SemSorGrid4Env

FP7-223913

Deliverable

D7.1 Flood User Requirements Specification

WP7: Coastal & Estuarine Flood Warning in Southern UK

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Executive Summary

This deliverable explores user requirements for the development of spatial data management applications for coastal planning, management and emergency response in the Solent region of Southern UK, particularly in the context of flooding. The applications will draw on real-time, historic and baseline data sets, including a real-time sensor network deployed through the southern coastal region. Interviews and interactions have been conducted in order to establish user requirements and to provide a context for the development of a functional architecture to be developed by the SG4E consortium.

The flood use case to be explored through WP7 of the SG4E project is fundamentally geared to providing a real-world anchor for the theoretical and practical software innovations of the project. It takes the line, for example, that the function of a mashup is to provide the technology base for joined-up thinking, and therefore targets user groups where such integrated approaches are prioritised. The document aims to provide a proof of concept for SG4E by specifying and defining representative applications that fit real users working within real management systems and driven ultimately by real business cases.

The deliverable document begins with an examination and analysis of the flood user environment; moves though identification and building of a representative stakeholder group, with detailed analysis of their requirements within the potential of SG4E. This process leads to descriptions of concrete examples of flood use applications and finally begins the process of specifying them within a web/mashup environment, taking into consideration the technologies and standards under examination within the project.

Note on Sources and Original Contributions

The SemSorGrid4Env consortium is an inter-disciplinary team, and in order to make deliverables self-contained and comprehensible to all partners, some deliverables thus necessarily include state-of-the-art surveys and associated critical assessment. Where there is no advantage to recreating such materials from first principles, partners follow standard scientific practice and occasionally make use of their own pre-existing intellectual property in such sections. In the interests of transparency, we here identify the main sources of such pre-existing materials in this deliverable:

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Abstract (for dissemination)	The deliverable explores user requirements for the development of spatial data management applications for coastal flood planning, management and emergency response in the Solent region of Southern UK. The applications will draw on real-time, historic and baseline data sets, including a real-time sensor network deployed through the southern coastal region. Interviews and interactions have been conducted in order to establish user requirements and to provide a context for the development of a functional architecture to be developed by the SG4E consortium. The flood use case to be explored through WP7 of the SG4E project is fundamentally geared to providing a real-world anchor for the theoretical and practical software innovations of the project. It takes the line, for example, that the function of a mashup is to provide the technology base for joined-up thinking, and therefore targets user groups where such integrated approaches are prioritised. The document aims to provide a proof of concept for SG4E by specifying and defining representative applications that fit real users working within real management systems and driven ultimately by real business cases.					
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1 Introduction

1.1 Scope

This document represents the Dl_7.1 of WP 7 *Flood User Requirements Specification* within the EU project "*Semantic Sensor Grid Rapid Application Development for Environmental Management (SG4E)*".

1.2 Document Structure

The information within this document is presented as follows:

Section 2: *User Requirements*: Provides a proof of concept for the SG4E flood user case by specifying and defining representative applications that fit real users working within real management systems and driven ultimately by real business cases.

Section 3: *Developing a Stakeholder Network*: Outlines the process by which a series of users have been integrated into the project to ensure efficacy and sustainability of project outcomes.

Section 4: *Flood Use Case Scenario Development*: User requirements are utilised as a framework for the specification of appropriate data sets and a related series of scenarios of potential utilisation of the spatial data interface application to address flood response and planning needs in the Solent, UK.

Section 5: *Flood Application Requirements*: Formulates specific functionality requirements of the flood use case applications, derived from the needs of the stakeholders and end users as specified in Section 2

Section 6: *Flood Use Case Web Applications*: Sets out initial specifications for web application components, prototype interfaces and example mashups in order to support the project system architecture development.

Appendix I: *Stakeholder Network Building*: Records the process and individual user interactions which have been carried out during the requirements specification

1.3 Acronyms

Acronym	Description
AA	Automobile Association
ABP	Associated British Ports (also AMPmer)
ATOM	The Atom Syndication Format
BODC	British Oceanographic Data Centre
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CCO	Channel Coastal Observatory
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency of England and Wales
ESRC	Engineering and Science Research Council
GeoRSS	Standard for encoding location as part of an RSS feed
LA	Local Authority
LiDAR	Light Detection and Ranging
NOCS	National Oceanography Centre Southampton
KML	Google Earth Keyhole Markup Language
OGC	Open Geospatial Consortium
ONS	Office of National Statistics
OS	Ordnance Survey mapping agency
QHM	Queen's Harbour Master
RDF	Resource Description Framework
SAS	OGC Sensor Alert Service
SG4E	Semantic Semsor Grids Rapid Application Development for Environmental Management
SOS	OGC Sensor Observation Service
VTS	Vessel Traffic Services
WFS	OGC Web Feature Service
WMS	OGC Web Mapping Service

WSN	Wireless sensor network

Table 1 List of acronyms

2 User Requirements

2.1 Purpose

The flood use case to be explored through WP7 of the SG4E project is fundamentally geared to providing a real-world anchor for the theoretical and practical software innovations of the SG4E project. It takes the line, for example, that the function of a mashup is to provide the technology base for joined-up thinking, and it therefore targets user groups where such integrated approaches are prioritized. It provides a proof of concept for SG4E by specifying and defining representative applications that fit real users working within real management systems and driven ultimately by real business cases. While it is true that the disciplines of the market are not fully experienced at this pre-market level, it is deemed unrealistic and unhelpful to devise applications for which no formal business case is conceivable.

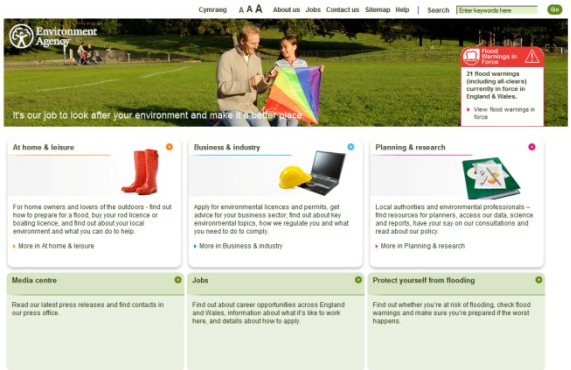

Figure 2.1 User-profiled web access: Environment Agency

An immediate challenge for a research project working with the user-driven market is that there is already a great deal of innovation – so the sensor grid and mashup focuses of SG4E need to be positioned carefully in order to demonstrate that significant and valuable innovation is likely to be achieved. For example, one potential user partner for SG4E is the Environment Agency of England and Wales, which places great emphasis on web services and attracts very high usage (perhaps 10 million hits during a large storm or flood). Even the home page is structured to attract visitors into a web experience closely tailored to a stereotype of their likely wants – and these user requirements include real-time (or near real-time) hazard event data such as the information yielded by sensor networks.

Figure 2.2 User categories and varied expectations

The users envisaged by the Environment Agency include 8 “typical” web visitors – and some of these categories are likely to have relatively little web or scientific sophistication. SG4E in this case will need to gear applications to very large volume but low-complexity uses, but will find that data integration – (and specifically the broader remit of mashup) – are commonplace assumptions. Users expect data to fit together. They expect systems to respond to their idiosyncratic as well as routine enquiries. They are a potentially rich source of challenge for web-service software design. This is one end of a spectrum of demand that the flood use case seeks to represent.

The approach adopted has been to view the use cases as bridges between the software designer and the real-world user. The starting point has thus been to identify the core elements of SG4E – sensor networks and information mashup have been noted as two –

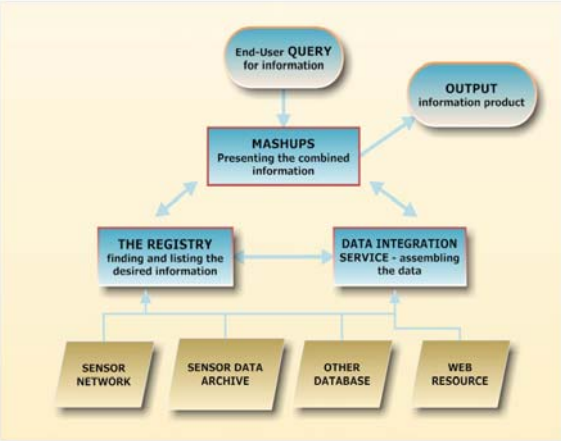

Figure 2.4 Basic concept structure for an SG4E mashup

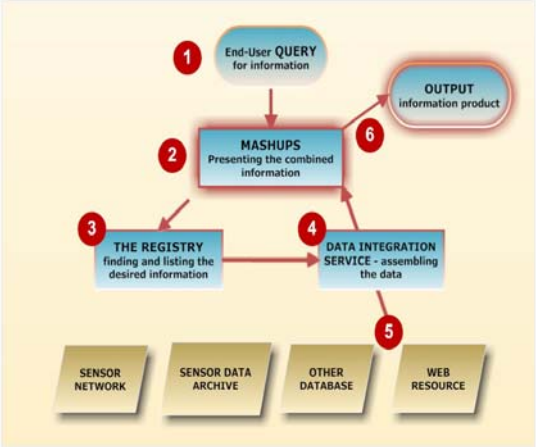

Figure 2.3 Basic workflow structure for SG4E mashup

and consider these from the twin viewpoints of designer and user. For example, Figure 2.4 offers a very basic conceptual structure for a mashup, showing how SG4E might structure the Registry and the Data Integration Services to mediate between the mashup and its user on the one hand, and the sensor and data networks on the other. This architecture has yet to be agreed in detail, but it serves to demonstrate the type of project concept that might be envisaged. This kind of diagram, however, is unlikely to win the enthusiastic allegiance of a user partner: it is focused inwards towards the project rather than outwards towards the user.

As a response, the flood user case team (GeoData) has concentrated on translating this kind of potential into the language and concept of a business-driven or personally motivated user. The mashup concept has thus been presented to potential users as a very practical response to a very common problem. In the numbered workflow shown in Figure 2.4, users ask for information, and the mashup coordinates lodging this request in the Registry, drawing on the power of the Data Integration Service to assemble diverse data sets, using the mashup capability to synthesise and present this set of inputs in a single information product with a single visualisation, and returning the output to the user. If the difficulty of drawing together hitherto unrelated data is reviewed, mashup is made to look very attractive to potential user partners.

The WP7 of the SG4E project will generate a set of Solent coastal flooding and associated applications to explore a range of types and scales of stakeholder need. Although no strict geographic boundaries have been set, as some data operate most convincingly at regional or national scale, the user partners all share an interest and professional remit within the coastal waters of Southern England around the estuary known as the Solent upon which Southampton is located. This is the context for a set of

potential users that includes government agencies, local government authorities, emergency services and recreational providers and users. Some 1750 commercial

Figure 2.5 Flood use case location

organisations are located on the waterfront, and there is a population of 500,000. In addition, the environment is of the highest value and importance: this area has every one of the national and EU conservation designations. We have within this one area a microcosm of the user world - and as a working basis for SG4E, we have defined three application demonstrator categories each representing a different data source type

2.1.1 TYPE 1: Active Sensor Networks

An active SG4E sensor network with quasi real-time, archived and potentially forecast inputs in the form of the EMU-managed Solent marine network with the intention of feeding models, mashups and visualisations. We hope to generate specific stakeholder interest, but without specifically making a commitment on data and output format to these stakeholders at the outset, as the in-project modelling is the key application. Database design is in our hands. File size is likely to be relatively small, and data are largely in the form of dynamic time series.

2.1.2 TYPE 2: Integrating Existing Data Sets

New SG4E structures for feeding existing (real-time and archive) data into new stakeholder management applications. Database design is probably in our hands, but with a strong commitment to stakeholders about data and output format, and we may have to input from and output to existing stakeholder databases. File size is likely to be medium to large, but probably using static datasets (albeit with periodic update).

2.1.3 TYPE 3: Major Public Information Services

SG4E will seek to add functionality (often, but not exclusively, via mashup) to existing public information services e.g. the Environment Agency “In your backyard” flood website, and the UK Government Defra-funded Channel Coastal Observatory (CCO), which is hosted by the National Oceanography Centre Southampton (NOCS) and delivered by GeoData at the University of Southampton. Input and output data will be from/to existing databases over which we have no control or influence. These data sets will be numerical, verbal and image: static but periodically updated data: medium to large file size.

2.2 Analysis of User Requirements: A Channel Coastal Observatory case study

2.2.1 Introduction

Research was carried out by EMU Limited into the requirements of the users of coastal sensor network data. These professionals are potential key users of the outcomes of the SemsorGrid4Env project application discussed in 2.1, and so their opinions are therefore, potentially valuable in the development of the application. These users represent the sort of groups that we will aim to reach during the dissemination and exploitation stages of the project. The Channel Coastal Observatory (CCO) sensor network data output, which is integral to the development of the Flood Warning Use Case, has been taken as an example. Statistics relating to the types of users accessing the data are presented in this report. Also presented are the responses of users who were interviewed as part of the research. The main findings were that the use of a mashup facility would depend on its functionality, in terms of speed and ease of use. If the service provides some added value such as standardising the file formats of data and making metadata more accessible, then it would be used. The largest proportion of download activity from the Channel Coastal Observatory website can be attributed to students. Other highly active groups include commercial consultants and local authorities. The Channel Coastal Observatory data helps them to make policy decisions regarding the management of the coastal zone and every-day health and safety decisions.

The Flood Warning Use Case is one of the two use cases designed to test the IT architecture developed by the SemsorGid4Env project. The Use Case will incorporate a network of heterogeneous sensors run by the Channel Coastal Observatory which are already in operation, and bespoke datasets collected by this project from data already in existence. One of the aims of the Use Case is to utilise the CCO data, in order to produce real-time flood risk predictions for The Solent, Southern UK as well as possibly supporting longer term coastal planning through the development of scenarios. The outcomes of the project will also enable users to combine datasets from different sources, by creating mashups. This will again, aid in the environmental management of the coastal zone.

As the project outcomes are intended to be user-centric, the decision making support systems must be as flexible as possible to user requirements. Therefore, the requirements of users of coastal data were studied by EMU Limited in order to aid in the development of the requirements specification and ultimately the architecture.

An analysis of users of sensor network data was carried out by EMU Limited in order to identify any trends in the requirements of the users. Interviews were carried out with key users of coastal sensor data. The Channel Coastal Observatory sensor network was taken as a data example which is considered relevant to the type of user profiles that might utilise a mashup application, and interviews carried out with 8 of its users. The responses of the 8 users are presented below.

2.2.2 Channel Coastal Observatory Sensor Network: User Statistics

The Channel Coastal Observatory is a well-used sensor network data source. The website received 457,630 hits in January 2009 alone. Of those hits, 11,890 were unique users. The download pages require an account to be set-up, and so monitoring of the usage type is facilitated. These pages have 1,282 registered users from 536 organisations (including private individuals). Figure 2.6 details the user types and their percentage of the total downloads from the website.

As is clear from Figure 2.6, the most active registered users of the download pages are university students and consultancy organisations. During EMU Limited's ongoing research and dissemination of the SemsorGrid4Env project, we will endeavour to reach these types of user.

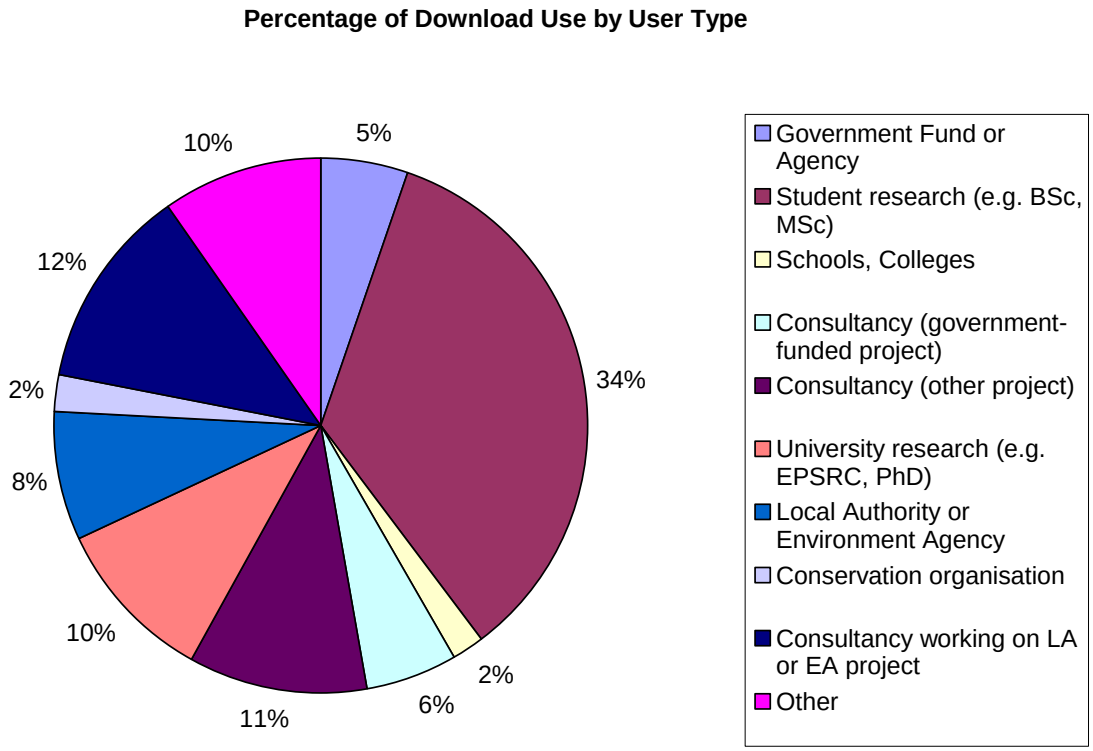

Figure 2.6 Percentage of Download use by user Type

2.2.3 Interviewee Responses

All traffic volumes relate to enquires as opposed to data volumes.

1.	**How do you access the CCO network data**?

Local Authority Coastal Engineer 1:

- I download data sets from the website, or obtain them directly by email from the CCO

Local Authority Coastal Engineer 2:
- Via email request to the CCO
- The download pages of the website are too unfriendly
- This way, the data is in an excel spreadsheet format which is immediately useable

Local Authority Coastal Engineer 3:
- Download datasets
- Look at live data pages

Local Authority Coastal Engineer 4:
- Receiving computer visual display
- Public viewing screens elsewhere in building
- CCO website- live pages
- CCO website – download pages

Local Authority Pier Attendant:
- Receiving computer visual display
- CCO website – live data pages

Commercial Workboat Skipper:
- CCO live data pages

Commercial Marine Scientist:
- CCO live data pages
- Download pages

Modeller within a Marine Environmental Consultancy:
- CCO live data pages
- Download pages

2. What data do you use?

Local Authority Coastal Engineer 1:
- Local Waverider Buoy data
- Local meteorological data

Local Authority Coastal Engineer 2:
- Local beach profile data
- Local wave data

Local Authority Coastal Engineer 3:
- Aerial photos
- Lidar data
- Wave and tidal data
- Bathymetric and topographic data.

Local Authority Coastal Engineer 4:
- Local wave tide and meteorological data
- Local beach profile data and aerial photos

Local Authority Pier Attendant:
- Local meteorological data.
- Sea surface temperature data from different sites.

Commercial Workboat Skipper:
- Wave and meteorological data from different sites

Commercial Marine Scientist:
- Wave, tide and meteorological data from different sites

Modeller within a Marine Environmental Consultancy:
- Wave climate data

3. How frequently do you use the data?

Local Authority Coastal Engineer 1:
- All of the data is collated on a monthly basis
- Any greater frequency would be too time consuming

Local Authority Coastal Engineer 2:
- Monthly

Local Authority Coastal Engineer 3:
- Download data sets monthly
- Look at live data 2-3 times a week

Local Authority Coastal Engineer 4:
- Receiver computer visual display – daily
- CCO website download pages – every 2 months

Local Authority Pier Attendant:
- Hourly
- If conditions are bad, every 5 minutes

Commercial Workboat Skipper:
- Weekly or every time we leave port

Commercial Marine Scientist:
- The live data pages are viewed as often as daily
- Occasionally, a dataset is downloaded for a specific consultancy job (roughly 6 monthly)

Modeller within a Marine Environmental Consultancy:
- Very infrequently at the moment, because I rarely do survey work any more

4 What do you use the data for?

Local Authority Coastal Engineer 1:

- In combination with sediment sampling data - calculating sediment transport rates for coast protection purposes
- Decision making – improvements to coastal defences
- Studying areas vulnerable to coastal erosion
- Producing sediment movement predictions based on wave characteristics
- Localised flooding and storm event studies
- Establishing thresholds of rainfall in places prone to flooding

Local Authority Coastal Engineer 2:

- Design of the local beach replenishment scheme
- Comparison of wave statistics with surfer numbers (half hourly beach staff counts)
- Would like to use the digital ortho-rectified photography in combination with digital O.S maps in order to analyse the evolution of the coastline. However, whether or not this study happens depends on how easy it will be to combine these two data types.

Local Authority Coastal Engineer 3:

- Downloaded data is used for:
    - Coastal defence assessment
    - Erosion Mapping
    - Asset Management
    - Flood Risk Mapping
    - Development of the Shoreline Management Plan
    - Habitat Mapping
- Real time data is viewed for:
    - Storm surge observation
    - Gauging whether or not it is safe for contractors to be working on coastal defence maintenance.

Local Authority Coastal Engineer 4:

- Ensuring monitoring systems are functioning
- Monitoring wind climate and storm surges
- If the storm threshold of wave height is exceeded, action is taken to mobilise emergency crews. The crews may be required for sand-bagging or to evacuate people at risk of flooding.
- Other action may include a beach survey following a storm.

Local Authority Pier Attendant:

- Health and safety decision making
- A high tide in conjunction with certain wind directions may necessitate the closure of the lower deck of the pier.
- If the wind speed is exceptionally high, the pier will be shut to the public
- Curiosity – comparison of sea temperatures between our site and others
- Public information

Commercial Workboat Skipper:

- To aid in decision making as to whether it's safe to go to site
- To get a picture of what the conditions will be like, in combination with all available weather forecasts
- To view several neighbouring Waverider Buoy sites and compare wave conditions

Commercial Marine Scientist:
- Operational decision making – whether it is safe to conduct survey work
- Consultancy work – analysis of oceanographic data from a particular geographic area. Other historical data sets and Admiralty Charts of the study area would be used.

Modeller within a Marine Environmental Consultancy:
- The real time pages are used as an aid to operational planning
- Downloaded data sets are used for model calibration and validation
- Statistical analyses are also performed on historical datasets as a part of metocean studies

5. What other sensor data do you use?

Local Authority Coastal Engineer 1:
- None

Local Authority Coastal Engineer 2:
- Local tidal data

Local Authority Coastal Engineer 3:
- Local rain gauge data

Local Authority Coastal Engineer 4:
- We pay for a cell of a met-office wave model
- We get advanced Environment Agency flood warnings and subscribe to the Met Office "talk to a forecaster" service

Local Authority Pier Attendant:
- None

Commercial Workboat Skipper:
- None

Commercial Marine Scientist:
- Wave, tide and current data from sources such as:
    - The British oceanographic Data Centre (BODC)
    - Cefas WaveNet
    - The National Data Buoy Centre

Modeller within a Marine Environmental Consultancy:
- Metocean data from sources such as:
    - Cefas WaveNet

- The British oceanographic Data Centre (BODC)
- The National Tide and Sea Level Facility

6. Would you use a real-time flood forecast site, based on a model which takes into account coastal defences?

Local Authority Coastal Engineer 1:
- There are already systems in place which we use, so it would depend on what it can offer on top of what's already available.

Local Authority Coastal Engineer 3:
- Yes
- Departments looking at land drainage and emergency planning may also be interested

Local Authority Coastal Engineer 4:
- We already have systems in place, so I would have to know more details of the model before I decided whether to use it
- I would appreciate something which takes into account more details of the local defences and beach characteristics

Local Authority Pier Attendant:
- Probably, yes
- The public see us as providing a public information service, so the information would be useful. For example, when the storm surge occurred in November 2007, local residents came down to us to see if we knew what the likelihood of flooding was.

Modeller within a Marine Environmental Consultancy:
- I personally wouldn't use it within the work I do
- As a general comment though – the modelling method and the data quality would be paramount. If I didn't have confidence in the model or the quality of data used, I would not use the output

7. Would you use a "mashup" or data fusion site which allowed you to combine multiple data sets?

Local Authority Coastal Engineer 1:
- It sounds good in theory as data sets in different formats can be time consuming to sort out
- It would depend on the functionality of the website

Local Authority Coastal Engineer 3:
- Yes, if it is:
    - Quick
    - User Friendly (more so than the National Flood and Coastal Defence Database)

Local Authority Coastal Engineer 4:

- Yes, as long as the system can easily access all the datasets I'm interested in

Local Authority Pier Attendant:
- Probably, yes. Just out of personal interest

Modeller within a Marine Environmental Consultancy:
- Yes
- Things that would help would be:
    - A standard file format
    - Clear metadata
    - Improved searchability of metadata (for example – when you are looking at data taken by a vertical array of sensors, they have the same time stamp and position and so all of the files are returned from a search. You cannot filter the search for height in the water column)
    - Metadata needs to be easily accessible (i.e.- in the data file itself)
    - A standardised time-step

2.2.4 Conclusions

From the research undertaken, the following conclusions may be drawn:

- Data need to be more easily accessible. Some respondents find the CCO website download pages difficult to use
- Real-time or near-real time data are required as well as historical datasets
- The majority of users interviewed focus on their local area only. However, these users are very closely involved with their particular local site. It was found that some users would like to be able to readily compare sites on one page. To be able to view the value of one parameter at all sites would be useful
- Datasets must be in a format which is quick and easy to use
- If all datasets were of the same file type this would speed up their use
- Clear metadata within the file itself is needed, for example explicit column headers
- A mashup facility would have to be quick and easy to use in order to be a useful tool

3 Developing a Stakeholder Network

The starting point for effective user engagement is to identify the key stakeholders through whom we might explore and develop demonstration case studies for WP 7. The short list has been derived from an in-house review of options, supplemented by initial discussions with key stakeholders following the launch of the project. The list covers the main players in the production, storage and delivery of coastal information services within the Solent Region of Southern England. The aim has been to identify organisations that represent the three demonstrator types specified above in Section 2.1.1 – 2.1.3, and at the same time to identify individuals within those organisations who would have a genuine and sustained interest in exploring new value-added approaches to their data holdings. It is also convenient that the three main targets represent a spread across the main user attributes that would be of interest in establishing a broad application demonstration or proof of concept:

- Public Information Services
  - High traffic volume, low query complexity, routine enquiries
  - Example: The Environment Agency of England and Wales
- Professional data systems/services
  - Medium traffic volume, high query complexity, highly varied user base
  - Example: the Defra Channel Coastal Observatory
- Professional/Public Information Services
  - Low traffic volume, medium query complexity, mixed frequency
  - Example: the Solent Forum

These examples are discussed further below, together with one additional potential user partner for SG4E, the Port Operating Authorities of Southampton and Portsmouth.

3.1 Environment Agency (England & Wales): Flood Risk Website

User Profile

- Very high volume traffic (millions per day)
- Mix of professional and public users
- Numerical modelling and general text/map output
- Environmental quality regulation
- Flood management and warning (real time response and advanced planning)
- Moving towards Web 2.0 approaches: user profiling, community links
- Includes national real-time sensor networks

3.1.1 Business Case

The URL http://www.environment-agency.gov.uk/subjects/flood/ gives access to the flood risk website of the Environment Agency (EA) for England and Wales. The EA is a high-profile national-scale stakeholder that might offer a quick-win demonstration in the form of a core mashup based on the EA flood risk map layers (already available on-line) superimposed on Google Maps, possibly with the flood-risk zones depicting uncertainty through a gradient/feathered edge, to be searched by end-user postcode and address. It would be possible to aim for a prototype on-line by mid 2009. This would be our main TYPE 3 Demo. The EA has high in-house technical skill levels, and has a long working relationship with GeoData on which this cooperation could be based. The effective presentation of flood risk information to the general public is a core mission of the Agency's website, and this site experiences in excess of 1 million user hits per day during periods of high flood risk. A successful mashup prototype using flood risk data might lead on to a more challenging application scenario using quasi real-time flood warning data (a separate EA service and separate section of the EA website).

3.1.2 Strategy

The flood risk mashup would provide a foundation for subsequent more sophisticated information demonstrations with the EA. The aim would be to develop an on-line mock-up with a non-EA URL which would serve as a proof of concept and a possible platform for user-testing. A recent Mike Clark/Sally Priest ESRC Research Project on the EA Flood Website has already established a link with Simon Ashley (who manages the EA website), and the final recommendations of this project included assessing the mashup here specified.

Figure 3.1 Environment Agency Flood Risk

The EA website currently depicts areas of flood risk as GIS layers – specifically one for flood risk areas and one (larger and lighter Output layering) for extreme flood. These are superimposed on an Ordnance Survey map background within a small window. The latest version of the website (January 2009) has improved both the quality of the map (it was previously black and white) and the navigation. However, the window remains small, (though this was a source of irritation for users in a recent user survey), and the maximum scale (largest amount of detail shown) remains too small to identify individual properties.

There is scope for prototyping an application which loads the EA flood risk zone areas and displays them on a Google Maps platform which would provide more familiar navigation and a more easily scaled map base with high resolution. It would also offer

the possibility of adding other layers or features via Google Maps. In principle, the resulting mashup would be delivered via the EA website, though this operational facility would not be included at prototype stage.

3.1.3 Action

Simon Ashley, Environment Agency, has discussed and approved the principal of working with SG4E to provide data inputs and support for application design. A more detailed scoping of work is now under way, and a further meeting has been arranged. This will involve gaining management approval within the Agency, and designating specific experts for cooperation with SG4E.

3.2 The Channel Coastal Observatory (CCO)

User Profile

- Medium volume traffic (thousands per month)
- Mix of professional, student and public users
- Government data archive and information service
- Science/technical focus: numerical modelling and general text/map output
- Sea state, tide, flooding, water quality, beach state
- Complex data handling, visualisation and value-add
- Includes important real-time sensor networks
- Hosted by University of Southampton (National Oceanography Centre, Southampton): system managed by GeoData

3.2.1 Business Case

The URL http://www.channelcoast.org/southeast/ gives access to the Channel Coastal Observatory (CCO), which is the data management centre for the Regional Coastal Monitoring Programmes in South-East England. CCO is hosted by New Forest District Council, in partnership with the University of Southampton and the National Oceanography Centre, Southampton (NOCS). The technical delivery of this public domain online service is provided by the GeoData Institute. While the data are accessible to the public, in practice the service is aimed at and used by professional coastal zone managers in southern England – local authorities, government agencies, research institutions and consultancies. The service carries both real-time data and archives.

Figure 3.2 Channel Coastal Observatory Website

3.2.2 Strategy

The CCO is clearly a key "power user" stakeholder, delivering information services on to public and professional end users. It is mission critical in terms of implementing any service based on a TYPE 1 Active

Sensor Network in the Solent, since it already hosts the existing sensor network data streams. It also offers an attractive context within which to develop and deliver mashups for TYPE 3 Information Services based on real-time and/or archive data, both as time series and maps/charts.

Given the close links with the University of Southampton, and specifically with the GeoData Institute, it is probably the most important candidate to provide sustainable roll-out of value-added data services at the end of the SG4E project.

The CCO is in part a data repository and in part a data portal. It already provides an element of data integration and value-add, but there is significant potential for increasing this component. The fact that the Observatory is an information source for the majority of professional coastal managers in the region makes it an ideal source for SG4E development effort, but it may be that end-users rather than just the CCO itself should be consulted in specifying priority demonstrators and applications (see section 2.2.3)

3.2.3 Action

Formal contact has already been established with CCO on behalf of SG4E, and work is now under way to scope and specify both a TYPE 1 sensor network and a TYPE 3 information service mashup application. This is regarded as a high priority with quick-win potential for identifying demonstrator applications.

3.3 The Solent Forum

User Profile

- Medium volume traffic (thousands per week)
- Mix of professional and public users, but mainly non-specialist
- Government-recognised agency
- Planning and strategic focus: much use of qualitative data
- All aspects of coastal and inshore environment, industry and business
- Information and advice portal: no major data holdings
- Does not involve real-time sensor networks

3.3.1 Business Case

The URL http://www.solentforum.org/forum/ gives access to the Solent Forum, which is an organisation that was established to develop a greater understanding among the authorities and agencies involved in planning and management in the Solent coastal area, and to assist and influence them in carrying out their functions. The Forum was set up to consider and provide advice on strategic coastal issues, and it achieves this through a well-established network of key coastal stakeholders. As a long established and recognised coastal partnership with a neutral status, the

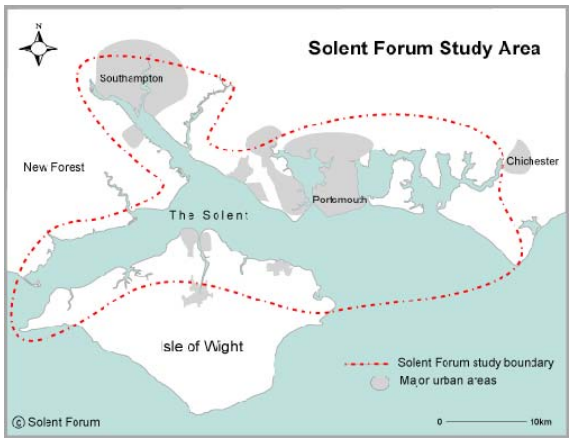

Figure 3.3 Solent Forum Study Area

Solent Forum is well placed to provide a platform for cross-sector communication and to facilitate partnership working. Its stakeholder database contains more than 1,000 people with an interest in the coastal zone made up of a wide variety of organisations. The Forum runs an on-line Solent coastal information service (Solentpedia) and an on-line meta-database (DISC). DISC is a database cataloguing Solent-related research, reports (both published and unpublished), books and journal papers established to enable easier access to information about the Solent. The Solent Forum is a key contact (and potential service partner) for SG4E both in terms of its cross-sector stakeholder network and its interest in delivering an information portal and value-add services. It is a potential SG4E delivery partner for a TYPE 2 data integration service.

3.3.2 Strategy

While the Solent Forum itself has the potential to contribute directly to the application case study remit of SG4E, it also incorporates specific end-user sectors that might have short-term application-development potential. One specific target might be the Solent Water Quality Association, which is a subset of the Solent Forum. Its primary focus is bathing water quality although it also considers issues relating to the Water Framework Directive. Core members include the environmental health departments of the 8 local authorities, the harbour authorities, the Environment Agency and Southern Water. Other stakeholders are co-opted to the group as needed. The Association's Chair is Rob Crichton, Southampton City Council. Coastal water quality is a diversion from the core SG4E focus on coastal flooding (although water quality does impact the cost of clear up associated with flooding particularly where sewage is involved), but it is of interest because of its reliance on near-real time data and because daily operational decisions need to be made when water quality is threatened. This gives data visualisation and integration applications a strong potential role in meeting management needs.

3.3.3 Action

Formal contact has already been established for SG4E through a presentation to the Forum's Steering Group, and also through several meetings with the Solent Forum Officers (Karen McHugh and Rhian Davies). Cooperation with the Forum has been agreed, and a framework for a possible application use case has been identified.

3.4 The Port Operating Authorities: Southampton and Portsmouth

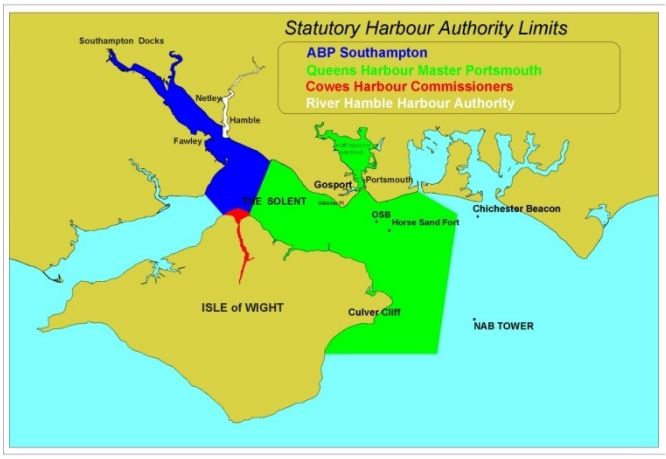

Figure 3.4 Statutory Harbour Authority Limits

3.4.1 Business Case

The other main stakeholders involved in marine and coastal management in the Solent Region are the operating authorities of the two major ports – **Associated British Ports** (ABP) for the Port of Southampton and the **Queen's Harbour Master** (QHM) for the Port and Naval Dockyard at Portsmouth. These operating authorities are responsible for vessel traffic services (VTS) and pilotage.

Thus ABP and QHM are prime potential users of sea state information, which is a core output of the proposed SG4E sensor network. They are also potential users for other data mashups. Given their focus on VTS, both the port operating authorities run real-time radar services which depict every vessel within their operating area. At peak time, this may amount to several thousand vessels given the extremely high usage level of the Solent by small recreational vessels. The radar systems and their archives of images represent a further major data source for SG4E end-user applications.

3.4.2 Strategy

The VTS interests of the two port operating authorities provide a focus on sea-state information that is of significant potential interest to SG4E. At the same time, the real-time data inputs provided by the VTS radar systems represent a potential data feed to SG4E applications. While the immediate "user" might be seen as ABP or QHM, the on-line information services run by these two organisations are accessed by ship operators, shipping support services and very many end-users, including individual recreational vessel owners. In principle, this provides a broad public-private user base for any information application developed and delivered by SG4E.

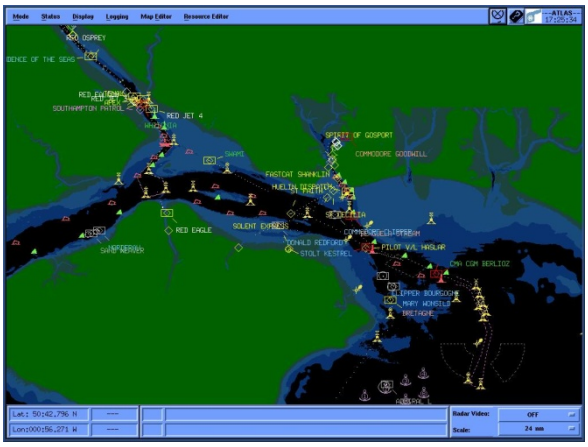

Figure 3.5 VTS radar system

It should also be stressed that the significance of ABP and QHM as potential users/distributors of SG4E applications is not limited to the real-time or archived radar data. The provision of accurate and timely sea-state information which might affect the pilotage of large vessels may

also provide a suitable target for SG4E mashup application development, as well as a potential output from the active sensor network.

3.4.3 Action

The two port operating authorities (ABP and QHM) are both formally aware of SG4E through their membership of the Solent Forum and their attendance at its presentation and discussion on SG4E. In addition, GeoData has previously discussed with QHM the principle of gaining access to VTS archive radar data for research and development purposes. These two user groups are regarded as having high relevance to the SG4E project, with abundant technical expertise and access to important coast/flood data sets, some of which are real-time. To avoid over-complicating SG4E with a large number of use cases, it is envisaged that links with the Port Operating Authorities would be pursued through their relationship with the Channel Coastal Observatory and, to a lesser extent, the Solent Forum.

4 Flood Use Case Scenario Development

4.1 Purpose

Traditional systems for preventing and detecting Floods rely on methods that need too many human resources and are not automated. The proposal is to develop a system that will use cutting-edge data management technologies utilising real-time, real-time modelled, regularly updated and historical data to provide useful information to a range of users from expert/professional/government to interested members of the public in order to analyse, respond to and plan for flood risk situations.

The flood based application is supported by an active WSN (Channel Coastal Observatory). This network consists of a large number of strategically deployed nodes with appropriate sensors which when associated with an appropriate spatial model can detect with a high accuracy if a flood is ongoing or likely in the near future throughout the Solent region. This information, combined with additional data sets pertaining to asset and ecological services will create a system where the potential for minimising the impact of flood will be provided in an emergency response and planning mode.

In the following sections, user requirements are utilised as a framework for the specification of appropriate data sets and a related series of scenarios of potential utilisation of the spatial data interface application to address flood response and planning needs in the Solent, UK.

4.2 Key data domains

Throughout the application, data will be managed through a hierarchy of data classification (see Section 6). This organisation approach to the data results in the characterisation of data “Domains” which represent the highest data level within the hierarchy. The defined domains are intended to capture the key thematic areas of interest to flood and related coastal management in both a real-time context and that of planning.

Dependent upon user requirements, the domains might include such data sets as:

4.2.1 Environmental domain

- Terrestrial terrain
- Meterological forcast data
- Detailed River Network
- CCO Sensor network
- Shoreline Evolution
- NFCDD (National Flood & Coastal Defence Database)
- Flood extents and depths
- Sites of Special Scientific Interest

- Special Areas of Conservation
- Special Protection Areas
- National Nature Reserves
- Ramsar sites
- Land Cover Map 2000
- Protective landscape designations
- Coastal Habitat Surveys

4.2.2 Infra-structure/Asset domain

- Scheduled Ancient Monuments
- Local Development Plans
- Existing land use
- OS 1:10,000 (OS MasterMap topographic database)
- OS 1:50,000
- OS Boundary Line
- Road type and distribution data (AA)
- Points of Interest

4.2.3 Socio-Economic/vulnerability Domain

- Enumeration Districts / Output Areas
- Population (ONS)
- OS Address Point

4.3 Example scenario development

4.3.1 Scenario 1: Emergency Planner (Local Authority)

In this context, an interaction between data demand might rest upon the following:

Domain	Data set	Parameter
Socio-Economics (Vulnerability)	UK National Census 2000 (ONS)	*Socio-economic characteristics of population* - spatial location of bottom quintile (20%) deprivation index (poorest) SOA (Super Output Areas) *Population density* – Highest population density quintile wards Output option: Overlap of the above to determine highest socio-economic vulnerability
Infra-structure/Asset	AA road watch real-time data	Regions with highest traffic density at predicted time of flood event (evacuation/emergency access) Regions with highest potential for road congestion due to roadwork or other road obstruction (evacuation/emergency access)
Environmental	CCO based flood model	Current & 4 hour flood probability forecast model output

Integrated Output:
Combination of above outputs to produce a first order flood risk map: e.g. similar output to Fig 4.1 (EA)

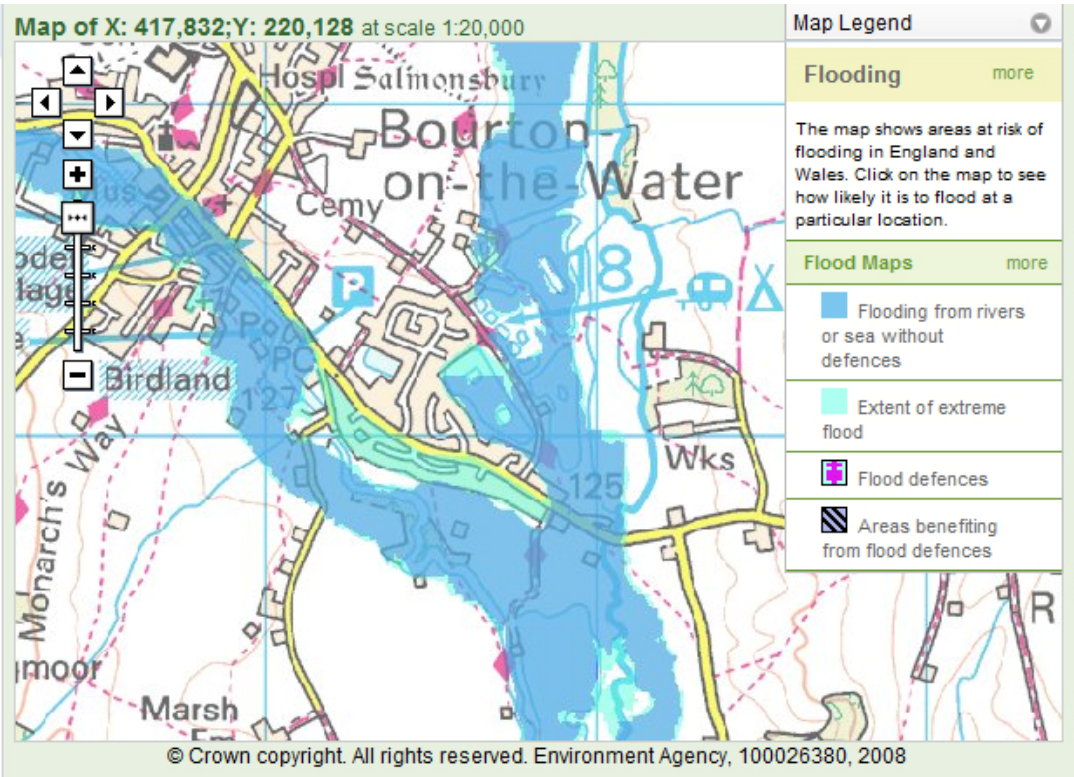

Figure 4.1 Conceptual integrated output (based upon current EA flood mapping)

4.3.2 Scenario 2: Short/mid term coastal development planning (Local Authority)

In this context an interaction between data demand might rest upon the following:

Domain	Data set	Parameter
Socio-Economics (Vulnerability)	UK National Census 2000 (ONS)	*Socio-economic characteristics of population* - spatial location of bottom quintile (20%) deprivation index (poorest) SOA (Super Output Areas) *Population density* – Highest population density quintile wards Output option: Overlap of the above to determine highest socio-economic vulnerability
Infra-structure/Asset	OS data sets	Defining the spatial distribution of residential/commercial /government assets as well as roads and utilities

Infra-structure/Asset	Future land use (Local authority)	Land allocated for future development
Environmental	Land protected from development	Biodiversity Cultural Government Conservation
Environmental	CCO flood probability model	Current flood probability map across Solent region Scenario of sea level rise and peak flood probability across Solent region for 5 & 10 years time

Integrated Output:
Probability of flood inundation impacting planned development areas in the Solent region within given time frames based upon climate change and sea-level rise estimates

4.3.3 Scenario 3: Public recreational user

Domain	Data set	Parameter
Environment	CCO flood probability model	Wave/tide state forecast model (1-4 hours) at beaches in Solent
Environmental	Meterological	Wind speed and direction forecast (1-4 hours)
Infra-structure/Asset	AA road watch real-time data	Regions with highest potential for road congestion due to roadwork or other road obstruction + Current location of user/optimal route planning

Integrated Output:
Optimal location for good surfing/windsurfing conditions offset against potential travel time.

5 Flood Application Requirements

5.1 Purpose

This task formulates specific functionality requirements of the flood use case application derived from the needs of the stakeholders and final users as specified in section 2.

5.2 Specification

The following table contains the identified high-level requirements the Flood use case application should fulfil and includes a coded ( ) reference to the relationship to the Fire Use Case study.

Requirement	Description
Req-010 (**H**)	The application will display the geographical area in which the sensors/data/model outputs/relevant qualitative information is deployed.
Req-020 (**H**)	The application manages and represents graphically the different kinds of data, organised in layers.
Req-030 (**M**)	The application has the following layers: some layers for the representation of the sensor network, layers for the representation of baseline data, layers for the representation of additional real-time data, layers for the representation of the combined data (mashup).
Req-040 (**L**)	The application will geo-locate every deployed sensor over the geographical area in a layer. This layer describes each sensor showing its position, its current state and its current measured observations.
Req-050 (**H**)	The application will have facilities for displaying graphs and charts to visualise sensed or modelled data for a user-selected specific point within the model output.
Req-070 (**M**)	The application will be able to display the combined information composed of the data coming from the sensor network and additional data layers.
Req-080 (**L**)	The application will be able to display historical data measured by the sensor network.
Req-090 (**H**)	The application will display current modelled flood probability data in a spatial layer and provide an ongoing forecast of up to 4 hours in advance.
Req-100 (**L**)	The application will display the combined historical data (the data from the sensor network and additional sources of data) in a layer.
Req-110 (**L**)	The user will be able to choose layer(s) to be displayed in order to facilitate monitoring.
Req-120 (**H**)	The application will support two modes: Real-time mode and Planning mode.
Req-130 (**H**)	Real-time and forecast flood modelling mode will allow categories of potential asset impacts based upon probability of failure of coastal defences and asset mapping data (residential/infra-structure/ecological)

Req-140 (**H**)	Planning mode will allow for the development of flood related scenarios for the purpose of spatial planning for development and emergencies by the capacity to pre-set real-time and baseline variables as scenarios.
Req-170 (**H**)	The application will allow the user to set categories of flood risk in relation to flood probability. These categories can be spatially represented.
Req-180 (**L**)	In both working modes, the user may select an observation sub-area for monitoring. After that, the application will only display data from this sub-area. This operation affects the information received from the network and from additional data sources.
Req-190 (**H**)	The application will provide a sea-surface state and wave state visualisation for the entire Solent estuary. Additionally there will be a model confidence estimate to allow for judgement of output veracity as well as assisting in the planning of further sensor deployment.
Req-200 (**L**)	The application will display the working state of each sensor in the network in real-time. This information will also be available on a historical basis.
Req-240 (**L**)	The topology of the network, the sensor coverage and the image resolution has to be defined taking into account their interdependencies.
Req-280 (**L**)	There is a facility to move (ad-hoc) sensors to address specific long term points of interest within flood modelling.

Overlap with Fire case study: (**L**) = Low (**M**) = Medium (**H**) = High

Table 5.1 Requirements of the application with comparison with Fire case study

6 Flood Use Case Web Applications

6.1 Purpose

This section sets out initial specifications for web application components, prototype interfaces and example mashups. To support the project system architecture development, we delineate between web applications and mashups, defining the latter as web applications which integrate data, usually using simple, exposed APIs, from two or more separate sources, at least one of which being external to the project.

Initial use case applications have been defined through early meetings and discussions with the selected flood user community representatives (detailed in Appendix I and discussed in Section 3) and in response to the use case requirements as described in the preceding sections.

After refining the initial designs, the web applications will need to be developed upon, and make use of, the SG4E mashup API (currently being specified in WP5) and therefore upon the SG4E system architecture with which this layer interfaces.

The process of specifying example web applications is by no means complete and will need to develop in an iterative manner though further demonstrations and discussions with the users identified in this document.

6.2 Data Flows

In order to stimulate discussions with the identified flood users and draw together initial ideas, the flows of different data sources into and through the system were considered. These are illustrated in a simplified form in Figure 6.1. The diagram illustrates the flow of data through the SG4E architecture, which in practice will comprise a complex collection of interrelated modules and APIs, with the production of web applications and mashups as the end-result (from the flood user point of view).

Data sources which are provided by members of the project are shown on the left (with diagonal pink lines) and comprise:

- ad-hoc sensor equipment deployed ‘on-the-fly’ (EMU Ltd project partners)
- the Channel Coastal Observatory (CCO) real-time sensor network and historic database of existing sensed data
- modelled data sources produced by the SG4E project partners derived from various sources (including the above CCO data)

Data sources incorporated into the project from external organisations are shown to the right of the figure (with vertical green lines) and include:

- real-time flood-related sensor data from external sources, such as the British Oceanographic Data Centre (BODC)

- additional and more varied data from external sources useful for flood application development, such as weather data, socio-economic variables, traffic information

The external set of data sources, and in particular the 'Other' category are more typical information flows which would be utilised in a common web mashup application, as they are likely to be combined in ways which data providers did not initially intend.

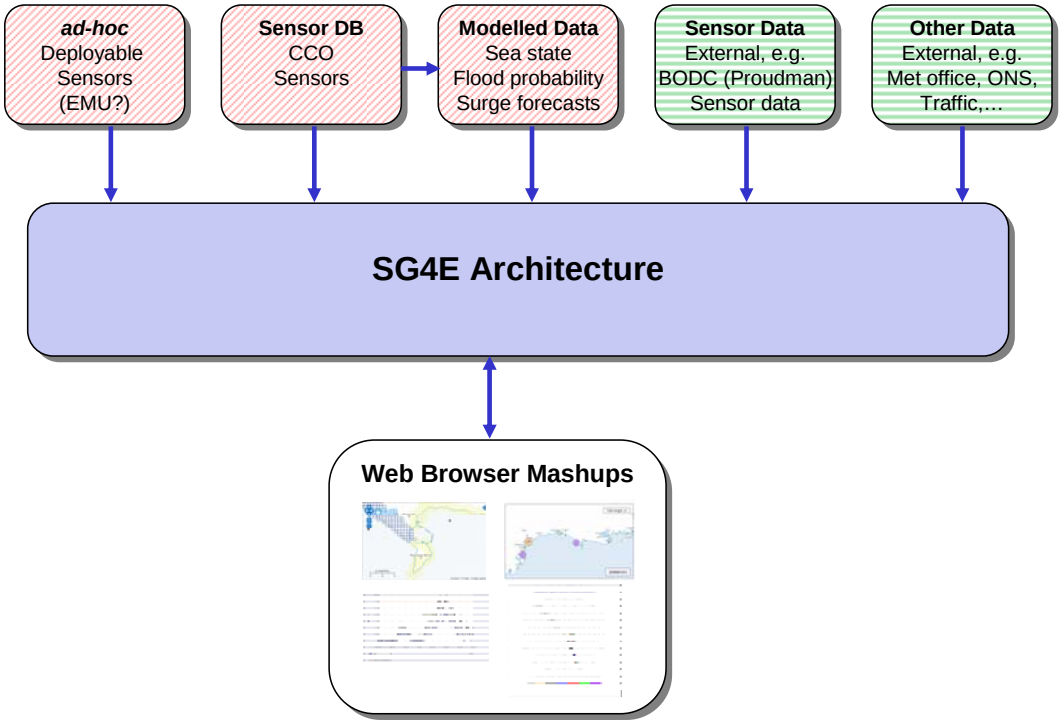

Figure 6.1: SG4E web application data flows

The following sections set out in more detail the initial SG4E flood user web applications and mashups which have been designed and described in discussion with the selected flood users.

6.3 Example 1: Emergency Planning

The first example application (Figure 6.2) corresponds with the Local Authority emergency planner scenario set out in Section 4.3.1 above and represents, from the mashup API point of view, a 'low-tech' development. It is designed to present a simple interface, bringing together key information sources for a Local Authority user who, though an expert in environmental data interpretation, may not be an expert technology user.

The web application assembles the following components:

- maps of real-time coastal sensor data, with the ability to scroll back in time to view previous variable state
- maps of modelled sensor data, such as flood forecast

- graphical visualisations of sensed and modelled data for a selected point
- external flood risk data maps, typically from the Environment Agency

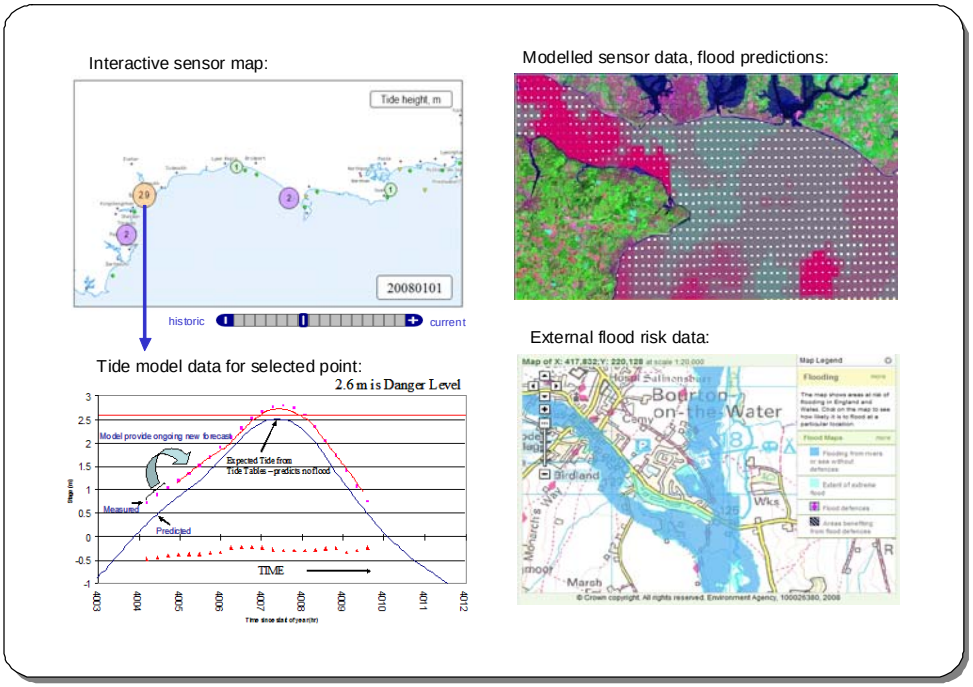

Figure 6.2: Emergency planner scenario example

6.4 Example 2: Coastal Development

The second web application example, corresponding to the short-medium term coastal management development scenario is illustrated in Figure 6.3. The application represents a 'high-tech' development and comprises a significantly more sophisticated user interface, demanding more complex functionality of the SG4E mashup API.

The application provides a more free-form data integration environment for advanced flood users, enabling them to explore and assemble components, such as:

- maps to discover, visualise and query available data for a specified area
- a browse/search application component displaying a range of available 'known' (semantically identified) data sources, arranged in a logical, user-friendly hierarchy
- add/query application components, enabling users to incorporate (*mash-up*) external data sources not previously identified to the architecture (non-semantic), but most probably compliant with well known standards (e.g. Atom, OpenSearch)
- data visualisations tools for dynamic display of selected and combined sources of data

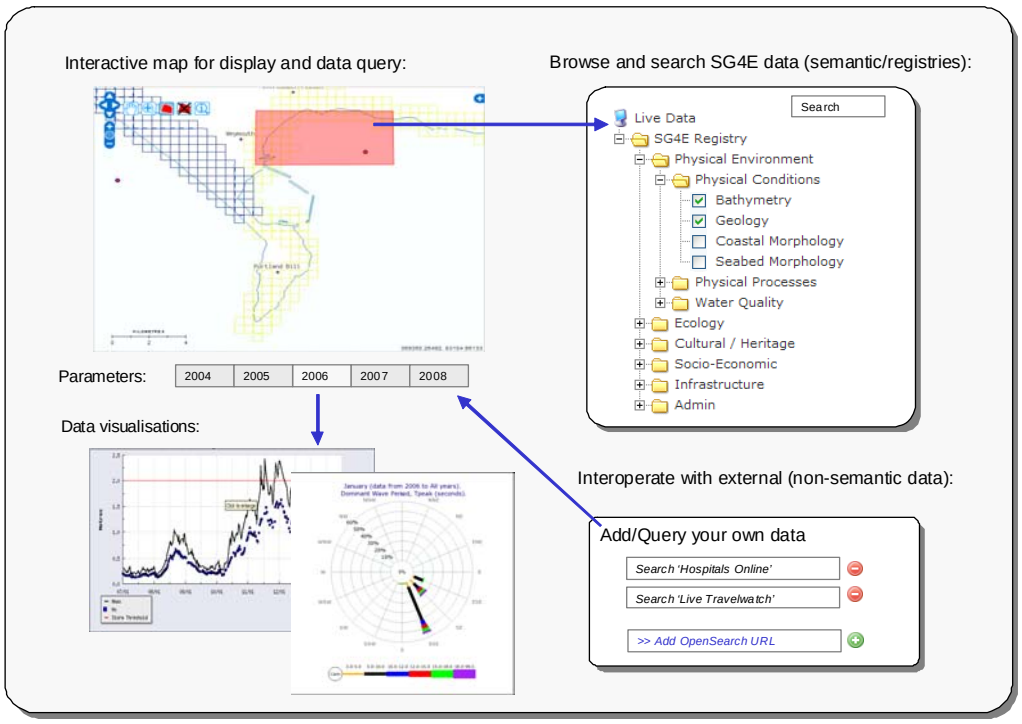

Figure 6.3: Coastal Planner scenario example

6.5 Example 3: Alert information system

This example application may be relatively simple to develop, but would be immediately useful for SG4E users, including 'leisure' users (members of the public identified in the recreational scenario, Section 4.3.3) and CCO coastal managers and data providers. The development, illustrated in Figure 6.4, also represents a more traditional mashup application by utilising simple services and APIs published by external website providers.

The application would present users with a standard web map as in previous examples, displaying locations of available sensors. Navigating the map would enable users to locate and select specific sensors and variables from a corresponding discovery window (contained data would be found by querying the SG4E Registry service) or define a bounding box constraining their area of interest spatially.

By selecting sensor locations and variables and defining comparison and value thresholds for constraint, users would build up a list of Alert definitions. They would then select a preferred Alert Service through which to expose their definition. Their selected service would make use of either an SG4E Mashup Interface API service (e.g. Atom, GeoRSS, Google Earth KML) or perhaps deploy an external site to complete their mashup application (e.g. Twitter, Yahoo Pipes). The final steps would be to edit and accept the format of their specified alert and add it to their saved alert list (or even a communal list held in the SG4E Registry for discovery by other users and systems).

Through the Alert mashup, users of all kinds will be able to rapidly assemble a collection of custom alerts for sensor data values. A relatively simple, human-

accessible interface would bring together the semantic/registry SG4E components, appropriate OGC sensor observation protocols (SOS) and standard messaging services and APIs.

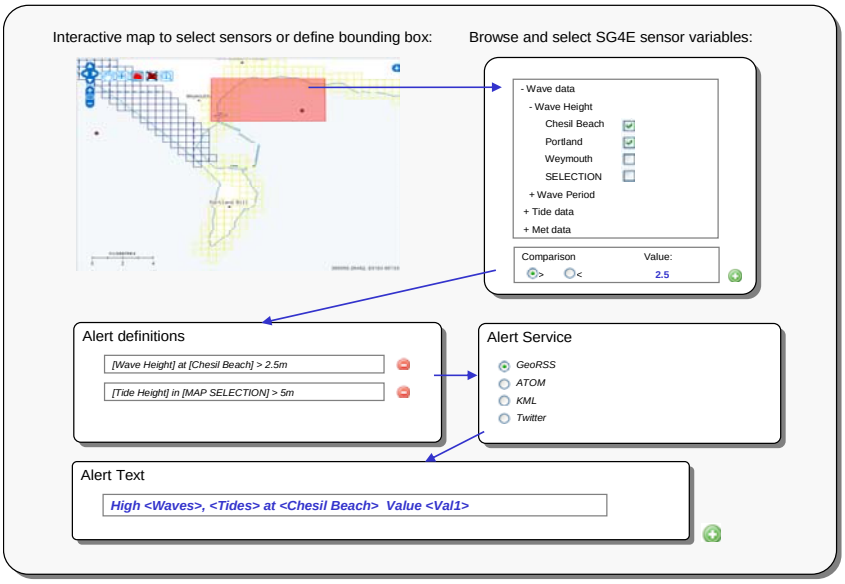

Figure 6.4: Alert information system mashup

6.6 Example 4: Decision Support tool

The final web mashup description takes the components and concepts introduced in the second example above, to produce an altogether more sophisticated application which would form the basis of a Decision Support tool, assisting users concerned with long-term environmental and socio-economic strategy and policy implementation. These requirements respond to those discussed in meetings with the Solent Forum flood users (see Section 3 and Appendix I).

Illustrated in Figure 6.5, the application consists of 6 main components:

1. Map & result viewer
2. Spatial Layer control
3. Data viewer
4. Data source selection
5. Data search panel
6. Reference window

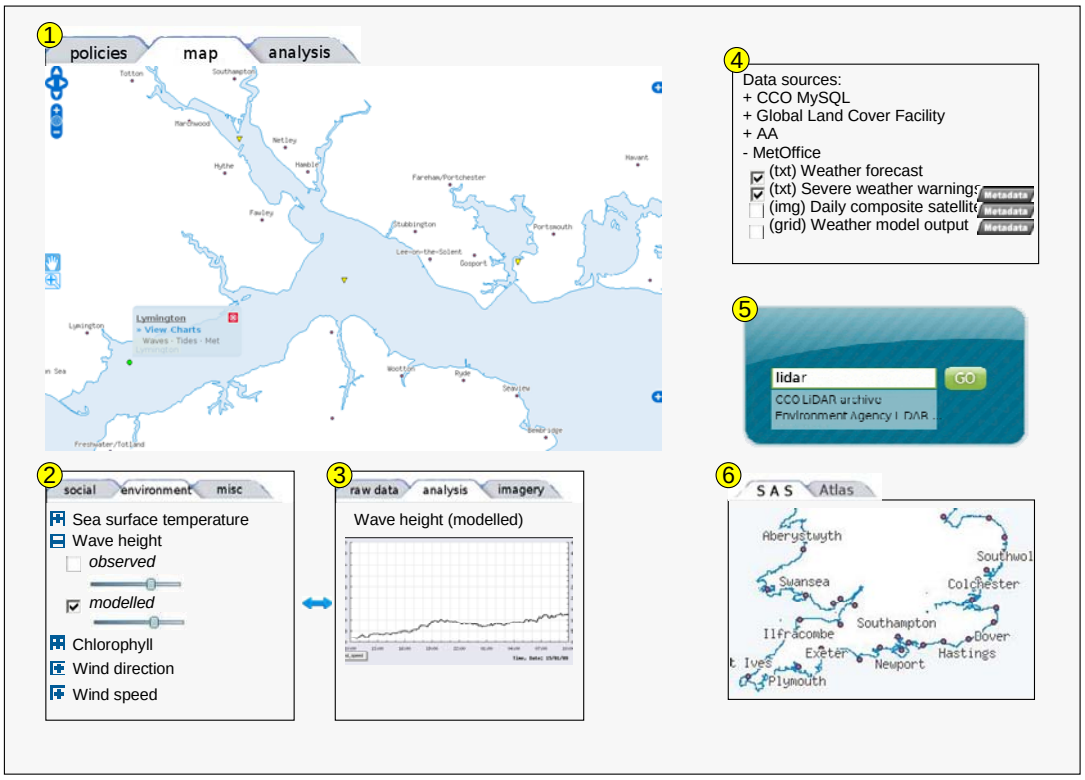

Figure 6.5: Decision Support tool example

A typical user interaction with this more complex application may operate as follows. The user might begin their interaction by exploring default (or retrieved from a previous saved session) datasets (4). Additional external and internal data can be added to this list by searching for available data (5) or manually pointing the application to existing data sources. The application might access various types of spatial and non-spatial datasets, effectively parsing textual information and extracting the relevant semantics.

The spatial data which are made available through the Data selection window (4) are further narrowed down in the Layer control (2) and visualised in the Map window (1). Relevant layers are parsed into social, environmental and miscellaneous groups, while visualisation of temporally-enabled datasets is assisted through a calendar or horizontal date/time scrollbar. Most data would be queryable, with the exact query fields being determined by relevant (semantic) metadata. Query results are displayed in a Data view window (3) and are essentially split into one-off measurements ("raw data" tab), historic data view ("analysis" tab) and sensor "imagery" (web-cams, satellite and aerial photography, etc).

The Map and visualisation window (1) is the main user view and interaction tool, which allows the end user to view and analyse spatially-enabled datasets ("map" tab), access relevant policies and guidance ("policies" tab) as well as other explicitly non-spatial data from (4). The content of each tab is defined and constrained by selections in (4), (2) and the map bounding box (1).

The user's decision-making process is further supported by an auxiliary Reference window (6). This is used to display alerts about malfunctioning or corrupt sensors,

typically using the OGC SAS - Sensor Alert Service, as well as displaying a set of pre-set maps (i.e. an atlas with static maps and spatial analyses – long term flood risk, population density, slope & elevation, etc).

As a whole, this example web application aims to explore the requirements for a group of flood users who wish to explore spatial data, including real-time and historic sensor data, but within the context of environmental policy, advice and guidance, scoping studies, consultation findings, etc.

6.7 Application Components and Standards

As part of the process to initiate and stimulate discussions with users and SG4E technical partners (and in response to those initial discussions), the Flood development team carried out prototype technical implementations to produce early examples of useful web application and mashup components.

The first of these was a dual map interface to the Channel Coastal Observatory data repository, enabling users to explore and visualise the range of available spatial data though a common web map interface, and display and compare two views side by side. For example, a coastal manager may wish to visualise aerial photography for a specific region for two specified years or to compare aerial photography with LiDAR data, as shown in Figure 6.6.

The application is currently accessible to project partners and users through the URL: http://www.channelcoast.org/data_management/online_data_catalogue/metadata/search/dual.php.

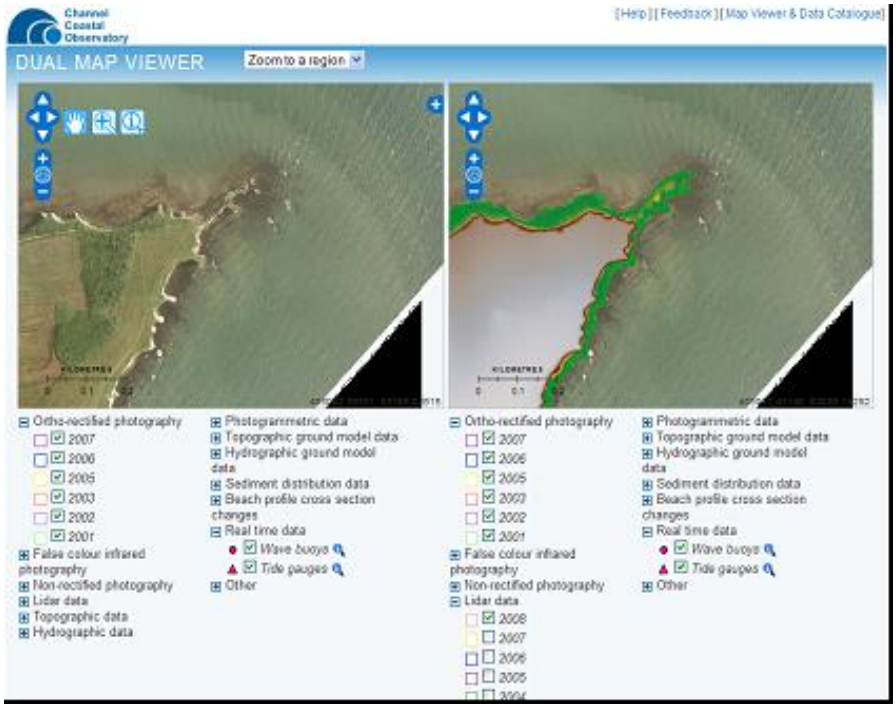

Figure 6.6: CCO Dual map interface

A second early development, which should form a useful contribution for prototyping and longer term application development, was a map for visualising live and historic sensor data. The component incorporates a time axis control enabling users to explore real-time and historic data by selecting a date of interest, and, as above, a dual map interface enabling them to identify a region of interest and compare different time scenarios side by side. Symbols are overlaid on the maps indicating wave height values at each CCO wave buoy location, with sizes and colours varying according to the attribute value. An obvious extension to the application would be the facility to select alternative wave, tide and met variables from the CCO real-time network, or any source of sensed data discovered using the SG4E Registry service.

The application, illustrated in Figure 6.7, is also accessible to project partners and users, through the URL: http://www.channelcoast.org/data_management/online_data_catalogue/metadata/search/sensors.php.

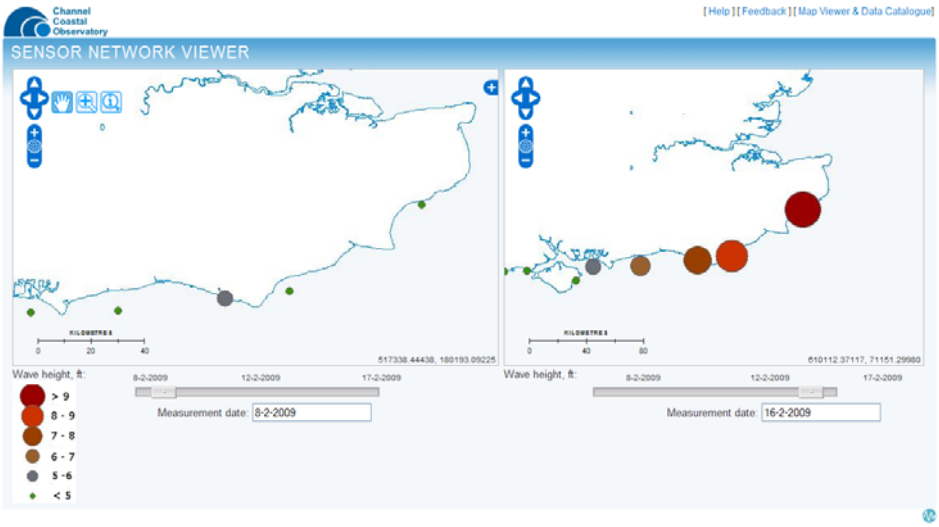

Figure 6.7: CCO Sensor map

As well as providing a tool to help potential flood users envisage possibilities, these initial implementations have assisted the Flood development team in the design and selection of the appropriate interfaces and standards which would enable such components and identification of data sources to interface with other elements of the SG4E architecture.

For example, the development of the Sensor map above has assisted with the initial design of a simple RESTful interface to the CCO sensor network (Figure 6.8) which would be developed to integrate with the SG4E middleware and support the Data Access and Mashup API services. The design of the interface would also comply with the semantic infrastructure (RDF) and spatio-temporal Registry metadata (SensorML) standards adopted by the project.

As part of the design process in the development of the sensor map components and their associated back-end services and APIs, the team considered how a typical wave buoy sensor would be described through an RDF document (Figure 6.9) in order to

identify ‘competency’ questions which the web application/mashup API would ask the SG4E Registry API on behalf of flood users (Figure 6.10). The resulting RDF structure is based closely on examples used in other sensor network projects and would be updated to take into account the spatio-temporal ‘constraint’-based RDF extensions being defined by other project partners.

The web mapping technologies used to develop the interfaces described above are based on open source tools (OpenLayers, MapServer) which support open standards for spatial data manipulation and display (OGC WMS – Web Mapping Service and WFS - Web Feature Service). These standards will be combined with other open standards for querying sensor data (OGC SOS - Sensor Observation Service). An example OGC SensorML XML metadata record was defined for one of the CCO wave buoy sensors to provide example data for semantic registry development. This is included in Appendix II.

/sensors/aqua/tide/chesil_beach/20080101/1200	Tide height at 12:00 a.m.
/sensors/aqua/tide/chesil_beach/20080101	Average daily tide height + collection of hourly tide height measurements
/sensors/aqua/tide/chesil_beach	*Accept*: *text/html*: Simple time series visualisation interface
	Accept: *application/rdf+xml*: RDF with Chesil beach tidal sensor data, provided via OGC Sensor Observation Service
/sensors/aqua/tide	Collection of all available tide sensors
/sensors/aqua	Collection of all available aquatic sensors
/sensors/	List all available sensors

Figure 6.8: RESTful interface to the CCO sensor network

```
<sit:Location rdf:about="&sit;chesil_beach"
rdfs:label="Chesil Beach"
geo:lat="50.79472"
geo:lng="-1.2875"
sit:altitude="1">
</sit:Location>
<sit:Sensor rdf:about="&sit;chesil_beach/tide_height"
rdfs:label="Tide height">
<sit:sensorType rdf:resource="&sit;tide_height"/>
<sit:location rdf:resource="&sit;chesil_beach"/>
</sit:Sensor>
<sit:SensorType rdf:about="&sit;tide_height"
rdfs:label="Tide height">
</sit:SensorType>
<sit:Unit rdf:about="&sit;metres"
rdfs:label="Metres"
sit:unitAbbr="m">
</sit:Unit>
<sit:Reading
rdf:about="&sit;chesil_beach/tide_height/reading/1234"
rdfs:value="9.3"
sit:datetime="2008-01-01T21:55:00">
<sit:sensor rdf:resource="&sit;chesil_beach/tide_height"/>
<sit:unit rdf:resource="&sit;metres"/>
</sit:Reading>
```

Figure 6.9: Example RDF describing a wave buoy sensor

Discovery type requests

- Find all available aquatic/tide/SST sensors
- List all aquatic datasets for the Isle of Wight during the last week of 2008 (bounding box/polygon/buffer query)

Combined with RESTful Interface or Data integration service type requests

- Obtain maximum wave height at Folkestone on 2 January 2009
- List names, coordinates and measurements from all wave height gauges in the Solent where wave height > 1.5 m
- Calculate the upper 10th percentile of sea surface temperature in Cornwall
- Display coordinates of all drifting sensors
- Display coordinates and metadata information for all sensors which provide corrupt or no data

Figure 6.10: Sample competency questions

Appendix I: Stakeholder Network Building

- A series of in-house GeoData brainstorming sessions were used to identify and characterise the primary attributes of information service providers and information users, as a basis for profiling useful stereotypes for SG4E partners.

- Meetings have been held with, and presentations made to, each of the short-list of user partners:

    - The Environment Agency of England and Wales
    - The Channel Coastal Observatory
    - The Solent Forum
    - Associated British Ports, Southampton
    - The Queen's Harbour Master, Portsmouth

- The establishment of the partner network has been expedited by the fact that Mike Clark has existing and long-standing research project links with the Environment Agency, the GeoData Institute hosts the web-based delivery service for the Channel Coastal Observatory, and Mike is Chair of the Solent Forum and through this position has Steering Group links with Associated British Ports and the Queen's Harbour Master. These existing links have, in effect, opened the doors that have allowed us to lobby on behalf of SG4E, hereby reducing the time taken to bring major organisations into the user network.

- Specific SG4E project face-to-face discussions have been held with:
    - Simon Ashley, Head of Interactive Development, Environment Agency
    - Professor Anrew Bradbury, Director, Channel Coastal Observatory
    - Travis Mason, Channel Coastal Observatory
    - Karen McHugh, Solent Project Officer, Hampshire County Council
    - Rhian Davies, Solent Forum Officer, Hampshire County Council
    - Rob Crighton, Chair, Southern Water Quality Association, Southampton City
    - Ron Hancock, Associated British Ports, Southampton
    - Commander Stephen Hopper, Royal Navy, Queen's Harbour Master, Portsmouth

Appendix II Sample SensorML Document


```
<?xml version="1.0" encoding="UTF-8" ?>
- <sml:SensorML xmlns:sml="http://www.opengis.net/sensorML/1.0.1" xmlns:swe="http://www.opengis.net/swe/1.0.1"
  xmlns:gml="http://www.opengis.net/gml" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/sensorML/1.0.1
  http://schemas.opengis.net/sensorML/1.0.1/sensorML.xsd" version="1.0.1">
  - <!--

    -->
- <sml:member>
- <sml:System gml:id="WHG01">
  - <!--
    ==============================================
    -->
  - <!--
                System Descrition
    -->
  - <!--
    ==============================================
    -->
  <gml:description>Wave parameters are recorded using a Datawell Directional WaveRider Mk III buoy. The buoy was deployed on 08
    July 2003 from the MV Wessex Explorer</gml:description>
  - <!--
    ==============================================
    -->
  - <!--
              System Search Keywords
    -->
  - <!--
    ==============================================
    -->
- <sml:keywords>
- <sml:KeywordList codeSpace="http://gcmd.nasa.gov/Resources/valids/keyword_list.html">
  <sml:keyword>WAVE HEIGHT GAUGES</sml:keyword>
  <sml:keyword>OCEANOGRAPHY</sml:keyword>
  <sml:keyword>MARINE SENSORS</sml:keyword>
    </sml:KeywordList>
    </sml:keywords>
  - <!--
    ==============================================
    -->
  - <!--
                System Identifiers
    -->
  - <!--
    ==============================================
    -->
- <sml:identification>
- <sml:IdentifierList>
- <sml:identifier name="UID">
- <sml:Term definition="urn:ogc:def:identifier:OGC:uuid">
  <sml:value>urn:ogc:object:sensor:WHG:v1:01</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Short Name">
- <sml:Term definition="urn:ogc:def:identifier:OGC:shortName">
  <sml:value>WHG</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Long Name">
- <sml:Term definition="urn:ogc:def:identifier:OGC:longName">
  <sml:value>Wave Height Gauge</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Manufacturer Name">
- <sml:Term definition="urn:ogc:def:identifier:OGC:manufacturerName">
  <sml:value>Datawell</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Model Number">
- <sml:Term definition="urn:ogc:def:identifier:OGC:modelNumber">
  <sml:codeSpace xlink:href="urn:ogc:def:identifier:SBE:modelNumber" />
  <sml:value>WaveRider Mk III</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Serial Number">
- <sml:Term definition="urn:ogc:def:identifier:OGC:serialNumber">
  <sml:codeSpace xlink:href="urn:ogc:def:identifier:SBE:serialNumber" />
  <sml:value>0000000-000</sml:value>
    </sml:Term>
    </sml:identifier>
- <sml:identifier name="Device ID">
- <sml:Term definition="urn:ogc:def:identifier:WHG:deviceID">
  <sml:codeSpace xlink:href="urn:ogc:def:identifier:WHG:CCO" />
```

```
  <sml:value>01</sml:value>
      </sml:Term>
      </sml:identifier>
      </sml:IdentifierList>
      </sml:identification>
    - <!--
      ==============================================
      -->
    - <!--
                        System Classifiers
      -->
    - <!--
      ==============================================
      -->
- <sml:classification>
- <sml:ClassifierList>
- <sml:classifier name="Sensor Type">
- <sml:Term definition="urn:ogc:def:classifier:OGC:sensorType">
  <sml:codeSpace xlink:href="urn:ogc:dictionary:WHG:sensorTypes" />
  <sml:value>Directional waverider</sml:value>
      </sml:Term>
      </sml:classifier>
- <sml:classifier name="Deployment Role">
- <sml:Term definition="urn:ogc:def:classifier:WHG:deploymentRole">
  <sml:value>Instrument</sml:value>
      </sml:Term>
      </sml:classifier>
      </sml:ClassifierList>
      </sml:classification>
    - <!--
      ==============================================
      -->
    - <!--
            Temporal Validity of this description
      -->
    - <!--
      ==============================================
      -->
- <sml:validTime>
- <gml:TimePeriod gml:id="DOC_TIME">
  <gml:beginPosition>2008-01-25T20:00:00Z</gml:beginPosition>
  <gml:endPosition indeterminatePosition="now" />
      </gml:TimePeriod>
      </sml:validTime>
    - <!--
      ==============================================
      -->
    - <!--
                      System Characteristics
      -->
    - <!--
      ==============================================
      -->
- <sml:characteristics name="Physical Properties">
- <swe:DataRecord definition="urn:ogc:def:property:physicalProperties">
- <swe:field name="weight">
- <swe:Quantity definition="urn:ogc:def:property:weight">
  <swe:uom code="kg" />
  <swe:value>105</swe:value>
      </swe:Quantity>
      </swe:field>
- <swe:field name="diameter">
- <swe:Quantity definition="urn:ogc:def:property:diameter">
  <swe:uom code="mm" />
  <swe:value>700</swe:value>
      </swe:Quantity>
      </swe:field>
- <swe:field name="material">
- <swe:Category definition="urn:ogc:dictionary:OGC:material">
  <swe:value>Stainless steel AISI316</swe:value>
      </swe:Category>
      </swe:field>
      </swe:DataRecord>
      </sml:characteristics>
    - <!--
      ==============================================
      -->
    - <!--
                        Relevant Contacts
      -->
    - <!--
      ==============================================
      -->
- <sml:contact xlink:arcrole="urn:ogc:def:classifiers:OGC:contactType:manufacturer">
- <sml:ResponsibleParty>
  <sml:organizationName>Datawell BV</sml:organizationName>
- <sml:contactInfo>
- <sml:phone>
  <sml:voice>+31 23 531 41 59</sml:voice>
  <sml:facsimile>+31 23 531 19 86</sml:facsimile>
```

```
      </sml:phone>
- <sml:address>
  <sml:deliveryPoint>Zomerluststraat 4</sml:deliveryPoint>
  <sml:city>LM Haarlem</sml:city>
  <sml:administrativeArea>Haarlem</sml:administrativeArea>
  <sml:postalCode>2012</sml:postalCode>
  <sml:country>The Netherlands</sml:country>
      </sml:address>
  <sml:onlineResource xlink:href="http://www.datawell.nl" />
      </sml:contactInfo>
      </sml:ResponsibleParty>
      </sml:contact>
- <sml:contact xlink:arcrole="urn:ogc:def:classifiers:OGC:contactType:owner">
- <sml:ResponsibleParty>
  <sml:organizationName>Channel Coastal Observatory</sml:organizationName>
- <sml:contactInfo>
- <sml:phone>
  <sml:voice>+44 (0)23 8059 8467</sml:voice>
      </sml:phone>
- <sml:address>
  <sml:deliveryPoint>European Way</sml:deliveryPoint>
  <sml:city>Southampton</sml:city>
  <sml:administrativeArea>Hampshire</sml:administrativeArea>
  <sml:postalCode>SO14 3ZH</sml:postalCode>
  <sml:country>United Kingdom</sml:country>
      </sml:address>
      </sml:contactInfo>
      </sml:ResponsibleParty>
      </sml:contact>
- <sml:contact xlink:arcrole="urn:ogc:def:classifiers:OGC:contactType:operator">
- <sml:ResponsibleParty>
  <sml:organizationName>Channel Coastal Observatory</sml:organizationName>
- <sml:contactInfo>
- <sml:phone>
  <sml:voice>+44 (0)23 8059 8467</sml:voice>
      </sml:phone>
- <sml:address>
  <sml:deliveryPoint>European Way</sml:deliveryPoint>
  <sml:city>Southampton</sml:city>
  <sml:administrativeArea>Hampshire</sml:administrativeArea>
  <sml:postalCode>SO14 3ZH</sml:postalCode>
  <sml:country>United Kingdom</sml:country>
      </sml:address>
      </sml:contactInfo>
      </sml:ResponsibleParty>
      </sml:contact>
    - <!--
      ==============================================
      -->
    - <!--
                    System Documentation
      -->
    - <!--
      ==============================================
      -->
- <sml:documentation xlink:arcrole="urn:ogc:def:classifiers:OGC:documentType:datasheet">
- <sml:Document>
  <gml:description>Directional Waverider MkIII datasheet</gml:description>
  <sml:date>2008-02-28</sml:date>
  <sml:format>application/pdf</sml:format>
  <sml:onlineResource xlink:href="download.datawell.nl/documentation/doc.php?doc=datawell_brochure_dwr-mk3" />
      </sml:Document>
      </sml:documentation>
    - <!--
      ==============================================
      -->
    - <!--
          System Location (Fixed in this case)
      -->
    - <!--
      ==============================================
      -->
- <sml:location>
  <gml:Name>Folkestone</gml:Name>
- <gml:Point gml:id="SYSTEM_LOCATION" srsName="urn:ogc:def:crs:EPSG:6.1:4326">
  <gml:coordinates>51.05 1.12</gml:coordinates>
      </gml:Point>
      </sml:location>
    - <!--
      ==============================================
      -->
    - <!--
                        System Inputs
      -->
    - <!--
      ==============================================
      -->
- <sml:inputs>
- <sml:InputList>
```

```
- <sml:input name="wave_height">
- <swe:ObservableProperty definition="urn:ogc:def:phenomenon:OGC:wave_height">
  <gml:description>Wave height</gml:description>
      </swe:ObservableProperty>
      </sml:input>
- <sml:input name="temperature">
- <swe:ObservableProperty definition="urn:ogc:def:phenomenon:OGC:temperature">
  <gml:description>Temperature</gml:description>
      </swe:ObservableProperty>
      </sml:input>
      </sml:InputList>
      </sml:inputs>
    - <!--
      ==============================================
      -->
    - <!--
                          System Output
      -->
    - <!--
      ==============================================
      -->
- <sml:outputs>
- <sml:OutputList>
- <sml:output name="output data">
- <swe:DataRecord gml:id="DATA">
- <swe:field name="temperature">
- <swe:Quantity definition="urn:ogc:def:phenomenon:OGC:temperature">
  <gml:description>Sea Water Temperature</gml:description>
  <swe:uom code="Cel" />
- <swe:constraint>
- <swe:AllowedValues>
  <swe:interval>-5.0 46.0</swe:interval>
      </swe:AllowedValues>
      </swe:constraint>
- <swe:quality xlink:role="urn:ogc:def:phenomenon:OGC:accuracy">
- <swe:Quantity definition="urn:ogc:def:sensor:OGC:absoluteAccuracy">
  <swe:uom code="Cel" />
  <swe:value>0.2</swe:value>
      </swe:Quantity>
      </swe:quality>
      </swe:Quantity>
      </swe:field>
- <swe:field name="wave_height">
- <swe:Quantity definition="urn:ogc:def:phenomenon:OGC:wave_height">
  <gml:description>Wave Height</gml:description>
  <swe:uom code="M" />
- <swe:constraint>
- <swe:AllowedValues>
  <swe:interval>-20 20</swe:interval>
      </swe:AllowedValues>
      </swe:constraint>
- <swe:quality xlink:role="urn:ogc:def:sensor:OGC:accuracy">
- <swe:Quantity>
  <swe:uom code="cm" />
  <swe:value>1</swe:value>
      </swe:Quantity>
      </swe:quality>
      </swe:Quantity>
      </swe:field>
- <swe:field name="date">
- <swe:Time definition="urn:ogc:def:phenomenon:OGC:date">
  <gml:description>Measurement Date</gml:description>
  <swe:uom xlink:href="urn:ogc:def:unit:ISO:8601:date" />
      </swe:Time>
      </swe:field>
- <swe:field name="time">
- <swe:Time definition="urn:ogc:def:phenomenon:OGC:time">
  <gml:description>Measurement Time of Day</gml:description>
  <swe:uom xlink:href="urn:ogc:def:unit:ISO:8601:time" />
      </swe:Time>
      </swe:field>
      </swe:DataRecord>
      </sml:output>
      </sml:OutputList>
      </sml:outputs>
      </sml:System>
      </sml:member>
      </sml:SensorML>
```