Paper 132 - Smart Navigation System for the Port of Seville

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ABSTRACT: This paper focuses in the development of an information platform for rivers and integrated navigation aid system in waterways. The proposed system will not only offer vessel traffic services (VTS) and other RIS basic services but also those advanced and customized services of interest for the Port of Seville. This system, eRIO, is being developed under the project TECNOPORT2025 which is initiative of the Port Authority of Seville, co-funded by the European Commission by means of the European Region Development Funds, under the Pre-commercial Public Procurement model aiming the "Port of Future".

1 INTRODUCTION

The Port of Seville is the only inland seaport in Spain being the waterway from Seville to the coast is part of the TENT Trans-European Transport Network with the name of Guadalquivir EuroWay E.60.20. The Port of Seville is an important logistics hub that serves a population of over one million people and maintains a leadership position in some logistic corridors such as the Madrid-Seville-Canary Islands one. The Port Authority of Seville (PAS) launched in 2014 the TECNOPORT 2025 project, conducted by the University of Seville in collaboration with five leading companies in their respective fields. An important subproject within TECNOPORT2025 is called eRIO (eRiver Information and Optimization), aimed at improving the navigability of the EuroWay, and at the adoption of RIS (River Information Services) standard adapted to the specific needs of the Guadalquivir River.

eRIO project comprises two subsystems, one of them devoted to manage information of the waterway, which is aimed at capturing data coming from a network of sensors deployed along the river that provide environmental data and navigation data (such as non AIS – Automation Identification System - target detection, height of the tides, etc.), together with an intelligent navigation system based on a Port Monitor and a Portable Pilot Unit (PPU) along with a system for traffic optimization and planning in the waterway in order to improve its capacity and optimize the management of resources, increasing the added value to all actors involved in port activities, and the security of navigation.

Figure 1. A view of the "Batan" dock at the Port of Seville with the container terminal at the rear.

This paper presents the eRIO project, its objectives, components and expected results. The TECNOPORT2025 project (and consequently the eRIO subproject) ends in December 2015 with a demonstration of the different systems and tools developed in the project. These systems and tools

will be later converted to commercial products that satisfy the PAS needs and simultaneously provide innovative solutions to other inland ports with similar characteristics.

The CUTS project is being developped by the University of Seville and Portel. Worldwide Internet access and integration platform are provided by Telefónica.

2. TECNOPORT2025

The Port of Seville, with the aim of making a more efficient port that optimizes its services as an intermodal logistics hub, is committed, as part of its long-term planning, to investment and technology development, especially in three key areas: container tracking, railway traffic optimization and improvement of navigation by the Guadalquivir river.

TECNOPORT2025 is an initiative of the Port Authority of Seville, co-funded by the European Commission by means of the ERDF (European Region Development Funds), under the Pre-commercial Public Procurement model. In TECNOPORT2025 the University of Seville is leading a team of four European companies (Telefónica, Thales, Portel e Isotrol) with a leadership in their respective fields with the aim of building the "Port of the Future". A fifth company, Serviport, provides consultancy related to the activities of the Port. TECNOPORT2025 is conceived as an initiative to enhance existing physical infrastructure by means of an exhaustive use of Information and Communication Technologies (ICTs) in order to optimize their exploitation with the long term objetive of increased growth, while ensuring environmental sustainability, and maintaining a leadership position in some key logistic corridors like the Madrid-Sevilla-Canary Islands one.

To this end, an innovative infrastructure for some key enabling technologies (such as a heterogeneous communication network and a platform for service integration) are being deployed, and three subprojects are being carried out, each one targeted to an area of particular interest to the activity of the Port of Seville: "Container Unitized Tracking System" - CUTS (focused in container tracking), "Ferro Port System" - FPS (focused in railway traffic operation), and "e-River information and optimization" - eRIO (focused in sensor monitoring and enhanced navigation in the Guadalquivir River).

The final result of TECNOPORT2025 will be a set of innovative products, designed to meet the needs of different stakeholders and users of the Port of Seville: the port authority itself, logistic operators, shippers, carriers, consignees, stevedores, ancillary companies, and inspection bodies, among others.

The scope of the project is the construction of a full-scale demonstrator of the overall solution and of each of its components in order to test both, their technical feasibility and their effective creation of value.

The overall solution will lead to the development of new products, which will find an application in other areas with similar requirements, so that the results of the project, in addition to meeting the needs of the PAS, will become commercially exploitable products.

3 eRIO SYSTEM

3.1 *Scenario*

The Port of Seville is located on the Guadalquivir River, about 80 km from its mouth. The Guadalquivir estuary is a natural resource that extends over several tens of kilometers, largely unpopulated areas. In its margins villages and important agricultural areas are located. It is, in part, a large protected natural area. The estuary is an inland waterway, with maritime navigation, being the only inland port in Spain. Of great importance in its operation, navigability is strongly limited by the shallow waters which make it greatly dependent on the tides.

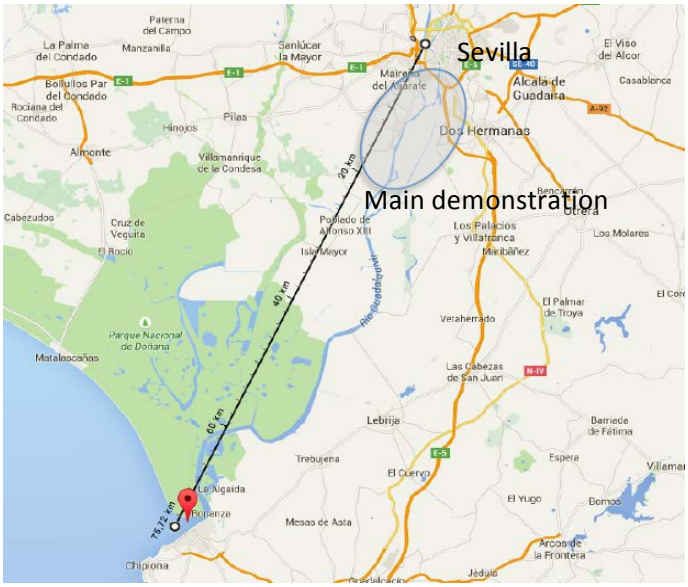

Figure 2. The Guadalquivir EuroWay in the South of Spain, showing the main demonstration area for the eRIO project and the Doñana National Park.

River management in Guadalquivir River is complex, because it has social, environmental and economic implications. A prerequisite for a proper management is to have an adequate handling of complex information. It is complex for several reasons: high volume and variety of data, difficulty

for monitoring such a large area, multiple sources of information and systems that use it (both, own and third party), etc.

In addtion, for a inland seaport, restrictions in the waterway traffic path can be a severe limitation. This limitation is caused by its maximum capacity and for the inconveniences it cause to shipping companies and other stakeholders (coming from delays associated costs, possible incidents, etc.).

The Guadalquivir estuary has been recently incuded in the TENT European transport network (Trans-European Inland Waterway network) under the name of Guadalquivir EuroWay E.60.02.

3.2 *Objectives*

Enhancing the competitiveness of inland waterway transport requires the improvement of inland navigation safety in ports and rivers, the optimization in the management of resources, and the provision of value-added services to all the actors involved in the activity. The deployment of River Information Services (RIS) aims at the achievement of these objectives; however, and according to the report provided by Panteia regarding the RIS implementation in Europe for the period 2006-2011, "… few of the list of services are currently provided… only basic information services are provided." In addition, this report exposes that no activities were yet done in Spain in that direction.

The eRIO project has the challenge to optimize the management and operation of the Guadalquivir Euroway by means of better use (higher capacity, greater security, lower operating costs, etc.), while ensuring environmental sustainability, as well as the adoption of the RIS standard adapted to the Guadalquivir River characteristics. To this end eRIO makes an exhaustive use of ICTs.

eRIO comprises two sub-systems: one concerning information and another concerning the traffic on the waterway.

The information sub-system is a platform that includes an unattended communication network for data monitoring and instrumentation deployed along the waterway, mainly on maritime signaling, and a database that facilitates the integration of data coming from internal and external sources, their visualization and their exploitation by other applications and systems. These data are especially relevant for the administration in charge of natural resources.

The second sub-system (traffic) is an integrated aid system for traffic management in the waterway system, according to a specific adaptation of the RIS standard. It includes support for the skippers, as well for assisting traffic management operators, and some capacity for action on maritime signaling. This sub-system optimizes the use of the waterway.

Logically, eRIO is a set of technological solutions that complement other existing conventional solutions, according to National and European regulations.

3.2 Main Functionality

The main functions of the eRIO information subsystem are:

- Facilitate the installation of sensors along the river and get their readings (synchronous readings or asynchronous events) in near real time.
- Send commands to the control equipment deployed on the river in near-real time.
- Integrate data coming from external sources.
- Facilitate the display of the available information and its exploitation by other systems.

The main functions of the eRio traffic subsystem are:

- Implement a navigation system on the inland waterway (NVIS) as a specific adaptation of the RIS standard, by combining different tools.
- Real-time monitoring of environmental conditions, of the state of the waterway, of the position of vessels (including vessels without AIS), etc.
- Develop recommendations and suggestions concerning the traffic on the waterway both, globally for the Port Authority, and locally for a certain ship, in order to optimize traffic and intermodal operations.
- Provide the navigator aboard Electronic Navigational Charts (ENCs) suitable information for browsing the estuary, selecting proper information and making useful suggestions.
- Provide information and suggestions to other agents involved in the traffic in the waterway (such as other administrations).
- Send commands to the maritime signaling sub-system, with the objective of making a smart regulation of the waterway signalling

Because of the low depth of the Guadalquivir River, an optimum use of the navigable channel requires the maintenance of bathymetric data of a high resolution, superior to current standards, what makes necessary the development of specific tools for the generation of Port Electronic Navigational Charts (PENCs) for the Port of SevilleBecause of the low depth of the Guadalquivir River, an optimum use of the navigable channel requires the

maintenance of bathymetric data of a high resolution, superior to current standards, what makes necessary the development of specific tools for the generation of Port Electronic Navigational Charts (PENCs) for the Port of Seville.

3.2 Beneficiaries

The eRIO information subsystem offers the ability to manage information that requires proper administration of natural resources, providing a technological foundation upon which new information circuits can be easily implemented, and future opportunities or needs (related to traffic, transportation, security, water quality, environment, emergencies, etc.) could be attended. Therefore, the main beneficiaries of the subsystem; therefore the main beneficiaries of the system are those entities which are responsible for natural resource management. In general, it will be the entity that holds the responsibility of them, or specialized agents acting on behalf of that entity.

The eRIO traffic subsystem will optimize traffic on the waterway. In particular, it will increase its capacity, reduce the operating costs and times, raise their standard of security and increase the level of intermodal coordination. Therefore, the main beneficiaries of this subsystem are those entities which are responsible for the organization of traffic in the waterway. In general, it will be the entity that holds the responsibility of it or specialized agents acting on behalf of that entity.

Finally, the eRIO solution is designed to add value not only to its main user: the Port Authority, but also to those key entities involved in the sustainable use of the river and in the optimization of its navigation. It can provide information and tools to some actors such as other governments, navigators, operators, etc. As an example the eRIO project could help to reduce the ship stopover time.

4 TECHNICAL APPROACH

4.1 *eRIO System Specifications*

The main features of the eRIO information subsystem are:

- An almost unattended communication network: The communication network has to be deployed with little effort and to require practically no maintenance for a service life of several years.
- Data platform: New sensors and actuators have to be easily attached to the communication network, and the exchanged data have to be easily integrated in the information system of every stakeholder.
- "Big data" orientation: The platform has to be capable of dealing with a large volume of information, addressing, if necessary, a "big data" orientation.
- Interoperability: The solution has to be based on open standards and has to be ready to include new information coming from third parties (such as external sensors, remote databases, etc.) as well as to deliver the stored information to external systems.
- Low Cost Solution: The solution shall require low investment costs, and relatively low operating costs.

The main features of the eRIO traffic subsystem are:

- Integrated Solution: Despite the subsystem is composed of a set of different components, as it will shown later, they have to constitute a single, integrated solution satisfying the requirements of the main actors that participate in, or are affected by, the waterway traffic.
- Low Cost Solution: The solution shall require low investment costs, and relatively low operating costs.
- Standardization: This subsystem responds as a whole to the design established by the specific adaptation of RIS standard to the characteristics of the Guadalquivir EuroWay.

4.2 *eRIO System Architecture*

The eRIO system comprises three main components:

- Capturing Information
- Assisted Navigation
- Integration Platform

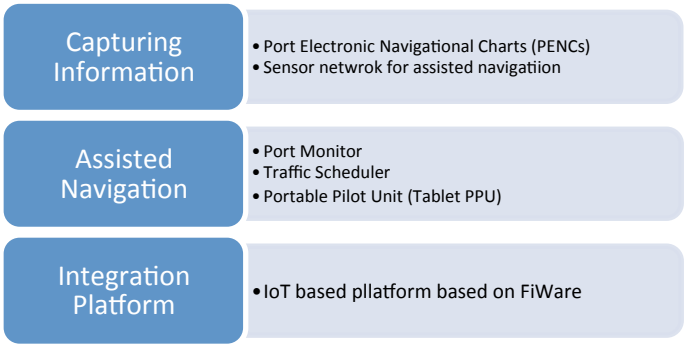

Figure 3. Architecture of the eRIO System.

4.2.1 *Capturing Information*

The eRIO project includes the development of the tools, and the design of the workflow, required to compile the Port ENCs (PENCs) specific to the Guadalquivir EuroWay, where, due to the low depth

of the navigable channel, it is necessary to maintain bathymetric data with a very high resolution. This workflow, as well as its associated tools, have been built on top of a set of current commercial solutions.

The River instrumentation platform is based on multiple segments of local wireless networks deployed on the marine signaling elements (buoys and other fixed signalling elements) forming a network practically unattended. Each point is equipped with a network node that connects a set of selected sensors to the local network. Collected data are delivered to the integration platform (to be discussed later). The network node also drives a set of actuators by means of a set of commands received from the integration platform through the wireless network. This wireless network, based on the IEEE 8014.15.4g standard has been specially designed to accomplish with the stringent requirements of this project.

Figure 4. A sensor for tide height installed in the "Gate of the Sea" lock at the entrance of the Port facilities in the city of Seville. This sensor is wirelessly linked to the integration platform.

The proposed wireless network has a tree architecture to maximize the coverage along the river. The maximum branch depth has been fixed to 3 routers between the coordinator and terminal nodes. The wireless network uses several channels in the 169 MHz band. It allows both, synchronous data transmission suitable for periodic sampling with a guaranteed bandwidth per terminal node, which is especially useful to save power battery in autonomous terminal nodes, and asynchronous data transmission, which is suitable for event driven data sampling or alarm reporting. Although one single stand-alone network would have been desired, two tree sub-networks are necessary to cover the entire estuary. The integration of the data provided by both sub-networks is made in the integration platform.

The eRIO demonstrator, to be deployed in the last quarter of 2015, includes, among others, flow current meters, tide height sensors, meteorological stations, fog sensors, brightness sensors, and a specially developed sensor based on thermographical cameras to detects boats that are not equipped with AIS.

In addition, sometimes, skippers face with the confusion between different signaling elements due to their alignment in the waterway. Since the eRIO system has an accurate position information of ships equipped with AIS, and of the location of the different signalling elements (buoys, beacons and threadings), the intensity of the different lights that mark the course of navigation are automatically regulated by the eRIO system in order to minimize the risk of confusion.

4.2.2 *Assisted Navigation*

The traffic assistance system mainly comprises a Port Monitor software (of the VTS – Vessel Traffic System - type) targeted to Port traffic operators, and an onboard computer (PPU type) for the navigator. It allows to send commands to the maritime signaling and applies an optimization logic to the problem of traffic managment in the waterway. So, depending on the present vessel position, the current depth of the navigable channel, the general state of the waterway, the ETA (Estimated Time of Arrival), and the computed trajectories for the nearby vessels, it prepares the corresponding specific recommendations for the short-term navigation.

A specific adaptation of RIS standard to the characteristics of the estuary defines the System Information Waterway of the Guadalquir EuroWay, where the services offered to the various stakeholders are described. Most of the items in he RIS implementation guidelines have been carefully analyzed, adapted and transposed to the special characteristics of the Guadalquivir River.

One of the remarkable characteristics of the maritime inland waterways such as the Eurovia Guadalquivir, is the influence of the tides along the riverbed. The eRIO project has developed a scheduler which takes information on the historical tide, the channel bathymetry, and real-time readings of the level of depth of the river to provide present and future information about the navigable channel depth along the waterway.

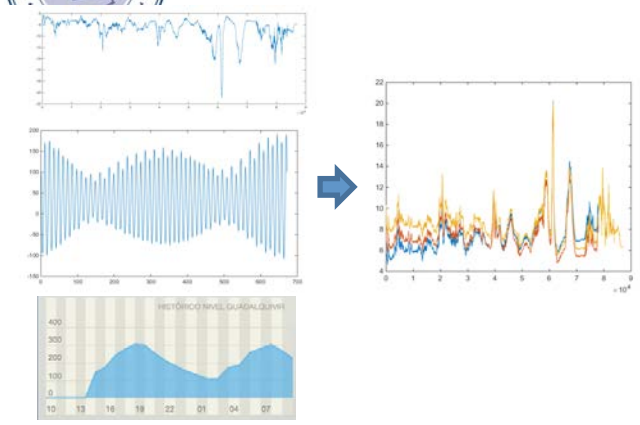

Figure 5. .Example of captures coming from the TECNOPOT2025 project, s part of the Port Monitor,

Once the channel depth has been projected in the short and medium terms, it is possible to determine the most appropiate position of a vessel in the the up- or down-stream convoy, and to propose time windows for vessel passage at selected channel points where sedimentation imposes major limitations of seaworthiness.

This information, along with the requests for docking submitted for vessel, and, in every case, according to the Port general rules, is used to optimize the navigation plan.

4.2.3 *Integration Platform*

TECNOPORT2025 requires an integration platform that collects the information coming from the sensor network deployed in the estuary, in the port facilities and in the means of transport (trucks, trains, etc.), stores them in a distributed database and serves them to the different services and applications used in the project. To this end, an innovative platform is based on FiWare has been used. FiWare has been pushed by the European Commission in the Future Internet initiative.

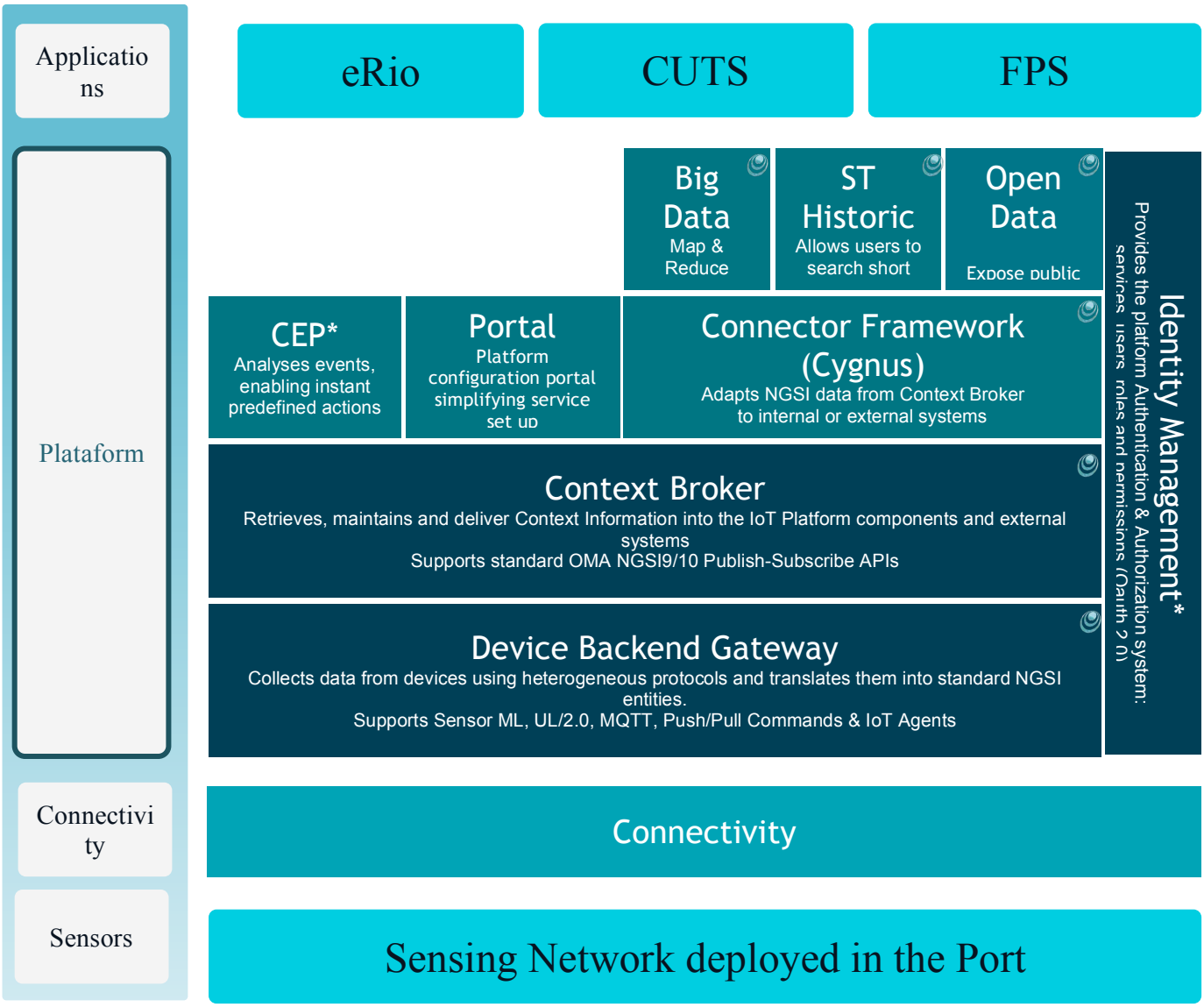

Figure 5. Architecture of the Integration Platform based on FiWare.

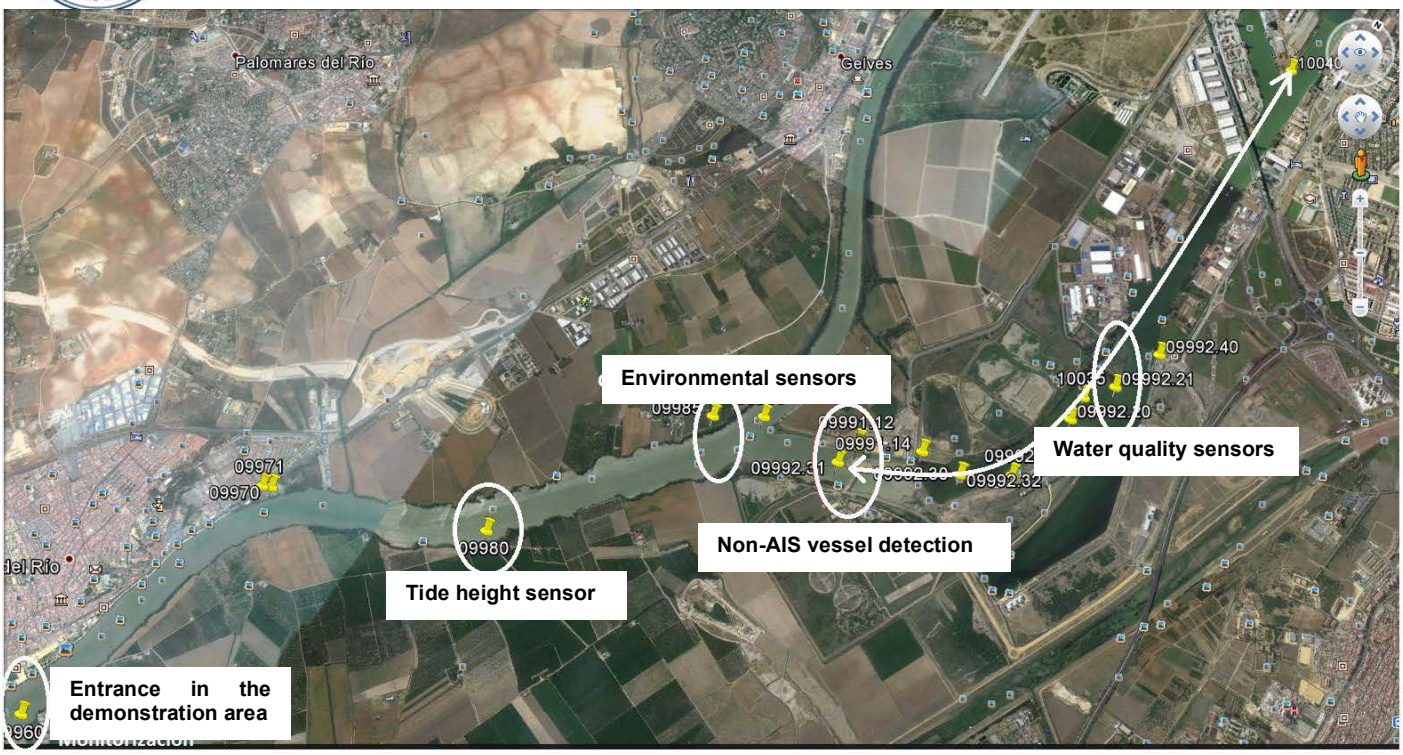

Figure 6. A detail of the proposed demostrator for the eRIO project, showing the location of some of the sensors deployed in the demonstration area.

FiWare is an open cloud-based infrastructure for cost-effective creation and delivery of Future Internet applications and services based on the Internet of the Thing (IoT) paradigm. The API specification of FiWare is open and royalty- free, driven by the development of an open source reference implementation which accelerates the availability of commercial products and services based on FIWARE technologies.

The involvement of users and developers is critical for this platform to become a standard and reusable solution FiWARE targets a variety of areas, including smart city, sustainable transport, logistics, renewable energy and sustainability.

The same integration platform can receive information from various external systems (such as other administrations) and the available information is made available for exploitation by own or third party systems.

5. eRIO DEMONSTRATION

The eRIO demonstrator will be deployed basically in a zone of the estuary between Coria del Rio and Sevilla, which is near the "Gate of the Sea" lock located at the entrance of the Port facilities in the city of Seville. It will be in operation at the late September and will show the functionalities of eRIO system in real conditions

REFERENCES

Evaluation of RIS Implementation for the period 2006-2011. Main Report. Panteia, Zoetermeer, July 2014.

Electronic chart display and information system for inland navigations (inland ECDIS): 909/2013;

Implementation guidelines, RIS Guidelines: Commision Regulatiom (EC) No 414/2007, of 13 March 2007

FiWare Homepage: http://www.fiware.org/

TECNOPORT2025 Homepage: http://www.tecnoport2025.es