

# Taking the Leap: From Disparate Data to a Fully Interactive SEIS for the Maltese Islands

Saviour Formosa<sup>1</sup>, Elaine Sciberras<sup>2</sup>, and Janice Formosa Pace<sup>1</sup>

<sup>1</sup> Institute of Criminology, University of Malta, Humanities A (Laws, Theology, Criminology), Msida MSD 2080, Malta

{saviour.formosa, janice.formosa-pace}@um.edu.mt

<sup>2</sup> Malta Environment & Planning Authority, Floriana FRN 1230, Malta  
elaine.sciberras@mepa.org.mt

**Abstract.** Taking environmental and spatial planning data to the masses has proven an arduous, expensive and barrier-strewn reality. Data costs, inaccessibility and lack of interactive sites have impeded the implementation of online analysis and knowledge building. The implementation of the Aarhus Convention, the transposition of the INSPIRE Directive and the launching of the SEIS initiative have enabled the Maltese Islands to take the next step into the dissemination of spatial and environmental data to the academic, scientific and public communities. This was made possible through the implementation of a project entitled “Developing national environmental infrastructure and capacity” co-financed under the 2007-2013 European Regional Development Funds (Structural Funds) Programme for Malta, which project was aimed to take national environmental monitoring capacity from a semi-analogue state to a fully interactive online system. The project aims at procuring hardware and software, taking innovative scans of the terrestrial and bathymetric domains, launching SEIS-based information management systems and disseminating the all the data for free.

**Keywords:** Aarhus, SEIS, INSPIRE, data interoperability, geoportal, LIDAR, spatial data, environmental data.

## 1 The Need for Speed

### 1.1 Identifying the Ills of Data Access and Inaccessibility

The state of affairs in information management and dissemination is peppered with both success stories and uphill struggles. Users plodding through the data-information-knowledge-action process experience various barriers to access to data, high costs, archaic mapping, baurocratic procedures and aged data the currency of which is unusable in a rapidly changing world. Various initiatives have enabled users to partake to the process with the onus placed on the national agencies. Such

initiatives such as the Aarhus Convention [1], the INSPIRE Directive [2]<sup>1</sup> and the Shared Environmental Information System [3] initiative have laid the proverbial carpet to ensure that the process is eased. Though the legislative aspects have been instrumental in enabling the academic and scientific field to be aware of the availability of data for further analysis, the general public lagged in the understanding of the use to which such data could be employed at governance and locality levels.

The Malta case study sought to analyse the situation on the ground as at 2006 most datasets were disparate, basemaps were dated as at 1988, environmental data capture was ad hoc and the dissemination, a mapserver was available with a date tag of 2000 and data were available to the public on a request basis [4].

The idea to bring all the aspects of baseline information, a comprehensive nationwide digital terrain and bathymetric model, environmental and spatial data into an interactive medium was brought to the fore with the eventual application for ERDF funding. This was aimed at the eventual dissemination of all information for free through an INSPIRE compliant online tool. This sequence of events brought to the fore the need for a speedy approach to implement the changes to ensure compliance with the legislative requirements [5].

## 1.2 State of Play: The Spatial Irony

Malta has a strong GIS background with developments in the field dating back since the colonial period (pre-1964) with various progressive steps being taken that culminated in the most recent drive to digitize the legacy and to be prepared for the rapid changes that were brought about due to the improvements in visualization and rapid data transfer [6].

A brief overview of the history of geographic information systems (GIS) reveals a rapid (post-1985) pace of development in this arena. Figure 1 below depicts that the two main phases of the process were based on i) the Digital Mapping/ data collection phase and ii) the GI application phase pertaining to Phase i).

Whilst the process entailed the setting up of a national mapping agency in 1988 with a remit to digitize the basemap, the transition to a fully digital scenario required the implementation of GIS between 1994 and 1998, which was brought to the fore for public consumption in 2000 through the launching of a mapserver [7].

Whilst the first phase concentrated on the national implementation of hardware/software installations as infrastructural activities across the different social and physical agencies, phase two took on a legalistic and strategic trust aimed at ensuring that the diverse initiatives were pushed by the international scene. The latter called for integration, which is where the cracks started to appear in terms of dissemination of spatial data in the wider for a. The first pitfall referred to the lack of a appropriately projected base datasets which would allow integration to international cross-border datasets.

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<sup>1</sup> The acronym INSPIRE refers to the Directive 2007/2/EC of the European parliament and the Council of 14 March 2007 with the aim to establish an Infrastructure for Spatial Information in the European Community. The directive entered into force on 15 May 2007 and will be fully implemented by member states in 2019.

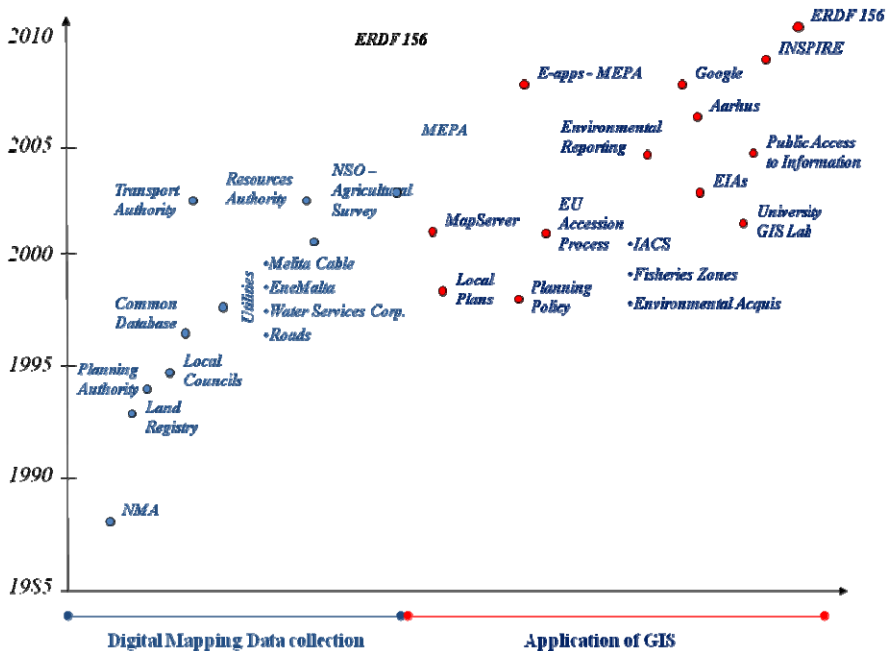


Fig. 1. The GI data process

Due to severe hardware restrictions and high storage costs, a decision was taken to truncate all the spatial data (Malta falls within 1 zone on the UTM projection). Such was done in order to save money on harddisk space, a decision that was aimed to ease the rolling-out costs but which is currently hindering all the EU/EEA data reporting to the various agencies, since any such data need to be reconverted to the original full UTM. This space and cost-saving measure is now estimated to incur EUR100,000s since the whole country's organisations have to reconvert all their data to fit within the international projection and which is causing severe restrictions on data convergence.

This process was further hindered by Malta reporting requirements to the EU which dealt several shocks to the system. Late deliveries due to reporting mishaps, missing or non calibrated data, spatial elements not supported by metadata and other hiccups resulted in negative outcomes for Malta's position in the EEA league [8]. However, the process had its bright moments with the creation of several high level outputs in conjunction with other agencies such as the Austrian Umweltbundesamt (UBA)<sup>2</sup>. Such datasets included the Corine Landcover 1990-2000-2006 and the relative change analysis, elevation maps, environmental protection maps (EEA

<sup>2</sup> The project was developed through an agreement between the European Environment Agency, the Malta Environment and Planning Authority and the Umweltbundesamt-Vienna, the latter providing interpretation and implementation expert support through the Twinning Project MT2002/IB/EN-01 "Establishing Institutional Capacity in the Environmental Sector".

CDDA, Natura 2000, SAC) [9], terrestrial and marine habitats as well as a Posidonia baseline survey and, in 2011, the Land use/cover area frame survey (LUCAS) field survey [10].

In conjunction with the above process, various research initiatives were initiated. These have ranged from organisational change initiatives [6], remote sensing [11], census web-mapping [12], environmental-landuse [13], GML-related dissertations [14], ethics in GIS [15], 3D GIS for spatial planning [16], environmental [17], quality improvement cycle [18], through to socio-technical approaches to GIS [19]. Each served a role to create and ultimately shape GI-related change in the Islands which led to the preparation of the new foundation for national geographic information data cycle.

### **1.3 Taking the Plunge and the Availability of Resources**

With the integration of the spatial planning and the environmental agencies, the need was felt to consolidate all the data gathering processes, create a comprehensive strategy for data reporting, integrate the initial data-related projects such as those emanating from the Structural Funds 2007-13, EAFRD 2007-13, Transition Facility Programme for Malta, Pre-Accession Funds, and other programmes, with the main project being that related to the establishment of institutional capacity in the environment sector [20]. The latter project that laid the ground for the current project was entitled "Establishing Institutional capacity in the Environment Sector" and was financed by the National Plan for the Adoption of the Acquis Programme for Malta 2002 which aimed to prepare the Maltese administration to face the challenges posed by EU accession. The overall objective of this project was to strengthen the institutional capacity within the environment sector in order to achieve compliance with the EU environmental Acquis. The project team closely examined the organisational structure of the institutions involved in the implementation and enforcement of the environmental Acquis and provided multi-disciplinary training to staff engaged in carrying out environment protection functions. Finally, the project also laid foundations for the development of further technical capability to manage new and existing infrastructure in various sectors, including waste, air quality, biodiversity and water, establishing technical standards and codes of practice for various functions related to environmental protection.

The outcome of the project which was concluded in 2004 set out the groundwork for the creation of a strategy to improve the data availability to the experts trained through the 2002 project. The groundwork laid out, the time was ripe to take a decision on the identification of a way forward for the integration of the environmental domain with the spatial development domain through the integration of information resources and information technology infrastructure in line with the Aarhus, INSPIRE and SEIS requirements as well as the outcomes of such projects as Plan4all [21].

### **1.4 The Integrative Project**

This project is co-financed by the European Regional Development Fund, which provides 85% of the project's funding and the Government of Malta, which finances the rest under Operational Programme 1 - Cohesion Policy 2007-2013 - Investing in

Competitiveness for a Better Quality of Life. The authors are implementing the project through the Malta Environment and Planning Authority (MEPA) in collaboration with the Malta Resources Authority (MRA), the Department of Environmental Health, the National Statistics Office (NSO) and the University of Malta. The project has a budget of € 4,780,480, of which € 4,657,760 are eligible costs.

As a small densely populated and highly urbanised island economy, Malta faces wide-ranging environmental challenges in the areas of air, water, waste, nature protection, noise, chemicals, industrial pollution, sewerage, land use planning and control of urban sprawl, and other sectors. Various initiatives have already been undertaken to upgrade Malta's environmental regulatory capacity, including efforts to ensure full compliance with the relevant Community Directives as well as national legislation. However, environmental monitoring and reporting are hampered by lack of baseline environmental data on ambient conditions, lack of monitoring infrastructure, modern monitoring equipment and limited human resources. These factors result in ineffective monitoring and reporting on the state of the environment, increased risk of failure to detect, prioritise and address environmental degradation, as well as in an inefficient use of financial, human and natural resources.

The project focuses on radically improving the national environmental monitoring capacity in five environmental themes – air, water, radiation, noise, and soil. It will result in the procurement of equipment, information management systems, environmental baseline surveys, training of staff, and the enhancement of the national monitoring programmes in these five environmental themes. The purpose of the project will be achieved through a series of various service and supply contracts that will lead to the procurement of equipment, development of information management systems, gathering of critical baseline data, development of monitoring programmes and training of human resources in the operation of equipment and systems. The following outputs will be delivered:

- 100% of environmental monitoring requirements in the areas of air, water, radiation, noise and soil will be assessed, and an environmental monitoring strategy and detailed monitoring programmes will be designed and drawn up by Q2 of 2013 to cover all monitoring requirements. The strategy will be accompanied by detailed tender specifications for the procurement of equipment, systems, training and data collection requirements that could not be identified prior to the completion of the strategy;
- Air, noise and radiation equipment, information resources systems and infrastructure procured, installed, tested and commissioned, and relevant staff trained in their operation by the Q4 of 2012;
- Baseline studies with 100% scan coverage of the Maltese Islands conducted in the areas of water, radiation, noise and soil, together with terrestrial spatial surveys and bathymetric surveys of coastal waters within 1 nautical mile by Q2 of 2013;
- Shared Environmental Information System (SEIS) designed and implemented by Q2 of 2013;
- Results of the project will be disseminated throughout the project to a wide range of stakeholders and the public through an information campaign.

As a result, public awareness of issues pertaining to the environment will be improved, and better policy decisions can be taken in the field of the environment.

The above investment will contribute to achieving between 25% and 100% compliance with the monitoring requirements of around 17 legislative instruments (Directives, Regulations, Decisions) in the areas of air, water, soil, noise and radiation.

## 2 The Technologies and the Project Launch

The study, initiated in 2006, identified the situation that environmental monitoring and reporting is hampered by an incomplete monitoring strategy, a lack of baseline environmental data on ambient conditions, a lack of monitoring infrastructure & modern monitoring equipment and limited human resources. The process identified the need to enhance the national monitoring programmes in the five environmental themes<sup>3</sup> through the identification of information gaps in monitoring processes and filling data gaps, carrying out environmental baseline surveys and through the procurement of monitoring equipment & information management systems and finally the training of staff.

The project results are aimed to reach the following objectives:

(1) Environmental monitoring requirements in the areas of air, water, radiation, soil, noise and chemicals assessed, an environmental monitoring strategy and detailed monitoring programmes designed and drawn up. The strategy will be accompanied by detailed tender specifications for the procurement of equipment, systems, training and data collection requirements that could not be identified prior to the completion of the strategy;

(2) Air, water, noise and radiation equipment, information resources systems and infrastructure procured, installed, tested and commissioned, and relevant staff trained in their operation;

(3) Baseline studies conducted in the areas of water, radiation, noise and soil, together with terrestrial spatial surveys and bathymetric surveys of coastal waters within 1 nautical mile;

(4) Shared Environmental Information System (SEIS) designed and implemented;

(5) Results of the project will be disseminated throughout the project to a wide range of stakeholders and the public through an information campaign.

Therefore the project will result in the following deliverables which will enable the integration of the requirements for EU environmental reporting through the employment of the INSPIRE Directive for the spatial component, the use of the Aarhus Convention as the conveyor for the dataflow and ultimately the employment of a tool pertaining to the SEIS requirements for the eventual online dissemination<sup>4</sup>. This triumvirate of Directives and Initiatives were used as a fulcrum to ensure that the full spectrum of Maltese environmental and spatial information reaches the public at no expense, empowering both the individuals, non-governmental organisations and

<sup>3</sup> The 5 monitoring themes: air, water, noise, radiation and soil.

<sup>4</sup> Standards employed in the Malta-SEIS: OGC WMS, OGC WMS - T, OGC WFS, OGC WCS, ANSI SQL, INSPIRE, Z39.50 and CSW.

governing bodies to receive knowledge at first hand in order to debate on strategic and local plans as well as monitor the health of their environment and in turn give the social structure the power to react with readily available knowledge as against being faced with barriers to access. This process is the fruition of a process begun in 1995 by the authors to ensure that data are disseminated for free.

The project outcomes can be structured into 4 sectors: Environmental Acquisition, Spatial Constructs, Dissemination Media and Access as per Table 1.

**Table 1.** Project Outcomes

<p><b>Environmental Acquisition</b></p> <ul style="list-style-type: none"> <li>(1) Air Strategy and Baseline Study</li> <li>(2) Water Strategy and Baseline Study</li> <li>(3) Noise and Radiation Strategy</li> <li>(4) Soil Strategy (degradation processes and contamination in diffuse sources)</li> </ul>	<p><b>Spatial Constructs</b></p> <ul style="list-style-type: none"> <li>(1) Full LIDAR Scan: Terrestrial and Bathymetric</li> <li>(2) Ground truthing for sea substrate type</li> <li>(3) Oblique aerial imagery &amp; satellite imagery</li> <li>(4) An address point dataset</li> </ul>
<p><b>Dissemination Media</b></p> <ul style="list-style-type: none"> <li>(1) Online information service</li> <li>(2) Online mapservice - SEIS</li> <li>(3) Statistical backing for experts – inc. spatial stats</li> </ul>	<p><b>Access</b></p> <ul style="list-style-type: none"> <li>(1) ALL Data are to be disseminated for FREE</li> </ul>

**2.1 The GIS Components: Data Capture and Technologies**

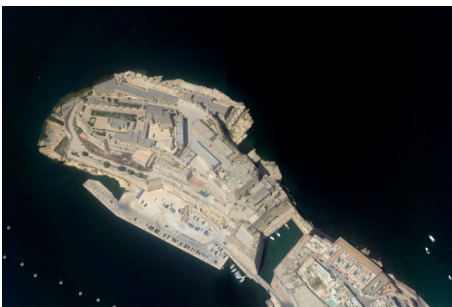
The requirements for data acquisition based on bathymetric and terrestrial 3D as well as aerial imagery were deemed essential to the analytical and decision-making processes related to environmental monitoring and the project since the state needed a new baseline from which to launch all its data capturing exercises across the different themes. Whilst some basic bathymetric data are available from legacy nautical charts, such data need to be updated to higher resolutions so as to be suitable for environmental modelling and EU reporting purposes. No comprehensive and detailed terrestrial 3D surveys have ever been carried out in Malta. The resulting lack of high quality 3D spatial data hinders land use planning, environmental monitoring and management processes that rely on such data. It was deemed useless to gather ad hoc datasets without an established reference baseline dataset and the decision was taken to take a series of scans using different technologies in order to provide a comprehensive seamless dataset that covers all the terrestrial area and the marine area up to 1 nautical mile from the baseline coast as designated by the Water Framework Directive which falls within the remit of the domains under study in this project. The aim was to address the identified data lacuna by delivering high resolution 3D terrestrial data coverage for the Maltese Islands using a combination of oblique aerial

imagery and Light Detection and Ranging (LIDAR) data (Figures 2 a-b), as well as through a bathymetric survey of coastal waters within 1 nautical mile (nm) radius off the baseline coastline, using a combination of aerial LIDAR surveys, acoustic scans and a physical grab sampling survey. The use of this technology, as well as other fieldwork technologies, has equipped the researchers with a launching pad for the diverse physical, environmental and social studies that are undertaken in relation to social and environmental health.

The outputs from the project include the following services and supply (Table 2):

**Table 2.** Project Outputs

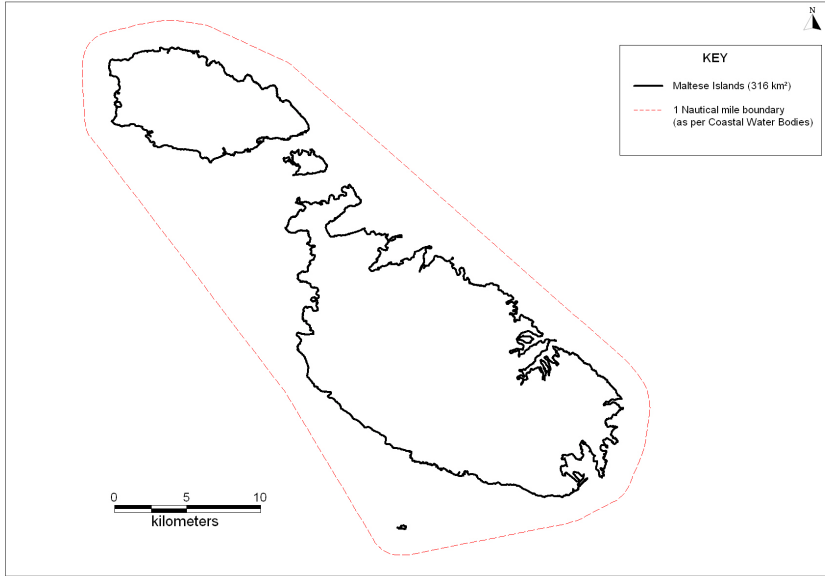
Services	Supply
<ul style="list-style-type: none"> <li>(1) LIDAR Scan: Terrestrial (Topographic Light Detection and Ranging (LiDAR)) Digital Surface Model (DSM) and Digital Terrain Model (DTM) (316 km.sq) – Figure 3a</li> <li>(2) Bathymetric LIDAR aerial survey - depths of 0 m to 15m within 1 nautical mile from the Maltese coastline (38 km.sq) – Figure 3b</li> <li>(3) Bathymetric Scan: Acoustic (side scan sonar) Digital Surface Model and an acoustic information map of sea bed (361 km.sq) – Figure 3c</li> <li>(4) High resolution oblique aerial imagery and derived orthophoto mosaic and tiled imagery of the Maltese Islands (316 km.sq)</li> <li>(5) Satellite imagery</li> <li>(6) A complete address point database</li> </ul>	<ul style="list-style-type: none"> <li>(7) Remote GPS Cameras (Remote capture GPS receiver)</li> <li>(8) 3D scanner</li> <li>(9) GIS Handhelds</li> <li>(10) Global Navigation Satellite System Station and geodetic receivers</li> </ul>



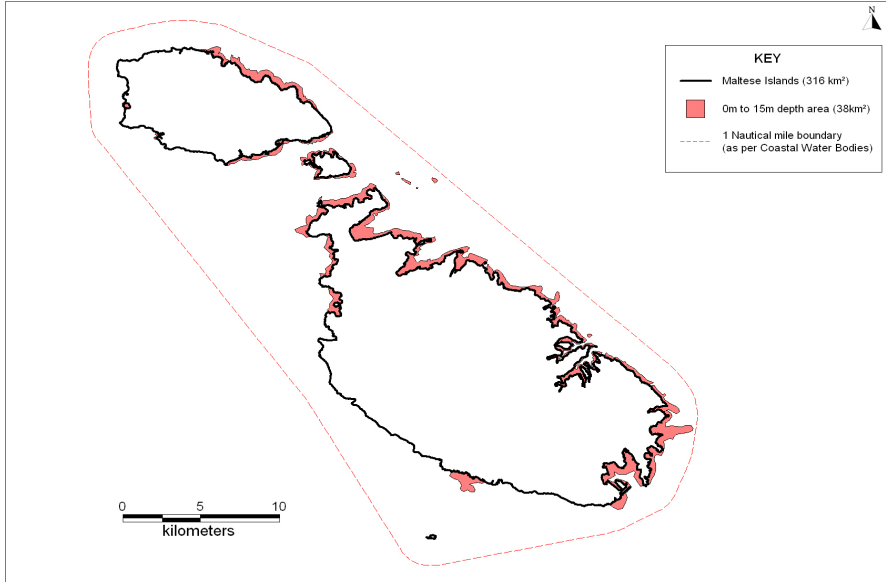
**Fig. 2. a.** Oblique Imagery Output 2011



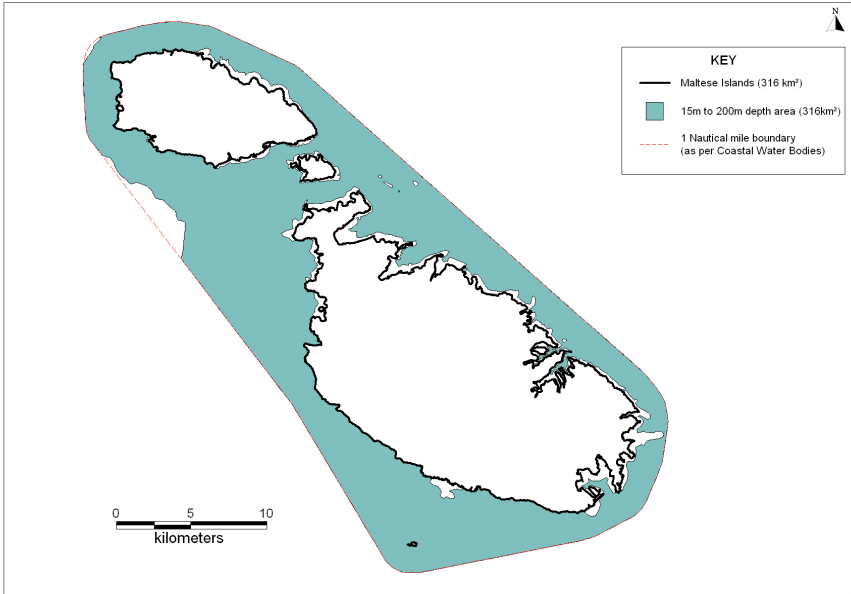
**Fig. 2. b.** LIDAR Scanning Exercise 2012



**Fig. 3. a.** Maltese Islands coast inclusive of 1 nautical mile boundary from the baseline coastline



**Fig. 3. b.** Maltese Islands showing coastal water area with depths of 0m to 15 m within 1 nautical mile from the Maltese baseline coastline



**Fig. 3. c.** Maltese Islands showing coastal water area with depths of 15 m to 200 m within 1 nautical mile from the Maltese baseline coastline.

### 3 Integration and Dissemination

The final phase but most crucial of the project entailed the implementation of an SEIS-based strategy and implementation of an online tool. This tool will build on the previous experiences with the MEPA Mapserver, the EEA CDR and the Aarhus capacity building project<sup>5</sup>. The objectives of this phase were set out to review and analyse the MEPA’s, national and EU-level requirements for the development and operation of the SEIS, taking into consideration all relevant factors. On the basis of this review, design the Maltese component of the SEIS and in turn develop and implement the SEIS, including a dedicated geoportal based on ArcGIS geodatabase design as based on ArcGIS server architecture and finally train staff on the use, operation, data analysis, maintenance and customisation of the developed SEIS.

The phase is aimed to review the state of play of the current developments with respect to the Shared Environmental Information System (SEIS), including the following:

- EU Directives supporting the EU’s SEIS initiative and any proposed recommendations of the EEA, JRC, EUROSTAT;
- Commission’s Communication COM (2008) 46 Final “Towards a Shared Environmental Information System”;

<sup>5</sup> [www.ambjent.org.mt](http://www.ambjent.org.mt) (a project implemented under a Austrian – Maltese Twinning Project MT/06/IB/EN/01 “Further Institution Building in the Environment Sector”).

- SEIS developments by the European Environment Agency (EEA);
- Overview and updates on the SEIS-BASIS (Shared Environmental Information System Baseline and Evolution Study) project which aims to provide guidance on how to improve the comparability and quality of environmental data, as required by SEIS;
- The outputs of the NESIS project and roadmap developments on how to move from the current information systems of EU's environment agencies towards an INPSIRE-SEIS based system. To include relevant results for the NESIS State of Play study on examples of best practice as a source of guidelines for MEPA's proposed SEIS as informed by recent developments;
- Relevance of the INSPIRE Directive (Directive 2007/2/EC) and the Aarhus Convention to the EU's SEIS;
- Linking of an integrated reporting system is required in line with the EEA Reportnet initiative and its CDR (Common Data Repository) structure to SEIS;
- An analysis of the existing Maltese information management systems and platforms, as well as an assessment of the present institutional capacity necessary for the operation of the Maltese component of the SEIS;
- New or emerging reporting standards currently being adapted, such as XML-related standards, to which the SEIS should conform.

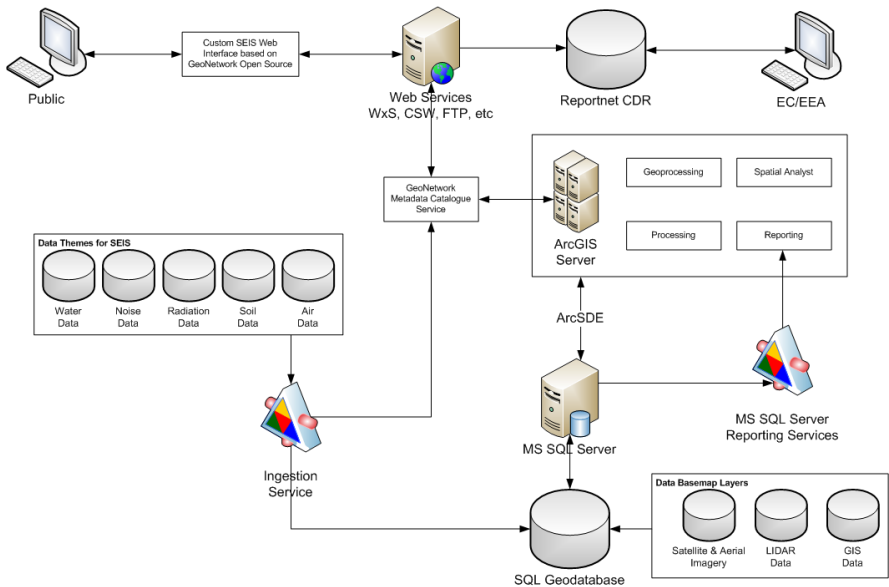
This process will involve the analysis of the current systems in place to process environmental monitoring data and data flows required, the design of the SEIS for Malta, and the development of such a web-based environmental information system.

The output will result in the creation of a web-based environmental information system, on the basis of existing platforms, as well as on the basis of any other additional platforms and components that may be required, to achieve full interoperability and functionality of the Maltese component of the SEIS, in line with the applicable guidelines and best practices in this field. This phase forms a key part of the ERDF-funded project and will integrate all the environmental monitoring data acquired through this project and through other environmental monitoring initiatives administered by MEPA and other Maltese entities.

The development of the SEIS will amongst other include the delivery of a web-based GIS dedicated to environmental monitoring data incorporating existing aerial orthophotos and basemaps as well as newly acquired satellite imagery, oblique aerial imagery, LiDAR terrain datasets and bathymetric data. Moreover, since the plans are in place to migrate from an ArcInfo database to an ArcGIS geodatabase structure, the SEIS will be developed using an ArcGIS Server platform. The SEIS is expected to be a modular and scalable system which is flexible to meet the varying demands of usage and applications with time.

The proposal was to design a geodatabase data model that is flexible, caters for potential expansion, easily adaptable by the environmental agency and supports migration from current data structures. The following steps were highlighted in order to improve the development of the geodatabase schema.

- i) Identify the data sources and key data themes for the GIS and characterise each thematic layer (including symbology, annotation, map scale, accuracy, data use, integration with other datasets)
- ii) Develop representation specifications and relationships of the geodatabases (modelling of feature classes, definition of tabular database structure, spatial behaviour and data integrity rules, were relevant)
- iii) Define the data capture procedures, map display properties and assignment of procedures for geodatabase building, conversions, editing and maintenance.
- iv) Document the proposed geodatabase design (such as schema diagrams, map layer examples, metadata documents)
- v) Since an ArcGIS Server platform will be used for the development of the SEIS, ArcSDE must be employed to manage the underlying geospatial data that will be stored in Microsoft's SQL Server RDBMS (Figure 4) [22].



**Fig. 4.** Malta-SEIS Architecture: Source: Bonazountas M., and Karampourniotis I (2012, 17)

Finally, the project envisaged a structure that conforms to the Aarhus, INSPIRE and SEIS structures as follows:

**Web Interfacing and Security**

ArcGIS Server’s .NET API will be used to interface with ArcSDE to present the data on the web. This system would allow the viewing, data querying, reporting and analysis of all spatial datasets identified in the five themes and the information resources datasets;

**Front end Flexibility**

Since it is expected that the SEIS will develop with time based on the increasing levels of geospatial data to be acquired, varying reporting demands and data analyses, the Malta SEIS will have an extensible front end that can be tailored to meet the new requirements of a changing and dynamic environment;

**Discovery Services/Functions**

The SEIS will include appropriate discovery services and functions since this is a requirement for users and such automated tools requesting data. Key spatial data sets should be published in ways that support the discovery of the data and provide access to these resources via product-neutral visualization and downloading services;

**Geoportal**

The geoportal is to be linked to the National Spatial Data Infrastructure (SDI) should this be established during the lifetime of the project and eventually linked to the EU SDI under development. All relative documentation relating to how spatial data and services can be interlinked respect the INSPIRE Directive's implementing rules as already outlined in the Plan4all project Malta test (Formosa, Magri, Neuschmid, Schrenk; 2011);

**Social Dataset Integration**

The system will ensure that other environmental domains not covered in the five themes will be covered as identified in the Plan4all Malta case study which reviewed the potential for such systems to integrate information from the physical, social, criminological, psychological and health domains. The studies of the impacts of environmental factors on health issues are seen as a major component that will lead to the public interest in the system and may eventually create a real scenario for volunteered geographic information in the Maltese Islands;

**Spatial dataset standards**

All spatial datasets will conform to the INSPIRE Directive (Directive 2007/2/EC) standards. The SEIS must conform to the requirements emanating from the various standards established by the environmental thematic areas. Therefore the project takes into account developments within the various ETCs (European Topic Centres) and to ascertain that the SEIS conforms to and seamlessly links to the European ones, where such protocols have been created. The geographic coordinate system for the SIES should be based on a Projection (UTM Zone 33 S), Datum (ED 1950) and Ellipsoid (Hayford International 1924);

**Spatial data transfer**

The project structure requires that the spatial data-transfer processes of the systems currently in place and new ones acquired through the project are thoroughly understood and depicted into the model with a target to establish a coherent data integration system that will allow the further transmission through the online portal.

In conclusion, the project, whilst an ambitious one, ensured that the whole process was an integrated one which takes into account the conceptualisation of a nation-wide strategy for access to data [23] employing various Directives and Conventions in order to ensure that data is transmitted for free to the general public whilst ensuring that the quality is assured. The project which was launched in December 2009 is expected to be concluded in 2013, with a planned maintenance procedure as established through such standards as ISO 9001: 2008 and those emanating from the INSPIRE and information related Directives.

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