

Coastal Informatics: Web Atlas Design and Implementation

Dawn J. Wright
Oregon State University, USA

Ned Dwyer
University College Cork, Ireland

Valerie Cummins
University College Cork, Ireland

Information Science
REFERENCE

INFORMATION SCIENCE REFERENCE

Hershey • New York

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Cover Design: Lisa Tosheff
Printed at: Lightning Source

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: <http://www.igi-global.com>

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Library of Congress Cataloging-in-Publication Data

Coastal informatics : web atlas design and implementation / Dawn Wright, Ned Dwyer, and Valerie Cummins, editors.
p. cm.

Includes bibliographical references and index. Summary: "This book examines state-of-the-art developments in coastal informatics (e.g., data portals, data/ metadata vocabularies and ontologies, metadata creation/ extraction/ cross-walking tools, geographic and information management systems, grid computing) and coastal mapping (particularly via Internet map servers and web-based geographical information and analysis)"-- Provided by publisher. ISBN 978-1-61520-815-9 (hardcover) -- ISBN 978-1-61520-816-6 (ebook) 1. Coasts--Geographic information systems. 2. Coastal mapping. 3. Management information systems. I. Wright, Dawn J., 1961- II. Dwyer, Ned. III. Cummins, Valerie, 1974- GC10.4.R4C63 2010
526.0914'6--dc22

2009052431

British Cataloguing in Publication Data

A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter 13

United Kingdom

David R. Green
University of Aberdeen, UK

ABSTRACT

This chapter briefly examines the origins and evolution of electronic coastal and marine atlases, and online mapping and GIS in the United Kingdom (UK). Beginning with some early examples, such as the UK Digital Marine Atlas (UKDMAP), initially distributed on floppy disk (MS-DOS) and later CD (MS-Windows), consideration is then given to some of the first online Internet-based information systems e.g., The UK Coastal Map Creator, some of the current systems now available e.g., MAGIC, MESH, and UKSeaMap, and finally the potential of Google Earth (GE) and Google Ocean (GO) to provide a framework for the development of simple local scale coastal and marine atlases. In each case, attention is paid to the origins of the atlas, its development, the user-interface, functionality, data and information content, and the target audience. Some of the advantages and disadvantages of electronic atlases are also discussed, together with some of the problems, and possible solutions.

INTRODUCTION

This chapter briefly examines some of the origins and the evolution of Internet or Web-based marine and coastal atlases, and online mapping and GIS in the United Kingdom (UK). Using some of the early disk and CD-based marine atlases first available in the 1990s as the earliest examples of electronic atlases that became widely available

in the UK, it also explores some of the earliest web-based equivalents when the potential of the Internet was first realized. Subsequent developments, paralleling the rapid evolution of computer technology, have provided the platforms for more recent and more widely available examples of web-based atlases. The chapter will firstly introduce the electronic atlas as a modern day equivalent of the traditional paper-based atlas. Reference to the rapid developments in computer hardware and software, coupled with increasing familiarity with

DOI: 10.4018/978-1-61520-815-9.ch013

the tools and skills required to construct web-based applications, provides a contextual framework to the origin and development of web-based atlases and online map information systems. Some of the problems faced by potential atlas authors are also highlighted, including access to data and information and copyright issues that frequently inhibit the development of such atlases and their maintenance.

FROM PAPER TO ELECTRONIC: THE CONTEXT

Electronic or digital atlases are a natural evolution of the paper-based traditional paper atlas, albeit for use in a computer environment. There are many examples of electronic atlases available, some of which cover the marine and coastal environment. Electronic atlases originated at a time when computer technology (hardware and software, storage, processing, and display capabilities) had reached a stage when it was possible to design, create, and present maps and charts in an electronic or computer-based environment using computer-aided or computer-assisted cartography (CAC). While some early examples relied upon very basic black and white computer displays, the arrival of high resolution color monitors greatly enhanced the possibilities to display increasingly better quality maps on the computer screen. These took advantage of the additional dimension of color for mapping. In recent years, desktop computers (PCs) and small mobile geographic information system (GIS) hardware have evolved so rapidly that it is now possible to provide very high resolution color displays of maps and charts on the smallest of mobile platforms, including mobile phones. There are also many examples for displaying electronic chart displays on the modern yacht.

Whilst computer hardware has evolved quickly, providing the storage and memory capacity and processor speed to handle large volumes of geographical data on the desktop and mobile

platform, so too has computer software. Software applications now provide the tools to design, create, and display very sophisticated map and chart displays. At the same time, software has become more user-friendly and so many more people are now empowered to create their own electronic maps, aided by software that provides the necessary cartographic, design, layout, and publishing tools. Map and graphic design software (e.g., Golden Software's MapViewer and Adobe Illustrator) can be used to create maps and present them as dynamic examples with the aid of MS-Powerpoint-based slideshows.

The potential of the electronic atlas as a medium to access, view and share coastal and marine information, has been further enhanced with the development of the Internet and a range of website development software tools, as well as GIS and online GIS-based mapping software that has ultimately led to the development of a wide range of different web-based examples of marine and coastal atlases. A sample of these can be accessed from the International Coastal Atlas Network (ICAN) website: <http://ican.science.oregonstate.edu/atlases>. The ICAN initiative (<http://ican.science.oregonstate.edu>) seeks to document best practice in the development of coastal web atlases (CWA) around the world by coordinating the sharing of international knowledge and expertise. It therefore represents a significant step in the evolution of Internet-based electronic atlases and may in turn have considerable influence on the development of data models and spatial data infrastructures (SDIs) that may underpin electronic atlases in the future.

In this chapter, the term electronic or digital atlas covers a wide range of examples ranging from electronic mapping to online GIS. The overview presented and the subsequent discussion necessarily also includes a number of other examples that are based around a searchable online catalogue of datasets, make use of maps as the interface to such a catalogue, or provide an online map/image-based service. Whilst not strictly fulfill-

ing the definition of an electronic atlas they are nevertheless closely related and in effect form the basis of an electronic atlas.

EARLY ELECTRONIC ATLASES IN THE UK: SOME EXAMPLES

In the UK, some notable marine and coastal atlases were first developed in the 1990s by the British Oceanographic Data Centre (BODC) at Bidston. The United Kingdom Digital Marine Atlas Project (UKDMAP) and the UK Current Meter Series Database are two good examples. Other examples from the same source were the Global Bathymetric Chart of the Oceans (GEBCO) atlas and the North Sea Project Database. Together these represented a combination of software, database and visualization packages that were initially distributed on one or more 3.5" floppy disks and subsequently on CD. These were some of the first examples of electronic marine and coastal atlases in the UK, and were very similar to a number of other examples that became available at approximately the same time in North America such as the Coastal Ocean Management, Planning and Assessment System (COMPAS) and Atlas T. COMPAS (Alexander and Tolson, 1990) was developed by NOAA for the Apple Macintosh using Hypercard software and was accompanied by a Guided Tour for user familiarization. Atlas T written by Rhines in 1992, was a micro-computer-based ocean atlas for tracer and hydrographic sections based on ship tracks. Running under MS-DOS, and controlled by keyboard input, Atlas T provided visualizations of ocean data including depth profiles and contour maps. It was also accompanied by a detailed Help file. All of these examples of computer-based atlases reflect the growing availability of digital data, mapping and visualization software, and the state-of the art computer technology at the time.

Some UK examples will now be briefly examined to provide some evolutionary context for

the subsequent development of UK Internet-based electronic map information systems and atlases.

The UK Digital Marine Atlas

The UKDMAP (http://www.bodc.ac.uk/products/bodc_products/ukdmap/) was probably the most notable and widely available example of a UK coastal and marine atlas, and certainly the most popular and familiar (BODC, 1992; Barne et al., 1994; Green, 1994a, 1994b). This electronic atlas provided the end-user with access to a wide range of marine and coastal data (originating from BODC databases) presented in the form of a digital map or chart. Initially for desktop (PCs) computers running MS-DOS (later replaced by an MS-Windows version) and a color display monitor, this electronic atlas provided the potential for end-users to interact with and map a wide range of terrestrial, coastal, and marine datasets for the UK (Figure 1). At the time, UKDMAP was quite a novel application that had considerable potential as an information and educational resource and was targeted at people involved in research, conservation, engineering, fishing, transport and leisure, education, recreation, and planning (Green, 1994b). One advantage of the electronic format was the ease with which updated data could be made available to the end-user. Customization of the maps was also possible and there was some limited GIS functionality (Green, 1994b). One novel feature of UKDMAP was the capability to assemble a selection of maps into a slide show to examine changes over time, trends, and the exploration of specific themes (Green, 1994b). For various reasons (e.g., lack of funding, changes in computer technology etc.), after several releases of updated versions of UKDMAP, it was no longer maintained, although it is still available from BODC. This is unfortunate as the overall concept of a UK information system rapidly became very popular and the product was well-packaged; easy to use, low cost, and a very useful information and educational resource for the UK.

Figure 1. Screen snapshot of the UKDMAP (courtesy of BODC, UK)



British Oceanographic Data Centre Inventory of Moored Current Meter Data

Another example, also developed by the BODC, was the Current Meter Series Database (BODC, 1991). It was developed in co-operation with international marine organizations and comprised a database and visualization software with a similar user interface of pop-up/drop-down menus found in UKDMAP. It included moored current meter data collected by sixteen countries from around the World. Although not solely focused on the UK, a large part of the BODC Current Meter Series database (part of their National Oceanographic Database) contained current meter data for the UK. The end-user was able to browse the database, select a sample of records, and to display or visualize the selected locations on a map outline. Records could be selected according to various criteria such as the start date, country, and laboratory of origin, and sorted, retained, printed to file and previous record selections reloaded for review.

Whilst initially also distributed on floppy disk, the Current Meter Series Database is now accessible via a simple map interface based around the Environmental Systems Research Institute or ESRI's ArcIMS map server software (https://www.bodc.ac.uk/data/online_request/current_meters/). It is easy to use and comprises a descriptive web page and a help file, together with some simple navigational tools e.g., zoom and pan, and previ-

ous extent. This map interface allows the end-user to explore the data holding prior to making an online request for the data. In its current guise it is probably one of the most basic examples of an electronic interface to spatial data and utilizes only a small part of the full functionality of ArcIMS software. A similarly configured product is the Wave Data Series which also includes a web-based ArcIMS interface (https://www.bodc.ac.uk/data/online_request/waves/).

North Sea Project Database

The North Sea Project Database (Lowry et al., 1992) is a comprehensive collection of physical, chemical, and biological data collected from survey cruises and process study cruises containing data on temperature, salinity, and dissolved oxygen. It also included satellite AVHRR (Advanced Very High Resolution Radiometer) data from NOAA, metadata, the BODC Moored Current Meter database, and a North Sea Bibliography. As with the other BODC products the North Sea Project Database is now supplied on a CD and was designed as an electronic publication of data complete with visualization software. A range of tools was also provided to help visualize the variety of different datasets e.g., time series, underway data and the analysis of satellite imagery. The latter tools include UNESCO's Bilko image processing software (UNESCO, 1989), Image Display

Program in Interactive Data Language (IMDISP), and PicLab (a freeware graphics package). Data could be subset, listed to screen, printed as both black and white and color hardcopy, and images saved to the GEM .IMG format facilitating use of the information in a slide show, and integration in text documents. Cruise tracks could also be plotted. Customization of the visualization was controlled by the end-user allowing for the selection of colors and specification of contour intervals. Data could also be copied to a computer's hard disk to facilitate faster access (Lowry et al., 1992).

By comparison to other BODC products this was a less user-friendly source of data, comprising a number of different interfaces to different software used to view, analyze and visualize the data, and was aimed more at the specialist audience than the layman.

GEBCO Digital Atlas

The General Bathymetric Chart of the Oceans or GEBCO Digital Atlas (http://www.gebco.net/data_and_products/gebco_digital_atlas; Jones et al., 1994) was another BODC product, first released in 1994 on 3.5" floppy disk (software) and CD (data). Complete with a comprehensive 70 page printed Supporting Volume (including Annexes) to the GEBCO Digital Atlas (GDA), it contained the following: digitized bathymetric contours and coastlines; digitized trackline control; the existing digitized bathymetric charts from the Intergovernmental Oceanographic Commission (IOC) regional ocean mapping projects; a copy of the computerized gazetteer of geographic names of undersea features as maintained by the International Hydrographic Bureau; a standard world coastline (the US Defense Mapping Agency's World Vector Shoreline); and a trackline inventory of digital sounding data (Jones et al., 1994). The end-user interface and functionality were very similar to that of UKDMAP and the Current Meter Series Database. Running under MS-DOS, with an interface comprising drop-down

menus, the software provided a range of functionality to visualize the data on a map using overlays, to extract and save data, provide printout, and to generate slideshows. Current information about the latest release of GEBCO and the software is now available online at <http://www.gebco.net/>

In summary, all of these BODC products were clearly quite unique when first made available. Furthermore, they were well developed, executed, and subsequently supported, which at the time, placed the UK at the forefront of electronic access to coastal and marine data and information and electronic atlases. Although UKDMAP was not developed further by BODC, the closest equivalent now is the Marine Irish Digital Atlas (MIDA) (<http://mida.ucc.ie/>) which is discussed in Chapter 7 and utilizes web mapping technology.

HelFal

With the arrival of Windows-based operating systems, first pioneered by Apple and later pursued by Microsoft as a replacement for MS-DOS, came a new generation of micro-computers and software. As mentioned earlier in this chapter, NOAA developed their COMPAS system for the Apple Macintosh using Hypercard (a hypermedia application program) software. A similar approach was used at the University of Aberdeen by Green (1994c) to develop a simple demonstrator for coastal management of a UK estuary in Cornwall, South West England. HelFal (the Helford Passage and Fal Estuary Community Information System) was used to convey the concepts and potential of developing a multimedia GIS-based information system, using maps, text and imagery for the two estuaries. A version of this demonstrator was later also developed in Toolbook, multimedia training software program for the PC. The objective was to take advantage of the opportunities to construct a simple intuitive interface to a wide range of data and information about an estuary including maps, imagery and text documents using interactive multimedia software.

THE WORLD WIDE WEB AND SOME EARLY EXAMPLES

In the mid-to late-1990s, with the then emerging Internet, web browsers (e.g., Mosaic and Netscape), and accompanying software, attention soon turned to the potential the web offered as a means to construct online mapping and information systems and electronic atlases, and to provide access to spatial data and information by a wider end-user community via both network and communications software. A number of early web-based examples were soon developed, more often than not as demonstrators of the potential the Internet offered as an interface to a wide range of coastal and marine information from multiple disparate formats and sources.

Over time, progress towards web-based GIS has been greatly aided by the development of Internet map- and image- server software and the concept of an Internet map service (IMS). The best known software initially was perhaps ESRI's ArcIMS which has been widely used as the basis for many online GIS projects. Indeed, nearly all commercial GIS software packages now have their own IMS as part of the software or as an add-on. Besides commercial software products such as ArcIMS, there are a number of open source software examples such as GeoServer (<http://GeoServer.org>) and Minnesota MapServer (<http://MapServer.org>). Web Mapping Services (WMS), an Open Geospatial Consortium (OGC) standard, are also now supported by Google Earth (<http://earth.google.co.uk/>), NASA's World Wind (<http://worldwind.arc.nasa.gov/>), and Microsoft's Virtual Earth (<http://www.microsoft.com/maps/>).

Proposal for a UK Network-Based Spatial Information System: The United Kingdom Marine and Coastal Information System (UKMCIS)

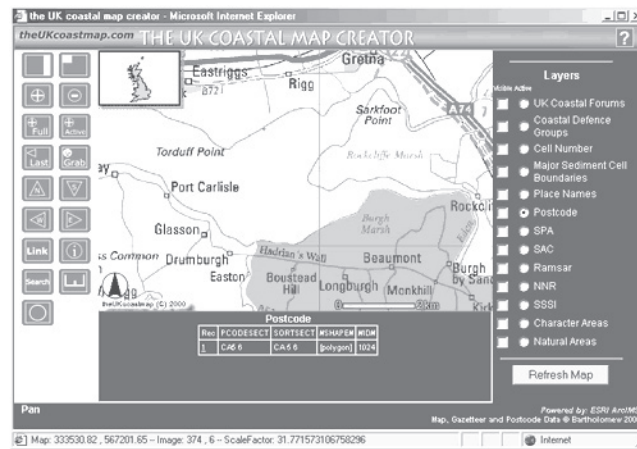
The success of UKDMAP clearly revealed the demand for a simple means to access UK marine

and coastal data and information. Green (1995) therefore proposed a national coastal and marine information system based around the world-wide web. At the time this represented a unique and potentially very useful way to translate the work and content of products such as UKDMAP into a format offering many advantages over distribution on a CD. UKMCIS (the United Kingdom Marine and Coastal Information System) was a conceptual idea to integrate existing disparate coastal and marine data and information held by many UK organizations into a widely accessible national information system based around the net, which would provide and enhance opportunities for more people to access and use coastal and marine information. The rationale for this approach lay with the following advantages: establishing a resource for multi-user access; promoting awareness, contact and discussion; providing improved communication links; providing opportunities for direct sharing of data, information and expertise; providing opportunities for integration of data; developing a multidisciplinary approach to research and problem solving; minimizing duplication of data and work; providing cost-effective solution to problems; enhancing planning and decision-making. Additional benefits included: overcoming the isolation of data and information sources; promotion of data standardization and documentation; encouraging regular updating; and an emphasis on data quality and error checking.

The UK Coastal Map Creator

As with all computer technology the Internet evolved very rapidly and by the mid- to late- 1990s software to generate map-based or GIS-based map delivery across the Internet was well developed. One of the most notable early examples was ESRI's ArcIMS, a product that allowed a developer to create web-based portals providing an opportunity for map and image based data and information to be accessed, and shared across a computer network.

Figure 2. The UK Coastal Map Creator



One early example that took advantage of the potential offered by the world-wide-web was the UK Coastal Map Creator (Green and King, 1998; Figure 2), the outcome of some research undertaken at the University of Aberdeen in Scotland, UK using ESRI's ArcIMS 3 software. Supported and hosted by ESRI UK, the UK Coastal Map Creator was one of the first examples of a web-based coastal zone information system in the UK. Building upon the ideas first presented by Green (1995) for UKMCIS, the UK Coastal Map Creator took advantage of the functionality of ESRI's ArcIMS to develop a framework to deliver coastal and marine information to the UK coastal community. Initially developed as a demonstrator to enhance access to UK coastal and marine information, the UK Coastal Map Creator sought to encourage potential data providers to make their data and information more widely available.

The rationale for the development of the UK Coastal Map Creator was that access to data and information is an essential component of day-to-day coastal planning and decision-making in integrated coastal zone management (ICZM). In the United Kingdom (UK), coastal zone management was undertaken by a wide variety of government and non-government agencies and institutions guided and co-ordinated by voluntary

forums or partnerships for specific areas of the UK coastline. Although many of these organizations gathered data and information relating to the coast, often it was not stored in a standard or accessible format for people to use outside of a particular agency or to share easily. The web environment therefore provided an opportunity to overcome such constraints.

The Bartholomew 1:200,000 raster data provided the navigational base map for the system, developed with their postcode and gazetteer data, providing the end-user with the ability to search the database either by town name or postcode. Other datasets included were English Nature's (now Natural England) boundaries of national and international conservation site designations in England. Proposed additions to the system included aerial photography, satellite imagery, and Lidar, some aided by commercial agreements with Infoterra (<http://www.infoterra.co.uk/>). Considerable care was taken to develop a user-friendly and aesthetically pleasing interface for the end-user, bearing in mind the growing and ever widening end-user community for such information. Customization was easily achieved using the ArcIMS software tools.

However, whilst successful as a conceptual framework, the UK Coastal Map Creator ulti-

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mately proved practically difficult to develop into a national resource for a number of reasons, even despite an attempt to commercialize the system. One reason was the difficulty in getting map data suppliers to contribute data into the system. Commercial agreements to both list and show an example of available information on the website with a pointer to the data supplier's contact details overcame some of these difficulties but did not lead to wider population of the system with spatial datasets of interest to the coastal and marine community. Another was the ever present problem of copyright issues in the UK which usually made the base datasets prohibitively costly to purchase and use in an online system such as this.

Geo-Information Decision Support Processing and Dissemination System

An extension of the UK Coastal Map Creator idea was the GDSPDS (Geo-Information Decision Support Processing and Dissemination System) (<http://www.abdn.ac.uk/~geo402/index.htm>) developed by King at the University of Aberdeen in the Centre for Marine and Coastal Zone Management (CMCZM) (<http://www.abdn.ac.uk/cmzcm>) between 1999 and 2001. Constructed using ESRI's ArcIMS 3 software, the GDSPDS sought to extend the basic and typical concept of a GIS and mapping portal into one that included links to a wide range of additional geographical data and information representations, thereby providing a multimedia information system for planning and decision-making in the coastal zone. The system focused on the Solway Firth in Scotland, UK.

In addition to ESRI's ArcIMS software used for the mapping component, the system offered the end-user access to digital satellite and airborne imagery, panoramic photography, mobile GIS data, and video, all within a single system. A key component of the work involved emphasis on the end-user interface, with a focus being placed on the aesthetics, functionality, and usability of the interface by the coastal manager and coastal

practitioner, and development included some end-user tests. Some additional experiments were undertaken to explore the utilization of image compression software e.g., LizardTech's Mr. Sid (<http://www.lizardtech.com/>) and ER-Mapper's ECW compression formats (<http://www.erdas.com>), and a range of software utilities to process and visualize data and information, as well as some more experimental ideas utilizing software to develop a 3D realistic navigational interface to the coastal zone information.

As an experimental decision-making framework, based around recognition of the importance of the ease of access to coastal data and information for coastal managers, this research revealed how off-the-shelf software and hardware could easily be utilized and customized to create the framework for an online GIS mapping, data and information system for coastal zone management.

SOME RECENT UK WEB-BASED EXAMPLES

With greater availability of spatial data and developments in web-based technology, coupled with a desire to develop institutional and national online information systems using map servers, more and more organizations have been placing their marine and coastal data and information online in one format or another. Whilst some simply provide access to catalogues of data holdings with accompanying search tools, others have provided online mapping systems with customized interfaces, metadata, tutorials, manuals, help files and data download facilities. Recognition of the potential of the Internet-based marine and coastal information system is finally beginning to take shape particularly now with the UK Marine Bill (<http://www.defra.gov.uk/>) and the Scottish Marine Bill (<http://www.scotland.gov.uk/Publications/2009/09/28115722/0>). The growing use of GIS and the need for spatial datasets is also being influenced by the greater emphasis now placed

on the development of Marine Protected Areas (MPAs), marine national parks, and the overall enthusiasm for marine or maritime spatial planning. A few different examples of such developments are summarized below to illustrate some of the progress that has been made to date.

Data Archive for Seabed Species and Habitats

The Data Archive for Seabed Species and Habitats (DASSH; <http://www.dassh.ac.uk/>) is an archive centre for digital benthic data, as well as images and video, and an online catalogue of data and metadata, providing a long-term store and a data and information resource. Funded by Department of Environment, Food and Rural Affairs (DEFRA), DASSH works with the Marine Biological Association, the Marine Life Information Network, the National Marine Biological Library, the Marine Environmental Digital Information Network (also known as MEDIN), and the Marine Data Archive Centers regarding data standards. Although primarily a search-based interface, there is a simple map interface search window in SEArchable Benthic Data or SeaBED. This is interactive and allows one to draw a bounding box around an area on a map and returns the coordinates to the search tool and a list of datasets. These can then be downloaded in the comma separated value or CSV file format for use in a spreadsheet and subsequently imported into a GIS such as ESRI's ArcView or ArcGIS. Links to other organizations are provided where the data are not held by DASSH. Registration of a user's details allows continuing access to any datasets retrieved from the database.

Marine Environment Data and Information Network

MEDIN (<http://www.oceannet.org/>) is hosted at the BODC and comprises a partnership of UK organizations whose aim is to improve access to

marine data. The web interface is being tested at present and provides links to marine data held by a number of other organizations e.g., DASSH, British Geological Survey (BGS), and the United Kingdom Hydrographic Office (UKHO). It provides hyperlinks to access a data discovery portal, a data search by theme, and advice on marine data standards, mainly for the UK. Searches return a series of links to detailed metadata files in Extensible Markup Language (XML).

ICES FishMap

The International Council for the Exploration of the Sea, Denmark (ICES) Fishmap (<http://www.ices.dk/marineworld/ices-fishmap.asp>) is an online atlas of fifteen fish species in the North Sea based on data collected from trawl surveys collected between 1983 and 2004. It was created by RIVO (Institute of Fisheries Research, The Netherlands), Center for Environment, Fisheries and Aquaculture Science, UK (CEFAS), and ICES and is partly funded by the European Commission's 6th Framework Program. Fishmap provides an online web portal together with background information, some downloadable as PDFs and includes data from GEBCO (see earlier). Fishmap has two modes: Basic and Advanced. In Basic mode, the end-user is provided with a simple, largely static, interface which provides a legend of the fifteen fish species in the North Sea. Selecting each fish species changes the map accordingly. Contextual information on each species is also provided. This is a very basic user-interface and functionality is limited to changing the fish species and the selection of Basic or Advanced mode. Advanced mode, by comparison, provides a more interactive interface with an array of zoom, measure, re-center, select area, and select polygon functionality. In addition, a pane provides the end-user with reset, export, select, query, clear and help functionality. The legend pane provides access to the data. The data layers can be selected and displayed. This is a simple web atlas with basic functionality. It

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operates in interactive Spatial Explorer and Administrator (iSEA), CEFAS's spatial data explorer and webGIS interface for UK data (<http://www.cefasc.co.uk/isea>).

WaveNet

Another web-based interface provided by CEFAS is WaveNet (<http://www.cefasc.co.uk/wavenet-mapping>) which provides access to DEFRA's wave buoy locations and wave height data. This is a very simple interface to a map, where interaction of the mouse with each symbol also reveals the data for that buoy, which includes wind and temperature information. As with ICES Fishmap, the CEFAS web interface includes a Basic and Advanced mapping capability. The Advanced mapping capability provides access to a similar map but with more functionality and many layers, including wind farms, buoys, and waveriders, that can be toggled on and off, selected, deselected, and redrawn. Clicking on a symbol takes the end-user to a separate web page with further options to display the data. Links to satellite and text data, as well as Google Earth KML files are also provided.

Mapping European Seabed Habitats (MESH)

The Mapping European Seabed Habitats (MESH) marine mapping and metadata portal is one of the outcomes of the MESH project (<http://www.searchmesh.net/>). Funded by Interreg IIIB NW Europe, MESH was developed over three years, starting in 2004 and finishing in 2008. It involved twelve European partners led by the Joint Nature Conservation Committee (JNCC). Accompanying the webGIS mapping interface is a very comprehensive website providing both the scientist and the non-scientist with information about benthic habitat mapping and the process of producing a map, as well as details on a data model, metadata, and a series of case studies. The webGIS was developed using the open source GIS software

Minnesota MapServer, which can be freely downloaded and used to develop an online mapping system. The portal contains a wide range of marine datasets.

UKSeaMap

The UKSeaMap webGIS (<http://www.jncc.gov.uk/page-3663>) provides a map portal (described as a mapping data delivery service) giving access to information on seabed landscapes and seasonal water column features. Additional contextual layers (e.g., geology, bathymetry, tide stress, and salinity) are also provided. It was funded by the following organisations: the Countryside Council for Wales (CCW), DEFRA, Department of Trade and Industry (DTI), Natural England, The Royal Society for the Protection of Birds (RSPB), the Scottish Executive, the Crown Estate, the JNCC, and the World Wildlife Fund (WWF). UKSeaMap was developed as part of MESH (see above). The web GIS is launched using an initial layer chosen from a drop down menu list (e.g., a base map). The web-mapping interface was developed by the JNCC and exeGesIS SDM Limited and made use of Minnesota MapServer and the Javascript language. The interface comprises a typical web-mapping view on a map window, an overview map, a legend and a number of basic navigational tools, complete with tabs for Location, Legend, Info, Layers, and Help. These can all be selected and the information is displayed in the right hand pane of the view. Layers can be toggled on and off. The webGIS can be launched from a number of points in the website pages that accompany the mapping portal, and the water column data and the seabed landscape data can also be downloaded as zipped data files.

Multi-Agency Geographic Information for the Countryside (MAGIC)

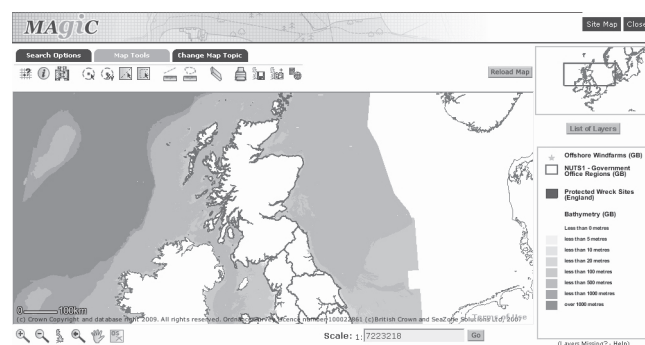
The Multi-Agency Geographic Information for the Countryside or MAGIC (<http://www.magic.gov.uk/>) is a website with an interactive map service providing public access to geographic information on the environment and designations. A detailed overview of MAGIC is provided by Askew et al. (2005). As part of this online resource, a Coastal and Marine Atlas was added in 2005. This is promoted as a tool for marine planning and contingency response. It is funded by the following organizations: the Maritime and Coast Guard Agency (MCA), DEFRA, the Scottish Executive (SE), Scottish Natural Heritage (SNH), the Energy Institute (EI), JNCC, the Environment Agency (EA), English Nature (EN; now Natural England), the Department of Trade and Industry (DTI), the Hampshire County Council (HCC), Essex County Council (ECC), Kent County Council (KCC), and the British Geological Survey (BGS). Much of the data are from the Ordnance Survey (<http://www.ordnancesurvey.gov.uk>) and also SeaZone (<http://www.seazone.com>). Compared to many of the other online mapping systems discussed earlier in this chapter, MAGIC has more GIS functionality accessible via the user-interface. There are a number of navigational functions including zoom, pan and the addition of an Ord-

nance Survey map backdrop, grid co-ordinates, identify, measure distance and area, print, save (in GIF format), re-project, and bookmark. The view window includes a map pane, a scale and scale bar, a legend pane, and an overview map. Up to fifteen thematic layers can be displayed at any one time. Tabs provide access to map tools, and other themed resources. Aside from the online map-based information the website also includes a map tutorial, dataset information, some static maps, a training manual, and work in progress (Figure 3).

Western Channel Observatory

The Western Channel Observatory (WCC: <http://www.westernchannelobservatory.org.uk/>) is hosted by the Plymouth Marine Laboratory (PML: <http://www.pml.ac.uk/>) and provides access to marine data e.g., ocean color, sea surface temperature, chlorophyll, weather data and webcams for the Western English Channel. Data, including remotely sensed data are integrated within a GIS. At present the interface is basic and provides web links to data and graphic visualizations, as well as the satellite data. The latter utilizes the NERC Earth Observation Data Acquisition and Analysis Service (NEODASS) (<http://www.npm.ac.uk/>), a Java image viewer which includes some zoom and GIS data overlay capabilities. An additional, and unique, feature of this portal is the interactive

Figure 3. Screen snapshot of MAGIC (courtesy of DEFRA)



Data Service) It was designed for scientists so as to facilitate analysis and visualization of data from various sources including climate, atmospheric and oceanic models. Godiva provides a map-based interface (Godiva2) for a range of marine spatial datasets from the ESSC Web Map Service for environmental data for a number of different areas and from different origins e.g., UK Met Office. One such area is the Irish Sea. Available datasets include: sea water velocity, sea surface height, sea water temperature, and wind speed. Data can be selected for viewing with the aid of a calendar and drop down time (clock) menu. The data are visualized against a map outline. The interface also includes some basic navigational tools for the map data e.g., Pan and Zoom, together with a legend. A choice of linear or log displays can also be selected. A Transect tool allows transect graphs to be shown in a separate window. The basic interface is simple and practical, aesthetically appealing, and functional, allowing the end-user to locate and display multi-temporal marine spatial datasets, and to focus on the information, thereby providing a useful browse service. It also allows for the comparison of different datasets from different EU projects e.g., MERSEA. The accompanying User Guide gives details about using Godiva and the ways in which it can be customized by the end-user e.g., navigation, changing the color palette, creating an animation, and changing the map projection, as well as saving and emailing a view.

SeaDataNet

SeaDataNet of the Pan European Infrastructure for Ocean and Marine Data Management (www.seadatanet.org) has been developed by a number of EU partners including the British Oceanographic Data Center (BODC) in the UK. The web portal provides access to marine datasets from thirty-six countries. The viewing services are in the form of a Catalog and Maps, with point, track and area entries. Developed in compliance with OGC (Open Geospatial Consortium) standards

and in co-operation with my-Ocean (see below) it includes a Common Data Index (CDI) Metadata Search interface. This includes a Geographical Box selection criteria function with a map view, simple navigational tools, and additional information resources. More details are provided at the BODC website: <http://www.bodc.ac.uk/projects/european/seadatanet/>.

MyOcean

At the time of writing, the MyOcean Service (2009-2012 - <http://www.myocean.eu.org>) is a new project (a contribution to Global Monitoring Environment and Security or GMES) that aims to provide a catalog of worldwide and European regional ocean products (in the form of real time observations, analysis and forecasts) that have been made available from previous projects e.g., MarCoast. It will include the INfrastructure for SPatial InfoRmation in Europe (INSPIRE) functionalities e.g., discovery, visualization and downloading tools and includes marine and coastal environments.

InterRisk

InterRisk (<http://interrisk.nersc.no>) is an EU funded project (FP6-IST) designed to provide GMES information services for environmental risk management in marine and coastal areas of Europe. It has been built on existing solutions from other GMES projects e.g., MASS GSTP and the Data Integration System for Marine Pollution Water Quality or DISMAR (<http://www.nersc.no/dismar/>) The pilot service is based on open system architecture of GIS and web service protocols and has been implemented for several European regional seas, one of which is UK/Irish waters (Plymouth Marine Laboratory). It is also based on a number of recognized standards including the World Wide Web Consortium (W3C), the OGC, the International Organization for Standardization (ISO), and follows INSPIRE recommendations.

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The Open-source Project for a Network Data Access Protocol (OPeNDAP) and software tools have also been investigated.

MarCoast

MarCoast (Marine and Coastal Environmental Information Services: <http://gmes-marcoast.com/>) was a three year (2005-2008) GMES (Global Monitoring for Environment and Security) project funded by the European Space Agency (ESA). It comprises a network of marine and coastal information services e.g., the MarCoast Service Portal and provides a catalog of the services provided by the MarCoast partners at a European scale, including the UK. These are in the form of surveillance, forecast, monitoring and alert, and assessment services. This includes access to oil spill, water quality, algae bloom, water quality assessment and Met-Ocean data. The basic map interface is simple and offers navigational and search tools, and an overview map. A 'map' link provides access to Google Map as a backdrop and a Google Earth file that displays a map of links to service providers. In addition, some data are available for download and services can also be added.

Proudman Oceanographic Laboratory Observatory

Included as part of the Proudman Oceanographic Laboratory's (POL) Observatory for the Irish Sea is a MapViewer link (<http://cobs.pol.ac.uk/gmap-per/>). The map interface is based on Google Maps, together with an interactive legend, instructions, and links to a map and satellite imagery backdrop. Additional map data layers include near real time data on Coastal Tide Gauges, WaveRider Buoys, SmartBuoys, as well as and RiverFlow monitor data, and model output. Switching to satellite provides an image backdrop instead of the map. The interactive legend can be hidden from view. This website takes advantage of the Google Maps interface as a backdrop to other layers. Clicking

on the symbols gives a pop-up window which provides further links to data. For example clicking on the tide gauge symbol for Lowestoft leads to web links for near real time tide gauge data and seven day predictions. The interface is aesthetically pleasing and easy to navigate and use, with its interactive legend, and is perhaps closest to a combination of a GIS and the Google interface, something that makes it potentially quite familiar.

Google Earth and Local Information Systems

With the availability of Google Earth and a range of software utilities it has become possible to consider this as yet another way to provide access to and share data and information relevant to the marine and coastal environment. As seen earlier some of the web-based services are already making use of Google Maps and Google Earth. However, while Google Earth, in its base form, provides access to geospatial information for anywhere in the World, the additional element explored in this section of the chapter lies with the potential to create a local information system allowing for the addition of additional data and information (vector and raster) as well as data collected with mobile systems to the base layers provided in Google Earth. With the aid of software utilities e.g., Shape2Earth (<http://shape2earth.com/>), MapWindow (<http://www.mapwindow.org/>) and a number of Google blogs (e.g., OgleEarth (<http://www.ogleearth.com/>)) it is possible to add more information to the Google Earth view that can then be shared as a KMZ (KML-Zip file) file and opened by anyone who has access to Google Earth. These provide a powerful toolbox to create a simple online GIS system.

The latest release of Google Earth, including Google Ocean, has extended the terrestrial information resources to the coastal and marine areas, allowing for the addition of bathymetric data. This combination can then be used to develop local GIS for small areas of the coast and, in an

Figure 5. Virtual Fieldtrip of Ythan Estuary in Google Earth



educational and training context, can be used as the basis for developing virtual fieldtrips or as a ground-truthing resource. Two simple examples are used here for illustration. The first is a local information system developed for the Ythan Estuary in North East Scotland, UK, which is also used to provide a virtual fieldtrip and tour of the estuary and the sand dune system. The second example is the use of Google Earth to create a local information system for Nigg Bay to the south of Aberdeen that is also used as the basis to create a multimedia coastal footpath walk, and a visual fly-through of the Bay as the basis for visualizing a proposed waterfront regeneration proposal (Figure 5). Although Google Earth has some limitations as a Geographical Information System (GIS) mainly in terms of its functionality, it has considerable potential to provide a relatively simple way to bring together and display spatial data and information, and to share the data and information without the need to have a GIS. Google Earth also allows for layering on top of an image back drop, the addition of more layers, and incorporates a DEM (Digital Elevation Model). The popularity of Google Earth is increasingly evident from the number of data providers who are now willing to share their GIS data layers in the KMZ format; for example, Scottish Natural Heritage (SNH), and the Maritime Coastguard Agency (MCA), and by the number of GIS software packages that now allow the export of data

in a GIS to the KML format. Perhaps the biggest drawback to using Google Earth is the apparent limitation in file sizes that can be handled, and in the UK problems that might arise when sharing data if the source originates with, for example, the Ordnance Survey (OS).

ISSUES AND DEVELOPMENTS: PAST, PRESENT AND FUTURE

Green (1994b) raised some general issues concerning ease of access to coastal and marine data and information for the wider community. Whilst progress towards overcoming some of the constraints has clearly been made over time, there still seem to be a number of the very same issues continuing to hinder progress in this area.

Access to data and information about the coastal and marine environment has clearly improved greatly over time. This has largely been aided by the development of web portals that allow end-users to find, locate and explore the data, to visualize database holdings in the form of an interactive map (some with simple GIS functionality), and in some cases to download the digital datasets for use in a GIS. In the UK there have been a number of initiatives to collect and make more widely available data for the marine and coastal environment. Two have been the result of collaborative projects to develop links between the

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Ordnance Survey (OS) terrestrial data and marine chart datasets from the UK Hydrographic Office (UKHO). This resulted in two map demonstrators. The first produced a single paper sheet map of the coastal zone for the area around Southampton and the Isle of Wight. The second, Integrated Coastal Zone Map (ICZMap), a collaborative project of the Ordnance Survey, the UKHO and the British Geological Survey (BGS) was completed in 2003 and resulted in an example demonstrator digital dataset. Latterly this led to the creation of SeaZone thematic GIS layers. These include: hydrospatial, digital survey bathymetry, charted raster, and charted vector data. These have since been successfully used within some of the web map portals described earlier. Recent developments for academic use (teaching and research) have been Marine Digimap (http://edina.ac.uk/digimap/description/marine_overview.shtml) which makes the SeaZone datasets available for in-class exercises and project work. This has been some time in coming but is definitely a very positive development for up and coming generations to be able to use the data in their education and research.

Interfaces to information systems have also clearly evolved, and whilst there is considerable variety in the end result and ultimately the functionality and usability of each one, the Internet (and some of the web mapping software) has had a huge impact upon improving access to information through more aesthetically appealing, navigable, intuitive, and usable interfaces.

In nearly all cases, the online portals also provide considerable contextual background which is focused on the likely potential end-user community and usually include resource pages with additional information, tutorials, links, manuals, and help files. This is not unlike earlier systems provided on disk and CD. What is still not included, however, for those systems where it is possible to create a new map, with the end-user having control over the choice and use of color, shading and symbols, and overall design, is guidance or

best practice guidelines on how to produce the most effective map as output. This is especially important where maps are to be exported to a document or used in a slideshow presentation for communication to a wider audience. While some systems do provide information about the mapping process (e.g., MESH has a link to a Mapping Guide), there is still a fundamental need to direct end-users of these online information systems towards the basics of map design through books and tutorials etc., particularly as Green (1994b) points out that: cartographic design is far from trivial and it is easy for those lacking knowledge and experience to end up with a poor map. This should not really be a problem as there are now many books and resources to aid the end-user (e.g., Brewer, 2005; Brown & Feringa, 2002; Dent, 2002; Erle et al., 2005; Krygier & Wood, 2005; Madej, 2000; Memorial University, 1998; Peterson, 2009).

There is clearly also a wide range of different digital examples of online mapping systems, online GIS, and electronic atlases, that provide interfaces to either databases via search tools, and/or interactive map searches, as well as providing online mapping tools, and even online GIS. Whilst many examples are simply little more than information systems, other examples allow one to download the actual map data for further analysis in a desktop GIS. Although not every end user requires the data, most simply requiring access to the information, in some cases the demand for datasets for spatial analysis in a GIS can be very advantageous for education, training, and research applications

Problems once associated with being able to read different data formats have largely disappeared and where data are available for download this is usually available in a number of well recognized and accepted formats that can be easily used directly in GIS software. These are typically ESRI shapefiles and coverages. More recently Google Earth KML Keyhole Markup Language (KML) and KMZ (KML-Zip) files are now often

an option, finding favor as the popularity and functionality of Google Earth and Google Ocean continues to grow.

More emphasis is now also being placed on the development of data models e.g., the Arc Marine data model (<http://dusk.geo.orst.edu/djl/arcgis/>), and metadata standards for documenting spatial datasets. In Europe the INSPIRE initiative is becoming increasingly relevant to the future of UK (as part of the EU) datasets. However, although much has also been written about national SDI and marine data infrastructures over the years (see Longhorn, 2009) there still seems to be some problems and perhaps even reluctance with translating words into practice, and there is much work still to be done in this area. As noted earlier, this is perhaps one area where the work and collective expertise of ICAN can begin to help to contribute to and drive progress in the future.

The main issue remaining, however, in the UK still lies with copyright and charging associated with digital datasets. On the whole most UK datasets are still relatively costly to buy and use and this tends to restrict their use by all the interested parties ultimately hindering attempts to produce Internet-based mapping and GIS systems at the local, regional, and national scale. While it is perfectly acceptable that data should be charged for (after all data costs money to collect, capture, create, and maintain) identifying what seems to be a 'reasonable' and 'acceptable' cost for use still appears to be quite difficult to achieve. Certainly substantial progress has been made over the years, as can be seen from the many online examples now available. But it would seem that despite the best efforts of people and organizations, many of the online websites are either very specific or are at best are still only partial solutions, despite the general availability of the software tools to create the resources. This is somewhat disappointing given the timeframe over which these ideas have been discussed, and the speed with which the technology has been developed to provide technical solutions. However, at the time of writing, recent

Government-led developments at the Ordnance Survey (OS) have launched a new initiative called OS OpenData designed to provide users with free and unrestricted access to most of its map data (<http://news.bbc.co.uk/1/hi/8597779.stm>). This is an interesting and welcome step forward and one that will hopefully address many of the issues that have prevented more widespread development of the online examples of marine and coastal atlases in the UK.

SUMMARY AND CONCLUSION

Rapid developments in computer hardware and software have provided considerable opportunities for accessing and sharing geospatial data and information about the marine and coastal environment in the last twenty years. While early examples of marine and coastal atlases provided opportunities for more people to explore and utilize such data and information, the Internet and associated software in the form of map and image servers have provided the biggest step forward in providing access to both data and information for the marine and coastal environment. Although still not plug and play solutions, Internet-based map server software is more widely available and can now be more easily configured by virtually anyone with the help of various manuals, tutorials, books and blogs, which means that more people can set up their own web portals and create electronic atlases. With the development of products such as GeoServer, MapServer, TimeMap and more recently Google Earth, and Google Ocean, there is now even more scope to share geospatial datasets across the net, and to develop digital coastal atlases. The University of Aberdeen, for example, is currently investigating the development of a coastal atlas for the Aberdeen and Aberdeenshire coast (<http://www.sacrp.info>), and another for the Living North Sea (LNS) (<http://www.livingnorth-sea.eu>) Project using Google Earth, TimeMap and MapServer.

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An historical overview reveals the development of the hardware and software, networking and communications technology, the Internet, and the growing freedom for the individual to upload and share their geographical data. In the UK though it has been relatively slow to develop and take off. Over the years there have been many examples of proposals, demonstrators, and project-based examples of Internet-based electronic atlases. In the UK, some of the potential and the will seems to have been lost in all the continuing discussions about data availability, data models, spatial data infrastructures, and a general lack of recognition of the value of the Internet as an information resource, as well as continuing to involve people who lack the vision of the potential, underfunding, lack of commitment, and to some extent the degree to which it is all become 'bogged down' in words rather than actions.. This perhaps goes some way towards explaining the origins and success of Google Earth! In other parts of the World there would appear to be far fewer constraints and barriers to accessing digital map and chart data which has, not surprisingly, led to the development of some very comprehensive and very appealing online examples of electronic atlases which provide the sort of resource that is desirable by the end-user community, including that in the UK.

Where to now in the UK? ICAN has revealed how useful, important and powerful web-based mapping, atlas, and GIS tools are and, from the list of examples provided, just how successful they have become. The technology is also proven and more and more digital spatial data are becoming available. It is a pity then that there are so few UK examples which truly mirror the earlier success of UKDMAP. The resources now available range from the basic to the comprehensive, simple to aesthetic and intuitive interfaces, and basic to sophisticated functionality. Certainly there are some good UK examples and much has been achieved. Yet it would seem, from looking at other examples originating in North America and Europe that we could do so much more and

better in the UK. Perhaps the work of ICAN will provide the required stimulus?

Finally, a thought. Despite the advantages of all this computer-based spatial technology to provide access to and share digital coastal and marine data and information, there are still a number of printed, paper-based examples of atlases being produced around the World (albeit with the use of electronic data and the help of computer software and usually provided on an accompanying CD/DVD for use in GIS software). While there are clearly advantages and disadvantages of both media, and a certain appeal and practicality associated with the electronic format, it is hard to beat the look and feel of information presented in the form of a bound paper volume. Maybe there is a challenge here to consider new ways of presenting and visualizing coastal and marine information in the electronic atlases of the future that tries to capture some of the visual attraction of the printed atlas? Assuming of course the data are available!

ACKNOWLEDGMENT

The Living North Sea (LNS) Interreg IVB North Sea Region Program: Investing in the future by working together for a sustainable and competitive region.

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KEY TERMS AND DEFINITIONS

Coastal Web Atlas: A collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet. Also known as web atlas, digital atlas, digital coastal atlas.

Coastal and Marine Information: Both spatial and non-spatial information regarding the coastal and marine areas of a region or country.

Metadata: Metadata in the geographical domain is structured information on a dataset, which

helps the data owner to document and catalogue the data, whilst helping a data user to understand the content and fitness for use of a dataset.

Spatial Data Infrastructure or SDI: A framework via an organization of people or government agencies, via the Internet, or via a series of guiding policies or standards to assist people with acquiring, processing, using, and preserving spatial data. The spatial data are often in geographic information system (GIS) format, are not, but not limited to this.

Spatial Data Visualization: The ability to view digital data with a spatial dimension in a computer environment containing a coordinate reference system.

Web GIS: A geographical information system which can be accessed over the Internet and allow visualization and interaction with spatial data via a map as well as providing analysis functionality such as spatial analysis, querying and buffering.

Virtual Globe: A three-dimensional visual rendering of the Earth or of other planets, usually available as online software application, or as an application for the desktop. A virtual globe provides the user with the ability to navigate throughout the virtual world freely in all directions, by changing viewing angle, azimuth, and heading. A virtual globe is primarily a visualization tool (oftentimes open source) and is not completely synonymous with a geographic information system in terms of spatial analysis capabilities. Examples include Google Earth, NASA World Wind, and Microsoft Virtual Earth.