selected datasets and give capabilities to use simple geoprocessing tools. Secondly, the Catalog works as a searching engine that looks into metadata to give availability and access to services. Finally the e-Research site gives access to the Project Viewers (with restricted access) where projects can be visualized and run through the WPS models existing in each project. The last option in this subsection is the Geoforum; an opened site to any user able to upload geo-data or associated GI through a FTP directory that later on will be included in one of the DB blocks.

However the DB can also be accessed directly through its IP address, giving the possibility to directly manage with files. This type of connection is only possible for UIB researchers, students and SDI administrators at the SSIGT. Between them, there is a clear differentiation in operational roles: When SDI administrators (thick clients) have edition privileges onto the DB and can manage it through Desktop, SDE and Server GIS, researchers and students[8] can only access to data for visualization and download through their Desktop GIS.

[8] The direct access to the SSIGT database by students is only permitted to thematic datasets and the opened access projects.

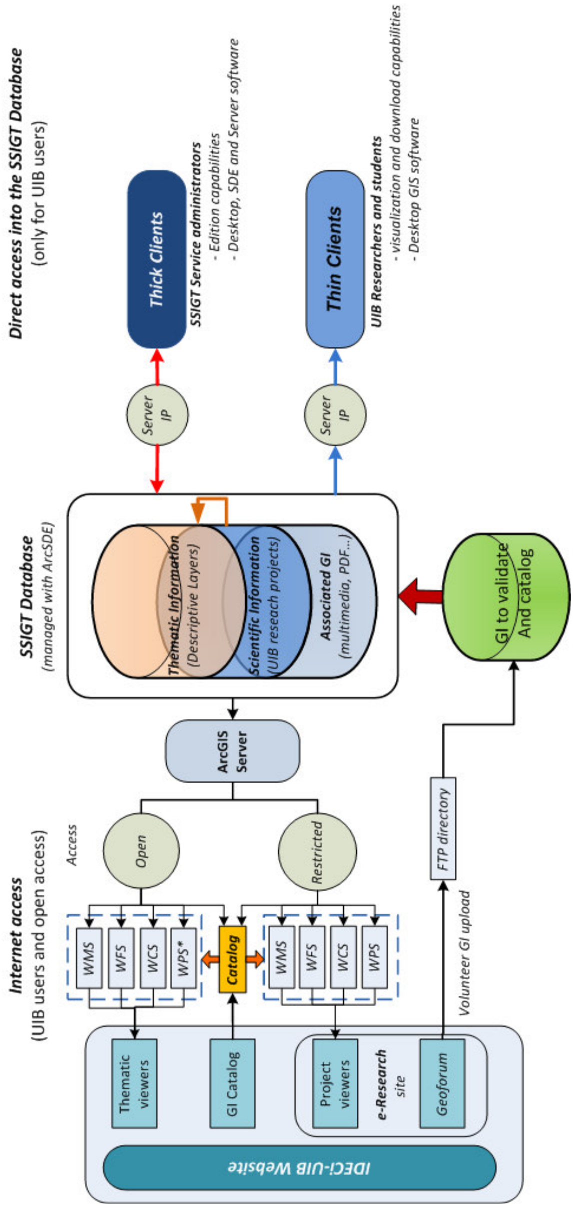

***Figure 5**:* System architecture structure and access to GI at the IDECi-UIB.
Own production on January 2011

Documentation and reviewing processes

The IDECi-UIB will be a reality in short. However this is the beginning of a long time project that may continue for several years expanding its content and complexity. Therefore it is necessary to document all used methods to build the infrastructure, creating procedure protocols for future SDI developers who will continue with this job.

Besides this, it is demonstrated that *"when developing SDI initiatives it is increasingly important to assess their outcomes in order to justify the resources spent on those infrastructure"* (Grus, et al. 2007, page 33). This is the case of the SDI's Strategic Plan, which following the Information System Development Technology method (ISDM) defines a base for system follow-up, review and improvement (Revee & Petch, 1999).

CONCLUSIONS

This project grows as one of the main SSIGT efforts since it supports its main mission and objectives: firstly reinforcing the use and application of GI to improve education and research tasks. Secondly, it is supporting the participation and activities transference I+D+i in geographic and environmental matters. And finally, it is managing and enlarging a GI database derived from the academic activity at the University opened to the Balearic society and the international scientific community through the SDI (SSIGT, 2011). Moreover the SDI also promotes the growth of GIS use and applications either at the university or in businesses and administrations.

On the other hand, and looking to the prospects expected from GIScience in the coming years (Goodchild, 2009), the IDECi-UIB ideas go in the same way: expecting a progressive growth on the citizen participation for GI production and use; working on the trend towards easy-to-use and opened systems helping to e-Research development; and finally working towards real-time or at least gain in higher temporal resolution, *less focused on the present like an snapshot* (Goodchild, 2009, p. 1041).

In terms of education, the recently implanted Bologna Process at the UIB (2009-2010) requires a new high quality learning methodology. In that sense, the creation of the Scientific SDI gives another support resource for students and professors.

In any case the development of this Scientific SDI represents a very important step forward for e-research, education and GI use and applications. Finally it is expected that the characterization of the concept of Scientific SDI gains value and expands to permit in a mid-long term a real expansion in GI use, application and exchange for research worldwide in universities.

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ANNEX 2: Interviews with experts: the first stage in the requirements analysis

This is the interview draft that was given to expert panel members some days before the interview execution. This document presents the research project and the role of experts when carrying out the interview. Afterwards, it presents the 17 questions that should be approached. However not in every case these questions were approached in the same order.

These interviews were recorded and are into audio files in the CD attached to this document.

. . . .

Dear expert panel members,

Before starting with the interview itself I would like to present you how this research is done so you can take a global idea of the whole project approach.

Research presentation:

The GIS and RS Service (SSIGT) at the Balearic Islands University (UIB) is currently working on the development of a Geographical Information Infrastructure (GII) to support the Research and Education activities. This is what we qualify as a Scientific Geographical Information Infrastructure (ScGII).

This concept is not totally formalized or agreed upon by the GIScience community. Still, there are many examples of ScGIIs worldwide. Up to the present, most GIIs are designed and developed following a techno-centric approach, where developers implement what is generally accepted as required. Nevertheless, there is no certainty that the chosen design is accomplishing user needs.

The research goal and objectives:

Therefore, this research sets out the need to follow a socio-technical approach, performing a User-Centred Design methodology at the UIB to develop a Scientific GII adapted to user needs. These include final users and external parties who may be involved. This study just involves the Requirements Analysis and the Prototyping phases, leaving the Usability Analysis out of scope. The study results will consist of an initial prototype meeting with the results of the requirements analysis.

The critical elements in this research are:

1) Determining the potential features of the ScGII, concerning the components that are susceptible to user views: stakeholders, information, technology, policies and standards. To approach these ideas from a user-friendly view, the survey pretends to set out tasks to be carried out using ScGII resources.

2) Determining the user needs for the research and education communities when dealing with the use and dissemination of geo-information and spatially-related knowledge (within the regional context of the Balearic and Spanish communities.

The methodology

The Requirements Analysis represents the main part of this research. *Figure A* depicts closely how this analysis is carried out:

1) **Theoretical background**: it is made based on three directions: Firstly, the critical topics that should be approached to analyze the GII (components: they are: stakeholders, geo-information, technology, standards and policies). Secondly, an external investigation over active ScGIIs: to find their aims, objectives and potential capabilities to support scientific activities. Finally, it is also important to set the context of the UIB's study case, as an internal investigation.

2) **Questionnaire preparation:** The Requirements Analysis is set out based on a web questionnaire that users and stakeholders must fulfil according to their needs. The construction of this questionnaire is based on theory and the study case settings. In this step, main approaches and contents are put in practice in a drafted questionnaire; moreover, a SWOT analysis serves to identify strengths, weaknesses, opportunities and threats of the Balearic Islands scientific community to build the ScGII at the UIB.

3) **Expert Panel:** In order to avoid from possible bias, it is expected that the expert panel determines whether the questionnaire approaches and contents are correct, or whether they should be amplified or redirected somehow. This is made by means of an interview made individually to each member from the expert panel. There are two main objectives for these interviews:

4) **The classification of stakeholders per types**: depending on their role as internal users or external partners.

5) **Identification of critical aspects on components**: the interview must solve all doubts concerning to GII components.

6) **Establishment of the final questionnaire**. Depending on the interviews results, the questionnaire may be split in two, if questions differ from users to other types of stakeholders.

7) **Seminar:** consists on meeting with users and partners directly, make a short seminar explaining what a GII is and what uses and opportunities it may have for the UIB community. This is made following the Joint Analysis Design (JAD) methodology, which tries to get the understanding and trust of users by means of practical explanation (Davidson, 1999)

8) **Web questionnaire:** Immediately after, they have to fill in the web questionnaire according to their needs.

Figure 17 was shown to experts in order to depict the past points.

Interview questions

Questionnaire approach:

1) The questionnaire has to be adapted to the users' view instead of the developers' view. To do so, it should be focussed on the potential tasks that can be executed using a GII. They correspond with the activities generally done with GIS, which consist of: capturing, storing, manipulating, analyzing, managing and presenting geo-information. They have been grouped depending on the stakeholder profile. Do you think this is a good approach? Would you make changes? Figure A is a summary from Figure 28

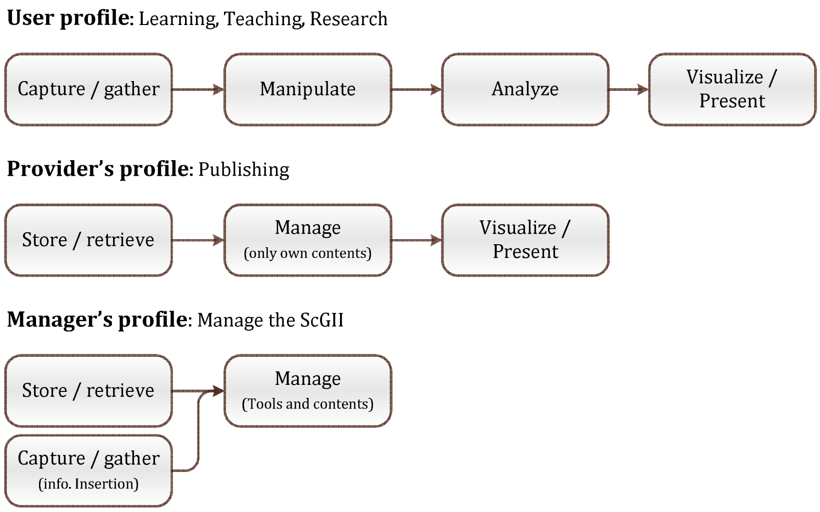


Figure A: Distribution of tasks per stakeholders' profile.

2) Figure 28 summarizes the structure in which the questionnaire may be made. In it there are the set of tasks that are normally done with a GII and/or a GIS software (horizontally); and a set of GII components (vertically). As we go through the model rise options related to each GII component. Moreover, tasks are related to certain role in the GII: user, provider and manager. Stakeholders may have different functions, but still their behaviour should adapt to this structure.

   What do you think about this approach? Do you think it is feasible if examples of every type of option are given? Is it too complex?

   Set a pause between each part? Would it be too complicated?

Here Figure 28 was shown to experts in order to depict the questionnaire's structure (tasks vs. GII components).

SWOT analysis:

The research and education communities in the Balearic Islands

3) To analyze and diagnose the strengths and weaknesses of the research and education community in the Balearic Islands / Spain, a SWOT table (**Error! No s'ha trobat l'origen de la referència.**) will be created (Strenghts, Weaknesses, Opportunities and Threats). There are already some arguments on it, although would be interesting to contrast this information with you. Would you correct, add or delete something from it?

Strengths	**Weaknesses**
• Initiative to create a ScGII for the Balearic Islands University community • Small research community easy to manage • Existence of soft/hardware resources to implement a proper ScGII (server side) • ...	• Lack of connexion between entities to share information and knowledge • Limited use of GIS in research • Lack of collaboration between research departments and between the UIB and external partners. • Worries for information transference policies, Intellectual Property Rights, privacy and security. • ...
Opportunities	**Threats**
• Large amount of existing GI in public organisations that could easily be shared • Amount of GI from research projects to be shared • Potential involvement from external partners (private or public) into the GII: education, research, decision-making • **...**	• Limited knowledge of potential users and stakeholders on GIS capabilities and applications • Level of knowledge and use of ICT resources • Unknown level of interest to finance the project • ...

This table is not complete, because this is how interviewees got it before the interview execution

SWOT analysis over the Scientific Community in the Balearic Islands (Incomplete model)

GII components

Stakeholders (people)

4) Literature describes 3 types of stakeholders, depending on their relation towards the ScGII. They are:
   - Primary: works regularly or directly with the product Q
   - Secondary: Use the product infrequently or through an intermediary Q
   - Tertiary: they are affected by the system (observers)
   - Anti-user: Someone who would never use the system in any way

   From this list of potential stakeholders (Table A) which ones would you consider as users and which ones should be set as external partners? Would you add any other party? Who?

Would you split them in two groups (UIB – External UIB) or would you follow this division? Why?

	Primary	Secondary	Tertiary	Anti-user
UIB students (grade, master, PhD				
UIB teachers				
UIB researchers				
SSIGT – UIB (ScGII developers)				
IMEDEA (CSIC-UIB) (Mediterranean Institute of Advanced Studies)				
Others at the Balearic Islands University...				
...				
Provincial Councils (*Consell Insulars*)				
IBESTAT (Balearic Institute of Statistics)				
IMI (Municipal Institute of Innovation, Palma)				
IEO (Spanish Institute of Oceanography)				
Spanish Cadaster				
OBSAM (Socio-Environmental Observatory of Menorca)				
NGOs e.g. GOB				
Private enterprises. E.g. GAAT, ESTOP				
External universities. E.g. UAB, UB, UPM, UAM, UNIZAR,...				
Others from any geographical context...				
...				

Table A: Potential stakeholders per types

5) The potential roles of the ScGII may be in research, education, governance, private interests and public participation in science. Do you think about any other?

6) What could be the roles from external partners who do not belong to the University Community? Would you ask them about what role they would like to have? How?

7) It is evident that not all users have the same skills in GIS, GIIs and ICT. Would you create a user profile section? What would you ask for?

8) Could the ScGII serve as a geo-collaborative research environment? How?

Data, information and knowledge

9) Ideally, the ScGII should be able to distribute a wide variety of information (Figure D): geo-information, processing services, and extra elements not necessarily spatial, like: statistics, reports, videos, images, hyperlinks, etc.

   Does this give enough value over ScGIIs versus Administration GIIs? Would administration GIIs be still necessary to support research and education?

Here Figure 20 was shown to experts in order to depict the geo-information component within the IDECi-UIB

Technology

10) In your opinion, what technological factors would you emphasize for a ScGII (architecture, interoperability capabilities, system usability and utility)?

    Examples:

    - SOA / Grid Architecture: How would you approach the possibility to base the system into a grid?

- Centralized (i.e. CEDAI) vs. Distributed catalogue (IDE-ULPGC) harvesting
- Trial with geoservices: Open standards (OGC) and non-standards (SOAP (num),GeoRSS, ArcIMS, atom...)
- Map viewers capabilities: focus on WPS capacity (IDEE, Territorial analysis, Geogrid, Volcanic lava flow modeler), LBS (QuakeSim)
- Geoportal: generic website (IDEE) vs. mash-up (LANDSCOPE) generic/specialized 1 generic geoportal

Policies

11) What laws and policies from the Spanish and European legislation would you remark as important or necessary for the ScGII? Anyone forcing researchers to publish their results? Here there are the main underlying laws in science and GIIs:
    - Spanish legislation in *Science Technology and Innovation* (Law 14/2011, BOE)
    - Spanish legislation in Geo-Information Infrastructures and Services (LISIGE) (Law 14/2010, BOE),
    - European Commission law in R&D (Seventh Regulation Programme, No. 1906/2006)
    - European Union Charter of Fundamental Rights (EU, 2010, Article 179)

12) Apart from the common benefits of sharing GI and knowledge in the University Community, what other opportunities would you propose to researchers to convince them? I already thought about some ideas:

    - It may a way of self-promotion, prestige, academic impact, and curriculum construct towards the scientific community

    - It may be a way to validate the quality, veracity and legitimacy of results and methodologies

    - Cataloguing and documenting all served information may serve as a way to protect intellectual property and avoid bias against misuse or illegal use of information.

    - A ScGII might serve as a tool to enhance the interactivity between users. A way to qualify and make productive criticizing about the research: a grading (1-5 qualification), but also the possibility to comment on data quality, accuracy, possible improvements, other approaches, etc.

13) Which factors, measures or arguments may be necessary to ensure users' trust towards the system (liability, security, privacy)? Is the creation of different accounts (login), which restrict the access to certain groups of people, a good measure?

14) Are Intellectual Property Rights a problem or an advantage to open Science? Do different kinds of IPR have a different restriction (by law): trademark, copyright and patent? Would you ask to users whether they consider necessary the aperture of science?

15) Infrastructure goals are set, but the infrastructure's legal base is not. Is this decision a role corresponding to users or just to GII developers? In what measure do users/providers have decision on this?

Standards

16) To ensure interoperability, OGC standards must be ensured. However, it may be also interesting to serve non-standard services (i.e.: GeoRSS, ArcIMS, ArcGIS Server, etc). Do you think it is a good choice to serve standards and non-standards?

17) A determining factor is also the GIS software users' make use of. The idea is asking on most used GIS/CAD softwares. I analyzed the capabilities of the next list. Would you add/remove any software or service from this table?

Here Table 1 was shown to experts in order to depict the compatibility between GIS/CAD softwares and geoservices

ANNEX 3: Requirements analysis survey

The requirements analysis was carried out through a web questionnaire with Lime Survey software. As mentioned in Chapter 6, three questionnaire models were developed: for students (1), teachers and researchers (2) and developers (3). They are attached in the coming pages.

Requirements Analysis to design the Balearic Islands University's ScGII (Students)

This survey is realized within the Master thesis in Geographical Information Management and Applications (MSc GIMA) from the Dutch universities of Utrecht, Wageningen, Delft and Twente (ITC), in collaboration with the Balearic Islands University (UIB).

(Students)

Welcome!

There are 30 questions in this survey

General user profile

This section should be completed **before** starting with the explanation over the ScGII potential capacities

1 [UP1]How old are you? *

Please choose **only one** of the following:

- ≤20
- 21-25
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-60
- ≥61

2 [UP2]What languages are you conversant in? *

Please choose the appropriate response for each item:

	1	2	3	4	5
English	○	○	○	○	○
Catalan	○	○	○	○	○
Spanish	○	○	○	○	○
German	○	○	○	○	○
French	○	○	○	○	○
Others	○	○	○	○	○

Indicate your hability level in each case. From nonexistent (1) to very high (5)

3 [UP3]What is your occupation at the UIB? *

Please choose **only one** of the following:

- Bachellor student
- Master / postgraduate student
- PhD student

4 [UP4]In which studies are you? *

Please choose **only one** of the following:

- Geography
- Biology
- Agriculture Engineering
- Economy
- Architecture Engineering
- Computer Science Engineering
- History
- Journalism
- Tourism
- Others

5 [UP5]In what course are you? *

Please choose **only one** of the following:

- 1st
- 2nd
- 3rd
- 4th
- 5th
- >5

6 [UP6]Are you just studying or are you also working? *

Please choose **only one** of the following:

- Full-timer student
- Part-timer student (also working)

User profile: Knowledge and experience on GIS

7 [SIG1]How often do you use GIS or CAD? *

Please choose **only one** of the following:

- Never
- Very few times
- Once or twice a month
- Once or twice a week
- Every day

8 [SIG2]Which GIS / CAD softwares do you use to work with? *

Please choose **all** that apply:

- Google Earth
- ArcGIS / ArcView
- GvSIG
- Miramon
- Quantum GIS
- GRASS GIS
- ERDAS / ER Mapper
- uDig
- Geomedia
- Microstation
- AutoCAD
- I don't use any
- Other:

9 [SIG3]What tasks do you use to carry out when working on GIS/CAD? *

Only answer this question if the following conditions are met:
° Answer was NOT A1'Never' at question '7 [SIG1]' (How often do you use GIS or CAD?)

Please choose **all** that apply:

- [ ] Data adquisition. i.e: GPS
- [ ] Data manipulation
- [ ] Visualization
- [ ] Edition of layers: digitation, georeferencing, etc.
- [ ] Spatial Analysis (basic): buffer, reclassification, overlay, etc.
- [ ] Spatial Analysis (advanced): interpolation, network analysis, dynamic modelling, etc.
- [ ] Remote Sensing: vegetation studies, land use changes
- [ ] Maps generation (to print in paper)

10 [SIG4]

Did you take specific courses in theory and methodologies on GIS or CAD? Which ones?

*

Please choose **all** that apply:

- [ ] Any (0)
- [ ] Geographical Information Systems (basic)
- [ ] Geographical Information Systems (Intermediate)
- [ ] Geographical Information Systems (Advanced)
- [ ] Remote Sensing
- [ ] Postgraduate course in GIS, CAD or RS
- [ ] Master in GIS, CAD or RS
- [ ] Other GIS/CAD/RS courses/programmes (non-university)

11 [SIG5]

In how many subjects more did you use GIS / CAD voluntarily or mandatorily?

*

Please choose **only one** of the following:

- Any (0)
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- +10

User profile: Knowledge and experience on GIIs

This section wants to clarify your skills and knowledge about GII use and capacities before starting with the informative seminar

12 [IDE1]Do you know what a Geographical Information Infrastructure (GII) is? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

13 [IDE2]How often do you use GIIs for your daily work? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure (GII) is?)

Please choose **only one** of the following:

- ○ Never
- ○ Ocasionally
- ○ Once or twice a month
- ○ Once or twice a week
- ○ Every day

14 [IDE3]What GIIs do you frequently use? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure (GII) is?)

Please choose **all** that apply:

- ☐ IDEIB (Balearic Islands GII)
- ☐ IDE Mallorca
- ☐ IDE Menorca
- ☐ IDEE (Spanish GII)
- ☐ Other: ____________

Choose all the GIIs you worked with

15 [IDE4]What tools do you use into a GII? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure (GII) is?)

Please choose **all** that apply:

- [ ] Metadata Catalogue
- [ ] Map viewer
- [ ] Geodata download (files)
- [ ] Geo-services (i.e. WMS)

16 [IDE5]

Have you ever used web applications like Google Maps or Bing Maps?

*

Please choose **only one** of the following:

- ○ Yes
- ○ No

17 [IDE6]What kind of tasks did you do with it? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '16 [IDE5]' (Have you ever used web applications like Google Maps or Bing Maps?)

Please choose **all** that apply:

- [ ] Search for locations
- [ ] Search for routes
- [ ] Layers edition (points, lines, polygons)
- [ ] Syncing with mobile devices (smartphone)
- [ ] Export layers (KML from Google Earth)

Task 0: SYSTEM'S STRUCTURING

18 [T0.1]In which of the next GII geoportals seems easier to find the next resources?

Please enter a number between 1 and 10 for each item:

	IDEIB (Balearic I. GII)	IDEE (Spanish GII)	SIB-ESS-C (Jena Univ. ScGII)	IDE-ULPGC (Las Palmas Univ. ScGII)	IDECi-UIB (Balearic I. Univ. ScGII)
Catalogue					
Map viewer					
Geo-services					
Geo-information download service					

1. **IDEIB:** http://www.ideib.cat/
2. **IDEE:** http://www.idee.es
3. **SIB-ESS-C:** http://www.sibessc.uni-jena.de
4. **IDE-ULPGC:** http://ide-ulpgc.eu/
5. **IDECi-UIB:** http://ssigt.uib.cat/serveis/IDE/

19 [T0.2]

Which secondary sections would you implement in the ScGII geoportal? Classify them from higher to lower relevance

*

Please number each box in order of preference from 1 to 5

☐ Support Section/manual
☐ Informative section about the ScGII (About)
☐ News (blog/website)
☐ Feedback postbox
☐ Links

Task 1: GEO-INFORMATION SEARCH

20 [T1.1]Which searching method do you think is more adequate? *

Please number each box in order of preference from 1 to 3

- [ ] Files directory
- [ ] Metadata catalogue
- [ ] Mash-up

Indicate it depending on your preference

21 [T1.2]Would you like to be able to search information from this GII into other catalogues simultaneously? *

Please choose **only one** of the following:

- Yes
- No

22 [T1.3]What type of geo-information -descriptive or derived from research projects- would you like to have access to? *

Please choose **all** that apply:

- ☐ Topographic maps
- ☐ Aerial / Satellite imagery
- ☐ Elevation: Digital Elevation Models (DEM) / Bathimetry
- ☐ Geology / Geomorphology / Soil
- ☐ Hydrology / Hydrography
- ☐ Climatology / Meteorology
- ☐ Biota / Biodiversity
- ☐ Oceanography
- ☐ Cadaster / Land planing
- ☐ Coverage / land uses
- ☐ Administrative boundaries
- ☐ Geographical names
- ☐ Society and population
- ☐ Communication networks
- ☐ Primary sector
- ☐ Secondary sector
- ☐ Tertiary sector
- ☐ Natural / technological risks
- ☐ Protected / restricted areas
- ☐ Environmental impact
- ☐ Other: ____________

Choose the preferred thematic areas

23 [T1.4]Are you interested on accessing crononlogic geo-information? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

24 [T1.5]Which spatial scope would you like to have information from? *

Please choose **all** that apply:

- ☐ Balearic Islands
- ☐ Spain
- ☐ Mediterranean basin
- ☐ Europe
- ☐ Other continents
- ☐ World
- ☐ Unknown / no answer
- ☐ Other: ________

25 [T1.6]Do you considerate adequate the integration of associated non-spatial information? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

26 [T.1.7]In which preference? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '25 [T1.6]' (Do you considerate adequate the integration of associated non-spatial information?)

Please number each box in order of preference from 1 to 4

- ☐ Text documents (i.e. research projects, publications, etc)
- ☐ Statistics (i.e. demographics, climatology)
- ☐ Multimedia (video, audio, photo, etc)
- ☐ Hypermedia (web links, applications, etc)

Task 2: MANIPULATION AND ANALYSIS

27 [T2.1]When you work with GIS/CAD, what do you prefer? *

Please choose **only one** of the following:

- Software GIS (installed into the desktop computer)
- Through the GII (Web browser)
- Both
- unknown / no answer

28 [T2.2]If you work with a GIS/CAD software you prefer to: *

Please choose **only one** of the following:

- Downloaded geospatial information (i.e. vectorial / raster files)
- Geo-services (i.e. WMS)
- Combine both
- unknown / no answer

29 [T2.3]If you work with a GIS software, which types of services are you able to use? *

Only answer this question if the following conditions are met:
° Answer was A2'Geo-services (i.e. WMS)' or 'Combine both' at question '28 [T2.2]' (If you work with a GIS/CAD software you prefer to:) *and* Answer was A3'Geo-services (i.e. WMS)' or 'Combine both' at question '28 [T2.2]' (If you work with a GIS/CAD software you prefer to:)

Please choose **all** that apply:

- Visualization geoservices (i.e: WMS, KML)
- Manipulation and download geoservices (i.e: WFS, WCS)
- Geoprocessing geoservices (i.e.WPS, WCPS)

Task 3: VISUALIZATION

30 [T3.1]

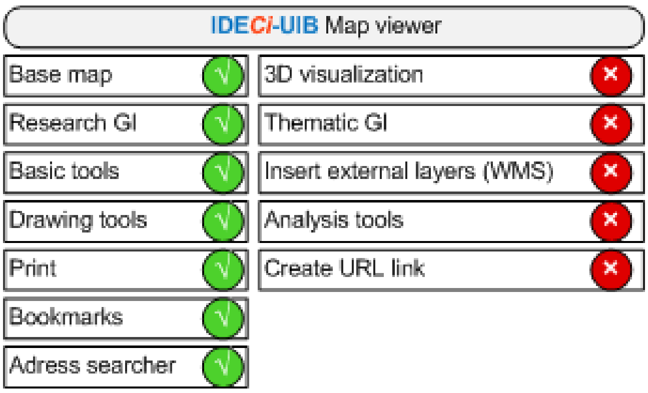
The current IDE-UIB's map viewer has basic contents and functionalities; however they can be improved. Indicate which of the next options you would eliminate, maintain, improve or add.

*

Please choose the appropriate response for each item:

	Delete	Maintain	Improve	Add
3D visualization	○	○	○	○
Layers from research projects	○	○	○	○
Thematic and descriptive layers	○	○	○	○
Add external layers (WMS)	○	○	○	○
Tools: query, zoom, legend, distance/area calculation, etc.	○	○	○	○
Analysis tools: environmental, insolation, buffer, etc.	○	○	○	○
Drawing tools and labels	○	○	○	○
Print: image, PDF	○	○	○	○
Create URL link	○	○	○	○

Currently, these are IDECi-UIB map viwer capabilities and shortages



Thank you very much for your cooperation!

01.01.1970 – 01:00

Submit your survey.
Thank you for completing this survey.

Requirements Analysis to design a Scientific GII

This survey is realized within the Master thesis in Geographical Information Management and Applications (MSc GIMA) from the Dutch universities of Utrecht, Wageningen, Delft and Twente (ITC), in collaboration with the Balearic Islands University (UIB).

(Researchers and Teachers - PDI)

Welcome!

There are 41 questions in this survey

General user profile

This section should be completed **before** starting with the explanation over the ScGII potential capacities

1 [UP1]How old are you? *

Please choose **only one** of the following:

- ≤20
- 21-25
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-60
- ≥61

2 [UP2]What languages are you conversant in? *

Please choose the appropriate response for each item:

	1	2	3	4	5
English	○	○	○	○	○
Catalan	○	○	○	○	○
Spanish	○	○	○	○	○
German	○	○	○	○	○
French	○	○	○	○	○
Others	○	○	○	○	○

Indicate your hability level in each case. From nonexistent (1) to very high (5)

3 [UP3]What is your occupation at the UIB? *

Please choose **only one** of the following:

- Researcher
- Researcher / teacher
- Research collaborator
- Teacher

4 [UP4]As a researcher, To what of the following ANEP subjects does your research group belongs to? *

Only answer this question if the following conditions are met:
° Answer was A1'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?) *and* Answer was A2'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?) *and* Answer was A3'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?)

Please choose **only one** of the following:

- Fundamental and systems Biology
- Ecology, and vegetal and animal Biology
- Biomedicine
- Food Science and Technology
- Education Sciences
- Technology and Computer Sciences
- Earth Sciences
- Social Sciences
- Law
- Economy
- Civil engineering and architecture
- Electrical Electronic and Automatic Control Engineering
- Mecanichal, nautical and aeronautical engineering
- Philology and Philosophy
- Physics and Space Sciences Area
- History and Art
- Mathematics
- Clinical medicine and epidemiology
- Psychology
- Chemistry
- Communications and Electronic Technology Area

ANEP areas in research at the UIB are found in this link: ANEP areas UIB

5 [UP5]Which is your studies do you teach and or research? *

Please choose **only one** of the following:

- Geography
- Biology
- Agriculture Engineering
- Economy
- Architecture Engineering
- Computer Science Engineering
- History
- Journalism
- Tourism
- Others

User profile: Knowledge and experience on GIS

6 [SIG1]How often do you use GIS or CAD in your daily work? *

Please choose **only one** of the following:

- Never
- Ocasionally
- Once or twice a month
- Once or twice a week
- Every day

7 [SIG2]What tasks do you use to carry out when working on GIS/CAD? *

Only answer this question if the following conditions are met:
° Answer was NOT A1 at question '6 [SIG1]' (How often do you use GIS or CAD in your daily work?)

Please choose **all** that apply:

- None (0)
- Data manipulation
- Visualization
- Edition of layers: digitation, georeferencing, etc.
- Spatial Analysis (basic): buffer, reclassification, overlay, etc.
- Spatial Analysis (advanced): interpolation, network analysis, dynamic modelling, etc.
- Remote Sensing: vegetation studies, land use changes
- Maps generation (to print in paper)

8 [SIG3]Which GIS / CAD softwares do you use to work with? *

Please choose **all** that apply:

- ☐ Google Earth
- ☐ ArcGIS / ArcView
- ☐ GvSIG
- ☐ Miramon
- ☐ Quantum GIS
- ☐ GRASS GIS
- ☐ ERDAS / ER Mapper
- ☐ uDig
- ☐ Geomedia
- ☐ Microstation
- ☐ AutoCAD
- ☐ I do not use any software (0)
- ☐ Other: ____________

9 [SIG4]

Did you take specific courses in GISciences? Which ones?

*

Please choose **all** that apply:

- ☐ No, any (0)
- ☐ Geographical Information Systems (basic)
- ☐ Geographical Information Systems (Advanced)
- ☐ Spatial Analysis Techniques (TAE - UIB)
- ☐ Remote Sensing
- ☐ Postgraduate courses in GIS, CAD or RS
- ☐ Master in GIS, CAD or RS
- ☐ Other GIS,CAD or RS courses out of University

10 [SIG5]

As a teacher, do you use GIS or digital cartography to support your the contents, practices, etc. of your courses? In how many?

*

Only answer this question if the following conditions are met:
° Answer was A2'Researcher / teacher' or 'Teacher' at question '3 [UP3]' (What is your occupation at the UIB?) *and* Answer was A6'Researcher / teacher' or 'Teacher' at question '3 [UP3]' (What is your occupation at the UIB?)

Please choose **only one** of the following:

- I do not use Geographical Information
- in 1 subject
- in 2 subjects
- in 3 subjects
- in more than 3 subjects

11 [SIG6]

As a researcher, do you use Geographical Information in your research projects? In how many did you make use of it?

*

Only answer this question if the following conditions are met:
° Answer was A1'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?) *and* Answer was A2'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?) *and* Answer was A3'Researcher' or 'Researcher / teacher' or 'Research collaborator' at question '3 [UP3]' (What is your occupation at the UIB?)

Please choose **only one** of the following:

- In any research project
- 1-5
- 6-10
- 11-15
- 16-20
- >20

Here we consider all your researcher career

User profile: Knowledge and experience on GIIs

This section wants to clarify your skills and knowledge about GII use and capacities before starting with the informative seminar

12 [IDE1]Do you know what a Geographical Information Infrastructure is? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

13 [IDE2]How often do you use GIIs for your daily work? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure is?)

Please choose **only one** of the following:

- ○ Never
- ○ Ocasionally
- ○ Once or twice a month
- ○ Once or twice a week
- ○ Every day

14 [IDE3]What GIIs do you frequently use? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure is?)

Please choose **all** that apply:

- ☐ IDEIB (Balearic Islands GII)
- ☐ IDE Mallorca
- ☐ IDE Menorca
- ☐ IDEE (Spanish GII)
- ☐ Other: ____________

Choose all the GIIs you worked with

15 [IDE4]What tools do you use into a GII? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '12 [IDE1]' (Do you know what a Geographical Information Infrastructure is?)

Please choose **all** that apply:

- ☐ Metadata Catalogue
- ☐ Map viewer
- ☐ Geodata download (files)
- ☐ Geo-services (i.e. WMS)

16 [IDE5]

Independently on what you have answered before, have you ever used web applications like Google Maps or Bing Maps? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

17 [IDE6]What kind of tasks did you do with it? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '16 [IDE5]' (Independently on what you have answered before, have you ever used web applications like Google Maps or Bing Maps?)

Please choose **all** that apply:

- ☐ Search for locations
- ☐ Search for routes
- ☐ Layers edition (points, lines, polygons)
- ☐ Syncing with mobile devices (smartphone)
- ☐ Export layers (KML from Google Earth)

Task 0: SYSTEM'S STRUCTURING

18 [T0.1]In which of the next GII geoportals seems easier to find the next resources? Give a grade from 1 to 10

Please enter a number between 1 and 10 for each item:

	IDEIB (Balearic I. GII)	IDEE (Spain GII)	SIB-ESS-C (Siberia ScGII)	IDE-ULPGC (Las Palmas Univ. ScGII)	IDECi-UIB (UIB's ScGII)
Catalogue					
Map viewer					
Geo-services					
Geo-information download service					

1. **IDEIB**: http://www.ideib.cat/
2. **IDEE**: http://www.idee.es
3. **SIB-ESS-C**: http://www.sibessc.uni-jena.de
4. **IDE-ULPGC**: http://ide-ulpgc.eu/
5. **IDECi-UIB**: http://ssigt.uib.cat/serveis/IDE/

19 [T0.2]

Which secondary contents are in your opinion more important into the ScGII geoportal? Classify them from higher to lower relevance

*

Please number each box in order of preference from 1 to 5

- [ ] Support Section/manual
- [ ] Informative section about the ScGII (About)
- [ ] News (blog/website)
- [ ] Feedback postbox
- [ ] Links

Task 1: GEO-INFORMATION SEARCH

20 [T1.1]Which searching method do you think is more adequate? *

Please number each box in order of preference from 1 to 3

[ ] Files directory
[ ] Metadata catalogue
[ ] Mash-up

Indicate it depending on your preference

21 [T1.2]Would you like to be able to search information from this GII into other catalogues simultaneously? *

Please choose **only one** of the following:

- ○ Si
- ○ No
- ○ Unknown / no answer

22 [T1.3]What type of geo-information would you like to have access to? *

Please choose **all** that apply:

- ☐ Topographic maps
- ☐ Aerial / Satellite imagery
- ☐ Elevation: Digital Elevation Models (DEM) / Bathimetry
- ☐ Geology / Geomorphology / Soil
- ☐ Hydrology / Hydrography
- ☐ Climatology / Meteorology
- ☐ Biota / Biodiversity
- ☐ Oceanography
- ☐ Cadaster / Land planing
- ☐ Coverage / land uses
- ☐ Administrative boundaries
- ☐ Geographical names
- ☐ Society and population
- ☐ Communication networks
- ☐ Primary sector
- ☐ Secondary sector
- ☐ Tertiary sector
- ☐ Natural / technological risks
- ☐ Protected / restricted areas
- ☐ Environmental impact
- ☐ I do not have any interest (0)
- ☐ Other: ____________

Choose the preferred thematic areas

23 [T1.4]Would you like to have access to geo-information derived from research projects? *

Please choose **only one** of the following:

- ○ Yes
- ○ No
- ○ No answer

24 [T1.5]Are you interested on geo-information to work on temporal evolution studies? *

Please choose **only one** of the following:

- Yes
- No

25 [T1.6]Which spatial scope would you like to have information from? *

Please choose **all** that apply:

- Balearic Islands
- Spain
- Mediterranean basin
- Europe
- Other continents
- World
- Unknown / no answer

26 [T1.7]Do you considerate adequate the integration of generic information associated with spatial features? *

Please choose **only one** of the following:

- Yes
- No

27 [T.1.8]In which preference? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '26 [T1.7]' (Do you considerate adequate the integration of generic information associated with spatial features?)

Please number each box in order of preference from 1 to 4

- Text documents (i.e. research projects, publications, etc)
- Statistics (i.e. demographics, climatology)
- Multimedia (video, audio, photo, etc)
- Hypermedia (web links, applications, etc)

Task 2: MANIPULATION AND ANALYSIS

28 [T2.1]When you work with GIS/CAD, what do you prefer? *

Please choose **only one** of the following:

- Software GIS (installed into the desktop computer)
- Through the GII (Web browser)
- Both
- unknown / no answer

29 [T2.2]If you work with a GIS/CAD software you prefer to: *

Please choose **only one** of the following:

- Downloaded geospatial information (i.e. vectorial / raster files)
- Geo-services (i.e. WMS)
- Combine both
- unknown / no answer

30 [T2.3]If you work with a GIS software, which types of services are you able to use? *

Only answer this question if the following conditions are met:
° Answer was A2'Geo-services (i.e. WMS)' or 'Combine both' at question '29 [T2.2]' (If you work with a GIS/CAD software you prefer to:) *and* Answer was A3'Geo-services (i.e. WMS)' or 'Combine both' at question '29 [T2.2]' (If you work with a GIS/CAD software you prefer to:)

Please choose **all** that apply:

- [ ] Visualization geoservices (i.e: WMS, KML)
- [ ] Manipulation and download geoservices (i.e: WFS, WCS)
- [ ] Geoprocessing geoservices (i.e.WPS, WCPS)

Task 3: VISUALIZATION

31 [T4.1]

Which of these map viewer tools do you consider more useful for a Scientifc GII? *

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
3D visualization	○	○	○	○	○	○	○	○	○	○
Layers from research projects	○	○	○	○	○	○	○	○	○	○
Thematic and descriptive layers	○	○	○	○	○	○	○	○	○	○
Add external layers (WMS)	○	○	○	○	○	○	○	○	○	○
Basic and navegation tools: query, zoom, legend, distance/area calculation, etc.	○	○	○	○	○	○	○	○	○	○
Analysis tools: environmental, insolation, buffer, etc.	○	○	○	○	○	○	○	○	○	○
Drawing tools and labels	○	○	○	○	○	○	○	○	○	○
Print: image, PDF	○	○	○	○	○	○	○	○	○	○
Create URL link	○	○	○	○	○	○	○	○	○	○

Indicate a grading depending on your preference on each type of content or tool from 1 (lowest) to 10 (highest)

Task 5: PUBLISH (Provider)

32 [T5.1]If a ScGII was constructed at the University where you currently work, would you be willing to share research projects that contain geographical information? *

Please choose **only one** of the following:

- Yes
- No

Intellectual property rights (IPR) respect is guarranteed. Moreover the holder or author has the right to define its own restrictions in use and access of these contents.

33 [T5.2]How many research projects could you share? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '32 [T5.1]' (If a ScGII was constructed at the University where you currently work, would you be willing to share research projects that contain geographical information?)

Please choose **only one** of the following:

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- ≥10

34 [T5.3]In which thematic classes would you classify these research projects? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '32 [T5.1]' (If a ScGII was constructed at the University where you currently work, would you be willing to share research projects that contain geographical information?)

Please choose **all** that apply:

- ☐ Topographic maps
- ☐ Aerial / satellite imagery
- ☐ Elevation: DEM, bathimetry
- ☐ Geology, geomorphology, soils
- ☐ Hydrology
- ☐ Climatology, meteorology
- ☐ Biota, biodiversity
- ☐ Oceanography
- ☐ Cadaster, Land planning, urban planning
- ☐ Coverage, land uses
- ☐ Administrative boundaries
- ☐ Geographical names
- ☐ Society and population
- ☐ Communication networks
- ☐ Primary sector
- ☐ Secondary sector
- ☐ Tertiary sector
- ☐ Natural / Technological risks
- ☐ Protected / restricted areas
- ☐ Environmental impact
- ☐ Ecology
- ☐ Other: ______

35 [T5.4]What is their geographical coverage? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '32 [T5.1]' (If a ScGII was constructed at the University where you currently work, would you be willing to share research projects that contain geographical information?)

Please choose **all** that apply:

- ☐ Balearic Islands
- ☐ Spain
- ☐ Mediterranean basin
- ☐ Europe
- ☐ Other continents
- ☐ World
- ☐ Other: ____________

36 [T5.5]A part from geodatasets, spatial analysis tools could also be published. Would you like to publish spatial analysis methodologies by means of these kind of tools? *

Please choose **only one** of the following:

- ○ Yes
- ○ No
- ○ No answer

37 [T5.6]

A part from publishing geospatial information, would you publish associated or complementary material?

*

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '32 [T5.1]' (If a ScGII was constructed at the University where you currently work, would you be willing to share research projects that contain geographical information?)

Please choose **only one** of the following:

- ○ Yes
- ○ No

38 [T5.7]What associated materials would you like to share? *

Only answer this question if the following conditions are met:
° Answer was Y'Yes' at question '37 [T5.6]' (A part from publishing geospatial information, would you publish associated or complementary material?)

Please choose **all** that apply:

- ☐ Text documents: research projects, tesis, publications, etc.
- ☐ Statistics, diagrams, conceptual diagrams, etc.
- ☐ Multimedia files: photo, audio, video
- ☐ Hypermedia: web links, applications, etc.
- ☐ Other: ____________

39 [T5.8]

The published information may be restricted. By what technological means would you like to publish your research projects? Who would be admitted to access into your contents?

*

Please choose the appropriate response for each item:

	No answer	Open access	UIB Community	Teaching and Research Personnel (PDI) - UIB	Own research group - UIB
Map viewer	○	○	○	○	○
Geo-services (i.e.WMS)	○	○	○	○	○
Spatial analysis tools	○	○	○	○	○
Geospatial information download (files)	○	○	○	○	○
Associated information download	○	○	○	○	○

Publication media is disposed in rows, and the restriction level is defined in the columns of this matrix.

40 [T5.9]

The Scientific GII may be used as a mean for geocollaboration between researchers from different disciplines. In your opinion, which technological means are more effective to promote the exchange and relation with other researchers?

*

Please number each box in order of preference from 1 to 3

- [ ] Mash-up
- [ ] Web site or blog
- [ ] Wiki space

41 [T5.10]

The Scientific GII serves as a good means to disseminate published research projects. Which of the next technological means to you think is most effective to disseminate publications?

*

Please choose **only one** of the following:

- ○ Metadata catalogue
- ○ Map viewer
- ○ File directory
- ○ Mash-up

Thank you very much for your cooperation!

01.01.1970 – 01:00

Submit your survey.
Thank you for completing this survey.

Requirements Analysis to design a Scientific GII

This survey is realized within the Master thesis in Geographical Information Management and Applications (MSc GIMA) from the Dutch universities of Utrecht, Wageningen, Delft and Twente (ITC), in collaboration with the Balearic Islands University (UIB).

(System managers)

Welcome!

There are 21 questions in this survey

General user profile

This section should be completed **before** starting with the explanation over the ScGII potential capacities

1 [UP1]How old are you? *

Please choose **only one** of the following:

- ◯ ≤20
- ◯ 21-25
- ◯ 26-30
- ◯ 31-35
- ◯ 36-40
- ◯ 41-45
- ◯ 46-50
- ◯ 51-55
- ◯ 56-60
- ◯ ≥61

2 [UP2]What languages are you conversant in? *

Please choose the appropriate response for each item:

	1	2	3	4	5
English	◯	◯	◯	◯	◯
Catalan	◯	◯	◯	◯	◯
Spanish	◯	◯	◯	◯	◯
German	◯	◯	◯	◯	◯
French	◯	◯	◯	◯	◯
Others	◯	◯	◯	◯	◯

Indicate your hability level in each case. From nonexistent (1) to very high (5)

3 [UP3]What is your occupation at the UIB? *

Please choose **all** that apply:

- ☐ SSIGT Technician
- ☐ Teacher
- ☐ Researcher
- ☐ Administrative charge

4 [UP5]In which studies are you teaching and or researching? *

Please choose **only one** of the following:

- ○ Geography
- ○ Biology
- ○ Agriculture Engineering
- ○ Economy
- ○ Architecture Engineering
- ○ Computer Science Engineering
- ○ History
- ○ Journalism
- ○ Tourism
- ○ Others
- ○ None (0)
- ○ Other ____________

STRUCTURE, INTERFACE AND TECHNOLOGICAL SYSTEM BASES

5 [T0.1]Do you think the geoportal should be served in the SSIGT web site, or it should be in a separated web? Explain why *

Please choose **only one** of the following:

- SSIGT web
- Other web

Make a comment on your choice here:

6 [T0.2]What contents should be accessible through the geoportal's main page? *

Please choose **all** that apply:

- Map viewer/s
- Geo-Information catalogue
- Direct access to geo-services
- Direct access to GI downloads
- Other:

7 [T0.3]Is it necessary to include explicative texts for each section into the geoportal's main page? Explain why

Please choose **only one** of the following:

- Yes
- No

Make a comment on your choice here:

8 [T0.4]

Which secondary contents are in your opinion more important into the ScGII geoportal? Classify them from higher to lower relevance

*****

Please number each box in order of preference from 1 to 5

- Support Section/manual
- Informative section about the ScGII (About)
- News (blog/website)
- Feedback postbox
- Links

9 [T0.5]Should the catalogue / map viewer resources be accessible from the main page without intermediate pages? Explain why *

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

Make a comment on your choice here:

10 [T0.6]Which software should be implemented to construct the catalogue? Explain why *

Please write your answer here:

11 [T0.7]Should the system have a unique security control? or should it have a security control in every protected resource / content *

Please choose **only one** of the following:

- Unique security control
- Security control in each protected resource / content

Make a comment on your choice here:

12 [T0.8]Do you think the restricted contents should be accessed with the "Campus Extens" (Virtual UIB) user name and password? Explain why if it is necessary *

Please choose **only one** of the following:

- Yes
- No

Make a comment on your choice here:

13 [T0.9]Which software should be used to implement the map viewer? Explain why *

Please write your answer here:

14 [T0.10]Do you think research projects' map viewers should be directly accessible through the geoportal's main page? or just through the catalogue? Explain why *

Please choose **only one** of the following:

- ○ Just through the geoportal
- ○ From the geoportal's main page, and from the catalogue

Make a comment on your choice here:

VISUALIZATION

15 [T3.1]

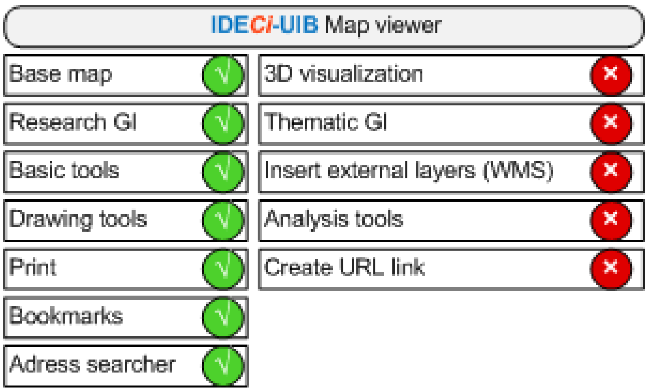
The current IDE-UIB's map viewer has basic contents and functionalities; however they can be improved. Indicate which of the next options you would eliminate, maintain, improve or add.

*

Please choose the appropriate response for each item:

	Delete	Maintain	Improve	Add
3D visualization	○	○	○	○
Layers from research projects	○	○	○	○
Thematic and descriptive layers	○	○	○	○
Add external layers (WMS)	○	○	○	○
Tools: query, zoom, legend, distance/area calculation, etc.	○	○	○	○
Analysis tools: environmental, insolation, buffer, etc.	○	○	○	○
Drawing tools and labels	○	○	○	○
Print: image, PDF	○	○	○	○

Currently, these are IDECi-UIB map viwer capabilities and shortages



CONTENTS MANAGEMENT

16 [C.1]Do you think the provider should be able to publish own GI on his own? Mention why *

Please choose **only one** of the following:

- Si
- No

Make a comment on your choice here:

The generation and maintainance of geoservices and applications should always the system's administrator work (SSIGT)

17 [C.2]In this case, what tasks should be carried out by the system manager? *

Only answer this question if the following conditions are met:
° Answer was A2'No' at question '16 [C.1]' (Do you think the provider should be able to publish own GI on his own? Mention why)

Please choose **all** that apply:

- Check the quality of geodata
- Check the quality of metadata
- Upload the geodatasets into the SSIGT repository
- Apply the provider's accessibility policies into the system
- Other:

The generation and maintainance of geoservices and applications should always the system's administrator work (SSIGT)

18 [C.3]Do you think that the ScGII should only distribute OGC standard services? or should it also distribute non-standard services (i.e. ArcGIS Service, ArcIMS)

Please choose **only one** of the following:

- Only standard services (OGC)
- Standard and other non-standard services

19 [C.4]Who should have access to thematic / descriptive GI? *

Please choose the appropriate response for each item:

	None	Geo-services	Download datasets	Both	No answer / unknown
Open access	○	○	○	○	○
Graduate students	○	○	○	○	○
Postgraduate students	○	○	○	○	○
Teachers and researchers	○	○	○	○	○

The open access data just refers to the contents published by the UIB, identified as open, or the contents published as open by other organizations or initatives.

20 [C.5]Who should have access to research projects? *

Please choose the appropriate response for each item:

	None	Geo-services	Download datasets	Both	No answer / unknown
Open access	○	○	○	○	○
Graduate students	○	○	○	○	○
Postgraduate students	○	○	○	○	○
Teachers and researchers	○	○	○	○	○

The open access data just refers to the contents published by the UIB, identified as open, or the contents published as open by other organizations or initatives.

21 [C.6]Who should have access to associated contents? *

Please choose the appropriate response for each item:

	None	Only consultation (just reading on screen)	Download datasets	No answer / unknown
Open access	○	○	○	○
Graduate students	○	○	○	○
Postgraduate students	○	○	○	○
Teachers and researchers	○	○	○	○

They include: text documents, statistics, hypermedia, etc.

The open access data just refers to the contents published by the UIB, identified as open, or the contents published as open by other organizations or initatives.

Thank you very much for your cooperation!

01.01.1970 – 01:00

Submit your survey.
Thank you for completing this survey.

ANNEX 4: Support materials for the Joint Analysis Design workshop

The workshops that took place just before the requirements analysis executions were supported with presentations explaining and showing how different use cases were working. Two different presentations were made for the two targeted groups of users: students (1) and teachers and researchers (2). They are just in Catalan since English is not necessarily understood by UIB members. They are attached in the next pages

Master of Science in Geographical Information Management and Applications
(GIMA MSc, The Netherlands)

Disseny centrat en l'usuari per la IDE Científica de la UIB

Estudi de requeriments
per a
Usuaris potencials

Llorenç J. Guasp Giner
email: llorenc.guasp@gmail.com

Universitat de les Illes Balears SSIGT GIMA Geographical Information Management and Applications

---

Estructura de la sessió:

1. Introducció a la recerca
2. Continguts de les IDEs
3. Explicacions / questionari

25 min aprox.

Avís important:

*Aquest és un **treball** de recerca **original** per estudiar la **viabilitat i potencialitats** de construcció d'una IDE Científica a la Universitat de les Illes Balears.*

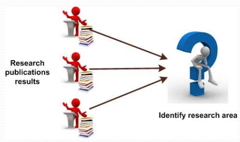
*El **SSIGT** de la UIB **podrà aprofitar** els resultats que **cregui convenients** per a la seva aplicació, si s'escau.*

---

1. Introducció:
La gestió del coneixement científic

Problemes:
1. **Creixement** de la **producció**
2. Dificultat per saber **que s'ha fet**
3. Dualitat: **gran producció** vs. **baixa accessibilitat**
4. Dificultat per **gestionar** aquests **continguts**

Solució:
IDE Científica



Accessibilitat al coneixement

---

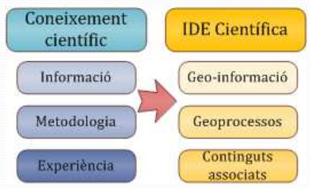
1. Introducció:
Objectiu i metodologia de la recerca

Objectiu:
Determinar quins haurien de ser els **continguts, estructura, interfície, eines i aplicacions** per a una IDE Científica de la UIB en base als **requeriments** dels **usuaris.**

Metodologia:
User-Centered Design (UCD)
Anàlisi de requeriments

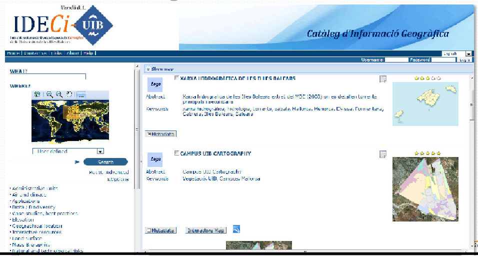
---

2. Continguts de la IDE Científica:
Continguts



2. Contingunts de la IDE Científica:
Components bàsics

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

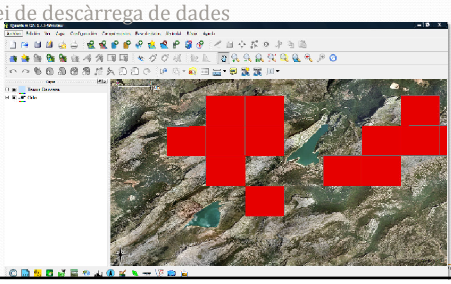


2. Contingunts de la IDE Científica:
Components bàsics

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

2. Contingunts de la IDE Científica:
Components bàsics

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

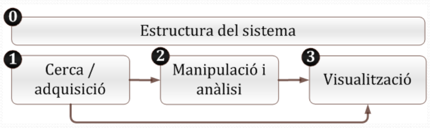


2. Contingunts de la IDE Científica:
Components bàsics

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

Questionari:
Tasques a realitzar

- Perfil d'usuari
- Tasca 0: Interfície i estructura del sistema
- Tasca 1: Cerca de dades
- Tasca 2: Manipulació i anàlisi de dades
- Tasca 3: Visualització



Questionari:
Accés a l'enquesta

Per favor, accediu al bloc:

http://blog-scgii.blogspot.com.es/

Podeu omplir la secció
de **Perfil d'usuari** del qüestionari

Tasca 0:
Interfície i estructura del sistema

Tasca 0:
INTERFÍCIE I ESTRUCTURA DEL SISTEMA

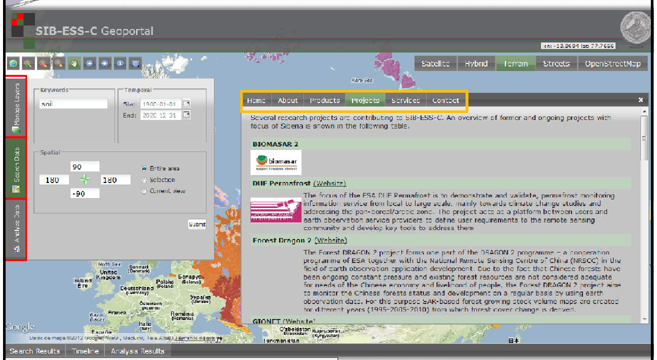
- Característiques
  - Útil
  - Fàcil d'emprar
  - Intuïtiu i simple
- **Seccions principals**
- Seccions secundàries

Tasca 0: INTERFÍCIE I ESTRUCTURA DEL SISTEMA
Suport, informació i enllaços

- Serveis de suport i ajuda
  - Manuals, FAQ,...
- Actualitzacions i notícies
- Propostes de millora
- Connexió a xarxes socials
- Enllaços
- Múltiples idiomes

IDEIB (I. Balears)
http://www.ideib.cat/

IDEE (Espanya)
http://www.idee.es/



SIB-ESS-C (Siberian Earth System Science Cluster)
http://www.sibessc.uni-jena.de

IDE-ULPGC (Univ. Las Palmas)
http://ide-ulpgc.eu

IDECi-UIB (UIB)
http://cedai.imedea.uib-csic.es

Fi de l'explicació de la Tasca 0

Ara per favor, **ompliu la TASCA 0 del questionari**

Tasca 1:

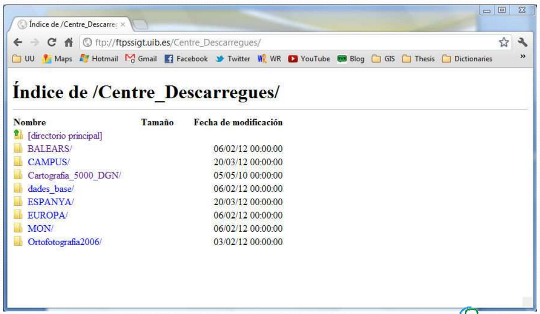
Cerca i adquisició de dades

Tasca 1: CERCA I ADQUISICIÓ

- Quin mètode de cerca?
- Quines dades?
- Amb informació associada?

Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

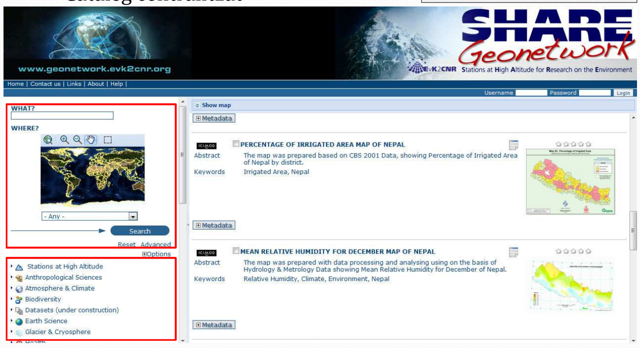
Directori (descàrrega de dades)



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

Catàleg centralitzat

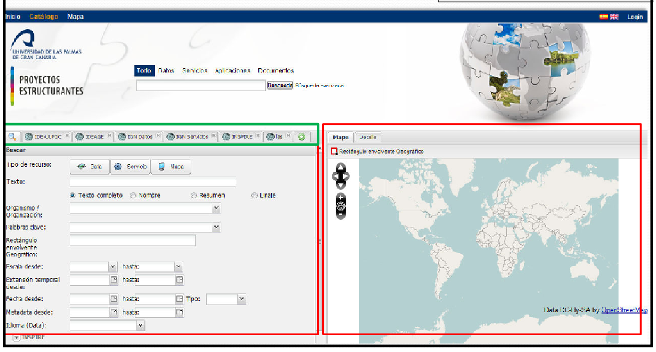
Evk2cnr SHARE
http://geonetwork.evk2cnr.org



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

Cerca per múltiples catàlegs

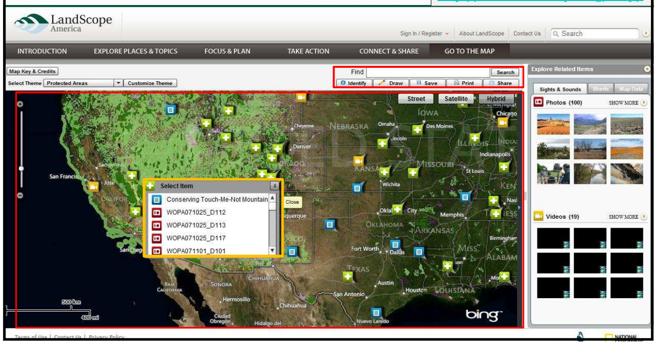
IDE-ULPGC (Univ. Las Palmas)
http://ide-ulpgc.eu/catalogue/



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

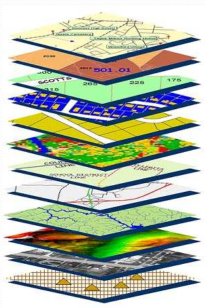
Mash-up

Landscope
http://www.landscope.org/map/



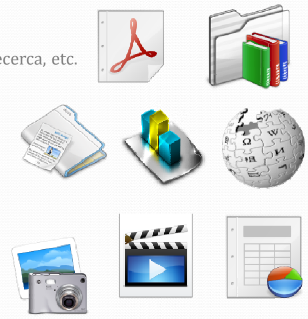
Tasca 1: CERCA I ADQUISICIÓ
Quines dades?

- Temàtiques
- Cronològiques
- Cobertura espacial



Tasca 1: CERCA I ADQUISICIÓ
Informació associada

- Documents de text
  - Articles, llibres, projectes de recerca, etc.
- Estadístiques i models
- Documents multimèdia
  - videos, fotos, àudio, etc.
- Enllaços d'hipermèdia:
  - aplicacions, enllaços web, etc.



Fi de l'explicació de la Tasca 1

Ara per favor, ompliu la **TASCA 1 del questionari**

Tasca 2:

Manipulació i anàlisi

Tasca 2: MANIPULACIÓ I ANÀLISI

- DADES: Informació Geogràfica

- MÈTODE: Eines d'anàlisi espacial
  (Eines de geoprocés)

Tasca 2: MANIPULACIÓ I ANÀLISI

- A través del navegador d'internet

- A través de programari SIG/CAD

Tasca 2: MANIPULACIÓ I ANÀLISI

Informació Geogràfica: Programari SIG/CAD

- Geoserveis / Serveis OGC (exemple: WMS)

IDE mallorca

Xarxa de carreteres

IDEIB Infraestructura de dades espacials de les Illes Balears

Imatge aèria 2008

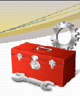
Geoserveis de **visualització**

Geoserveis de **descàrrega**

Quantum GIS

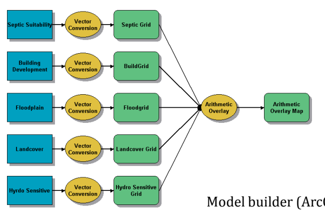
Tasca 2: MANIPULACIÓ I ANÀLISI

Eines d'anàlisi espacial



Característiques

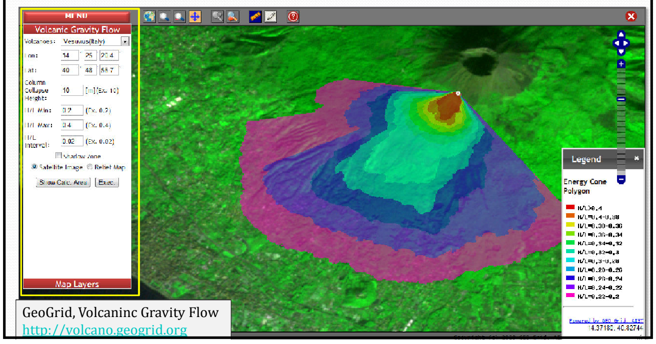
- Models de generació de dades
- Paràmetres costumitzables



Model builder (ArcGIS)

Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

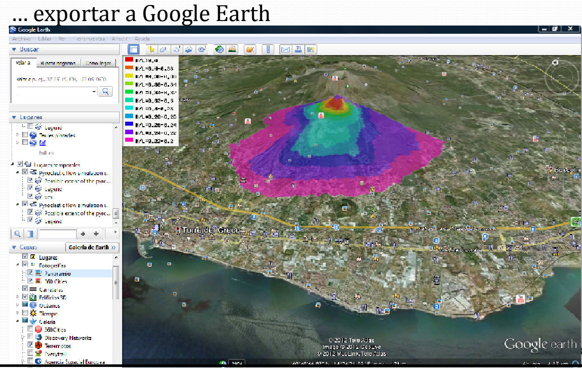
- Eina de geoprocés



GeoGrid, Volcaninc Gravity Flow
http://volcano.geogrid.org

Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

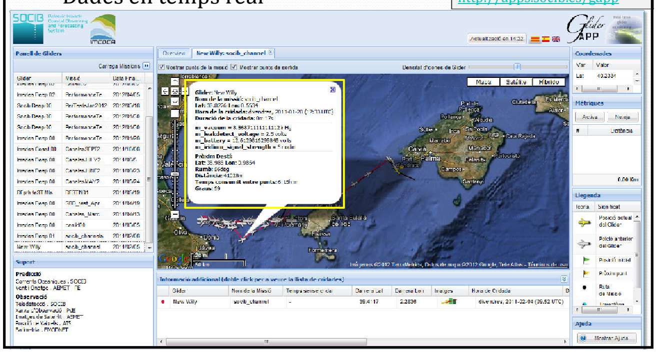
… exportar a Google Earth



Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

- Dades en temps real

SOCIB (IMEDEA) Glider App.
http://apps.socib.es/gapp



Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Programari SIG/CAD

Desenvolupament encara experimental i minoritari

Fi de l'explicació de la Tasca 2

Ara per favor, ompliu la **TASCA 2 del questionari**

Tasca 3:
Visualització

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

- Veure cartografia
- Realitzar consultes i operacions simples

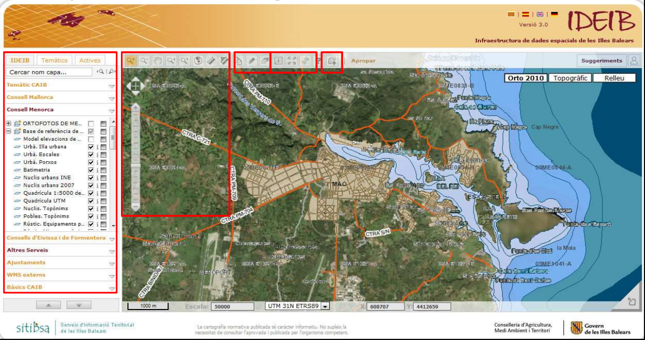
Cartografia temàtica	Cercador per adreça	Visualització 3D
Cartografia científica	Eines de dibuix	Impressió
Afegir capes externes (WMS)	Eines de consulta	
	Eines d'anàlisi	

GIMA 43

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Cartografia temàtica i eines bàsiques

Visualitzador IDEIB
(http://ideib.caib.es/visualitzador/visor.jsp)



Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

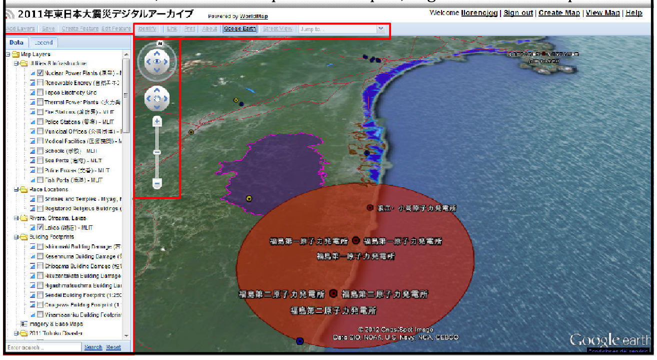
Cartografia científica, eines bàsiques i d'anàlisi espacial

Visualitzador SIB-ESS-C
(http://www.sibessc.uni-jena.de)

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Visualitzador WorldMap (Univ. Harvard)
(http://www.sibessc.uni-jena.de)

Visualització 3D, dades científiques i temàtiques, llegenda i eines bàsiques



Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Dades científiques i temàtiques, llegenda, eines de consulta i dibuix, impressió

GIMA 47

Fi de l'explicació de la Tasca 3

Ara per favor, ompliu la **TASCA 3 del questionari**

GIMA 48

Moltes gràcies per la vostra col·laboració!

Llorenç J. Guasp Giner
email: llorenc.guasp@gmail.com

GIMA 49

Master of Science in Geographical Information Management and Applications
(GIMA MSc, The Netherlands)

Tesina de Màster

Disseny centrat en l'usuari per la IDE Científica de la UIB

Estudi de requeriments
per a
Usuaris i proveïdors potencials

Llorenç J. Guasp Giner
email: llorenc.guasp@gmail.com

Supervisor principal: Dr. Corné van Elzakker (ITC)
Supervisor local: Dr. Maurici Ruiz Pérez (UIB)

Estructura de la sessió:

1. Introducció a la recerca
2. Continguts de les IDEs
3. Explicacions / questionari

35 min aprox.

Avís important:

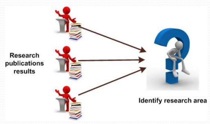
*Aquest és un **treball** de recerca **original** per estudiar la **viabilitat i potencialitats** de construcció d'una IDE Científica a la Universitat de les Illes Balears.*

*El **SSIGT** de la UIB **podrà aprofitar** els resultats que **cregui convenients** per a la seva aplicació, si s'escau.*

---

1. Introducció:
La gestió del coneixement científic

Problemes:
1. **Creixement** de la **producció**
2. Dificultat per saber **que s'ha fet**
3. Dualitat: **gran producció** vs. **baixa accessibilitat**
4. Dificultat per **gestionar** aquests **continguts**



Accessibilitat al coneixement

---

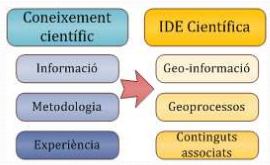
1. Introducció:
Objectiu i metodologia de la recerca

Objectiu:
Determinar quins haurien de ser els **continguts, estructura, interfície, eines i aplicacions** per a una IDE Científica de la UIB en base als **requeriments** dels **usuaris.**

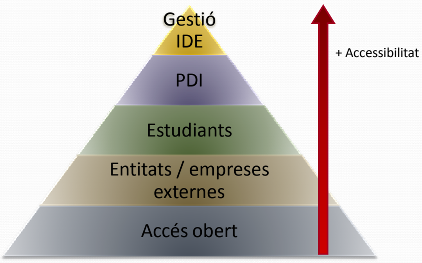
Metodologia:
User-Centered Design (UCD)
Anàlisi de requeriments

---

2. Continguts de la IDE Científica:
Continguts



2. Continguts de la IDE Científica:
Jerarquia d'usuaris i actors



GIMA 7

2. Continguts de la IDE Científica:
Jerarquia d'usuaris i actors

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

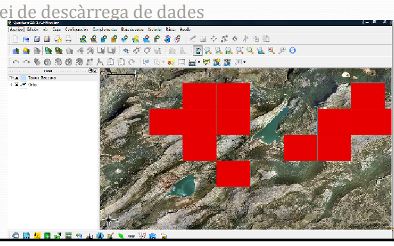
GIMA 8

2. Continguts de la IDE Científica:
Jerarquia d'usuaris i actors

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

2. Continguts de la IDE Científica:
Jerarquia d'usuaris i actors

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades



GIMA 10

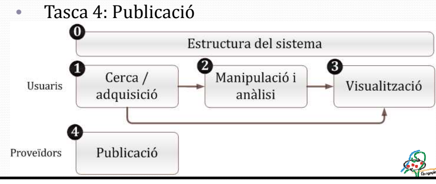
2. Continguts de la IDE Científica:
Jerarquia d'usuaris i actors

- Catàleg de metadades
- Visualitzador de mapes
- Geo-serveis
- Servei de descàrrega de dades

GIMA 11

3. Tasques a realitzar:
Estructura

- Perfil d'usuari
- Tasca 0: Interfície i estructura del sistema
- Tasca 1: Cerca de dades
- Tasca 2: Manipulació i anàlisi de dades
- Tasca 3: Visualització
- Tasca 4: Publicació



GIMA 12

Fi de la introducció

Ara per favor, ompliu la secció de **Perfil d'usuari** del qüestionari

Tasca 0:

Interfície i estructura del sistema

Tasca 0:

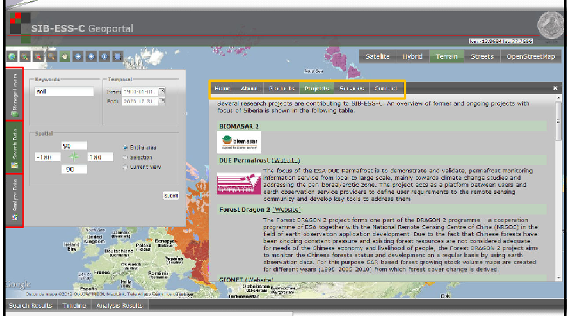
INTERFÍCIE I ESTRUCTURA DEL SISTEMA

- Característiques
  - Fàcil d'emprar
  - Útil
  - Intuïtiu i simple

IDEIB (I. Balears)
http://www.ideib.cat/

IDEE (Espanya)
http://www.idee.es/

IDEC (Catalunya)
http://www.geoportal-idec.cat



SIB-ESS-C (Siberian Earth System Science Cluster)
http://www.sibessc.uni-jena.de

GIMA 19

IDE-ULPGC (Univ. Las Palmas)
http://ide-ulpgc.eu

GIMA 20

IDECi-UIB (UIB)
http://cedai.imedea.uib-csic.es

Tasca 0: INTERFÍCIE I ESTRUCTURA DEL SISTEMA
Suport, informació i enllaços

- Serveis de suport i ajuda
  - Manuals, FAQ,...
- Actualitzacions i notícies
- Propostes de millora
- Connexió a xarxes socials
- Enllaços
- Múltiples idiomes

GIMA 22

Fi de l'explicació de la Tasca 0

Ara per favor, **ompliu la TASCA 0 del questionari**

GIMA 23

Tasca 1:
Cerca i adquisició de dades

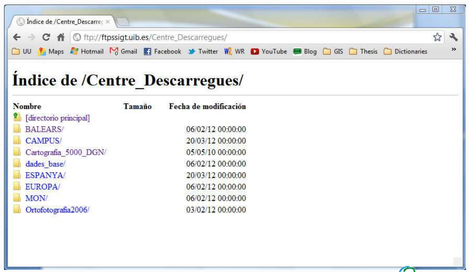
GIMA 24

Tasca 1: CERCA I ADQUISICIÓ

- Quin mètode de cerca?
- Quines dades?
- Amb informació associada?

Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

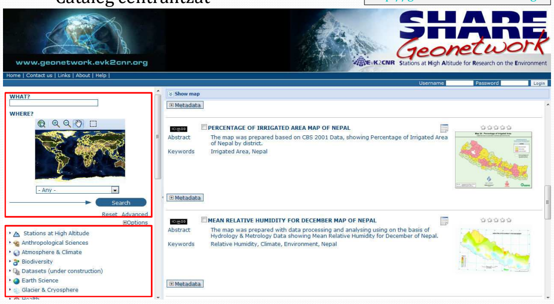
Directori (descàrrega de dades)



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

Catàleg centralitzat

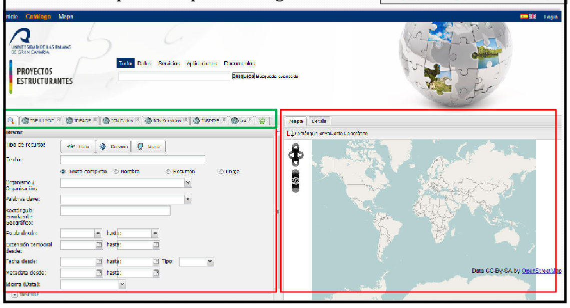
Evk2cnr SHARE
http://geonetwork.evk2cnr.org



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

Cerca per múltiples catàlegs

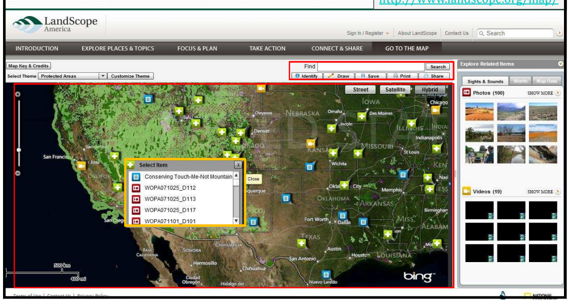
IDE-ULPGC (Univ. Las Palmas)
http://ide-ulpgc.eu/catalogue/



Tasca 1: CERCA I ADQUISICIÓ
Mètode de cerca

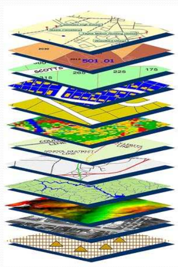
Mash-up

Landscope
http://www.landscope.org/map/



Tasca 1: CERCA I ADQUISICIÓ
Quines dades?

- Temàtiques
- Cronològiques
- Cobertura espacial



Tasca 1: CERCA I ADQUISICIÓ
Informació associada

- Documents de text
  - Articles, llibres, projectes de recerca, etc.
- Estadístiques i models
- Documents multimèdia
  - videos, fotos, àudio, etc.
- Enllaços d'hipermèdia:
  - aplicacions, enllaços web, etc.

GIMA 31

Fi de l'explicació de la Tasca 1

Ara per favor, ompliu la **TASCA 1 del questionari**

GIMA 32

Tasca 2:
Manipulació i anàlisi

GIMA 33

Tasca 2: MANIPULACIÓ I ANÀLISI

- DADES: Informació Geogràfica
- MÈTODE: Eines d'anàlisi espacial
  (Eines de geoprocés)

GIMA 34

Tasca 2: MANIPULACIÓ I ANÀLISI

- A través del navegador d'internet

- A través de programari SIG/CAD

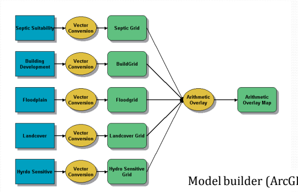
GIMA 35

Tasca 2: MANIPULACIÓ I ANÀLISI
Informació Geogràfica: Programari SIG/CAD

GIMA 36

Tasca 2: MANIPULACIÓ I ANÀLISI
Eines d'anàlisi espacial

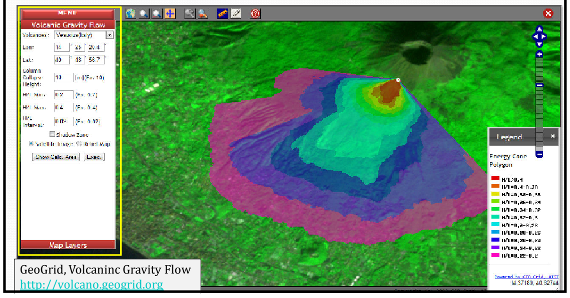
Característiques
- Models de generació de dades
- Paràmetres costumitzables



Model builder (ArcGIS)

Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

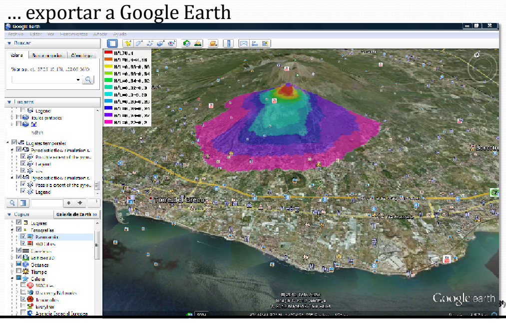
- Eina de geoprocés



GeoGrid, Volcaninc Gravity Flow
http://volcano.geogrid.org

Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

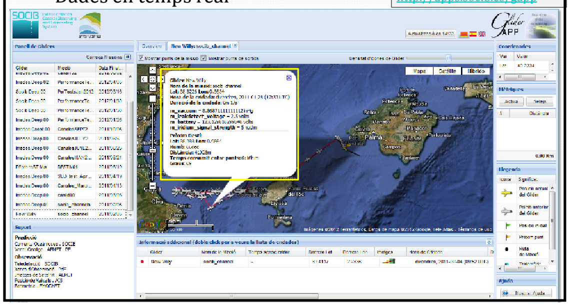
... exportar a Google Earth



Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Navegador web

- Dades en temps real

SOCIB (IMEDEA) Glider App.
http://apps.socib.es/gapp



Tasca 2: MANIPULACIÓ I ANÀLISI
Anàlisi espacial: Programari SIG/CAD

Desenvolupament encara experimental i minoritari

Fi de l'explicació de la Tasca 2

Ara per favor, ompliu la **TASCA 2 del questionari**

Tasca 3: Visualització

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

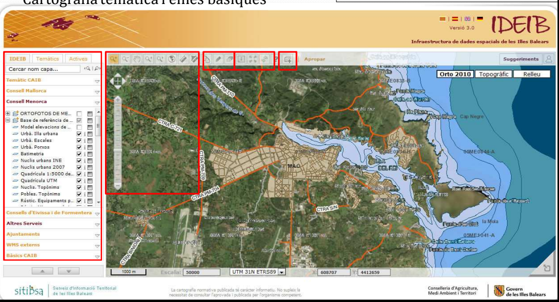
- Veure cartografia
- Realitzar consultes i operacions simples

Cartografia temàtica	Cercador per adreça	Visualització 3D
Cartografia científica	Eines de dibuix	Impressió
Afegir capes externes (WMS)	Eines de consulta	
	Eines d'anàlisi	

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

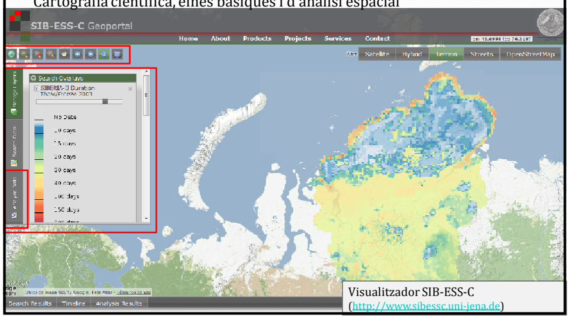
Visualitzador IDEIB
(http://ideib.caib.es/visualitzador/visor.jsp)

Cartografia temàtica i eines bàsiques



Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Cartografia científica, eines bàsiques i d'anàlisi espacial

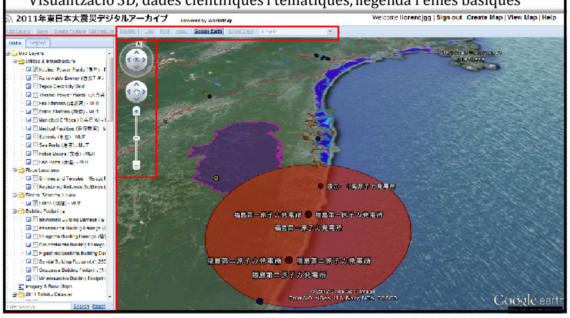


Visualitzador SIB-ESS-C
(http://www.sibessc.uni-jena.de)

Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Visualitzador WorldMap (Univ. Harvard)
(http://www.sibessc.uni-jena.de)

Visualització 3D, dades científiques i temàtiques, llegenda i eines bàsiques



Tasca 3: VISUALITZACIÓ
Visualitzador de mapes

Visualitzador IDECi-UIB
(http://ftpssigt.uib.es/campus/)

Dades científiques i temàtiques, llegenda, eines de consulta i dibuix, impressió

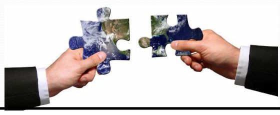
Fi de l'explicació de la Tasca 3

Ara per favor, ompliu la **TASCA 3 del questionari**

Tasca 4: Publicació de projectes de recerca

Tasca 4: PUBLICACIÓ
Avantatges

1. **Benefici comú**: compartir dades → potenciar la producció
2. Servei als grups de recerca: **eines de treball i publicació**
3. Potencia la **interactivitat / col·laboració**
4. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
5. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
6. Mitjà de **protecció de la propitat intel·lectual**



Tasca 4: PUBLICACIÓ
Avantatges

1. **Benefici comú**: compartir dades → potenciar la producció
2. **Eina de treball** a grups de recerca
3. Potencia la **interactivitat / col·laboració**
4. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
5. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
6. Mitjà de **protecció de la propitat intel·lectual**

Tasca 4: PUBLICACIÓ
Avantatges

1. **Benefici comú**: compartir dades → potenciar la producció
2. Servei als grups de recerca: **eines de treball i publicació**
3. Potencia la **interactivitat / col·laboració**

   (Canals de col·laboració)
   - entre investigadors **locals**
   - amb altres universtats, inst. de recerca, empreses, etc. **remotes**

1. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
2. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
3. Mitjà de **protecció de la propitat intel·lectual**

Tasca 4: PUBLICACIÓ
Avantatges

1. **Benefici comú**: compartir dades → potenciar la producció
2. Servei als grups de recerca: **eines de treball i publicació**
3. Potencia la **interactivitat / col·laboració**
4. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
5. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
6. Mitjà de **protecció de la propitat intel·lectual**
   - **Segell de temps**

Tasca 4: PUBLICACIÓ
Avantatges

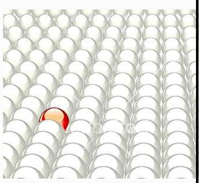
1. **Benefici comú**: compartir dades → potenciar la producció
2. Servei als grups de recerca: **eines de treball i publicació**
3. Potencia la **interactivitat / col·laboració**
4. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
5. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
6. Mitjà de **protecció de la propitat intel·lectual**
   - **Segell de temps**

Tasca 4: PUBLICACIÓ
Avantatges

1. **Benefici comú**: compartir dades → potenciar la producció
2. Servei als grups de recerca: **eines de treball i publicació**
3. Potencia la **interactivitat / col·laboració**
4. Mitjà de **promoció** del grup de recerca: dins i fora de la UIB
5. Mitjà de **validació** de **qualitat, veracitat, legitimitat** de resultats de la investigació
6. Mitjà de **protecció de la propitat intel·lectual**
   - **Segell de temps**

Tasca 4: PUBLICACIÓ
Requeriments de les dades a publicar:

1. **Unicitat** de les dades / mètodes d'anàlisi
2. **Qualitat**
3. Afegir **continguts complementaris** adicionals
4. **Metadades**

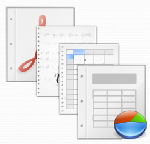


Tasca 4: PUBLICACIÓ
Requeriments de les dades a publicar:

1. **Unicitat** de les dades / mètodes d'anàlisi
2. **Qualitat**
3. Afegir **continguts complementaris** adicionals
4. **Metadades**

Tasca 4: PUBLICACIÓ
Requeriments de les dades a publicar:

1. **Unicitat** de les dades / mètodes d'anàlisi
2. **Qualitat**
3. Afegir **continguts complementaris** adicionals
   - Màxim de continguts; no només la publicació
4. **Metadades**



Tasca 4: PUBLICACIÓ
Requeriments de les dades a publicar:

1. **Unicitat** de les dades / mètodes d'anàlisi
2. **Qualitat**
3. Afegir **continguts complementaris** adicionals
4. **Metadades**
   - Eina de catalogació, gestió d'accessibilitat

Tasca 4: PUBLICACIÓ
Mitjans de publicació

1. Catàleg de metadades
   - Identificació
   - Polítiques d'accés
   - Coordenades, resolució espacial
2. Geoserveis (dades i/o anàlisi)
3. Descàrrega
4. Visualitzador de mapes / Aplicacions de geoprocés

Què?
Per a què?
On?
Qui?

Tasca 4: PUBLICACIÓ
Mitjans de publicació

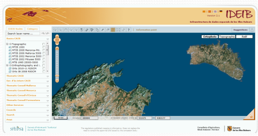
1. Catàleg de metadades
2. Geoserveis
   - Visualització (WMS)
   - Descàrrega (WFS/WCS)
   - Geo-procés (WPS)
3. Descàrrega
4. Visualitzador de mapes / Aplicacions de geoprocés

Tasca 4: PUBLICACIÓ
Mitjans de publicació

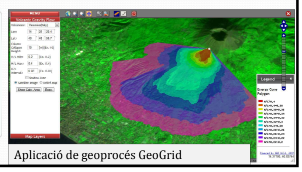
1. Catàleg de metadades
2. Geoserveis (dades i/o anàlisi)
3. Descàrrega
4. Visualitzador de mapes

Tasca 4: PUBLICACIÓ
Mitjans de publicació

1. Catàleg de metadades
2. Geoserveis (dades i/o anàlisi)
3. Descàrrega
4. Visualitzador de mapes / Aplicacions de geoprocés
   - Només per consultar dades
   - Eines (caixa negra)



Visualitzador IDEIB



Aplicació de geoprocés GeoGrid

Tasca 4: PUBLICACIÓ
Politiques d'accessibilitat

1. **Catàleg transparent** per consulta
2. Definició del nivell de protecció:
3. **Accés LIMITAT** segons cada **proveïdor**

Tasca 4: PUBLICACIÓ
Politiques d'accessibilitat

1. **Catàleg transparent** per consulta
2. Definició del nivell de protecció:
   1. Copyright
   2. Dret de propitat intel·lectual
   3. Patent
   4. Restringit
3. **Accés LIMITAT** segons cada **proveïdor**

Tasca 4: PUBLICACIÓ
Politiques d'accessibilitat

1. **Catàleg transparent** per consulta
2. Definició del nivell de protecció
3. **Accés LIMITAT** segons cada **proveïdor**
   - Només al grup de recerca
   - Al PDI de la UIB
   - Comunitat universitària UIB
   - Accés obert

GIMA 67

Tasca 4: PUBLICACIÓ
Eines de geo-col·laboració

Col·laboració multidisciplinar dins un mateix **espai geogràfic**

1. Espai web o blog
2. Espai Wiki
3. Mash-up

GIMA 68

Tasca 4: PUBLICACIÓ
Eines de geo-col·laboració

Col·laboració multidisciplinar dins un mateix **espai geogràfic**

1. Espai web o blog
2. Espai Wiki
3. Mash-up

wikispaces
wikis for everyone

GIMA 69

Tasca 4: PUBLICACIÓ
Eines de geo-col·laboració

Col·laboració multidisciplinar dins un mateix **espai geogràfic**

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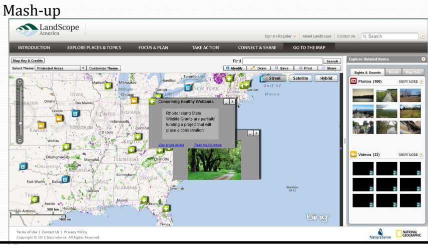

GIMA 70

Fi de l'explicació de la Tasca 4

Ara per favor, ompliu la **TASCA 4 del questionari**

GIMA 71

Moltes gràcies per la vostra col·laboració!

Llorenç J. Guasp Giner
email: llorenc.guasp@gmail.com

GIMA 72

ANNEX 5: External partners questionnaire

Potential external partners were contacted by telephone or email and were asked to answer a brief questionnaire. It is presented below, firstly presenting the research project, and then going through some open and some multiple-choice questions.

. . . .

QUESTIONNAIRE FOR POTENTIAL EXTERNAL PARTNERS IN THE IDE*Ci*-UIB

(English)

Mr. / Miss

The GIS and RS Service (SSIGT) at the Balearic Islands University (UIB) is currently working on the development of a Geographic Information Infrastructure (GII) for science, to support research and education activities inot this university. Moreover it also pretends to disseminate UIB's production into the society. The so called IDECi-UIB prototype is accessible through the next link: IDECi-UIB

In the meanwhile, a Requirements Analysis study is realized, to evaluate potential users', providers' and external partners' needs into this infrastructure. This study is framed into a collaborative project between Utrecht (Netherlands) and Balearic Islands (Spain) universities.

This assessment pretends to determine how the GII should be to considering potential users' and stakeholder's criteria. Stakeholders are maily into the UIB's community; nevertheless, it is interesting to analyze other entrreprises or entities who might want to collaborate somehow into the UIB's Scientific Geographic Information Infrastructure.

This questionnaire tries to reveal whether your organization would agree on collaborating somehow with this new UIB's initiative.

Would be great if you could respond to this questionnaire. It does not matter if the response is NO. If responded, the study would be more valid and realistic. This questionnaire just has 9 questions, which can be answered in less than 5 minutes.

Please, edit it with Word or similar and send it back in the same format.

Thank you very much for your collaboration in advance,

Kind regards,

Llorenç Guasp Giner

Organization's profile:

1. What's the organization / enterprise name?

   ………

   If required, which department / section? ………………………………………………

2. In which productive sector does your organization / enterprise work?

   (select all preferred fields)

   a. Agriculture, cattle, fisheries or forestry
   b. Extractive industries
   c. Manufacturing industries
   d. Energy supply
   e. Water supply and sewage
   f. Construction
   g. Trade
   h. Transport and logistics
   i. Hotel management
   j. Information and Communications
   k. Finances and insurance activities
   l. State agencies
   m. Administrative activities and auxiliar services
   n. Public administration and defense
   o. Education
   p. Health and social activies and services
   q. Artistic, recreative and enterntainement activities
   r. Housework activities
   s. Extraterritorial activities

   (Economic activities classification in Spain, Spanish Statistics Institute (INE)).

3. What type of orgaization are you?
   a. Private enterprise
   b. Public administration or institution
   c. Non-Governmental Organization (NGO)

4. Do you work with geospatial information?

   Yes/No

5. If the response was YES, in which activitives?

   (select all preferred fields, and if necessary add more)

   a. Cartographic production
   b. Decision-making support
   c. Environmetal / territorial consultancy
   d. Topography and geodesy
   e. Remote Sensing
   f. Aerial imagery production
   g. Others. Indicate which…………………

Knowledge and use of GIIs

6. Do you know what Geographical Information Infrastructures / Spatial Data Infrastructures (GII / SDI) are?

Yes / No

7. If the response was ***YES***, which GIIs do you use to work with?
    a. IDEIB
    b. IDE Mallorca
    c. IDE Menorca
    d. IDEE
    e. Others, please define…………
    f. Unknown / no answer

Collaboration with the UIB's GII

8. Would you like to collaborate with the UIB through the Scientific GII?

    Yes / No

9. If the response was ***YES***, how would you like to collaborate?
    (It is assumed that this collaboration involves geographical information contents and/or methods)

    a. Disseminate own contents or technologies
    b. Collaborate with research projects
    c. Establish some other kind of relationship. Please specify your interest……………….

IMPORTANT ADVICE: This is just a hipotetical and evaluative study. The response of this questionnaire does not bind or link your organization with the Balearic Islands University in any way. It does not stablish any formal agreement. The responses just involve the organization, but not any individual.