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Pearl

Port environmental information collector

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FINAL ACTIVITY REPORT

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Associated British Ports Marine Environmental Research	ABPmer	NL	
Polish academy of science – Space Research Center	SRC	PL	

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1 Publishable executive summary

Pearl

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Ports are highly affected by ocean conditions and pollution events near the Port. Moreover, European legislation is also requesting better information. A remote and continuous monitoring of a wider geographical area is a key aspect for improving the understanding port environment phenomena, as well as anticipating risk situations that will affect the port.
There are a large number of systems in place to gather relevant geo-information data, mainly meteorological, water quality, oceanographic and pollution related. However, it is clear that the systems used presently are in-situ sensors and are mainly used to gather specific data within or near the port area. Improving information flow by increasing the number of in-situ sensors deployed is a costly investment strategy.
Space data is seriously underused by Port Authorities due to different obstacles, although it space data is becoming more and more available appears that EO data is able to provide valuable information in areas near the coastline. At the same time, projects such as the FP6 IP MERSEA focus on the delivery of oceanographic products exploiting space data and model innovation. These data products are very relevant to Ports.
PEARL (Port EnviromentAl infoRmation colLector) is an international project co-funded by the European Commission within the Sixth Framework Programme (2002- 2006). PEARL seeks to address the above issues by developing a Port Environmental Management System enabling the optimal exploitation of space and in situ data products. Pearl aims at providing, for the first time, a platform focusing on Ports and their environmental problems for user friendly access of in situ and space data and models, and their efficient combination.
Pearl aims at educating the user community on the information content available from space and in-situ instruments, as well as on current limitations.

The primary objective of PEARL is the development of a Port Environmental Management System Platform capable of optimal exploitation of space and in situ data products and models.

To attain the overall objective, PEARL also seeks to achieve the following objectives:

- Provide a good profile of Port Authorities and their Environmental needs
- Review existing space data products and services, models and in situ sensors, and select the most relevant ones for Port Authorities
- Achieve an operational use of space data in the Port Sector
- Consider existing environmental in situ sensors (used in ports and in other sectors) for the Port area
- Achieve an effective integration of space and in-situ data and models to provide the most relevant information for the Port
- Develop an integrated effective platform, scalable and capable of ingesting future data products and models
- Provide the port environmental manager a user friendly tool for accessing and interpreting all relevant information (data and models)
- Achieve a good degree of market integration of the service

The achievement of the above objectives has produced the following results:

- Port sector profile and environmental needs
- Complete (in-situ and space) selected data set and gap identification

- Pearl System
- Validation of previous results in a real port environment.
- Exploitation and dissemination plan

So, the work is divided in the following workpackages:

- WP1 is Project Management,
- WP2 Port Profile and User Requirements,
- WP3 Data selection & data combination,
- WP4 Platform Development,
- WP5 Validation Campaigns and
- WP6 Exploitation and dissemination.

Pearl project has 7 partners:

- Atos Origin, SAE (coordinator)
- Starlab Barcelona S.L. (technical responsible)
- Institut Français de Recherche pour l'Exploitation de la Mer,
- BOOST TECHNOLOGIES,
- EcoPorts Foundation,
- ABP Marine Environmental Research Ltd,
- Space Research Centre Polish Academy of Sciences

And their roles across the project are depicted in the following diagram (Figure 1-1)

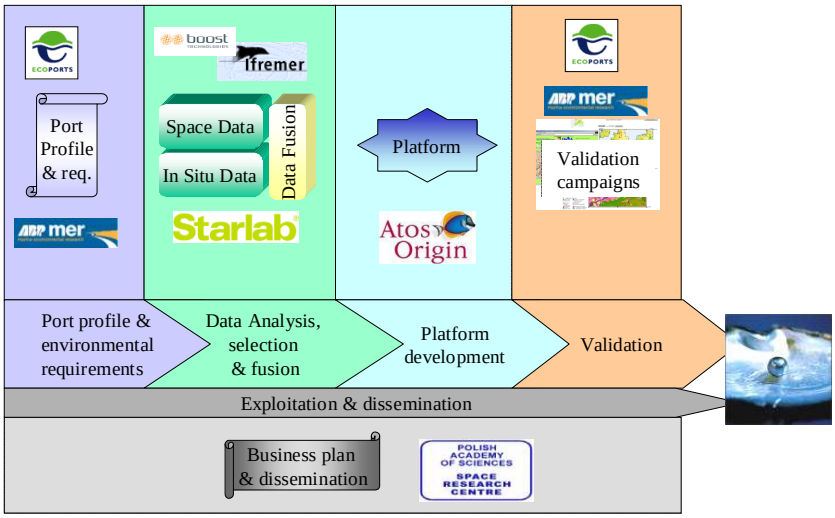

Figure 1-1: Project structure, partners and roles

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2 Activities

2.1 Port Profile and User Requirements

A sample of ports across Europe were selected to be interviewed to enable a representative survey to be completed. The selected ports covered a broad geographical variety (including estuarine, riverine and inland), and a range of sizes. To maximise the potential cooperation for the ports and to help with the goal of obtaining high quality responses and information, use was made of existing port contacts and accessibility to existing information. ABPmer and EcoPorts enjoy strong connections with a number of European ports due to past activities and contacts. Other ports were chosen to enhance the concept of a representative selection of port types.

A questionnaire was designed which captured port profile details, environmental management, environmental data needs and product specification. This enabled the collection of data for both components of required reporting. Information was also sought prior to interview via port websites.

Prior to interview, a PEARL project information sheet was sent to the port representatives, along with the port profile questions, and copies of specific questions relating to the needs identification and product specification sections of the interview. This was to allow time for consideration and completion of these in advance of the formal interview. Accompanying these questions were further details regarding the purpose of the project and examples of types of in situ and remotely sensed data. This method allowed interviewees time to gather information if necessary and to return any responses in advance of the interview.

Figure 2-1: Map of Europe Showing the Locations of the Interviewees

Each interview was conducted by two PEARL representatives from ABPmer or EcoPorts and usually involved two port representatives. This arrangement was intended to ensure that one representative with an environmental management background and one with a technical data management background would be present for interview and that all questions could be answered fully from a broad base of knowledge. Outstanding questions were followed up within a week of interview.

The primary source of information for data analysis was derived from the port interviews. The responses have been condensed to reflect key themes and findings.

Interview responses and answers were recorded in spreadsheets, and where possible, analysis was completed by migrating this data into a database that allowed for more rapid analysis. The results are represented graphically where possible, with supporting text summaries. A more general analysis was completed by those who completed the interviews, by reading the responses and then concluding on the significant points of interest.

Environmental policies were held by 88% of the ports interviewed. These policies contain statements regarding compliance with legislation, regulations and include objectives for the ports. Most include statements regarding commitment to the prevention of air and water pollution, waste management, biodiversity and the protection of natural resources. Many environmental policies include a commitment to sustainable development and a need for continuous improvement.

Monitoring of the port environment is undertaken for a number of reasons and the main drivers are;

International and National LEGISLATION	Local Harbour Authorities are regulated by International and European laws implemented through National Legislation. Legislation affecting ports, broken down by area, includes: Pollution from Ships: MARPOL, London Convention, Basel Convention, OSPAR, UNCLOS, International Convention for Ballast Water and Anti-Fouling, OPRC (International Convention on Oil Pollution Preparedness and Response) Port Development: UNCTAD, UNCED, ESCAP Environmental: HELCOM (Baltic Marine Environment Protection Commission), OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic), Ramsar Wetlands Convention, Kyoto Protocol (UNFCCC). Programme VI of the Community Action on the Environment (Climatic Change, Biodiversity, Health, Natural Resources), Strategic Environmental Assessment Directive, Environmental Impact Assessment Directive. Habitats Protection: Habitats Directive, Birds Directive Marine Protection: A European Marine Strategy is under development, Water Framework Directive, Water Bathing Directive Security: SOLAS (International Convention for the Safety of Life at Sea) and ISPS (International Ship & Port Facility Security Code) Transport: EU transport policy (White paper on Transport Policy) promoting Short Sea Shipping. As it can be seen observing recent legislation, ports will be faced with an increase in environmental regulation that will require not only careful monitoring but also careful management in order to understand root causes.
LOCAL RESPONSIBILITY	Many ports have local responsibilities such as conservancy requirements and consideration of the community as a whole together with the need to collect data to assist with the operation of the port itself.
OPERATIONAL & MAINTENANCE REQUIREMENTS	On occasions the ports will also need to carry out or collect ‘special project’ monitoring to provide data associated with a particular activity, such as a capital scheme which might include reclamation, dredging, construction (marine and landside) and habitat creation. Many ports also have the requirement to conduct occasional monitoring such as in the event of an oil spill incident. Operational requirements include monitoring of bathymetry, sediment quality, tidal levels, dust emission, etc.
ENVIRONMENTAL PLANNING	At global and local levels, there is a growing demand for improved and sustainable management of marine resources and ecosystems as well as protection of inland areas. The topics affecting ports are the beneficial use of Dredged Material, the Protection of Habitats, Integrated Coastal Zone Management, Rising Sea Levels, Increased Storminess, Accidental Contamination, Flooding risks… The trend is the long-term monitoring, Inter-Administration collaboration to cope with complicated global environmental problems (climate change, rising sea levels, reduced fishing stocks…) and publicly available environmental reviews by Ports. For cases where no legislation exists, ports are adopting self-regulatory measures in order to tackle environmental issues on a day-to-day basis.

OTHER INFLUENCES	Economic & Demographic	Ports are crucial to world trade development as connection points between sea-borne and land-based transport: Free Trade agreements, EU, NAFTA, ASEAN. They also affect other sectors such as fishing and tourism. Ports are facing pressure to accommodate Increased Traffic or to Increase Capacity, which means that they need to offer adequate infrastructure (limited by environmental & ecological considerations). The trend is an increased implementation of Quality Control (ISO), increase in size of ships, increase in port traffic and capacity.
	Socio-Cultural	Ports are usually located in highly sensitive areas with respect to large local populations, ecology, landscape and tourism. If environmental issues are not well handled, they can lead to conflict with the community and have a detrimental effect on the port's future and their ability to expand. The port-city relationship is very important and is recognised in legislation (Public Access to Environmental Information Directive, Public Participation in Environmental Programmes Directive...). Additionally, new concerns (especially after 11.09.2001) relating to terrorism and security are putting pressure on ports to adopt new measures. Lobbying by Political/Environmental Groups also puts pressure on ports. There is a tendency to public participation in Port Development and improved communication of environmental plans and actions in order to avoid conflict and to facilitate community approval of future plans.
	Technological	Technology is moving towards Real Time and On-Line Systems that combine different data sources. Trend: Integrated Systems to allow better management of disparate issues (example Vessel Traffic Systems with add-on services, like waste notification, oil spill detection…). Incorporation of more remote sensing technologies (including EO) combined with the advances in computing capabilities to achieve a higher degree of automation. Integrated geo -information systems with multiple sources leading to increased standardization.
	Geographic	Threat of Flooding, Prevailing Winds and Waves in the port area affect port operations and health and safety management. Size of the port is very relevant to the demand for geo-information, along with topography and access to the port hinterland.
	Industrial	Health and Safety issues & Quality Standards The tendency is to increase the Development of Common Tools to exchange environmental information, Budget Combination to have access to more sophisticated technology covering large areas (for example EO data), and more bargaining power.

Table 2-1: Port drivers for monitoring activities

Many ports have local responsibilities such as conservancy requirements and consideration of the community as a whole together with the need to collect data to assist with the operation of the port itself. On occasions the ports will also need to carry out or collect 'special project' monitoring to provide data associated with a particular activity, such as a capital scheme which might include reclamation, dredging, construction (marine and landside) and habitat creation. Many ports also have the requirement to conduct occasional monitoring such as in the event of an oil spill incident. Examples of data gathered for each type of monitoring are given in Table 2-2.

Operational	Legislation Driven	Special Projects e.g. Dredging	Occasional Needs
Barometric pressure	Water quality	Turbidity	Oil or chemical spill monitoring
Tidal height	Bird counts	Benthic communities	Noise monitoring of port activities
Currents	Waste water discharge	Fish	
Wind speed and direction	Sediment quality	Habitat mapping	
Dust	Sensitive area monitoring		
Noise	Land contamination		
Waves			
Waste			
Air quality			
Sediment density			
Turbidity			
Bathymetry			

Table 2-2: Data Requirements for Different Monitoring Drivers

The ports interviewed vary in size and extent of their jurisdictions and the responses to how they obtain their environmental data reflects this. Some ports have the capability and are expected to gather their own data whilst others rely on the data purchase or third parties to provide the necessary information. Third party data either from consultants or other data providers, on media such as CD-ROM, are collected in equal amounts with 7 ports operating in this way. Examples of how these data are obtained are given in Table 2-3.

Purchased	Provided by Third Party (Laboratory, Government or Agency)
Tidal predictions	Water quality (heavy metals and nutrients)
River flows	Land quality
Sample analysis (water and sediment)	Bird counts
Aerial photographs	Habitat mapping
(Admiralty) Bathymetric charts	Benthic counts
LiDAR	Fish
Landline information	Sediment quality
Data programmes	Currents
	Waves
	Air quality

Table 2-3: Examples of Data Purchase and Third Party Provision

Port environmental data and information requirements are summarised in Table 2-4 which also includes the common method for collecting these data with details on the type of *in situ* sensor used. Options for EO data provision and use are also included.

Information Required/Aspects that Require Monitoring	Data Type	Presently Obtained by *In situ* Sensors?	*In situ* Instrumentation Example	Presently Obtained by EO?	EO Instrumentation Example
Tide levels	Time series data every 10 minutes, 365 days of the year.	Yes	Pressure transducer tide gauges including vented, non-vented and acoustic gauges	No	Not used
Current flow	Time series data typically every 10 minutes, measurements taken for 2 - 4 weeks typically, for special projects such as tidal diamonds and EIA.	Yes	Fixed stations such as buoy mounted giving single point data. More sophisticated sensors allow for horizontal and vertical profiling in a number of discreet cells.	No	Not used

Meteorological data	Time series data typically every 10 minutes, predominantly wind speed and direction.	Yes	Automatic Weather Station with a suite of instruments such as; an anemometer, a thermometer, a hygrometer, a barometer and a rain gauge.	Yes	Meteorological satellites (specifically sensing cloud cover and rainfall intensity).
Air quality monitoring	Time series data typically every 60 minutes.	Yes	Air Quality Monitoring Station. Sensors measure dust emissions and pollutants.	No	Not used
Bathymetric surveying	Date, position and depth data to monitor changes and maintain navigable waters. Typically annually, also for special projects.	Yes	Boat-based echo-sounder with GPS.	No	Not used
Suspended solids measurement	Date, position and depth data or single point time series data. Typically for special projects.	Yes	Optical Back-Scatter (OBS) sensors. NTU (Nephelometric Turbidity Units) are converted into a suspended solid concentration of mg/l.	No	Not used
Wave spectral data	Time-series data, collected every 15 minutes. This can be required in real-time for operational purposes or after measurement for analysis and modelling purposes.	Yes	Sensors are placed on fixed platforms, buoys and bed mounted frames. Ground-based radar is also used to measure from the coastline.	No	Not used
Salinity	Time-series data, collected every 15 minutes from a single point fixed station, or annual measurements in profile from a boat.	Yes	Conductivity, temperature and depth (CTD) sensor.	No	Not used
Water quality monitoring	Time-series data, collected every 15 minutes from a single point fixed station, or measurements in profile from a boat.	Yes	Parameters measured include the following sensors; dissolved oxygen, turbidity, suspended solids, oil, heavy metals, chlorophyll and nutrient levels.	No	Not used
Topographic data	Date, position and height data. Typically for special project monitoring (e.g. habitat mapping, change in land forms)	Yes	Real-time Kinematic (RTK) Global Positioning System (GPS) or traditional land survey techniques.	No	Not used
Waste	Date, location,	Visual or	Tape measure	No	Not used

	quantity and type	measured			
Sediment density	Date, position, depth and density	Yes	Nuclear density gauge	Not possible	Not possible
Noise	Date, time, location and decibel level	Yes	Decibel level meter	Not possible	Not possible
Sediment quality	Date, position, depth and quality analysis.	No, by grab sampling	Van Veen and Day grabs	Not possible	Not possible
Monitoring of invasive species	Date and position (location e.g. vessel name). Sampling required for routine monitoring.	Yes	Water sampling from ships hulls and ballast water tanks, or at monitoring stations. Samples then analysed at a specialist laboratory.	No	Not used

Table 2-4: Port Environmental Information and Data Requirements Including Sensors Used and EO Options

Following a questionnaire put to a number of organizations including ports on the topic of water quality, the IMARQ study reported that “organisations do not have specific, critical needs which are not met - if so, they would not be operating. Regulatory standards take account of what is technically possible, rather than what might be possible in future. However, it did become clear that certain types of user organisation were willing to explore how they could benefit from a prospective technological advance” (MTS, 2002).

To provide a more quantitative assessment of the EO data needs, port interviewees were asked to provide descriptive information, to a predefined format, about the environmental information they might wish to be able to obtain from an information fusion platform such as PEARL. The responses from some ports were limited, particularly private ports where commercial considerations are ever present, and ports where the environmental jurisdiction belonged to a third party i.e. water quality measurements are the responsibility of the local or town authority.

Other ports, usually those with existing exposure or knowledge of EO data products or where the port is itself actively engaged in the environmental monitoring and reporting process, were able to succinctly specify their data needs. Figure 2-2 below provides a breakdown of the data needs identified by ports.

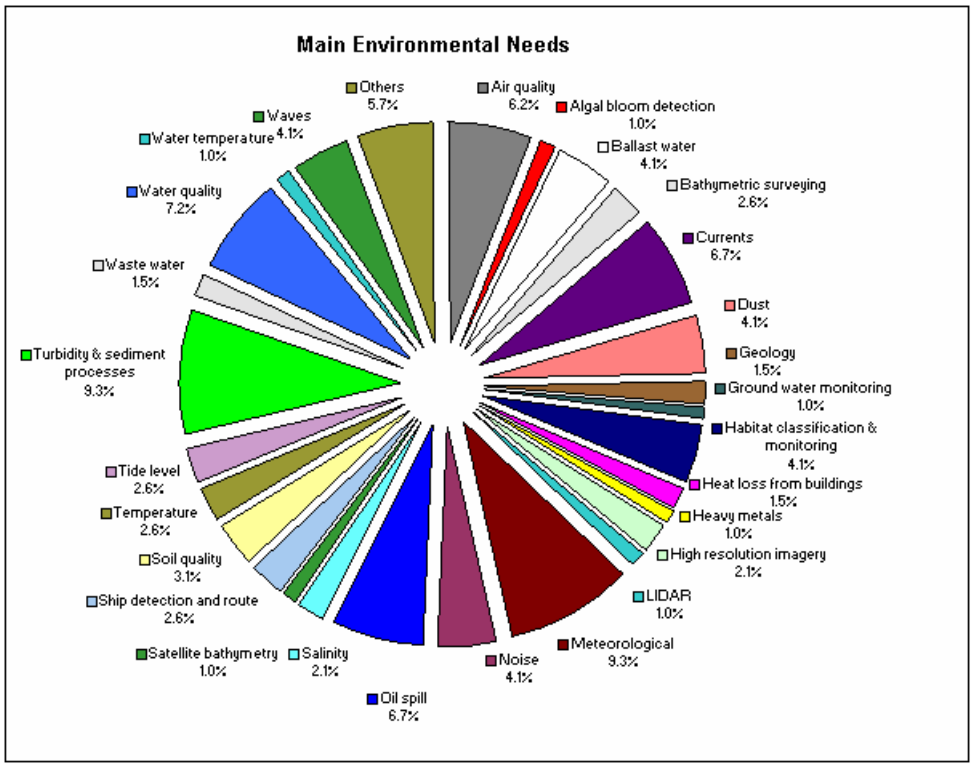


Figure 2-2: Main Environmental Needs

To assist in defining the requirements for the PEARL platform, data presented in this D2.2 has been further analysed to correlate environmental data needs with port characteristics presented in report D2.1. The main environmental needs have been linked to the port principal activities to attempt to highlight correlations between these two data sets. The analysis undertaken in D2.1 provided an insight into the main cargo types handled within the ports interviewed. To summarise, 'general cargo' was the most popular commodity handled (84%), followed by 'dry bulks' (76%), 'liquid bulks (non-oil)' (64%), 'fresh produce and perishables' (60%), with 'containers' and 'oil and petroleum' both being handled by 56% of the ports.

Using the headline information collected to date, a ranking of importance of environmental need and principal port activities was carried out, followed by evidence of correlations between these elements. Table 2-5 and Table 2-6 provide the results of the ranking exercise.

The Principal or Main Activities Identified in Report D2.1 Rank	The Principal or Main Activities Identified in Report D2.1	Environmental Needs Associated with the Activity
1	General cargo	Safe operation of ships.
2	Dry bulks	Dust dispersal any small particle solids; e.g. grains, chemicals and powdered minerals. Safe operation of ships.
3	Liquids bulks (non-oil)	Safe operation of ships.
4	Fresh produce and perishables	Safe operation of ships.
5th equal	Containers	Safe operation of ships.
5th equal	Oil and petroleum	Hazardous chemical cargos. Spills possible when transferring cargo, as well as in the event of a major incident. Safe operation of ships.

Table 2-5: Port Principal Activities and their Associated Environmental Needs

The top 6 port needs and their requirements are listed in Table 2-6.

The Top 6 Needs as Identified in the Needs Identification Section of the Report	Top 6 Needs Rank	Need Requirements
Turbidity and Sediment Process Analysis	1 equal	To manage sedimentation issues especially for dredge management, also for EIA.
Meteorological (most significantly wind)	1 equal	To ensure that ship and port operations can be completed efficiently and safely. The main impacts of wind are on sea state, dust dispersal, fume dispersal, crane operation and cargo handling, and ship berthing.
Water Quality	2	To ensure that water quality is not being detrimentally affected by port activities.
Currents	3 equal	To understand the currents for ship operational purposes.
Oil Spill	3 equal	To detect, monitor and track oil spills (including contaminated ballast water, minor leaks and major spills).
Air Quality	4	To ensure that air quality is not being detrimentally affected by port activities especially dust, gaseous and smoke impacts on local populations.

Table 2-6: The Top 6 Port Needs and their Requirements

The conclusion of this analysis was that an attempt was made to correlate the principal activities with the top 6 needs, and it is clear that it is difficult to do because the activities are not always easy to link with a need, and that additionally all port activities can be linked with certain needs such as 'Turbidity and Sediment Analysis' and 'Currents'.

This analysis does however provide a useful ranking of needs, which could be used to prioritise parameters that are of importance to ports. The list also reflects the parameters that ports already focus their efforts on. The numerical results (particularly the totals) should only be used as indicative values, as their magnitude is nominal and does not represent a quantifiable number.

The general needs have been highlighted in the matrix, however, it is possible to argue that there are alternative interpretations of environmental links when different environmental considerations can be applied, i.e. all shipping activities affect air quality because of the exhaust emissions from ships. This specific need has not been correlated, and instead the more major air quality impact of dry bulk dusts and oil and petroleum fumes have been detailed.

The results of the correlation of principal activities and top 6 needs result in a alternative ranking of issues in order of significance (Table 2-7);

Correlation Rank	Need
1 (equal)	Turbidity and Sediment Process Analysis
1 (equal)	Meteorological - Wind
2	Currents
3	Air Quality
4	Water Quality
5	Oil Spill

Table 2-7: Ranking Summary of Correlation of Principal Activities and Top 6 Needs

Most respondents completed a second specific questionnaire which was intended to provide a similar set of information to the 'Needs Identification', but to be focussed more closely on the PEARL platform product, the preferred form for its delivery and use, and the acceptable cost to benefit ratio of having access to and the use of such a system.

The interviews highlighted a majority opinion that the preferred format for the delivery of the PEARL platform should be from a centrally and most probably an independently controlled and managed resource. Major opinion was divided between those ports in which the use of GIS was already established and those where few or no such tools existed. Where GIS systems were in use the relative ease with which additional environmental data 'layers' could be added to existing systems was readily recognised.

For these ports, the regular update of environmental information, direct from the PEARL platform to their GIS would provide optimum functionality in conjunction with the usual operational uses of their systems. These updates could be at regular intervals, as required or as available. The choice of the update mechanism will depend on the criticality of the data requirement measured against the cost of update. A decision on which

GIS applications to support will be a necessary early decision for the system developer, to ensure acceptable development costs.

For those ports that have not yet, or do not intend to invest in GIS a clear preference emerged for access to a World Wide Web (Internet) based application via a remote graphical interface. This is similar in concept to the product 'Google Earth', with which many of the interviewees were already familiar. For such a system, the latest data would always be available and any charges for use or access should necessarily reflect this.

In addition to the basic concepts discussed above there was support among interviewees for a number of system enhancements. These were considered to be particularly desirable or important when considering incident management or the notification of alarm events. These included not only e-mail notifications to registered e-mail addresses but also the direct delivery of critical or essential notifications to key operating staff (such as the port Harbour Master) via mobile phone text message. Indeed, with an appropriately equipped notebook PC or Personal Digital Assistant (PDA) push delivery of e-mail notifications is also possible.

During one of the interviews an excellent suggestion was made regarding the potential benefits of the PEARL platform being able to provide information for ports that are in close proximity. Some ports are close enough to have similar environmental conditions and it would be useful to compare data and also to see if a phenomena occurring at one port is also being observed at another. This consideration is purely related to geographic proximity, which in some circumstances would allow for the international sharing of data.

2.2 Data Selection & Data Combination

Space data have now been used for several years in the operational process to observe, model and predict the general oceanic and atmospheric circulation at global state. Although research studies and developments on the exploitation of space data are certainly not finished yet to better understand the global behaviour of the marine environment and the interactions mechanisms involved, space information is indispensable today to operational modelling and predictions process. It provides indeed a unique opportunity for the operational numerical models to periodically ingest information on the conditions at sea. This process, known as assimilation, helps to provide as accurate as possible estimates of the physical states of the numerical models.

More recently, significant efforts were made to bring these activities towards coastal areas where the dynamics and the inter-dependencies of the parameters involved are much more complex. Perhaps more important, coastal areas are certainly the place where the economic, strategic and environmental needs are the most visible and urgent. Coastal areas are also the place where remote sensing of the marine environment is of uttermost importance because some processes at sea are almost unpredictable (oil pollutions resulting from ships operations, oil disasters, ships damages) or simply because the extreme complexity of physical process are far from being rendered by numerical models.

To this regard, the attempt to provide information on the local environmental conditions as well as on relevant human activities such as observed from space to port authorities is an idea that makes sense today.

Of course, the usefulness of remote sensing in coastal areas strongly depends upon the capacity monitor sea surface with spatial resolutions that are consistent with the scales and phenomena to be observed. Another essential criterion to be considered is the capacity of sensors to provide relevant, quantitative, valuable information on the area at stake. Should these first two criteria be roughly satisfied, is the availability of the proposed space data sufficient in terms of temporal frequency, accessibility, latency? Is it reliable and precise enough? And eventually, is it cost effective? All these issues are opened. It is one of the objectives of the Pearl project to provide to end-users the tools to make their own opinion.

Following the rather exhaustive list of space sensors and their potential marine applications, as well as the description of space data and products, a selection of space data was eventually proposed to be included in the Pearl platform. The sensors' family analysed can roughly be divided in two categories: the radar sensors (SAR, Scatterometry, and Altimetry) and the visible passive sensors. This enumeration of sensors is highlighted by the presentation of their respective potential marine applications. At this level, a significant attention has been paid to describe the applications in line with the current state of the art so as not to oversell their utility to end users.

Considering that there was no one-to-one match between possibilities offered by space remote sensing applications on one side and expectations of ports end-users on the other side, some criteria were proposed to establish a list of marine information derived from space data:

1. **The SAR imagery** is certainly the remote sensing information, fully understood by the consortium partners that answers at best end-users needs:
    a. The SAR instrument has no competitor in terms of spatial resolution except the visible high resolution imagery. Being an active radar instrument, it has the unique capacity to observethe sea surface regardless of day and night cycles and cloudiness conditions.
    b. It offers the unique opportunity to provide synoptic information of **winds** and **swell** fields in the vicinity of ports. The observation of **oil pollutions** resulting from ships operations and the geographic locations of **ships** at sea is also feasible (not mentioning that some oil pollutions can be associated with ships).

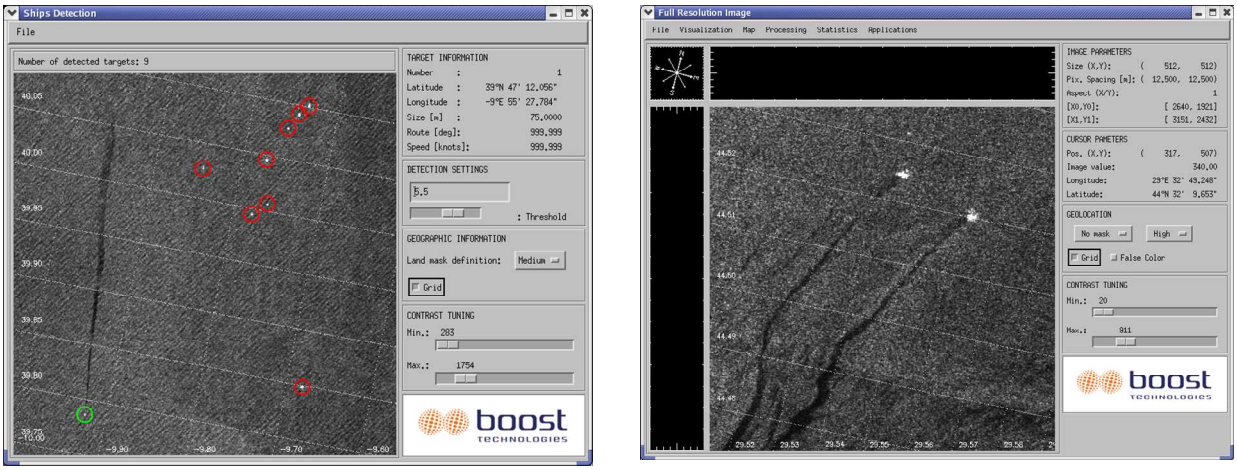
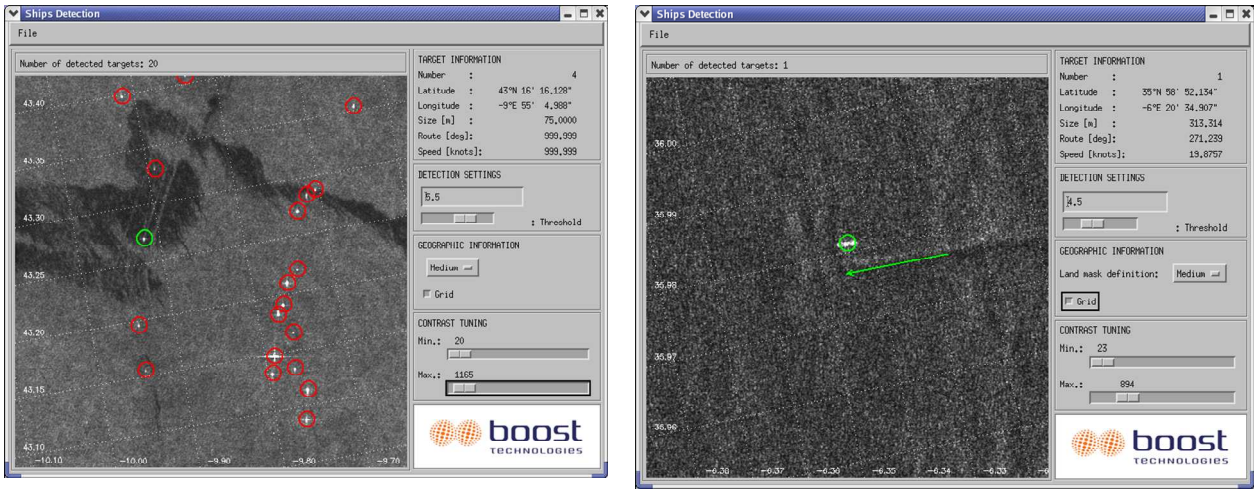


Figure 2-3: Examples of oil spills at sea as observed by ENVISAT cause by (left) illicit oil discharge from ships or (righ) leaks from oil platforms



(a) (b)

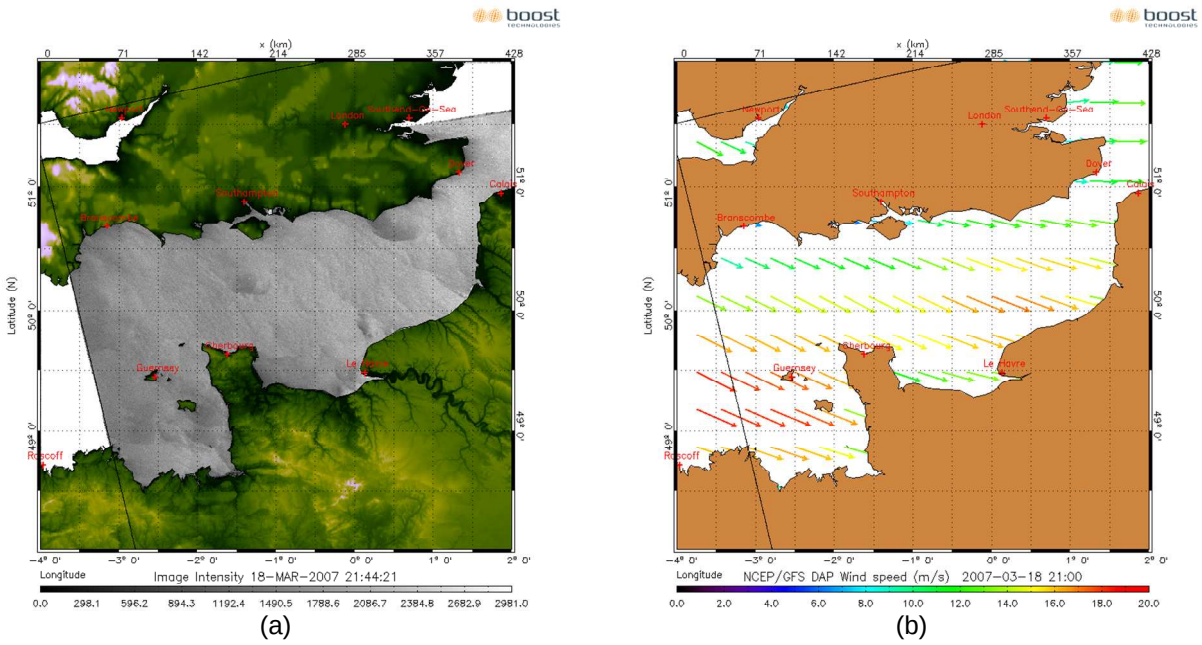
Figure 2-4: Examples of ships detection of ANVISAT ASAR Wide swath image (left) and ERS-1 Precision Image (right)

c. This information has been intensively assessed and validated in the past few years.

d. Although the cost remains quite high, the increasing number of satellite missions carrying SAR instruments onboard in the next decade should eventually (and hopefully) play in the favour of the market.
e. SAR-derived information can be delivered in near real time (ideally in less than one hour)

2. **Sea surface temperature products**
   a. Sea surface temperature is one of the few other environmental data requested by ports end-users that can be provided by space sensors
   b. Although the proposed spatial resolution does not correspond to the immediate needs of end users, recent developments have led to significant improvements (2km x 2km).
   c. **SST indirectly provides useful and valuable information** on other applications like **oil spill** (to remove potential ambiguities arising from the analysis of SAR images), **currents** (because it offers a synoptic view of water masses), **algae blooms** (because some algal species thrive under only certain temperature and salinity conditions).
   d. This information is easily accessible through MEDSPIRATION web site.

3. **Numerical Atmospheric model**
   a. Although this source of information cannot exactly be considered as space information, it must be stressed that most of numerical models include assimilation of space data. In particular, numerical atmospheric models assimilates scatterometer wind measurements (Quikscat, ASCAT)
   b. This **wind** information extends the SAR-derived wind information, although at a much coarser spatial resolution than SAR, **in providing predictions for the future.**
   c. BOOST Technologies has developed a DAP server to access this information for SAR applications, making the access on a given area at a given time easier.



(a) (b)

Figure 2-5: (a) Example of ENVISAT ASAR Wide Swath product over the English Channel (18/03/2007) and (b) the NCEP GFS wind field collocated in time.

Of course, it can be observed that only a limited number of environmental data needs expressed by ports end-users can effectively be addressed by marine information derived from space sensors. This is extremely frustrating particularly for partners that make the analysis and processing of space-borne remote sensing information the core of their expertise. Even though, significant efforts in the field of the analysis of high resolution remote sensing data have led to unprecedented progress in our understanding of physical process

in coastal areas, technical limitations or simply lack of appropriate applied research still prevent us to bridge the gap between marine coastal applications and very high resolution monitoring of ports areas. We still believe that the proposed selection are very instructive to ports end-users because, it has been frequently observed that very few know about the current possibilities of remote sensing from space.

Although Earth Observation can provide with a much wider geographical view, its applications cannot monitor subsurface parameters in coastal waters. For this reason, in-situ data and products are not only still in use, but are also the only option to include parameters such as chemical composition of bottom sediment in the environmental management of ports. The analysis was focused of the in-situ data and products, from instruments deployed on site. Airborne applications have been added in order to differentiate them from space products, taking into account that they scan the area of interest usually being aerially transported by a small plane.

The following parameters have been selected based on port current activities and needs, which were captured in WP2 of the PEARL project, and that represent essential data for the management of ports:

- Air quality: mainly ground-level ozone and particulates, but also includes sulphur dioxide, nitrogen dioxide, and hydrocarbons among others.
- Weather conditions that affect navigation, basically winds
- Environmental pollution such as noise
- Water Quality: salinity, dissolved oxygen, nutrients, algae growth, presence of invasive species, and particulate suspended matter
- Sediment Quality: composition in terms of siltation and navigational depth. Chemical analysis in terms of contamination, especially important for dredging purposes.
- Sea level: due to the importance of tides and ocean change in topography at specific locations
- Wave spectral: direction, speed, and height of waves, especially important for ports where this is an operational requirement.
- Current flow
- Bathymetry

Several instruments can be used for gathering each of the necessary data; some are already used by ports or third companies. A review of products has been carried out with the consequent selection of the most relevant ones considering their accuracy, reliability, cost, and sampling without forgetting port requirements.

Based on Port requirements, profiles and drivers, the review of the existing in-situ data and products, and their actual limitations, we selected in-situ sensors and data products for the following needs:

- **Meteorological needs – winds**: Anemometers are part of Automatic Weather Stations at ports, and included in monitoring buoys there are often wind sensors for speed and direction. This is the data and product used by ports at the moment. However, it is much localised and does not provide with preventive information.
- **Turbidity**: Optical Back Scatter sensors can be fixed, buoy-mounted or as part of CTD measurement. Turbidity measurements are extremely important and again, these measurements are localised, do not provide with prevention information. Cleaning the surface debris is a first step to maintain water quality stable, but certainly it is not enough. Suspended solids in the water column represent future sediment and cause of contamination. Also, optical sensors are tied to maintenance against fouling, and regular water sampling for calibration.
- **Water quality**: Apart from surface cleaning daily, complete CTD stations are essential in terms of water quality. It is the way of obtaining information about the water column. Salinity, temperature, density, dissolved oxygen, chlorophyll, suspended solid concentration, and nutrient profiles by means of depth provide with an extraordinary amount of information, not only about water quality at sampling time but also about the dynamics of waters bodies, this improves as data collection points increase in number and studies can be conducted. Disadvantages are time consumption, and required chemical analysis in a laboratory in some cases. Water quality monitoring is carried out in relation to certain activities such as dredging, or as part of a pollution study, also as part of routinely information collection; however, issues such as high algal blooms or oil spills are unpredictable by in-situ sensors and cannot be detected in time generally. An alert system based on earth observation

could be of great help to determine significant times when water quality monitoring must be run in ports locations. The accuracy of CTDs differs depending on the model and brand; typical accuracies are of 0.001 PSU.

- **Currents**: Although mechanical current meters are still in use, more modern technologies are taken over due to accuracy, maintenance, and type of data provided. At present, moored electromagnetic and acoustic current are constitute a good source of data. Radar technology does also with the advantage of not necessitating much maintenance since no bio fouling occurs; yet, it does not exist in all ports. Acoustic Doppler velocity meters or profilers are located at specific location in ports for operational purposes and as a source of information to study other parameters such as water quality and sediment transport. Accuracy is of 1% of measured value ± 0.5 cm/s, also to be taken into account, typical Doppler uncertainty, which is of 0.5-1cm/s for currents.
- **Air quality**: Air quality control in ports is mostly related to cargo and dredging activities, dust and pollutant emissions must be monitored. Automatic Analysers including HVPC are a good source of data with the disadvantage of being localised. An alert system could be possible if air quality data from as many locations as possible were integrated in a platform, mobile stations, usually located in a van, measure parameters at many points building a network of related data with location.
- **Waves**: Waves are important for operational purposes in many ports, and for safe waterway navigation. Important parameters are wave's height, speed, and direction. Different networks of wave-measuring buoys are active in Europe; however, due to the development of the networks, buoys cannot signify the only source of information about waves. AWAC Doppler profilers include a wave sensor besides the typical current meter and are used by a large number of ports; Doppler uncertainty for waves is 3.5 cm/s at 1 Hz for 1 m cells, the disadvantage of AWACs is that they only measure the directional spectrum of the wave, being height of great importance. Buoys and instrumentation data are integrated in wave models such as WAM and WW3, these are widely used and represent an excellent product to obtain essential wave spectrum data. These models, it seems like WW3 is taking over WAM, are implemented by most Met Offices. The UK Met Office has European wave model products that are available twice daily at 0.250 (N/S) by 0.400 (E/W) resolution. Parameters available are significant wave height, individual (wind-sea and swell) periods, heights and directions.
- **Sediment analysis**: Sediment sampling is the key point for sediment analysis. Some ports need to know of sediment density for scheduling their maintenance dredging activities. In general though, dredging performance is decided by means of changes in bathymetry. Environmentally, sediments must be analysed to avoid bioaccumulation and pollution. To do so, each port uses a different method, all provide similar data for chemical analysis, corers can provide more intact sediment blocks than grabs, the significant parameter to decide upon one product or another is the necessary depth of the sediment. Port of Barcelona, for example, habitually uses Van Veen grab samplers; they tried corer devices in the past and concluded that it was too much effort for the same type of results. In some locations however, the depth of the sediment desired is much higher than in others, and the use of corers seems indispensable. In any of the cases, sediment sampling in-situ is essential and the data gathered must contain heavy metals and organic pollutant concentration. Siltation estate should also be included in sediment data.

2.3 Platform Design and Development

The PEARL Platform shall provide port authorities with a Port Environmental Management System Platform capable of optimal exploitation of space and in-situ data products and models to assist port environmental managers in the monitoring of environmental aspects.

The two first premises that have been considered in the design phase of the PEARL platform are: integrability and scalability. The platform shall be able to incorporate new sensors, new models, new surveillance configuration and new acquisition protocols in order to be capable of adapt the platform to each current port infrastructure in an easy way. The concept of integrability is not only considered in the data acquisition, supporting several data formats and sources (local files, FTP, WWW, ..), it is also contemplated in the output of the platform which is based on web standards. So the PEARL platform user is going to be

able to interact with the platform using any standard web browser. The interoperability with the existing GIS systems already installed in the port is also considered by means of the support of Open GeoSpatial Consortium (OGC) standards. The standards defined by the OGC are essential for interoperability and extensibility between geospatial and location based services tools and information. As an important and added measure of assurance, the OGC offers technology the opportunity to test and certify their offerings for compliance with Open GIS specifications.

The use of Web technologies in the development of the PEARL platform does not involve their use through Internet. The platform requirements indicate that the system should be located in an Intranet network. This is not a technological limitation of the platform, since with the required network infrastructure it is able to operate through Internet, but this limits considerably the refreshing time and in consequence the surveillance capabilities of the platform.

The third, and not less important premise, is that the platform shall be able to provide port environmental staff with the relevant information required to their daily work, obtained from the combination of space and in-situ, by means of a user friendly interface. This flow of information shall be delivered by the platform to the user in near real-time. This means that information is refreshed (reported to the user) in ½ to 1 minute after its acquisition. This extra delay is not only the consequence of the data processing time, it is also due to the acquisition methods based on files and the output of the platform based on web. In this design decision the integrability and interoperability of the platform takes precedence over the real-time capabilities.

In this stage of the PEARL project, it is not foreseen the direct integration between the in-situ sensors located in the ports with the PEARL platform. This integration is expected to be performed by means of the exchange of files (local or remote) or from data placed on websites. This decision was taken in order to minimize the impact of the PEARL platform integration in the IT port infrastructure during the validation campaigns. The direct connection with the sensors could be analysed in the pre-operational stage of the platform in order to gain more real-time capabilities.

Another principle followed in the design of the PEARL platform has been to minimize the impact of the costs associated to EO data. It is a general assumption that EO data are generally quite expensive, at least in comparison with terrestrial data. This greatly limits the potential use of satellite imagery since small ports can not afford the cost associated to it. Moreover, EO imagery has a large FoV (Field of View) and sometimes encloses more than one port. This feature of EO imagery could be exploited by the platform to share the cost associated to it and in this way reduce it to a reasonable cost. However, sharing of images may not necessarily mean less income for the commercial data providers. By sharing images, the various users can each contribute financially towards e.g. one image, but receive several images from the MoU-group (image “pool-sharing”). This is likely to actually increase the sales of imagery, as more users are able to pass the threshold for investing in imagery, which currently is found to be too high. Hence, a win-win situation should be possible.

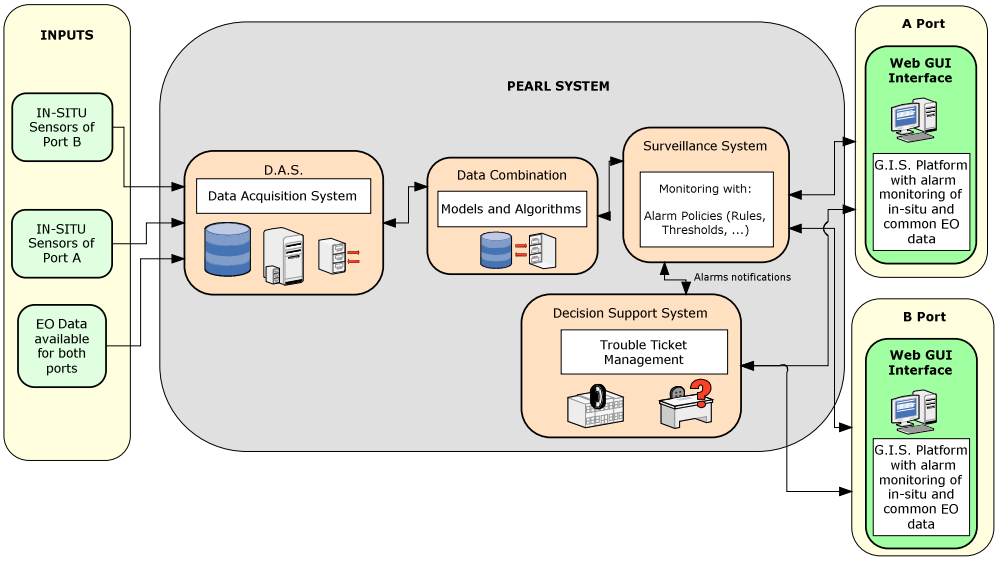


Figure 2-6: PEARL Platform – EO data sharing

The platform shall be able to combine information coming from in-situ data located with the EO data and provide to each port a customized view of its environmental issues. This approach not only reduces the impact of EO data costs, it also minimizes the impact of the costs related to owning PEARL platform since the expenses associated to it could be also shared among ports. The same scheme could even allow the sharing of in-situ data. This could be very interesting in nearby river ports or ports located in the same estuary where data captured by in-situ sensors could be applicable to different ports.

Following the hypotheses described above, the PEARL platform has been designed as a black box (composed by a laptop or PC) to be hosted inside port premises in an easily way and without interfere with the daily port operations. Other functional models, such as the web service approach, have been analysed during the project and have been rejected, mainly due to port authorities' feedback, since they imply some confidentiality and privacy issues that are outside the scope of PEARL project.

The PEARL platform has been divided in five main functional blocks, as it is presented in :

- **Data Acquisition System (DAS):** This component is in charge of acquiring the data coming from in-situ sensors and EO data.
- **Data Combination System (DCS):** This component is responsible of applying the models and algorithms required to EO data with in-situ data.
- **Surveillance System (SS)**: The SS is in charge of monitoring and detecting the risk/anomalous situations/conditions based on predefined criteria already defined by the user.
- **Decision Support System (DSS**): It is focused to aid the manager/operator in the decision making context.
- **User Interface (UI):** The UI is the platform component devoted to the interaction with the user.

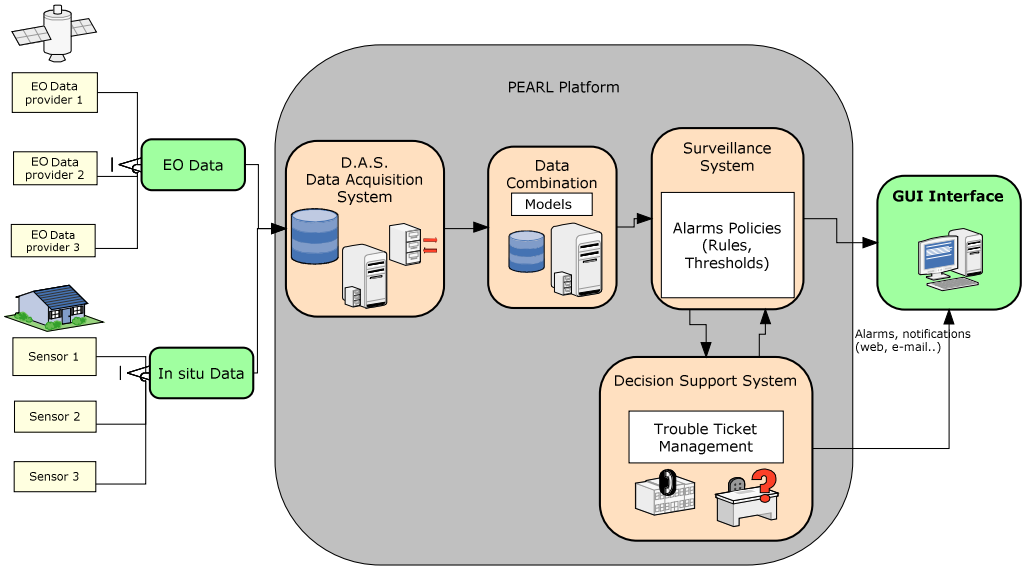


Figure 2-7: PEARL Platform - Main components

The User Interface is a crucial component of the PEARL platform since all interactions with operators occurs here. With this in mind, a technical note was prepared containing some proposals on visualizations of the EO and in-situ data. This technical note was circulated among the consortium and end users in order to get their feedback on user interface issues.

Two different ways to interface with the users have been considered at this level, the email and a GUI, but additional interfaces could be added in the future.

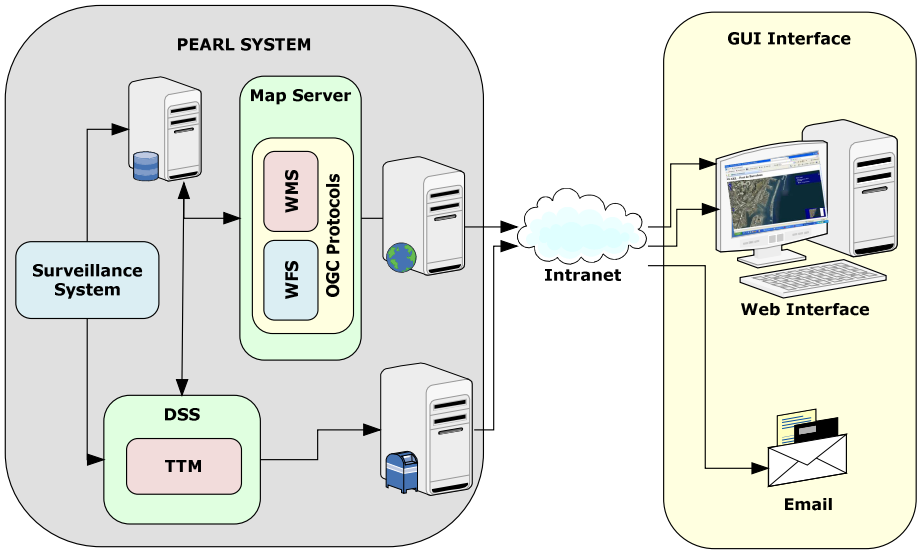


Figure 2-8: GUI overview

The email is be used to keep the suitable responsible informed when a high risk situation is detected by the platform and it evolves to the status to the TT. The GUI allows the user to configure the email notification policy for each type of event.

The GUI is based on the Web and it is composed of two different sections. The first one is focused on the administration of the PEARL platform and allows users to configure: the configuration of in-situ data sources (including the connection details), alarm policies, email notification policies, users profile, etc. The second is focused on the presentation of the information obtained from the combination of in-situ and EO data sources together with the events detected from monitoring a geo-referenced map of the port. Additionally, a section have been reserved to inform the user about the warning and alarms events detected, the TT as well as the complete list of correlated events.

The use of Web technologies in the development of the GUI does not involve their use through the Internet since without the required network infrastructure it limits considerably the refreshing time and in consequence the surveillance capabilities of the platform.

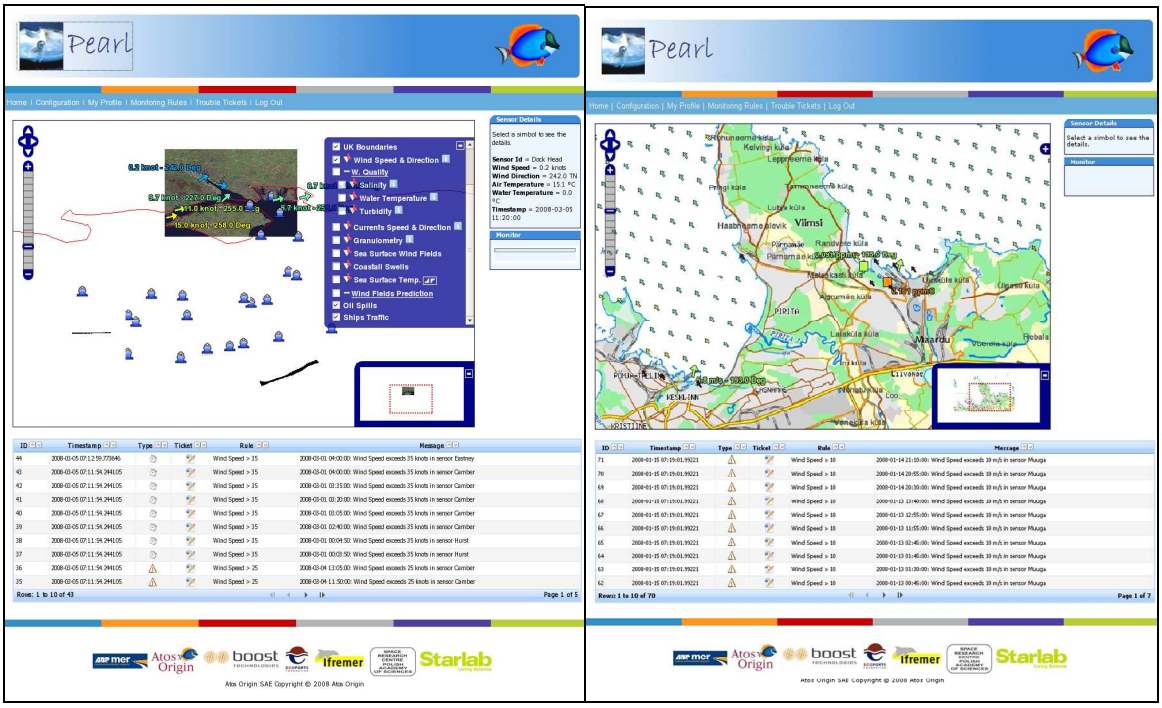


Figure 2-9: PEARL platform screenshots

The GUI is a multi-user interface, able to deliver the right information to the suitable user taking into account its user profile. This capability adds the possibility of sharing the PEARL platform and/or EO data among different ports with all the benefits that this implies.

Besides the User Interface, the PEARL platform contemplates the possibility of interface with other GIS systems already present in the port. This integration is feasible due to the fact that the data delivery performed by the PEARL platform follows the Open GeoSpatial Consortium (OGC) standards. To be able to provide this capability, the PEARL platform uses MapServer.

The use of COTS components and the applicable standards has been considered in the development of the PEARL platform whereas suitable. An open source web server (such as Apache) has been used as the entrance point to the platform services. The web server is in charge of accepting HTTP requests from the client (web browsers or other GIS systems), and serving them HTTP responses along with optional data contents, which are web pages such as HTML documents and linked objects (images, etc.). To generate these HTML responses, the web server executes the PHP pages stored in the server. If the HTML document includes a map request, the web server redirects the request to the MapServer which making use of the spatial data generates the map and returns it in a standard image format (jpg, gif, tif, png).

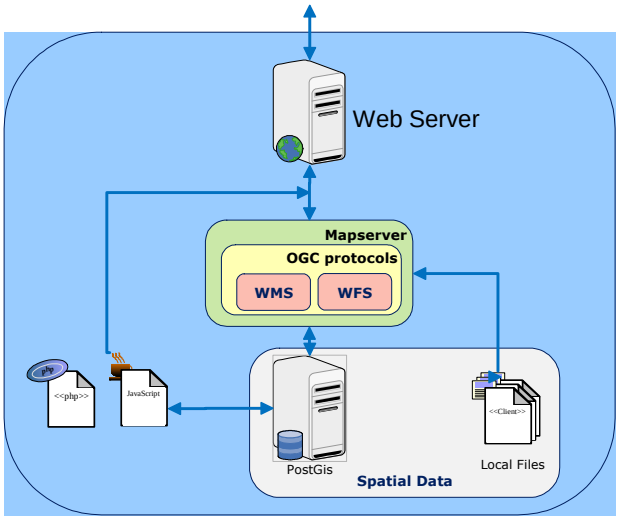


Figure 2-10: Platform architecture overview

The spatial data is stored in a repository that is composed of a PostGIS database, where vector data is stored, and the local file system repository where file-based data, mainly geoTIFF images and ESRI Shapefiles, are stored. PostGIS is an extension that adds support for geographic objects to the PostgreSQL object-relational database. PostGIS "spatially enables" the PostgreSQL server, allowing not only the storage of geographic data but also the manipulation of that data within the database using SQL commands. The PostgreSQL/PostGIS database is used to store spatial data, but also to save all non-spatial data required by the PEARL platform such as the information collected from in-situ sensors, the platform configuration parameters, the events and alarms generated by the platform, etc.

2.4 Validation Campaigns

The validation campaign aimed at testing the PEARL platform as a synthesis of the work done on the whole project, where; the focus was on the analysis of the possibility of satellite data to enhance the information already provided by in-situ sensors. During the validation campaigns port users were asked to provide further feedback regarding the usefulness of the platform and the provided data for their daily work. This information is to be taken into account for the extension of the platform (both in terms of technical characteristics and data sets).

The validation was designed to target the content (e.g. usefulness of provided information for the users), data format and visualisation (e.g. user friendliness, compatibility with existing systems and the cost quality relation) of the PEARL platform. Tested items included:

1. the overall performance and interface (e.g. technical system, strengths and limitations, visualization aspects) of the Pearl platform,
2. the degree of usefulness of the current content of the Pearl platform especially regarding the Earth Observation data and related applications,
3. the added value of Earth Observation data to port environmental monitoring and management, and
4. the degree of usefulness (for port environmental managers) of one platform that processes and analyzes data from both in-situ and Earth Observation sources.

An additional aim of the campaign was to further assess the market potential of the Pearl platform.

The PEARL validation campaign took place in 3 ports; Barcelona (Spain), Southampton (UK) and Tallinn (Estonia) in the months of November and December 2008. The ports were selected to reflect different geographical areas within Europe and potentially different needs for environmental information. Therefore, a major port on the Mediterranean Sea, a port on the Atlantic Ocean, and a port on the Baltic Sea were

selected. It was felt that in such way the feedback would be broader in scope and not limited by specific geographical and cultural characteristics

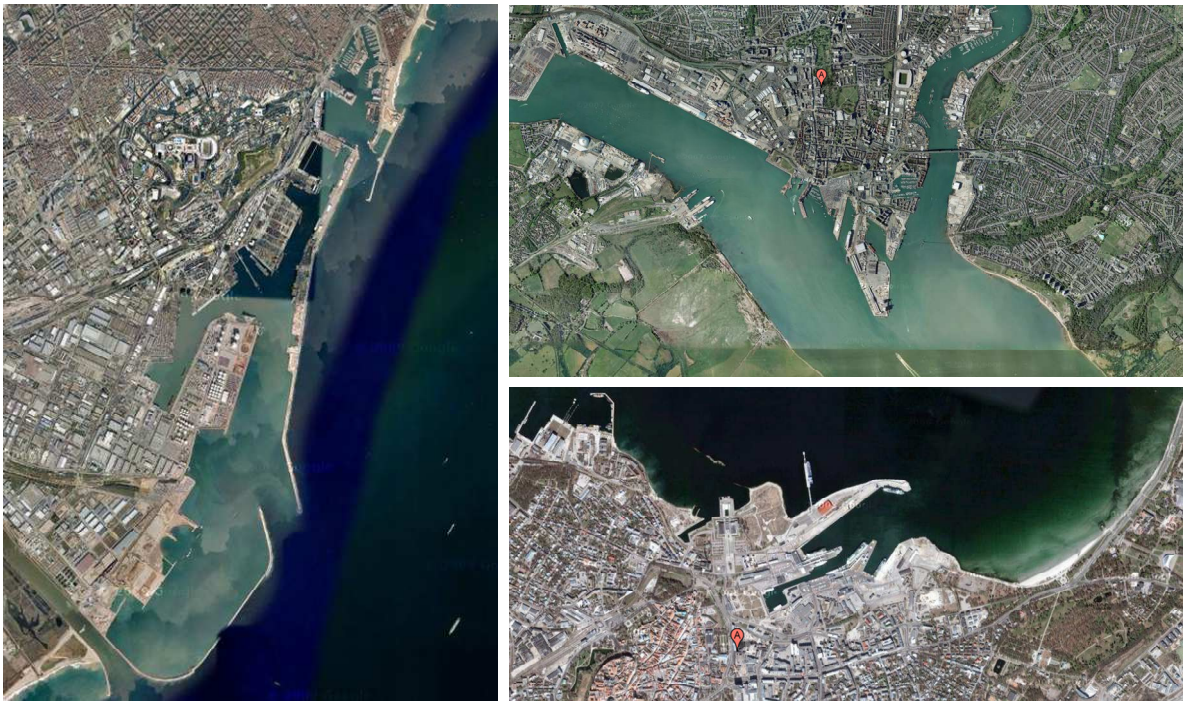


Figure 2-11: Validation ports: Barcelona, Southampton and Tallinn

The selected ports had already provided valuable input regarding their needs for environmental information at earlier stages of the project (WP2). In addition, the ports provided environmental data for the development and appropriate adaptation of the Pearl platform and its content (data sets). The target group for the validation campaign consisted of the following categories of port professionals: General Managers, Environmental Managers, Manager Health and Safety department, Managers on Logistics, and Environmental (technical) experts. Whilst the Pearl platform was focused towards environmental management, it was felt that the system may provide benefits in several sectors of Port operations. This was the reasoning behind inviting a variety of users including pilots, surveyors, hydrologists, sustainable developers and the Harbour Master, to attend the validation campaigns, to use the platform and to provide their feedback.

The general approach of the validation campaigns consisted of two main phases, preparation and realisation. The three main elements of the preparation phase are described below:

- In situ data collection and processing: The in-situ data provided by the ports has been processed in order to be integrated within the Pearl platform. The processing resulted in that data on different environmental aspects and in various formats could then be managed via a single interface. The focus was placed on the meaningful visualisation (for the port managers) of the data and on data management testing.
- Earth Observation data collection and processing: EO data products were selected by the Pearl project partners in consultation with the ports. The selection aimed at testing some examples of potentially promising applications of satellite data in port environmental management.
- Selection and preparation of the validation scenario: Two validation scenarios were selected by the project partners for the campaigns and in consultation with the ports the most appropriate was used according to technical capacity, data availability and convenience. The two scenarios were the “real time data” validation and the “historical data validation”.
    - Real time data validation scenario: Real time in-situ data is continually processed during the validation campaign by the Pearl platform for visualization and management purposes. In

addition, EO data (a couple of satellite pictures) referring to selected times during the validation period is being processed in parallel in order to examine and demonstrate the potential added value. The “real time” scenario was selected to be followed for the campaign in the Port of Barcelona.

- Historical data validation scenario: When real time processing of in-situ data was not possible or practicable then processing of historical data was selected. In that case historical sample files of in situ data were used. It has been possible to test historical in-situ data in parallel with relevant (referring to the same time period) EO data extracted from EO data archives that were made accessible to the Pearl partners. The availability of archived EO data was in that case limited and therefore historical in-situ data from specific only periods in time could be used. The historical data scenario was followed for the campaigns in the ports of Southampton and Tallinn.

The realisation phase refers to the actual activities that were performed during the validation campaigns in the 3 ports. The realisation phase broadly consisted of installing the Pearl system, running the necessary technical checks, demonstrating the platform, using of the platform by the port users, and provision of feedback by the users. A “formal” day has been scheduled within every campaign where the overall Pearl project approach was presented and the platform was demonstrated to a wider audience (port managers and other stakeholders and interested parties). A Pearl partners’ team (consisting of 3 to 5 persons) visited the three ports and the platform was tested for a period of up to one week in each of the ports. The general approach followed for the 3 validation campaigns is summarised below:

- Visit Port 1 (Barcelona, 03-07/11/2008) – Validation – Analysis of results – Adapting the platform
- Visit Port 2 (Southampton, 24-25/11/2008) – Validation – Analysis of results – Adapting the platform
- Visit Port 3 (Tallinn, 10-11/12/2008) – Validation – Analysis of results – Adapting the platform

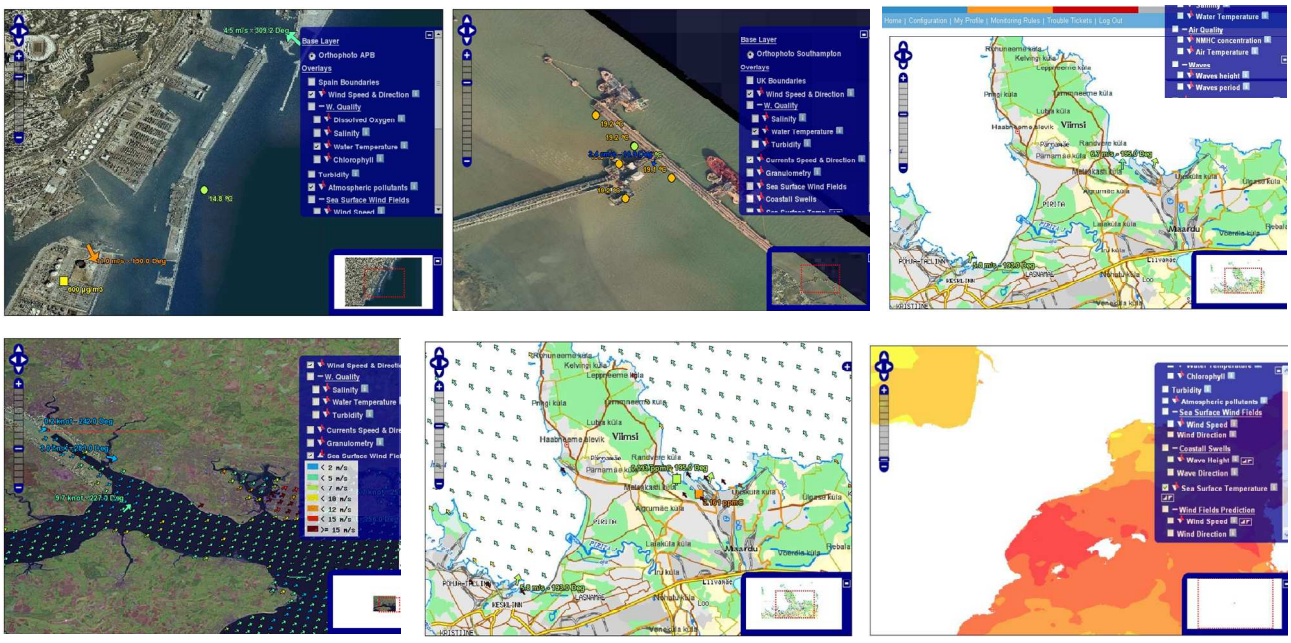


Figure 2-12: Validation campaign screenshots

A questionnaire has been developed in order to form the basis of structured interviews with the port professionals (general manager, environmental manager and technical expert) in the 3 ports. The interviews provided feedback regarding the content and the format of the Pearl platform. The questionnaire also dictated the structure and content of the feedback reports that were produced for the needs of deliverables D5.2, D5.3 and D5.4. The validation reports were distributed among the port users involved during the

validation in order to guarantee that the results and conclusion contained in the reports were fully aligned with the users' perspective

2.5 Exploitation and dissemination

2.5.1 Exploitation

The main objective of the exploitation plan, defined in WP6, is to achieve a good degree of market integration of the service. This report is the last work package of project PEARL. The exploitation task is dedicated to preparing necessary analysis and tools that are required to launch the final product, i.e. PEARL system into the market. Exploitation in the PEARL project basically means the commercialization of research results.
The PEARL exploitation plan consists of a market analysis and rough business plan. The exploitation plan comprises the following items:

- **Market analysis:** a survey was elaborated in order to segment different types of users and their characteristics. Special attention was paid to security and legislative issues and the main objectives are:
  - To define organizational and technical requirements for supporting the application of project's results s
  - To determine the current market trends as well as market characteristics
  - To identify and evaluate existing services and products as potential components or competitors of PEARL platform

- **Rough business plan:** building blocks of the business plan were presented and options for commercial activities listed.

The main objective of the exploitation plan is to provide information on the port market as well as a business plan for the implementation and commercial exploitation of the PEARL platform.

2.5.2 Dissemination

The effective dissemination of the project results, as well as the interaction and coordination with other related projects and programmes have been considered essential for the PEARL Project development. Moreover, the project dissemination objectives have always aimed at capturing the interest of potential stakeholders and maximising the exploitation of results.

Due to its recognised importance, dissemination activities within PEARL Project were initiated at an early stage and have been performed during the whole duration of the project.

The following subsections summarize the dissemination instruments that have been used within the PEARL, with the purpose of achieving the aforementioned objectives.

2.5.2.1 Web Site

The PEARL Project web-site (http://www.pearl-project.eu/) was created with the intention to allow an easy access to information about the project and an easy update of contents and results. This public web-site presents the project profile, goals, progress and the validation campaign results. Furthermore, it contains relevant information concerning the dissemination activities and is a contact point with end-users. The website was continually updated throughout the project lifetime.

Figure 2-13: PEARL webpage

The project has also counted on an intranet, used to ease the communication among project partners as well as with the European Commission. PEARL partners have been allowed to retrieve and submit technical, managing and financial information through this intranet.

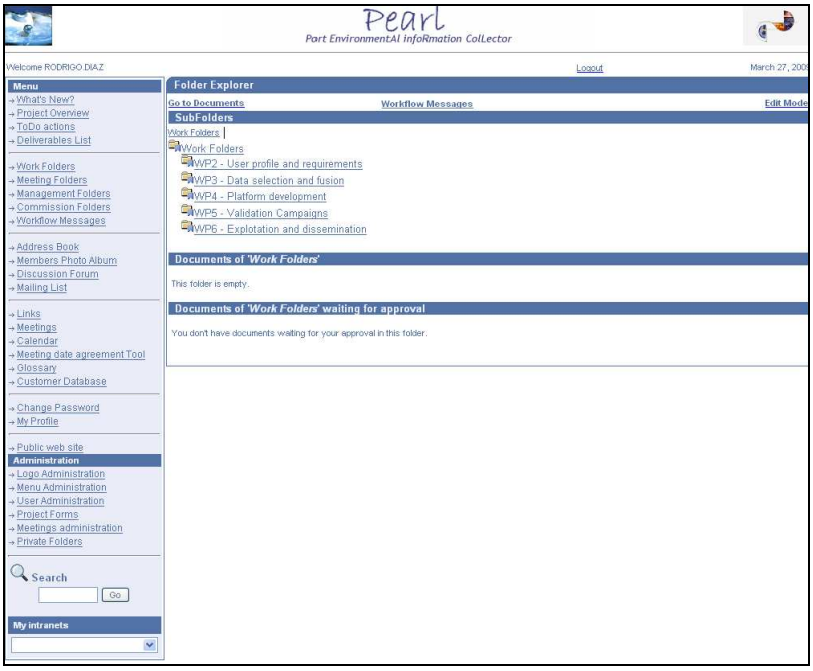


Figure 2-14: PEARL intranet

2.5.2.2 Meetings, Conferences and Workshops

The attendance to relevant workshops, conferences and congresses is considered, according to the Dissemination Strategy defined within PEARL, as an essential means to keep an updated knowledge of the current status of the port environmental sector, as well as to ensure an early wide spread of the project expected results. The attendance to this type of events also helps to ensure the coordination and complementarily of PEARL with other related projects.

Several dedicated meetings with port authorities and environmental protection authorities were organized. They commenced in the spring of 2007, when local experts were approached by PEARL partners with first mature proposals for implementing the PEARL system. Also during thematic conferences/workshops the PEARL project ideas were presented.

- The meetings with end-users can be divided into four groups:
- first approach during WP2 – survey conducted on market potential among European marine ports
- dedicated meetings
- project presentations during thematic workshops and conferences
- validation campaign

The main goals of the listed meetings were to exhaustively inform about the project, gather the broadest possible opinions on the proposed system and to establish a constituency of parties interested in exploiting the system on commercial basis.

For maximal impact of the PEARL project on the research and user communities, the project was presented at the following meetings, international workshops/conferences – see Table 2-8.

Date of Event	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Result
June 06	*Conference: European Seaports Organization meeting in Dover*	Port authorities	EU	approx. 50	ABPmer	Raised awareness of PEARL in the maritime community
September 06	*Conference: Ukrainian Space Conference in Evpatoria, Crimea*	Space community, users representatives, governmental officials	Eastern Europe	approx. 200	SRC	Raised awareness of PEARL in the space community, environmental authorities/agencies
October 06	*Conference: eChallenges e-2006 Conference. Barcelona*	Representatives of e-technology and risk management developers	EU	100s	Starlab	Exchange of know-how in e-technology
October 06	*ITMMA Maritime and Port Symposium*	Port authorities, stakeholders	EU	approx. 100	SRC Ecoports	Raised awareness of PEARL in the maritime community
December 06	*Conference: Maritima 2006*	Environmental authorities/agencies, port authorities	EU	approx. 100	SRC	Contacts with potential users

Date of Event	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Result
December 06	*Conference: Ecoports annual Conference "From Environment to Sustainability" in Genoa, a dedicated PEARL session*	Environmental authorities/agencies, port authorities	International audience	100s	Ecoports, Atos, ABPmer, Starlab, SRC	Updating the audience with project first results
December 06	*Direct e-mailing*	Port authorities	EU	approx. 30 ports	ABPmer	Updating the audience with project first results
January 07	*Conference: The EcoPorts Foundation annual Conference*	Port authorities, stakeholders	EU	approx. 100	ABPmer, Atos Origin	Raised awareness of satellite data and PEARL in the end-users community
February 07	*Workshop on Polish-Ukrainian co-operation in space applications domain*	Remote sensing experts, governmental officials	Poland, Ukraine	approx. 30	SRC	Exchange of information on on-going activities in remote sensing & port/coastal applications
March 07	*Workshop: EDSnet SANY Workshop National Oceanographic Centre Southampton*	Academic	UK	approx. 10	ABPmer	Updating the academic community with project first results
May 07	*Conference: Future Challenges for Local and Regional Authorities…, Barcelona, Spain*	Port authorities, GMES community, governmental officials	EU	approx. 80	Starlab	Raised awareness of satellite data and PEARL in the end-users community
May 07	*Meeting: Integrating in situ monitoring and EO in the framework of GMES and GEOSS, Brussels, Belgium*	Space, GMES community, users representatives, governmental officials	EU	approx. 200	Starlab	Informed audience about PEARL and its objectives, promotion of the project
June 07	*Conference: Green Week: Lesson from the past, challenger for the future, Brussels, Belgium*	Non-governmental organisations, businesses, various levels of government and the public	EU	approx. 200	Atos Origin	Informed audience about PEARL and its objectives, promotion of the project
June 07	*Workshop: Days of satellite techniques, Warsaw, Poland*	Non-governmental organisations, businesses, various levels of government, academic and the public	EU	approx. 100	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation
June 07	*Project presentation for Polish Ports*	Port authorities	Poland	approx. 20	SRC	Raised awareness of satellite data and PEARL in the end-users community, market analysis (questionnaire conducted)

Date of Event	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Result
September 07	*Workshop: Efficient Management of Coastal Regions and Cities: Implementation and use of space application-based services, Tallinn, Estonia*	Port authorities, GMES community, governmental officials	EU	approx. 80	SRC	Raised awareness of satellite data and PEARL in the end-users community
October 07	*Conference: Space for Humans – 50 years of Space Age, Warsaw, Poland*	Space community, governmental officials, academic and public	EU, Eastern Europe	approx. 80	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation
December 07	*Direct e-mailing*	Port authorities	EU, Eastern Europe	approx. 80 ports	SRC	Updating the audience with project first results
June/July 08	*Publication: Science Issues (polish monthly magazine)*	academic	Poland	approx. 1000	SRC	Informed audience about PEARL and its objectives
August 08	*Publication: The Public Service Review: Science and Technology*	governmental officials, academic community	EU	approx. 1000	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation
September 08	*Publication: The Parliament Magazine*	GMES community, governmental officials	EU	approx. 1000	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation
December 08	*Abstract submission to the 33rd International Symposium on Remote Sensing of Environment under a title:* ***PEARL – Environmental Management System for Port Authorities***	GMES community, remote sensing specialists	EU	approx. 200	SRC	The PEARL project results presentation

Table 2-8: PEARL Dissemination diary

2.5.2.3 Publicity Material

The design and production of leaflets, brochures, etc. within the PEARL Project has had the objective of extensively disseminate the project concept and achievements, taking advantage of public events attended by PEARL partners for its distribution. With this objective in mind, a collection of posters and leaflets were prepared.

Figure 2-15: 1st PEARL introductory brochure

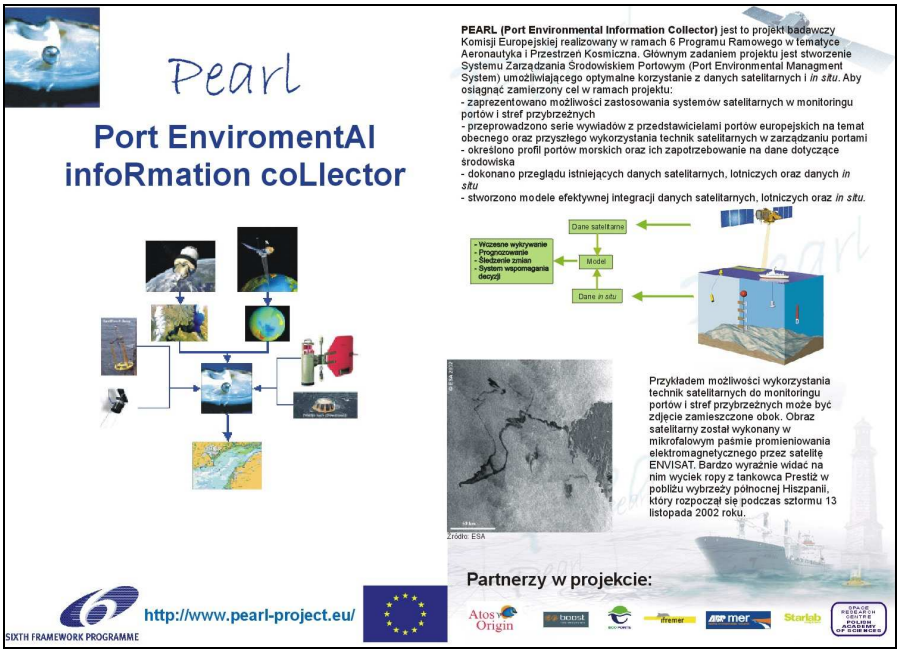


Figure 2-16: 2nd PEARL introductory brochure

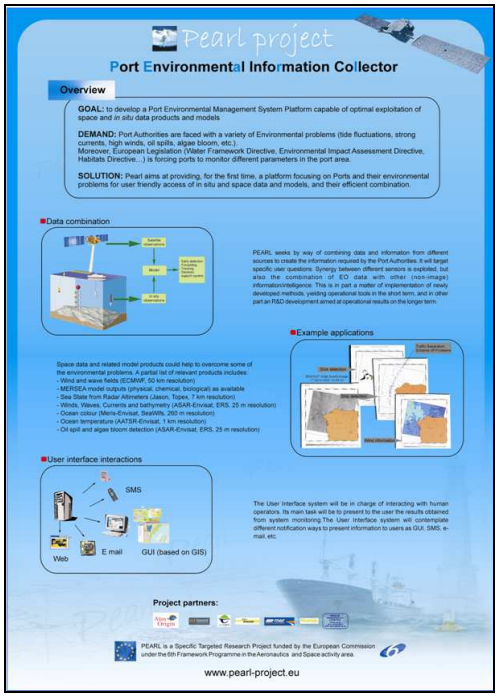


Figure 2-17: PEARL poster

2.5.2.4 Exhibitions

PEARL Project has performed three validation campaigns, with the intention to present the project achievements to all kind of interested stakeholders as well as the PEARL partners. The demonstrations consisted on a brief but concise introduction to the project in general as well as to the different services provided by the PEARL platform, followed by the real application demonstration. These demonstrations have contributed to get the feedback of the end users about the project results.

2.5.2.5 Journals and Magazines

Technical journals and magazines provide a high impact publication opportunity. However, technical aspects of PEARL have a relatively limited research character since the project tends to focus on effective utilisation of existing solutions.

PEARL was and is committed, though, to exercise some impact on the research and industrial communities by publishing the most important results in both academic and more popular journals.

Date of Event	Type	Type of audience	Countries addressed	No. of readers	Partner responsible /involved	Result
June/July 08	*Publication: Science Issues (polish monthly magazine)*	academic	Poland	approx. 1000	SRC	Informed audience about PEARL and its objectives
August 08	*Publication: The Public Service Review: Science and Technology*	governmental officials, academic community	EU	approx. 1000	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation

Date of Event	Type	Type of audience	Countries addressed	No. of readers	Partner responsible /involved	Result
September 08	*Publication: The Parliament Magazine*	GMES community, governmental officials	EU	approx. 1000	SRC	Informed audience about PEARL and its objectives, promotion of the project as a part of the SRC presentation
December 08	*Abstract submission to the 33rd International Symposium on Remote Sensing of Environment under a title:* ***PEARL – Environmental Management System for Port Authorities***	GMES community, remote sensing specialists	EU	approx. 200	SRC	The PEARL project results presentation

Table 2-9: PEARL Publications

3 Validation Outcomes

This section presents the collective findings of the Pearl validation campaigns and synthesises those in order to derive the project's final conclusions. The structure of the section is dictated by the selected areas of feedback as those are outlined within the validation questionnaire that was designed to guide the discussion with the port users.

3.1 Functionality of the PEARL platform

The Pearl platform can be seen as a tool that performs 2 main functions. First, it is a system that integrates, manages and visualises together all sort of in-situ environmental information that is collected by the port as part of its environmental monitoring program. Secondly and more importantly, the platform complements this already available data with selected Earth Observation data in an attempt to investigate whether this approach offers an added value to daily port environmental management.

The message that was received from the validation campaigns in the ports of Barcelona, Southampton and Tallinn is that the Pearl platform can be seen as an interesting prototype that through further development can take its final form (adapted to each port) as a practicable tool that assists on daily port environmental management. The port users considered of particular interest the function of the prototype as an integrator of environmental data originating from different sources. The part of the system that collects, processes, visualises and manages port in-situ data in one single interface is considered to be useful and applicable in ports. The users in all the 3 ports considered that significant added value is being offered by the Pearl system including the use of background maps in a GIS environment, the technical capacity to integrate data originating from different sources, and the automatic generation of alerts to the port managers when control indicators reach certain user defined thresholds. The users expressed their overall satisfaction regarding the performance and visualisation of the interface and acknowledged the value of having a single system in place for the management of environmental information.

The validation campaigns confirmed that satellite Information may provide valuable additional information for port environmental management. It can offer continuity of data by filling in information gaps; it adds another level of insight; it contributes the larger scale overview that in combination with detailed in-situ data collection can facilitate the interpretation of the causal chain of environmental damage; and it enables data cross checking. However, despite the potential added value some challenges with regard to the demonstrated EO data characteristics were pointed out. The users considered that the applied resolution and data characteristics are limiting factors on the added value to the daily management of operations under the strict responsibility of the port authorities. The wide coverage (coarse resolution) of areas often outside the operational responsibility of the port authorities might be more interested for parties with a wider interest in environmental data such as national and international environmental authorities and EC agencies such as EMSA. The frequency of the provided EO data services is considered as a challenge. EO data cannot currently be provided under a continuous real time framework mainly due to data provision restrictions and associated costs. A realistic scenario for the use of EO data products in ports would enable the approximate projection of 2-3 satellite pictures a week. Under this restriction, the ports called for high resolution EO imagery that focuses in detail within the responsibility area of the port authority. In that case cost and quality (e.g. degree of added value over existing systems) considerations would be the decisive factors for the ports willingness to invest on such a system.

3.2 Overall performance and interface

While working with the Pearl prototype the users were satisfied with the overall performance and interface. All users found the interface intuitive to follow, they regarded the system as being user friendly, they were satisfied by its technical capacities, and by the overall visualisation of the data. The main strengths of the system were considered to be:

1. the integration of data from different sources and parallel visualisation,
2. the applied technical solutions in bringing data (primarily in situ) together,
3. the ability to be integrated within other port systems (e.g. the presented data layers can be used in other GIS interfaces that are used by the port and vice-a-versa), and

4. the automatic generation of alerts to the port managers when control indicators reach certain user defined thresholds.

3.3 Usefulness of current content and applications

Pearl platform included selected in-situ and EO data sets. The current in-situ data content of the Pearl platform was assessed as being well developed for a prototype and were considered important as an example for testing.

Regarding the usefulness and applicability of the demonstrated EO data, the main added value as acknowledged by the users was the broader geographical coverage that can in cases offer continuity by filling in information gaps, by enabling data cross-checking, and by offering another level of insight. Furthermore, it was felt that the combination of different data sets can be interesting such as oil spills together with ship traffic that can identify the polluting ship, and oil spills together with wind data that can provide information on whether an oil spill is heading towards the port. However, some challenges were also identified by the majority of the users while assessing the overall applicability of the demonstrated EO data for operations under the responsibility of the port authority. It was felt that although the demonstrated data sets presented valuable information this was not though always relevant to port authorities. A further issue was the quality of the demonstrated EO data in terms of resolution and frequency of obtaining the information. The resolution of the EO data (both spatial and temporal) was in cases seen as being a bit too low for Port requirements. The users with a background in collecting and processing data such as the surveyors and hydrographers in the Port of Southampton seemed to rate the system higher than those without such a background. This may have been due to a greater interest in the data and its wider potential. Overall, it has been suggested that parties with a wider interest in environmental data should also be included on the target group of a final Pearl service or product. The involvement of parties such as national and international environmental authorities, EC agencies, and port umbrella organisations (e.g. ESPO, Ecoports) could offer possibilities for data sharing and cooperation.

3.4 Usefulness of a single system

The users considered that the Pearl platform offers a good potential for representing EO and in-situ data sets in on one single interface. They rated high the degree of usefulness of one system that processes and analyzes together data from different sources. The combination of data was considered useful since it allows data comparison and cross-checking. It enables the user to make a more informed judgment at that time, without having to refer to different datasets/systems and this enhances efficiency in data handling. Therefore, the combination of data brings efficiency in the environmental management system. In addition, by bringing into a single platform a range of users the potential exists to share a range of otherwise retained information sets. All parameters can be viewed together for analysis and this may help to detect relationships between them. Further added value includes the broadening of the geographical coverage, the simplicity in using the tool, the potential application of combined information in models, the expansion of the scope of the applications, and the possibility to generate GIS layers in an easy way.

3.5 Market potential

While the costs that are associated with EO data remain relatively high, the users were challenged to answer whether they foresee any options for reducing or sharing the EO data associated costs with other potentially interested organizations (e.g. companies, environmental authorities, agencies such as the European Maritime Safety Agency, ministries, and policy bodies). They all agreed that exploring the possibilities for cost sharing is an interesting but challenging option and they regarded as significant the potential role of umbrella organizations such as EMSA (European Maritime Safety Agency), ESPO (European Sea Ports Organization), “Puertos del Estado” in Spain, and Ecoports towards that direction. In the UK, the system may also be of interest to the Channel Coastal Observatory (separate DEFRA funded organization) or to the National Oceanographic Centre (NOC) which focus on data collection. Other parties that could be interested in sharing such a platform in the UK include the Environment Agency (responsible for the shore generated water pollution) and the maritime coastguard agency (primarily interested in air quality information).

Regarding the ports’ willingness to invest in financial terms in obtaining a service driven by the Pearl concept the ports were quite skeptical. Monitoring systems are in place in the ports, and the necessary information is

made available and covers the needs. It is therefore a question of costs and added value. A budget could be made available but the ports need to be convinced on the usefulness and benefits of such an investment. The service would have to have considerably more benefits over existing systems in order for an investment to be worthwhile. Whilst the demonstrated system was acknowledged as having useful features, it was overall felt that there is no immediate need for such a system at the moment. There was a general feeling that the platform would have to offer greater functionality and be a significant improvement over existing services before it would become a viable replacement. The system as such needs to be improved, applications need to be added, and the potential of data and cost sharing between ports and other interested organizations needs to be investigated.

4 Conclusions

A profile of Port Authorities and their Environmental needs has been prepared giving an insight into the status of the potential European port market in terms of core profile information, based on a survey of 26 ports. This profile aims to provide a summary and simple analysis of the port market (circa 2005). It is clear that there is a broad range of ports across Europe, with large variations in size, location and trade activities. Each port has its own specific identity. It should be noted that the sample chosen is representative of European ports and is not exhaustive. The aim has been to select as representative a sample as possible, for the purposes of this study.

The main findings were that; most were publicly owned; estuaries and rivers were the main geographic locations; port areas varied significantly reflecting the diverse range of ports; and general cargo was the most popular commodity handled. Regarding port business size; the most common total annual tonnage was between 5 and 15 million; the majority of ports handle less than 250 thousand TEUs annually; half of the ports carry less than 1 million passengers annually; and turnovers are very varied with an average of 68 million euros annually. To cover this diversity, PEARL platform needs an element of scalability to allow for smaller ports to benefit from the system as well as the larger ones. This has been a key consideration, taken into account in the design of the platform from the beginning.

From the quantitative and qualitative analysis of the interview responses there are a number of general conclusions that may be drawn. The parameters of turbidity (and sediment processes), meteorological data (particularly wind), water quality, currents, oil spill and air quality were foremost in the environmental management requirements of ports. Four of these parameters are all contained within the top 10 Environmental issues for ports reported in the ESPO Environmental Survey of 2005.

Key environmental data parameters that stand out as meeting definite needs, and also fit well the exploitation of EO data, are wave climate data and the sharing of all types of single point data from ports in close proximity to each other. If an EO service for wave data in the approaches to ports were made available, then a rapid uptake by a number of ports would be likely, as this is an area of great importance.

The potential to provide wide area data which is calibrated by ports in close proximity also fits very well into the potential of the PEARL platform technology. This could allow for the strengths of the platform to be fully exploited, and for national and international cooperation in combining, managing and disseminating enhanced port environmental data for the benefit of all involved. Additionally the costs of obtaining the EO data could be shared among the ports instead of paying individually, resulting in significant economic savings.

In terms of the desirability of the PEARL platform 48% the port interviewee's rated the market potential for the PEARL platform to be 'Strong' or 'Very strong'. This desirability was a positive response that increased during the validation campaigns when users saw the platform in operation. Participants from the ports were informed of the progress of the project, and invited to provide feedback. This feedback is very valuable to ensure that the platform is designed to meet the potential market's needs.

The Pearl project was acknowledged during the validation campaigns as a valuable initiative towards the direction of exploring the potential for complementing in-situ data that is currently collected by the ports with EO data sets and applications. The aim is to create added value and to assist in daily port operations and port environmental management. The selected EO data sets and applications that were used within the Pearl prototype demonstrated that satellite information can indeed have a valuable contribution towards that direction. In order to derive some overall conclusions regarding the value of EO data applications at ports also other experiences that can be encountered worldwide in various projects and initiatives should be taken into consideration. Actually, in some ports already some experience is available in using satellite information for port environmental management.

Synthesising the ports' feedback during the Pearl validation campaigns and the existing experience in the field of applying satellite information to port environmental and operational management the following overall conclusions can be derived:

1. Satellite data provides valuable additional information for port environmental management:
   - it can offer continuity of data by filling up the gaps in information

- it adds another level of insight and it contributes the larger scale overview that in combination with detailed in-situ data collection can facilitate the interpretation of the causal chain of environmental damage
- it gives a quick check in practice on calculating environmental damage from port operations (e.g. about the size of the plume of disturbed water during dredging activities - practical experience in Australia)

2. EO data can be seen as complementary to in-situ monitoring data systems. EO data provides information at a different often broader and more strategic level that the in situ systems. The interpretation of satellite information may contain a degree of uncertainty and therefore has to be combined with in situ information for verification purposes (e.g. identification of oil spills).

3. EO imagery could deliver additional information and assist on the sustainable management of the logistic chain and in particular the sea leg of it. Here however cooperation is needed between ports and other authorities involved in environmental management of the seas.
4. The costs of EO data are quality (e.g. resolution) dependent. The more detail is requested the higher the costs involved. Detailed satellite pictures are relatively expensive but depending on the costs of the operation could be nonetheless an efficient and additional way for monitoring and control (e.g. for controlling dredging operations during a port development project).
5. Possibilities for data and cost sharing can occur where EO imagery is useful for different parties. Imagery of larger areas (e.g. the North Sea) could be of interest for more users and sharing of data could therefore bring the costs per user at an acceptable level. Parties with an interest in EO data sharing could be ports but also parties with a wider interest in environmental data such as national and international environmental authorities, EC agencies, and port umbrella organisations (e.g. ESPO, ABP, Ecoports). In addition, the sharing of environmental data would improve the cooperation between the ports and between the ports and the above mentioned organizations and enhance the efficiency in data handling. Users can then be brought together and share a range of otherwise retained or not accessible information.
6. Pictures from smaller areas, such as seaports, are relatively more expensive and will normally have only one interested user (the port authority or the environmental authority). The costs will be relatively high compared to in situ measurement. Depending on the costs of the project involved these costs can however nonetheless be seen as acceptable. For example in the case of high cost port expansion plans that need dredging activities and that need a thorough measuring and monitoring system connected with environmental permits satellite pictures could deliver worthwhile additional information.

Summarising, the Pearl prototype can be seen as a valuable step towards the integration of EO data to existing port environmental monitoring systems. Pearl offered the technical solutions in bringing data originating from different sources together in a common and user friendly interface. The parallel visualisation and management of data demonstrated its added value to daily port environmental management. Some challenges still remain and need further investigation such as the optimal application of EO data for operations in the area under the responsibility of the port authorities. The decisive factor in ports decision to invest on a system driven by the Pearl concept would depend on the cost and added value ratio of the offered product or service. Towards improving this ratio, the possibilities for cooperation, cost and data sharing between ports and other parties such as national and international environmental authorities, EC agencies, and port umbrella organisations (e.g. ESPO, Ecoports, “Puertos del Estado” in Spain) need to be investigated. Cooperation in information exchange could contribute to the management of sustainability in the logistic chain.