# Joint European Research Infrastructure network for Coastal Observatories

# Report on current status of Ferrybox

## D 3.1

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# 1. Document description

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# 2. Executive Summary

This report provides:

1. A review of the present status of the 16 Ferrybox systems currently operated by JERICO partners.
2. Access to detailed information on the Ferrybox systems on line at the FerryBox project web site (www.ferrybox.org) at the link http://www.ferrybox.org/routes/northern_europe/index.html.en.
3. A set of recommendations and guidance for setting up a new Ferrybox system, based on the experience of the current status of the operation of Ferrybox systems.

Next steps are considered in an overview of potential advances resulting from the work of the JERICO project.

4. Part of the JERICO vision is the improved harmonisation of activities through the sharing of information and the standardisation of operating procedures connecting operations at sea and generation of real time data through to the archiving of fully quality controlled and documented data sets. Items following on from the 1st JERICO Workshop are discussed.
5. Ferrybox information is being used to review the current status of and best technical practice for operating Ferrybox systems as part of JERICO work packages WP4 (Harmonizing Operation and Maintenance Methods) and WP5 (Data Management and Distribution). For example, delayed-mode Ferrybox data activities will be routed through WP Task 5.2. This task will also manage the necessary interaction between JERICO and SeaDataNet II. JERICO needs to think how this will be developed in practice across the different user groups and the training required.
6. A task of the JERICO meeting in Crete (October 2012) should be to define a “roadmap” for fully developing the links between MyOcean and the potential providers of near real time data from Ferryboxes that are useful in the context of the activities of MyOcean.

# 3. Introduction

"FerryBox" systems are cost-effective tools supporting the collection of marine scientific and monitoring data. The concept evolved in Europe through the activities of EuroGOOS and the realisation that if a few of the 800 ferries operating in European waters could be fitted with "boxes" of scientific instruments a valuable increase in observations of some key marine parameters could be achieved (Fischer *et al.*, 1999; 2000). Ferryboxes would produce a high yield of reliable high-frequency high-quality data along repeated transects, improving on conventional monitoring strategies based on infrequent sampling. Many technical problems typical for fixed and isolated marine measuring systems such as buoys would not be a problem for Ferryboxes. These include constraints in availability of power, installation and storage space, protection of components against harsh marine environments and longer-term fouling. As the measuring device would "come back to the operator", servicing and calibration could be done directly in a nearby home port. Compared to devices deployed off shore the operating costs of Ferrybox systems would be significantly lower.

The global future of these systems has been considered by the SCOR working group "OceanScope" (2008 to 2011). This working group looked at the overall future expansion of the use of such systems both for work in coastal waters and the deep sea, including aspects related to the shipping industry, ships, the law of the sea, equipment and the demands for scientific data (Rossby *et al.*, 2011)

These ideas were developed and tested in the EU-FP5 FerryBox project (Petersen et al., 2007). That project included tests on nine different systems and clearly showed that the expectations of such systems were met. Key oceanographic parameters water temperature, salinity, chlorophyll-fluorescence dissolved oxygen and turbidity were easily and consistently observed. It also showed that the basic measurements could be extended to provide information on a wider range of process, for example: - (1) Chemical sensors and measuring devices were developed for nutrients (2) For investigations of water and sediment transport the use of ADCPs was found to be a valuable (Buijsman and Ridderinkhof, 2007). The instruments were stable and had low maintenance requirements once an appropriate installation had been developed. The period from 2000 onwards has seen a steady growth in the number of Ferryboxes and related deep-sea systems in operation around the world. The potential for considerable further growth has been widely recognised (Borges et al., 2010; Hydes et al., 2010). On the deep sea measurements of air sea fluxes of carbon dioxide have been a focus of activity and this work has clearly demonstrated the power of the concept, when data from a number of routes can be merged together as was done by Watson et al., (2009).

The high resolution of Ferrybox systems in space and time can provide deeper insights into marine processes that can be used to better assess the ecosystem and the underlying physical-biogeochemical processes in the marine environment. Special events like intense short-term algal blooms, rarely detected by standard monitoring methods, can be studied in detail and related to variations in influencing factors such as temperature, wind and nutrient load. This information can be used for the further development of ecosystem models. Techniques to assimilate Ferrybox data into numerical models can be used to improve reliable forecasts (Grayek et al. 2010, Stanev et al. 2011). By combining remote sensing imagery with hydrodynamic model transports the ‘one-dimensional’ view along a ferry transect can be expanded into a 2D spatial view (Petersen et al., 2008; Volent et al, 2012).

All marine science has an important practical side in relation to overcoming the problems of working in the often harsh environment of the sea. Sea worthiness requires robust systems that work well in harsh physical conditions. Relaying data to users also requires a robust supply chain. Added to these demands are the extra ones associated with working with shipping companies and their commercial constraints and on ships that were not designed as scientific laboratories. Examples of these problems and limitations include:- (1) Shipping lines are not always ideally positioned for the desired objective and thus a Ferrybox application is often a compromise between available routes and scientific or monitoring needs. (2) For longer-term assessment and monitoring purposes the selected shipping route needs to be stable over periods of years ideally decades. Vessel operators may from time to time terminate services, alter shipping routes, or replace a vessel at short notice. To cope with this a good relationship with the vessel's operator is required to maintain operations. (3) The installation possibilities depend on the goodwill of the vessel operator or owner. The systems have to be designed and operated in such a way that their installation and operation does not disturb the routine work of the vessel. Information has to be gathered from the experience of existing operators to make things easier for new comers to the field. This report begins the task of distilling some of this experience gain by Ferrybox operators as to the source of operational problems that can arise and how they can be solved.

The 2002-2005 FerryBox project was successful in proving the concept. But it was based on the work of individual laboratories on individual routes (Petersen et al., 2007). The next stage is to achieve an integrated system for the production of data sets that are consistently produced meeting agreed common standards for the quality assurance of the data. Then that data should be made freely available in a form (with all the appropriate meta data) which enables it to be easily assimilated by users of the data. The JERICO project has been set up to provide the mechanism for this required greater coordination of the effort to happen. JERICO will provide information that will allow groups to achieve common standards of best practice and allow new comers to follow this best practice. The aim of this report is to describe what is in place already and to lay out the practical work that is and will be carried out in JERICO. This work will finally be reported on and then documented following the workshop that is planned for month 42 of the project.

In this report we cover the work that has been developed in the first stage of JERICO an important focus of which was the first workshop which took place at HZG end of August 2011 and brought together partners working in both WP3 (Harmonizing Technological Aspects), WP4 (Harmonizing Operation and Maintenance Methods) and WP5 (Data Management and Distribution) which in their harmonisation roles are closely related. The first steps have been to discover what is being done across the Ferrybox operating community at the moment as being the basis for discovering the mechanisms through which greater harmonisation can be achieved. The expectation is that the harmonisation can be achieved by enhancing the exchange of information on operating experience rather than working towards imposing a common equipment system on all ships. A common equipment system is not a practical solution as the science and monitoring foci of the different operations are different. The physical circumstances on ships dictate different solutions to the problem of the specification of an installation.

However once data has been captured the expectation is that a high level on commonality in processing can be achieved. A JERICO “quality stamp” will show that an agreed system of best practice has been applied to the processing and validation of the data and production of the archived data stream.

This report therefore covers:- (1) Current Status of Ferrybox Operations (2) Installation of new Ferrybox systems (3) Advances to be developed by the JERICO project.

# 4. Main Report

## 4.1. Current Status of Ferrybox Operations (In European Waters)

Information regarding on-going activities using Ferryboxes in European Waters can be found on the FerryBox web site - www.ferrybox.org. Following on from the successful EU-FP5-FerryBox project (2002-2005) the community has expanded and kept in touch via the web site and conferences at 18-monthly intervals that have attracted attendance from around the globe (these were in Oslo, 2007; Southampton, 2008; Gothenburg 2010; Hamburg-Geesthacht, 2011; Helsinki, 2013).

The current positions of Ferrybox lines working in North West Europe are shown in Figure 1 below.

JERICO questionnaires have been completed by all operators of Ferryboxes working in the project. The completed questionnaires are publicly available on both the FerryBox.org and JERICO (www.jerico-fp7.eu) web sites. Table 1.1 (at end of this section) lists the core lines currently in operation and the contact details of the Principal Investigators in charge of each line. The data returned are briefly summarised here. The questionnaires provide a ready access for JERICO partners and other interested bodies to discover what is being done, by whom using what equipment and where.

As of December 2013, a total of 21 Ferrybox systems are in use in European waters, 16 of these are run by operators who are partners in the JERICO project. In addition FerryBox type systems are operated on research vessels by CEFAS, HZG, MUMM, RIKZ, IMR and NERC-NOC (Working with Marine Scotland Science). The numbers of JERICO Ferrybox systems located in each region are 7 in the North Sea; 5 in the Baltic;; 2 in the Atlantic; 1 in the Mediterranean plus 1 that came into service in June 2012.

The core FerryBox parameters are Sea Surface Temperature (SST), Salinity, Turbidity and Chlorophyll-a-Fluorescence. For example, in addition 6 systems measure dissolved oxygen, 6 - nutrients (nutrients are measured from most other systems following collection of water samples), 3 - pH, 3 - pCO2, 2 – Phycocyanin.

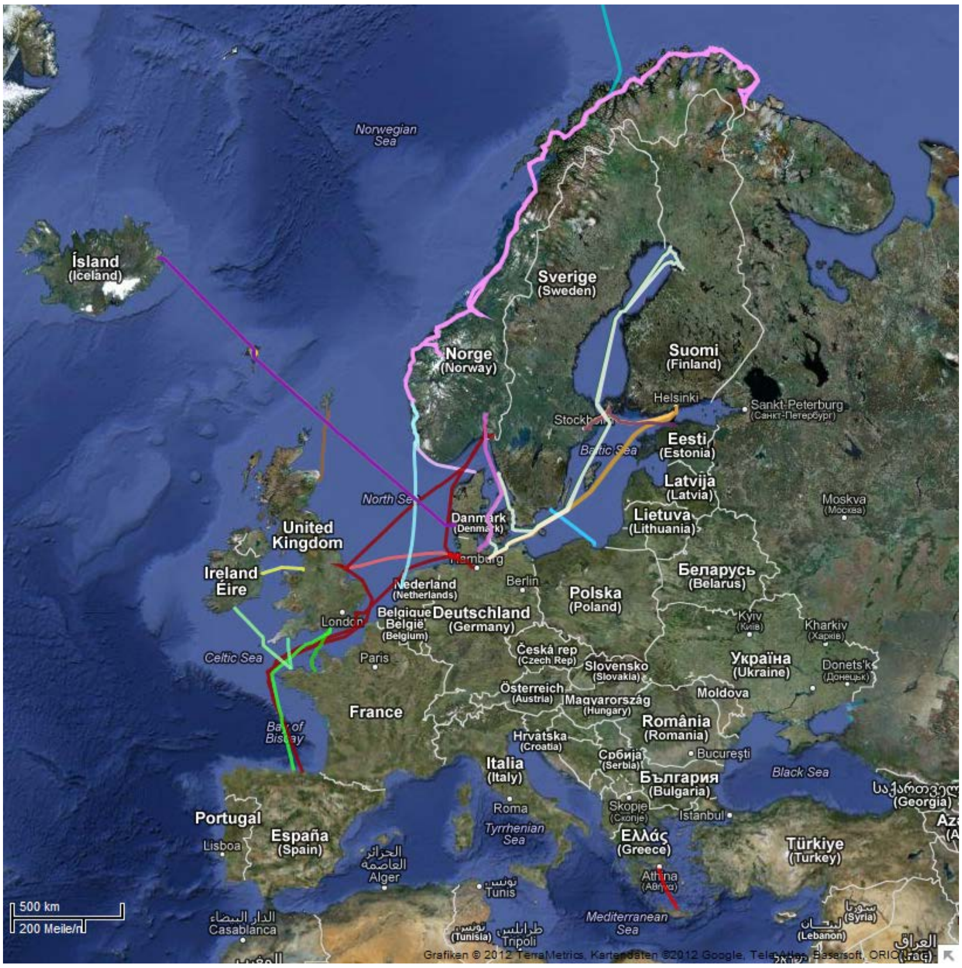

Figure 1.1. Map is showing Ferrybox routes currently operating in European waters (www.ferrybox.org).

Table 1.2 (at the end of this section) provides an example of the information from the questionnaires and is a listing of the specific measurement instruments installed in some of the Ferrybox systems in use. Information is also provided on how and with what frequency different systems are serviced by technicians visiting the ship.

Table 1.3 (at the end of this section) provides data, extracted from the questionnaires and is a list identifying the specific measuring devices used in the individual Ferrybox systems.

Details are given of the methods used by the operators to access data from their systems and the regularity with which this is done. Nearly all users have some form of automated data transmission system from ship to shore. This is done in near real time either by cooperating with the ship's own data transmission systems such as Inmarsat or using a user installed systems based on Orbcomm or Iridium. Other systems use less regular transfer of data done when the ship is in port using mobile phone connection (GPRS or UMTS). Once received ashore some of these data are immediately displayed publicly in raw form on the operators own website. This allows easy access to the data for all concerned. It also enables the operators to control the system when two ways communications are in place and to regularly monitor the functioning of the system without the need for special facilities or being in a specific location. For example data from the three HZG systems can be viewed via the COSYNA database (http://ferrydata.hzg.de and www.cosyna.de). Currently on a MyOcean FTP site, ftp-myocean.niva.no, data from 11 lines (HZG, IFREMER, INSU, MSI, NIVA, SMHI/SYKE and SYKE) is partly available within a few days for the core parameters. The number of lines available each day can fluctuate depending on internet access and data delivery of the various ferries/vessels. The data are stored as netcdf files and to get these data you need to register on www.myocean.eu. Development of visualisation tools for simple data viewing is being done by the MyOcean II project. A demonstration version is available at http://www.ifremer.fr/oceanotronPortal/ (but as of December 2013 does not include Ferrybox data).

A major focus of development in JERICO is moving forward with automatic data checking in real time. In particular, this is needed for any data that are being fed into MyOcean (see section 4.1 below) and then assimilated into operational models. For example, this is currently being done by NIVA. At HZG real time data control following the recommendations of MyOcean and the EuroGOOS DATA-MEQ group (Data Management, Exchange and Quality Working Group; see Annexe link -1) are looking into near real time quality control for in-situ data (RTQC). These measures will include checking housekeeping parameters such as flow rate, speed of the ship and statistical information (e.g. variance, frozen (unchanging) values etc) to achieve appropriate quality flagging of the near real time data transferred to MyOcean (see section 4.2.2 below). This will be done prior to full quality control of the data.

Table 1.1, Part one of summary information from the Ferrybox questionnaire listing the routes involved in the JERICO project and the Principal Investigators in charge and the appropriate contact details (shown is an excerpt of the full list). (http://www.ferrybox.org/routes/northern_europe/index.html.en).

| Institution | Destination harbours | Name of platform | Observed parameters | Ship type | name of contact person | Start of operation | End of operation | repetition rate of route |
|---|---|---|---|---|---|---|---|---|
| BCCR, UiB | Amsterdam - Bergen | M/S Trans Carrier | pCO2, T, S, Trb, Chl-a, pH | cargo ship | | 2005 | today | weekly |
| EMI | Tallinn - Mariehamn - Stockholm | Victoria I | T, S, Trb, Chl-a, CDOM | car/passenger ferry | Andres Jaanus | 2006 | today | daily |
| HCMR | Piraeus-Heraklion | Olympic Champion | T, S, Trb, Chl-a, DO, pH | car/passenger ferry | George Petihakis | 2002-2003 | today | daily |
| HZG | Cuxhaven - Harwich | Duchess of Scandinavia | T, S, DO, Chl-a, pH, Trb, nutrients | car/passenger ferry | Wilhelm Petersen | 2002 | 2005 | 6 - 7 times per week |
| HZG | Cuxhaven - Immingham | TorDania | T, S, DO, Chl-a, pH, Trb, nutrients | Ro/Ro-ship | Wilhelm Petersen | 2006 | 2012 | 3 - 4 times per week |
| HZG | Moss-Halden-Zeebrugge-Immingham | LysBris | T, S, DO, Chl-a, pH, Trb, nutrients | cargo ship | Wilhelm Petersen | 2007 | today | 14 days |
| HZG | Büsum - Helgoland | MS Funny Girl | T, S, DO, Chl-a, pH, Trb | passenger ship | Wilhelm Petersen | 2008 | today | daily during summer time |
| HZG | Cuxhaven-Helgoland | MS FunnyGirl | T, S, DO, Chl-a, pH, Trb | passenger ship | Wilhelm Petersen | 2009 | today | 3 times/week autumn &winter |
| Ifremer | Portsmouth-Santander-Plymouth-Roscoff-Cork | Pont-Aven | T, S, DO, chl-a, Trb, CDOM | car/passenger ferry | Paul Jegou | 2011 | today | weekly |
| IMGW | Gdynia - Karlskrona | Stena Balitica | T, S, Trb, Chl-a, DO | car/passenger ferry | | 2008 | 2009 | every second day |
| IMR | Bergen-Kirkenes | MS Vesterålen | T,S, Chl-a fluorescence | car/passenger ferry | Henning Wehde | 2006 | today | 11 day roundtrip |
| IMR | Norwegian West Coast (Bergen) | KV TOR | T,S, Oxygen | Coast Watch ship | Henning Wehde | 2011 | today | Unregular trips surveying the western Norwegian Coast |
| Marlab | Lerwick - Aberdeen | MV Hascosay | T, S, Trb, Chl-a | | | | | |
| MIO (CNRS/INSU) | Genova - Libyan harbours | Jolly Indaco | T, S | RoRo container ship | Isabelle Taupier-Letage | may 2010 | may 2011 | 2 times/month |
| MIO (HYMEX/CNRS/INSU) | Marseilles-Algiers | Niolon | T, S | RoRo | Isabelle Taupier-Letage | feb 2012 | today | 2-4 times/month |

Table 1.2, Part two of summary information from the Ferrybox questionnaire listing the routes involved in the JERICO project and the Principal Investigators in charge and the appropriate contact details (shown is an excerpt of the full list). (http://www.ferrybox.org/routes/northern_europe/index.html.en).

| Institution | Destination harbours | Name of platform | Observed parameters | Ship type | name of contact person | Start of operation | End of operation | repetition rate of route |
|---|---|---|---|---|---|---|---|---|
| MSI/TUT | Tallinn - Helsinki | MS Silja Europa | T, S, Chl-a, turb, (pCO2); nutrients, Chl-a, phytoplankton (wkl sampl in spring-summer) | passenger ship | Urmas Lips | 1997 | today | daily |
| NIVA | Histhals, Stavanger, Bergen | MS Bergenfjord | T, S, Trb, Chl-a, nutrients (weekly samples) | car/passenger ferry | Kai Soerensen | 2008 | today | 3 times per week |
| NIVA | 36 locations from Bergen to Kirkenes | MS Trollfjord | T, S, Trb, Chl-a, nutrients (weekly samples), irradiance, radiance, wind | car/passenger ferry | Kai Soerensen | 2006 | today | 1 week |
| NIVA | Oslo, Kiel | MS Color Fantasy | T, S, Trb, Chl-a, CDOM, cyanobacteria, nutrients (weekly samples), irradiance, radiance | car/passenger ferry | Kai Soerensen | 2008 | today | daily |
| NIVA | Tromsø, Bjørnøya, Longyearbyen, Ny Alesund | MS Nordbjorn | T, S, Trb, Chl-a, nutrients (weekly samples), irradiance, radiance | cargo ship | Kai Soerensen | 2008 | today | 1 week |
| NIVA/MARLAB | Histhals, Torshavn, Seydisfjord | MS Norrøna | T, S | car/passenger ferry | Kai Soerensen | 2008 | today |  |
| NOCS | Portsmouth-Bilbao | Pride of Bilbao | auto:T, S, Chl-a, Trb, O2, pCO2; (monthly samples nutients, pigments, plankton, coccoliths) | car/passenger ferry | Mark Hartman | 2002 | 2010 | 3 days |
| NOCL | Birkenhead- Dublin | Lagan Viking | T, S, Chl-a, Trb | car/passenger ferry |  | 2006 | today | 12 time/ week |
| SMHI & SYKE | Gothenburg-Kemi-Oulu-(Husum)-Lübeck-Gothenburg | TransPaper | T, S, Trb, Chl-a-fluorescence, Phycocyan-fluorescence, CDOM-fluorescence, DO, PAR, airPress, airTemp, pH, pCO2 and CO2 in air, RC (phytoplankton, salinity, chl a, CDOM) | cargo ship | Bengt Karlson | 2009 |  | 1 week |
| SYKE | Helsinki - Stockholm | Silja Serenade | T, S, Chl-a, Turb, Phycocyan, nutrients, phytoplankton | car/passenger ferry | Seppo Kaitala | 1998 |  | daily |
| SYKE | Helsinki-Travemunde, Helsinki-Gdynia | Finnmaid | T, S, Chl-a, nutrients, Phycocyan, CDOM, TURB, nutrients, phytoplankton | Ropax | Seppo Kaitala | Finnpartner 1998 - 2006, Finnmaid 2007- |  | daily |
| Univ. Rhode Island | Esbjerg - Torshavn - Brimnes | Norrøna | T, S, Trb, Chl-a | car/passenger ferry |  |  |  |  |
| LIAE - MSI/TUT | Riga-Stockholm | MS Romantika | T, S, DO, Trb, Chl-a, phycocyanin (monthly samples nutrients, Chl-a, phytoplankton) | passenger ship | Juris Aigars/ Urmas Lips | 2013 | 2013 | every second day |

Table 1.3, Sensor data, extracted from the questionnaires and is a list identifying the specific measuring devices used in the individual Ferrybox systems (shown is an excerpt of the full list). (http://www.ferrybox.org/routes/northern_europe/index.html.en).

| **Ship & route** | **Parameter** | **Measurement principle** | **Sensor** | **Manufacturer** |
|---|---|---|---|---|
| Helsinki - Travemunde | | | | |
| Finnmaid | Water temperature | Pt 2000 | SBE Temp sensor 38 | Sea-Bird Electronics |
| | conductivity | inductively | SBE TSG 45 | Sea-Bird Electronics |
| | turbidity | light scattering (blue) | FLNTURT | WETLabs |
| | chlorophyll-a | fluorescence | FLNTURT | WETLabs |
| | Phycocyanin | fluorescence | microFlu-blue | TriOS |
| | CDOM | fluorescence | microFlu-cdom | TriOS |
| | automatic water sampler | phytoplankton nutrients chl-a-analysis | | ISCO (USA) |
| Gothenburg - Kemi | | | | |
| TransPaper | Water temperature | Pt 2000 | SBE Temp sensor 38 | Sea-Bird Electronics |
| | conductivity | inductively | SBE TSG 45 | Sea-Bird Electronics |
| | turbidity | light scattering (blue) | FLNTURT | WETLabs |
| | chlorophyll-a | fluorescence | FLNTURT | WETLabs |
| | Phycocyanin | fluorescence | microFlu-blue | TriOS |
| | CDOM | fluorescence | microFlu-cdom | TriOS |
| | oxygen | | optode | Aanderaa |
| | pH | fluorescent reagent | fluorescence detector | SMHI and the University of Gothe |
| | pCO2 | An equilibrator that balances the C02 in seawater with a head space gas that is analyzed with an infra red gas analyzer | General Oceanics 8050 with Li-Cor LI-7000 | General Oceanics + Li-Cor |
| | air pressure | | | |
| | air temperature | | | |
| | irradiation (PAR, photosynthetic active radiation 400-700 nm) | | BioSpherical Instruments | |
| | automatic water sampler | phytoplankton, salinity, CDOM ,chl-a-analysis | Microscopy, laboratory analysis | ISCO (USA) |
| Helsinki - Stocholm | | | | |
| Silja Serenade | Water temperature | Pt 2000 | SBE Temp sensor 38 | Sea-Bird Electronics |
| | conductivity | inductively | SBE TSG 45 | Sea-Bird Electronics |
| | turbidity | light scattering (blue) | Scufa | Turner Design |
| | chlorophyll-a | fluorescence | Scufa | Turner Design |
| | Phycocyanin | fluorescence | microFlu-blue | TriOS |
| | automatic water sampler | phytoplankton nutrients chl-a-analysis | | ISCO (USA) |

## 4.2. Advice on the planning and installation of a new Ferrybox system

### *4.2.1. Shipping Company*

One of the first steps when planning the installation of a Ferrybox system is to approach the shipping company. As in any business relationship, the first contact will be important for the outcome of the collaboration. Contacts should span different levels of the hierarchy.

- Ideally the relationship should include the senior management of company that owns and operates its own ships. Endorsement at the top level of management then makes it easier for people at lower levels to say yes.
- However the ownership and operation of ships is often separate and tracing the "chain of command" can in reality be more difficult than you would expect. This means the people you talk to such as the ship's captain may not be able to say yes as quickly or as often as you or they might like.
- The captain and first engineer are responsible for getting access to the ship for all operations on the ship. For them the safety of the ship is their paramount concern. Any request for support from the ship must be passed through them.
- That said the ship's crew may be able to provide considerable help installing and maintaining a system. The degree to which this may be the case depends on the size of the crew and the management structure operating the ship.

Environmental concerns and IMO regulations with respect to "green" ships mean that many companies are interested in helping when approached. "Web-displays" of data from the systems can be of interest for the company to help promote a good image.

A Ferrybox installation is a constantly evolving system. New sensors may need to be implemented, systems break down, the ships system themselves may be modified and ships routes may change. Whatever the source of the problem, a good relationship with the ship's crew at all levels is of invaluable importance.

Other points to consider are:-

- Stability of the company: how often they have changed owners, registrations or routes in the past.
- The likely stability of route is important - find out how often the company moves its ships around (e.g. moving people and bananas tend to be stable trades, moving cars and oil much less so).
- Stability of the crew: some companies keep the same persons on the same ships, some move their staff randomly on their ships (this issue might be delicate or difficult to discover).
- Working conditions, nationality and language capabilities of the crew need to be taken into account for instance maintenance instructions may need to be in more than one language. Often the officers may be European and the crew from the Philippines.
- Specific regulations and routines on board may apply in different companies and on different types of ships

Keeping in mind the stability of contacts on board, it is an important advantage if the crew are not changed too often. This opens the possibility developing interest of the crew in the system so they feel a part of your science team as well as the ship's company.

Following the regulations and routines on board is also of critical importance in order to avoid conflicts and degradation of relations.

### 4.2.2. Ship Type

Ship type and its primary use (ferries or cargo ships) will influence where and how easily a Ferrybox can be installed and operated.

- All ships tend to be different even ships of the same class supplied to the same company.
- Ships need to be inspected carefully to find the most appropriate location for equipment.
- The category of regulations applied on board varies.
- Your water inlet must be ahead of outlets for black and grey water from the ship (sewage and other contamination)
- As stated above, work by the crew or for the ship's operators may interfere with the Ferrybox installation: This can range from dry docking and modifications to the ship to the frequency and methods used for washing the Ferrybox room (Is your system water proof if the room itself is hosed down. will heavy oil and the vapour depositing in your system damage it?)

All ships at present will present some levels of technical challenge for your installation. The space available on the ship and the quality of services on board such as electrical power supply are dependent on the design of the specific ship rather than say the age of the design. Newer ships may provide more and easier possibilities for installing cabling either through appropriate trunking or the existence of ”spare cable runs”. Also on newer ships, where assistance is available from the shipping company, access to the ship's system signals may be possible (e.g. navigation, gyro etc.). For connecting the Ferrybox data-system to shore possibilities are increasing as ships are increasingly installing open satellite communication systems so the crew can watch television for example. The ship may also be interested in for example better wind instruments that might be part of some Ferrybox systems. The ships's engineers may welcome seeing where the ship actually is if the Ferrybox data is shown on a screen in the engine space where the Ferrybox is located.

The way the ship behaves at sea may also influence the placement of the Ferrybox installation on board.

There are examples of problems of finding the right location taking a few years to solve. You should be aware of the experience now available in the Ferrybox community. They can provide more practical advice on such things than we can give here. Cargo ships can roll to high amplitudes and periods, while passenger ships try to avoid this with the help of stabilisers. The water line can also vary by several meters on the same ship with the time of year so the water sampled will come from different depths relative to the sea surface. Travelling on a potential ship is recommended to inspect levels of vibration when the ship is underway. They will be higher and in some ships much higher than when the ship is in port. On such ships careful shock mounting or bracing may be necessary.

Sharing of experience within the Ferrybox community and teams operating ships of opportunity systems on deep-sea routes is important. For collecting information on which types of ships are the best platforms. A particular concern to all is bubbles. Bubbles can effect sensor reading e.g. for salinity or acoustic measurements (such as Doppler Profiling). They can change concentrations of oxygen or other gases in the water. Bubbles can be produced in the bow wave and when a ship rolls. Bulbous bows are a ship design feature specifically for inducing bubbles which reduce friction and drag below the ship. The community needs to know more about these effects on different designs and classes of ship and how they may change with the speed at which ships operate.

### *4.2.3. Route*

The choice of the route also determines the technical solution needed for any given installation.

- To some extent, the main purpose of the Ferrybox installations (monitoring or science) dictates the frequency with which a route needs to be repeated. Short repeat rates of hours to a few days are useful where biological processes are of dominant interest to every few weeks if the main target is changes in the $CO_2$ system for example.

- Long routes will reduce the possibilities to service the system.
- Long port calls may leave the Ferrybox system in a standby state that promotes bio fouling.
- Short port calls make the servicing difficult and staff may need to travel with the ship to do the work. (The duration of port calls range from a few hours to few days).
- It is an important factor that the ship stays on the same route long enough for a valid data set to be obtained.
- It should be considered if the speed of the ship and speed of flow of water to the sensors will allow data to be collected at the resolution you need.

### 4.2.4. *Regulations*

It is out of the scope of this document to describe the different regulations that may apply. However, meeting the regulations surrounding ship operations must be included in any project plan and then the subsequent operations. The shipping company will know what regulations must be met.

Regulations depend on the type of ship, the national waters it is navigating and the port of registration. They may be different from ship to ship and this must be taken into account if moving a Ferrybox system from one ship to another one.

Other routines applied on board and within the shipping company may not be part of the official (say IMO) regulations, but are nevertheless important to understand. This may be as simple as knowing the meal times but when you have staff sailing with the ship, these can be important.

### 4.2.5. *Working Space*

Having adequate space around the system for working and servicing is important. Too small a space will decrease the ability to service the system and reduce its reliability. The ability to inspect for leakage into the ship is absolutely critical.

Accessibility to the area of the ship where the system is or will be installed is important since heavy parts and/or bulky items may have to be transported during installation or replacement activities.

When considering automatic, remote or manual servicing and work close to the Ferrybox installation, check for the availability of facilities such as fresh water, power and internet/cable runs.

In order to avoid failure of electronic or mechanical moving parts, the ambient temperature in the room hosting the system should not exceed a certain value, and the atmosphere should be as clean and dry as possible. Routines onboard will determine to a large extent the last condition, such as welding and water splash activities. Some spaces onboard may have stronger regulation on electrical installations (IP-class, air and gas under pressure).

### *4.2.6. Inlet*

The source of water used should be as close as possible to the Ferrybox installation. This is to avoid contamination both by heat, fouling of the line and other potential changes in water properties. Some sensors like inlet temperature or oxygen can be placed just after the inlet valve.

Different ships may present different opportunities for obtaining water depending on the size and design of the ship:-

(1) A direct intake with a penetration through the hull may be possible (see note below on regulations) this will require the Ferrybox system to have a dedicated pump(s) to drive or pull water through the system and then return it through a hull outlet to the sea. If the Ferrybox is above the ships water line the ships drainage system can be used. Penetration of the hull can only be added in dry dock and must be certified. The inlet must be suitably positioned to minimise the possibility of bubbles being drawn into or induced in the water being sampled.

(2) Water can also be drawn in from the sea chest, this may be more accessible than a simple hull penetration and the sea chest is designed to reduce air bubbles being pumped into the ships internal cooling water systems.

1 and 2 require emergency shuts off valves to be installed as part of the system to enable the Ferrybox system in and outlets to be sealed quickly if a leak were to occur.

(3) Connection to internal ship circuits system is possible (and less regulated) and can be made at any time the expertise available. Suitable designs can avoid the installation of dedicated water pumps. A key point is to know is the quality of the water. Biofouling chemicals or chlorine generations systems may be used on board and one must avoid them being drawn into the Ferrybox system. One solution to avoid this is where it is available is to use water drawn in for the ships drinking water making system (this is usually pumped at high pressure to a reverse osmosis used to purify the seawater).

Regulations onboard will determine how and where it is possible to install an inlet. Installation of separate penetrations and valves requires certification by a classification society such as Veritas or Lloyds.

### 4.2.7. Pump

If the system is designed with an independent water take off point different types of pump are available, for example peristaltic or impeller pumps. It is not straightforward to define which types are better. In a peristaltic pump, moving parts are not in contact with the liquid. Therefore, they may be less subject to corrosion with time. On the other hand, the tubing parts of peristaltic pumps must be replaced at regular intervals.

When choosing the pumps, one should also consider if the pump might modify some of the water properties being measured. For instance, for many systems where biological measurements are a key part of the operation, the pump should not damage phytoplankton cells.

### 4.2.8. Types and dimensions of water supply lines

Regulations onboard will determine the category of pipes to be used for pumping and flushing water through the system. All piping or hosing used to carry water to and from the system will need to meets the ship's requirements for burst pressure. Its diameter should be appropriate for the flow rate needed and the pump used. Replacement costs and availability of replacement parts should be considered.

### 4.2.9. Include Servicing in Design

When designing the inlet or outlet, one should consider repair and servicing activities. A critical factor to consider is the ease of replacements of supply hoses or pipes. Supply piping does biofoul so it should be replaced at least annually particularly if say potentially sensitive measurements of oxygen and $CO_2$ are being made. The installation should allow this to be done easily.

### 4.2.10. Valves

For direct penetrations through a hull or into the sea chest the use of ball valves at the inlet and outlet are recommended, as these make it possible to clean the parts through the hull when the ship is in dry dock.

### 4.2.11. Choice of System

There are now commercially available Ferrybox systems to complement system developed by different institutions. A basic design point which affects where and on what ships a system can be installed is if the water circuit is open or closed. In a closed circuit, water is pumped through the system using a single pump and no free water surface is involved reducing the risk of leaks and flooding. So such a system is more acceptable to a wider range of ship operators. In an open system water is pumped into the ship's systems such as $CO_2$ equilibrator form where it flows into a reservoir tank which then has to emptied and pumped out of the ship using a second pump. This generates a higher risk of leaks and flooding and may be less acceptable to some shipping companies. Other arguments to consider when taking a decision on the choice of system include:-

Is the range of sensors and their accuracy what you need?

Will a third party system fit in the allocated place on the ship?

To install it, would it have to be split in smaller parts and remounted in the ship?

Can extra sensors be added in the future?

Does the system use standard parts available locally?

How open is the system hardware and software to user modifications?

Will the logging software allow data from the ship's system to be included (GPS, Wind, Gyro)?

Is it possible to modify settings and software using an external communications link to the ship from shore?

#### *4.2.12. Include Servicing in Design*

When designing the piping system, one should take care to consider servicing, cleaning and repair activities.

It is strongly recommended to use ball valves at the inlet and outlet. The use of unions between pipes at adequate places in the system provides a handy way for maintenance. A careful choice of both ball valves and unions at inlet and outlet provides an easy way to clean them from the inside.

#### *4.2.13. Dimensions of Pipes*

Together with the pump used, pipe dimensions will determine to a large extent the flow through the system. Whether one should have a fast or low flow in the system will depend on the sensors used. However, flow rate has an upper limit determined by the production of bubbles.

#### *4.2.14. Electrical Considerations*

#### *4.2.15. Regulations*

Regulations onboard may define the type of electrical hardware that is allowed on board (IP class). This will be the case if the platform or its route is related to production of gas or other inflammable matter.

#### *4.2.16. Onboard Routines*

Check on board routines and existing installations in order to get a stable and reliable power supply.

#### *4.2.17. UPS*

An uninterruptible power supply in true-line or online mode is strongly recommended. It not only provides a power backup if the ship mains should drop, it also regulates the input power and acts as a filter against spikes. Make sure the specification of the UPS matches the power requirement of the installation and can deal with the duration of likely losses of power.

#### *4.2.18. Power Consumption*

The power consumption of a system must be known before its installation. A typical installation will work well with 16A/220VAC, if a pump is included. The core sensor system may need less than 1A. Power requirements will increase in complex systems that for example include robotic samplers and low temperature (-80 $^{o}$C freezers).

## 4.3. Overview of potential advances resulting from the work of the JERICO project

The first JERICO WP3 workshop which took place at HZG end of August 2011, brought together partners working in both WP3 (Harmonizing Technological Aspects), WP4 (Harmonizing Operation and Maintenance Methods) and WP5 (Data Management and Distribution). WP4 and WP5 are closely related in working to harmonise the different procedures used by different operators.

The first part of the workshop considered the present status of operations and past experience that can be built on to establish new routes. These two areas have been reported on above.

The expectation of the JERICO project is that the greater harmonisation and coordination of operations can enhance the power of an already cost effective tool for delivery of information critical to the successful implementation of European policies such as the Water Framework Directive. Once data has been captured the expectation is that a high level of commonality in processing can be achieved and a JERICO “quality stamp” will be possible. The “stamp” would demonstrate that an agreed system of best practice had been applied to the processing and validation of the data and production of the archived data stream. This will be achieved through work across the three Work Packages, WP 3, 4 and 5 and be aided by research led initiatives supported by WP10 (Improved Existing and Emerging Technologies).

Two data streams will be produced by the systems. First are the near real time data sets that are required by MyOcean. The second are the fully quality controlled data sets (accompanied all appropriate meta data) that will be archived in national data bases (which are linked by SeaDataNet protocols). This data will be made universally searchable and accessible through activities such as EMODNet and EMECO. The Ferrybox data streams will be aligned with other JERICO data streams from gliders and data buoys.

At the JERICO WP3 workshop on Crete in October 2012, three main points have been discussed: FerryBox best practises regarding calibration and biofouling and platform-depending end-to-end quality assurance.

On the subsequent workshop in April 2013, held in Helsinki, the main topics have been the FerryBox handling and best practises, as well as the status overview of developments of sensors and of JERICO User Display (JUD). Also the introduction of a JERICO label for data quality assessment has been discussed.

### 4.3.1. *Data transfer*

#### 4.3.1.1. JERICO-Ferrybox near real time data sets in the context of MyOcean (*www.myocean.eu.org)*

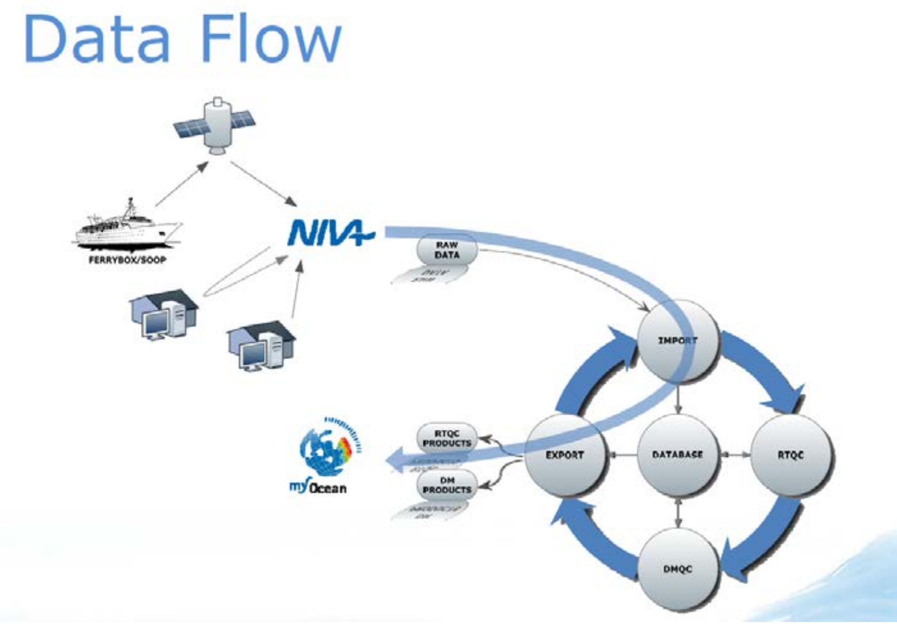

Figure 4.3.1.1. Data flow of Ferrybox data in the MyOcean QC

At a global and EU level a number of initiatives now exist which potentially provide an overarching framework for Ferrybox operations and which also need the data collected by Ferrybox systems. At the first workshop Dominique Durand (NIVA) gave an overview about the role of JERICO in Operational Ocean Observations, infrastructure projects and related EU initiatives. He explained the role of Ferrybox systems in MyOcean (see Jaccard et al., (2011) Annexe link-2). The Ferrybox data is acquired from vessels through various sources (mostly ftp servers). Any format of data can be imported, such as ASCII text files or MyOcean netCDF files. After the import and before export to the MyOcean FTP server, all data go through a Quality Control (QC) check - a defined procedure of checking and QC flagging. The netcdf format of metadata, data variables and QC flagging is set by OceanSITES v1.1. The MyOcean Ferrybox data is provided both as "latest" and as monthly netcdf files.

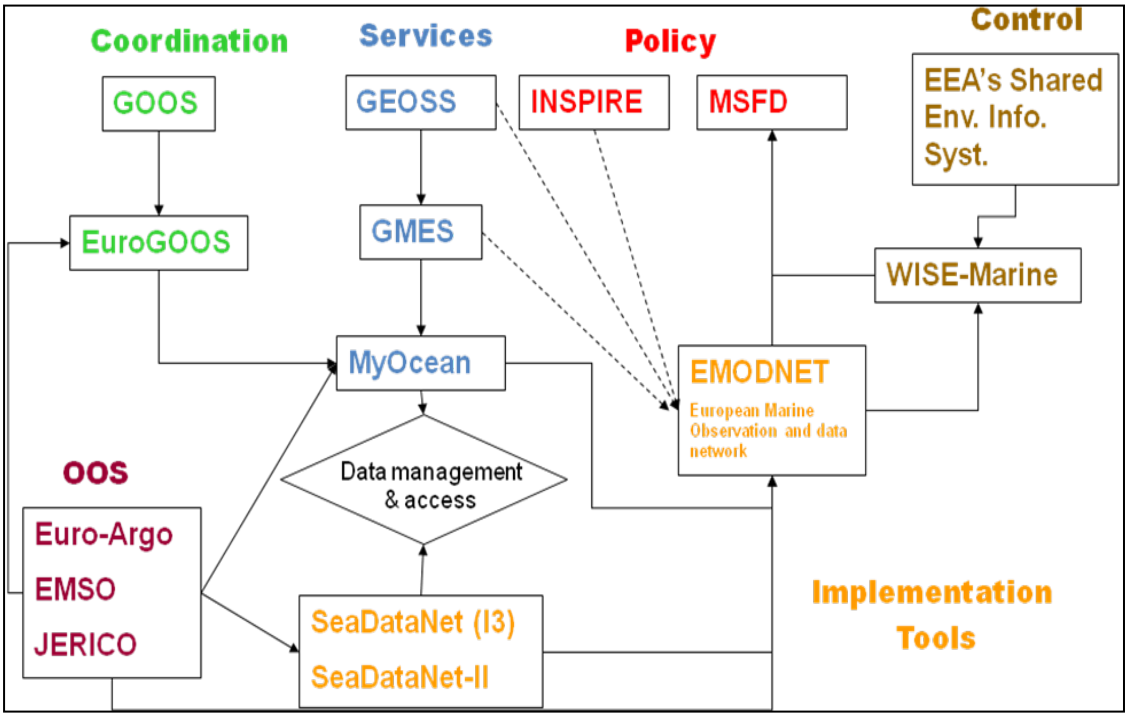

Figure 4.3.1.1. Summary diagram the relationships between the range of European operational ocean observations and the associated flow of information (from D. Durand)

Final archiving of data to be used for example to meet the needs of the Marine Strategy Framework Directive (MSFD) should be linked to the European Marine Observation and Data Network (EMODNet). EMODNet has the potential to link existing and developing European observation systems, by providing a common data management structure across European data centres. This should facilitate long-term and sustainable access to the high-quality data on bathymetry, biological, chemical and physical parameters. Currently cross linkage of the data centres and access to the data is being tested through the development of data portals. EMODNet will be mechanism for providing data to WISE-Marine, the marine component of the EEA's Shared Environmental Information System (SEIS). WISE-Marine is intended to fulfil the reporting obligations of the Marine Strategy Framework Directive. The relationships of these activities are shown in Figure 4.3.1.1. It will inform the public on indicators for Good Environmental Status of sea basins. EMODNet exists at EU level within the INSPIRE directive and large-scale framework programmes on European and global scales (GMES and GEOSS) (See Annexe link - 3).

The SeaDataNet project (www.seadatanet.org) provides the data tools and common vocabularies needed for the implementation of the EMODNet data access management processes and establishing practical interoperability with other GMES, GEOSS, and WISE-Marine activities. The important point being (relative to MyOcean) is that data needs to be archived with the full complement of meta data (which will confirm its reliability) this should be done via national data centre following SeaDataNet procedures and linked across Europe by EMODNet.

A task of the JERICO meeting in Crete (October 2012) is to define a “roadmap” for fully developing the links between MyOcean and the potential providers of near real time data from Ferryboxes that are useful in the context of the activities of MyOcean.

In Crete as well as in Helsinki, the links of JERICO to MyOcean and EMODNet has been discussed. FerryBox data of JERICO partners are going continuously to the MyOcean ftp server, but are also stored in the HZG data base including visualization tools.

#### 4.3.1.2. Data Management and Distribution - In context of MyOcean

At the HZG workshop in 2011, Rajesh Nair (OGS) gave a presentation concerning Ferrybox data from the WP5 (Data management and distribution) perspective. The idea being developed by WP5 is that operators of Ferryboxes would cooperate with MyOcean developments of Ferrybox data handling methodologies and quality assurance procedures as being the basis for establishing common standards and practices across the community.

The following action need to be worked on:-

1. Data should be managed/distributed using the MyOcean infrastructure and procedures.
    a. Real-time Ferrybox data will be routed through Task 5.3 of WP5. This task will also manage the necessary interaction between JERICO and MyOcean.
    b. Delayed-mode Ferrybox data activities will be routed through Task 5.2. This task will also manage the necessary interaction between JERICO and SeaDataNet II.
2. In the context of these ideas the degree of real-time data transfer that can be achieved in different systems on different ships has to be established by the different JERICO partners operating Ferryboxes. In the first instance a number of basic problems need to be addressed, including the feasibility of installing data transfer systems or linking into the ship's own systems (the capital and running costs involved need to be considered).
3. In terms of data QA realistic expectations of the quality targets of each parameter need to be explicitly defined by the group. For example for salinity the target precision would better than ± 0.05.
4. OGS (Partner 8) are preparing a Data Management Handbook. This will define the approaches that need to be taken for automated QC of the data. In the context of JERICO this needs to be aligned with activity planned in WP10 for developing related algorithms. A mechanism for promoting uptake of these procedures by the different operating partners needs to be established. This could be done through a training workshop. More details have been presented on the JERICO workshop at FerryBox meeting in Helsinki, April 2013. A platform for algorithm programs for QA has been launched by WP10 in autumn 2013 and will be further developed.

### *4.3.2. Quality control*

Within the structure of the JERICO Project the development of common quality control efforts is shared across the three work packages WP3 (Harmonizing Technological Aspects), WP4 (Harmonizing Operation and Maintenance Methods) and WP5 (Data Management and Distribution).

With respect to the operation of Ferryboxes (WP3) the focus is on the physical-practical activities needed to provide a validation pathway for the measurements that will be reported in the meta data set, such as: (i) the use of pre and post calibration of instruments either in the home laboratory or by the instrument manufacturer e.g. $pCO_2$ (ii) validation of measurements through the contemporaneous collection of samples of water which are then analysed in the home laboratory for the same parameter as is measured automatically in the Ferrybox system e.g. salinity) (iii) the use of inter-laboratory calibration exercises to cross check between laboratories e.g. annual workshop on chlorophyll-fluorescence instruments organised by SYKE within the work of JERICO.

Production of the fully QC'd delayed-mode data activities will be aided by WP5 Task 5.2. This task will also manage the necessary interaction between JERICO and SeaDataNet II. Task 5.2's aims are:

#### 4.3.2.1. JERICO WP 5 task 5.2

This task will define, establish and oversee the data management infrastructure for dealing with delayed-mode data in JERICO. The infrastructure will be designed so as to supplement the EU funded SeaDataNet initiative aimed at setting up an efficient distributed-pan-European marine data management system. An assessment will be performed to test the performance of the system once it is running (OGS). The availability of services offered by the infrastructure within JERICO will be continuously monitored and reported (HCMR).

Methodology

1. Survey the existing delayed-mode data handling practices of JERICO partners.
2. Formulate a viable proposal for a common JERICO delayed-mode data management platform that can serve to reinforce the SeaDataNet effort; the guidelines established by DG-Mare/EMODNET and WISE-Marine will be also taken in account when doing this.
3. Create common vocabularies for JERICO delayed-mode data formats and meta-data-bases, building upon the work that has already been done in SeaDataNet.
4. Implement delayed-mode data and metadata formats that are compatible with those of SeaDataNet (in compliance with the EU INSPIRE Directive); the Sensor Web Enablement family of the OpenGIS consortium family of standards (SensorML, Sensor Registry, O&M) will be considered in the implementation.
5. Reconcile, wherever possible, the data quality assurance procedures/protocols for delayed-mode data amongst the JERICO partners (link to WP4, WP5.1).
6. Ensure easy sharing and secure archival of delayed-mode data within JERICO by employing common data transport formats and storage criteria making use of the experience gained by SeaDataNet.
7. Furnish users with standard tools for online data access and visualization.

A task of the meeting in Crete (October 2012) is to define a “road map” for the delivery of this effort to the Ferrybox operating partners. Work has been done for developing a JERICO User Display (JUD) which can be installed on ships of opportunity for providing real-time data to passengers. On the FerryBox meeting in Helsinki it was discussed that there are still technical problems as well as there is rather low interest by the shipping companies so far.

#### 4.3.2.2. Quality control flagging

A basic dichotomy exists in reporting of the near real time data (MyOcean) and the delayed mode data (SeaDataNet) in terms of the time allowed for quality control and the capacity of the receiving system to accept QC-related-meta-data. In the case of MyOcean the capacity is limited while in the case of SeaDataNet the capacity tends to being infinite. In the first case MyOcean sets the limits. In the second case agreement has to be reached between data producers and data users on what meta data is actually needed for a data set to be valid (validate-able) and useful.

Key to improved data use is the reporting of appropriate meta data. The simplest form is the data quality flag attached to the reported data. So the first stage for validation of data is the setting of quality control flags by the data provider and understanding of those flags by the data user.

JERICO has to ensure that consistent data flagging is used across all its data sets. In MyOcean all data will be flagged according to the recommendations of the SeaDataNet and EuroGOOS Data MEQ working group. For real-time or near-real-time data flags 0, 1 and 4 are mandatory, Table 4.1).

For the final reporting of delayed mode data, reporting should follow the best practice being set by global expert activities. The Ocean Data Standards Report (http://www.oceandatastandards.org/) is recommending splitting data flagging in two parts. The primary layer must be simple and strictly limited to data quality with unambiguous definitions of flags. It should offer quick access to quality information to assess the fitness for purpose of the data. The second layer provides information justifying the quality flag applied at the primary level and information on data processing history. The proposal is intended for all local, national, and international bodies, programs, and projects that exchange oceanographic and marine meteorological data. It applies to all instances where quality flags are used to inform the users of the quality of oceanographic and meteorological data.

| Table 4.1 MyOcean data quality flags | |
|---|---|
| code | Meaning |
| **0** | no QC was performed |
| **1** | good data |
| 2 | probably good data |
| 3 | bad data, but correctable |
| **4** | bad data |
| 5 | value changed |
| 6 | below detection limit |
| 7 | in excess of quoted value |

There are five primary data quality flags, similar to the MyOcean and SeaDataNet flags. The idea is the flag order is monotonic to aid a user. A link to the full proposal for this flagging scheme is provided in the Annexe link - 4.

### 4.3.3. Harmonising operations

Within the concept of the JERICO project it was seen that harmonisation of activities should centre around (i) distilling recommendations for best practice from existing experience and (ii) reviewing existing physical support facilities and seeing if they could be shared between user groups rather than the work all being done by each laboratory on an individual basis. If this latter action is to be taken forward in future a practical "cost model" will need to be developed for after the end of the JERICO. The approach being taken is to consider three highlight activities that are of concern to all operators. These are the (1) the calibration of instruments (2) preventing biofouling of sensors and (3) having a quality assurance in place at all stages of the operation from field work to the archiving of data. The work is separated into further subtasks for each of the platforms (Ferrybox, gliders, data-buoys) plus a further subtask specifically to assess running costs.

A similar approach is under way in all these fields, the first stage being finding out what is happening through the use of questionnaires, then analysis of the information in the replies the next stage being the development of an implementation plan which should start to be discussed at the Meeting in Crete in October 2012.

In all sub tasks we have three major actions:

#### 4.3.3.1. Calibration

In all sub tasks we have three major actions:

1. Harmonization of calibration practices through documentation and assessment of existing calibration methodologies.
2. Sharing of calibration facilities.
3. Best practices, dissemination of know-how.

#### 4.3.3.2. Biofouling

1. To describe all different methods used across the network with reference to the cost (implementation, maintenance) and adaptability (different sensors and areas). Following the results from the questionnaires, two workshops will consider best practices and methodologies.
2. To share best practices and methodologies.
3. To evaluate new methods used by the community external to JERICO. A key discovery action in work on biofouling is to find out which are the more reliable sensors, and assess why they are less prone to biofouling.

#### 4.3.3.3. End-to-End QA

1. To describe best practices in all phases of the system (pre-deployment test, maintenance, calibration etc).
2. To adopt common methodologies and protocols.
3. To move towards the harmonisation of equipment with an expectation of thereby reducing maintenance and calibration costs. For this activity inter calibration tests and in-situ validation exercises will be organised and linked to Calibration and Biofouling task activities

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## Annexe - Weblinks

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5. The vision statement of OceanScope is "In partnership with the maritime industries an integrated approach will be developed to observation of the global ocean on a regular and long-term basis as an essential component of, and contribution to, the Global Ocean Observing System (GOOS). This activity, 'OceanScope' will equip commercial ships with fully automated unattended instrumentation to accurately measure and report upon the currents and the physical, chemical and biological characteristics of the water column throughout the world ocean. The freely distributed data generated will be a fundamental resource for understanding the climatic state and health of our planet." The full report can be downloaded from http://www.scor-int.org/Working_Groups/wg133.htm.