OMS – AN END-TO-END COASTAL AND OCEAN MONITORING SYSTEM

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Abstract

OMS stands for *Ocean Monitoring System* with an innovative, integrative approach to coastal and marine observation and hazard prediction. Its development is driven by increasing needs for coastal and marine surveillance and requirements for coastal states to monitor their Exclusive Economic Zones (EEZ), to enhance maritime security and to manage sustainable coastal zones (refer to e.g. the United Nations Convention on the Law of the Sea, UN (1982) and International Convention for the Safety of Life at Sea, IMO (1974). Coastal regions are inhabited by more than 50% of the world's population and particularly endangered by impacts of climate change and environmental stresses. These facts and a series of international conventions and initiatives like GOOS (cf. e.g. WMO & IOC (2004)) but also recent disasters like the 2004 tsunami catastrophe in the Indian Ocean call for significant enlargements of observational forecasting and warning capacities and capabilities.

Because of ever shrinking public budgets integrated and low-cost surveillance systems composed of well-proven and commercially off-the-shelf available components and sub-systems are required. The OMS matches these challenges with an open and highly flexible modular system design, integration and management scheme. The project is industry driven and enjoys strong backing by scientific institutions and governmental agencies. The OMS is an end-to-end system with the following main components: (1) sensing and information production with in-situ sensors, buoys, piles, aerial remote sensing and surveillance systems like X-Band radar and HF-SWR, (2) operational now- and forecasting, (3) system/sub-system integration, control and management, (4) information processing and tailoring and (5) dissemination including rapid warning facilities capable to reach large people communities in hazard threatened areas.

The OMS is presently developed as a pilot system covering the Southern North Sea including major parts of Germany's territorial waters and EEZ. Primarily the system will deliver reliable data and information and additionally serves as a demonstration and reference system for interested parties and users.

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Introduction

Throughout the last decade an increasing demand for coastal and ocean surveillance systems can be observed worldwide. This is fostered by a variety of requirements in governance, management, exploitation, utilisation and protection of coastal and marine regions and their resources. More than 50% of a still increasing world population already live in coastal regions. Migration towards attractive, rapidly developing and resourceful coastal areas is still ongoing on the global scale. This leads to increasing pressure on these areas. For instance, most fish stocks in coastal waters, shelf seas and nowadays increasingly in open oceans are overused, coastal waters are frequently nutrified and many areas are overpopulated or polluted. Also wetlands, mangroves and coral reefs are degrading in terms of extension, quality and biodiversity. Offshore oil and gas resources are to a major extent exploited on the continental shelf forcing exploration and production to move towards deep and ultra-deep waters or very sensible environments like the polar seas. Renewable energy resources are increasingly developed in the marine space with offshore wind energy generation as a pioneer technology and wave, tidal and ocean thermal energy have future potential. Methane hydrates are a huge ocean energy resource which in amount might increase all on- and offshore located conventional hydrocarbon resources by a factor of two. For the decades to come, it can be expected that methane hydrates from larger reservoirs will be extracted. Following a decline in research and exploration in the 1980s, nowadays also ocean mineral resources like deep-sea located manganese nodules and ore-muds become of interest again. Utilisation of coastal space for food production has increased tremendously and strong environmental impacts are already observable. This tendency is ongoing and even increasing due to enhanced food demands but also by presently exploited perspectives to use ocean resources in biotechnology and pharmacy. Moreover, the major part of global trade and a large part of recreation and leisure activities take place in marine areas which can be clearly seen in the tremendous increase of ship and fleet sizes with corresponding cargo and passenger capacities.

In addition to associated pressures and stresses on coastal zones and offshore regions climate change impacts like sea level rise, stronger and more frequent extreme weather conditions and warming of the seas have to be seriously considered. Moreover, maritime security and safety is a strong driver and concern as already small disturbances and interrupts in marine trade and shipping can seriously affect the world's economies which crucially depend on in-time delivery of goods and raw materials. Marine and coastal areas are also very vulnerable to disasters of which the impacts of the 2004 tsunami throughout the Indian Ocean and the severe destruction of the City of New Orleans in consequence of a hurricane are only two prominent examples which happened in the past couple of years.

All these and other issues and associated socio-economic processes call for improved governance and management of marine and ocean space and resources. A series of initiatives, policies and instruments are presently developed and implemented. This includes for instance the step-wise realisation of the Global Ocean Observing System (GOOS) or developments of integrated management schemes and tools (e.g. ICZM) with incorporation of coastal and offshore areas in spatial planning. Further, the Law of Sea and the ongoing refined determination of Exclusive Economic Zones (EEZ) demand from coastal states to monitor and manage their marine areas. All this requires profound knowledge on marine environments and eco-systems with associated physical, chemical and biological processes including their temporal and spatial variability. Accordingly appropriate decision-making, reaction, response and mitigation measures need rapid and in many cases real-time information and reliable forecasts on several system and state variables. It is also obvious that matching of such demands requires multi-source and multi-tasked coastal, marine and ocean observing and monitoring systems with increased capacities for real-time surveillance, hazard prediction and early warning. Whereas such systems are implemented and further developed for long in higher industrialised countries they are entirely lacking or significantly underdeveloped in other regions and countries.

However, even "rich" countries have clearly identified large gaps between demands and needs in marine surveillance and monitoring on the one hand and available financial resources and observational capacities on the other hand. This calls for innovative approaches on all levels. This includes sharing of costs, infrastructure and resources and development of cost-efficient, highly automated, less maintenance intensive and more robust technologies. The needs for integrated approaches requires also that "classical" demarcations between for instance marine monitoring, maritime surveillance and security, management of sea and land transport, disaster response and mitigation or exploration of living and non-living resources are vanishing as all these activities depend on and share common information sources and knowledge bases.

Motivation for and Objectives of the OMS

Based on the above depicted facts and trends but also strongly stimulated by the 2004 Indian Ocean tsunami catastrophe considerations were made among a group of companies together with scientific institutions loosely associated in the so called Maritime Cluster of Schleswig Holstein on bringing together individual experiences, technologies, knowledge and capacities and to join forces to develop an innovative approach towards coastal and ocean observing, monitoring and surveillance. Besides integration observation capabilities for a series of key parameters and processes of relevance the system should also include operational forecasting and simulation, task specific and cross-sector evaluation as well as end-user tailored dissemination of acquired data and information. Moreover, as the "last mile" the system shall demonstrate the capability to quickly issue and broadly distribute public warnings in case of danger or foreseeable hazards or catastrophes.

Figure 1: Illustration of the main OMS components and its end-to-end approach.

Such a system has to be built modularly and flexible in order to be tailored to regional specifics and application intentions as well as for matching individual demands of users and customers. It must be also possible to integrate the system as a whole or only some of its subsystems or even individual components into already existing applications. Contrary to existing monitoring and surveillance systems which usually have a long design, development and implementation history in governmental agencies the OMS shall be entirely composed of commercially available off-the-shelf components which are intelligently integrated, interfaced, controlled and managed within a highly modularised and accordingly very flexible system.

Moreover, the OMS shall be an end-to-end system spanning from sensing, data acquisition and information generation side ("the first mile") on the one end to the warning and information transmission ("the last mile") on the other end.

By this approaches the costs and efforts for development of the pilot system as well as for subsequent tailoring and implementation of other systems are significantly reduced but the system remains still open for new developments as well as for integration of new subsystems, supplementary modules and components. In addition linkage with or incorporating data and information from already existing monitoring systems has to be ensured. Consequently the project and system development is industry driven but enjoys strong support by public agencies and is strongly backed by scientific institutes. All therefore needed technologies, components, products, services and experiences are available within the formed group of companies together with the associated public institutions which form the so called "OMS Team".

As to our knowledge such an approach to develop and functionally demonstrate a multi-source and multi-task coastal and ocean observing system was never conducted elsewhere before. The objective of the OMS pilot project is also to establish, test and operate an in-front-of-the-door pilot implementation to demonstrate the system and its components to interesting parties as well as to provide supplementary data and information to regional authorities, institutions, users and to the general public. As application area the North German coast with the adjacent world-wide unique Wadden Sea and parts of the German Bight was selected. This was strongly motivated by the rough environment of the Southern North Sea, the storm surge endangered North Frisian isles and coastal areas and the regional managerial and protection needs. The system is installed at the West Coast Research Centre based in the town of Büsum which provides infrastructure and logistic support. Also the centre contributes with already existing components and also has a strong interest in its future use.

Description of the OMS North Sea Pilot System

Basically the OMS consists of four main compartments or blocks: (1) subsystems and sensors for in-situ observation, remote sensing and surveillance acquiring data and information of key parameters and processes like water levels, waves, currents, other state parameters and information such as ship traffic, (2) operational simulation models utilising data and information from the system for short-term forecasts of e. g. tide, surge, wave and current fields and which are also usable for hind- and nowcasts as well as for rapid scenario simulations (e.g. spills), (3) system control and data management including the overall system control and maintenance functionalities and interfaces. It controls all subsystems, modules as well as sensing devices and it displays, validates and stores data and information. It is also openly designed for later integration of components for enhanced information processing, data evaluation, generation of higher level data and information (data products), and (4) the warning and dissemination part which can issue and spread rapid public warnings and routinely provides dissemination services for end-users and the general public.

In the following sections and paragraphs we provide a brief overview on these main system components which, however, can be illustrative only within the scope of this paper (for more details one is referred to the OMS website (OMS, 2007) which will be successively supplemented with Internet based information services, actual information and data.

<u>Sensing, Surveillance and Data Acquisition Subsystems and Devices</u>

It is one of the intentions of the OMS development to demonstrate that different data and information collecting subsystems with a representative cross-cut of devices and sensors typically applied in ocean monitoring and marine surveillance can be effectively integrated and jointly function in a combined system. In the present pilot application these are the following subsystems:

Fixed Monitoring Stations on various platforms which are classically used in marine monitoring. Typically the platforms are buoys, light vessels, offshore piles or platforms and coastal or harbour stations which hoist a variety of sensors.

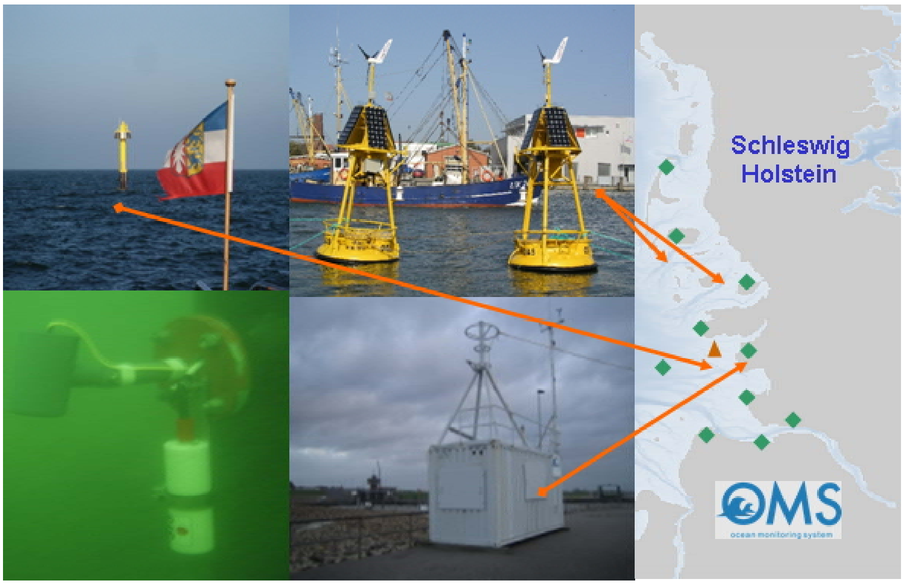
The OMS pilot system presently integrates

(a) three multi-sensor buoys (1 existing research and 2 new commercial ones with an innovative anti-fowling system) on which e.g. water temperature, salinity (conductivity), turbidity and currents through interlinked bottom-deployed acoustic Doppler current profilers are measured,

(b) a newly established measurement pile which in addition to the parameters listed for the buoys includes a meteorological station, an acoustic water level and wave gauge and an underwater mounted high-frequency pressure gauge. This pile also serves as a test site for new sensors and developments. For instance one OMS science partner plans to interface newly developed bottom-mounted seismic detectors, and

(c) a containerised coastal station situated at the port mole head of Büsum equipped with a high-frequency acoustic tide and wave gauge and a meteorological station.

Figure 2: Deployment positions and photos of the fixed monitoring stations of the OMS. The photos on the left show the measurement pile and a thereon mounted pressure sensor, the upper right one the 2 new ODAS buoys during test deployment in the port of Büsum and the photo below the measurement container in Büsum with the meteorological sensors. The black triangle depicts the location of a third buoy, the squares the locations of some tide gauges all operated by third parties. Photos courtesy of -4H- JENA Eng. GmbH and FTZ – West Coast Research & Techn. Centre.



Coastal X-Band Radars with Integrated Wave and Current Monitoring at 2 locations. In surveillance mode the radars monitor ship traffic ranging approximately 50 km offshore. When switched to wave/current acquisition mode the built-in monitoring system acquires wave and surface current fields and produces derived wave state parameters as maximum and mean wave height, wave direction and spectra with approx. 20 km range.

HF-SWR Radars installed at 2 locations measuring surface currents and wave conditions in a typical range of 80 to 100 km. They are also capable to detect disturbances in the water surface conditions up to 200 km (well beyond the visual and radar horizons). Evaluation of the back-scattered signals allow also the detection of targets with lacking electro-magnetic signature or low radar-cross-section (e.g. wood or plastic boats, possibly also radar-stealth constructed vessels) as these cause typical disturbances on the water surface. Such targets are not detectable by classical surveillance radars. Specialised evaluations allow also detection of disturbances on the water surface as they are typical for tsunami wave trains in deeper water. By this a tsunami can be detected before the waves enter shallower nearshore and coastal waters where they may pile up disastrously. By this detection, response and warning times for approaching tsunami wave trains can be significantly enlarged.

Figure 3: Locations and illustrations of the X-Band and HF-SWR Radar systems of the OMS. The two photos on the left show the site of the X-Band and wave monitoring radar installation at the port lock building of Büsum. The photo on the right shows the HF-SWR radar antennas installed in Büsum. Photos courtesy of Raytheon Anschütz GmbH and Helzel Messtechnik GmbH.

External Data and Information Sources

A series of external sources feeds the OMS with supplementary data and information. This includes several tide gauges operated by the German Federal waterway authorities and/or the regional environmental agency, a weather station operated by a private meteorology company and a research station on the island of Helgoland. This also demonstrates the capabilities of the system to include and handle almost any monitoring and surveillance data from arbitrary other sources, like existing monitoring networks or other surveillance systems.

Operational Fore- and Nowcasting

The OMS incorporates an operational numerical modelling system (see e.g. Duwe and Nöhren (2000), Nöhren et. al. (2003), Pfeiffer and Mahnke (2006)) which provides in routine operation modes short-term forecasts of currents and water levels (optional other parameters like water temperature and salinity). The OMS three-day forecasts are produced routinely and automatically every day after the receipt of automatically transmitted information to compile boundary and forcing conditions (wind conditions, air pressure, water levels and river runoff) from a larger scaled North Sea / Baltic Sea forecast model operated by the German Maritime and Hydrographic Agency (BSH). The set-up and initialising information also includes results from the routine weather forecast of the German Weather Service (DWD) and actual run-off measurements of the River Elbe and other larger rivers entering the Southern North Sea.

The OMS model system consists of three main components:

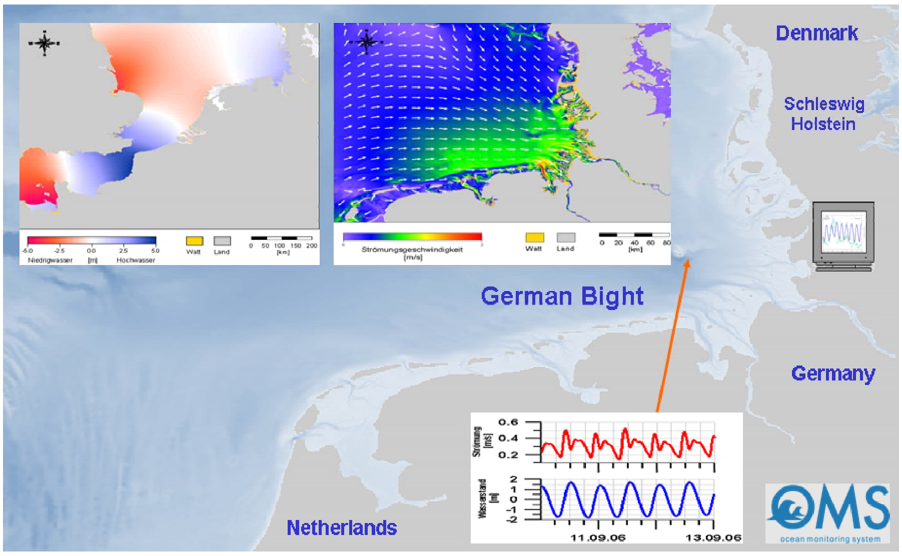
(1) the **Southern North Sea OMS Model** – a larger-scale model with about 600 metres horizontal resolution which covers the southern North Sea between the entrance of the Channel between near Trèguier (Brittany) in France and Salcombe (Devon) in the UK in the west to its northern boundary which is located approximately between the Danish town of Esbjerg and Newcastle-upon-Tyne in the UK,

(2) the **German Wadden Sea OMS Model** which is an embedded higher resolution model (about 150 metres) covering the Schleswig-Holstein and parts of the Danish North Sea coastal areas and Wadden Sea towards approximately 30 kilometres offshore. It also includes in more detail the main shipping approaches in the area and into the River

Elbe to the Kiel Canal as well as the entire tidal part of the River Elbe up to the town of Geesthacht east of the City of Hamburg, and

(3) a **Lagrangean Tracer Module** (usually kept in stand-by mode) which can use results from both models for prognosis of for instance oil and chemicals spills or drifting objects on demand.

Figure 4: Illustration of simulation and forecasting results overlaid on a part of the North Sea model and bathymetry. The upper left panel displays a snapshot of the water level distribution in the entire model domain, the upper right one a scope of the current field (shaded for current speeds with a subset of displayed current vectors) in the German Bight. The time series illustrates simulated tidal conditions at a position near the island of Helgoland. The computer screen depicts the location of the OMS control centre in Büsum. Courtesy of HYDROMOD GbR.



Besides operational forecasting the model can also produce nowcasts when updating boundary and forecasting conditions obtained from forecasts with assimilated actually measured data. In the same way hindcasts are possible to conduct when historic data and information are used. When operated in case-study-mode the model system can be fed with scenario dependant boundary and forecast conditions and thereby it can also be utilised for simulation of planning scenarios. For instance it can forecast and access changes and impacts in case of configuration changes (e.g. dredging of shipping lanes, construction of ports or marinas, manmade and natural coastline changes). Another application of the model system is for rapid response and decision support by "playing through" various feasible or highly probable scenarios. For the North Sea this is of particular importance to assess the possibility of storm surges. Usually weather forecasts reveal a certain uncertainty in wind direction and speed. Even smaller directional changes may result in significant alterations of local surge heights and local distributions and, correspondingly, to different situations of danger or threats.

The model system produces a series of data / information products such as time series at relevant or interesting positions or snapshots of distributions which can be also compiled to animated graphs or short video scenes.

OMS System Control and Data Management

The control and data management system of the OMS (OMS-DMS) controls, manages and integrates all components and subsystems on the corresponding levels. It further quality-controls, pre-processes and displays the data and information and finally archives them for subsequent access and further use.

Each OMS subsystem (i.e. a measurement station, an ODAS buoy or a radar system) has its own data management, control and data transmission system which is intelligently interfaced with overall system control and management. The same applies – one or two levels deeper respectively – to instruments and/or sensors which are part of an OMS Subsystem. For this and in order to guarantee system flexibility, modularity and efficiency all components are integrated by intelligently designed interfaces usually on software levels. This is of utmost importance as one cannot force a manufacturer of a sensor, instrument or subsystem to adjust their specific hard- or software to the OMS but, vice-versa the OMS has to accommodate the manufacturer specifications entirely by (a) transferring the produced or acquired data and information in a OMS conform and consistent manner and (b) ensuring that possible functionalities to control and command the components are appropriately integrated into the OMS control unit.

The two main elements of the OMS control and management subsystem are (1) the **OMS Control Centre (OMS-CCU)** which includes display, watch-dog and system control consoles of all subsystems and also integrates system-specific consoles and processing devices of larger or stand-alone subsystems like the radars, and (2) the **OMS Data Base System (OMS-DBS)** which receives the incoming data and/or produced information (including system information), conducts further consistency and quality checks of incoming data and files them in the systems' central data base and data archives. The data base has a generic design, a comprehensive meta-data repository and parameter lexicon which generally support almost all types of arbitrary time and geo-referenced data.

Information Processing and Tailoring

Information and data can be specifically tailored to various end-user needs and requirements. This is done with a series of embedded evaluation and data product generation tools which are either part of the subsystems themselves or are embedded in the OMS data processing and evaluation part. Typical examples in the pilot system are the generation of animated graphs and video scenes of current distributions from HF radar surveillance or simulation models, the generation of video scenes from X-Band radar images or production of time series from historic data.

Generally the various end-users specify the individual implementation of a monitoring and surveillance system and area specific requirements determine what kind of data products are matching best user-needs and application desires. Hence data products and the kind of information extracted from such a system as well as the way how such information is produced inside a system vary considerably. For instance, real- or near-real-time applications need sound and rapid evaluation of multi-source data and fast transfer to the warning system which is usually achievable at cost of data accuracy and quality control measures. On the other end use of the data for long-term assessment of e.g. environmental and climatological changes requires reference sampling, precise calibration against laboratory measurements or water samples and validation with sophisticated statistical tools which is usually conducted on a larger time frame. Accordingly, a module is foreseen inside the OMS which can easily accommodate specific and additional evaluation and information processing routines.

The database model and design allows incorporation of multi-level data products. Furthermore, the value of the system increases along with its continuous operation. Accordingly the data base is consecutively filled with acquired data and produced information.

This facilitates the system to act as a resource for long-term monitoring objectives as well as for enhanced evaluations and statistics. Hence the system will be a versatile inventory of historic data and it will also provide important baseline information for a variety of applications ranging from scientific objectives to support of operational and managerial needs.

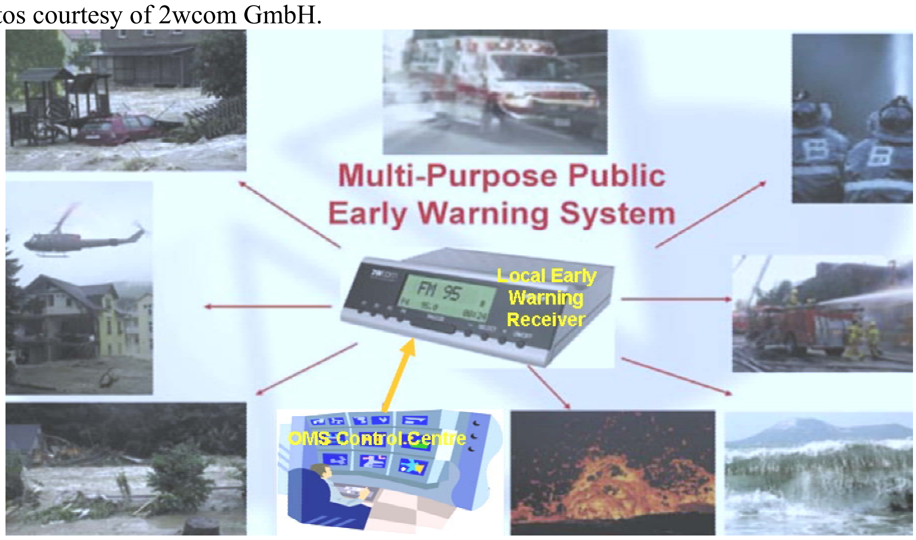
System Maintenance

Maintenance of the OMS as a whole as well as of its subsystems is supported by wide area access through web and Internet services and protocols. By this control and maintenance of the system is eased and its operators can be remotely supported by individual specialists (e.g. from the manufacturers of subsystems) which reduces operation and maintenance costs considerably. However, it must be kept in mind that in-situ sensors and especially offshore deployed components need regular maintenance, periodic replacement of sensors and also from time to time reference sampling for calibration. This can only be done by technical staff on site and requires regular transfer of personnel and equipment to the sampling locations.

Hazard Prediction and Early Warning

As said above, the OMS is an end-to-end monitoring and surveillance system and thus incorporates also the so called "last mile". This is realised by a robust, autonomous and rugged computer controlled radio transmittal system integrated into the control centre. Through this the operator can broadcast warnings which are either distributed through public information services or to a network of low-cost receivers and display units with the size of a radio clock. The receivers give audio alarms and also display short alarm messages visually. Such alarm units can be deployed in public places, agencies, administration, police stations but also in hotels and other tourist facilities.

Figure 5: Illustration of the "last mile" of the OMS with the early warning receiver in the centre. Photos courtesy of 2wcom GmbH.



This subsystem is well proven and for instance installed in large numbers in Sweden to transmit alarms in case of nuclear power plant failures across wide, remote and low-dense populated areas to a large community of people. It was also most recently installed on the island of Bali in Indonesia for transmission of tsunami warnings and other hazards to the population.

Dissemination and Distribution of Data and Information

Data and information produced by the OMS is distributed and disseminated on three levels. First and system-internally, data are rapidly transmitted to the control centre and there displayed on a series of monitors together with other system information, performance and housekeeping data. This enables the system operators to control the system and, if necessary, invoke corrective actions or react to site-specific conditions. Typical examples of the latter are changes in data acquisition speeds of specific sensors if an interesting or dangerous situation is identified or switching the acquisition mode of the X-Band radars to wave monitoring in case of storms with associated dangers for shipping.

Secondly, hazardous situations could also be identified by the system itself and the operator receives a high-priority threat or warning notification to support response and mitigation actions and associated decisions.

The operator can then rapidly decide to whom and in which way such warnings are transmitted further and what kind of warnings have to be broadcasted. Practically such warnings can be also issued automatically but in almost all cases a "human interface" takes the related decisions and actions.

Further, routinely data and information is also transmitted to end-users and the general public which is done through the OMS web server and web site, OMS (2006). The level of access to information and data and the use of related web-based information services are distinguished among the community of users. Some information and data are routinely displayed on the public web site whereas other services require access permission of authorised users or user-groups. In this conjunction it is important to point out that the OMS pilot system demonstrates a series of such information processing and tailoring measures but that finally the customers and end-users specify which services and routines are integrated into a specific system implementation.

Preliminary Results, Discussion and Perspectives

Presently the OMS pilot and reference system for the German North Sea is in advanced stage of implementation. Most platforms and sensors are already installed and in test-operation and the remaining ones will be installed within spring 2007. The system overall integration and the adaptation of management and information processing routines is also proceeding well. According to the project plan the system will enter into test operations in late summer/early autumn 2007 and will from thereon deliver data and information to the end users. By then it will also facilitate as a demonstrator and reference system and can be presented to interested parties.

Innovation Aspects

The OMS incorporates a series of innovations which are also considered to have certain implications on future applications and also on the raising market for marine monitoring and surveillance systems and technologies. Firstly, the described end-to-end approach "from sensing to warning" is integrated in such a system for the first time. Secondly the OMS combines aspects and objectives of environmental monitoring with marine surveillance and security as well as with hazard prediction and early warning. By this the possibilities of application are considerably enhanced and the community of end-users is greatly widened.

Furthermore, the modular and flexible design of the OMS allows integration of almost arbitrary subsystems for sensing and generation of data and information including interfacing with existing systems. It is also not only limited to marine applications but can also be transferred to purposes of land- or inland water monitoring. Last but not least the OMS development is industry driven and composed of proven and commercially available modules (products and services). Combined with the broadened user community this should significantly reduce cost and efforts of monitoring and surveillance and this will also ensure that its further development matches with market potentials and end-user requirements.

Challenges for Future Applications

However, with the introduction of the OMS also a series of new approaches and procedures emerge which are presently rather vaguely adopted at parties and especially stakeholders concerned. In most countries the thematic areas and objectives covered by the OMS are vertically structured and in many cases cross-sector cooperation and horizontal collaboration among therefore responsible agencies and administrations is underdeveloped. Accordingly topics of joint use of a system like the OMS which necessarily includes sharing of responsibilities, budgets and other resources among the end-user community have to be resolved.

This likely requires difficult and longer-lasting decision-taking and organisational processes and, correspondingly, large efforts along with the definition and initialisation of an OMS implementation project and for its organisational and financial engineering.

Moreover, there is also still a large gap between user needs and expectations to such systems and the ability to adequately contribute to system operation and maintenance costs which has been proved by a series of activity and surveys within operational oceanography communities throughout Europe.

Another challenge is the public-private cooperation in marine surveillance and monitoring which are considered as predominantly public services and activities conducted by agencies and partly also by research institutions on their behalf. In this more traditional approach industry is still considered as a smaller-scale provider of hardware components or specific services rather than in the role of a system provider and partner in its operation.

A major challenge for the near future will be ensuring the sustainability and continuous operation of the OMS. The developing companies can certainly contribute by own resources and vice-versa gain commercial benefits and advantageous market position. However, contributions of the user communities are also needed to ensure proper operation of the system and continuous functioning of infrastructure and subsystems including shared coverage of costs and efforts for maintenance and in day-to-day operation.

<u>Conclusions and Outlook</u>

We expect that with the availability and operation of the OMS pilot, reference and demonstrator implementation for the German North Sea area the interest at communities, stakeholders and countries will raise considerably. This applies for both, the system and its end-to-end approach as a whole as well as for certain components and subsystems. The pilot project also proves the functioning of the cooperation between different industries ranging from very small enterprises to large companies with system integration capacity as well as collaboration between industry, science and governmental agencies. In mind of the maritime markets and the administrative and industrial structures in the area of marine monitoring and surveillance such partnerships are vital for successful applications and future implementations of the OMS. Moreover, this constellation gives excellent possibilities for further marketing and qualification of the system.

The OMS is expected to attract other institutions and administrations to feed the OMS with data and information from other networks or from single stations. Also voluntary ship of opportunity observations (Ferrybox systems) as presently test-wise applied in several countries can be integrated. Besides from being a functional and operational reference, the OMS pilot system will facilitate as test site for new developments. By this it will also provide possibilities for developers and users to test and qualify specific components, sensors and services as well as for exploitation and future use of data and information. As such the system also comprises a sound infrastructure for follow-up projects as well as for operational use to match the upcoming requirements and challenges in the area of marine monitoring and surveillance.

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