(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

Estimating the costs of an SDI-based project

J. Nogueras-Iso, R. Béjar, M.A. Latre, E. Fernández-Villoslada, P.R. Muro-Medrano, and F.J. Zarazaga-Soria

Computer Science and Systems Engineering Department
University of Zaragoza
María de Luna 1, 50018 Zaragoza, Spain
{jnog, rbejar, latre, evaf, prmuro, javy}@unizar.es

Summary. The development of any information system entails a set of costs that must be estimated well in advance. The estimation of costs facilitates an appropriate project planning and helps monitoring the different project tasks, verifying whether the expected cost of tasks is out of step with their real development. Given the multidisciplinary nature of Spatial Data Infrastructures (SDI), the estimation of costs for SDI-based projects is particularly complex. Apart from the complexity of technical aspects, they usually require the coordination of resources coming from different institutions in the public and private arenas. In such complex scenarios, the task of estimating may benefit from the development of small prototypes that can help the large scale estimation. This work estimates the costs for the implementation of an SDI-based project (SDIGER) in the European context based on the background given by a first prototype.

Key words: Cost estimation, Spatial Data Infrastructures, SDI, INSPIRE, European SDI, Water Framework Directive, WFD

1 Introduction

The first activity in process management for the development of an information system is the development of a project management plan. For providing an accurate project management plan, it is necessary to make a correct estimation of the resources that will be needed along the project. Around this estimation of costs, project managers can provide an estimated budget to the clients that requested the development of the information system, schedule the development activities, and assign the associated resources. Moreover, this estimation of costs is used in many cases as a decision-making instrument by both clients and project developers. On the one hand, clients may decide which is the best offer among the different possible developer companies. On the other hand, the project developers may decide the feasibility of the project according to the budget limitations imposed by the client. Additionally, the estimation of costs helps monitoring the different project tasks,

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

verifying whether the expected cost of tasks is out of step with their real development. And in turn, the gap between expected and real costs provides the feedback to create a baseline history to improve future estimations.

Taking into consideration the development of projects strongly related with geographic information, it is worthwhile considering the influence of the new concept of Spatial Data Infrastructures (SDI). The increasing relevance of geographic information for decision-making and resource management in diverse areas of government has promoted the creation of this kind of infrastructures, which are usually defined as the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data [1]. The widespread use of the SDI concept has meant an important revolution in the geographic information community, moving from monolithic and stand-alone applications towards a dynamic and cooperative environment of services and applications [2].

However, the development of a project on the basis of existent SDI services does not necessarily imply an easier project management. Despite the clear advantages derived from the use of SDIs, the task of estimating the costs increases in complexity given the special features of them. Their multidisciplinary nature involves the combination of very diverse technologies such as distributed computing, information retrieval, spatial data bases, geographic analysis, multimedia or remote sensing. Furthermore, in addition to the complexity of technical aspects, they usually require the coordination with public and private institutions which are responsible (provider, publishers) for the spatial information resources accessed, managed or exploited in an SDI-based project. That is to say, the development of SDI-based projects usually imply the integration of technologies from very different disciplines, the development of technology for new added-value functionality, and a not inconsiderable sum of activities devoted to the political aspects (rights, permissions, agreements) involved in the access to spatial information resources.

Economics and Software Engineering disciplines usually recommend that previous to the estimation of costs/resources it is necessary to estimate appropriately the size of a project. Based on the estimation of size and a history (*know-how*) of productivity by the development team, project managers can provide an estimation of costs. The Software Engineering discipline proposes several techniques for size estimation based on *fuzzy-logic*, *function points*, *standard components* or more sophisticated methods like *Delphi* estimations [3]. All these techniques have in common two things: they are based on baseline history of previous projects, and all of them use some software related unit of measure such as *lines of code* or total number of *function points*. However, these two assumptions are not valid for SDI-based projects. On the one hand, there is not such a background history of SDI-based projects that facilitate the estimation of size for individual activities. On the other hand, many of the activities (e.g., data modelling, access rights negotiation, ...) are not directly connected with typical software deliverables (e.g., analysis and design documents, source code, user manuals,...). Thus, it is not easy to estimate

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

the size of an SDI in terms of *lines of code* or similar software size measures. This also restricts the applicability of techniques for the estimation of costs (i.e., manpower, project duration). Most of cost estimation techniques that are based on parametric models (e.g., COCOMO) use *lines of codes* (or similar measures) as the main attribute of the product to be estimated.

Therefore, in such a complex scenario it seems sensible to apply other approaches for an accurate cost estimation of an SDI-based project. This work proposes the development of small prototypes in order to gain the experience that can facilitate the final large scale estimation. This approach is somehow connected with those methods for cost estimation that are based on project analogies (or case-based reasoning) [4]. The prototype acts as a replacement for a background history of SDI-based projects. Additionally, it provides an accurate basis for the estimation of each activity in terms of cost measures such as manpower.

The objective of this paper is to present the work done during the development of the SDIGER Project [5] as concerns with a prospective study for the implementation of an SDI-based project at the European level. SDIGER[1] is a pilot project of the proposal for a European directive with the aim of establishing an infrastructure for spatial information in Europe (INSPIRE)[6]. And as a pilot project it aimed at demonstrating the feasibility and advantages of the solutions for sharing spatial data and services following INSPIRE principles, estimating the costs, and finding the problems and obstacles of implementing interoperability-based solutions on the basis of real cases. Therefore, this project was structured in three main steps: the proposal for an SDI-based application scenario involving typical problems in the European context such as inter-administrative and cross-border coordination; the implementation of a small prototype for the application scenario; and a third phase devoted to the analysis of the experience acquired, the identification of problems, and a prospective study of the implementation of the proposed scenario at a real European level.

The application scenario at the SDIGER project proposed the development of an inter-administrative and cross-border SDI to support access to environmental resources, in particular the geographic information resources concerned with the Water Framework Directive (WFD) [7]. Additionally, two added-value applications were proposed in this application scenario to exemplify useful applications for the users: a WFD Reporting application, and a Water Abstraction Request application. The first one is devoted to perform the reporting activities required by the WFD to the member states in an INSPIRE compliant way, i.e. the required data and information is directly accessible from an SDI. And the second use case is oriented to improve the administrative processes initiated by the citizens that want to obtain a water abstraction authorization for private uses. With respect to the prototype implemented, the SDIGER project selected the cross-border area between

[1] http://www.sdiger.net

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

France and Spain, which involves the two main River Basin Districts (RBD) on both sides of the border: the Adour-Garonne basin district and the Ebro basin district. The area covered by this SDI project is particularly interesting because although most of the Adour and Garonne river basins lay in French territory and Ebro river basin lay in Spanish territory, in both cases some stream and river headwaters are located in the other country. This prototype involves, at both sides of the border, access to SDI services both from the national mapping agency and from the WFD Competent Authorities of each RBD involved. In Spain, they are the *Instituto Geográfico Nacional* and the Ebro River Basin Authority (*Confederación Hidrográfica del Ebro*), while in France, they are the *Institut Géographique National* and the Water Agency for the Adour-Garonne River Basins (*L'Agence de l'Eau Adour-Garonne*). Additionally, this prototype had to fulfil the requirement of providing a multilingual interface in Spanish, French and English.

The rest of this paper is structured as follows. Next section describes the prerequisites for the estimation of an extrapolated context of the SDIGER concept. That is to say, it proposes an appropriate unit of measure, a scalable way of increasing the area covered by the SDI, and a decomposition of activities to perform in the project. Then, based on the figures derived from the costs of implementing the prototype in the cross-border area of France and Spain, section 3 estimates the cost of implementing SDIGER at national and European levels. Section 4 describes the expected impact, in qualitative terms, of the implementation of SDIGER at the European level. Finally, the paper ends with some conclusions.

2 Prerequisites for the estimation of an extrapolated context

2.1 Definition of the geographic extent and its granularity

One of main problems in the estimation of the costs for the implementation of SDIGER at the European level is the heterogeneity that can be found in two main aspects: the administrative organization of the member states of the European Union; and the status of technologies together with the availability of data in the context of Spatial Data Infrastructures.

The heterogeneity in the administrative organisation of the country affects in the definition of granularity used to extrapolate the SDIGER prototype. One could consider the extrapolation of the SDIGER prototype as the addition of a new country into play, i.e. the involvement of a new National Mapping Agency, a new Environment Agency, and so on. However, this assumption is not realistic because many European countries (including France and Spain, involved in the SDIGER application scenario) instead of establishing centralised agencies at the National level have delegated these responsibilities into federal/regional agencies, applying the INSPIRE principle that states

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

that *"Data should be collected once and maintained at the level where this can be done most effectively"*. In fact, the SDIGER prototype implemented at both sides of the border between France and Spain has not faced all the possibilities because the range of possibilities for administrative organization is very wide. It is not just a decision between federal and centralized. Although France is more centralised than Spain, Spain is not an example of federal country like Germany. And the case of United Kingdom or Belgium is again quite different from Germany.

The heterogeneity in the status of SDI technology makes more complex this extrapolation exercise because it is not possible to assume a basic infrastructure. In fact, the estimation of costs for an extrapolated scenario must be flexible enough to provide accurate estimations for all cases: not infrastructure at all, some services available, or availability of an advanced SDI availability.

Therefore, we have considered appropriate to use a River Basin District (RBD) together with its respective competent authority as the incremental unit for an extrapolated context. There are two main reasons for this election. On the one hand, each RBD is an indivisible unit whose responsibility lays in one RBD Competent Authority in each member state. As defined in Article 2(1) of the WFD[7], *"a 'river basin district' means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management or river basins"*. On the other hand, the status of technology and data availability is or should be quite homogeneous. Since the Water Framework Directive (WFD) entered into force, each member state is obliged to provide the European Commission with a series of datasets and reporting data at concrete deadlines, data that each member state obtains from each of their RBD Competent Authorities. These datasets are precisely the layers that are required for the proposed added-value applications. Nowadays, the status of technology at RBD Competent Authorities is not uniform, but in the future (being the WFD at a more advanced implementation status) all RBD Competent Authorities should reach a comparable technological level to provide the required data. At least, the infrastructure required for a RBD is restricted enough to provide a reasonable estimation.

2.2 Definition of the unit of measure

Another additional problem for the cost estimations of an SDI-based project is the selection of an appropriate unit of measure.

A first approach would have been the selection a monetary unit to be able to include in the estimations both the cost of the human resources and the required hardware and software products (e.g., data application server hardware, operating system, RDBMS engine, development environment, ...). Nevertheless, it is not sensible to include hardware&software costs in the estimations because the experience says that the price of most commercial products is not fixed and depends on many unknown factors, e.g. the nature of the

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

client, number of machines involved, public impact of the project, hard&soft acquisition policies (e.g., everything under *linux* platform, open source strategy, ...), or tax policies in every country. The only thing that can be agreed in a general context is that hard&soft solutions will have a similar cost regarding the human resources needed for installation and customization.

Table 1. Relationship between training/experience level and *normalized working days*

Level of training and experience	***Normalized working days* per day**
Project manager (>3 years of experience)	3
Project manager (<3 years of experience)	2
Software engineer (>3 years of experience in analysis)	2.5
Software engineer (<3 years of experience in analysis)	1.5
Software engineer (>3 years of experience in design)	1
Software engineer (<3 years of experience in design)	0.75
Software programmer (>3 years of experience)	0.75
Software programmer (<3 years of experience)	0.5
Metadata creator (>3 years of experience)	0.5
Metadata creator (<3 years of experience)	0.25
System administrator (>3 years of experience)	1
System administrator (<3 years of experience)	0.75
Geodesic engineer (>3 years of experience)	1.5
Geodesic engineer (<3 years of experience)	1
Geographer (>3 years of experience)	1
Geographer (<3 years of experience)	0.75

On the other hand, the cost of the man-power has many differences across the different member states of the European Union. This circumstance does not allow a uniform pricing of man-power. Therefore, the final decision has been the definition of a *normalized working day* as the standard unit used for the evaluation and estimation for the cost of project activities. This standard unit corresponds with the work done during one working day (37.5 working hours per week, that is 7.5 working hours per day) by a *normalized employee*. A *normalized employee* represents the abilities of a medium/high level expert in one specific area. Table 1 presents a set of equivalences between the different levels of training/experience and their corresponding productivity in *normalized working days*. The use of this kind of equivalence tables is a common practice for budgeting, even for tenders in public calls.

2.3 Analysis of activities to estimate

This section provides a description of the activities needed for the implementation of the application scenario proposed in the SDIGER project. These activities can be categorized in three levels: assumed activities (1); modelling and reusable activities (2); and context-specific activities (3).

The first level (assumed activities) encompasses the activities that are assumed by the institutions that are going to participate in an extrapolated context. It is taken for granted that these institutions have a minimum set of

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

information which is absolutely necessary for the development of the project: geospatial data layers required for the applications proposed in the application scenario; the geographic features that will used to create the contents of the gazetteer service; and sufficient information about the legislations and regulations that dictate the administrative processes connected to the added-value applications. If this information is not available, these institutions are not suitable for the participation in the implementation of the extrapolated context.

The second level of activities (modelling and reusable activities) consists of the activities that have been fulfilled for the SDIGER prototype and that can be reused in an extrapolated context, i.e. these activities do not need to be redone. The activities in this category include the definition of models, development of methodologies and technology, and decisions taken as regards third party software and hardware. Examples of activities related with the definition of models are the definition of the application scenario, the definition of metadata profiles, and the definition of conceptual models for geospatial data and gazetteer contents. As regards technology, the following tools and implementations were carried out: a metadata edition tool, an internationalized geoportal, client interfaces for catalog and gazetteer services, implementation and configuration of an internationalized map viewer, web applications for the proposed add-value application, and software for the multilingual customization of the geoportal and the applications. Additionally, other activities related with deciding the acquisition of hardware/software and general project management must be considered.

The third level of activities (context-specific activities) consists of the activities depending directly on the features of the extrapolated context and the institutions involved, i.e. RBD competent authorities are responsible of most of these activities and they must be instantiated at each RBD. Under this category the following activities can be considered: re-engineering of data to fill the contents of web applications, gazetteer and thesaurus services; metadata collection; configuration of services (catalog services, gazetteer, data access, thesauri etc); multilingual adaptation of tools and interfaces; customization of the web application (this activity includes the study of legislation and the adjustment of application parameters); and maintenance of servers. Additionally, we must also consider here the efforts devoted to the acquisition of hardware and software, which depend on the specific situation of the institutions involved in the project, as well as other activities related to the communication and coordination with project managers.

It is worth mentioning that the estimation of costs in section 3 must focus on the activities considered in the second and third levels because the activities considered in the first level are taken for granted in an extrapolated context. The estimation of costs of the second level activities will represent the fixed costs (overheads) of the implementation whatever number of RBDs and competent authorities is considered. Additionally, it is necessary to pay special attention to the estimation of costs for the third level activities since they

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

represent the cost of incorporating/extending the scenario to a new RBD and competent authority. As it has been mentioned above, these activities depend on the nature of the institutions involved.

Therefore, in order to develop the estimation, it will be necessary to consider first the cost of modelling and reusable activities on the basis of the real costs that were measured for the implementation of the SDIGER prototype. And secondly, it will be necessary to estimate the costs of the activities depending on the nature of the entities involved in the application scenario. These costs can be considered as variable costs.

Last, it must be noticed that a further detailed description of this analysis of activities can be found in section 2 of the Study Report deliverable of the SDIGER project [8].

3 Estimation of the costs for the implementation of SDIGER at national and European levels

The objective of this section is to provide the cost estimation of the activities described in section 2.3. With these estimations it is possible to derive a formula to obtain the cost estimation for a flexible number of River Basin Districts and its respective competent authorities. In particular, the costs for the implementation at national and European levels are studied.

In order to carry out the cost estimation of the extrapolation scenario, table 2 presents a summary of the costs per activity facilitating the following information:

- *Normalized working days to develop 1 activity instance (WD).* This is the cost in normalized working days to complete one activity instance. That is to say, if a particular SDIGER implementation needs the configuration of several portrayal services (one per RBD), column *WD* only contains the estimation for the configuration of one instance. It must be noticed that the figures for this estimation are based on the generalization of the real costs measured for the implementation of the SDIGER prototype in the cross-border area of France and Spain. Section 3 of [8] provides a detailed justification for the estimation of these figures.
- *Scalability Factor (SF).* This column is only applicable for context-specific activities, which are dependent on the features of a particular implementation: number of river basin districts (RBD) covered, number of languages to be supported, number of selected thesauri, or number of years for service maintenance. Therefore, this column indicates the way to scale each context-specific activity for an extrapolated scenario. That is to say, this column explains how to compute the number of instances of each activity in an extrapolated context. For instance, if our extrapolated context covers two RBDs and the configuration of a Web Map Service is required at the servers of the two respective competent authorities, the scalability factor would be the number of RBDs.

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

Table 2. Cost Estimations per activity (WD=normalized working days to develop 1 activity instance, SF=scalability factor, NA=not applicable)

Activity	WD	SF
1. Assumed Activities (AA)		
1.1. Existence of Geospatial data	0	NA
1.2. Existence of Gazetteer data	0	NA
1.3. Existence of Legislation and Administrative Regulations	0	NA
2. Reusable Activities (RA)		
2.1. Definition of the application scenario	40	NA
2.2. Definition of metadata profiles	60	NA
2.3. Metadata edition tool	120	NA
2.4. Definition of common models		
2.4.1. Common model for the Web application data	60	NA
2.4.2. Common model for the gazetteer data	20	NA
2.4.3. Common model for the thesaurus data	5	NA
2.5. Development of the infrastructure for an internationalized Geoportal		
2.5.1. Infrastructure	40	NA
2.5.2. Catalog client	50	NA
2.5.3. Gazetteer client	20	NA
2.5.4. Map viewer	20	NA
2.5.5. Web applications	180	NA
2.6. Hardware and software acquisition	12	NA
2.7. Infrastructure for multilingual adaptation	25	NA
2.8. General management	80	NA
3. Context-Specificic Activities (CSA)		
3.1. Re-engineering the data		
3.1.1. Web application data	20	RBD
3.1.2. Gazetteer data	15	RBD
3.1.3. Thesaurus data	5	thesaurus
3.2. Metadata collection	10	RBD
3.3. Configuration of services		
3.3.1. Catalog services	15	centralized
3.3.2. Gazetteer services	10	centralized
3.3.3. Portrayal services	12	RBD
3.3.4. Data access services	12	RBD
3.3.5. Thesaurus services	10	centralized
3.4. Multilingual adaptation	31	language
3.5. Customization of the web application	10	RBD
3.6. Hardware and software acquisition	10	RBD
3.7. Maintenance of servers	26	RBD, year
3.8. Other activities	25	RBD

From table 2 a general formula can be derived to estimate the cost of a project implementing the SDIGER concept in a wider area than the one used for the prototype. Thus, the cost of the project $cost_{project}$ can be computed as follows

$$cost_{project} = cost_{AA} + cost_{RA} + cost_{CSA}$$

where $cost_{AA}$ denotes the cost of assumed activities (0 working days), $cost_{RA}$ denotes the cost of reusable activities, which represents 732 working days (derived from table 2), and $cost_{CSA}$ denotes the cost of context-specific activities. $cost_{CSA}$ is a variable measure which receives as parameters the number of RBDs ($|RBD|$), the number of maintenance years ($|year|$) the number of thesauri ($|thesaurus|$) and the number of languages ($|language|$). It can be computed as follows

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

Table 3. Cost estimations at national and European levels (EU=European Union, $|year|$ and $|thesaurus|$ are kept constant)

Country/EU	**Area(km^2)**	$\lvert RBD\rvert$	$\lvert year\rvert$	$\lvert language\rvert$	$\lvert thesaurus\rvert$	**Cost(WD)**
Austria	83871	3	1	1	8	1258
Belgium	30528	7	1	3	8	1880
Cyprus	9251	1	1	2	8	1009
Czech Republic	78866	3	1	1	8	1258
Denmark	43094	13	1	1	8	2658
Estonia	45100	3	1	1	8	1258
Finland	338145	8	1	2	8	1989
France	674843	13	1	1	8	2658
Germany	357050	10	1	1	8	2238
Greece	131990	14	1	1	8	2798
Hungary	93030	1	1	1	8	978
Ireland	84412	7	1	2	8	1849
Italy	301318	7	1	3	8	1880
Latvia	64589	4	1	1	8	1398
Lithuania	65300	4	1	1	8	1398
Luxembourg	2586	2	1	3	8	1180
Malta	316	1	1	2	8	1009
Netherlands	41526	4	1	2	8	1429
Poland	312685	7	1	1	8	1818
Portugal	92391	10	1	1	8	2238
Slovak Republic	49037	6	1	1	8	1678
Slovenia	20273	2	1	1	8	1118
Spain	505992	14	1	4	8	2891
Sweden	449964	10	1	1	8	2238
United Kingdom	244820	17	1	3	8	3280
EU	**3976372**	**164**	**1**	**20**	**8**	**24387**

$$cost_{CSA} = |RBD| \times (cost_{3.1.1} + cost_{3.1.2} + cost_{3.2} + cost_{3.3.3} + cost_{3.3.4} + cost_{3.5} + cost_{3.6} + cost_{3.8}) + |RBD| \times |year| \times cost_{3.7} + |language| \times cost_{3.4} + |thesaurus| \times cost_{3.1.3} + cost_{3.3.1} + cost_{3.3.2} + cost_{3.3.5} = |RBD| \times 114wd + |RBD| \times |year| \times 26wd + |language| \times 31wd + |thesaurus| \times 5wd + 35wd$$

Thus, the formula for the project cost can be simplified and expressed in the following way

$$cost_{project} = 732wd + cost_{CSA} = 767wd + |RBD| \times 114wd + |RBD| \times |year| \times 26wd + |language| \times 31wd + |thesaurus| \times 5wd$$

For instance, if we estimate the cost of a project having similar characteristics to the prototype implemented in the cross-border area of Spain and France (3 RBDs, 1 year maintenance, 3 languages, 8 thesauri), the result would be an estimated cost of 1,180 normalized working days ($767wd + 2 \times 114wd + 2 \times 1 \times 26wd + 3 \times 31wd + 8 \times 5wd = 1180wd$), which is quite close to the human resources that were needed for the prototype implementation.

Table 3 extends this initial example to the European context, showing the cost estimations for the 25 official member states of the European Union (EU) in 2006. This table also shows the cost estimation for the whole European Union. The number of RBDs per country has been obtained from the Water Information System for Europe (WISE) application (statistics derived from the Article 3 reports of the WFD)[2], developed by the European Com-

[2] http://wise.jrc.it (last access: 17 February 2007)

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

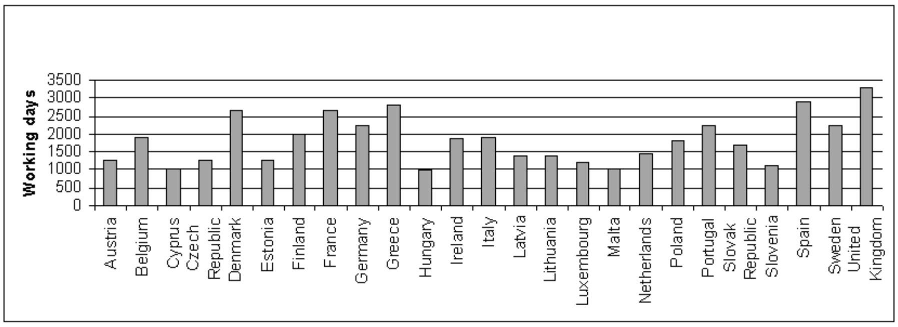

Fig. 1. Cost estimations by country

mission. The number of languages and the area of each country have been derived from the Encyclopaedia Britannica World Atlas[3]. The comparison of the estimations by country is also shown in the bar chart of figure 1. Independently of the accuracy of costs per activity in the $cost_{project}$ formula, it is possible to derive some conclusions from these estimations:

- The cost by country is not directly proportional to the geographic extension of the country. It can be seen that countries like Denmark with a relatively small extension ($43,094km^2$, 7th smallest country) have the largest associated costs ($2,658wd$, 4th biggest cost). But the opposite may also happen. Countries like Austria or Czech Republic with double geographic extent in comparison with Denmark have some of the smallest costs in working day terms. This is due to the fact that in this scenario, where local authorities take the responsibility, the main factor is the national policy dictating the division of the territory into RBDs and their competent authorities. The definition of RBD size may vary in every country since the criterion for the aggregation of river basins into a unique district is open to the most adequate interpretation of member states (Article 3(1) of WFD[7]).
- The fixed costs ($cost_{RA}$) and the number of languages play an important role for the smallest countries like Luxembourg or Malta, whose costs are not especially lower in comparison with bigger countries like Hungary.
- Last, it must be noted that the cost for the whole European Union is not the sum of the costs for each country. According to the same pattern followed for the national estimations, it has been considered that RBD competent authorities can cooperate at the European level without the mediation of a national body. Therefore, fixed costs are only considered once. Additionally, the work done by a RBD competent authority as regards the support of a new language can be reused (with minor adjustments) by other RBD competent authorities sharing the same language.

[3] http://www.britannica.com/eb/atlas (last access: 17 February 2007)

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

This cooperative approach at European level implies an important reduction in costs. The sum of the costs by country would be 1.78 times bigger than the cost estimated for the cooperative approach.

4 Analyzing the possible benefits of implementing the SDIGER concept

Despite the spread of SDI initiatives across continents and levels of government during the last 10 years or more, relatively few published studies have addressed the issue of assessing the impact of SDIs [9]. As stated in [9], one of the reasons may be a problem in the ambiguous definition of SDI-based projects in the so-called first generation of SDI projects: *"we consider all of these projects under the SDI umbrella but it is a very fragmented type of SDI, leading to multiple interpretations of what an SDI is, and difficulty in developing meaningful comparison"*. Other works like [10] also argue that the traditional cost-benefit analysis methods are not suitable for complex information infrastructures, such as SDI, due to the large number of assumptions that need to be made in such analysis. For instance, it is difficult to identify clearly the users that will benefit from the implementation of an SDI. Moreover, it seems clear that as well as costs not all the benefits can be expressed in monetary terms. It is necessary to combine quantitative and qualitative approaches for the estimation of benefits, with a particular care in stating clearly all the assumptions made [11].

Taking into account the complexity of this task and the difficulty of defining clearly all the possible users derived from the implementation of SDIGER at European level, this section only aims at describing in qualitative terms the expected impacts for those users that have had a direct involvement in the definition of the SDIGER scenario, and the implemented prototype. That is to say, this section describes the impacts expected for the Competent Authorities, the European Commission in charge of monitoring the WFD, and the citizens involved in the Water Abstraction Request application. Additionally, these benefits are categorized according to the classification of benefits proposed by [9]: efficiency benefits (e.g. time saved in searching or retrieving), effectiveness benefits (e.g. reduced uncertainty due to higher quality data), and wider socio-economic benefits (e.g. increase in the number of users or business opportunities).

As regards the efficiency, the SDIGER adoption provides benefits regarding the avoidance of bureaucracy and time save:

- On the one hand, the proposed Water Abstraction Request application provides e-gov capabilities to individuals and companies in order to initiate and estimate the feasibility of applying for a private use of a water resource. Additionally, the work of competent authorities is simplified since the data they must process has been submitted electronically.

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

- On the other hand, the WFD Reporting application facilitates the deliver of the reports that must be submitted to the European Commission. Once the parameters of the report are defined, competent authorities can directly produce the reports and dedicate their efforts just to supervise the data or write the abstract summaries that can not be automatically reported. Additionally, the European Commission monitoring office could also have direct access the last up-to-date reports just establishing an internet connection with the SDIGER geoportal of the competent authority.

As regards the effectiveness, the following benefits can be considered:

- The implementation of SDIGER forces RBD competent authorities to be compliant with INSPIRE and WFD principles. This facilitates interoperability with data and services offered by other competent authorities.
- The implementation of SDIGER implies the adoption of guidelines and good practices that increase the quality of data produced by the competent authorities. For instance, the possibility of overlapping layers produced by two competent authorities through a Web Map Service enables the detection of edge matching problems.
- Up to now, the WFD and the subsequent WFD reporting guides give clear directions for the specific layout of the reports competent authorities should deliver. But apart from the required reports, the flexibility of WFD Reporting application enables uncountable possibilities to customize these reports and analyze the same information in other ways.

Last, with respect to socio-economic aspects, the following issues can be taken into account:

- The implementation of SDIGER implies an increase of collaboration between competent authorities in neighbouring areas, facilitating the communication and adoption of similar guidelines.
- The participation of competent authorities in SDI initiatives has increased their prestige with respect to other organizational bodies at higher levels. The authorities are invited to provide feedback and consultancy for the development and implementation of national or European initiatives such as WFD or INSPIRE.
- The implementation of SDIGER will probably encourage the development of similar SDI-based projects to solve other problems in the environmental area, e.g. problems related with risk management whose responsibility also rely on local bodies (in the last term).

5 Conclusions

This work has shown a method for estimating the implementation of an SDI-based project at national and European levels. The method proposed implies

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

a clear statement as regards: the granularity of the area covered and the institutions taking the responsibility for these divisions (i.e., RBD and their competent authorities), the definition of a normalized unit of measure, and a detailed breakdown of activities and their categorization. Then, based on measures taken from the implementation of a small prototype, this work has shown the cost estimations in different extrapolation contexts: costs by country, and costs for the whole European Union.

One of the obvious advantages of this method is that the estimated costs per activity are borne out by a real experience. However, it must be recognized that this prototype implementation requires an important initial investment and this is not possible for every SDI-based project. But in any case, independently of the accuracy of the estimations per activity and the possibility of basing them on real experiences, the exercise of analyzing the activities to develop and the identification of the main factors that influence the costs may always derive useful outcomes. For instance, in the case of implementing SDIGER at the European level, a cooperation of RBD competent authorities at the European level is always more efficient that a coordination in terms of national bodies.

Finally, it must be noted that the work done here as regards estimation of costs can be translated to other application scenarios with minor adjustments. Most of the services (e.g., catalogs, WFS, WMS, ...), components (e.g., metadata edition tools, internationalization tools, ...) and related activities described in section 2.3 can be directly reused in other application scenarios with an intensive use of geographic information [12]. Even in the case of the added-value applications, although these applications have a specific character, the services and the architectural patterns they are built over can be adapted to other scenarios.

Acknowledgements

This work has been partially supported by the Spanish Ministry of Education and Science through the project TIN2006-00779 from "the National Plan for Scientific Research, Development and Technology Innovation" and by the European Commission through the Statistical Office of the European Communities (Eurostat), contract number "2004 742 00004" for the supply of informatics services in the various domains of the Community Statistical Programme.

References

1. Nebert D (ed) (2004) Developing Spatial Data Infrastructures: The SDI Cookbook, v2.0. Global Spatial Data Infrastructure (GSDI) http://www.gsdi.org.

(Draft) Lecture Notes in Geoinformation and Cartography (LNG&C). The European Information Society: leading the way with Geo-information. 2007, vol. XVII, p. 201-215. ISSN 1863-2246

2. Smits PC, Friis-Christensen A (2007) Resource Discovery in a European Spatial Data Infrastructure. IEEE Transactions on Knowledge and Data Engineering **19**(1): 85–95
3. Putnam L, Myers W (1992) Measures for excellence. Yourdon Press
4. Shepperd M, Schofield C (1997) Estimating software project effort using analogies. IEEE Transactions on Software Engineering **23**(11): 736–743
5. Zarazaga-Soria FJ, Nogueras-Iso J, Latre MA, Rodríguez A, López E, Vivas P, Muro-Medrano P (2007) Providing SDI Services in a Cross-Border Scenario: the SDIGER Project Use Case. In: Research and Theory in Advancing Spatial Data Infrastructure Concepts. ESRI Press
6. Commission of the European Communities (2004) Proposal for a Directive of the European Parliament and of the Council establishing an infrastructure for spatial information in the Community (INSPIRE). COM(2004) 516 final, 2004/0175 (COD)
7. Official Journal of the European Union (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. The EU Water Framework Directive - integrated river basin management for Europe. L 327, 22/12/2000 pp. 0001-0073
8. Zarazaga-Soria FJ, Nogueras-Iso J, Vivas-White P, Latre-Abadía MA (2007) Study report. v1.1, SDIGER project, http://www.sdiger.net 79 pp.
9. Craglia M, Nowak J (eds) (2006) Assessing the impacts of Spatial Data Infrastructures. European Commission, DG Joint Research Centre, Institute of Environment and Sustainability (IES), Luxembourg: Office for Official Publications of the European Communities
10. Longhorn R (2006) MOTIIVE Experiences Using Simulation Software to Assess SDI Cost-Benefit. In: Proc. 12th EC-GI & GIS Workshop, ESDI: From Inspiration to Implementation, pp 97
11. Craglia M, Nowak J (2006) Towards the Socio-economic Assessment of Spatial Data Infrastructures. In: Proc. 12th EC-GI & GIS Workshop, ESDI: From Inspiration to Implementation, pp 98–99
12. Friis-Christensen A, Bernard L, Kanellopoulos I, Nogueras-Iso J, Peedell S, Schade S, Thorne C (2006) Building Service Oriented Applications on top of a Spatial Data Infrastructure - A Forest Fire Assessment Example. In: Proc. 9th AGILE Conf. on GIScience: Shaping the future of Geographic Information Science in Europe, pp 119–127