JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 37 - 46

ISSN: 1697-4040, www.jmr.unican.es

SHIPPOL, Towards an Automatic Green House Effect Gases Tracing and Accounting System in Harbor Areas by Using AIS Technology

S. Velásquez[1] and F. X. Martínez de Osés[2,*]

ARTICLE INFO

Article history:
Received 12 July 2013;
in revised form 27 July 2013;
accepted 08 October 2013

Keywords:
GHGs, AIS, GIS, Data Base, LRIT, Global Warming, Wireless Sensors.

ABSTRACT

Identification, tracing and monitoring of ships have been widely exploited by means of the Automatic Identification System (AIS). Considerable improvements in safety, collision avoidance and vessel traffic services operations (VTS) have been reached since the system was mandatory in 2002 and applied to ships built on or after 1 July 2002 and to ships engaged on international voyages constructed before 1 July 2002[1]. Nevertheless, the possibility to storage, exchange and exploit dynamic and static information, for other reasons different to those mentioned above, can result in complementary associated phenomena analysis in shipping industry. Because of the possibility to observe and identify a vessel in a specific place and time, dynamic parameters like speed and position can be linked to the identification vessel data services in order to compute real time fuel consumption and therefore, the volume of pollutant gases emissions, providing more precise air pollutants emissions accounting different than the fuel consumption declarations. With this assumption, we have proposed a model which applies identification and speed information from AIS, and in consequence, the type of engines operating during the voyage, extracting data from public EQUASIS databases. With the help of Geographic Information Systems (GIS), real time and dynamic air pollution data can be computed and mapped in congested waters. Critical infrastructures like ports and its surroundings need other kind of data treatment because of the manoeuvring operations during berthing or piloting, most of them under different consumption conditions in the main engines. The present paper shows our first steps in analysing a suitable mathematical model which fits the three components (earth observation, communications and navigation satellite, airborne and land data acquisition) in air pollution from shipping dynamic mapping. This is our first step to approach to an Automatic Green House Effect Gases Tracing and Accounting System..

1. Introduction

Considering the current global freight and the international carriage of goods growths, maritime transport continues being the main option to carry cargo, considering its cost effectiveness, fuel consumption efficiency and low contribution to the greenhouse effect (GHG) emissions within the transport field. Nevertheless, Bunker fuel emissions from international shipping are not covered by the international regulatory framework under the Kyoto protocol (United Nations, 2010). To this respect the authors have been analysing this gap in the local, national and international frameworks regarding the global warming and the maritime transport contribution to the full picture of anthropogenic GHG emissions. Even the amounts of pollutant emissions can be well computed from the volume of fuels consumption during a voyage, and post evaluated declarations, the true effects on the vessel corridors, ports and influenced maritime traffic environments are not well studied, evaluated or declared. According to the Second IMO GHG Study 2009 (International Maritime Organization, 2009), "emissions of exhaust gases from international shipping are estimated in that study, based on a methodology where the total fuel consumption of international shipping was firstly defined. Emissions are subsequently calculated by multiplying fuel consumption with an emission factor for the pollutant in question. Fuel consumption for the year 2007 was estimated by an activity-based methodology. This is a change in methodology compared to the first IMO

[1] Project Manager at Spanish Institute of Navigation, Lecturer at Technical University of Catalonia, PhD Candidate in Nautical Science and Engineering, Spain.
[2] Director and Professor of the Nautical Science and Engineering Department, Spain. Email: fmartinez@cen.upc.edu
* Corresponding author.

[1] IMO Resolution A.917(22) Guidelines for the onboard operational use of shipborne automatic identification systems (AIS)

study on greenhouse gas emissions from ships, published in 2000, which relied on fuel statistics. The investigations that are presented in that study suggest that international fuel statistics would under-report fuel consumption. The difference between the fuel statistics and the activity-based estimate is about 30%. Guidebook emission factors from CORINAIR and IPCC were used for all emissions except for NOx, where adjustments were made to accommodate the effect of the NO_x regulations in MARPOL Annex VI. Estimates of emissions of refrigerants were retrieved from the 2006 United Nations Environmental Program (UNEP) assessment of refrigerant emissions from transport. The emissions of VOC from crude oil were assessed on the basis of several data sources".

This situation contributed to reinforce our idea of using a more precise and quasi real time balance of shipping GHGs emissions, in harbour areas mainly, by means of AIS data combined with in situ data acquisition techniques and Earth Observation information.

2. State of the art

The US Environmental Protection Agency (EPA) initiated a review of its guidance on developing emission inventories for ocean-going and harbor vessels operating at port areas. This methodology was based on a three step calculation. The first step apportions the time spent by a vessel in a port area to different operating modes. The second calculates fuel consumption in each operating mode. The third step calculates emissions using fuel consumption specific emission factors, which is how marine engine emission factors have been historically specified. All of these calculations are by vessel type and class, with the type specifying whether the vessel is a tanker, passenger liner, etc., and the class specifying either the weight or horsepower range.

Operating mode data on non-oceangoing vessels is not easy to characterize. Typical estimates have been based on power factors of 80 percent, 40 percent, 20 percent and idle, for cruise, slow cruise, manoeuvring, and trawling or waiting. No estimates of auxiliary loads for such vessels are available.

The operating mode data on both oceangoing and non-oceangoing vessels appears to be derived from numerous assumptions that have not been subjected to any validation by European Environmental Agency (EEA). However, this is the best available data within the time and resource constraints of this project[2].

Emissions from the maritime transport sector account for a significant portion of total emissions, affecting air quality and contributing to climate change and human health problems. The estimation and geographical characterization of maritime transport emissions are therefore important to the work of, for instance, atmospheric scientists or policy makers who try to analyze and address the problems associated with them.

In general, the level of detail achieved and achievable within a certain study depends on the approach followed (bottom-up or top down) and the specific purpose of the analysis itself.

For example, emissions of CO_2 may be analyzed at a global scale, whereas NO_x and SO_x emissions should be analyzed at a more local scale since their greatest effects are produced on the environment in which they are released.

In a bottom-up approach, each single element involved in a certain phenomenon is modeled and then the global impact is evaluated by aggregating the impacts of the different elements.

For the evaluation of emissions arising from maritime transport, two dimensions have to be considered: the quantity of emissions produced and where they are emitted.

Due to data availability, nearly all the studies evaluate emissions attributable to vessels whose gross tonnage is greater than 100.

Several inventories have been established over the past two decades. The debate on the evaluation of maritime emissions is still open and has resulted in several different estimations being made over the past decade. These are not all that easy to compare, since different contexts are analysed and different assumptions are made.

In our case, some assumptions on the convenience of using AIS data to estimate air pollution from shipping industry some considerations must be taken into account.

Further to the definition of the ships' activities, AIS data may be usefully applied for the evaluation of the vessels' speed. The service speed provided by the ships' databases is an average value declared by the ships' operators. In order to calculate ships' fuel consumption and emissions, the operational speed of a ship would be required in addition to its service speed.

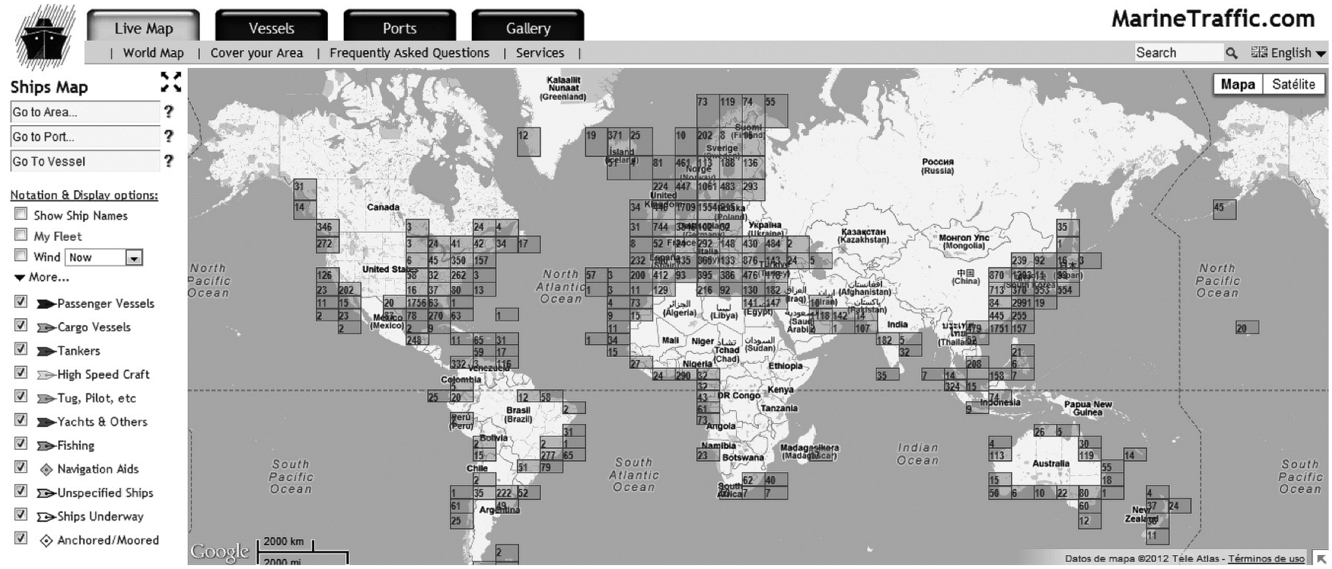
In particular, the relationship between fuel consumption and the ratio between operating speed and service speed is a cubic function (Corbett *et al.*, 2009), meaning that an estimation of the operating speed can be used to calculate an estimate of the fuel consumption and emissions. AIS data could therefore substantially improve the global estimation of emissions from maritime traffic.

However, some risks exist with AIS data. These are mainly connected to:

- Incomplete spatial coverage of maritime traffic. In Figure 1 this is pointed out. In addition, exceptions to the use of AIS data are given in the clause established in the IMO 22nd meeting of the General Assembly, resolution A.917(22);
- Penetration of the AIS technology in the fleet working in the area which is being considered. At the global level, approximately 50% of ships have this system on board (Ou and Zhu, 2008), but at the local scale the picture may be very different (for instance, according to a recent study, MARIN, 2008, the coverage rises to

[2] Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data. Office of Transportation and Air Quality U.S. Environmental Protection Agency. EPA420-R-00-002; February 2000.

Figure 1. MarineTraffic.com AIS data coverage.



Source: Authors

90% in the Baltic Sea, meaning that in other areas the percentage of coverage will be much lower).

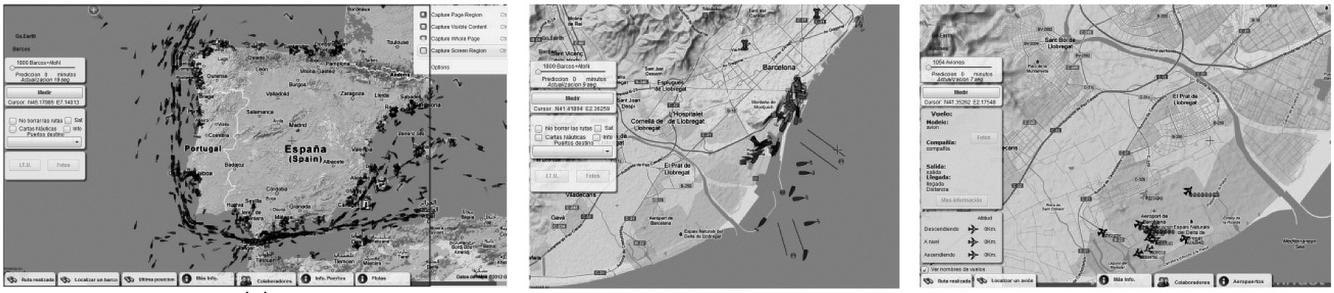
- Incomplete coverage for the entire route. For instance, the data available for the entire route may potentially only be connected with the departure and the arrival of the vessel. It is possible to have an estimate of the average cruise speed, but this is of course only an approximation. This problem can be overcome by using another data source, the Long Range Identification and Tracking (LRIT) of ships. Although the LRIT contains less frequent information (collected only four times per day) it is available everywhere. It was established as an international system in 2006 by the IMO and applies to ships engaged on international voyages (in particular to all passenger ships, cargo ships of 300 GT and above, and mobile offshore drilling units).

[3] Regulating air emissions from ships: the state of the arte on methodologies, technologies and policy options. Joint Research Centre. Institute for Environment and Sustainability. European Commission 2010.

All these problems could be reduced if a single entity were to take responsibility for accurate data collection and distribution. In Europe this role will be filled by the European Maritime Safety Agency (EMSA), which will take care of both AIS and LRIT data. This would lead to a considerable improvement in the data accuracy for European researchers in the maritime transport field[3].

Nevertheless, local AIS web services at local level make possible to reduce our study to the harbour areas. Within this context, an isolated control boundary can be selected and several sources of information can be used. In the case of AIS information, ships, aircrafts and even trucks may be located and traced by means of localizadotodo.com, Figure 2. In the Barcelona harbour, some environment stations are deployed, both static and mobile, and the Catalan environmental service has other stations near to the airport and the port of Barcelona and all of those data are available for the public use and consultation. A combined data management method can produce satisfactory models which can be scaled to wider control boundaries as soon as LRIT and Satellite AIS are wholly operating.

Figure 2. Spanish AIS webservice localizatodo.com; (a) Coverage, (b) ships' location and identification and (c) aircrafts' location and identification



(a) (b) (c)

Source: Authors

3. The port as a first candidate to apply an automatic ghgs emissions monitoring system

Ports are very complex and heterogeneous entities. There are ports that are even larger than their host cities, sometimes hosting important industrial assets, while others are just a part of an industrial plant or serve just a local community. The port is a context where a number of actors develop a wide spectrum of activities sharing the same facilities such as, berths, docks, terminals, cranes, piloting, towing, and safety and security operations regarding SAR, VTS and ISPS.

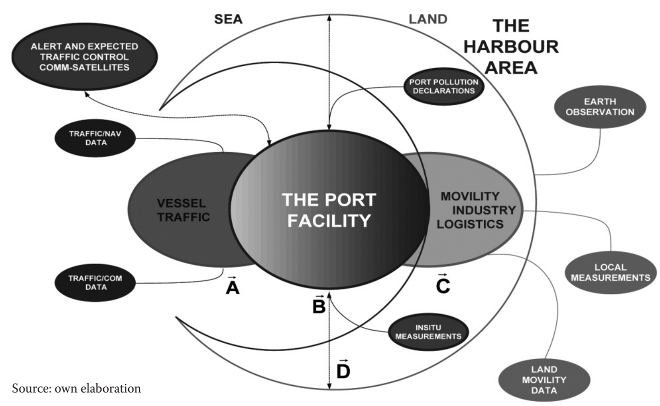
The main activities related to our research are listed in Table 1. It is also proposed to scale our research to a wider area including an Emission Control Area (ECA). The next Transeuropean Transport Network Policy promoted by the European Commission for the next 20 years require a deep analysis on the real impact on environment from the different modes of transport and the logistics networks. In Figure 3 a control boundary has been defined to apply our research activity. The port Authorities support is an essential key to establish and consolidate the data sources from official entities. The access to the public SafeSeaNet databases in order to obtain ships' information and engine data is a paramount issue too.

The port as main user will be the data source and scenario for the application of the proposed architecture. The related tasks will list the air pollution data acquired into the port facilities and its surroundings.

Users like local and national environment authorities need to improve environmental management tools in order to quantify, qualify and rule pollution from all the active and potential sources. Current climate change, global warming and pollution are on the first line agendas at political, scientific and technological level. From Kyoto to Copenhagen United Nations initiatives, the launching of satellite platforms like SMOS and GOSAT and finally, worldwide campaigns to standardize methods and data into networks like GMES are clear arguments to promote such architecture as explained in this proposal.

Because of the definition of the port, the local government and international decision makers as end users the

Figure 3. The Harbor area and the potential fields of knowledge applied to the Automatic GHGs Emissions monitoring model.



Source: own elaboration

Table 1. Impacts on air due to maritime transport and port activities, including illegal activities.

		IMPACTS OF SHIPPING ON AIR				
Activities – events/Impacts		Local Air Pollution NOx, SO_2, CO_2, CO, VOC, PM	Noise	Vibration	Odor	Global Air Pollution Impact
In Ports	Maneuvering					
	Loading/unloading operations on terminals					
	Hoteling (lighting, heating, refrigeration, ventilation, etc.)					
	Dredging					
	Land Traffic (heavy vehicle, railways, near highways, etc.)					
	Waste disposal/illegal dumping					
	Port expansion/infrastructures construction and maintenance					
	Fuels deposits					
	Air traffic (neighboring airports)					
	Bulk handling and goods movement					
	Industrial activities					
	Spills					
At Sea	Cruise					
	Spills					
	Heavy fuels consumption					

Source: own elaboration from Miola et al. (2009, p. 23)

Table 2. Gaps in the air pollution management from shipping industry and potential improvements from SHIPPOL research.

Users	Role	Current situation	Problem	SHIPPOL Improvement
Port communities	End user	In situ measurements are not enough to manage all the parameters involved in air pollution monitoring.	Air pollutants dynamics (wind, sea sorption, decomposition, accumulation)	A suitable information service. Data sources and Dynamics and Prediction Models
Local administration	End user	Lack of integrated systems to implement and apply environmental measures	Apart of its own tools, the authorities depend on the pollution declarations from all the industrial and transport actors to manage environmental indicators	To become much more operative and effective applying environmental actions
State administration, IMO and EMSA	End user	Lack of integrated systems to implement and apply environmental measures	Apart of its own tools, the authorities depend on the pollution declarations from all the industrial and transport actors to manage environmental indicators	To become much more operative and effective applying environmental actions. Correct emissions declarations and real reports

Source: Authors

following table summarizes some problems or gaps within the current scenario of shipping and port industry.

4. Legal aspects and basis

The first IMO study on emission of greenhouse gases from international shipping was commissioned following a request by the Diplomatic Conference on Air Pollution that was held at the IMO Headquarters in September 1997. The conference was convened by the Organization to consider air pollution issues related to international shipping and, more specifically, to adopt the 1997 Protocol to the MARPOL Convention (Annex VI – Regulations for the prevention of air pollution from ships). The first IMO study of greenhouse gas emissions from ships used figures for 1996 and was published in the year 2000 as document MEPC 45/8.

The 1997 MARPOL Conference (September 1997) convened by the IMO adopted resolution 8 on "CO_2 emissions from ships". This resolution invited, inter alia, the IMO to undertake a study of emissions of GHG from ships for the purpose of establishing the amount and relative percentage of GHG emissions from ships as part of the global inventory of GHG emissions. As a follow-up to the above resolution, the IMO Study of Greenhouse Gas Emissions from Ships was completed and presented to the forty-fifth session of the MEPC (MEPC 45) in June 2000, as document MEPC 45/8.

MEPC 55 (October 2006) agreed to update the "IMO Study of Greenhouse Gas Emissions from Ships" from 2000 to provide a better foundation for future decisions and to assist in the follow-up to resolution A.963(23). MEPC 56 (July 2007) adopted the Terms of Reference for the updating of the study, which has been given the title "Second IMO GHG Study 2009".

A significant potential for reduction of GHG through technical and operational measures has been identified from the report. Together, if implemented, these measures could increase efficiency and reduce the emissions rate by 25% to 75% below the current levels. Many of these measures appear to be cost-effective, although non-financial barriers may discourage their implementation[4].

From the port point of view, the regulatory basis must be applied according to each state harbour/port area definition. This feasibility study will include a deep analysis on the way how each member state can apply proposed architecture from a legal basis.

5. Shipol, a proposal for the European Space Agency

In December 2010 the SHIPPOL proposal was submitted to the European Space Agency within its Integrated Applications Promotion Program. The outline proposal has been received and iterated. The involved users leaded by the Spanish Institute of Navigation and the cooperation of Barcelona Regional Agency, Gijon Port Authority in Spain, the International Centre for Applied Numerical Methods in Engineering (CIMNE), GMV, Infoterra and the Cartographic Institute of Catalonia expressed their interest to participate in the activity.

Following the approval of the activity by the Joint Board on Communications Satellite Program (JCB) of European Space Agency, the consortium was invited to submit a full proposal according to the requirements of AO 6124 (IAP Open Call for Proposals for Feasibility Studies).

[4] PREVENTION OF AIR POLLUTION FROM SHIPS, Second IMO GHG Study 2009, Update of the 2000 IMO GHG Study Final report covering Phase 1 and Phase 2. MEPC 59/INF.10, 9 April 2009

Table 3. Regulatory basis and SHIPPOL Competency.

Regulation and Date	Issued by	Contents	Scope	SHIPPOL Competency
IMO Assembly Resolution A.963(23) Adopted on 5 December 2003	Internationa l Maritime Organizatio n (IMO)	Policies and Practices Related to the Reduction of Green House Emissions from ships	IMO's Marine Environment Protection Committee (MPEC) will identify and develop mechanisms needed to achieve limitation or reduction of GHGs emissions from international shipping	SHIPPOL tools would contribute to the mechanisms required by IMO
Decision 2/CP.3 Conference of the Parties to the UNFCCC December 1997	United Nations Framework Convention on Climate Change (UNFCCC)	The UNFCCC has adopted reporting requirements and agreed on guidelines and good practice guidance concerning methodologies for calculating the emissions from international bunker fuels	• the establishment of a GHG emission baseline; • the development of a methodology to describe the GHG efficiency of a ship in terms of a GHG emission index for that ship; • the development of Guidelines by which the GHG emission indexing scheme may be applied in practice. The guidelines are to address issues such as verification; • the evaluation of technical, operational and market-based solutions	The information and data acquired by SHIPPOL tools would complement GHG indexes from real traffic information apart from the declarations
IMO, MARPOL 73/78, Annex VI, adopted in 1997 and Revised Annex VI adopted October 2008	Internationa l Maritime Organizatio n, Maritime Pollution Convention (MARPOL)	MARPOL Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. The MPEC recognized that IMO guidelines on greenhouse gas emissions have to address all six greenhouse gases covered by the Kyoto Protocol (Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6).	At IMO, MEPC in the mid-1980s had been reviewing the quality of fuel oils in relation to discharge requirements in MARPOL Annex I and the issue of air pollution had been discussed. In 1988, the MEPC agreed to include the issue of air pollution in its work programme following a submission from Norway on the scale of the problem. At the next MEPC session, in March 1989, various countries submitted papers referring to fuel oil quality and atmospheric pollution, and it was agreed to look at the prevention of air pollution from ships - as well as fuel oil quality - as part of the committee's long-term work programme, starting in March 1990.	SHIPPOL tools would update expected air pollutants emissions from the declared fuel oil amounts against those monitored and observed

Source: Authors

The team was ready to submit a full proposal within Q1/2011, nevertheless, the economic crisis in Spain cuts some crucial resources to start this project and the SHIPPOL research is carried out under some financial limitations. It is expected to present the final results to the European Space Agency with the aim of obtain its support again for launching the service proposed in the way of a web service to improve existing decision making tools at European level.

Our approach within this research is that the information which would be provided by the SHIPPOL services will be the sensed and measured data of the real-time situations (not only modelled data but very high spatial resolution

Figure 4. Coastal edge of Barcelona harbour.

Source: Authors

sampling information) and the quality, density and distribution of such data would improve the current air pollution services that uses Earth Observation (EO)-data, reinforced with the tracking of ships coming/leaving the port using communication channels and navigation assets, ship to shore, shore to ship, like Automatic Identification System (AIS), LRIT, GMDSS, NAVTEX and finally, using communication satellite services to generate real time data collections accessible by environmental agencies and emergency missions within the harbour context. This approach has been of the interest of the European Space Agency because of its integration of several Space Assets.

6. The technical approach and research hypothesis

6.1. The service

The proposed service architecture is based on three main elements: navigation, earth observation and communication facilities. The overall concept is to correlate space and ground segment information for vessel traffic management and for air pollution monitoring and alert purposes.

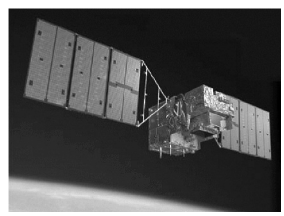
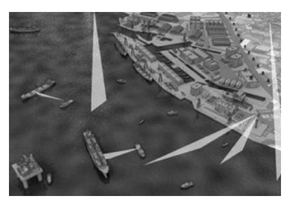
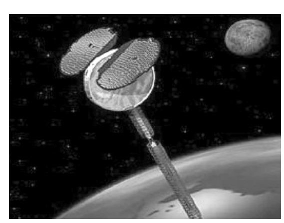
Ground information would be derived from the navigation segments (AIS-VTS coastal stations) as well as from the network of air pollution sensors deployed along the port and the metropolitan area, to this respect, Barcelona Pilots has a modern and powerful VTS service, the Barcelona Port Authority has local sensors for pollutants measurements and the Catalonian Environment Agency provides air pollutions measurements too.

Space based information would be derived from NAV-COMM satellites as well as from EO platforms that would provide regional scale vision on air pollution scenarios. Projects for specific monitoring/measurement of CO_2, NOx, SOx, VOCs, etc, like next coming GOSAT (The Greenhouse Gases Observing Satellite) as well as the recently lost Sciamachy sensor onboard ENVISAT and the next replacement payloads on board SENTINEL satellites, will provide valuable information to be contrasted in Now-cast/Forecast reports.

Satellite technology can complement terrestrial research and monitoring networks data, allowing a fast deployment of sensors and communications channels globally to uncovered services apart from search and rescue operations, tracing and tracking to facilitate transport flows, forest and agriculture management, etc. To this respect the regional and worldwide coverage of satellites offers important solutions to the growing scope of the European Union policies regarding security and defence, transportation and mobility, transport safety, research and development, environment monitoring, etc.

Sampling techniques and periodic inspections to the port emissions are not enough to generate a dynamic pollution index. Most of the measures are under the responsibility of unchained actors and integration of information is required.

Table 4. Identification of space assets.

Element	Infrastructure	Sensors	Data
Earth Observation		Fourier Transform Spectrometer, Cloud and Aerosol Imager, and X-band Antenna, Thermal, SWIR sensors	CO_2, Methane, Aerosols
Navigation		AIS transponders and receivers	Ships identification, speed, ETA, ETD, other useful navigation data
Communications		Rx: 137 – 138 MHz, 4800 bps, Tx: 148 – 150.05 MHz, 2400 bps Minimum Detectable Signal: -120 dBm, Transmit Power: 5 Watts	GSM/GPRS/EDGE cellular wireless services with LEO Satellite network, providing complete M2M network service. LRIT functions

Source: Authors

The step forward regarding environmental information on climate change and environmental monitoring systems means that a new paradigm in real time information production will reinforce the making decisions tools and policies involving all the main actors (port, local, state and European environmental authorities).

6.2. The principle

In terms of the operational aspects regarding this research, the proposed model which fits the above mentioned technologies is based on the Mass Conservation Law.

The law of conservation of mass/matter, also known as principle of mass/matter conservation is that the mass of a closed system will remain constant over time, regardless of the processes acting inside the system. A similar statement is that mass cannot be created/destroyed, although it may be rearranged in space, and changed into different types of particles. As the earth's atmosphere being a closed system in material terms, this principle must be applied.

The formal mathematical way of describing the black-box approach is with conservation equations which explicitly state that what goes into the system at specific time must either come out of the system somewhere else, get used up or generated by the system, or remain in the system and accumulate, the Figure 3 shows the streams mentioned in the mass balance applied to this research. The relationship is as follows:

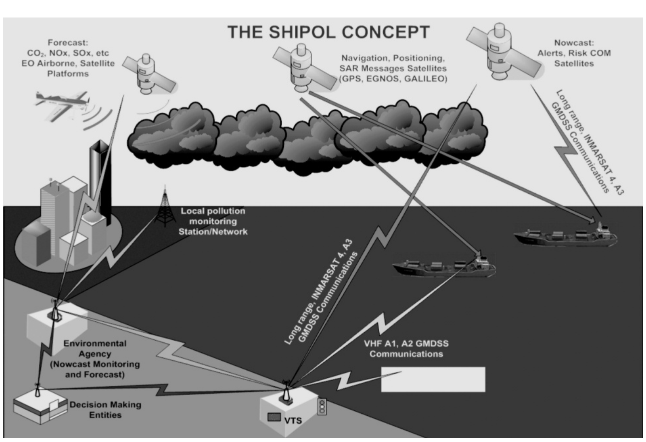
- The streams entering the system cause an increase of the substance (mass, energy, momentum, etc.) in the system, (A, C in this case)
- The streams leaving the system decrease the amount of the substance in the system (A_{out} or the amount of mass leaving the system by the effects of wind)
- Generation or consumption mechanisms (such as chemical reactions, combustion processes in the case of shipping) can either increase or decrease the stuff in the system (B, B_{out} referred as the amount of pollutants absorbed by sea)
- What's left over is the amount of stuff in the system (D)

From the energy and mass balance principles applied to the harbor area, the system must be reduced to the so called "Control Volume" or black-box in order to take into account all the mass and heat fluxes within the borders of the system and with these four statements we can state the following very important general principle:

Equation 1. General Mass Balance in the Harbour Area

$$\left[\vec{D}\right]=\left[\vec{A}\right]+\left[\vec{B}\right]+\left[\vec{C}\right]-\left\{\left[\vec{A}_{out}\right]+\left[\vec{B}_{out}\right]\right\}$$

Figure 5. SHIPOL service architecture concept.



Source: Authors

6.3. The tools

Green House effect Gases Mapping tool (Quasi real time pollutants location, discrimination and concentrations), now-casting and forecasting functions.

Episodes Alert Tool, this option will provide emergency or contingency messages according to the risky situations from extraordinary pollutant concentrations in the harbour surrounding areas. Decisions and contingency actions will be suggested too to the Port Authorities and the Local Environmental Agencies.

Traffic and Surveillance control tool, from Automatic Identification Systems (VHF and satellite), this decision support option shall regulate traffic in congested and over-polluted areas if it's the case. When an episode alert has been reported, valid and regulated mechanisms shall be activated.

Maritime transport air pollution data provider tool, this solution shall provide an active and dynamic air pollution data provider which will make possible to validate GHGs declarations from shipping industry, reinforce environmental statistics and forecast air pollution behaviour and its impact on air quality and sea and human health, near to congested waters (due to traffic and port operations). Short, medium and large scale measures and rules shall be also considered according to the users role (environmental, transport and government authorities) at local or international level. Future market based instruments as carbon credits for instance, shall be supported from the information provided by this tool.

7. Current and future steps

During the research phase, a few reasonable implementation scenarios have been analysed against technical and system operational/exploitation considerations. The purpose of this approach is to ensure that the final architecture proposed is tailored to the technical, environmental and operational needs. The work is being carried out according to the following work packages and tasks.

7.1. Evaluation of the User Needs and Requirements based on national/international environmental laws

- The port as main user is the data source and scenario for the application of the proposed architecture. This task lists the air pollution data acquired into the port facilities
- National, European and International environmental stakeholders requirements analysis
- International pollution networks integration. Analysis of GMES (Global Monitoring for Environment and Security) case and other environmental initiatives worldwide.

7.2. The methods employed includes

- Personal interviews with some Spanish port authorities and their environmental agents
- Local environmental administration interviews
- Databases, image collections and GIS software tools acquisition

7.3. Technical architecture proposal

- Inventory of current payloads and sensors for air pollution monitoring in ports and harbour areas
- Now-cast and land stations for pollution monitoring in port surroundings and neighbourhoods inventory
- Satellite forecasting and simulation technologies currently employed for global pollution monitoring
- Analysis of the navigation data, mainly from VTS, as traffic data source and pollutants calculations from maritime field (AIS)
- Inventory and analysis of current communication satellite facilities to alert environmental episodes and decision making tools.

7.4. The methods employed include:

- Internet searching of data providers
- Online pollution forecasting systems analysis
- Interview with other ports which apply similar services (Bremen port Authority is a clear candidate to be visited)
- Visit to Barcelona Pilots as VTS service provider
- Manoeuvring information within the port waters
- Algorithms reported to compare or improve own assumptions
- Free download data to verify algorithms

8. Expected results

Even SHIPPOL research is conceived at harbour area scale, a wider future vision is possible to be implemented understanding the overall scenario of air pollution monitoring and the impact evaluation of GHGs. For that reason, SHIPPOL proponents have agreed to promote the impact and the future project results among them in the three level actor's scenario (Developers, end users and Stakeholders/ Policy Makers). When the service feasibility has been demonstrated, the project can be promoted to (ESA) and GEMS (EU) in order to become user of their medium scale products already delivered on a regular basis through their dedicated regional services. Apart of helping to make the connection between the local and the regional scenarios, these products will give support to the interpretation and detection of potential risk events.

The bidders expect that this collaboration will reinforce the key role of the air pollution services already developed in the frame of PROMOTE and GMES networks as well as it will generate the convenient environment for improving the services already existing by the specific added value of SHIPOL at European level.

In particular the results and recommendations of the SHIPPOL work, will most likely contribute to the achievement of the following aspects of the European Maritime Transport and its impact on environment:

- To propose a suitable architecture which will make possible to obtain remote information from ships outside controlled borders worldwide.
- To quantify and qualify how much ships pollute in a more precise way, this capability may be used to apply right taxations from emissions to the right flagged ships.
- IMO and Environmental Organisms will benefit from these future developments in order to improve international regulations and policies.
- Shipping companies and ship constructors will improve their productive activities more efficiently and will improve energy consumption making maritime transport greener and cleaner, in other words, a more sustainable transport mode.
- Now-casting and Forecasting technologies will improve their models of global warming and climate changes because they will be able to include more parameters which actually are not considered.

9. conclusions and recommendations

The execution of our research is considering all the actions needed to demonstrate the principles and prove the added value of the concepts that are developed under the SHIPPOL concept. The feasibility of the concept might consider different aspects from different groups, but in the case of SHIPPOL, the European Space Agency, the competent authorities of the Member States and the port authorities, environmental authorities and ship owners are the most important stakeholders.

The SHIPPOL concept also strives to minimize errors from the pollution declarations and monitoring information and the effects on the environment and climate change phenomena. The information that is collected through the public systems can be shared with commercial stakeholders, if they have an interactive system that can be considered of the public interest. This is part of the public authorities' wishes to improve and facilitate maritime transport pollution monitoring and control. Connection with Port Authorities Environmental Systems and other networks through the global environmental monitoring services is expected to be demonstrated.

The scenarios and processes in relation to the functional architecture in a wider approach will be used to describe in process diagrams and swim lanes the scenarios for the demonstrations. When the modelling is completed, it is possible to define the equipment and software that is required to carry out a demonstration. The test bed is used to assess and test the different components that are needed to show the SHIPPOL-concept. The initial tests will be made by means of current in-situ measurements and satellite data available on the market/public providers such as ENVISAT/GOSAT/AIS, but in other cases it is necessary to emulate functions without the use of next generation facilities like long range identification and tracking systems. Special equipment that will be tested should fulfil the requirement of portability so that tested elements can be used in the demonstrations.

References

Commission of the European Communities (2006): *The Green Paper. Towards a future Maritime Policy for the Union: A European vision for the oceans and seas.* Brussels.

European Commission (2010): *Regulating air emissions from ships: the state of the arte on methodologies, technologies and policy options.* Brussels.

International Maritime Organization (2002): *IMO Resolution A.917(22) Guidelines for the on-board operational use of shipborne automatic identification systems (AIS*). London.

International Maritime Organization (2008): *Guidance to search adn rescue services in relation to requesting and receiving lrit information.* London: IMO.

International Maritime Organization (2009): *Prevention of air pollution from ships, Second IMO GHG Study 2009, Update of the 2000 IMO GHG Study, Final report covering Phase 1 and Phase 2.* London: IMO.

Office of Transportation and Air Quality U.S. Environmental Protection Agency (2000): *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data.* USA.

Tsou, M.C. (2010): Discovering Knowledge from AIS Database for Applications in VTS. *The Journal of Navigation* 63(3). 449-469.

United Nations (2009): Multi-year expert meeting on transport and trade facilitation: Maritime Transport and the Climate Change Challenge, *Summary of proceedings of the United Nations Conference on Trade and Development,* 16-18 February, Geneve, Italy.

United Nations (2010): *Review of Maritime Transport 2010.* New York and Geneva.