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SUMMARIES AND PROCEEDINGS

1 THE COOPERATIVE INLAND WATERWAYS SAFETY PROGRAMME IN SOUTH AFRICA

James Collocott. SAMSA, South Africa

This Paper describes the safety programme model for inland waterways that is being developed, implemented and tested on five (5) pilot dams in South Africa. Once the model has reached a certain maturity level, it will be progressively phased in on all the inland waterways in South Africa.

The Cooperative Inland Waterways Safety Programme (CIWSP) project is a partnership between multiple government entities and between the government and the community. The aim is to enhance the development of a best practice model to ensure a safe and structured inland maritime environment and culture, whilst protecting the country's precious water resources.

Esta ponencia describe el modelo de programa de seguridad para vías navegables interiores que se está desarrollando, implementando y ensayando en cinco (5) embalses piloto en Sudáfrica. Cuando el modelo haya alcanzado un determinado nivel de madurez se introducirá progresivamente en todas las vías navegables interiores de Sudáfrica.

El proyecto Cooperative Inland Waterways Safety Programme (CIWSP) es una colaboración entre múltiples entidades gubernamentales y entre el gobierno y la comunidad. El objetivo es mejorar el desarrollo de un modelo de buenas prácticas para garantizar una cultura y un entorno marítimo interior seguro y estructurado, protegiendo al mismo tiempo los preciosos recursos hídricos del país.

Le rapport décrit le modèle du programme de sécurité des voies navigables intérieures qui est en cours de développement, de mise en service et d'essai dans cinq (5) lacs de retenue d'Afrique du Sud. Dès que ce modèle aura atteint un certain niveau d'avancement, il sera progressivement appliqué dans toutes les voies navigables intérieures d'Afrique du Sud.

Le projet résulte d'une coopération entre plusieurs services gouvernementaux et entre le gouvernement et la communauté. L'objectif est d'améliorer le développement d'un modèle de bonne pratique pour assurer un environnement et une culture maritime intérieurs sains et structurés, tout en protégeant les précieuses ressources en eaux du pays.

The Cooperative Inland Waterways Safety Programme in South Africa

James H Collocott

South African Maritime Safety Authority

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The Cooperative Inland Waterways Safety Programme in South Africa

James H Collocott
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South Africa

1. INTRODUCTION

The South African Cooperative Inland Waterways Safety Programme (CIWSP) is a cooperative governance project that is building a model, which is being developed and tested at five pilot sites, to address inland waterways safety, incident and environmental management. The project is driven by the synergy of collaboration and innovation.

1.1 Where it all started

The CIWSP arose from a concern relating to the inability to enforce and regulate the National Small Vessel Safety Regulations. These regulations intend to ensure that qualified skippers with safe vessels are operating on South African inland waterways.

Government's intention to establish a consistent and safe environment for small vessels that will allow for recreation and commerce, while facilitating law enforcement, resulted in the Minister of Transport promulgating the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 ("the NSVS Regulations") in August 2007. This extended the South African Maritime Safety Authority's (SAMSA) mandate to include small vessels operating on inland waterways.

There is a need to create a system that monitors the registration and fitness of vessels and the certification of skippers wherever they operate, including the monitoring of the nature and the number of incidents and casualties. Many accidents involving small vessels can be attributed to incompetent skippers with apparent lack of appropriate training and certification – and of unsafe vessels which do not meet the minimum safety requirements and where the enforcement of regulations are inadequate.

Following the promulgation of the NSVS Regulations, it became clear that, in addition to administering the regulations, the responsibilities of other departments, such as the management and control of water resources by Department of Water Affairs (DWA), the management of invasive alien species by the Department of Environmental Affairs (DEA), policing by the South African Police Service (SAPS) and events management (sports and recreation) are equally important. On inland waterways, no regulations will serve the purpose for which they are intended, unless they are implemented and administered in an integrated manner by the various Government Departments.

The aim of CIWSP is to enhance the development of a best practice model to ensure a safe and structured inland waterways environment and culture, whilst protecting South Africa's precious water resources.

Once the model has been tried and tested, it could be rolled out on all waterways comprising 315 Government reservoirs (dams), the 4 783 (of the approximately 60 000) dams in the country registered as having a safety risk, rivers and their riverine communities in South Africa.

1.2 Aids to Navigation (AtoN)

One element of the CIWSP is the implementation of standardised marine Aids to Navigation (AtoN) and demarcation markers on inland waterways.

1.3 Major intergovernmental cooperative governance project

The CIWSP is a major intergovernmental cooperative governance project as it integrates and coordinates various departmental mandates under one umbrella.

The CIWSP is facilitated by the Centre for Public Service Innovation (CPSI) with multi-stakeholder engagement, such as:

- Department of Transport (DoT)
- Department of Water Affairs (DWA), including its "Blue Scorpions
- Department of Environmental Affairs (DEA), including its "Green Scorpions"
- Department of Sport and Recreation (DoSR)
- Department of Health (DoH)
- South African Maritime Safety Authority (SAMSA)
- South African Police Service (SAPS)
- South African Navy, Hydrographic Office

- Council for Scientific and Industrial Research[1] (CSIR)
- Relevant communities

1.4 Project principles

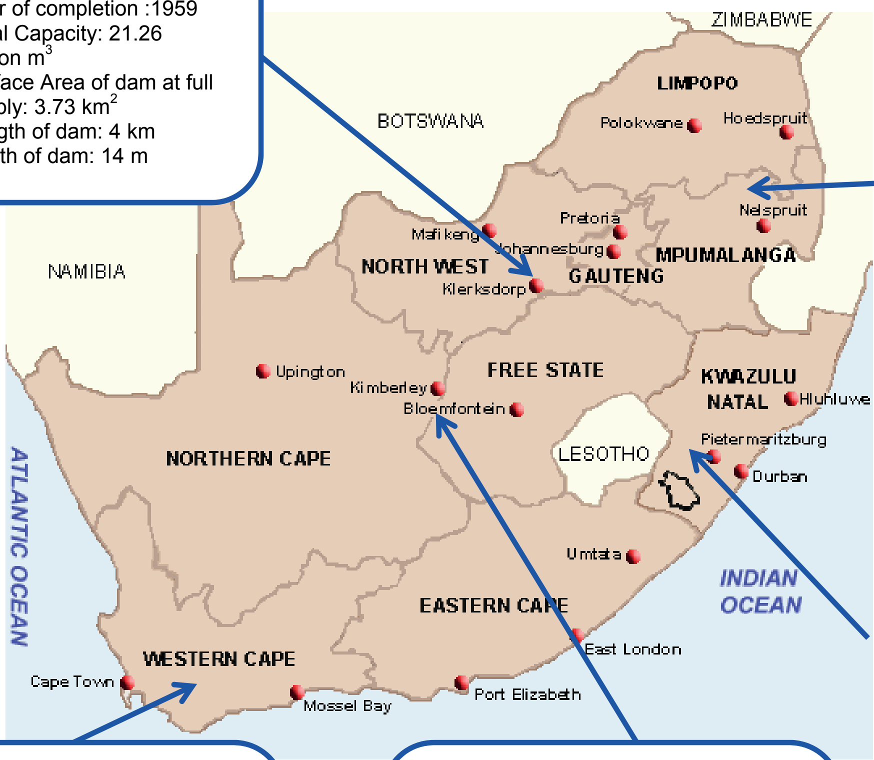
The CIWSP aims to conceptualise, develop and test solutions before exposing it to the community. Its motto is *"Be part of the solution rather than complain from the side"*.

The aims of the model are:

- To create a toolbox of solutions and procedures for different spheres of dams and river users that can be used for guidance and implementation
- To change South Africans' attitude towards inland water safety
- To promote safe and lawful access and use of water by communities
- To promote boating safety
- To administer the NSVS Regulations
- To support the containment, management and/or eradication of invasive aquatic species
- To monitor pollution in the surface water resources
- To create a trustworthy, community-based incident management system for inland waterways
- To stimulate a synergy of solutions through intergovernmental cooperation
- To create a foundation for inland maritime transport to become a formal mode of transport
- To promote eco-tourism development (CIWSP at dam = safe tourism)
- Pilot sites to be points of excellence that promote innovative, best practises for the South African inland waterways environment and the national implementation thereof.

Image 1: Location and summarized detail of the 5 pilot dams

Boskop Dam
- North West Province
- Year of completion :1959
- Total Capacity: 21.26 million m^3
- Surface Area of dam at full supply: 3.73 km^2
- Length of dam: 4 km
- Depth of dam: 14 m



De Hoop Dam
- Limpopo Province
- Year of completion: 2013
- Total capacity: 347.4 million m^3
- Surface area of dam at full supply: 16.90 km^2
- Length of the Dam: ±12.5 km
- Depth of the dam: 66 m

Midmar Dam
- KwaZulu-Natal Province
- Year of completion: 1964
  <u>Note</u> that the dam was raised by 3.6 m in 2003
- Total Capacity :235 million m^3
- Surface area of dam at full supply: 17.93 km^2
- Length of the dam: ± 4.7 km
- Depth of the dam: 22 m

Theewaterskloof Dam
- Western Cape Province
- Year of completion: 1980
- Total capacity: 434 million m^3
- Surface area of dam at full supply: 51 km^2
- Length of the Dam: ± 18 km
- Depth of the dam: ±30 m

Vanderkloof Dam
- Northern Cape and Free State Provinces
- Year of completion: 1977
- Total Capacity: = 3,187 million m^3
- Surface Area of dam at full supply: 133 km^2
- Length of the Dam: 114 km
- Depth of the Dam: = 80 m

1.5 Target Environment

The five (5) pilot dams are shown in **Figure 1**.

The criteria used to select the pilot sites were, among others:

- To be in different provinces
- Being in the public eye
- DWA structires in place
- Size of dam
- Number of users
- Political interest
- Distance to travel for VIPs and the CIWSP team
- Presence of SAPS
- Accommodation availability
- Potential to involve local community
- Sport clubs involvement.

2. BACKGROUND

2.1 Current status on inland waterways in South Africa

Unlike many other countries where inland waterways are used mostly for transportation of goods and passengers, this is not the case in South Africa.

South Africa has approximately 60 000 dams and 23 large rivers. The rivers and dams are located over a large area of the country, in all nine provinces.

These inland waterways are utilised by over 1,2 million boats mostly for sport, recreation, tourism and by local communities as a source for food.

Of the approximately 60 000 dams, 4 783 are registered by the DWA as having a safety risk[2] and 316 are government reservoirs under the custodianship of the DWA. The regulations and requirements described in the National Water Act, Act No 36 of 1998 are in addition to the owners' common law responsibility to ensure the safety of their dams.

In 2008, SAMSA was delegated the additional responsibility of implementing the NSVS Regulations on South Africa's inland waterways. SAMSA collaborates with various other government departments and private-sector role-players in order to implement the regulations. This includes departments such as the DWA, provincial and local governments, as well as accredited agencies, training institutions and clubs.

2.1.1 AtoN on Inland Waterways

2.1.1.1 Current background on AtoN on Inland Waterways in South Africa

A number of AtoN exist on South African inland waterways, however, these are not considered adequate, standardised, harmonised and/or comprehensive enough to contribute satisfactorily to the safety of navigation on inland waterways.

2.2 Challenges identified on Inland Waterways

2.2.1 Illegal Infrastructure, slipways and lack of access control

There has been a lack of proper management over many years, specifically on Government dams, with the result that illegal infrastructure had been erected. In addition, lease agreements with adjacent landowners and clubs have been not been kept up to date. In essence, there are no up-to-date Resource Management Plans (RMPs) available, without which the management of dams cannot be undertaken properly.

There is currently no efficient control of the access to waterways. Although the many clubs based at the dams and rivers, have their own control measures, it does not apply to those participants having their own slipways. There are quite a number of these illegally operated slipways.

2.2.2 Boating and incidents

On any particular day, the number of vessels on an inland waterway could exceed more than 5,000. Boats and vessels using waterways could vary from canoes, windsurfing boards, jet skis, motorised boats and yachts to "anything that floats". Taking the number of dams and rivers into consideration, there is currently no structure in place to:

- monitor the registration and fitness of vessels and the certification of skippers
- oversee implemented safety measures - that is to say if there are any measures in place - and to be able to take action against perpetrators
- react in a co-ordinated manner to any incidents

In addition, many diverse and in some cases conflicting water activities take place in confined waterways, resulting in increased safety risks, hence the urgent need for a structured inland waterway environment approach.

2.2.3 Large variety of recreational activities

There are thirty-eight (38) different recreational activities that have been identified and that need to be accommodated, albeit not all at the same time and location.

1) Tube Fishing
2) Pontoon Fishing
3) Bass Fishing
4) Motorised Boat
5) Jet Powered Boat
6) Motorised Pontoon
7) Rigid-hulled inflatable boat, (RHIB)
8) Jet Ski
9) Dragon Boat
10) Slalom Canoe
11) Fishing Canoe
12) Jet Ski Fishing
13) Windsurfing
14) Kite Surfing
15) Ski Jumping
16) Slalom Skiing
17) Ski and Wakeboard Boat
18) Kayaking Sprints
19) Kayaking Marathon
20) Kayaking Water Polo
21) Kayaking Touring
22) Kayaking Fishing
23) Paddle Ski
24) Surf Ski
25) Pedal Boat
26) Hovercraft
27) Stand Up Paddling
28) Boat Paragliding
29) Water Toys
30) Flying Boats
31) House Boats
32) Keel Boat Sailing
33) Dinghy Sailing
34) Open Water Swimming
35) Snorkelling
36) Diving
37) Shore Fishing
38) Remote Control Toys

2.2.4 Invasive aquatic species

Invasive aquatic species are becoming a serious threat on many, if not most inland waterways. The species form dense canopies, which can change ecosystems and these impacts on aquatic biodiversity. If left uncontrolled, it could, amongst others:

- disrupt water abstraction
- destroy fishing grounds
- block waterways inhibiting boat traffic and prevent vessels from docking
- cause rapid siltation of water bodies
- block irrigation channels and hydro-electric turbine coolant intakes
- devastate aquatic biodiversity
- result in poor habitats for fish populations
- affect the quality of drinking water
- poses a health risk by creating conditions suitable for mosquitoes and bilharzia-carrying snails
- interfere with recreational activities
- impact negatively on power generation, irrigation and water delivery
- impede water flow and trap particles in suspension, it also increases siltation of rivers and dams

Image 2: Examples of water hyacinth infestations, with the Vaal River on the left and Klipfontein dam on the right

There are 10 categorised invasive aquatic weed species in South Africa, under the Conservation of Agricultural Resources Act (CARA). The higher priority macrophyte species are Water hyacinth (*Eichhornia crassipes*), Red water fern (*Azolla filiculoides*), Kariba weed (*Salvinia molesta*), Water lettuce (*Pistia stratoides*) and Parrots feather (*Myriophyllum aquaticum*).

The water hyacinth is the most invasive aquatic weed in South Africa and it was first recorded in the country around 1900. This invasive alien plant grows in all types of freshwater systems. Water hyacinths vary in size from a few centimetres to over a metre tall. It disrupts all normal activities associated with water use, and causes substantially increased water losses through transpiration.

Furthermore, the lack of natural enemies and the presence of nutrient enriched waters have facilitated its spread throughout South Africa.

Until a few years ago only haphazard controlling methods in the water systems to ensure efficient utilisation of resources existed and the protection and enhancement of the natural environment. The situation was further exacerbated by the lack of coordination, especially given the fact that there are so many interested and affected parties involved.

Infestation of invasive aquatic species is not only limited to plants, but invasive fish are also a factor.

Although the DEA has an overall integrated weed management programme to ensure that an integrated containment, control and eradication strategies are developed and implemented correctly, the programme alone would not succeed if travelling vessels (on boat trailers) were not prevented from carrying alien aquatic weeds and seeds from one water system to the other.

Image 3: Boat trailers and boat anchors are vectors of the spread of aquatic weeds and seeds from one water system to another

Submerged waterweeds

Where the overall integrated weed management programme has been successful in eradicating invasive aquatic species, a further, and larger problem has been identified. As the surface alien species are being eradicated, thus allowing more

Myriophyllum spicatum, spiked water milfoil

sunlight and oxygen in the water, this now creates the perfect habitat for submerged waterweeds, which is a far greater threat.

The reason being that it is much more difficult and more expensive to eradicate these weeds.

The currently flowering on the Vaal River, one of South Africa's largest rivers covers approximately 310 km² and the total cost to clear this would cost about USD($)41 billion.

Worst case scenario: With 0.01 km2 of water hyacinth and nothing is done, the following will happen:

- 0.01 km2 costs about USD($)110 to clear. In 2 weeks the infestation has doubled to 0.02 km2, which would now costs about USD($)220 to clear
- After 1 month – 0.04 km2 = about USD($)440
- Within 6 months – 40.96 km2 = about USD($)455 550

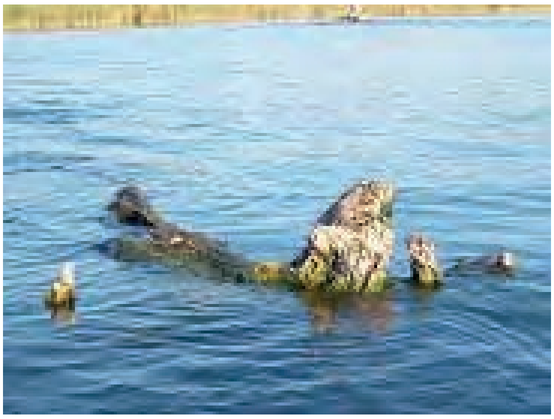
2.2.4.1 Emerging Aquatic Weeds

There are some emerging aquatic weeds that are starting to show a potential of becoming aggressive invaders and the DEA is conducting research and monitoring to curb their invasive potential. Examples of these are, amongst others, *Egeria densa, Vallisneria spiralis, Hydrilla verticillata* and *Myriophyllum spicatum.* Currently, the spread of these species is not being sufficiently controlled, but will be chemically controlled once there is a registered herbicide for them. In the meantime, it is being controlled manually.

One of these, Watercress (*Nasturtium officinale*), is a mat forming, rooted aquatic plant with erect, creeping or floating stems up to 1 metre long. This species was introduced from Europe and cultivated for its edible stems and leaves and it invades riverbanks and the edges of dams and streams. The problem with watercress is that it can clog waterways, reduce waterfowl, compete with indigenous riverbank species and obstruct access to the water's edge. This would then cause problems and interfere with recreational watercraft. This species also highlights the problems faced with conflict species as communities utilize this species for food.

2.2.5 AtoN on Inland Waterways

Many underwater obstacles pose danger to boating on inland waterways. These obstacles vary from tree trunks, rocks, sand banks to structures such as infrastructure foundations, gravestones, etc., the latter were never demolished/removed before the dams were filled. Furthermore, due to the large variation in the water levels from wet to dry periods, obstacles, which are not posing a danger at all when the water level is high, are very dangerous when the water is at a lower level, and vice versa.



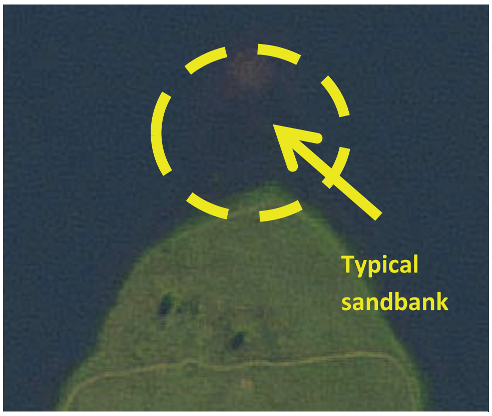


Image 4: Typical obstacles at inland waterways

The challenge to mark the relevant areas where the volume of traffic and the degree of risks require appropriate AtoN is, amongst others:

- To put measures in place to ensure that standardised AtoN are implemented
- To identify where, what type of AtoN and how many need to be implemented
- The large capital layout to provide the required AtoN
- The lack of knowledge and experience to operate and maintain AtoN
- To put measures in place to monitor the operational status thereof
- To put measures in place to advise when an AtoN had failed
- To deploy and retrieve buoys
- To keep the swinging circle of buoys to a minimum during the rise and fall of the water levels during dry and wet periods
- To make provision for other types of markings that are required for inland waterways, such as no go areas, limited access to certain areas, no wake zones, etc.

2.3 Governance

There are a number of Government Departments and Agencies whose mandates require them to attend to inland waterways. Below is a brief on some of these institutions.

2.3.1 Centre for Public Service Innovation (CPSI)

The CPSI is a Government Component reporting to the Minister for Public Service and Administration. It is a facility of the whole of government, established to entrench and drive the culture and practice of innovation in the Public Service in response to identified service delivery challenges and focuses on government's priority outcomes.

The CPSI is mandated to develop innovative, sustainable and responsive models for improved service delivery. The work of the CPSI is guided by an understanding of innovation in a public sector context as "*the creation and implementation of new and service delivery solutions (systems, processes, methods, models, products and services) resulting in significant improvements in outcomes, efficiency, effectiveness and quality*".

2.3.2 Department of Transport (DoT)

The DoT is responsible for creating a framework of sustainable policies, regulations and implementation models for all modes of transportation in South Africa, including shipping and other transport by water or sea.

2.3.3 Department of Water Affairs (DWA)

The DWA is the custodian of South Africa's water resources. It is primarily responsible for the formulation and implementation of policies governing this resource. It also has an overriding responsibility for water services provided by local governments.

While striving to ensure that all South Africans have access to clean water and safe sanitation, the DWA also promotes effective and efficient water resources management to ensure sustainable economic and social development.

The DWA is responsible, in terms of the National Water Act, to control aquatic weeds and invader plants on all open water systems, excluding privately owned reservoirs.

The DWA, its delegated public sector partner, or a delegated water management institution, has the responsibility to provide the required AtoN on all Government Waterways for general navigation. These AtoN include marine navigation buoys.

2.3.3.1 "Blue Scorpions"

The DWA has a special Compliance Monitoring and Enforcement Unit that is tasked with enforcing the National Water Act and to protect South Africa's scarce water resources. This unit is commonly referred to as the "Blue Scorpions".

2.3.4 Department of Environmental Affairs (DEA)

The DEA, Environmental Programmes, is responsible for implementing the control activities and operations of all invasive alien species present in and on all water bodies. These control activities are governed by the Conservation of Agricultural Resources Act (CARA) 83 of 1948, and the National Environmental Management: Biodiversity Act (NEM:BA) 10 of 2004.

2.3.4.1 "Green Scorpions"

The DEA has Environmental Management Inspectors to enforce environmental legislation and chase down trespassers. The primary areas of enforcement include biodiversity, protected areas, pollution and waste, as well as coastal, marine and environmental impact assessment. These inspectors are commonly referred to as the "Green Scorpions" and fall under the DEA's Directorate: Legal Authorisation, Compliance and Enforcement (LACE).

2.3.5 South African Maritime Safety Authority (SAMSA)

SAMSA is a statutory body established in terms of the SAMSA Act, No. 5 of 1998. The Act enables SAMSA to administer and control activities falling under a number of maritime related acts. SAMSA's mandate is to:

a) to ensure safety of life and property at sea;
b) to prevent and combat pollution of the marine environment by ships; and
c) to promote the Republic's maritime interests.

Some provisions of the International Maritime Organisation (IMO) Conventions are clearly implemented in South African national legislation, particularly in regard to the International Convention for the Safety of Life at Sea (SOLAS) mandate.

In August 2007, the Minister of Transport promulgated into law the Merchant Shipping (National Small Vessel Safety) Regulations, 2007 ("the 2007 Regulations") which extended SAMSA's mandate to include small vessels operating on inland waterways. This covers the surveying and registration of small vessels, safety awareness and regulations related to these vessels, accident investigation, control of recreational boating, setting examination standards and the issuing of certificates of competence and seaworthiness.

Since SAMSA is a government agency responsible to ensure the safety of ships and small vessels at sea and on inland waterways, it would therefore be the appropriate authority to ensure compliance with both international conventions and national regulations for all AtoN, both at sea and on navigable inland waterways of South Africa.

3. THE MODEL

3.1 Introduction

3.1.1 Accountable CIWSP Steering Committee

The initiator and the very able Project Leader of the CIWSP formed a steering committee, with the core members representing those intuitions as indicated in **clause 1.3**. Although each of the members is responsible and accountable for their own disciplines' outcomes, they also contribute towards the overall strategic objectives and decision-making of the CIWSP.

As the committee operates within an innovative environment provided by the CPSI, the members have to conceptualise and implement the CIWSP in a sustainable manner, while keeping innovation alive. In this regard, the CIWSP is being used as a platform to test and implement innovative ideas and products.

Since this is a ground-breaking initiative, the model is being adapted as time goes on and new information becomes available.

The model is described in detail below.

3.2 Resource Management Plans (RMPs)

The DWA is in the process of developing a comprehensive RMP for each pilot dam. A RMP can be described as a systematic process for the sustainable development and management of a water resource in the context of social, economic and environmental objectives. One of the main functions of the RMP process is to implement an Institutional Plan. This focus on institutional arrangements is accompanied by a Zonal Plan together with a detailed Strategic Plan. In addition, a Financial Plan provides guidance on what funds can be collected and how these should be used.

Together these components provide a comprehensive guide on the "what?", "why?", "how?" and "who?" of the management of prioritised Government Waterways.

The RMP would be the institutional framework for the overall management of the dam.

3.2.1 Period of usage

At the outset it was decided that no night-time activities would be allowed on the Government inland waterways, except in exceptional cases such as organised events, etc. The reason being that allowing night-time activities would result in unnecessary resources having to be catered for and other more challenges to be addressed.

3.2.2 Zoning areas (Marine Spatial Planning) for activities

The RMP would include the zoning where specific activities like boating, fishing, sailing, etc. can take place. This would promote safety by ensuring that water activities that pose a danger, or intrusion to each other are separated, e.g. power boating, swimming and shore angling are separated, thus enhancing enjoyment for all.

The zoning would also indicate the areas of interest, such as the sanctuary areas (birds/fish) as well as the infested areas by invasive aquatic species, which are areas to be avoided.

The zoning is thus the cornerstone for the identification and implementation of AtoN on the relevant waterway.

3.3 Certification of recreational and licencing of commercial inland vessels

The CIWSP would be the tool to ensure that only SAMSA certified vessels and skippers would be using the water resource, thereby addressing the enforcement and regulation of the National Small Vessel Safety Regulations. Refer to **clause 1.1** in this regard.

The licencing by SAMSA of commercial vessels operating on inland waterways would be preceded by the DWA's approval for commercial activities on the relevant waterway. This will also satisfy the South African Treasury's regulations.

The CIWSP is well aware that it is very important to ensure a smooth and effective approval regime in order not to suppress entrepreneurship and the job creation activities that goes with it.

3.4 Aids to navigation

3.4.1 Competent Authority and Safety of Navigation Compliance

SAMSA, as the Competent Maritime Authority, has to ensure safety of navigation by compliance and harmonisation of all maritime AtoN in the Republic of South Africa (RSA), both at sea and on navigable inland waterways by:

1) Ensuring that, as it deems practical and necessary for appropriate AtoN to be provided as the volume of traffic and the degree of risks requires.
2) Obtaining the greatest possible uniformity in AtoN by taking into account appropriate international directives, requirements, recommendations and guidelines, including those of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA).

3) Ensuring all AtoN meet acceptable standards. IALA Recommendations, the IALA Maritime Buoyage System (MBS) and IALA Guidelines would be the guiding factor, with the main emphasis on:
   a) Meeting the minimum IALA objectives on availability of the various categories
   b) Compliance to the IALA MBS
   c) Colour
   d) Light characteristics
1) Ensuring all AtoN, including inland waterways:
   a) Meet the requirements of present and changing needs of all mariners
   b) Ensuring natural and or man-made hazards, which are dangers to navigation, are adequately marked
   c) Recommending new and or additional AtoN to be established, where necessary.

3.4.2 AtoN Principles

Prior to the start of the CIWSP there was no standardised AtoN regime for inland waterways in South Africa. SAMSA's approach was that all mariners that sail on inland waterways should be accustomed to the requirements of sailing at sea and the AtoN that are available at sea. Therefore, the principle adopted was that there should be no difference between coastal and inland waterways AtoN. This led to the decision to implement the AtoN according to the IALA MBS and for the "buoyage direction" to be upstream.

This approach was taken as many of the small vessels operate on inland waters and at sea.

3.4.2.1 AtoN for general navigation on Government Waterways

DWA is responsible for safety on its waterways, to control aquatic weeds and invader plants on all open water systems, excluding privately owned reservoirs. Its delegated public sector partner, or a delegated water management institution, has the responsibility to provide the required AtoN on all Government Waterways for general navigation.

3.4.2.2 Local Accountable AtoN Parties (LAAP)

In addition to the DWA, Local Accountable AtoN Parties (LAAP) providing access to Government Waterways, watercourses, privately owned dams and other navigable watercourses, or requiring a specific demarcated area for specific recreational usage, have a responsibility to ensure that the required AtoN are provided after obtaining the necessary support from DWA and thereafter the permission by SAMSA.

3.4.3 Identification of AtoN locations

As would normally be the case, nautical charts would be one of the means used to identify where AtoN should be positioned. There were only two nautical charts available for two dams, both which are not part of the pilot dams, nautical charts, could not be consulted. Fortunately, the DWA's survey branch had undertaken underwater surveys at one pilot dam, which provided valuable information and confirmed the local knowledge that was obtained from the locals.

The approach to identify where AtoN should be positioned at the pilot dams was as follows.

Site visits were undertaken to those areas on the dam which are being utilised by the public, as well as those areas which have limited access for the public, being sanctuary/reserve areas. In addition to the SAMSA, DWA and representatives, during all of these site visits persons having local knowledge also accompanied the group, as well as SAPS representatives, where available. In view of the cooperative nature of the project, representatives from DEA and the local environmental entities also formed part of the site visits. Representatives of NEMAI Consulting, the company that DWA appointed to compile the RMPs also accompanied the group.

During these site visits, areas and features of interest and areas which poses danger to vessels were pointed out, taking into consideration the high and low levels of the dams during wet and dry periods. The DEA used these site visits to get a good understanding of the nature of infestation by invasive aquatic species.

Also, decisions were made as to which areas should be made available for recreational usage and which areas should have limited, or no access by the public.

Following this, an AtoN plan was drawn up to indicate roughly where and what type of fixed and floating AtoN, as well as demarcation markers should be positioned. This was then presented to the local interested parties and fine-tuned.

Those areas where fixed and floating AtoN are required are to be surveyed by DWA in order to obtain the best position to locate the AtoN, as well as the relevant coordinates and water depths, where applicable. All this information would be made available to the national hydrographic office for inclusion on future nautical charts for the dam in question.

3.4.4.2 Fixed AtoN

As there are a few areas, e.g. sand banks and rocks which are underwater and would pose no danger to boating during wet periods, but not so during dry periods, the intention is to mark these with durable, fixed AtoN made from, e.g. poly vinyl chloride

1. Special Mark buoys – No Access Zone markers
2. No Access Zone. Use current yellow yacht club course markers with 3-X top marks and pictograms
3. Special Mark buoys – Restricted Zone markers – bird sanctuary
4. North Cardinal Mark buoys
5. Special Mark buoys – Restricted Zone markers
6. Special Mark buoys – Restricted Zone markers– bird sanctuary
7. Special Mark buoys – No Access Zone markers
8. Fixed Restricted Zone Markers, with Special Mark buoys – Jet ski area – see next slide
9. Port Hand buoys – power boat channel
10. Starboard Hand buoys – power boat channel
11. Special Mark buoys – Slow Zone markers

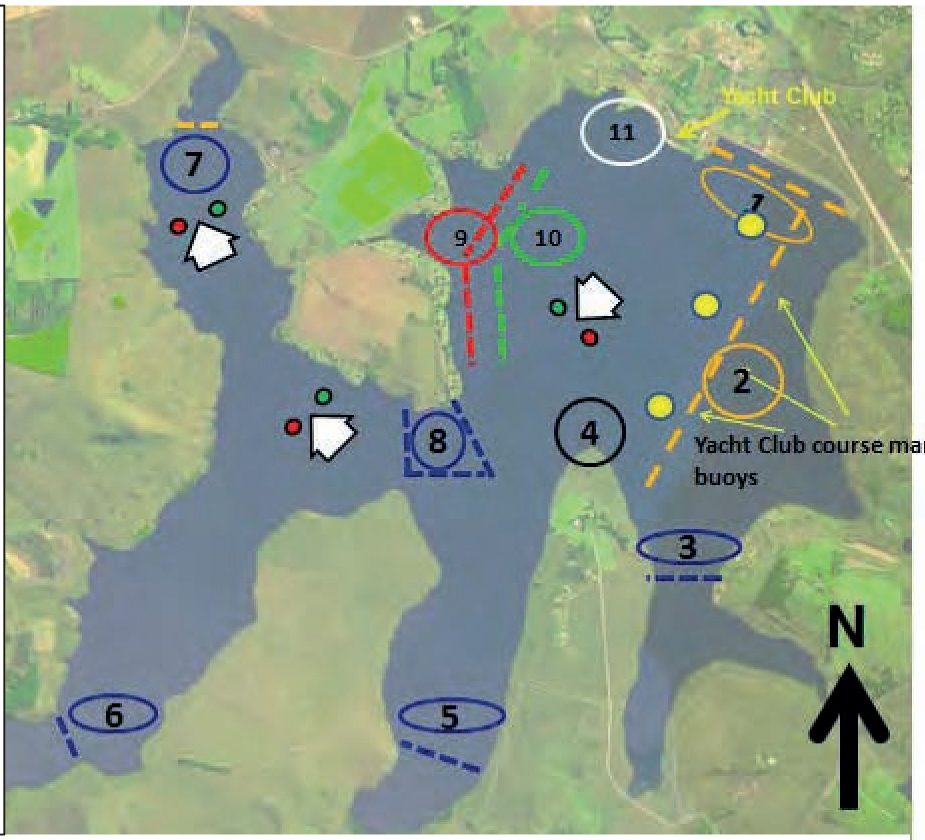


Image 5: Applying the AtoN principles where markings are required on Midmar dam

Phasing in of AtoN

Due to the large capital layout that is required, where relevant, the provision of AtoN would be done on a phased-in approach.

3.4.4 AtoN design

3.4.4.1 Environmental conditions

The pilot dams are located in various provinces in South Africa, all of which have diverse weather patterns. The meteorological and other conditions that are encountered on most, if not all of these dams are very strong winds at some stages, which results in choppy conditions. There are no real currents to speak of, but once the focus is on rivers, this would have to be taken into consideration.

(PVC) and polyethylene. As the level of the dam would fall during dry periods, the fixed AtoN would identify those areas that should be avoided. Only time would tell as to what effect it would have on fixed AtoN being underwater for some time, e.g. the muddy water, and then become visible during dry periods. The possibility would be more than likely having to wash these AtoN down to make their day marks visible.

3.4.4.3 Buoys

The aspect of buoys to be deployed on the inland waterways is very interesting. Unlike coastal areas, the size of vessels on the pilot dams warrant buoys having a focal plane height of no more than 800 mm – this may be more on other inland waterways once the CIWSP is rolled out to other inland waterways.

With the assistance of a local manufacturer, DWA experimented with a pillar type buoy design that would be suitable, at least for the pilot dams. The design had to allow for topmarks and pictorials not causing buoys to lean over excessively during high winds.

The basic dimensions of the design buoy is as follows:

Total length 1 350 mm
Focal plane height 890 mm
Diameter at waterline 550 mm
Weight 29 kg

← *Image 6: Design Special Mark buoy with top mark and pictorial*

3.4.4.4 Mooring

Sinkers

DWA currently make use of various types of unconventional type sinkers to hold their demarcation markers in place. At Boskop Dam a quarter of a 210 litre drum filled with concrete works well to keep the navigational buoys in position, taking into consideration that this dam does not fluctuate more than 500 mm annually as water from a spring keeps the dam full.

The intention is to manufacture and start experimenting with 25 kg, 50 kg en 75 kg mushroom-shaped concrete sinkers.

Mooring line

As the CIWSP is venturing into the unknown, as a start, the approach regarding mooring lines was to "keep it as simple as possible".

Due to the depth of water that would be changing quite significantly during wet and dry periods, and to make the swinging circle of the buoys as short as possible during the rise and fall of the water levels without having to manually shorten the mooring line ever so often, DWA did some research as to the type of mooring methods that could be used.

The possibility of utilising an elastic mooring line was not successful, as the fluctuation of a water level of more than 5 metre could not be accommodated.

Other possibilities that would be attempted are the sub-surface float method and sub-surface sinker- and sub-surface float method. For practical reasons, it was preferred not to use pulleys as they are likely to jam.

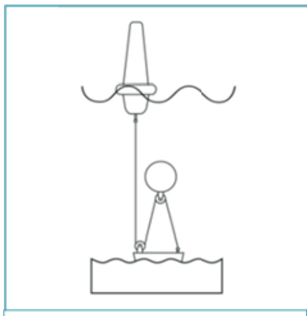


Image 7: Typical sub-surface float method

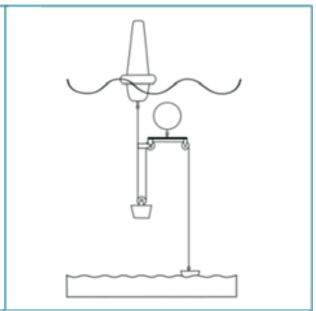


Image 8: Typical sub-surface sinker and sub-surface float method

Another method, the "two sinker and sub-surface float" method would also be experimented with, although in this case a diver would have to assist, which would add to the inconvenience and cost.

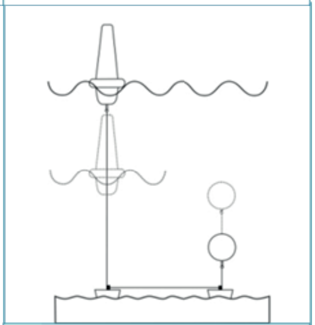


Image 9: Two sinker and sub-surface float method

In the meantime DWA is using wire- and/or nylon rope, fitted with a rope thimble at each end and a D-shackle to fix it to the buoy body. Testing and research is continuing in this regard in order to find the best solution.

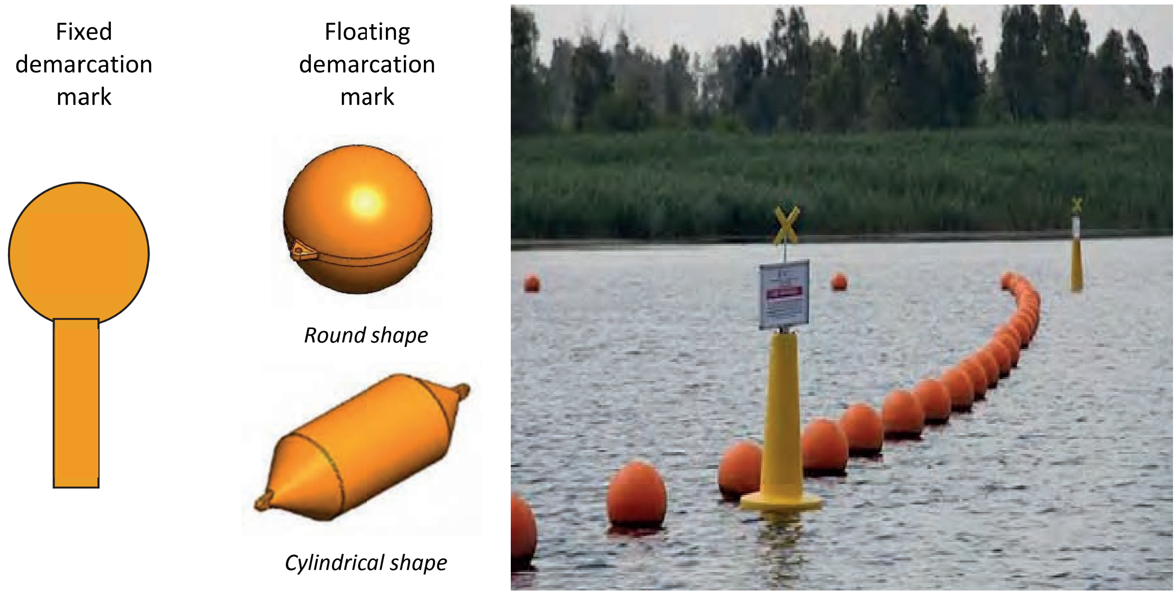
3.4.4.5 Demarcation Markers

In order to demarcate specific zones, standardised demarcation markers are to be used in conjunction with the relevant AtoN. In most cases IALA Special Mark buoys would be used which are fitted with appropriate pictograms, or signage. The principle was that demarcations markers should not be confused with, nor interfere with AtoN, hence the following standardised, round demarcation markers are being implemented.

(a) <u>No Access Zone</u>: **Orange marking**

No access zones, such as near dam spillways, outlet towers, etc. would be marked with No Access Zone demarcation buoys, supplemented with Special Water Markers.

Image 10: No Access Zones being marked with orange demarcation markers, in conjunction with Special Marks with pictograms



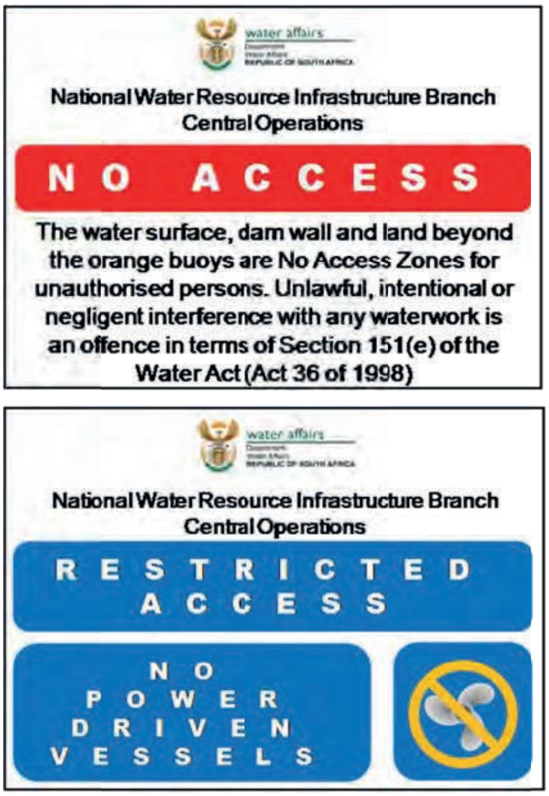


Image 11: Examples of typical signage / pictograms that may appear on AtoN Special Water Markers on Government Waterways

(b) Restricted Access Zone: **Blue markings**

Restricted access would be to nature conservation areas, bird or fish breeding areas, etc.

(c) Dead Slow Zone: **White markers**

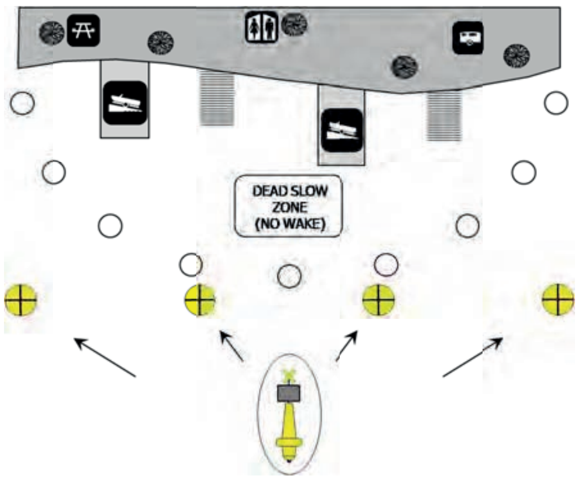


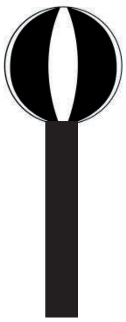
Image 12 A typical example of the demarcation of a dead slow zone markings, in conjunction with IALA Special Mark buoys.

(d) Special Areas: **Yellow markers**

These demarcated areas could be where sporting events would be taking place and other areas of interest. This is the only demarcation colour that would have a similar colour as one of the MBS markings.

Responsible organisations of recreational activities that have been given a zoned area on the waterway would have to implement and maintain their own demarcation markers and AtoN according to DWA specifications and approval. These organisations are then responsible to ensure their members adhere to the AtoN "rules" on the waterway

(e) Shallow Water: **Black and white markers**



Floating demarcation mark

Fixed demarcation mark

3.4.5 Deployment and retrieval of buoys

The most suitable method to deploy and retrieve the buoys and sinkers is still a challenge as the only available vessels at this stage are DWA's rigid-hulled inflatable boats (RHIB), also referred to as rubber ducks.

DWA is envisaging a small mooring barge with a winch at each dam. This idea is still in a concept stage and could most probably be given to DWA mechanical students to come up with a design and related drawings.

3.4.5.1 Inland Waterways Nautical Charts

The South African National Hydrographer of the South African Navy has agreed to compile nautical charts for each of the pilot dams. Local knowledge of specific points and areas, e.g. local names for bays and specific areas, etc. would be included on the relevant charts.

3.4.6 Dissemination of relevant AtoN information

As a start, the Unique Position Number (UPN) system – refer to **clause 3.7.1.1** in this regard – would be used to report any movement, loss or damage to a fixed of floating AtoN.

The UPN would also be used to inform those on the database about any AtoN failures, and/or disseminate any related AtoN.

3.5 Containment of invasive aquatic species

3.5.1 Vehicle, vessel and trailer wash process

A streamlined and effective wash process of a vehicle, vessel and trailer would ensure a high percentage of attached plants and seeds are removed within the shortest time. Therefore, critical to the success of the containment of invasive aquatic species would be the wash bays that would be available at each waterway.

The purpose of these wash bays is to ensure that no plant species is allowed in from another waterway, or are allowed out to infest another waterway by spraying each travelling vehicle, vessel and trailer in order to get rid of any plant species, or seed. These wash bays are to be provided by DWA and would be optimally positioned, eco-friendly, highly energy efficient and user-friendly.

The design and organisational regime would take into consideration the fact that, especially during an event taking place at a waterway, congestion of vehicles should be prevented.

The current wash bays being constructed focuses mainly on vessels being trailered to the waterway. A simplified wash bay for non-trailered vessels like e.g. canoes, dinghy's, etc. is in the process to be designed and constructed, sharing the same catchment area as that of the wash bays for the larger vehicles.

3.5.2 Wash Bay design Principles

The design philosophy has had to evolve along with the containment strategy development. The initial conceptual design incorporating a header tank for herbicide dosing and post washing sieves for plant detritus capture and possible recycling of water, has been amended to a concept incorporating (filtered) water supply direct to the mobile pressure pumps and free draining to a temporary holding reservoir (at which point contact herbicides are added). The intention is to develop a facility independent of electrical supply for both energy efficiency and safety of operators and users, while minimizing the risk of damage to equipment and vehicles by avoiding suspended solids in the water supply, and optimize efficiency of contact herbicides in the event of either overdosing, or excessive peak usage reducing retention time.

Hence, the siting of the wash bay becomes a critical element in assessing feasibility, as the development must incorporate and be integrated with significant influencing factors of transport, environmental affairs, and user management.

The current design makes provision for a standardised concrete slab with a 2% cross fall, whose dimensions allow for a single stage 7 metre boat and access around the towing vehicle and boat by the operator with mobile pump and hose in tow. The sump dimensions are limited to a maximum depth of less than 1,5m for the safety of the operators during cleaning. The free draining overflow is to return to the source, in compliance with the National Water Act, and is as close as practicably possible to the selected slipway site for optimising any residual benefit of return water.

The design allows for the ease of construction by emerging contractors once the CIWSP is being rolled out all the other inland waterways.

Image 13

High pressure washer

An image of the high-pressure regulated washer used, is shown on the left. It has a header tank with a low-level cut-out and float valve, all of which is fitted on a durable stainless steel chassis on wheels and is supplied with 10 m high-pressure hose gun, lance and nozzle.

It was found that the optimum pressure to operate these pumps at is 200-250 kPa. At this pressure, it gets rid of all plants and seeds, but does not damage the vehicle/vessel.

3.5.3 Checkpoint

The wash bay also becomes a pro-active safety checkpoint for valid Certificate of Fitness (CoF) of vessels and Certificate of Competence (CoC) of skippers, thus helping DWA to ensure only safe and lawful participants of recreational water activities are allowed on its waterways.

3.5.4 Wash Bay Gate procedure (entrance / exit)

Accessible and efficient gate entrance and exit procedures would be placed at all wash bays for travelling vessels.

3.5.4.1 Basic Safety Check – vessel and skipper

A visual chart used by Wash Bay Officers would indicate the basic safety equipment and certificates required to ensure legal compliance by skippers of all kinds of vessels, as well as the vessels. If a skipper does not adhere to the safety requirements, he/she will not be given a Tag and thus will not be allowed on the waterway.

3.5.4.2 e-App

A cell phone, or tablet-based application (App) that registers the entrance and exit of a vessel at the wash bay will be supplied. The e-App would be linked to the SAMSA Small Vessel database, which is currently in the development stage, and it would verify if a skipper has done his/her annual CoF. This would also assist in compiling statistics around inland boating.

The e-App can also be used to identify weeds being washed off vessels and thereby help identify the travelling trends of weeds. This also promotes an M-Governance [3] mobile governance solution approach.

3.5.4.3 Tag and Date Stamp

A tag to be issued confirming that the vessel had been washed at the wash bay and adhered to the safety checks. The tag and date stamp ensures that the gatekeeper allows through his/her gate only travelling vessels that were at the wash bay on the current date. Vessels without a

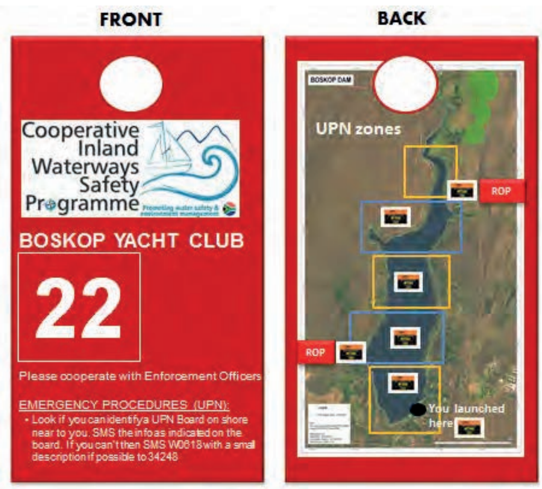


Image 14:

Typical tag

current date stamp will not be allowed by Gatekeepers to launch from their property.

The Tag must be on the vessel at all times. Enforcement Officers and SAPS would be able to, at any time, request a skipper on the water to produce the tag. Should a skipper not be in possession of a valid tag, the skipper would be instructed to go ashore.

The gatekeeper who allowed the vessel through his/her gate without the tag will be identified and reported to the chairperson of the Gatekeepers Committee in order for the necessary corrective action be taken to prevent a re-occurrence.

3.5.4.4 Wash Bay Management Agents / Officers (Working for Water)

DEA are currently in the process to appoint Wash Bay Officers. They are in essence Working for Water [4] teams with the added responsibility of manning and washing vessels at the wash bays. Wash bay officers will execute Working for Water duties during those periods when the wash bay is not active.

A Wash Bay Agent appointed by the DEA has to take responsibility to monitor the Working for Water team. In addition to monitoring the work, the wash bay agent would also have to provide frequent reports to the DEA.

3.5.5 Informative infrastructure

3.5.5.1 Entrance

CIWSP information signs that inform the public of all arrangements and tourism related information before they enter the wash bay would be available. The content thereof would empower the public to make informed decisions without any human assistance.

3.5.5.2 Wash Bays

The erection of appropriate, clear precautionary and information signage at wash bays would be very important, which, amongst others would address notices such as no smoking areas, AtoN that are available on the waterway and the directions to the different approved launch sites would be clearly indicated.

3.5.5.3 Launch sites

At each launch site (gatekeeper), relevant information would be available, indicating hours of operations, activities allowed, etc.

3.6 Localised operations and coordination

3.6.1 Gatekeepers

Gatekeepers are persons, or bodies that provide access to the water surface by means of slipways, jetties, etc. Each gatekeeper would obtain official approval from DWA to allow access to the water surface.

Before allowing any vessel access to the water, the gatekeeper would have to ensure that the skipper is in procession of a valid tag and date stamp. Frequent, unannounced inspections would take place to ensure that the gatekeeper is executing his/her tag and safety responsibility tasks satisfactorily.

3.6.2 Gatekeepers Committee

A co-ordinating and implementation body, called the Gatekeepers Committee will be established by the CIWSP at each pilot site.

The main aim of the gatekeepers committee would be to implement, coordinate and monitor the CIWSP at each waterway. The functioning of the gatekeepers committee is therefore critical to the success of the CIWSP by ensuring the sustainable management of the CIWSP at the waterway.

An appointed DWA official would chair the committee. The committee is a forum where the local role-players from government and the local community at a waterway work as a team to address issues pertaining to the safety, environment and incident management of that specific waterway.

3.7 Organisational structures

3.7.1 Incident Management System

3.7.1.1 CIWSP Operational (OPS) Points at pilot waterways

Incidents at waterways can be related to any of the following.

- Accidents
- Criminal activities
- Medical
- Environment
- Fire
- AtoN
- Lack of Search and Rescue

To address incidents in sometimes very rural waterways, the CIWSP linked up with a company that developed the UPN (refer to clause 3.7.1.1). Successful testing during a number of real life threatening incidents, resulted in DWA purchasing a national licence for all its waterways and personnel.

In order to ensure a coordinated and integrated rescue or response to an incident when the UPN system has been activated, specific Rescue Operational Points (ROP) have been identified at a pilot site where Response Team Members gather.

Depending on the incident, the response team members would consist of, amongst others, representatives from the disaster management of the local municipality, SAPS (Water wing, reservists and community policing), fire services and medical and ambulance services. For specific incidents, the Blue and Green Scorpions would also be activated.

At each ROP there is a volunteer Incident Response Vessel would enable those response team members arriving first, to get to the incident scene on the water and be able to, at least, assist the victim in the best reasonable manner possible.

The incident response vessel only becomes accessible to response team members when they receive the UPN sms/text message.

The incident response vessel will be the responsibility of the appointed CIWSP OPS Point Agent (volunteer from within the gatekeepers), which must ensure the vessel is 24/7/365 ready to respond to an incident.

SAMSA undertook to survey the volunteer Incident Response Vessel annually at no cost.

Image 15: Typical information board that would be displayed at an OPS point

At least four voluntary key holders to all gates and the vessel will be appointed by the CIWSP OPS Point agent and will form part of the response team. When the UPN sms is received by them, they will open all gates and, if needed, skipper the incident response vessel.

A basic Standard Operational Procedure (SOP) for non-professional response team members is being developed for the following scenarios of an injured party. The possibility to link this to a triage process norm where injuries are categorised, either in colour coding or on a point scale, is being investigated.

Injured Party:

1) Breathing – no injury
2) Breathing – minor injury
3) Breathing – major injury
4) Breathing – life threatening injury
5) Not breathing

3.7.1.2 Annual incident exercise at pilot waterways

An annual, unannounced safety drill exercise will be activated by the CIWSP Steering Committee in order to test the readiness of the incident management system. A debriefing will be held after each exercise in order to address any problems that were identified. This process would also assist response team members to familiarise themselves with the system and to have self-confidence in participating in an incident response situation.

3.7.2 Incident alerting system and information distribution system

3.7.2.1 Unique Position Number (UPN)

The DWA has obtained a licence to operate the UPN system on all of its Waterways. The UPN is a 24 hour cell (mobile) phone based incident alerting system that activates relevant and localised response team members at a specific waterway in the following manner:

In any incident the victim or public calls *120*34248# and selects from the menu any of the following options available to the caller:

- **SOS:** Life threatening incidents– to be used by anyone to report any situation where a person's life is threatened, such as a criminal or medical related incident

- **ECO:** Ecological threatening incidents – to be used by anyone to report any form of pollution in or flowing into the waterway
- **ATON:** AtoN incidents – to be used by anyone to report any damage, movement or loss of AtoN / demarcation buoys on the waterway
- **ENFORCEMENT:** Enforcement actions - to be used by the gatekeepers and response team members. This is used only in order to call for back-up support from other response team members in a case where an enforcement situation becomes an incident, e.g. a person becomes violent, or ignore safety requests, etc.
- **TEST**: This function tag allows anyone to test the program to ensure it actually is operational. The person submitting the TEST will receive an acknowledgement message together with a reference number.

The process shown at **Image 16** is followed.

Information stickers, as shown at **Image 17**, would be distributed widely in order to inform the public of the process to follow should an incident occurs.

Initially only SOS and ECO options would appear on these stickers, it being seen as the most critical to inform visitors about an emergency situation and pollution. The ATON and ENFORCE-MENT would mostly be used

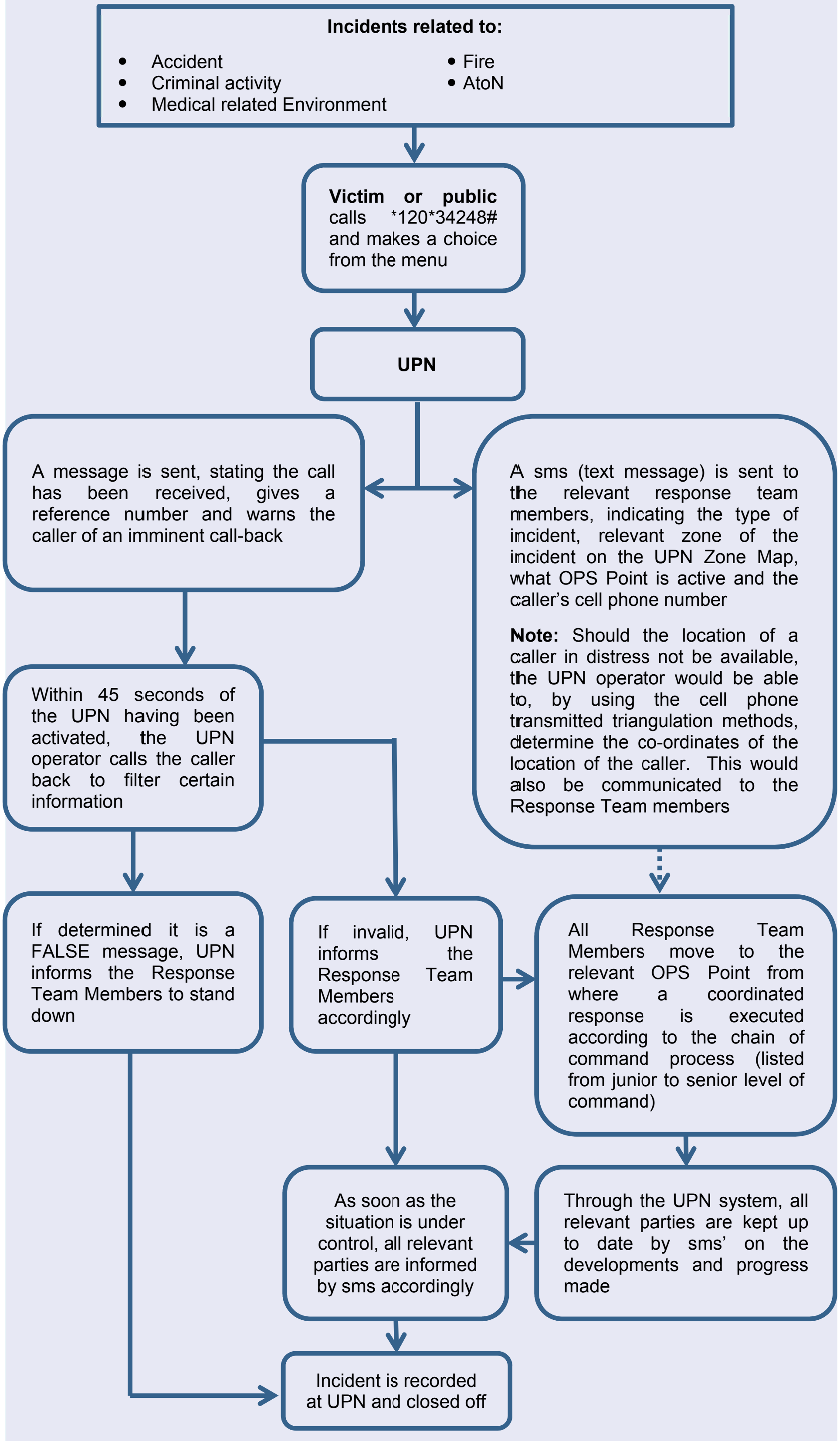


Image 16: Flowchart indicating the process followed when an incident occurs

by those that are part of the management of the dam.

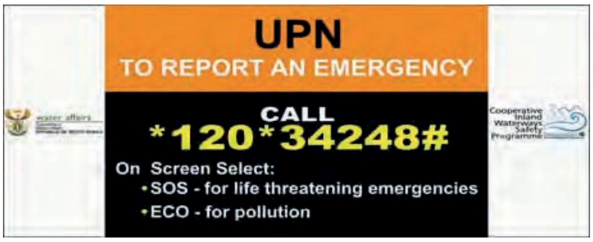


Image 17: Information Stickers

3.7.2.2 Personal Locator Beacon (PLB)

At Vanderkloof Dam, which is 114 km long, the UPN system cannot operate on the total length of the river due to the lack of cell phone coverage of a large part. It order to address this challenge, it is the intention that all users that want to go beyond specific points on the river would have to:

- Obtain a permit from the local SAPS office
- Hire a Personal Locator Beacon[5] (PLB) – this would be made available through the CIWSP

The PLB signal is relayed via satellite transmissions, this will enable those in distress to be identified and the necessary rescue being done in the remote areas of the river.

3.7.3 Enforcement Officers

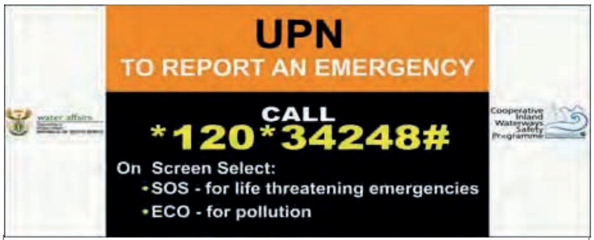
The National Small Vessels Regulations empowers SAMSA to appoint Enforcement Officers. In order to keep a vigilant lookout on a waterway, SAMSA trained and appointed enforcement officer volunteers would approach enforcement through constructive awareness and educational engagement with the public.

These officers would have the power to order a vessel off the waterway should it endanger other users, or does not adhere to safety regulations and rules of the waterway.

If the enforcement officers get involved in a situation where an awareness and educational response becomes an incident, e.g. a skipper becomes aggressive and threatens the officers, he/she would then activate the UPN system, using "Enforcement" on the cell phone menu, resulting in the relevant response team members coming to his/her assistance.

If a vessel was involved in an incident, the enforcement officer could start a preliminary SAMSA Incident Investigation until a SAMSA Official arrives on the scene.

Below is a typical sign that would be visible at a waterway.



22-BOSKOP DAM
Please adhere to safety and general rules of the dam. SAMSA appointed Enforcement Officers monitor the dam and has the power to remove transgressors from the dam. Resistance will result in the involvement of the South African Police Service and a possible fine.

Image 18: Typical signage

3.7.4 South African Police Service (SAPS) support

Although it would be ideal to have a fully equipped and functioning SAPS inland water policing and diving services at each waterway, reality is that this would not be possible at the majority of waterways. The aim is therefore is to have a localised SAPS inland water policing and diving services representative at each waterway that can activate and coordinate SAPS reaction to an UPN incident message.

One of the priorities of CIWSP is for a standard inland waterway SAPS Rule and Fine document to be compiled and signed off by all relevant magistrates in order to empower the relevant SAPS unit to enforce the rules. The ideal would be to have a national document signed off by the Department of Justice.

3.8 Approval of events on inland waterways

In order for DWA to fulfil its safety mandate on its waterways it is important that all events on its waterways be approved beforehand according to a standard event compliance checklist. This is to ensure that all safety regulations and incident response services are pro-actively notified and in place on the day of the event.

To institute this, the CIWSP model requires from organisers of an event to complete the checklist at least a month in advance and submit it to the relevant Gatekeepers Committee's chairperson who in turn would distribute it according to the correct channels for approval. No event will be allowed on a DWA waterway without this approval.

3.9 Business Intelligence (BI) Reports

Business Intelligence (BI) Reports would assist the CIWSP Steering Committee members to be kept up to date with happenings on all waterways. It would also be a great tool in collecting data in order to make well-informed decisions in order to, amongst others, take necessary action, or fine-tune the programme.

3.9.1 UPN Report

This report would indicate the following regarding incident management at a waterway:

- The contact details of the current Gatekeepers Committee members
- The contact details of all previous Gatekeepers Committee members
- State of readiness following "test sms'" sent and the percentage of responses received
- Names of response team members who hasn't responded to Test sms' three times in a row
- List of UPN incidents activated at the relevant waterway

3.9.2 Invasive and alien species report

This report would keep track of the actual situation of invasive and alien species (fauna and flora) at the relevant waterway. The report parameters still to be defined.

3.9.3 Water Quality Report

Specific water quality monitoring points on a waterway would contribute towards keeping track of the water quality at a relevant waterway. The resultant reports to be used to take pro-active measures in warning the community should the water be determined to detrimental to their health. These reports would also be tabled at Gatekeepers Committees.

3.9.4 Reports on the spreading of invasive and alien species

The reports will be compiled in order to get an overall picture of the current and projected situation regarding invasive aquatic species at the relevant waterway in order for the necessary counteraction measures to be taken.

3.10 Touching the lives of the community in more ways

3.10.1 Career development opportunities

In addition to job creation – by appointing Wash Bay Officers - the CIWSP would also be a platform for career development opportunities for these officers. The aim is to make the Wash Bay Officer job a sustainable career by adding responsibilities, such as to make the wash bay a one-stop-point for CoC training and CoF surveying at a waterway. This would make it easier for skippers to obtain the necessary certification, while at the same time assist in creating real sustainable jobs within the community.

Other opportunities for the wash bay officers could be in the various disciplines that they would be getting exposure to, e.g. in municipalities' disaster management or tourism sections, a SAMSA surveyor, or within the DWA, or DEA structures.

3.10.2 Community sport development

It is the intention that sporting clubs next to a waterway would have to partake in the South African Sports Confederation and Olympic Committee's (SASCOC) development and transformation programmes. With the aim of local community development and integration through sport, it is intended that lease agreements of sport clubs on state land at waterways be concluded between the relevant SASCOC accredited National Sport Governing Bodies of the different sports and DWA. These National Sport Governing Bodies then become responsible for the developmental performance of all their relevant affiliated clubs on state property.

These affiliated clubs on state land would become sport specific Training and Development Centres and have to implement their National Sport Governing Body's development and training programmes as accredited by SASCOC.

3.10.3 Community eco–tourism

The CIWSP also lends itself to community eco-tourism by developing lawful areas on the shore of a waterway where the public can access from the waterside for recreational activities like fishing, picnicking, camping, etc. These facilities would have the necessary infrastructure e.g. ablution facilities, waste and refuge management, incident management support, etc. to accommodate the visitors.

3.10.4 Incident Management System – informal settlement

The principles and technologies being used by the CIWSP is being tested in rural informal settlements in order to be rolled-out to other rural and informal settlements where, e.g. an incident management system, using the UPN system would be very beneficial, e.g. as runaway fires regularly affects a community.

3.10.5 SA Scout programme

In order to make the CIWSP a way of life at waterways and ensure future evolution of it according to developed benchmarks and principles within communities, a representative of the Scouts has now joined the CIWSP steering committee.

The intention is for the CIWSP to be part of the Scouts' training. The Scouts would also be able to contribute by doing certain activities to promote the CIWSP and to complete certain safety and environment tasks in order to get certain badges or certificates.

3.10.6 Basic rescue capacity development – NSRI WaterWise programme

The largest number of drowning taking place in South Africa involve children that live close to rural waterways. This is due to children not being able to swim, get caught up in vegetation, flash floods, etc.

The National Sea Rescue Institute [6] (NSRI) has initiated a programme called WaterWise, with a vision to proactively prevent drowning tragedies. The primary focus is on children between the ages of nine (9) and fourteen (14) from underprivileged communities, as they are most at risk of drowning. Competent swimmers can also drown, so instead of teaching kids only to swim, they also teach them in practical ways to rescue their peers.

By using the Wash Bay Officers as trainers, the CIWSP would enhance the NSRI WaterWise programme in the communities at the inland waterways.

3.11 Awareness and communication

3.11.1 Inland Maritime Boating Guide

It is the intention to compile and print a comprehensive and user-friendly boating guide addressing all aspects of inland boating in South Africa, which will amongst others, feature the CIWSP. This publication to be distributed as widely as possible.

3.11.2 CIWSP Awareness Programme

An official CIWSP Awareness programme will be launched to make the public aware of CIWSP and its objectives. The critical aspect would be to develop a standard content that the various partnering institutions can use in their different awareness initiatives. This will ensure the public receives a standard message.

3.11.3 Social media

In addition to the CIWSP web site, which would focus on activities related to recreational and commercial inland waterways and the safety, incident management and environment issues that goes with it, it is intended to make use of the following media in order to get the necessary exposure.

3.11.3.1 CIWSP Facebook

This would be the social media tool where government and relevant community role-players can share information and experiences through comments, photos and video material. The idea would be to share constructive comments, criticism and ideas in order to find solutions.

3.11.3.2 CIWSP Twitter (public)

This would be the social media tool where government and relevant community role-players at a waterway can quickly share information and experiences through short comments.

3.12 Current and future innovations

The CIWSP would also be used as a platform to implement, test, or develop new innovations.

3.12.1 M–Strat Task Management System

One of the challenges in South Africa is implementation. An M-Strat Task Management System is a model that the CPSI is developing in order to enhance innovation, alignment and the sustainable implementation thereof, through a simplistic, visual approach in order to involve all levels of the communities, including those in rural areas, to be meaningful and which will empower them through information sharing.

In order to support the implementation and monitoring of the CIWSP over a wide geographical area, it would be important to keep track of all tasks given and the execution thereof. The M-Strat Task Management system, once completed, should cater for this.

3.13 Future innovations

3.13.1 Disaster Management System at pilot waterways

The Council for Scientific and Industrial Research (CSIR) is currently developing a localised electronic disaster management system where all information pertaining to weather, pollution, fire, incidents and geographical data are to be integrated in such a way that it provides live, early warnings and incident management support to local response teams. This will also ensure a coordinated and integrated local response by the community to an incident. The data would be fed from the CSIR Satellite Pollution Monitoring System, its Fire Information System, Water Quality Analysis System, Satellite images monitoring, Weather system, etc.

The DWA's geographic information system (GIS), underwater mapping, water monitoring system and the UPN system could all be linked in order to provide the necessary data input.

3.13.2 Potential solutions box

3.13.2.1 AIS-SART

An Automatic Information System (AIS) and Search and Rescue Transmitter (SART[7]) system (AIS-SART) was one of the technologies that was tried and tested at one of the pilot sites was. A local company approached the CIWSP team to test their integrated system of hardware made in Germany and software created in India. Their system comprises portable, handheld watertight AIS transmitters (it starts transmitting on AIS frequencies once the emergency button has been activated) that could be used for emergency purposes, along with a base and monitoring stations.

Although the system allows for the tracking of persons or vessels, it was not deemed to be practical and hence affordable as various transmitter antennas would have had to be erected in order provide coverage of an inland waterway.

This resulted in the final decision to incorporate the UPN system.

3.13.2.2 Incident Response Vessel victim board

It is intended to develop a device on which a victim in the water can easily and safely be put on in order to get him/her out of the water and, if need be, be transported to a safer area by the Incident Response Vessel.

3.13.2.3 DWA waterway mapping (Garmin, TomTom, etc.)

In cooperation with companies like Garmin, TomTom, etc., develop inland waterways software, which incorporates, amongst others:

- Dam layout and related information
- AtoN
- Location of the wash bays
- Launch points
- ROP
- Relevant rules, etc.

By making this information available electronically to the public, they could in turn use it to access the waterway virtually in order to see how to navigate the waterway if the water is at a specific and where danger areas are.

3.13.2.4 Underwater 3-D mapping of pilot waterways

By compiling underwater 3-D maps of a waterway, this would assist with the rescue and recovery by response team members. It will also have a commercial value for anglers and divers.

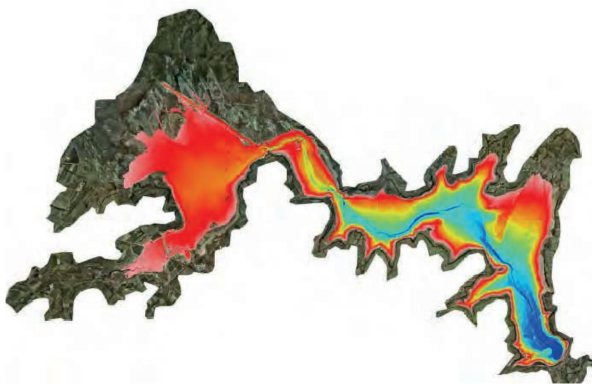


Image 19: Result of the underwater 3-D surveys that was done at the Theewaterskloof Dam

3.13.2.5 CIWSP cell application (App) developments

Develop CIWSP cell phone App for:

- Teaching children to steer /sail a vessel on a waterway, while being exposed to safety and environmental issues that they need to overcome to in order to "win the game".
- Tourists – to provide tourism, safety and environmental information of specific waterways

3.13.2.6 International vessel border crossing

In order to protect SA waterways from invasive fauna and flora from other countries it is foreseen that wash bays based on the CIWSP design, and management principles be constructed at international border points.

3.13.2.7 Sailing simulator

Under the guidance of the yacht club, build a simple sailing instruction simulator that will teach the basic sailing principles on land, thus proactively assist in preventing potential incidents on the water.

3.13.12.8 Drone incident support

Enhance rescue capabilities at larger waterways by using unmanned aerial vehicles (UAVs), also known as drones, to be operated from the Incident Response Vessel to search for victims in different areas while the Incident Response Vessel makes its way to the area.

Future developments can be that the drone can carry cell phone signal enhancing equipment, first aid packages, life jackets, etc.

4. CONCLUSION

Given its unique co-operative government integrative nature, the CIWSP model aims to create a single point for inland maritime information for the public, thus promoting transparent, user-friendly information, accessibility and empowerment. Recreational and commercial water users would further receive additional value through the integrated incident management and response system, aids to navigation and improved environmental management.

The CIWSP is a pilot project where solutions are conceptualised, developed and tested before exposing them to the community. It furthermore provides opportunities:

- To build meaningful community and government partnerships
- To develop a toolbox of excellence (best practices)
- To instil good habits that will enhance a constructive inland waterway culture
- To ensure user-friendliness through standardisation, alignment, integration, synergy building and cooperation
- For the CIWSP model to form a basis for continuous innovation and orientation
- To touch the lives of the community through developing career and sport opportunities, eco-tourism, informal settlement incident management systems and basic rescue capacity.

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[1] The CSIR in South Africa is one of the leading scientific and technology research, development and implementation organisations in Africa. It undertakes directed research and development for socio-economic growth.

[2] Dams having a safety risk is described in Article 117 of National Water Act, Act No 36 of 1998

[3] Mobile government, or m-Government, is the extension of e-Government to mobile platforms, as well as the strategic use of government services and which are only possible using cellular/mobile telephones, laptop computers, personal digital assistants (PDAs) and wireless internet infrastructure.

[4] Invasive alien species are causing billions of Rands of damage to South Africa's economy every year and are the single biggest threat to the country's biological biodiversity. The fight against invasive alien species is spearheaded by the Working for Water (WfW) programme, launched in 1995 and administered through the Department of Environmental Affairs. This programme works in partnership with local communities, to whom it provides jobs, and also with Government departments, including the DWA and DAFF.

[5] A PLB is an emergency beacon that works on the same principle as an EPIRB (Emergency Position-Indicating Radio Beacon). It is a tracking transmitter, aiding in the detection and location of boats and people in distress. It interfaces with the worldwide offered service of Cospas-Sarsat, the international satellite system for search and rescue (SAR). When manually activated, it sends out a distress signal. The signals are monitored worldwide and the location of the distress is detected by non-geostationary satellites, and can be located by some combination of GPS trilateration and Doppler triangulation.

[6] The National Sea Rescue Institute (NSRI) is a volunteer rescue organisation

[7] An AIS-SART is a self-contained radio device used to locate a survival craft or distressed vessel by sending updated position reports using a standard Automatic Identification System (AIS) position report.

The Cooperative Inland Waterways Safety Programme in South Africa

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The Cooperative Inland Waterways Safety Programme Team as a whole

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Acronyms and Abbreviations

AIS Automatic Identification System
AIS-SART Automatic Information System Search and Rescue Transmitter
App Application
AtoN Aids to Navigation
BI Business Intelligence
CARA Act Conservation of Agricultural Resources Act, 83 of 1948
CIWSP Cooperative Inland Waterways Safety Programme
CoC Certificate of Competence
CoF Certificate of Fitness
Cospas-Sarsat The international satellite-based search and rescue distress alert detection and information distribution system
CPSI Centre for Public Service Innovation
CSIR Council for Scientific and Industrial Research
DEA Department of Environmental Affairs
DoH Department of Health
DoSR Department of Sport and Recreation
DoT Department of Transport
DWA Department of Water Affairs
EPIRB Emergency Position-Indicating Radio Beacon
GIS Geographic Information System
GPS Global Positioning System
IALA International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO International Maritime Organisation
kPa Kilo Pascal
LAAP Local Accountable AtoN Parties
LACE Legal Authorisation, Compliance and Enforcement
MBS Maritime Buoyage System
NEM:BA Act National Environmental Management: Biodiversity Act 10 of 2004
NSRI National Sea Rescue Institute
NSVS Regulations National Small Vessel Safety Regulations
OPS Operational
PLB Personal Locator Beacon
PVC Poly Vinyl Chloride
RHIB Rigid-hulled inflatable boat
RMP Resource Management Plans
ROP Rescue Operational Points
RSA Republic of South Africa
SAMSA South African Maritime Safety Authority
SAPS South African Police Service
SAR Search and Rescue
SART Search and Rescue Transponder
SASCOC South African Sports Confederation and Olympic Committee
SOP Standard Operational Procedure
UAV Unmanned aerial vehicle
UPN Unique Position Number
VIP Very important person
WfW Working for Water programme

Interpretations

"**Inland Waterways**" means the waters of any navigable dam, lagoon, lake, river or wetland

14 ROUTE TOPOLOGY MODELLING AS A POTENTIAL MEANS TO RECONCILE MARINE SPATIAL PLANNING WITH DEMANDS OF SEA TRAFFIC – THE NORTH SEA REGION EXAMPLE

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With the advent of, in particular, many offshore renewable energy installations in coastal states' national waters and in coastal states' Exclusive Economical Zones (EEZ) there has emerged the need for Marine Spatial Planning (MSP). At best, MSP will assist in the negotiation of interests of different stakeholders, both ashore and onboard. As a result, sea areas formerly considered "open sea" for shipping may not be that open for shipping in the future any more; rather MSP will likely render the available sea space just a grid of "lanes", as soon as the plans materialize. Such a situation can clearly be foreseen in the North Sea Region (NSR) which is one of the most crowded shipping areas globally. While there is a positive attitude towards offshore sea area usage for renewable energy installations, there must to be taken into account the needs of shipping in the remaining sea areas in regard to both an individual vessel's safe navigation as well as safe and efficient traffic flow.

A fundamental and therefore powerful tool to that end may be Route Topology Modelling (RTM). RTM builds on the fact that most traffic flows through clearly recognizable routes not only when the available waterways and fairways are constrained by limitations such as those introduced by MSP. By RTM, the routes where vessel traffic may take place are abstracted into a description model, which is composed of discrete legs, junctions, and nodes (e.g. ports), to each of which a set of appropriate attributes representing relevant static and dynamic features is attached. Thus, as a first step, a generic RTM is created. According to a specific rule base, the RTM of any given sea area can be constructed for a given point in time. The RTM derived for a specific sea area may then be used for a variety of applications, both shipboard and shore-based. Since the RTM is an application to the maritime domain of the mathematical graph theory, the associated findings and tools for optimization as developed by mathematics may be employed in the maritime domain as well.

The paper introduces the features of RTM both generically as well as by a live example, namely the emerging RTM in the North Sea Region in Northern Europe.

Con la aparición, en particular, de muchas instalaciones de energías renovables mar adentro en aguas nacionales de estados costeros y en Zonas Económicas Exclusivas (ZEE) de estados costeros, ha surgido la necesidad de una Planificación del Espacio Marino (MSP). En el mejor de los casos, la MSP ayudará en la negociación de los intereses de las diferentes partes interesadas, tanto en tierra como a bordo. Como consecuencia, áreas marinas anteriormente consideradas «mar abierto» para el tráfico marítimo puede que nunca más estén abiertas para la navegación en el futuro; más bien, la MSP probablemente representará el espacio marino disponible como una parrilla de «rutas», tan pronto como se materialicen los planes. Esta situación puede ser claramente prevista en la Región del Mar del Norte (NSR), que es una de las áreas de tráfico marítimo más concurrida de todo el mundo. Aunque existe una actitud positiva hacia el uso del área marina mar adentro para instalaciones de energías renovables, deben tenerse en cuenta las necesidades del tráfico marítimo en el resto de áreas marinas respecto tanto a la navegación segura de cada buque como a un flujo de tráfico eficiente.

Una herramienta poderosa y fundamental para este fin puede ser el Modelado de Topología de Ruta (RTM). El RTM se basa en el hecho de que la mayoría del tráfico fluye a través de rutas claramente reconocibles no solo cuando las vías y canales navegables disponibles están constreñidos por limitaciones como las introducidas por la MSP. Mediante el RTM, las rutas donde puede realizarse el tráfico de buques se condensan en un modelo de descripción, que está compuesto por etapas, confluencias y nodos (p. ej. puertos) discretos, a cada uno de los cuales se incorpora un conjunto de atributos apropiado que representa características estáticas y dinámicas relevantes. De este modo, en una primera etapa, se crea un RTM genérico. De acuerdo con una base de normas específica, puede construirse el RTM de cualquier área marina dada para un punto y un momento determinado. La RTM derivada de un área marina determinada puede después utilizarse para diferentes aplicaciones, tanto con base a bordo como en la costa. Como el RTM es una aplicación de la teoría de gráficos matemáticos al dominio marítimo, los resultados asociados y las herramientas para la optimización desarrollados por los matemáticos también pueden emplearse en el dominio marítimo.

La ponencia presenta tanto las características genéricas del RTM como un ejemplo de actualidad, concretamente el RTM emergente en la Región del Mar del Norte, en Europa del Norte.

Avec l'arrivée, en particulier, de nombreux sites de production d'énergie renouvelable en mer dans les eaux territoriales des pays côtiers et dans les zones économiques exclusives (EEZ), a émergé le besoin d'une planification de l'environnement maritime (MSP). Une telle planification pourrait aider les négociations entre parties prenantes, à terre et en mer, de sorte que les zones jusqu'à présent considérées comme « ouvertes » à la navigation pourraient ne plus être aussi ouvertes dans l'avenir. On pourrait plutôt aboutir à une sorte de réseau de couloirs navigables. Une telle situation peut très bien être envisagée en mer du Nord, qui est une des régions du monde où la navigation est la plus dense. Bien qu'il existe une attitude positive vis-à-vis de l'utilisation des espaces maritimes pour la production d'énergie renouvelable, il faut aussi prendre en compte les besoins de la navigation maritime dans les espaces restant, tant en sécurité de la navigation du navire lui-même qu'en sécurité et efficacité du trafic.

Un outil fondamental, et donc puissant, d'y arriver pourrait être un Modèle Topologique de Route (RTM), reposant sur le fait que la plupart du trafic suit des routes clairement reconnaissables, at pas seulement lorsque ces routes sont soumises à des contraintes telles que celles introduites par la MSP. Par le RTM, les routes que peuvent suivre les navires sont résumées dans un modèle de description qui comprend de petits passages, des jonctions et des nœuds (par exemple des ports), avec pour chacun une série d'attributs représentant des traits caractéristiques, statiques ou dynamiques. Ainsi en première étape, un RTM générique est créé. Suivant une règle de base spécifique, le RTM d'une zone donnée peut être construit pour un moment donné. Le RTM créé pour une zone maritime donnée peut être utilisé pour différentes applications, à bord et à terre. Comme le RTM est une application au domaine maritime de la théorie du graphique mathématique, les découvertes et outils associés destinés à l'optimisation telle que développée par les mathématiques, peuvent aussi être utilisés dans le domaine maritime.

Le rapport présente les spécificités du RTM aussi bien de manière générique que par un exemple vivant, celui du RTM émergeant en du Nord, au nord de l'Europe.

Route topology modelling as a potential means to reconcile marine spatial planning with demands of the sea traffic – The North Sea example

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Route topology modelling as a potential means to reconcile marine spatial planning with demands of the sea traffic – The North Sea example

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1. MOTIVATION

This chapter presents the motivation to engage with Route Topology Modelling (RTM). Basically, the advent of several new developments has led to that engagement.

1.1 The advent of Marine Spatial Planning (MSP)

With the advent of, in particular, many offshore renewable energy installations in coastal states' national waters and in coastal states' Exclusive Economical Zones (EEZ) there has emerged the need for Marine Spatial Planning (MSP). UNESCO defines MSP as follows: "Marine spatial planning is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process" [1]. Stakeholders of that process are, by default, any and all stakeholders involved in marine activities, "including energy, industry, government, conservation and recreation" [2]. "Industry" could be construed to contain in particular shipping.

At best, MSP therefore will assist in the negotiation of interests of different stakeholders, both ashore and onboard. As a result, sea areas formerly considered "open sea" for shipping may not be that open for shipping in the future anymore; rather Maritime Spatial Planning will likely *render the available sea space just a* ***grid of "lanes", i.e. a grid of lines,*** as soon as the plans materialize.

IALA has also recognized the above challenges and therefore entertained a Workshop in 2013 to discuss the bearing of MSP on the Aids-to-Navigation (AtoN) in general and Vessel Traffic Services (VTS) in particular. The Workshop demonstrated that MSP is a global topic and arrived, amongst others, at the following conclusions:

- "Early and widespread stakeholder involvement and buy in to the Marine Spatial Planning process is essential;
- Marine Spatial Planning requires a single point of leadership for facilitating engagement in the process and assist with inter-stakeholder co-operation at the national and international level. (…)
- Geographical information that aligns with standards contained in the IHO's developing S-100 Geospatial Information Registry will be increasingly helpful for Marine Spatial Planning, noting that IALA is working on two S-100 domains, VTS and AtoN.
- Marine Spatial Planning benefits from the sharing of information across international borders;
- IALA members are recommended to participate in the Marine Spatial Planning process and encourage other relevant stakeholders to liaise with the appropriate Marine Spatial Planning body; (…)
- Risk mitigation control measures, such as VTS and other AtoN, may need to be amended as a Marine Spatial Plan continues to develop, to ensure safe and efficient use of the sea for all stakeholders" [3].

In Europe, the EU now has legislation and regulation under way to harmonize the MSP efforts and regulations along the European coasts [4].

The challenge for shipping as identified above can clearly be foreseen in the *North Sea Region* (NSR) which is one of the most crowded shipping areas globally. Germany, for example, which has ambitious plans to harvest off-shore electrical energy as part of its "Energiewende" scheme, has already undergone a MSP for the German EEZ which resulted in appropriate domestic legislation [5]. Foreseeing a full deployment of the presently planned offshore activities, the German legislation renders a MSP plan regarding its impact on shipping as depicted in **Figure 1**.

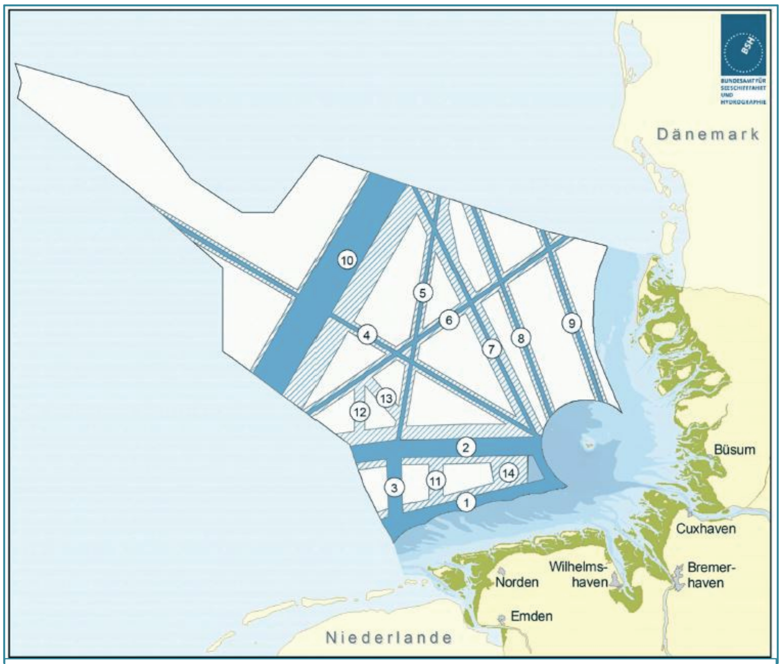

Figure 1: Marine Spatial Planning in the North Sea region, the German example [5]

Note that the numbered corridors reserved for shipping even with the advent of all projected offshore usage. The precise coordinates for those shipping lanes are also available in the German legislation.

The EU-part funded project ACCSEAS (Accesibility for Shipping, Efficiency Advantages and Sustainability), the membership of which in particular consists of the shipping and waterways administrations around the NSR, started its work with an assessment of the known present and future plans for sea usage in the North Sea Region, taking into account in particular the MSP activities of the countries surrounding the North Sea region. As a first result, ACCSEAS has produced a composite picture of that situation as seen from the point of view of vessel traffic (compare **Figure 2**; [6]).

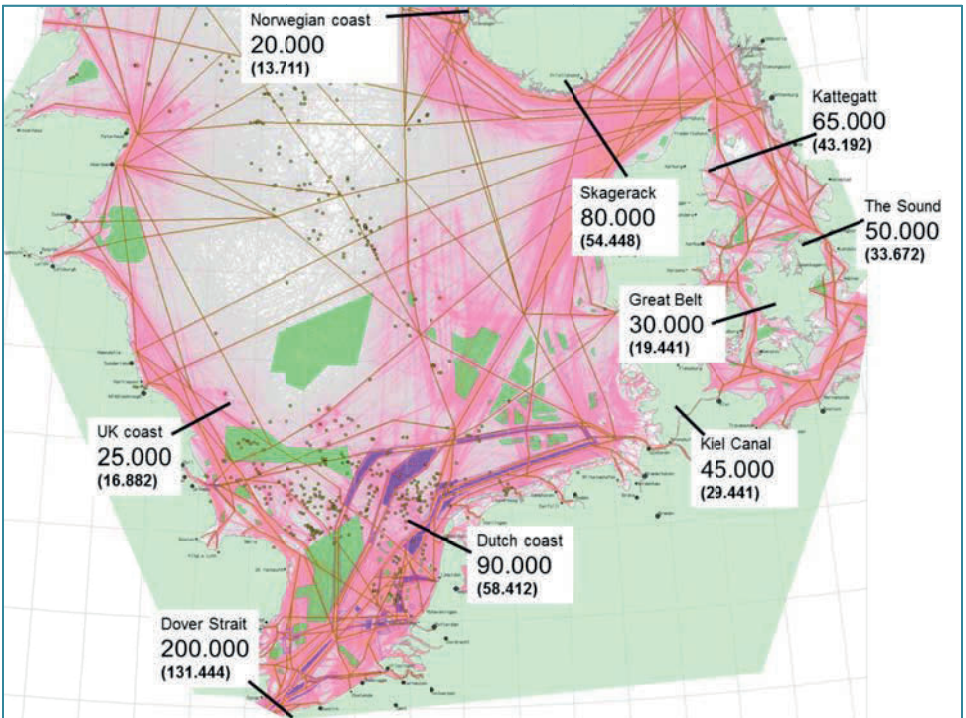

Figure 2: Marine Spatial Planning in the North Sea Region, the ACCSEAS findings

Note: The present traffic as based on the AIS footage gathered by the administrations' coastal AIS shore networks around the NSR is depicted in red. The numbers at the gates denote the vessel movement forecasts for 2020+, and in brackets there are given the AIS footage based vessel traffic figures for the present (2012). A detailed description regarding the forecast is contained in [6], chapter 2.

While there is a positive attitude towards offshore sea area usage for renewable energy installations, there must to be taken into account the needs of shipping in the remaining sea areas in regard to both an individual vessel's safe navigation as well as safe and efficient traffic flow. "Accessibility" of ports, "permeability" for waterways (natural and artificial) as seen from a vessel traffic perspective, while maintaining its safety and efficiency and the protection of the environment, are therefore key terms for the abovementioned ACCSEAS project.

1.2 The advent of Maritime Service Portfolios (MSPs)

In 2008 the International Maritime Organisation (IMO), after some consultations with IALA, agreed on a so-called "e-Navigation" strategy [7]. Later on, while working on the overarching e-Navigation architecture, IMO has identified, amongst other key elements (compare **Figure 3**), the establishment of so-called "Maritime Service Portfolios (MSPs)" as a key element for the success of their e-Navigation strategy.[1]

A Maritime Service Portfolio is generically defined as *"a set of operational and/or technical services which are bundled together for a specific purpose"* [9]. **Figure 4**, i.e. the Figure depicting the overarching e-Navigation architecture as defined by IMO, shows the MSPs as a dotted line at the interface between the shore side and the "links" to the shipboard side: Each and every service, both operational and technical, crossing that line will eventually need to be represented digitally in one or several (generic) MSPs. Employing the imagery of physics one can speak of a spectrum of services or of spectra of operational and technical services from which the different MSPs can be assembled. From that architectural diagram it can also be inferred, that there will be a cascade of dependencies between operational services and technical services and amongst technical services.

IALA, being invited by IMO to progress the shore aspects of the e-Navigation strategy, started work to better understand the nature of the MSPs, in particular their structure (compare [9] for tentative results). It is clear already from that initial work that the MSPs will be key to a defined electronic delivery of shore-based digital services at "open" sea and at waterways (natural and/or artificial), including the digital representations of both existing operational and technical services in the many fields already represented in an initial top-level MSPs list tentatively defined by IMO, such as "VTS

Information Service (IS)", "VTS Navigation Assistance Service (NAS)", "VTS Traffic Organization Service (TOS)", "Local Port Service (LPS)", "Maritime Safety Information (MSI) service", "Pilotage service", "Vessel shore reporting", "Nautical Chart Service", "Real-time Hydrographic and environmental information services", and "Search and Rescue (SAR) Service" [11].

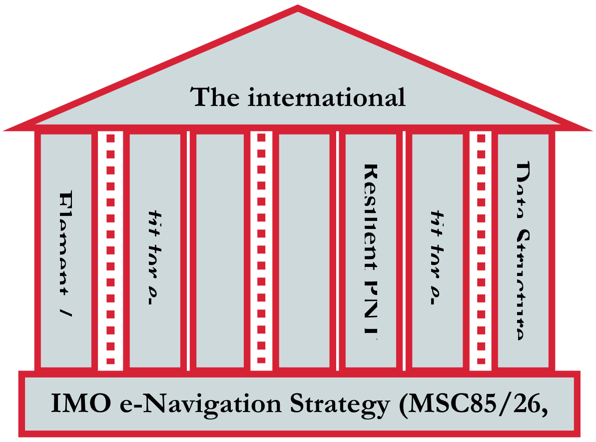

Figure 3: Mapping of key elements to fields of work, i.e. the "7 pillars-model" as developed by IALA [8]

IALA, being invited by IMO to progress the shore aspects of the e-Navigation strategy, started work to better understand the nature of the MSPs, in particular their structure (compare [9] for tentative results). It is clear already from that initial work that the MSPs will be key to a defined electronic delivery of shore-based digital services at "open" sea and at waterways (natural and/or artificial), including the digital representations of both existing operational and technical services in the many fields already represented in an initial top-level MSPs list tentatively defined by IMO, such as "VTS Information Service (IS)", "VTS Navigation Assistance Service (NAS)", "VTS Traffic Organization Service (TOS)", "Local Port Service (LPS)", "Maritime Safety Information (MSI) service", "Pilotage service", "Vessel shore reporting", "Nautical Chart Service", "Real-time Hydrographic and environmental information services", and "Search and Rescue (SAR) Service" [11].

IMO has stated tentatively that MSPs should be applied to (large) areas such as "port areas and approaches", "coastal waters and confined or restricted areas", "open sea and ocean areas",

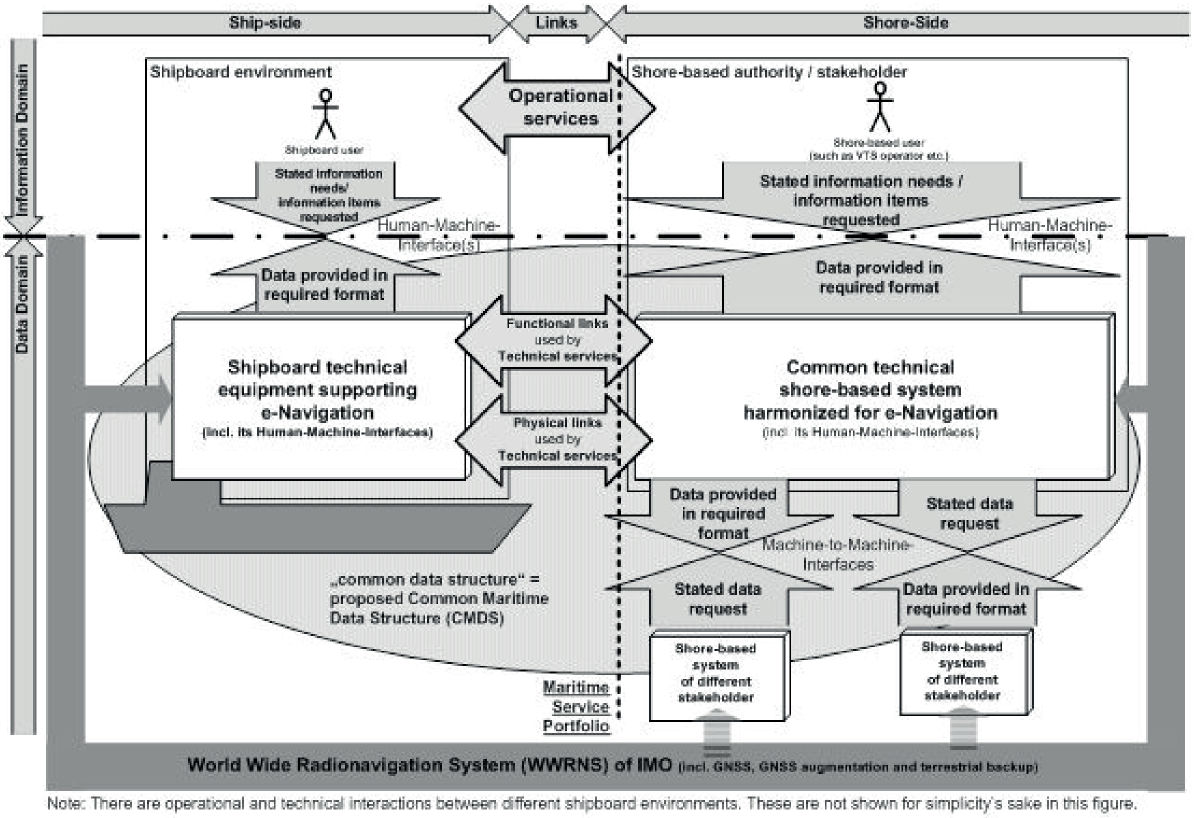

Figure 4: The Maritime Service Portfolio(s) in their context within the overarching e-Navigation architecture as defined by IMO [10].

"areas with offshore and/or infrastructure developments", "polar areas" and "other remote areas [12]. It is suggested by IALA's abovementioned initial work that the concept of the MSPs may be more effectively and/or efficiently employed when ***applying it to shipping lanes at "open" sea and to waterways (natural and/or artificial), i.e. to lines and their respective start/end points*** instead of (coverage) areas. This holds true in particular from a shore-based vessel traffic management and shore-based service provider point of view. I.e. it is expected that the concept of the MSPs, as developed within the e-Navigation initiative, has thus also the power to provide solutions for the above challenges of Marine Spatial Planning.

1.3 The Advent of IMO's Concept for a 'Sustainable Maritime Transportation System (SMTS)'

On the occasion of the World Maritime Day 2013 in September 2013, the Secretary General of IMO presented a "Concept of a Sustainable Maritime Transportation System (SMTS)" [13]. This concept attempts to sketch an answer from the transportation angle of perspective to the challenge recognized by e.g. the World Summit on Sustainable Development (2002, Johannesburg) as "ensuring the conservation of natural resources through their balanced management and use and the protection of the environment" [13, 4], which also is the reason for Marine Spatial Planning. The concept mentions specifically e-Navigation and finally derives expressively the consequential goals and resulting activities from a point of view of a ***Sustainable*** Maritime Transportation System, i.e. from a ***sustainable*** logistics chain towards vessel traffic management.

Specifically, under the heading "Maritime Traffic Support and Advisory Systems" the following goal is derived: "***A Sustainable Maritime Transportation System requires*** co-operation and harmonization in the ***development of optimal systems for navigation, including*** pilotage and ice breaking services, where necessary, ***the use of intelligent routeing systems*** and aids for weather routeing, ***including e-naviga-tion,*** so as ***to optimize safety and fuel efficiency,*** without undermining the Master's authority and competency in the operation of the vessel. Reliable charts, based on up-to-date hydrographic, oceanographic and environmental data are of paramount importance. ***Consideration should also be given to further expansion of traffic information systems*** such as the ***Marine Electronic Highway*** concept" [13, page 6; emphasis mine].

Maritime transportation traditionally takes place within a grid of "shipping lanes" with the ports as terminal points or nodes, i.e. which is where the term originally was coined. The IMO SMTS now takes the traditional concept of the logistics chain, including its maritime part, to the domain of sustainability considerations. This in turn introduces certain requirements for e.g. vessel traffic management efficiency in regards to e.g. energy consumption efficiency due to optimal routeing of vessel traffic within the lane- or line-shaped grid of "shipping lanes".

1.4 Summary of resulting task

From the above introductions the motivation for the Route Topology Modelling may be concluded as follows: *A tool is required which is capable to map the connectivity of* ***lane- or line-shaped vessel traffic and thereby maritime transportation relations,*** *both past, present and projected future ones, into a easy-to-handle abstract domain and thereby enabling the application of powerful management and optimisation tools from that abstract domain to the vessel traffic flow.*

In addition, the desired tool should be capable to support *defined electronic delivery of shore-based digital services, as implied by both the IMO concept on Sustainable Maritime Transportation System and the IMO e-Navigation Strategy,* i.e. it should be possible to easily render the above abstract representation into an electronic and, more precisely, digital representation for use by shipboard and shore-based IT systems.

2. ROUTE TOPOLOGY MODELLING AS A POTENTIAL SOLUTION

The previous chapter introduced the motivation to search for a tool which would be able to map the connectivity of lane- or line-shaped vessel traffic and maritime transportation relations into an abstract representation which would be feasible to be handled in the digital domain by IT systems and their conceptual correlates such as data models and machine-to-machine interfaces or data exchange protocols.

When looking for abstract tools, system engineering and informatics tend to look for mathematics for foundational answers. The concept of a line together with a associated end points of that line is called a ***"graph"*** within mathematics. The theoretical framework of mathematics dealing with graphs is called ***"graph theory."***

There may be a flow direction associated with a graph, thus rendering it a ***"directed graph" or "vector."*** There may be associated additional so-called ***"attributes"*** both to the line and to its end points, thus allowing qualifying the graph further as required by the application in mind. It is the application domain – in our case the maritime transportation and the vessel traffic management domains – which determines terminology, scope and extension of attributes, as well as the appropriate digital representation of the graph ***"models"*** developed for the application domain under consideration. In the maritime domain, meaningful terms to be used are e.g. ***"leg", "waypoint", "junction", "node", "route", and "voyage".*** Any grid of graphs exhibits a certain **"topology"**, which may be analyzed due to certain features of that topology.

Therefore, from an application point of view it is here deemed an appropriate name to call the desired tool a ***Route Topology Model (RTM) of the vessel traffic and maritime transportation relations,*** thus making use of the above introduced fundamental terms. In the following the short terms "Route Topology Model" for the ***"product"*** or "Route Topology Modelling" for the associated activities are used, both abbreviated by "RTM".

More sophisticated maritime concepts within the well-defined class of IMO described "Routeing Measures" which are clearly graph-related, such as a ***Traffic Separation Scheme (TSS),*** may be described by these terms as a compound, too.

Within mathematics, graph theory is a well established field, and it provides a wealth of abstract ***optimization methods*** developed over time. Graph theory is already therefore employed by other modes of transport and by the logistics domain to their benefit.

Hence the ***central proposal of this paper*** is: ***The mathematical graph theory together with its correlated optimization methods should be transferred to the maritime domain of shipping and in particular to the domain of vessel traffic management in an appropriate way, taking into account the specifics of the maritime domain. This transfer process should be called Route Topology Modelling, which renders both generic and/or sea area-specific instances of Route Topology Models.***

The RTM of the vessel traffic and maritime transportation relations, when considered in the terminology and architectural framework of the overarching e-Navigation architecture, would be an integral part of the IMO defined ***Common Maritime Data Structure (CMDS)*** (compare Figure 4 above). This would allow many maritime applications to access the very same data structure definitions regarding RTM in a ***globally harmonized manner*** (which is the point of the e-Navigation strategy). Regarding the digital representation format, the IMO has decided that the CMDS should be expressed by using ***the S-100/S-99 framework and standards*** developed and maintained by the International Hydrographic Organisation (IHO) [14].

When considering the relationship of RTM to the CMDS using Figure 4, it should be noted, that the Maritime Service Portfolios (MSPs) as also defined in **Figure 4** also directly tap into the CMDS whenever data objects are referred to. Thus, it is now demonstrated, that there is a clear architectural relationship between MSPs and RTMs via the CMDS. Thus, the RTM qualifies as the desired tool for MSPs as stated above.

In theory, there may be several ***generic*** RTMs developed, but ideally there should be just one as part of the above global overarching e-Navigation architecture eventually. When it comes to the ***"instances"*** of the generic RTMs, i.e. to RTMs developed for specific sea areas based on the (same) generic methodology, then there may be at least as many sea area specific RTMs as there are sea areas under consideration. An instance of the generic RTM developed for the North Sea Region may be called NSR-RTM appropriately, for instance.

Finally, it is important to note here, that the (digital) abstract representation of the RTM does ***not imply any specific application and/or any regulatory force whatsoever.*** The other way round: The RTM is to be construed as a powerful tool, however, which may be used by several applications to their benefit; any regulatory force, if at all, lies with those applications and with those applications alone. It should be also noted, that the

RTM does ***not imply any constraints in time,*** so that a generic RTM or a RTM developed for a specific sea region may be used for both ***strategic*** (long term) and ***tactical*** (short term) purposes of ship/vessel traffic management. Again, it is the application which determines the time duration and constraints.

3. APPLICATIONS OF ROUTE TOPOLOGY MODELLING OF VESSEL TRAFFIC AND MARITIME TRANSPORTATION RELATIONS

Within the abovementioned ACCSEAS project, the following applications of a generic RTM as well as the North Sea Region instance of it (i.e. the NSR-RTM) have been identified tentatively:[2]

- *(NSR-)RTM supports the Maritime Service Portfolios (MSPs):* The (NSR-) MSPs can be associated with the (NSR-)RTM in order to arrive at a service provision scenario tailored to the need of specific (NSR) routes (both shipboard and shore-based stakeholders and users);[3]
- *(NSR-)RTM may enable (NSR) transport and traffic pattern analysis for policy making:* based on (NSR-) RTM the (NSR) transport volumes, the cargo flows, and the development of the (NSR) vessel fleet can be assessed (shore-based stakeholders);
- *(NSR-)RTM may assist in the Marine Spatial Planning* of a given sea area (shore-based stakeholders);
- *Traffic planning and management in strategic and tactical terms* for parts of the NSR or for the NSR as a whole may be supported (shore-based);
- *Transport management by employing an improved route and voyage planning* on the basis of RTM, both regarding initial (pre-trip) and en-route (re-)planning (logistic chain stakeholders, ship-owner and shipboard application);
- *Maritime information dissemination can be tailored to the specific needs of different user groups* based on RTM (shipboard and shore-based users and stakeholders, such as service providers, alike);
- *Just-in-time arrival processes and planning may be supported* by (NSR-)RTM (logistic chain stakeholders, shipboard and shore-based stakeholders);
- By establishing a RTM for a given sea area, *the features of that instance of the RTM are being agreed by all participating parties.* Thereby, the features are harmonized (all stakeholders);
- *Improved risk assessment by basing the risk assessment on defined routes* within the sea area under consideration (as opposed to area-based risk assessment), which in turn supports several of the above applications and may facilitate decision making regarding the implementation of safety measures(shore-based stakeholders);
- *NSR-RTM may assist in establishing improved Routeing Measures,* in particular an improved TSS scheme, for the NSR (via the usual IMO procedures);
- *(NSR-)RTM may assist in extensive or more precise cost / benefit analysis* for the area under consideration. Costs/benefits could be applied both to commercial operators and authorities.

It should be noted that the above identified potential applications of the (NSR-) RTM provide a strong justification for creating them.

4. DEVELOPING A GENERIC ROUTE TOPOLOGY MODEL AND A NORTH SEA REGION SPECIFIC EXAMPLE

The ***ACCSEAS project*** has now set out to develop both a generic Route Topology Model and a North Sea Region specific example, i.e. the NSR-RTM. The results of this work together with precise proposals for the development of S-100 based "products" and standards would be contained in a so-called ***"RTM Description"*** which would be publically available at the end of the ACCSEAS project (i.e. in February 2015).

The above applications require appropriate presentation of the (NSR-)RTM data to a specific user; hence there is a need for a ***specific portrayal mode*** for an application from the above list. Eventually, the different requirements of the above applications will result in a variety of portrayal modes. The ACCSEAS project so far has identified ***three fundamentally different portrayal modes for RTM data*** each of which addresses different fields of applications and user needs:

- ***the London tube map portrayal mode***, as originally developed by Harry Beck (1902-1974) for London Transport in the 1930's [15], which is "reduced-to-the-max" in that it only shows the fundamental features of the vessel traffic relations, i.e. it deliberately omits e.g. geographical references and details of the precise course of navigation. The London tube

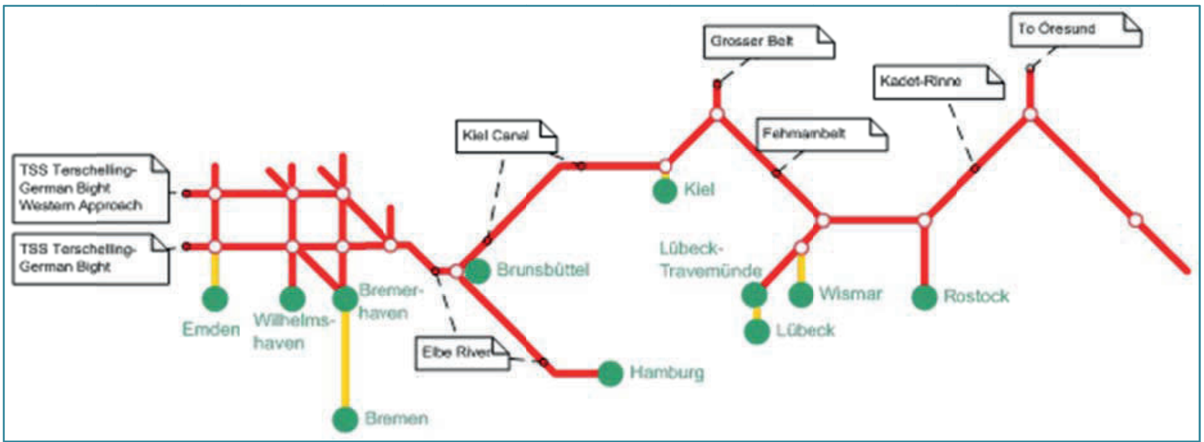

Figure 5: Initial transfer study for the RTM of the German Motorways of the Seas grid (top level waterways) into the London tube map portrayal mode [Ongoing work within the ACCSEAS WP4 MSP-Stream; study by the present author]

map portrayal mode, therefore, is best suited for any strategic purpose where those features are of no importance. **Figure 5** gives an example of a resulting RTM for the "Motorways of the Seas" level of the German coastal waterway system.

- ***the ECDIS portrayal mode***, which presents the RTM in an ENC layer. Therefore, this kind of portrayal mode would be required for more tactical applications but could also be used for some strategic purposes. **Figure 6** gives an initial impression of a NSR-RTM in the ECDIS portrayal mode.
- ***the Head-Up-Display portrayal mode***, embedded in a shipboard ***Augmented Reality Environment:*** Here the RTM data would be used to project trajectories, upcoming junctions, nodes (and associated service options, when combined with Maritime Service Portfolios) within the windscreen image of the ship's bridge crew (compare **Figure** 7). Obviously, this portrayal mode would be essentially geared towards tactical ship handling applications.

It should be noted, that the ***supporting data for all the above RTM portrayal modes would be the same for the same sea area***, and that all three different portrayal modes could ***co-exists*** at the same time at the same work place, although for different purposes and tasks.

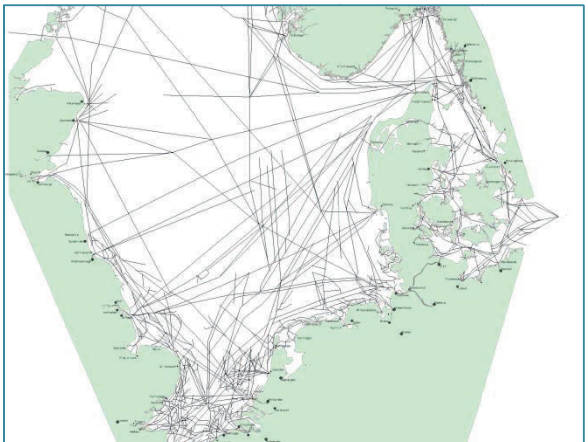

Figure 6: Initial Identification and depiction of Vessel Routes in the North Sea Region [Ongoing work within the ACCSEAS WP4 MSP-Stream; courtesy Maritiem Instituut Willem Barentsz, Mr. Stephan Procee]

Figure 7: Conceptual Study for Portrayal of a vessel's route based on the RTM data to the brigde team using Head-Up-Display portrayal mode (dotted line) [Ongoing work within the ACCSEAS WP4 MSP-Stream; courtesy Maritiem Instituut Willem Barentsz, Mr. Stephan Procee]

5. TRAFFIC SITUATION DEPENDENT MARITIME SERVICE PORTFOLIOS AND SERVICES PROVISION USING ROUTE TOPOLOGY MODELS

It was stated above that the lane- or line-oriented application of MSPs, as supported by RTM, may have benefits compared to the blanket area coverage application of services and/or MSPs in certain cases.

- RTMs are, by definition, traffic oriented, i.e. they map where there could be any meaningful traffic and where there is traffic (if based e.g. on AIS footage). Thus, an application of the services and/or MSPs can be tailored to the specific service needs of a certain leg, a certain route, a certain shipping lane as well as to a certain node, a certain junction or a certain terminal point.
- Thus the service/MSPs deployment by shore-based service providers can be tailored specifically to the need of the traffic on that particular part of the RTM, i.e. differentiated.
- This in turn allows for the definition of different classes of shipping lanes – what is e. g. the distinction between a "Motorway of the Seas" or "Marine Electronic Highway" and an "ordinary" road of the sea in terms of services and MSPs, i.e. in functional terms? By analogy with the roads ashore, one expects different MSPs also operating at different levels of service quality parameters from an "Autobahn" (highway, motorway) than from a national road and again from a local road or even track.
- There could be established a differentiated and fully transparent derivation chain from user needs via user requirements to service/MSPs provision requirements, even to the extent of different service levels for the same generic service/MSPs at different routes, legs, or nodes within the grid, thus allowing "traceability" of the requirements and fulfilment relations.
- For the same reasons, from a service provider's management point of view, the tailored deployment of services/MSPs may be highly efficient as opposed to the blanket coverage concept in terms of resources used, depending on the nature of the services under consideration.

These benefits, and potentially more, can be reaped in the MSPs domain when attaching the provision of MSPs and services to RTMs.

It should be noted, that MSPs may also contain services geared specifically to the needs of a *Sustainable* Maritime Transportation System as envisaged by IMO. Thus, the RTM-based deployment and application of the MSPs may be beneficial or even key to deliver those logistics chain related services where needed most.

Having said this, there is still margin for a blanket coverage concept as blanket coverage areas in most cases cover some or several routes, legs, nodes and junctions of a RTM in the area under consideration simultaneously. The point which is made here is that there should not be made any regulation which excludes any of the two by default. The two options to the application of the MSPs should rather be construed as co-existing. This principle should be taken into consideration when further defining the generic MSPs and services internationally.

6. CONCLUSION

Turning back to the title of this paper – „Route Topology Modelling as a potential means to reconcile Marine Spatial Planning with Demands of Sea Traffic – the North Sea Region example" –, it was the aim of this paper to demonstrate that the introduction of the mathematical graph theory and its associated optimisation methods into the maritime domain, as appropriate, in the shape of Route Topology Models, has the potential to render an adequate solution, due to its lane- or line-shaped method of working, to the lane- and line-shaped traffic situations in shipping which are there traditionally or which are the residue of the previously "open sea" left to shipping as a result of Marine Spatial Planning in intensively and diversely used sea areas.

This was illustrated by looking at the example of the North Sea Region as a region where there is both dense vessel traffic as well as Marine Spatial Planning throughout.

If the emerging Maritime Service Portfolios, which would also include services specifically supporting the maritime part of the logistics chain and in particular the aspirations of the Sustainable Maritime Transportation System as projected by IMO, would also be applied to the lanes rendered by Marine Spatial Planning and described by the RTMs eventually, there could be achieved a convergence of mutual benefits between the different stakeholders involved.

Thereby, true reconciliation of shipping interests and practice with Marine Spatial Planning may be achievable, as implied by the title of this paper.

Finally, it is concluded that an international generic RTM, which would be part of the IMO envisaged

Common Maritime Data Structure (CMDS), would lend itself as a common reference point for the description and consequential implementation of several maritime transportation, vessel traffic, and ship handling applications, thus fulfilling *from the outset* the global harmonisation desired by IMO's e-Navigation strategy. RTMs may thus be instrumental to implement the e-Navigation paradigm [7]. ■

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[1] Please note, that MSP is used as an abbreviation for Marine Spatial Planning, while MSPs is used as an abbreviation for Maritime Service Portfolios throughout this paper in order to avoid confusion between the two concepts. It should be noted, however, that also the abbreviation MSP is used for Maritime Service Portfolios where the context doesn't allow for confusion.

[2] It should be noted, that the following list of applications has been compiled during a user/sta-keholder consultation process within the ACCSEAS project, as required by the EU regional funding ru-les relevant for ACCSEAS. It should also be noted, that this is ongoing work of the so-called "MSP stream" of Working Package 4 of the ACCSEAS project; the present author is the co-ordinator of that work.

[3] The (NSR)MSP provision may be further differentiated to the needs of different user groups within the same route.

4018 INTRODUCTION OF AN OPERATION & MAINTENANCE FRAMEWORK FOR THE COASTAL-WIDE AIDS-TO-NAVIGATION NETWORK AT THE GERMAN COAST AND INTEGRATED MANAGEMENT SYSTEM FOR MAINTENANCE PROCESSES

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The implementation of a new coastal-wide service oriented system architecture at the German coast introduced not only state-of-the-art technology but also lead to coastal-wide standardisation. This system comprises three data processing centres as nodes, many remote shore stations for various Aids to Navigation technologies, such as radar and AIS, and supports nine VTS centres. It replaced nine proprietary VTS systems. As a consequence, the structure and the operations of the technical operation and maintenance also needed to be adapted. The concept of many different, discrete services coordinated by the overarching service oriented system architecture is instrumental for governance of the system at large and supports both an effective and efficient run-time system management: Each of the different services has certain stand-alone capabilities and is, by default, separated from other services both in terms of data processing and physically. Each service also has its own service management by means of which the intricacies of each service's technology are encapsulated. The introduction of the new coastal-wide service oriented system architecture required the technicians, who were working independently formerly, to co-operate closely, although they still belong to different bodies of the administration and although they are still residing at several locations all over the German coast. This challenge was tackled by subdividing the different maintenance tasks into two groups, namely those which can only be done at one central point and those which need to be done at various locations similarly. This assignment resulted in synergies regarding the governance of the whole of the system from one site without grossly increasing work load at the decentralized sites. There were also synergies regarding the deployment of personnel due to the introduction of standardisation throughout. The consequential new work processes were introduced in and by a so-called Operation & Maintenance Framework, which essentially is a rule book and which is binding for the different bodies of the administration involved. Thus, a harmonisation of the technical operation and maintenance for the coastal-wide system was achieved, which in turn may lead to further synergies in terms of e.g. improved service quality. The paper will discuss the O&M Framework, the challenges encountered, and report on experiences gained.

La implementación de una nueva arquitectura de sistemas orientada al servicio costero en la costa alemana no solo ha introducido la tecnología más moderna, sino que también ha conducido a la estandarización en toda la costa. Este sistema incluye tres centros de procesamiento de datos que funcionan como nodos, muchas estaciones terrestres remotas para diferentes tecnologías de Ayudas a la Navegación, como radar y AIS, y presta apoyo a nueve centros VTS. Además, sustituyó nueve sistemas VTS patentados. Como resultado, también fue necesario adaptar la estructura y las operaciones de funcionamiento y mantenimiento técnico. El concepto de muchos servicios discretos diferentes coordinados por la arquitectura global de sistemas orientada a servicios contribuye a la gobernanza del sistema en general y respalda una gestión efectiva y eficaz del funcionamiento del sistema: cada uno de los diferentes servicios tiene ciertas capacidades independientes y está, por defecto, separado de otros servicios tanto en términos de procesamiento de datos como físicamente. Cada servicio también dispone de su propio servicio de gestión por medio del cual se encapsula la complejidad de la tecnología de cada servicio. La introducción de la nueva arquitectura de sistemas orientada al servicio costero requirió que los técnicos, que anteriormente trabajaban independientemente, cooperaran estrechamente, aunque continuaran perteneciendo a distintos organismos de la administración y residiendo en diferentes localizaciones a lo largo de toda la costa alemana. Este reto se afrontó subdividiendo las diferentes tareas de mantenimiento en dos grupos, a saber, aquellas que solo pueden realizarse en un punto central y aquellas que necesitan realizarse en diferentes localizaciones igualmente. Esta asignación produjo sinergias respecto a la gobernanza del conjunto del sistema desde un lugar sin incrementar exageradamente la carga de trabajo en las localizaciones descentralizadas. También hubo sinergias en relación con la utilización del personal debido a la introducción total de la estandarización. Se introdujeron los consiguientes nuevos procesos de trabajo mediante un denominado Marco de Funcionamiento y Mantenimiento, que esencialmente es un libro de

normas vinculantes para los diferentes organismos de la administración implicados. De este modo, se consiguió la armonización del funcionamiento y mantenimiento técnico del sistema costero, lo que a su vez puede originar otras sinergias en términos, por ejemplo, de mejora de la calidad de servicio. La ponencia analizará el Marco de Funcionamiento y Mantenimiento, los desafíos encontrados e informará sobre la experiencia adquirida.

L'installation d'une nouvelle architecture de système côtier orienté vers le service le long de la côte allemande a non seulement introduit une technologie de pointe, mais aussi conduit à une standardisation côtière. Ce système comprend trois centres de traitement de données en tant que nœuds, beaucoup de stations éloignées à terre pour des aides de diverses technologies comme le radar et l'AIS, et dessert neuf centres VTS. Il remplace neuf systèmes VTS indépendants. En conséquence la structure, le fonctionnement technique et l'entretien devaient être adaptés. Le concept de plusieurs services différents, un coordonnés par un système dominant orienté vers le service, contribue à la gouvernance du système en générale et aide à la gestion effective d'un système de gestion efficace. Chacun de ces services a des possibilités individuelles et est, par défaut, séparé des autres physiquement et pour le traitement de données. Chaque service a sa gestion propre, où les complexités des technologies sont enfermées. L'introduction de cette nouvelle architecture de système côtier orienté service, demande aux techniciens qui auparavant travaillaient indépendamment de coopérer, même s'ils appartiennent toujours à différents services de l'administration et même s'ils sont sur différents sites de la côte allemande. Le défi a été relevé en subdivisant les tâches d'entretien en deux groupes : celles qui ne peuvent être réalisées qu'en un seul site central et celles qui doivent être effectuées sur différents sites. Cette décision a fait naître des synergies de gouvernance de tout le système sans augmenter la charge de travail des sites décentralisés. Il y a eu aussi des synergies concernant le personnel dues à l'introduction de la standardisation. Les nouveaux processus de travail en découlant furent introduits dans et par un Cadre de Fonctionnement et d'Entretien qui est essentiellement un recueil des règles qui engage les différents corps de l'administration concernés.

Donc, une harmonisation des fonctionnements technique et d'entretien pour le système côtier était achevée, qui pourrait conduire à d'autres synergies, par exemple en termes de qualité de service. Le rapport discutera du Cadre de fonctionnement et d'entretien, des défis rencontrés et de l'expérience acquise.

Introduction of an operation & maintenance framework for the coastal-wide aids-to-navigation network at the German coast and integrated management system for maintenance processes

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German Federal Waterways and Shipping Administration

IALA·2014·AISM

XVIII Conference · A Coruña · Spain

HISTORY

The VTS service at the German Coast consisted of nine individual VTS-systems. Each VTS-Centre had its own operational personnel. These nine VTS-Centres did not do any data exchange or only in a limited way via proprietary interfaces, see **figure 1**. The transferred data consists of static and voyage related ship data but there was no exchange of radar tracks. For that reason each VTS-Centre had to correlate the radar tracks with the ship data every time a traffic object came in sight of the VTS-area. To equalise the different quality levels of the different VTS-systems and to get the possibility, to develop new functionalities for the whole German coast in a short time the idea of the Maritime Traffic Technology System was born, see figure 3. Simultaneously it was of high importance to reorganise the technical operations of the VTS-systems along the German coast because of necessary staff reductions in the future.

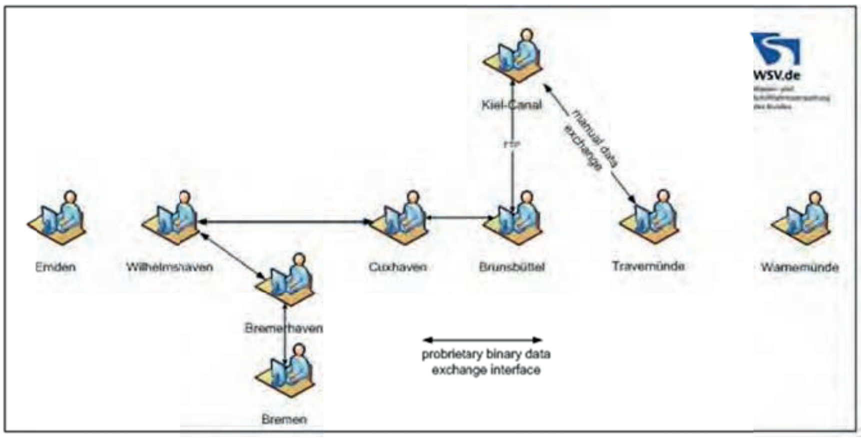

Figure 1: Intercommunication of VTS-Centres before the Maritime Traffic Technology System

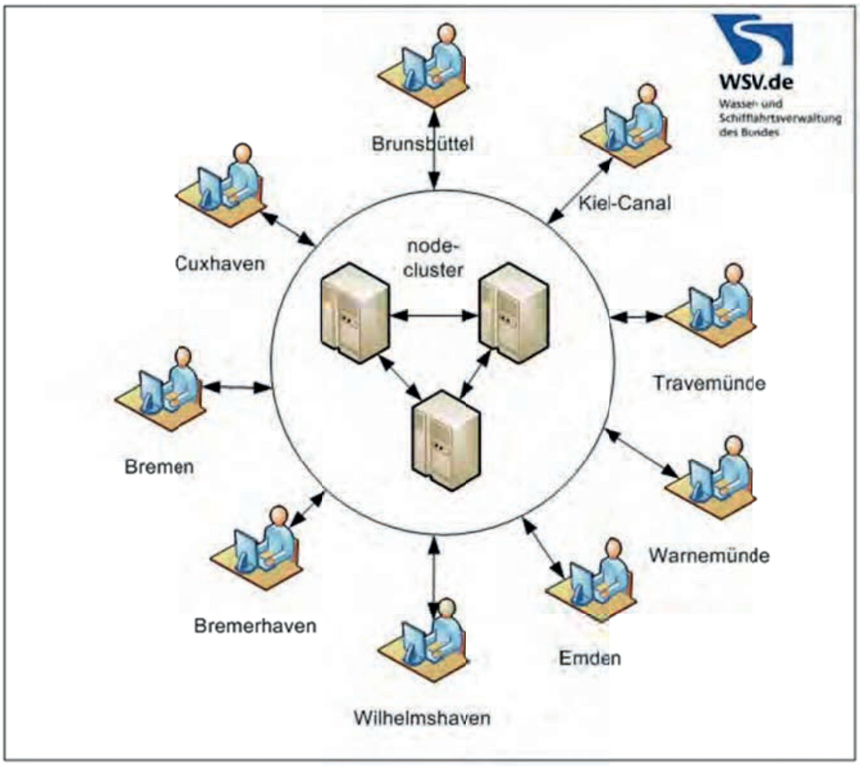

Figure 2: The same data for all VTS centres

THE MARITIME TRAFFIC TECHNOLOGY SYSTEM (MTTS)

Technical Structure of the MMTS

The MTTS is a coastal wide distributed system with three data processing service centres called “nodes” collecting, processing and distributing data. Data is received on the coastal wide distributed remote stations and is transferred to the nodes to be stored and processed. Because of data replication between the nodes a high level of data integrity is reached. It is guaranteed that all nine VTS-Centres can get all these data in the same level of quality for operational use, see **figure 2**. The services of the MTTS are redundantly installed in all three nodes. In case of a breakdown of one of the nodes, another node will take over and will provide the missing functionalities.

Architecture of the MTTS

The basic idea of the MTTS is to arrange the collection, the processing and the display of coastal-wide required information and functions in independent operating, functionally and physically seperatedservices. At present there is a plan to realize about 30 services, see figure 3. Each service has accurately specified and open interfaces to interact with other services and its functions. This consequent segregation of functional areas allows further technical and functional development of services without direct effects to other depending or interacting services (functions) of the MTTS (black box principle). The advantage of dividing functions in independent services is the possibility to focus the development on the field of expertise. This guarantees an optimum while development and later in operational work.

The services of the MTTS are seperated into four groups. The Data Collection Services are the interface to environment and shipping, e.g. AIS, Radar, VHF, visual aids-to-navigation and environmental sensor service. The processing of this information is done in the group of Value-added Data Processing Services, e.g. position determination service, ship data consistency service within the nodes. The nautical personnel of the VTS-centres utilise the functions of the User Interaction Service. With this service data from the radar systems, tracks determined from radar and AIS and the ship data are available. The operations diary can be written online furthermore. Environmental data like water gauges, wind speeds and visibility ranges are displayed. Communications with the nautical personnel onboard is done by VHF.

Data exchange to external users like other agencies, harbours and so on is enabled by the Gateway Service.

For data transport from the remote sites to the nodes the German Administration runs an own wide area network. The operation of this network is done by regional distributed personnel. The demand on high available and secure data transmission is caused by the high relevance of the information belonging to the safety of traffic alongside the German coast.

Figure 3 illustrates the logical structure of the MTTS as an overview.

Operational Challenges

The transformation of the technical structure of the Maritime Traffic Technology Systems and its start of operations causes a reorganisation of the operational personnel.

In the historical grown structures there was one pool of technicians per VTS-location responsible to run the systems of the VTS-centre. A breakdown of the systems or a failure during operations had only local consequences; only the local VTS-centre was affected.

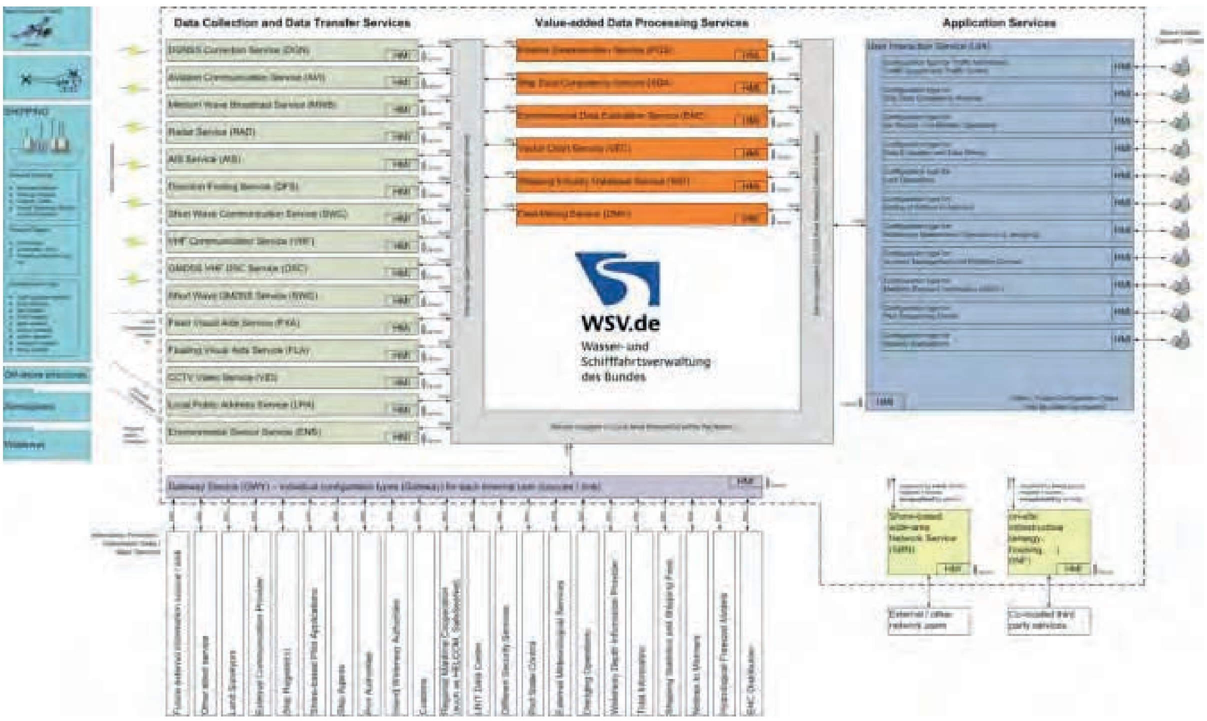

Figure 3: Structure of the MTTS

In the new Maritime Traffic Technology System all data is centrally collected and processed and the functionality for the users of the VTS-centres are centrally provided by the mentioned services. This central approach means that any intervention to a service can have a coastal wide impact. This circumstance is compensated by the redundant provision of the services through the three nodes and by the great advantage of service division: the failure is limited to the functions of this service; all other services can be used as usual.

Figure 4: Paths of communication

Because of the coastal-wide homogeneous technical equipment the MTTS provides a high potential of uniform technical operation including knowledge transfer between the colleagues along the coast. The diversity of spare parts is limited by the homogenous equipment to a necessary minimum. By the use of custom-of-the-shelf products the replacement of computer hardware can be done across service borders.

But how all these services with all these coastal-wide functionalities can be operated effectively with ten different pools of technicians?

This is a big challenge!

OUR SOLUTION

The solution of the German Federal Waterways and Shipping Administration consists of a personal and a technical part.

Personnel Implementation

While introducing the "MTTS" a "coastal-wide technical operation" was installed. The "coastal-wide operational personnel" fulfils its tasks at a central location by using remote access and infrastructure monitoring tools to get an overview across all running equipment along the German coast (see "Technical Implementation"). The technicians at the VTS-sites remain as "local operational personnel". These colleagues maintain the components of the services located at the VTS-sites and the remote sites along about 3,660 km of the German coastline. The coastal-wide distribution of the technicians retains short reaction times by short ways.

The first-level-support changes for the nautical employees in the VTS-Centres. While the local technician was the first contact in the previous system, now the costal-wide operational personnel is contacted at first, because only those colleagues have an overview about all actions made along the coast. With this central point of contact we ensure the coastal-wide coordinated execution of required tasks, planned or unplanned.

The close collaboration between "costal-wide" and "local" operational personnel is regulated by processes according to DIN 31051. The tasks of scheduled service, first-level-support and fault clearance have to be mentioned. As aforementioned clear rules for communication from and to the user of the system and between "coastal-wide" and "local" operational personnel are very important.

Beside the rules of teamwork between "coastal-wide" and "local" operational personnel also local operational concepts were developed defining the work of the local organisational units. These concepts ensure that all tasks, planned and unplanned, can be done with the available staff in the same level of quality. Furthermore these concepts permit a knowledge transfer to new employees and a fast training of the new colleagues because they show mandatory code of practice of the internal processes. The periodic update of the concepts is done to ensure optimal processes to maintain the system.

Technical Implementation

The Maritime Traffic Technology System consists of about 30 services which are delivered by partly different manufacturers. For this reason the management interface of the services are generally different. Of course it is possible for the operational personnel to use each management interface of each single service but this reduces ergonomics and actionability. The necessary operational tasks must be supported by another technical application. The markets offer a wide range of applications and software product to help in the daily work.

The ambition of the technical operations of the MTTS is a smart and compact solution. This solution has to be flexible to enhancements, shall be usable from all locations within the system and it shall be clearly laid out in face of all the various functions.

From these requirements the "Toolsystem" was developed. This is a toolbox that meets the following requirements:

- Modular structure (basic module with modules for specialised and system tasks)
- Open interface for services and other, perhaps unknown modules
- Loose coupling of the modules for data transfer
- One central data storage for all modules
- The same "look-and-feel" for all graphical user interfaces of all modules
- Web-based user interface

What do terms like "basic module", "specialised module" and "system task module" mean?

The "basic module" controls the communication between the other modules. It provides interfaces to the other modules and to the services of the MTTS. The "system task modules" provides functions like persistent data storage, the framework for the user interface and a part of self-monitoring. "Special modules" realise specific requirements of displaying data received from the services and provide functions to map the working processes into the application.

Which specialized modules (SM) are needed for operations of the MTTS at the German coast?

- SM "Zustand" ("state"): How is the health of all the components?
- SM "Auftragsmangement" ("order processing"): This trouble ticket system maps the working processes between coastal-wide and local operations personnel into the application
- SM "Geoinformation" (GIS): location focussed state of the services displayed in a map and direct access to related documents and tasks
- SM "Dokumentenmanagement" ("management of documents"): Here we put and arrange all data required for operations of the Maritime Traffic Technology System
- SM "Fehlerdatenbank" ("failure database"): This module collects failures and the possible solutions (best-practises)
- SM "Auswertung" ("analysis"): Are the services running stable? Which kinds of failure occur very often? Etc.
- SM "Benachrichtigung" ("notification"): Main function for forwarding error message to the technical operation personnel
- SM "Komponente" ("component"): in this module special data of the components are stored, e.g. manufacturer of a component, terms of guarantee, type of spare part, firmware version, etc.

How does this work together?

The individual service of the MTTS connects to the defined interface of the basic module of the Toolsystem. Is there a successful connection the basic module of the Toolsystem interrogates the service. The main task is to get the states of the components and their geographical location. The basic module stores the data and provides it to the specialized modules for further processing. If e.g. a technician opens the module "Zustand" in a web browser the data is transported through a web server to the client. This principle is the same in all modules. Information are collected, processed and provided to the other specialised modules. A direct communication between specialised modules is possible; one module connects to the interface of the event handler of the other module and gets the requested information. By means of this concept it is possible to create new functionality by adding a new specialised module. It is relatively simple to exchange a specialized module because of the open interfaces.

Figure 5 shows the interworking of the basic module and the specialised modules on a logical basis.

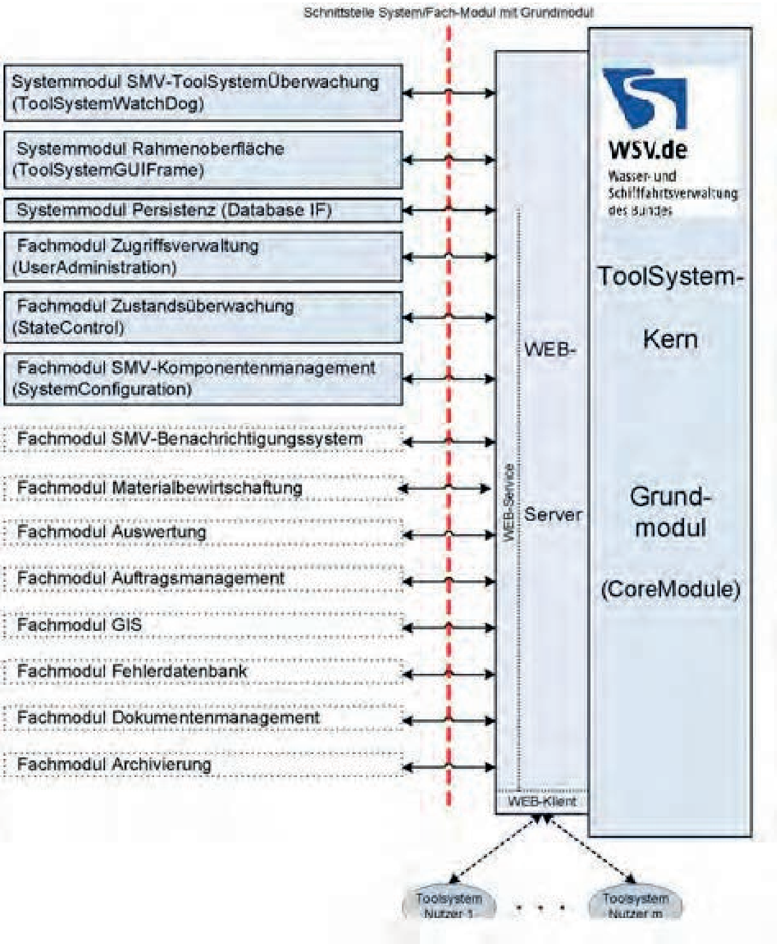

Figure 5: Architecture of the Toolsystem

How does it look like in real?

The basis for display and use is a Toolsystem-wide stock of defined styles and functions for interaction. The technician shall have the feeling that all modules were realised by the same manufacturer.

The following **figure 6** shows the GIS-Module. The coloured circles show the regional reference to the state of the components of the services of the Maritime Traffic Technology System. In the upper part of the figure icons of the specialised modules are shown which can be opened by mouse click.

Figure 7 illustrates a detailed zoom of a location within the GIS-module. In the box the state of the components is shown subdivided by the services.

The “Auftragsmanagement” (“order processing”) for implementation of work and communication processes in software is shown in **figure 8**.

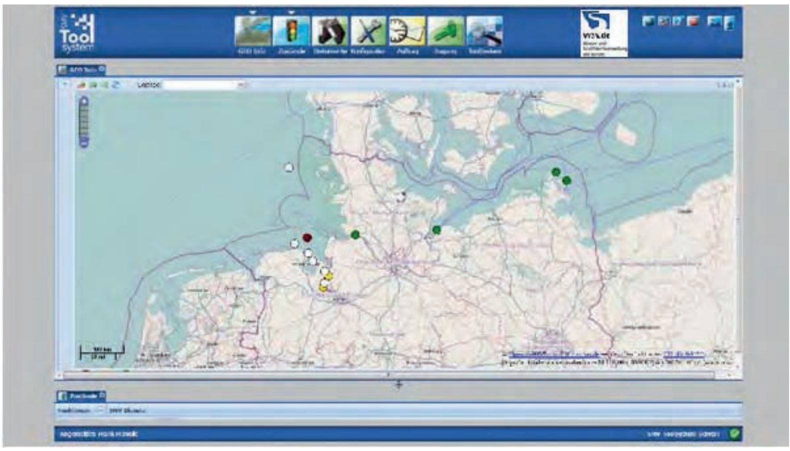

Figure 6: GIS module

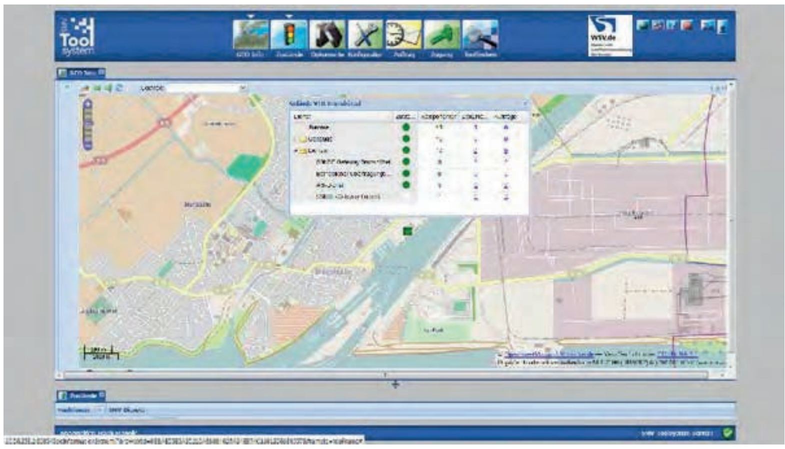

Figure 7: GIS module, detailed view

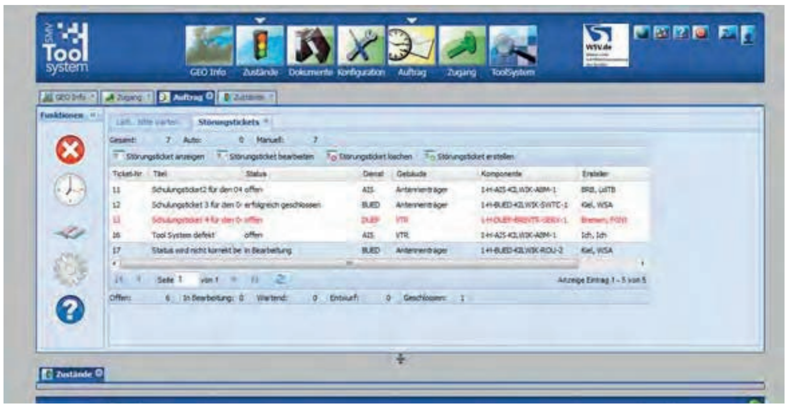

Figure 8: Auftragsmanagement (order processing)

CONCLUSION

The division of the technical operational personnel into “coastal wide” and “local” operational personnel causes advantages and disadvantages.

However there are more advantages.

Definitely the combination of personnel with a coastal-wide overview of the whole system and a local part of personnel with short ways to the components of the system is a great benefit. Because of the homogenous systems the training on different VTS-systems can be omitted. In case of emergency technicians are able to help in other locations.

With the central approach the coastal-wide coordination of tasks and an effective use of resources is possible.

The use of coastal-wide homogenous hardware allows a centralised spare part management with decentralised storage of the parts for fast access by the technicians.

The users of the services of the Maritime Traffic Technology System have a central point of contact (one face to the customer). The establishment of a standby duty makes a 24/7-contact possible.

While there is an advantage of short ways through the distribution of the personnel along the coast, this circumstance is a disadvantage in daily communication between the personnel.

Tools and applications like the Toolsystem help the coastal-wide distributed technicians to get an overview on the system, to store and update documentation and to manage the processes to ensure that the system is running. The main objective is to assure the safety and efficiency of vessel traffic on German waterways.

Last but not least: all the technical equipment and electronic communication tools do not substitute the direct human contact with the colleagues, they are only an addition! ■

34 LESSONS ON DISASTER PREPAREDNESS FOR AIDS TO NAVIGATION LEARNED FROM THE GREAT EAST JAPAN EARTHQUAKE

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The Great East Japan Earthquake on 11th March, 2011 caused huge tsunamis as well as earthquakes. 158 AtoNs suffered damages including collapse of lighthouses, shift of lighted buoys, black out of AtoNs and so on. The Japan Coast Guard (JCG) has been recovering them through 3 steps method and 72% of them have been completely recovered as of November, 2013.

In the area which recorded the JMA Seismic Intensity 6 upper or more, only 5 of 72 lighthouses which satisfied the earthquake-proof standards were slightly damaged, and 15% of the AtoNs which installed stand alone power system blacked out.

The JCG has learned many lessons from past disasters which we faced. We make the best use of our experience to install the more disaster resilient AtoNs system which ensures the safety of navigation even when a disaster occurs.

El Gran Terremoto del Este de Japón ocurrido el 11 de marzo de 2011 causó enormes tsunamis y fuertes réplicas. Resultaron dañadas 158 AtoN, incluyendo el colapso de faros, el desplazamiento de boyas luminosas, el apagón de AtoN y otras consecuencias. La Guardia Costera de Japón (JCG) las ha estado recuperando mediante un proceso de tres etapas y en noviembre de 2013 ya había recuperado totalmente el 72 %.

En el área donde la Agencia Meteorológica de Japón (JMA) registró una intensidad sísmica por encima de 6 o más, solo 5 de 72 faros que cumplían las normas de resistencia a los terremotos resultaron ligeramente dañados, y el 15 % de las AtoN que tenían instalado un sistema de energía independiente se apagaron.

La JCG ha aprendido muchas lecciones de anteriores desastres a los que nos tuvimos que enfrentar. Hemos sacado el máximo provecho de nuestra experiencia para instalar sistemas de AtoN más resistentes frente a desastres, que garantizan la navegación segura incluso en el caso de que se produzca un desastre.

Le grand tremblement de terre à l'Est du Japon du 11 mars 2011 a entraîné de grands tsunamis. 158 aides à la navigation ont été endommagées, dont des phares détruits, des bouées lumineuses renversées, des feux éteints, etc...La Garde côtière japonaise (JCG) les a remises en état en trois étapes, et 72% d'entre elles étaient totalement en état en novembre 2013.

Dans la zone où l'intensité du séisme a atteint 6 ou plus, seulement 5 des 72 phares construits aux normes antisismiques ont été légèrement endommagés ; et 15% des aides à la navigation équipées d'une source d'énergie indépendante se sont éteintes.

La JCG avait déjà retenu les leçons des désastres précédents. Elle a fait de son mieux grâce à son expérience et installé les systèmes d'aides à la navigation les plus résistants pour assurer la sécurité de la navigation même en cas de catastrophe.

Lessons on disaster preparedness for Aids to Navigation learned from the Great East Japan Earthquake

Kazuyuki Tanaka

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IALA·2014·AISM
XVIII Conference · A Coruña · Spain

1. INTRODUCTION

The Great East Japan Earthquake (hereinafter referred to "the Earthquake") on 11th March, 2011 caused huge tsunamis as well as earthquakes, which brought destructive damage to the areas around the Pacific coast in the Tohoku region. The Japanese people were forced, through the Earthquake, to recognize that there was no upper limit to a natural disaster.

It is important to learn from the past cases of disasters in order to take measures for disasters. Therefore it is significant for the persons who are engaged in the AtoN services in the world to share the lessons from the Earthquake. In this paper, we describe the damage of AtoNs by the Earthquake, their recovery status and the measures of reducing damage of AtoNs by mega earthquakes and tsunamis in the future.

2. OUTLINE OF THE GREAT EAST JAPAN EARTHQUAKE

2.1 The 2011 off the Pacific Coast of Tohoku Earthquake

A massive earthquake of magnitude of 9.0 occurred Friday 11th March, 2011, off the Pacific coast of the northeastern part of the Japanese main land (Tohoku Region) and caused devastating damage. The Japan Meteorological Agency (JMA) named this earthquake "The 2011 off the Pacific coast of Tohoku Earthquake".

The summary of this earthquake is shown in ***Table 1***: ***Table 2*** [1] shows the outline of JMA Seismic Intensity.

2.2 Tsunami

The Earthquake caused a colossal tsunami. The JMA issued Tsunami Warnings and Advisories on 11th March, 2011, 14:49 JST (05:49 UTC). ***Figure 1*** shows the distribution of JMA Seismic Intensity and observed Tsunami of the Earthquake.

2.3 Damage (Source: the Report of the Japanese Governmental Extreme Disaster Management Headquarters as of 24th September, 2013)

2.3.1 Casualties

Deceased: 15,883, Missing: 2,654, Injured: 6,146

2.3.2 Damages of Structures

Completely collapsed houses: 126,578, Partially collapsed houses: 272,305

Some damaged houses: 742,664

3. OUTLINE OF ATONS' DAMAGES CAUSED BY THE EARTHQUAKE AND THE TSUNAMI

3.1 AtoNs' Damage Check

The Earthquake gave damage to the Pacific coast area of Tohoku Region and a land transportation

Date and Time	11th March, 2011 14:46 JST (05:46 UTC)	
Magnitude	9.0 (the largest earthquake recorded in Japan)	
Epicenter	38°6.2'N, 142°51.6'E (130km ESE off Oshika Peninsula), Depth 24km	
JMA Seismic Intensity [1]	7 (Max)	Kurihara City of Miyagi Prefecture
	6+	28 cities and towns in Miyagi, Fukushima, Ibaraki and Tochigi Prefecture
	6- or weaker	Observed nationwide from Hokkaido to Kyusyu

Table 1: Summary of the 2011 off the Pacific Coast of Tohoku Earthquake

JMA seismic intensity	0	1	2	3	4	5 Lower Upper	6 Lower Upper	7
Acceleration gal [cm/sec²]	0.0	2.5	8	25	80	250	400	1000

Table 2: Outline of JMA seismic intensity

network was cut apart. The JCG carried out the AtoNs' damage check as well as the overall damage check with our fixed wing airplanes. The JCG immediately provided this information of damage through the Navigational Warnings, MICS[2] and so on.

Due to the accident at Fukushima Daiichi Nuclear Power Station, the Government of Japan (GOJ) established restricted areas. Only one of AtoNs which the JCG operates existed in the area. Oragahama Lighthouse, which was located in the area, was checked in August, 2012 as the radiation level around the lighthouse decreased. As a result, we confirmed that the lighthouse was black out due to a commercial power failure although no damage was found in the facility. When the commercial power around the lighthouse was restored due to the reconsidering of the restricted areas in April, 2013, we recovered this lighthouse after batteries replacement.

3.2 Number and Distribution of Damaged AtoNs

Table 3 shows the number of damaged AtoNs.

AtoNs which located from Hokkaido to Kochi prefecture were widely damaged by the Earthquake. ***Figure 2*** shows the distribution of damaged AtoNs.

The damage of the AtoNs in Iwate and Miyagi was especially serious because these prefectures were near to the epicenter. The 115 of 184 AtoNs (63%) in both prefectures were damaged.

3.3 Detail of the AtoNs' Damage

3.3.1 Lighthouses and Lightbeacons

3.3.1.1 Collapse and Tilt

46 AtoNs were collapsed. 44 of them were breakwaters lighthouses, the breakdown is as follows: 38 of them were collapsed together with their breakwaters and remaining 6 were collapsed alone.

11 AtoNs were tilted. 10 of them were breakwaters lighthouses and they were tilted due to the breakwater's collapse or tilt. Another one, a lightbeacon tilted due to a land slide at the bottom of the sea caused by tsunamis.

The causes of AtoNs' collapse and tilt were seismic ground motion and shocks of tsunamis.

3.3.1.2 Burned out

2 AtoNs were burned out caused by Tsunami Fire[3].

3.3.1.3 Black out

53 AtoNs were black out. 38 of them were black out caused by commercial power failures due to the Earthquake. They had recovered as soon as the power supply was restored.

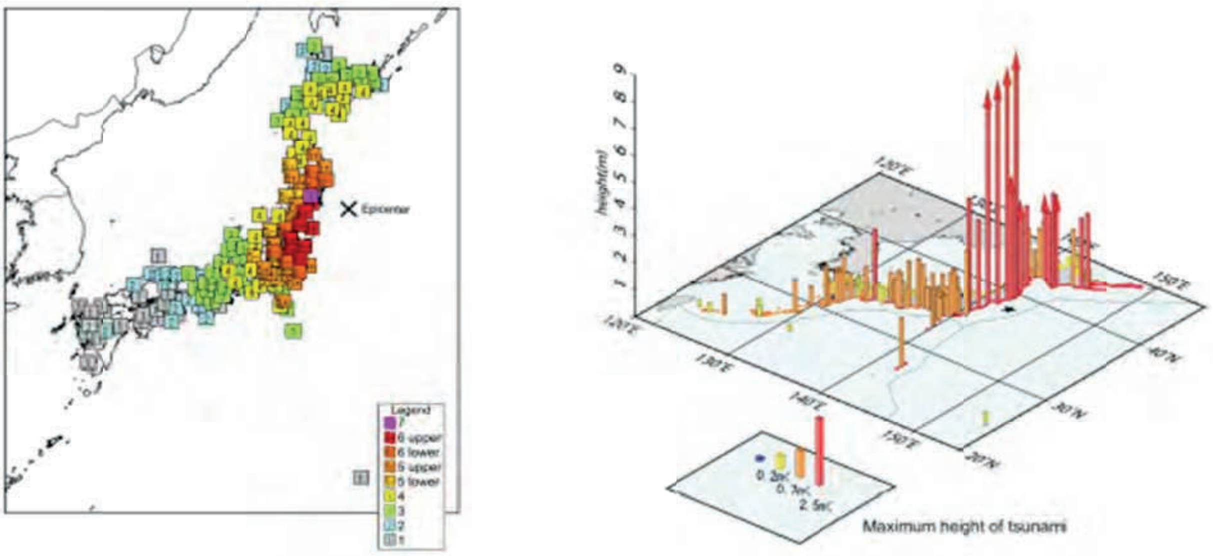

Figure 1: Distribution of the JMA seismic intensity and observed tsunami of the earthquake
(source: the Japan Meteorological Agency Website)

	Hokkaido	Aomori	Iwate	Miyagi	Fukushima	Ibaraki	Chiba	Tokyo	Kanagawa	Mie	Tokushima	Kochi
Collapse		1	29	14	2							
Tilt		1	5	2	1		2					
Burned out				2								
Black out		1	16	22	8	5				1		
Shift	6			22		1	2	4	5		1	2
Missing				2								
Off-air				1								
Total	6	3	50	65	11	6	4	4	5	1	1	2

Table 3: Number of damaged AtoN

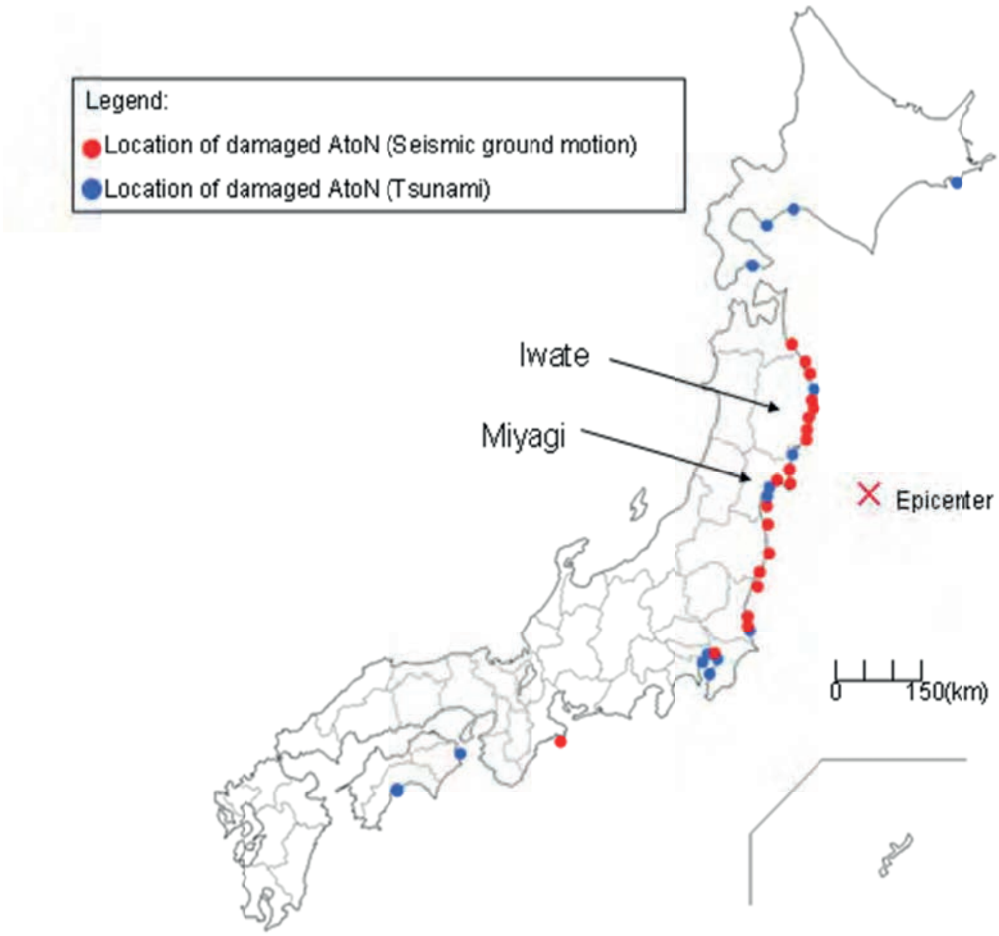

Figure 2: Distribution of damaged AtoN

Figure 3: Examples of damage (collapsed and tilted lighthouses)

Figure 4: Examples of damage (burned out and submerged AtoN)

7 AtoN had utilized commercial power sources as a main power source. The breakdown is as follows: 6 of them were black out due to power failures caused by troubles of a power line, and another AtoN was black out due to over-discharging of batteries caused by a lengthening of the commercial power failure

The remaining 8 AtoNs had utilized a stand-alone power system[4], but they blacked out due to trouble of solar power panels or batteries. 3 of them were black out because the batteries and equipment in the lighthouse were submersed by tsunamis.

3.3.2 Lighted Buoys

43 lighted buoys were shifted and 2 lighted buoys were missing caused by the tsunami.

3.3.3 Radio Aids (Differential GPS Station)

Because of a commercial power failure, Kinkasan Differential GPS station used its private power generation (the engine driven generator). Fuel for the generator, however, was all consumed due to a lengthening of the commercial power failure. It was hard to supply fuel to the station on an island, and we could not continue operation of the station.

In addition, the crustal movement caused by the Earthquake shifted the position (latitude and longitude) of the reference point of Differential GPS observation; therefore we had to survey and fix the correct position of the reference point before we restarted operation of Kinkasan Differential GPS station.

3.3.4 Other Damages

All the lantern panes at Shioya-saki Lighthouse were broken due to the seismic ground motion.

7 lighthouses cracked. Although its function as a lighthouse had maintained, they were scrapped and will be reconstructed finally.

In addition, damages including dipping of piers for patrolling AtoNs, falling down the road for accessing AtoNs and so on occurred. Some AIS shore stations and fixed stations for communication continued their operations using their private power generation after commercial power failure, but it became impossible to continue

Figure 5: Examples of damage (broken lantern panels and cracked lighthouse)

supplying fuel, so communication lines were finally disconnected in some cases.

4. RECOVERY OF DAMAGED AIDS TO NAVIGATION

4.1 Recovery Plan for the AtoNs

The Earthquake had damaged AtoNs over large area and kinds of damage were various, so it was impossible for us to equally recover whole damaged AtoNs at the same time. Therefore the recovery steps were decided as follows: Clarify the situation of a disaster area, specify AtoNs to be preferentially recovered and carry out the recovery according to the "3 steps recovery methods" of "Emergency Recovery", "Temporary Recovery" and "Full Recovery" depending on damage levels.

"Emergency Recovery" means an emergency action for short term that we install an emergency light or lighted buoy (LED with Dry Battery) which has a visible distance of 4km as an alternative of damaged AtoNs.

"Temporary Recovery" means a temporary action that we install a lighted buoy near a breakwater temporary as an alternative of a breakwater lighthouse which was collapsed due to the Earthquake or tsunamis, because we cannot install it to the breakwater until the breakwater is reconstructed.

"Full Recovery" means an action to recover the function of AtoNs as it had worked before the disaster.

Figure 6 shows the scheme for recovery of damaged AtoNs.

4.2 Present Situation of Recovery

Figure 7 shows the changes of the number of damaged/recovered AtoNs in the Earthquake.

As of November, 2013, the progress of full recovered AtoNs is only 72%. The reason why it has been so late is that the coastal area including ports, fishing ports etc. have been devastatingly damaged. Although the GOJ goes on with reconstruction work for the damaged ports and fishing ports, it has taken much time because many of them need large scale improvement to reconstruct breakwaters, to measure ground subsidence which was occurred at wide area and so on. We have to progress recovery of damaged AtoNs according to progress of improvements of surrounding environment; therefore it is still difficult for us to progress recovery of damaged AtoNs rapidly.

5. REVIEW

When we consider measures against AtoNs' damages caused by natural disasters, it is important for us to learn from our past experience against natural disasters. The JCG has reviewed damage conditions of AtoNs from the Earthquake, efficiency of measures against natural disasters and implementation processes of emergency/temporary/full recovery.

5.1 Earthquake–proof Standard, Seismic Retrofit and Seismic Isolation Device

The earthquake-proof standard for AtoNs' facilities is defined that the strength of a whole building structure should not deteriorate significantly even after the maximum acceleration of a seismic motion reaches 300-400cm/sec². We had installed a seismic retrofit for the facilities which had not satisfied the earthquake-proof standard.

In the area (Iwate, Miyagi, Fukushima and Ibaraki Prefecture) where the JMA Seismic Intensity 6 upper or over was recorded, we had 72 AtoNs which had installed the seismic retrofit and 5 of them were slightly damaged. On the other hand, we had 4 AtoNs which had not installed the seismic retrofit and 2 of them were damage. This fact surely shows that to install the seismic retrofit for AtoNs' facilities to clear the earthquake-proof standard is effective to improve the seismic performance.

At the Shioya-saki Lighthouse, we installed a seismic isolation device[5] to prevent serious damages to Fresnel lens from an earthquake. Although the lantern panes were broken, there was no damage of Fresnel lens by the Earthquake. This fact shows that to install a seismic isolation system is effective to prevent the serious damage to a lens and a rotating system from earthquakes.

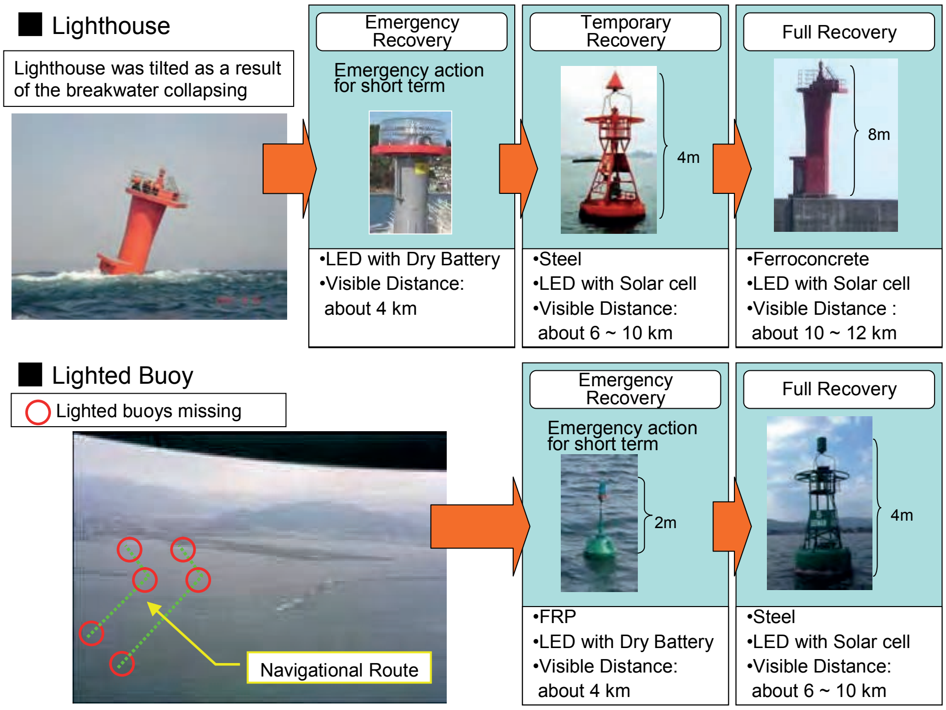

Figure 6: Scheme for recovery of AtoN

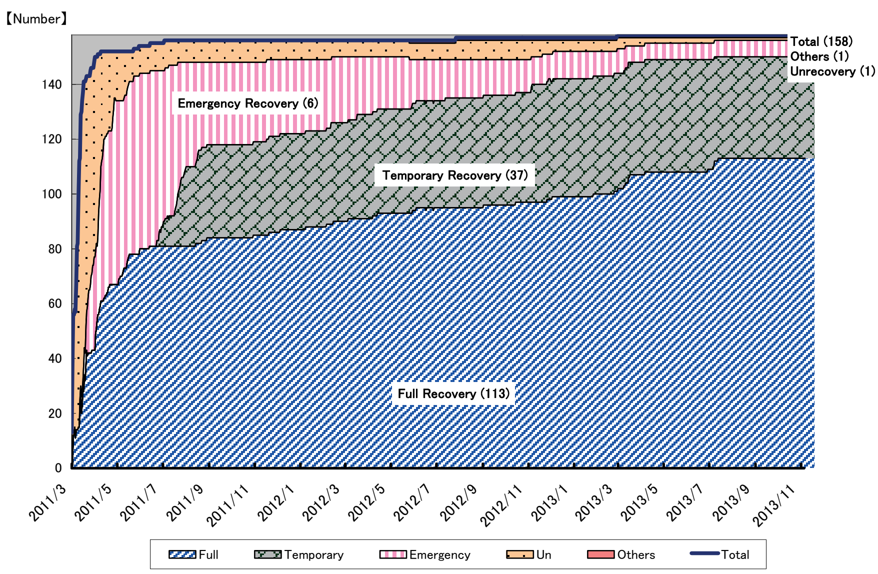

Figure 7: Changes of the number of damaged/recovered AtoN

5.2 Stand Alone Power Source

As a result of the review of 99 lighthouses, excluding 42 lighthouses which were collapsed due to the Earthquake from 141 lighthouses in Iwate and Miyagi Prefecture where 72% (38/53 lighthouses) of the AtoN black out accidents occurred, we found that 15% (11/75 lighthouses) of lighthouses using the stand alone power system blacked out compared to 83% (20/24 lighthouses) of lighthouses using a commercial power source. Therefore we find that to install the stand alone power system is effective as a measure against massive and long-term commercial power failure.

In addition, we point out that the solar power system is easy to recover rather than the other power system in case of the facility of AtoN maintains.

6. FUTURE PLAN

In the Earthquake, it becomes clear that conventional disaster prevention measures were insufficient and unable to cope with a natural disaster, especially a huge tsunami, even if facilities of AtoNs were considerably strong.

"The Basic Disaster Management Plan", which the GOJ amended after the Earthquake, says that the basic policy of the disaster prevention should be "damage reduction" which aims to minimize damages when a natural disaster occurs. It also says that it should be need for us to take measures which is combined hardware and software measures against disasters.

According to this Basic Plan, the JCG will take measures which is combined software and hardware measures for ensuring safety of navigation soon after the disaster occurs.

As regards the hardware measures, we will implement the measures at 2 levels of "prevention of damage" and "reduction of damage". Against the disaster which may occur frequently, measures aimed at "prevention of damage" should be taken for each AtoN to prevent serious function failures. On the other hand, "reduction of damage" policy should be applied to mega disasters such as the Earthquake and measures should be taken aimed at continued operation of the critical AtoNs' facilities and ensuring rapid recovery systems in the aftermath of a disaster.

As regards the software measures, we focus on the information provision to ensure the safe marine transportation. We will provide the information such as operational status of AtoNs, progress of the navigational route elimination, berth information, floating obstacles and so on. In addition, we consider that we will use AIS AtoNs to indicate the anchorage area of refuge and/or navigational routes of refuge in an emergency.

The examples of the hardware measures are shown as follows.

6.1 Measures against the Seismic Motion

6.1.1 Seismic Capacity Evaluation and Seismic Retrofit

We are carrying out a seismic capacity evaluation for 1,184 AtoN facilities, among the AtoNs the JCG has jurisdiction over, including AtoN heritages or facilities which collapse and injury to the public in case of an earthquake is a concern. As of March, 2013, we have already evaluated 1,087 AtoNs facilities and we will go on with evaluation to the remaining AtoNs facilities. Based on the result of evaluation, we will carry out the required seismic retrofit for AtoN's facility systematically.

6.1.2 Structural Improvement

We found that the joining section of a lighthouse tower and an adjoining facility tend to be weak against a seismic motion as the Otsu-misaki Lighthouse's case showed. Therefore we will improve the AtoNs facilities structures to divide it to the 2 partition such as a lighthouse tower and an adjoining facility so that they are structurally robust against in an earthquake.

6.1.3 Installation of the Stand Alone Power Source

The JCG has jurisdiction over about 5,200 AtoNs except daymarks. We had already installed the stand alone power source for about 4,500 AtoNs of them (84%). We will push on with installing it for AtoNs excluding large scaled coastal lighthouses, projectors, radio aids and VTS, which are not suitable to install it due to large power consumption.

6.1.4 Prevention of the Optical System's Damage

We will push on with installing a seismic isolation system for large-scall lighthouses which have Fresnel lens of over the 3rd order.

Now a day, all lighthouses in Japan are unmanned. When an earthquake occurs, however, there is the possibility that maintenance personnel might be injured by broken lantern panes. For their safety, we will accordingly seal lantern panes with scattering glass preventing films.

6.2 Measures against Tsunami

6.2.1 Measures against Tsunami which may occur with high frequency (once in several decades or hundreds of years)

We will take measures to prevent serious damage of AtoNs functions.

We specifically incorporate the structural consideration against tsunamis into the design standard of AtoN facilities structure.

In addition, as a measure against submersion of batteries, a basic policy is to place batteries where no submersion is expected. However, for lighthouses where such a measure is impossible, we will install a buoy float to floor scuppers and/or vents of AtoN facilities to prevent submersion.

The measure with a floor scupper is shown in **Figure 8**.

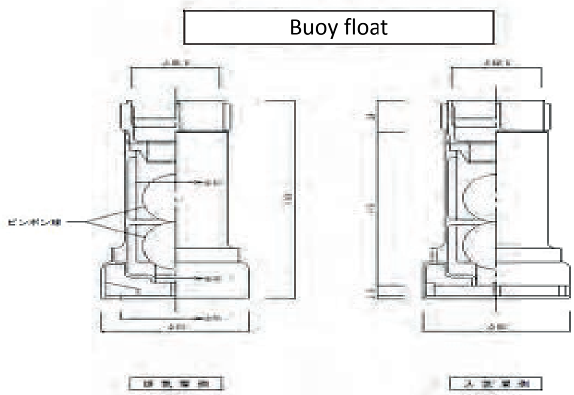

Figure 8: Measures against submersion through floor scuppers (FLC type)

6.2.2 Measures against Mega Tsunami (only once in hundred years or a millennium)

We take measures to reduce damages of AroNs or to facilitate recovering AtoNs' function.

For example, we prepare materials for emergency recoveries such as emergency lights etc. and deploy them on the nationwide in order for an emergency recovering AtoNs to be smoothly carried out.

7. CONCLUSION

Since the Great East Japan Earthquake, we have often used the terms "Unanticipated" or "beyond expectation" to express the enormity of the disaster when we faced serious damage from the Earthquake. We have tried to estimate, based on the various kinds of elements, when, where and how a disaster will occur, but it is still far from accurate and highly uncertain.

How should we prevent or reduce the AtoNs' damage caused by natural disasters which have high uncertainty? It is not possible for us to find a quick and final answer at this moment, but we might be able to find the answer to review estimations of AtoNs' damages and measures against natural disasters over and over again. That is to say, measures to reduce AtoNs' damages from natural disasters should be challenges for us to tackle continuously and in the long-term although it is urgent issue for us.

The JCG has learned many lessons from past disasters which we faced. We make the best use of our experience to establish a disaster resilient Aids to Navigation system even more in order to ensure safety of navigation even when disaster occurs.

Finally we would like to express our sincere gratitude for all the international cooperation to recover from the damage of the Earthquake disaster. ■

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(3) Hajime KANDA and Makoto YAMAMOTO, "Preservation of Historical Fresnel Lens by Bearing Rotation System and Seismic Isolation System", 17th Conference of the International Association of Marine Aids to Navigation and Lighthouse Authorities (2010)

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[1] JMA Seismic Intensity is classified into 10 categories; namely 0 to 4, and 5 lower, 5 upper, 6 lower, 6 upper and 7

[2] MICS (Maritime Information and Communication System) is a navigational information provision system through web site or mobile phone operated by the JCG

[3] Tsunami Fire is a fire in the flooded area triggered by tsunami waves.

[4] Stand Alone Power System is a power source for AtoNs which works with a combination of solar cell and batteries without any commercial power source. Please refer to Reference (2).

[5] Seismic Isolation Device is installed between the rotating system and the building as a cushion and the strong horizontal seismic motion is reduced, thus the lens is protected. Please refer to Reference (3).

110 THE AIDS TO NAVIGATION (AtoN) SERVICE IN SPAIN

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This paper presents the Spanish AtoN service's management model based on public regulation and inspection, which involves centralised regulation and distributed inspection, along with the public or private provision of the service depending on the scenario in question. The provision of the AtoN service in Spain is carried out by taking three scenarios into account: the Coastal Network, port signalling and the marking of other facilities. Hence, within the scope of the Coastal Network, the General Administration of the State is the provider of the service through the Port Authorities. With regard to port signalling, responsibility for these facilities lies with the Port Authorities in their ports and regional authorities (Autonomous Communities) or private organisations in port facilities under a concession. The signalling of other facilities is managed by those holding responsibility for such facilities, which include fish farms, underwater outfalls, shore protection facilities, wind farms, etc.
We coordinate 28 Port Authorities that provide this service, assuming their management, inspection and maintenance in the geographic area assigned to them. The definition of all beacons is one the functions, among others, entrusted to Puertos del Estado, for which a procedure is followed that includes an open stakeholder consultation process and comments from a Consultative Inter-Ministerial Committee, in which there are representatives from all agencies holding competencies in the safety of navigation.

The annual cost of the Coastal Network (coastal lighthouses and beacons, DGPS, etc.) amounts to approximately €10 million and there is a national duty to fund it known at the "AtoN Duty", which is collected by each Port Authority.

There are 205 lighthouses and main lights (49 of which are manned), 2,139 beacons and 1,219 floating aids. There are also 18 racons, 18 DGPS Tx-stations, 12 AIS-SBS and 50 AIS_AtoN.

Esta ponencia presenta el modelo de gestión de los servicios AtoN españoles basado en la regulación e inspección pública, que implica regulación centralizada e inspección distribuida, junto con la prestación pública o privada del servicio dependiendo del escenario en cuestión. La prestación del servicio AtoN en España se lleva a cabo teniendo en cuenta tres escenarios: la Red Costera, la señalización portuaria y el balizamiento de otras instalaciones. Por lo tanto, dentro del alcance de la Red Costera, la Administración General del Estado es el proveedor del servicio a través de las Autoridades Portuarias. Respecto a la señalización portuaria, la responsabilidad de estas instalaciones recae en las Autoridades Portuarias en sus puertos y en las autoridades regionales (Comunidades Autónomas) u organizaciones privadas en el caso de instalaciones portuarias bajo concesión. El balizamiento de otras instalaciones está gestionado por quienes tienen la responsabilidad de tales instalaciones, que incluyen piscifactorías, emisarios submarinos, instalaciones de protección costera, parques eólicos, etc.

Coordinamos 28 Autoridades Portuarias que proporcionan este servicio, asumiendo su gestión, inspección y mantenimiento en el área geográfica que tienen asignada. La definición de todas las balizas es una de las funciones, entre otras, confiadas a Puertos del Estado, para lo que se sigue un procedimiento que incluye un proceso abierto de consulta a las partes interesadas y observaciones de un Comité Interministerial Consultivo, en el que hay representantes de todas las agencias que tienen competencias en la seguridad de la navegación.

El coste anual de la Red Costera (faros costeros y balizas, DGPS, etc.) asciende a aproximadamente 10 millones de EUR y existe un impuesto nacional para financiarla conocido como «Impuesto AtoN», que es recaudado por cada Autoridad Portuaria.

Hay 205 faros y luces principales (49 de los cuales están habitados), 2139 balizas y 1219 ayudas flotantes. También hay 18 racones, 18 estaciones Tx DGPS, 12 AIS-SBS y 50 AIS_AtoN.

Le rapport présente le modèle de gestion du Service de signalisation maritime espagnol, fondé sur la réglementation et l'inspection publiques qui impliquent une réglementation centralisée et une inspection décentralisée, avec un service fourni par le secteur public ou privé, selon les cas. La fourniture du service d'aides à la navigation en Espagne relève de trois scénarios : le réseau côtier, le balisage portuaire et les autres formes de balisage. Pour ce qui concerne le réseau côtier, c'est l'Administration Générale de l'Etat qui assure le service par le biais des Directions des Ports. Quant au balisage portuaire, la Direction du port est responsable des aides à la navigation pour son port, tandis que ce sont les autorités régionales ou privées qui en sont responsables lorsque le port est donné en concession. Les autres formes de balisage sont à la charge de ceux qui en ont la responsabilité : fermes aquacoles, conduites sous-marines, protection de la côte, champs d'éoliennes, etc...

Nous coordonnons 28 Directions de ports qui assurent ce service, responsables de la gestion, de l'inspection et de l'entretien dans la zone géographique qui leur est assignée. Entre autres, la définition de toutes les marques est du ressort de Puertos del Estado, qui doit suivre une procédure comprenant la consultation de parties prenantes et les commentaires du Comité Consultatif Interministériel constitué des représentants de tous les organismes compétents en sécurité de la navigation.

Le coût annuel du réseau côtier (phares et balises de la côte, DGPS, etc..) atteint environ 10 millions d'euros et une taxe nationale « redevance balisage » est collectée par les Directions des Ports.

Il y a en Espagne 205 phares et feux importants, dont 49 gardés ; 2 139 balises et 1 219 aides flottantes. Il y a aussi 18 racons, 18 DGPS Tx-stations, 12 AIS-SBS et 50 aides à la navigation AIS.

The Aids to Navigation (AtoN) service in Spain

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NATIONAL FRAMEWORK

The Spanish Constitution assigns competence in matters connected to AtoNs to the General Administration of the State, which is exercised through the Ministry of Development, without forgetting other ministries holding concurrent competencies in this area, as will be seen below.

This paper presents the Spanish AtoN service's management model based on public regulation and inspection, which involves centralised regulation and distributed inspection, along with the public or private provision of the service depending on the scenario in question. It also presents the service's funding model.

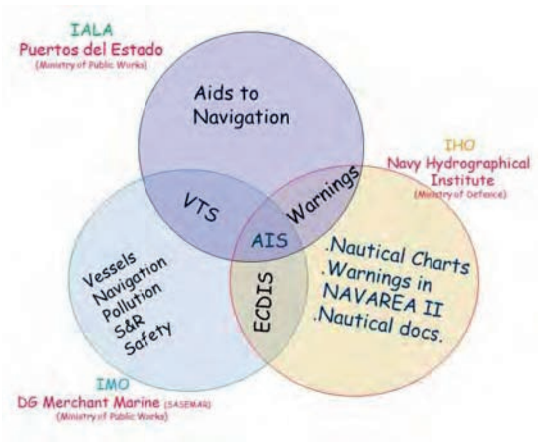
Taking into account Chapter V of the SOLAS Convention, Regulation 12 is assigned to the Directorate-General of the Marine Merchant with regard to any aspects related to VTS services, though VTS services in port environments are provided by the Port Authorities (under Puertos del Estado's responsibility). Competence for paragraph 3, Regulation 13 lies with the Navy Hydrographical Institute (Ministry of Defence) and the Directorate-General of the Marine Merchant regarding the communication of incidents, depending on whether they are respectively notices to mariners (hydrographical area) or navigational warnings (navigational safety area).

Competence for paragraphs 1 and 2, Regulation 13 of the SOLAS Convention corresponds to Puertos del Estado as the national agency responsible for AtoNs in Spain. Due to its competencies and functions, it is the regulatory authority in this matter. As a regulatory authority, however, it does not directly provide the service, though its mission is to ensure operators do indeed do so.

Puertos del Estado is a public agency dependent on the Ministry of Development and is responsible for the implementation of the government's ports policy; coordinating and monitoring the efficiency of the state-owned port system; training and promoting research and technological development at ports; and, expressly, for the "*planning, coordination and monitoring of the Spanish AtoN system and for promoting training, research and technological development in these matters*". It is also responsible for representing Spain at an international level, especially in matters connected with aids to navigation, without prejudice to any competencies reserved to the Ministry of Foreign Affairs and Cooperation.

SCOPE OF COMPETENCE

The state-owned port system is made up of 28 Port Authorities that group together 46 general-interest ports. These Port Authorities are likewise public agencies with their own legal personality and resources and have full capacity to act. They depend on the Ministry of Development through Puertos del Estado. Their competencies include: providing general and port-related services; planning, designing, building and operating port works and services; managing the public port domain; optimising ports' economic management; promoting industrial activities; regulating port traffic and, expressly, "*planning, designing, building, maintaining and operating the maritime signals entrusted to them*".



PROVISION OF THE ATON SERVICE

The provision of the AtoN service in Spain is carried out by taking three scenarios into account:

a) The Coastal Network, which includes general-use coastal navigation and the marking of certain natural hazards;

b) Port signalling; approaches and entries to ports; and

c) Other signalling of man-made facilities which limit navigation in some areas, such as fish farming, energy and shore protection facilities, wrecks, etc.

AREA	SCOPE
COASTAL NETWORK	General-use coastal navigation. Natural hazards
PORT SIGNALLING	Approach, entry and interior of ports
SIGNALLING OF OTHER FACILITIES	Signalling of fish farms, energy facilities, shore protection elements, wrecks, other facilities (man-made)

Hence, within the scope of the Coastal Network, the General Administration of the State is the provider of the service through the Port Authorities.

In the case of port signalling, the providers of the AtoN service are the agencies responsible for these infrastructures, which are the Port Authorities at their ports and the port agencies of the regional authorities (Autonomous Communities) or private organisations holding port facility concessions.

Lastly, the providers of the maritime signalling service for man-made facilities in the sea, are the organisations which develop or are responsible for such facilities.

The definition of all kinds of signals is among Puertos del Estado's functions in this matter. In order to do so, it follows a procedure that includes an open stakeholder consultation process and comments from a consultative Inter-Ministerial Committee, in which all agencies holding concurrent competencies in the safety of navigation, including hydrography, are represented, along with representatives from the fishing, leisure navigation and commercial navigation sectors.

LIGHTHOUSE COMMISSION

The Lighthouse Commission was set up in 1842 and continuous with its activities to this day, more than a century and a half later, having held 519 meetings to date.

The Lighthouse Commission was created in 1842 based on the French model in order to design and implement the first Spanish AtoN Plan of 1847. It was in that year, that the Spanish State took over responsibility for this matter through an ambitious lighthouse building plan that covered the Spanish coastline, as well as the regions under its sovereignty in Africa, America and the Philippine Islands. This Commission was initially comprised of civil engineers and Navy officers.

Today, the Lighthouse Commission has been totally reformed and is governed by the provisions set forth in a Ministerial Order of 1996. It is still an inter-ministerial consultative body which has to issue an opinion prior to the approval of new AtoNs or the modification of existing ones.

ATON INSPECTION

There is a very important function among the regulatory tasks and the provision of services carried out by Puertos del Estado: inspection. Inspection corresponds to the General Administration of the State and is exercised through the Port Authorities, which have been assigned a part of the coast for this function, and through Puertos del Estado, which inspects the aids under the Port Authorities' management.

This public regulation and inspection model, involving centralised regulation and distributed inspection, along with the public or private provision of the service, depending on the scenarios, means it is essential to make a significant effort in training. Such training is being carried out on the basis of the WWA and IALA model courses and their adaptation to a competence-based management system for the personnel of the State Port System (Puertos del Estado and the Port Authorities). We are in the process of initiating a project aimed at certifying the personnel in charge of AtoNs, according to IALA Recommendation-E 141.

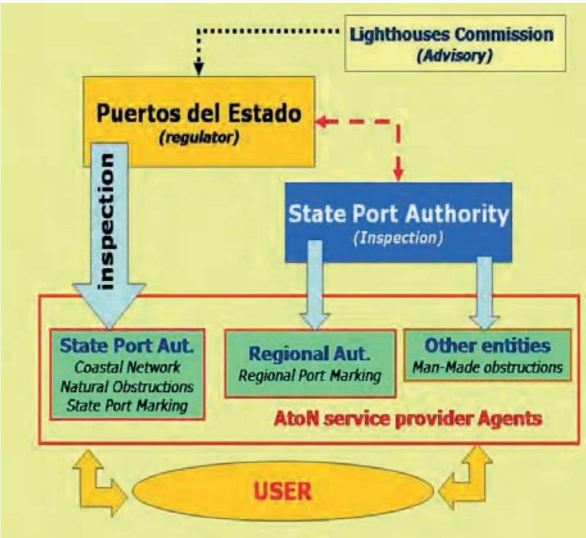
The inspection tasks, conducted by Puertos del Estado, are limited to the AtoNs under the responsibility of the different Port Authorities, as that same Law assigns the Port Authorities the following functions, among others:

d) Ensuring effective fulfilment of the signals laid down by Puertos del Estado, so that, if those responsible for their installation and maintenance fail to do so within the established time limit, they have to be executed by the Port Authority at the cost of those responsible;

e) Mandatorily informing about execution projects for new devices or the modification of existing ones, whose installation and maintenance is the responsibility of third-party stakeholders; and

f) Conducting inspections on the AtoNs, whose installation and maintenance are the responsibility of third-party stakeholders (installed in an inspection area assigned for such purposes) and, if necessary, adopting measures at the latter's cost leading to the service's re-establishment, including measures arising from their sanctioning powers, where appropriate.

The stakeholders responsible for installing and maintaining AtoNs, are obliged to give notice of both the entry into service of new signals and, as appropriate, the withdrawal of any signals, as well as of any incidents that may come about in the provision of the service.



FUNDING

Regarding this model's funding, each organisation holding responsibility for AtoNs in principle covers the provision of the service for which it is responsible, with its own economic resources with respect of the design project, acquisition, installation and maintenance of the service's equipment and monitoring systems.

Nevertheless, there is a nation-wide duty known as the "AtoN Duty" for the general public service comprised of the Coastal Network (lighthouses, DGPS, etc.), whose annual cost amounts to around €10 million. This duty is collected by each Port Authority, but 80% of the amount collected is consolidated into a single account which is then redistributed among the Port Authorities, on the basis of the number of lighthouses, coastal beacons and other aids included in their own coastal network. This means that the State, in the form of the State Port System, reverts back to the Port Authorities, at least, part of their operating costs for this AtoN service to ensure that, this public service, does not significantly weigh on their profit and loss account and come to affect their profitability.

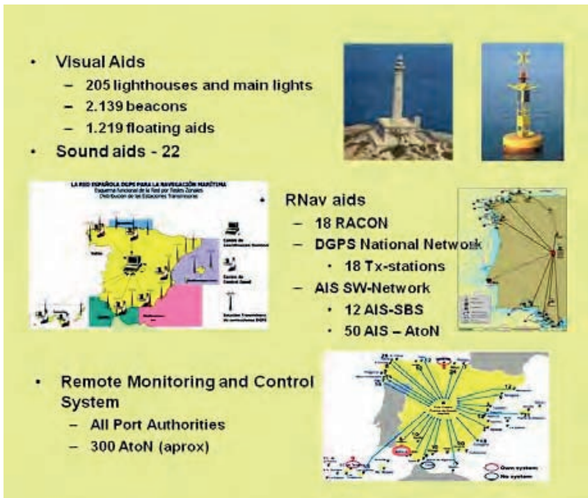
ATON FACILITIES IN SPAIN

The AtoN service for the Spanish coastline (in other words, excluding aids directly applied to the approaches, entries and internal waters of ports, the marking of fish farming facilities, underwater outfalls, breakwaters and other shore protection elements) is currently comprised of:

g) The Coastal Network of visual aids; and

h) The Spanish DGPS Network for maritime shipping and other radioelectric aids

As a coastal network, the former is made up of 187 lighthouses and 152 beacons. As a network of radioelectric aids, the latter is equipped with six area networks and 18 DGPS differential correction transmission stations, 17 of which are located at already existing lighthouses.



"FAROS DE ESPAÑA" (LIGHTHOUSES OF SPAIN)

As their historical evolution has borne out, the service entrusted to lighthouses can currently be provided without the need of a permanently manned on-site technical presence, due to equipment automation, new monitoring technologies and the use of hybrid photovoltaic, solar and wind power feed systems, along with new low-power lamp technologies providing the same light intensity as older lamps. Lighthouses have thus become technologically advanced and highly reliable facilities.

Nevertheless, there are still 49 manned facilities in Spain. Regarding the service, lighthouse management and operation corresponds to the Port Authorities, which take decisions on the use and allocation of available resources. The withdrawal of people from lighthouses or, better said, the accommodation buildings attached to them, leads to two highly significant problems: on the one hand, the material conservation of an infrastructure located in a harsh environment, essentially the effects of saline humidity; and, on the other, the effects of vandalism, to which any infrastructure is vulnerable without a permanent manned presence. Though it has been used on occasion, turning these facilities into bunkers does not resolve the problem of environmental deterioration. This option can also be expensive and its visual impact is high. It is therefore being abandoned around the world.

In order to provide a solution, to the lack of a manned presence at lighthouses due to reasons of the AtoN service, actions aimed at encouraging interchange with cities/society at lighthouses have been initiated by promoting so-called alternative or complementary uses, thereby also overcoming two significant problems: deterioration due to environmental causes and vandalism.

However, it should not be forgotten that, in all the cases, lighthouses are still in service. It is therefore necessary to take into account both these uses and, additionally, the fact that lighthouse facilities were built at a time when safety and risk prevention requirements were not as stringent as they are today.

This means that any new activities promoted at lighthouse spaces should:

- Be contemplated as permitted activities in lighthouses under a concession or authorisation scheme according to prevailing legislation, as they are in the public port domain.
- Be compatible with the lighthouse's operation and its encumbrances.
- Keep a permanent manned presence
- Comply with health and safety regulations for both the people who use them on a day-to-day basis as well as visitors.

Additionally, along the lines of heritage protection, work is being done to get certain lighthouses listed as Assets of Cultural Interest (*Bienes de Interés Cultural*) under the Monument category. Ten lighthouses have already been listed, among which the Tower of Hercules stands out, which was also declared a World Heritage Site in 2009. Furthermore, two more lighthouses are in the process of being listed.

Several Port Authorities have already started to promote complementary uses at lighthouses with activities that are usually performed by third-party stakeholders, such as regional authorities, local authorities, cultural organisations and other bodies. This, for instance, is the case of the Port Authorities of Santander, Las Palmas, La Coruña, Avilés, the Balearic Islands, Tarragona and Barcelona.

In order to assess complementary use projects, the following requirements, among others, must be met:

- The night-time signal cannot be affected. Any possible lighting of the building and its surroundings, should be installed in a way which does not hide or interfere with the lighthouse's light. Such lighting, has to be done with a fixed, tenuous, white light focused downwards from above, without exceeding the lighthouse's balcony in order to avoid interfering with the maritime signal.
- The daytime signal cannot be affected. The tower's appearance, colour and shape cannot be altered, as it is a daytime recognition mark for mariners.
- Not only should the lighthouse tower be reserved for the maritime signal, but also sufficient space for any ancillary equipment.
- Port Authority personnel should be given unrestricted access to the lighthouse grounds and tower, as well as to any other technical areas.
- The access point to technical areas reserved for the maritime signal should be independent from the access points planned for any other kind of planned activity.
- Electricity, water, etc. supplies to areas dedicated to other uses should be totally independent from the area reserved for the maritime signal.
- The project should ensure the electromagnetic compatibility of any electric or electronic devices that are expected to be installed with the maritime signal's existing devices.
- If technological evolution makes it necessary to install new AtoNs, the complementary use should not cause any kind of constraints to the public service, regardless of any encumbrances which may come about.
- The project should comply with all prevailing regulations on electrical installations and health and safety, apart from any others which may apply.

Since the legislative reform of 2004, amended in 2011, aimed at preserving the architectural heritage constituted by lighthouses, the Cabinet or the Minister of Development may, as appropriate (regardless of whether or not the lighthouse is located in a protection encumbrance area), authorise hotel, hostel or accommodation facilities that could encourage the performance of cultural or similar activities of a social interest, provided no new buildings are constructed and the provision of the service is not conditioned or limited, after having received a prior report from Puertos del Estado and, in cases where the facility is located within a protection encumbrance area, the competent administration on coasts.

In this regard, an initiative called *Faros de España* (Lighthouses of Spain) was launched in 2013, which is aimed at contributing to promote the *Marca España* (Brand Spain) concept through a novel tourist sector.

As in numerous other European countries like the United Kingdom, Denmark, Norway and Croatia, it also seeks to promote the adding of value to lighthouses for society as a factor which can drive forward the Spanish tourist business fabric through the use of lighthouses as accommodation in a unique destination for exclusive tourism that respects that environment. Hence, an effort is being made to encourage and stimulate investment in tourist development, by private initiatives within their area of influence, through a strategy that is always in keeping with sustainability, to allow for the conservation of lighthouses in a way which is compatible with their function as maritime signals, while making a significant contribution to the area's economic growth, by promoting and incentivising the setting up of new companies capable of creating jobs and diversifying, modernising and strengthening the local business fabric.

If these residential uses can be developed, an outstanding way of conserving heritage would be achieved. At the same time, it would be an interesting source of revenue to collaborate in the AtoN service's general maintenance, through the levies applied on the occupation and use of the lighthouses' public domain. These uses, would continually improve lighthouses and provide a response to mariners' future positioning and navigational safety needs, not to mention protecting the historical heritage that has been handed down to us.

FUNCTIONS OF PUERTOS DEL ESTADO'S ATON AREA

The following functions are performed by Puertos del Estado's AtoN Area:

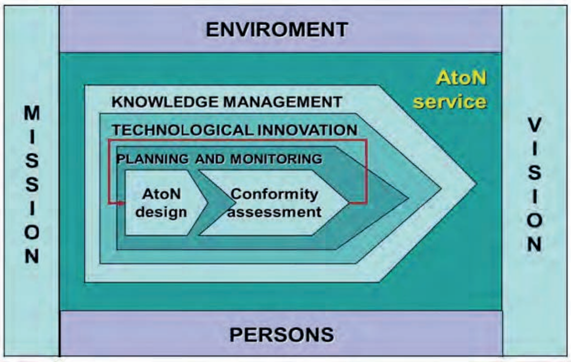
- Putting forward the policy and strategy for the entire national maritime signalling and AtoN system.
- Planning and setting targets, service and quality levels, technical guidelines, standards, inspection and control.
- Performing tasks inherent to the Lighthouse Commission's Deputy Chairmanship and Standing Secretariat.
- Promoting training, research, development and technological innovation in the area of AtoNs.
- Enhancing the conservation of historical and technical heritage and representing Spain in international forums, organisations and committees dedicated to this matter.
- Facilitating harmonisation among different organisations and institutions responsible for providing the national AtoN service and with neighbouring countries in border areas, as well as gathering users' needs and expectations.

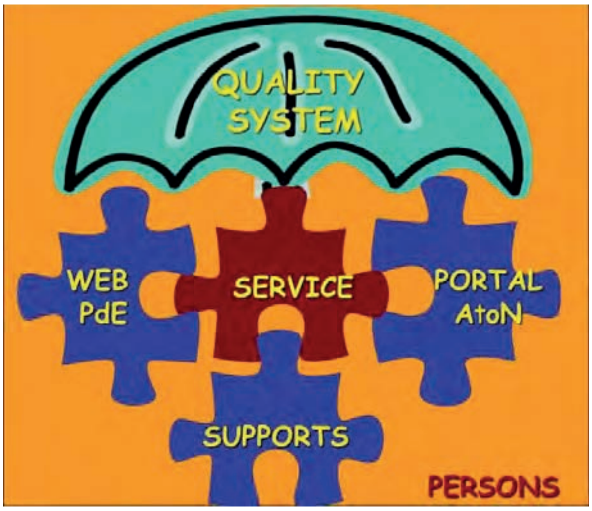
These tasks are performed in three kinds of areas:

- Internal: actions having to do with ordinary activities and relationships with other PdE departments.
- External: actions having to do with Port Authorities and other stakeholders which provide the service, as well as with other entities related to AtoNs.
- International: actions having to do with international organisations and working groups, as well as relationships with AtoN services or other entities from other countries.

QUALITY

Puertos del Estado has implemented and certified a Quality System for the AtoN service and is highly committed this kind of quality assurance for the AtoN service.





MAIN PROCEDURES

1. Processing of applications for new signals or for the modification of existing ones

An application for a new signal or for the modification of an existing one, can be filed by

Puertos del Estado, Port Authorities, regional authorities, private organisations or other public or private entities or organisations before the agencies indicated below, depending on the case:

1) Before the relevant Port Authority, where the signal is related to the approach, entry and/or internal signalling of a general-interest port or if it affects its service area, including facilities under an authorisation or concession scheme.

2) Before Puertos del Estado, where the signal is located in any other area other than the ones mentioned above.

Signals are classified under case 2) where they are needed for:

- The approach, entry and/or the internal signalling of ports and facilities under the responsibility of regional authorities, including any under a concession or authorisation scheme;
- Facilities belonging to other public administrations or agencies dependent on them;
- Industrial facilities, fish farms and underwater outfalls.

Once the application for a signal or the supposed need for the signal has been filed, Puertos del Estado will assess the application and decide whether to admit it for processing or reject it. In the latter case, notice will be given to the interested stakeholder of the reasons which have led to the rejection of its application.

In cases, where it is necessary to define a provisional signal for safety reasons, the initial application will be sent to Puertos del Estado urgently, so that it may define such signal, notice of which will be given to the interested stakeholder and to the relevant Port Authority.

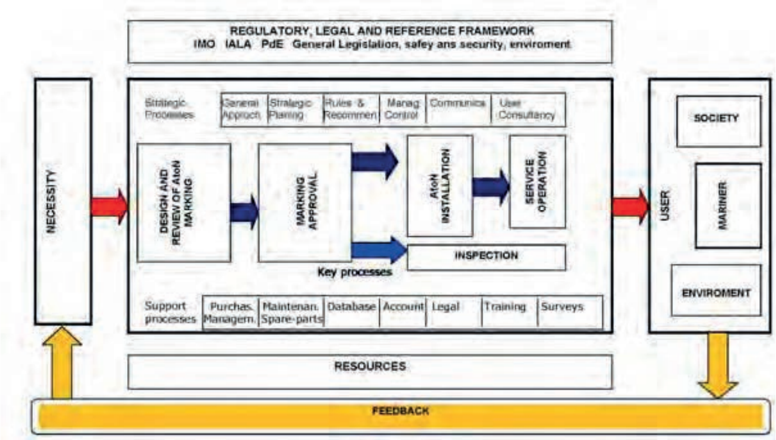
Once the application has been accepted in non-urgent cases, Puertos del Estado or the Port Authority will, as appropriate, draw up a signalling proposal, which will be subject to the official hearing process that includes the interested stakeholder. A time limit to reply, will be set in accordance with Act 30/1992 and the signal's complexity.

If the processing procedure corresponds to a Port Authority, the procedure will be sent to Puertos del Estado, along with a report issued by said Port Authority on the allegations received. In any event, Puertos del Estado will draw up a paper for submission to the Lighthouse Commission in view of the signalling proposal, the allegations received and the Port Authority's report.

The Lighthouse Commission then will discuss the paper and issue a mandatory opinion, which if approved by the President of Puertos del Estado, as appropriate, will become a resolution, notice of which will be given to the interested stakeholder and to the relevant Port Authority.

In view of the resolution, the interested stakeholder will then draw up a works design project only for newly built AtoNs or for AtoNs which require a significant modification. Where the interested stakeholder is a Port Authority, the design project will be approved by it. Where the interested stakeholder is another organisation or private entity, the design project will be sent to the relevant Port Authority for its report. In both cases, this will be done before its construction and entry into service.

Before a new AtoN is placed into service, the interested stakeholder will give notice thereof to the relevant Port Authority, or to Puertos del Estado in cases where the interested stakeholder is a Port Authority, so that an inspection may be conducted prior to its entry into service and to verify that all aspects of the procedure have been fulfilled and whether the facility meets the specifications laid down. In this case, the interested stakeholder will give the Navy Hydrographical Institute and Puertos del Estado notice of its entry into service when it comes about, as well as to SASEMAR's National Local and Coastal Navigational Warning Coordination Service.



2. Communication of incidents

Once signals have begun to provide a service, the stakeholder responsible for the signal should have the technical and human resources, as well as the internal procedures needed to ensure the service meets the required quality levels. It must be aware of the signals' operating status and notify any incidents that may come about and correct them as soon as possible.

The communication of any incident, will be done in accordance with the following procedure, which will always be the responsibility of the stakeholder in charge of the signal.

1. Notice of any incident should be given as soon as it is known, preferably before any corrective action is taken. However, in the case of light signals, if knowledge of an incident comes about outside the period the signal should be operational (during the day, for instance), it will be sufficient to give notice of the incident, only if it is expected that service cannot be re-established before its next service cycle (night-time period), in order not to overburden the agency in charge of local and coastal navigational warnings, with useless information.

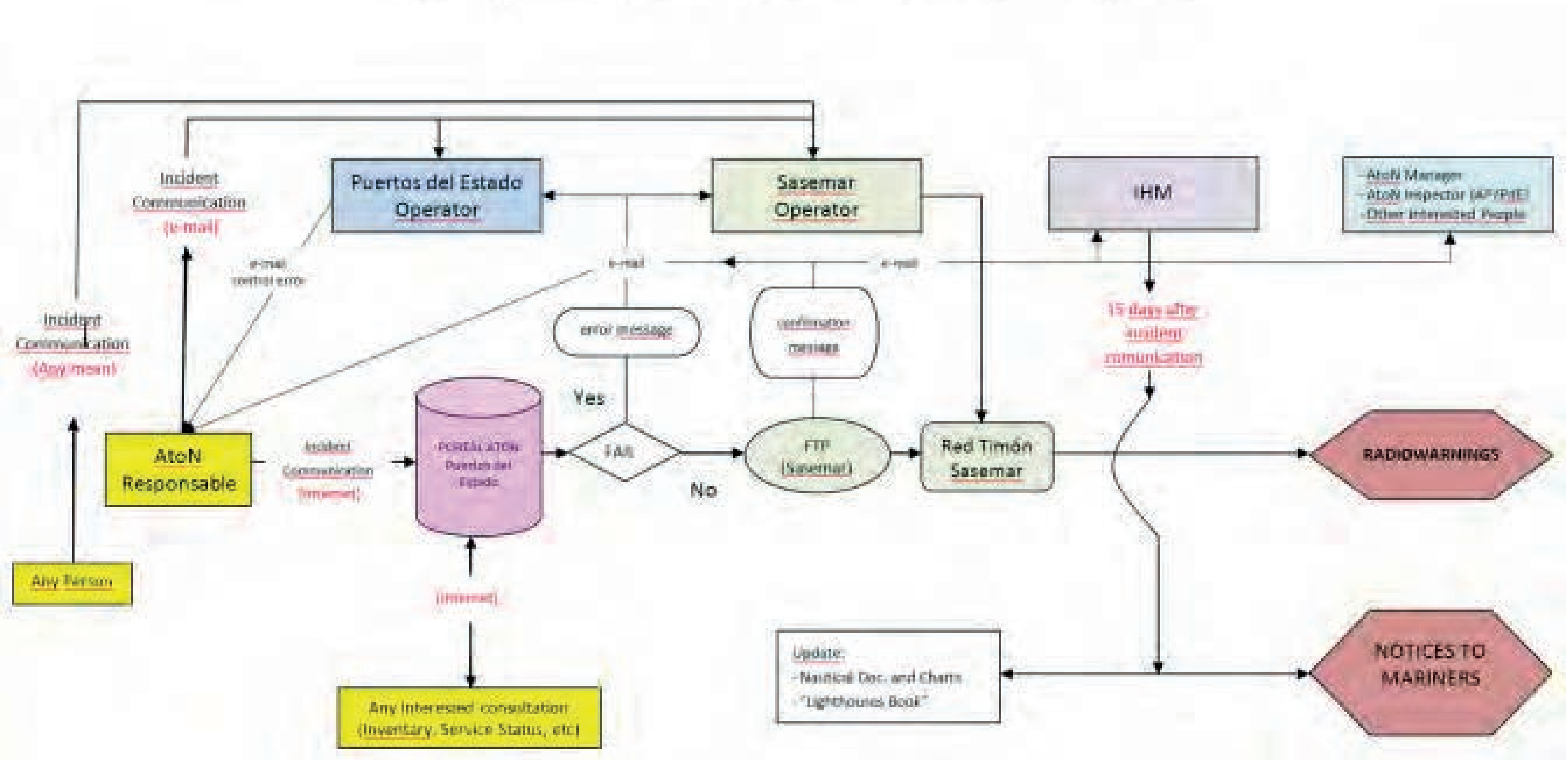
Nevertheless, ALL incidents should be accounted for and recorded, regardless of whether or not they generate notices to the agencies responsible for broadcasting them, as this information is needed to calculate the facility's "reliability" and the service's "availability" parameters.

1. After a failure (off) in a signal's service, it is mandatory to also give notice to the relevant agency that it is once again running normally (on) once service has been restored.
2. The standard form to give notice of any incidents can be found on the Puertos del Estado website.
3. Incident notices to the relevant agency can be given through either of the following two options:
   - Sending an e-mail
   - Using the application on the Puertos del Estado website.

When the Web application is used, the system distributes the notice automatically to relevant agency in charge of local navigational warnings and to Puertos del Estado, at the moment it is sent. Furthermore, the system can additionally send the message to other agencies or entities. In order to do so, the person holding responsibility, needs to have a password to gain access to the system, which is provided by Puertos del Estado.

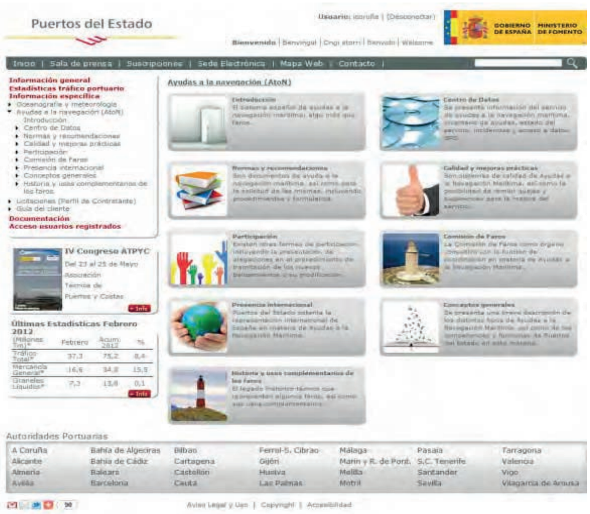
Should any kind of error come about, when delivering the message to the recipient's mailbox, the Web application will return an error message

AIDS TO NAVIGATION INCIDENT MANAGEMENT DIAGRAM



on the delivery. When this happens, the person holding responsibility, should send the notice by e-mail using the relevant form.

INFORMATION



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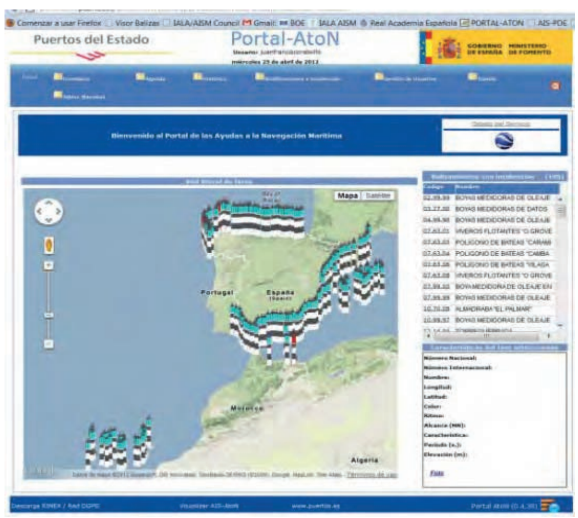

http://portalaton.puertos.es/portalAton

50 MAINTENANCE OF AIDS TO NAVIGATION BASED ON KNOWLEDGE, INNOVATION AND INTEGRATION OF IALA GUIDELINES AND RECOMMENDATIONS

Nick Goethals. Vlaamse Overheid- Agentschap voor Maritieme Dienstverlening en Kust Afdeling Scheepvaartbegeleiding, Belgium

The shipping assistance division of the Flemish Government is responsible for the management and maintenance of the fixed AtoNs in the ports of Nieuwpoort, Oostende and Blankenberge. Nieuwpoort is the biggest marina of Northern Europe and has more than 2.000 berths. The existing system of AtoNs consisted of a variety often installed in earlier years by various organizations and end-users, which resulted in a complex inventory of equipment and rising maintenance costs with little benefit for the yachtsmen and shipping industry. Where the previous maintenance was carried out based on a basic preventive maintenance schedule and an on-demand corrective maintenance, there was a strong need for a more structural approach to meet the current IALA guidelines and recommendations. This approach should also give more attention to the need of innovation, integration of cost efficiency in design, developing of a long-term vision and the interaction with the end-user.

La división de ayuda al tráfico marítimo del Gobierno Flamenco es responsable de la gestión y mantenimiento de las AtoN fijas en los puertos de Nieuwpoort, Ostende y Blankenberge. Nieuwpoort es la mayor marina de Europa del Norte y dispone de más de 2000 amarres. El sistema existente de AtoN está formado por una diversidad de elementos que en muchas ocasiones fueron instalados en años anteriores por diferentes organizaciones y usuarios finales, y que tiene como resultado un inventario complejo de equipos y unos elevados costes de mantenimiento, con pocas ventajas para los aficionados a la vela y para la industria naval. En aquellos lugares donde los mantenimientos anteriores se realizaron en base a un programa de mantenimiento preventivo básico y un mantenimiento correctivo bajo demanda, hubo una fuerte necesidad de un enfoque más estructural para cumplir las directrices y recomendaciones actuales de la IALA. Este enfoque también debería prestar más atención a la necesidad de innovación, la integración de la rentabilidad en el diseño, el desarrollo de un proyecto a largo plazo y la interacción con el usuario final.

Le service d'assistance aux navires du gouvernement flamand est responsable du fonctionnement et de l'entretien des aides à la navigation fixes des ports de Nieuwport, Ostende et Blankenberge. Nieuwport est le plus important port de plaisance de l'Europe du Nord avec plus de 2 000 places à quai. Le système d'aides à la navigation existant comprenait divers éléments souvent installés par divers organisations et utilisateurs, d'où un ensemble complexe d'équipements et des coûts d'entretien en hausse, et peu d'avantages pour les plaisanciers et l'industrie maritime. L'entretien en était alors assuré sur la base d'un plan d'entretien préventif et sur demande en cas de panne, il manquait une approche plus structurée respectant les Guides et Recommandations de l'AISM. Il fallait aussi s'intéresser à l'innovation, au coût dès la conception, développer une vision à long terme et une coopération avec l'utilisateur.

Maintenance of aids to navigation based on knowledge, innovation and integration of IALA Guidelines and Recommendations

Nick Goethals

Agency for Maritime Services and Coast
Belgium

IALA·2014·AISM
XVIII Conference · A Coruña · Spain

Nick Goethals, Agency for Maritime Services and Coast, Belgium

INTRODUCTION

The shipping assistance division (SAD) of the Flemish Government is responsible for the management and maintenance of the fixed AtoNs in the ports of Nieuwpoort, Oostende and Blankenberge. Nieuwpoort is the biggest marina of Northern Europe and has more than 2.000 berths. The existing system of AtoNs consisted of a variety often installed in earlier years by various organizations and end-users, which resulted in a complex inventory of equipment and rising maintenance costs with little benefit for the yachtsmen and shipping industry. Where the previous maintenance was carried out based on a basic preventive maintenance schedule and an on-demand corrective maintenance, there was a strong need for a more structural approach to meet the current IALA guidelines and recommendations. This approach should also give more attention to the need of innovation, integration of cost efficiency in design, developing of a long-term vision and the interaction with the end-user.

In 2013 we awarded a public tender contract to rationalize, optimize and standardize the current system of AtoNs. Following objectives were determined in this tender:

- Development of a structured organization;
- Development of a cost efficient maintenance plan and approach to reduce TCO;
- Making of an inventory of the availabilities of AtoNs as defined by IALA;
- Installing a control and monitoring tool for remote control of AtoNs;
- Integrating IALA guidelines and recommendations throughout the entire system;
- Organization of knowledge management and transfer.

A BRIEF HISTORY

The Flemish coast has four harbors: Nieuwpoort, Oostende, Blankenberge and Zeebrugge. The latter is in private-public hands. The fixed AtoNs in the other harbors are since 2011 owned by the SAD of the Flemish Government. Throughout the past years these AtoNs were installed by various organizations and end-users such as the Fleet division, Coastal division, private partners, sports clubs ….

When a new AtoN was necessary, the price was formerly often the only criteria and practically no attention was given to the maintenance cost afterwards. The choice was mostly based on available equipment, urgent needs, available technologies and available knowledge. The earliest still operational fixed AtoN date from the early 90's, the most recent AtoN is at least 6 years old.

The maintenance was based on a basic preventive maintenance schedule and on-demand corrective actions.

The past years some issues were encountered:

- equipment became obsolete;
- changing demands from users;
- no available manuals & as-built documents for some installations;
- a heterogeneous spare part list.

These issues made maintenance difficult, expensive and resulted in cost excessive repair of equipment and longer offline time due to long delivery times of equipment and trouble shooting.

DEVELOPMENT OF A STRUCTURED ORGANIZATION

The existing AtoNs consisted of a variety of AtoNs often installed in earlier years by various organizations and end-users, resulted in a complex inventory of equipment. As a result of this process there was an insufficient and unclear view on the existing network of AtoNs. There was a very strong need to know which AtoNs were installed throughout the different harbors including their technical specifications.

Therefore we started with the making of an inventory of all the AtoNs we could find within the different harbors. Of each AtoN we recorded, as far as we were able to, as many details as possible such as type of AtoN, range, exact location, height, type of lamp, light power, type power, access modalities, …

Parallel with the making of an inventory we analyzed, summarized and categorized the IALA recommendations and guidelines to find out which IALA documents are applicable. This results in a limited list of IALA documents, related to our AtoNs.

Starting from the inventory we consulted the key users in every harbor in order to re-examine and to look critically at this inventory from an operational and functional point of view with regard to usefulness and necessity and which existing AtoNs may be removed, moved, altered, or other in combination with a forward-looking cost-benefit analysis according to the IALA guidelines and recommendations. The key users are the pilots, yacht clubs, coastguard, harbor masters and shipping industry.

The result of the key user meetings was that some of the historical AtoNs were no longer used and others needed to be modified in order to meet the operational and functional requirements. A limited and modified list was the result.

Of this list we recorded for each AtoN if it was compliant to the international maritime regulations and IALA guidelines and recommendations and if not, the shortcomings were noted.

The necessary actions will also be taken to involve the end-users in a more structured way in order to keep the network of AtoNs up to date and to give the key users the opportunity to participate. Beside this we will profile our division as the only authority for installing and managing AtoNs in all the harbors under our jurisdiction.

DEVELOPMENT OF A COST EFFICIENT MAINTENANCE PLAN AND APPROACH TO REDUCE TCO

The total cost of ownership (TCO) is the sum of the procurement cost and the maintenance cost. In the illustration below you can see that the procurement cost increases with the reliability and at the same time the maintenance costs decreases. This TCO has an optimum value at a certain level of reliability. In reality we need to consider for each new AtoN, what is the necessary reliability and related procurement cost and what is the expecting maintenance cost in order to obtain an acceptable TCO.

Everything starts with good and thoughtful design in order to become an acceptable maintenance cost. Maintenance costs are the most important part in the TCO. When a new design needs to be made, we involve the maintenance team together with the engineering team in order to get the best suitable technical solution. Keywords in this engineering process are reliability, maintainability and supportability.

The existing system of AtoNs consisting of a variety of equipment often installed in earlier years

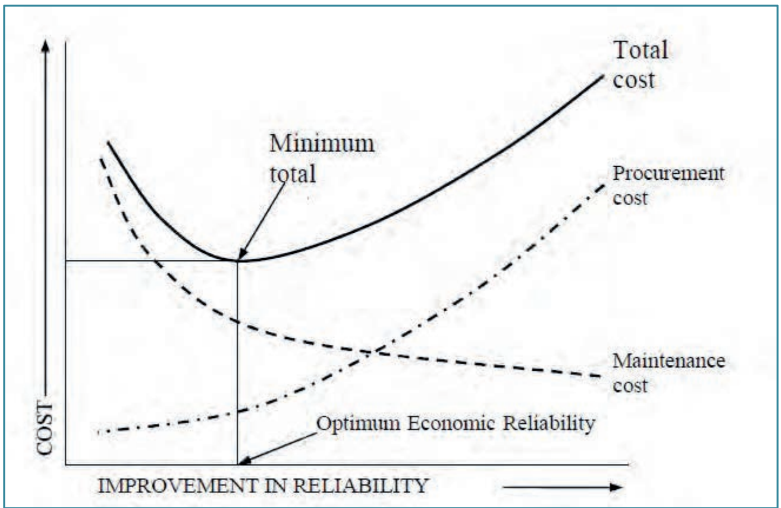

Figure 1: Procurement and maintenance costs vs improvement in reliability (IALA guideline No. 1035)

by various organizations and end-users, resulted in a complex inventory of equipment and rising maintenance costs. With this tender we will standardize the system of AtoNs by using types which can be used for multiple purposes. In this way we can:

- Reduce the number of spare parts;
- Create standardization for us and the end-users;
- Simplify the maintenance procedures;
- In case of malfunctioning remove and replace the Aton, no repair on-site;

Reducing the TCO can also be done by integrating new technologies, such as LED lights. This technology is more expensive than traditional solutions but gives the big advantage of less maintenance costs. That's why we decided for mostly all AtoNs that, when an AtoN needs to be replaced, it should be replaced by a new type based on LED-technology and according to IALA regulations.

The current maintenance is carried out based on a basic (monthly) preventive maintenance schedule and an on-demand corrective maintenance. To this day we are not able to monitor the current AtoNs. We do not know the status, identification of the failure, availability is not recorded, …. All the malfunctions are being reported by the end-users by telephone and email or noted during the preventive maintenance. At almost every intervention, a technician needs to go on-site and check which problem occurred and what spare parts he will need to fix the problem.

There is a very strong need for a control and monitoring system (CMS). It's a part of this tender to develop and to build a CMS for all the AtoNs under our jurisdiction.

Our goal is to solve the problem before someone can notice it!

In order to developing a cost efficient maintenance plan we classified all the selected AtoNs, according to IALA recommendation O-130, into 3 different categories with the necessary corresponding minimum availability objective.

CATEGORY	AVAILABILITY OBJECTIVE	CALCULATION PERIOD
1	99.8%	Availability objectives are calculated over a continuous three year period, unless otherwise specified.
2	99.0%	
3	97.0ù	

Figure 2: Categories of percentage availability (IALA O-130)

The minimum availability of any individual AtoN should be 95%. Where the availability of an individual AtoN consistently falls below 95%, consideration should be given to the discontinuance or replacement of that AtoN.

For each category we specified the failure response time in order to realize the availability objective. Thanks to the CMS we are able to send different kind of messages according to the different categories. So a service company will directly receive from the CMS for all the categories a notification by means of sms or email.

Thanks to the CMS we can develop a cost efficient maintenance plan because of:

- Immediate warning in case of a problem;
- Possibility to log on the CMS for making a first diagnose, identification;
- Supporting the maintenance team with additional live information (smartphone /tablet);
- No lost time for collecting the right spare parts;
- Reducing repair time, increasing availability;
- Reducing downtime through use of remote control resets;
- Monitoring the MTBF and MTTR.

The current CMS will monitor the state of the AtoN (ON/OFF, type of alarm…). In the future we would like to expand this CMS with additional parameters to indicate and to monitor the health of an AtoN, also known as Condition Based Monitoring (CBM). Thanks to this CBM we will be able to:

- Extending the time interval for required maintenance;
- Enable maintenance when it is needed (condition based maintenance);
- Reducing the corrective maintenance;
- Reducing repair time, increasing availability.

INSTALLING A CONTROL AND MONITORING TOOL FOR REMOTE CONTROL OF ATON'S

To improve the availability of the AtoNs, a CMS system will be rolled out. It's functionality and requirements are based on the IALA Guideline 1008 "Remote Control and Monitoring of Aids to Navigation" and the keywords are:

- identification of failures;
- optimize the AtoN maintenance;
- reduce the total cost of ownership of the AtoNs;
- calculate AtoN availability, mean time between failure (MTBF) and mean time to repair (MTTR).

The following aspects are considered when choosing the CMS system:

- The CMS system has to be integrated with the existing AtoN PLC network in the harbor of Oostende. In the harbor of Oostende an end-of-life AtoN PLC network is available. Modifications to this PLC network are expensive and sometimes not possible due to non-availability of parts. An alternative system is preferred when implementing a new CMS in this harbor.
  The CMS system should be able to interface with the new PLC system;
- Modular composition that offers the possibility to expand the system without exorbitant costs;
- The CMS has to be able to control and monitor the AtoNs;
  By means of the CMS the operator must have the possibility to monitor and control the AtoNs. The provided information must depend on the operator's level of authority.

- The graphical user interface (GUI) of the CMS has to be user-friendly and must be accessible from an internet browser;
  The graphical user interface of the CMS has to be straightforward (menus, pictograms, buttons… have the functionality the user expects), consequent (buttons, pictograms, etc. have the same meaning), prevent the user to make mistakes, give relevant feedback, and should have a low entry level.
- AtoN brand independent;
  A lot of AtoN brands offer CMS technologies, however often they work only with their own products. This CMS has to be brand independent with regards to the AtoNs, however this may not result in higher costs by expecting special requirements to interact with the CMS.
- Wide range of communication possibilities;
  The communication interface has to be transparent, depending on the available network interfaces in the area.
- Logging of data in a standard database;
  All operational actions from the AtoNs have to be stored in a relational database for analytic purposes.
- Ability to send SNMP traps;
  On failure of AtoNs it has to be able to send SNMP traps to a third-party SNMP management system that can inform the service desk.

Topology of the CMS

The CMS is based on a network of data loggers that communicate with a control and monitoring server. The data is stored in a relational database and the visualization is done by means of an internet browser. All items are custom of the shelf (COTS) products that are easily configured.

The data loggers are placed in several star topologies: in every harbor one 'master' data logger interrogates the other 'slave' data loggers installed at every AtoN. The advantages of using master data loggers is a simplified network topology.

Communication between server and the master data loggers is done by means of fiber, copper or GPRS; communication between master and its slave data loggers takes place via copper or spread spectrum radios.

GUI

The GUI is custom made using software of the distributor of the data loggers and easily configurable for developers. Every action of an operator on an AtoN is registered in the database.

Notifications of failures

Automatic notifications use the simple network management protocol (SNMP) that can send out messages to the desired interface (e-mail, mobile text messages, etc.) using a third party SNMP manager. To inform the SNMP manager an SNMP generator sends so-called SNMP traps based on

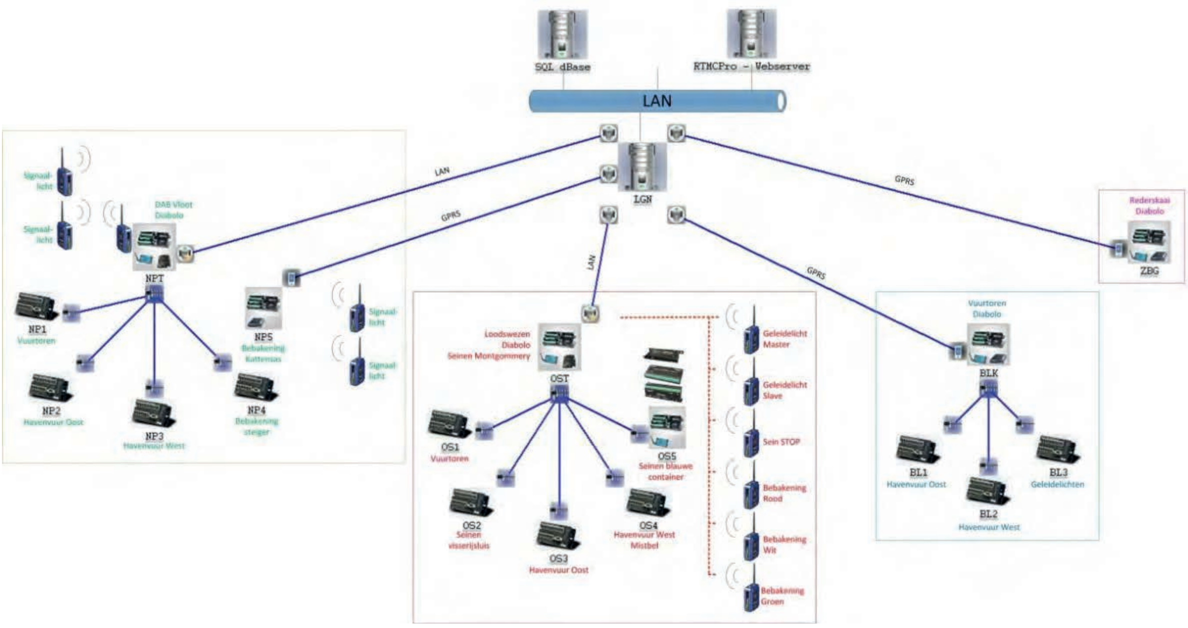

Figure 3: Network topology of the CMS

querying the data in the database.

INTERIM RESULTS

Actual status

- The public tender is awarded. The primary task – the inventarisation task is completed. The AtoNs in the three harbors have been identified.
  For example: the harbor of Ostend has over 30 AtoNs, but only 12 of them are under the responsibility of the SAD.
- The IALA guidelines and recommendations related to our AtoNs are categorized;
- All the key users are consulted;
- The study whether the AtoNs are conform the IALA guidelines and recommendations is in progress;
- Maintenance has been documented, checklists are created and technicians are instructed to sign off their visit at every AtoN.

Example 1: STOP sign

Figure 4: STOP sign yacht club Rico

Problem

Embarkment from the yacht club "Rico" is restricted by a giant "STOP" sign which indicate that large cargo vessels are sailing into the harbor. However the STOP sign is no official AtoN and should be altered.

Solution

This shall be altered during this contract by means of a standard maritime traffic light.

Example 2 : Leading lights of Oostende

The leading lights of Oostende are an example for the necessity of a AtoNs revision.

Figure 5: Leading lights (142°) of Oostende

Problem

End-users of the harbor of Oostende mentioned that not all 3 spots of the leading lights can be seen from a ship: it seems that the top light of the lower leading light overlays the bottom light of the higher leading light.

Cause

Study of the IALA recommendation E-112 "On leading lines" and guideline 1023 "The design of leading lines" determines the cause: the higher leading light is not designed for the segment they belong to as it is too low in worst conditions (stated as the highest high tide, minimum distance to the leading lights, observer on the lowest deck,…) and the lowest light of the higher leading light should be placed one meter above existing highest light of the higher leading light.

Solution

Solutions for this specific problem are (as mentioned by the guideline):

- Lowering the lower leading light;

This is not a good solution as this means that larger vessels may hide the structure.

- Modifying the distance between the leading light structures;
  This is not a good solution as the area in between the structures is reserved for storage purposes.
- Increasing the higher leading light;
  This implies a new concrete foundation and new construction; this will be the most expensive but only feasible solution.

CONCLUSIONS

The existing system of AtoNs consisted of a variety of equipment often installed in earlier years by various organizations and end-users, resulted in a complex inventory of equipment and rising maintenance costs. Maintenance of these AtoNs is based on basic preventive maintenance and an on-demand corrective maintenance.

In order to develop a cost efficient maintenance plan to reduce the total cost of ownership, the following actions will be rolled out:

- Development of a structured organization;
- Installing a control and monitoring tool for remote control of AtoNs;
- Integrating IALA guidelines and recommendations throughout the entire system;
- Organization of knowledge management and transfer

A good balance between procurement and maintenance costs must always be found in order to obtain an acceptable total cost of ownership.

All the malfunctions are being reported by the end-users or noted during the preventive maintenance. When a malfunctioning is being reported, there is no information available about this problem. Thanks to the CMS we will be able to get real time data from the AtoNs and will be able to manage the system of AtoNs on a proactive way. Our motto is trying to solve the problem before the end-user can notice it.

To avoid a proliferation of different AtoNs we will profile our division within the Flemish Government as the only authority for installing and managing AtoNs.

The realization is done by means of a public tender and is awarded to Cofely Fabricom, member of the GDF Suez group. Although the tender was only recently awarded, it has already given some interesting results, such as identifying international unknown signs, insufficient visible of leading lights, etc.

The IALA guidelines and recommendations are for our organization a useful guidance in order to manage our system of AtoNs in a professional and structured way.

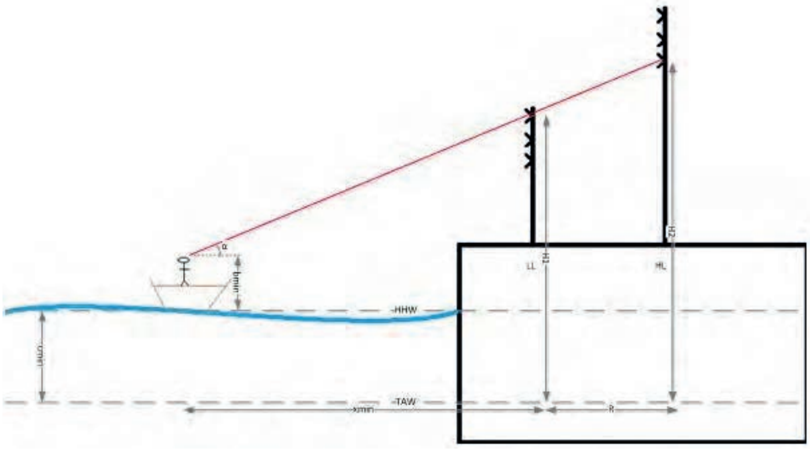

Figure 6: Drawing from study leading lights of Oostende

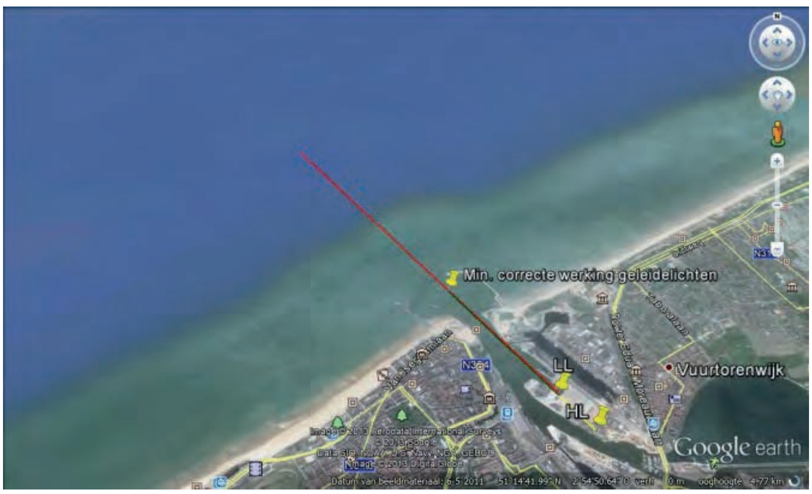

Figure 7: Google Earth drawing of the useful segment leading lights Ostend

51 RISK MANAGEMENT IN WATERWAYS AFFECTED BY HURRICANES

Julio Fidel Sierra Almaguer. Hydrographic and Geodetic Service of the Republic of Cuba

To minimize the destructive effects of hurricanes on Aids to Navigation, the Hydrographic and Geodetic Service of Cuba has changed its approach to risk management. One of the most effective risk management options has been the lighting system deactivation and the removal of other accessories for its preservation and the subsequent activation. This task is executed simultaneously in those waterways likely to be affected and during a short period of time. Once the hurricane has left the area the damage is assessed and the Aids to Navigation reactivated in accordance with the priority required by the risk level of the affected waterways. Throughout the process the maritime community is properly informed in compliance with Regulation 13, Chapter V of SOLAS.[1]

[1] "Contracting Governments undertake to arrange for information relating to aids to navigation to be made available to all concerned...."

Para minimizar los efectos destructores de los huracanes sobre las Ayudas a la Navegación, el Servicio Hidrográfico y Geodésico de Cuba ha modificado su enfoque hacia la gestión de riesgos. Una de las opciones de gestión de riesgos más eficaz ha sido la desactivación del sistema de iluminación y la retirada de otros accesorios para su conservación y posterior activación. Esta tarea se efectúa simultáneamente en aquellas vías navegables que es probable que se vean afectadas, y durante un corto periodo de tiempo. Cuando el huracán ha abandonado la zona se evalúan los daños y se reactivan las Ayudas a la Navegación de acuerdo con la prioridad requerida por el nivel de riesgo de las vías navegables afectadas. Durante el proceso se mantiene adecuadamente informada a la comunidad marítima de conformidad con la Regulación 13, Capítulo V del SOLAS[1].

[1] Los Gobiernos se obligan a disponer de la información relativa a ayudas a la navegación y a disposición de todos los interesados

Pour réduire les effets destructeurs des ouragans sur les aides à la navigation, le Service Hydrographique et de Géodésie de Cuba a modifié son approche de la gestion du risque. L'une des options les plus efficaces de cette gestion du risque été de désactiver et déplacer le système d'éclairage et ses accessoires pour les préserver et pouvoir les réactiver. Cette tâche, est exécutée simultanément, dans une période de temps très courte, dans les voies navigables qui seront probablement affectées. Dès que l'ouragan a quitté la zone, on évalue les dommages et les aides à la navigation sont réactivées, en fonction de la priorité par le niveau de risque de la voie affectée. Pendant ce temps, la communauté maritime en est informée en application de la Règle 13, Chapitre V de la Convention SOLAS[1].

[1] Les gouvernements s'arrangent pour que les informations concernant les aides à la navigation soient diffusées à tous ceux qui sont concernés.

Risk management in waterways affected by hurricanes

Julio Fidel Sierra Almaguer

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IALA·2014·AISM
XVIII Conference · A Coruña · Spain

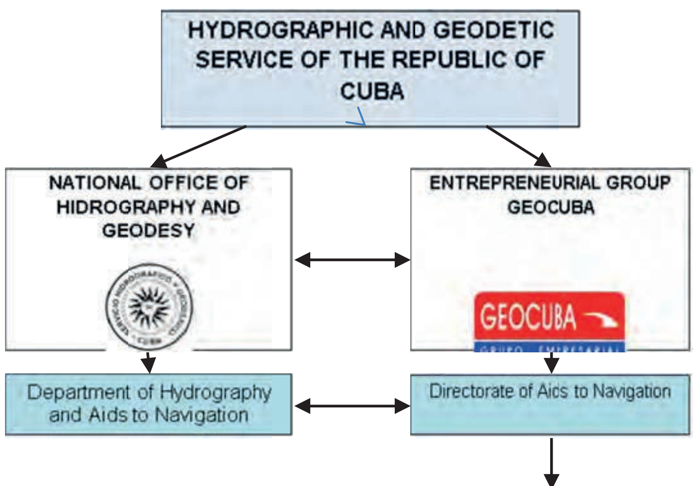
INTRODUCTION

The Republic of Cuba is an archipelago constituted by the largest island of the Antilles, named Cuba, the Isle of Youth (previously called Island of Pines) and other 3126 cays and islets. It has an area of 109 884.01 km² and a population of 11,247,925 inhabitants, bordered to the north by the Strait of Florida and the canals of St. Nicholas and Old Bahamas, to the south the Caribbean Sea and the Strait of Columbus, to the east the Winds Passage and to west the Strait of Yucatán[1]. Due of its geographic location at the entrance of the Gulf of Mexico, since the colonial period Cuba is known as "The Key of the Gulf".

The first Aid to Navigation installed in the country with permanent and official character began service in 1764 on the west side of Los Tres Reyes Magos Del Morro castle in Havana, in order to serve as a reference for the entrance to Havana Bay and it is currently one of the most representative symbols of the city.

THE AIDS TO NAVIGATION SERVICE IN THE REPUBLIC OF CUBA

In the Republic of Cuba the Hydrographic and Geodetic Service, established by Decree Law 179 of October 28th, 1997, is responsible for the Aids to Navigation (AtoN) System, assuming the National Office of Hydrography and Geodetics the responsibilities of state representation, direction and control, and the Entrepreneurial Group GEOCUBA those related to the marketing, maintenance, development and research activities, both organizations subordinated to the Ministry of the Revolutionary Armed Forces, combining efforts to guarantee the safety of the human life at sea, the navigation and the protection of the coastal and marine environment.



Aidás to Navigation	Manned lighthouses	16
	Automated lighthouses	71
	Leading lines/lights	71
	Beacons	452
	Buoys	432
Maintenance stations		15
Vessels	National use	3
	Regional use	6
	Local use	14

Diagram 1

Cuba is an IALA member since 1968, implementing the Recommendations, Guidelines and other technical documents to establish the management and practical operation policies of the AtoN System, systematically evaluating its performance.

HURRICANES

A hurricane (or tropical cyclone) is a low pressure system that appears at the seas and oceans, in a homogeneous environment and generally in the tropics. It is accompanied by a large area of clouds, with rain and thunderstorms, and has associated a superficial circulation of winds in counterclockwise direction in the northern hemisphere, and clockwise direction in the southern hemisphere. It is generally classified by the speed of its winds using the Saffir-Simpson scale:

Category of the hurricane	Wind speed units		
	Km/h	Knots	Miles/h
1	119 - 153	64 – 82	75 – 95
2	154 - 177	83 – 95	96 – 110
3	178 - 208	96 – 112	111 – 129
4	209 - 251	113 - 136	130 - 156
5	252 or more	137 or more	157 or more

Table 1: Saffir-Simpson Scale

According to Padre Las Casas, a Spanish priest defender of the natives who accompanied the colonizers in the sixteenth century, the Caribe Indians called juracán or jurakan (evil spirit - god of evil), to these atmospheric events.

The Republic of Cuba is located in an area particularly sensitive to be affected by the occurrence of these meteorological events, being from June to November the most likely months for their appearance. This period is commonly known as the hurricane season. The repercussions on the country's economy caused by hurricanes are substantial, requiring colossal human and material efforts to restore the damages, therefor the elimination or mitigation of risks and vulnerabilities to these events is a priority of the nation. In the past eleven years the material losses were valued at 25.711 millions, not including those expenses incurred in the mobilization of personnel, equipment damage restoration and disaster assistance to the population (relocation and protection, clothing, food, health services, etc.).

Obviously, the Cuban AtoN Service doesn't escape to this reality. As shown in **Table 2**, 620 Cuban AtoNs have been directly affected in the last eleven years by sixteen hurricanes and tropical storms (for an average of 1.4 events per year), representing the 59.6 % of the installed Aids in the country.

Name of the event	Year	Categ 2	Desacti-vated AtoNs	Affected AtoNs
Michelle	2002	4	0	37
Isidoro	2002	1	0	9
Lily	2002	2	0	13
Charley	2004	3	0	30
Iván	2004	5	0	29
Dennis	2005	4	64	104
Rita	2005	2	18	5
Wilma	2005	3	36	45
Ernesto	2006	TT	38	6
Dean	2007	4	70	0
Noel	2007	TT	84	6
Gustav	2008	4	67	124
Ike	2008	3	26	160
Paloma	2008	4	208	19
Isaac	2012	TT	120	0
Sandy	2014	3	47	33
TOTAL	***16***		***778***	***620***

Table 2: Hydro-meteorological events affecting the Cuban AtoNs in the past 11 years

RISK CONTROL

Before the year 2005 were rare, occasional and ineffective the risk control measures applied for the protection of AtoNs against the effect of meteorological events. After the severe damage to the Cuban Aid to Navigation System caused by hurricanes in previous years and thanks to the general theoretical support provided by IALA Guideline 1018, recently updated on its May 2013 issue, it was prepared and applied the Procedure PE 13-5 "Protection of Navigation Aids against the effect of weather events" that organizes and coordinates the country's efforts to protect the Aids to Navigation in a particular way and ensures the operation of the Cuban waterways from a strategic and cooperated point of view.

Procedure PE 13-3 establishes the content, presentation, frequency, responsibilities and flow of information on the actions to take before, during and after the phases ruled by the National Civil Defense (informative, alert, alarm and recuperative phases) upon the occurrence of hurricanes or tropical storms, to reduce or eliminate damages and to safeguard as much AtoN equipment as possible. It is part of the Civil Defense System of the Republic of Cuba as an element of the actions taken to protect the country from the consequences of such events. It is not the result of the exact application of IALA Guideline 1018 or the qualitative and quantitative tools available for analysis as PAWSA and IWRAP, respectively, but a working paper specially designed for the particular Cuban conditions where hurricanes are assumed as a natural type of hazard involving almost all types of losses in a greater or lesser extent. When analyzing the last eleven years the following results have being obtained:

- number of events in the Caribbean and West Indies: 98
- number of events directly affecting Cuba: 16
- Probability of affecting the Cuban territory: 16.3 % (low).
- Estimated economic impact on the Cuban AtoN System associated with the last 16 hurricanes: 1.5 million (severe).

When applying the probability and estimated economic impact to the Risk Matrix it can be determined that the risk represented by hurricanes for the Cuban Aids to Navigation System is acceptable with caution.

Several risk control measures were assessed, taking into consideration the criteria resulting from the essential process of consultation with members of the National Maritime Community. The most effective control measure has been to remove from the Aids to Navigation as many elements as possible (equipment and attributes, such as solar panels, lanterns, flashers, batteries, top and day marks, lamps) to prevent them from damage, loss or destruction, thus decreasing the severity of the consequences, as it is not possible to reduce the probability of occurrence when hurricanes storms are generated independently of the human will.

This practical step is performed by means of an organized process that includes the following:

Previous organizational actions[3]:

- Identification of the Aids to Navigation essential for navigation.
- Establishment of the routes for deactivation.
- Coordination of territorial cooperation.
- Preparation of the Deactivation and Activation Brigades (DAB).
- Approval and inclusion of the Deactivation and Activation Plan of the Maritime Aids to Navigation in the Plans against Catastrophes and Natural Disaster of the territorial Civil Defense Councils.

Actions prior to the Informative Phase:

- Clarification of the Plan against Catastrophes and Natural Disaster and Deactivation and Activation Plan of the Maritime Aids to Navigation.
- Preparation of Management Centers.
- Staff training to perform tasks for the protection of human life, equipment and facilities.
- Activation of the DAB according to the forecasted trajectory of the meteorological event.
- Initiation of the accomplishment of the Deactivation and Activation Plan (prior to the declaration of the Informative Phase and in correspondence to the forecasted trajectory).

Actions during the Informative Phase[4]:

- Conclusion of the deactivation of the Aids to Navigation.
- Protection of the dismantled equipment in the protected sites.
- Protection of the service vessels in safe locations. Evacuation of the facilities and the manned lighthouses.
- Activation of the DAB to respond to disaster situations and evacuate the equipment and other resources to safety if necessary.

Actions during the Alert Phase[5]:

- Conclusion of the evacuation of the most vulnerable facilities (Aids to Navigation stations and manned lighthouses).

Actions during the Alarm Phase[6]:

- The staff, facilities and resources remain in the protected sites.

Actions during the Recuperative Phase[7]:

- Reactivation of the DAB.
- Assessment of damage in waterways as soon as the navigational conditions permit.
- Detailed information of the damages suffered by AtoNs as it is being received.
- Preparation of equipment and reactivation of the Aids to Navigation prioritizing the most important for navigation.

It is necessary to clarify that this is not the only measure taken by the Hydrographic and Geodetic Service of the Republic of Cuba to minimize the effects of hurricanes on AtoNs. In 2009 it was finished a Research and Development Project that, among other issues, includes in its objectives the particular structural analysis of the existing Aids with the purpose to make them more resistant to these events in the medium term.

BRIEF ANALISIS OF THE HURRICANE SEASON 2008

Only in 2008, when Cuba was hit by three major hurricanes (Gustav, Ike and Paloma), equipment costs, despite the application of these risk control measures, reached the figure of 734.900.00 monetary units, affecting 303 Aids to Navigation (29.1% of total installed). If these measures had not been applied and had not been disabled 300 AtoNs, it is estimated that economic losses would have amounted to 1,465.000.00 monetary units, which is approximately twice, all without including mobilization of specialized vessels, personnel and other related costs. For a developing country to assume these losses and expenses represents a considerable challenge to the national economy.

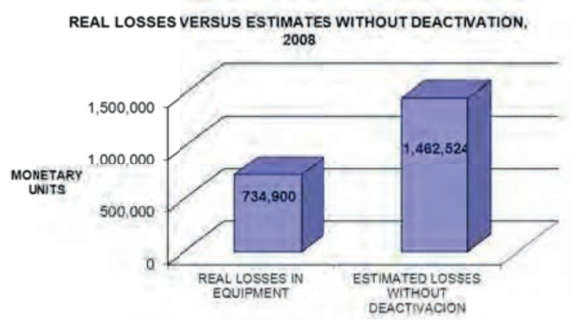


Diagram 2

To give an idea of the high incidence of hurricanes on key parameters of the Cuban Aids to

Navigation System, relative to the passage of three hurricanes in 2008 the Availability results were as follows:

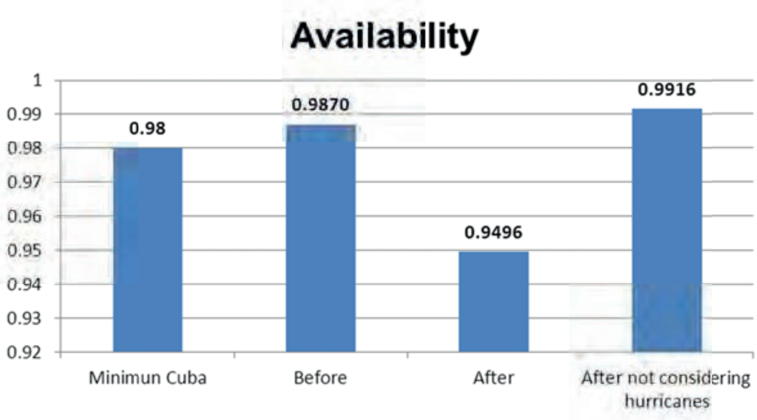


Diagram 3

The application of this risk control measure allowed the following Mean Time To Repair (MTTR) performance, even despite the large number of Aids affected, thanks to the rapid and coordinated response of all entities related in any way to the Aids to Navigation System, as shown in **Graphic 4**.

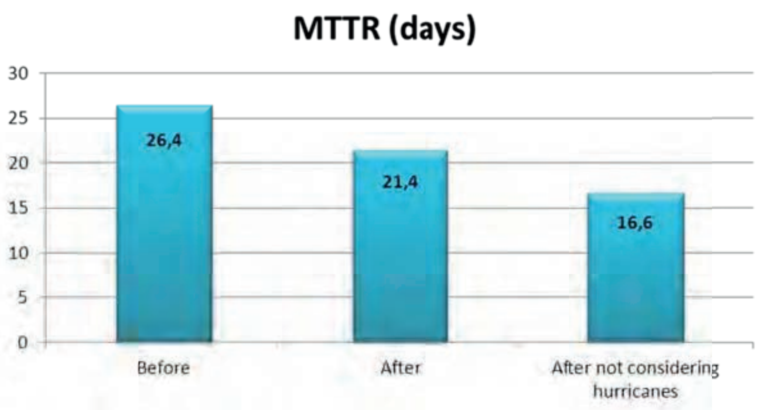


Diagram 4

LESSONS LEARNED

For proper implementation of this risk control measure posed by hurricanes is essential:

- To perform the deactivation simultaneously and rapidly in those waterways likely to be affected because there is a short period before the hurricane's proximity prevent its execution, therefore it is essential the information and analysis of the hydro-meteorological situation by means of the Meteorological Institute and the cooperation of the National Maritime Community members with their vessels and crews, as shown in **Graphic 5**.
- Weather conditions permitting the safe work of specialists and vessels, especially on floating Aids to Navigation and providing the necessary time to guaranty the return of the vessels to their refuges.
- The conclusion of operations at the port or waterway to deactivate, since deactivation without prior coordination would create an even greater risk than the one to be controlled.

Once deactivated the Aids to Navigation System in the area to be affected by the hurricane, its reactivation is also conditioned by the weather, element that may affect the operational capacities

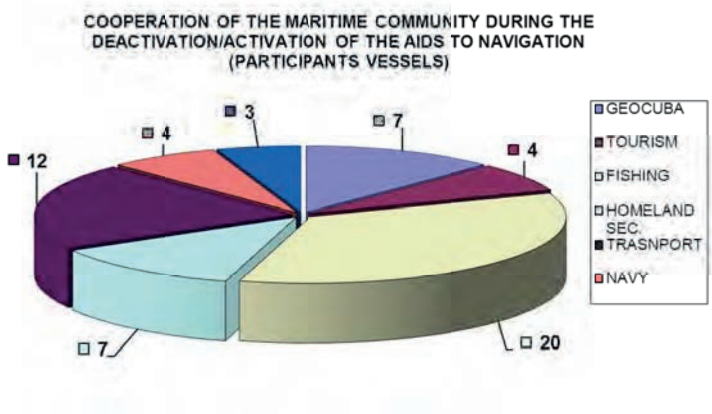


Diagram 5

of the waterways by restraining its use, causing negative effects on general navigation. That is why the DAB remain alert waiting for the stabilization of the navigational conditions and keeping close communication with the members of the Maritime Community about the particular situation of each waterway, publishing on a daily basis the changes generated on AtoNs in Notices to Mariners transmitted by various media in compliance with Regulation 13, Chapter V of SOLAS.

Beyond cold numbers and formulas, it must be also considered that if the deactivation is not performed, the Aids to Navigation System would face problems such as:

- The interruption or restriction of general navigation caused by not having the necessary equipment to restore the waterways, hindering the return to normal the economic and social life of the country when it is not possible the immediate and massive transportation of goods needed by those regions compelled to address the damages suffered, considering that these event also affect land communication routes (roads, bridges, railways).

- For the management of the national Aids to Navigation System it would be a great obstacle the lost equipment manufacture or importation process, which requires not only funding, but time and effort for contracting, manufacturing, transportation, preparation and installation.

Image 1: Pasa de la Manteca Automated Lighthouse, destroyed by hurricane Gustav, 2008

CONCLUSIONS

The application of the Procedure PE 13-5 "Protection of Navigation Aids against the effect of weather events" allows to developing countries with limited resources to keep the risk to the Aids to Navigation Systems related to the occurrence of hurricanes at a level as low as reasonably practicable[8].

References

[1] IALA Guideline 1018 on Risk Management.a. Edition 1, December 2005b. Edition 2, October 2008c. Edition 3, May 2013

[2] Website of the Meteorological Institute of the Republic of Cuba, http://www.met.inf.cu

[3] Procedure 13-5 PE "Protection of Navigation Aids against the effect of weather events", GEOCUBA, 2005.

[4] Website of the National Civil Defense http://www.cubadefensa.cu/?q=sistema-defensa-civil

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[1] National Statistics Bureau, Cuba, 2011

[2] Category of the event according to Saffir-Simpson scale. TT means Tropical Storm. Although Tropical Storms don't reach Category 1, they also affect the national territory in general and the Aids to navigation system in particular.

[3] To be performed before the beginning of the hurricane season.

[4] This phase established by the National General Staff of the Civil Defense (EMN-DC) begins when the Forecast Center of the Meteorological Institute (CP) has informed about the existence of a tropical event and its possible trajectory to any point of the country within a period of time of 72 hours, also considering the characteristics of the cyclonic organism.

[5] This phase begins when the CP has informed that a tropical event is about to affect any point of the country within a period of time of 72 hours.

[6] This phase begins when the CP has informed that is imminent the affectation of a cyclonic organism in the next 24 hours.

[7] This phase begins once the cyclonic organism has stopped to affect the Cuban territory and if it is necessary any restoration or reconstruction works.

[8] ALARP Matrix (As Low As Reasonably Practicable), IALA Guideline 1018 Ed. 3.

56 DEVELOPMENT, MAINTENANCE AND PROVISION OF AtoN SERVICES WHO PAYS FOR THEM?

Álvaro Rodríguez Dapena. Puertos del Estado, Spain

Aids to Navigation (AtoN) are currently financed through a great variety of sources and funds, public and private, all over the world. Economical and legal framework is crucial to determine financial conditions for supporting AtoN in each country. There is a high number of countries in which AtoN facilities and also services (investments and/or expenses), are covered by public sector, and other countries which have private support for specific facilities or services. Moreover, in some countries, economic conditions for developing and/or maintenance AtoN elements are established in coherence with a self-financing scheme, based on specific tariffs or taxes applied to the users (a user-pay system). In other countries we find a very important economic support coming from a public body or administration, linked to the general fiscal system, without a specific charge to be covered by users (non user-pay system). There are also several initiatives to create different kind of trust funds or similar, involving several countries to solve some specific maritime areas or straits sharing special difficulties for navigation. Collaborative schemes between public and private partners are not frequently used at the moment.

Spanish model for financing AtoN is an interesting example due to the fact that it covers all coastline with a specific tax applied for all users (following an user-pay system). Port Authorities are involved in this model, managing the part of coastline predetermined to each one, but also working in a common system. The aim of this work is to compare different systems for financing AtoN elements (facilities and services), not only related to sources (public and private funds; financing entities or providers), but also type of charges (taxes, tariffs...) and the way to apply them, in order to extract lessons coming from the experience and to identify also trends for the future.

Las Ayudas a la Navegación (AtoN) se financian actualmente a través de una gran variedad de fuentes y fondos, públicos y privados, en todo el mundo. El marco económico y legal es fundamental para determinar las condiciones económicas para la financiación de las AtoN en cada país. Hay un gran número de países en los que las instalaciones de AtoN y también los servicios (inversiones y/o gastos) están cubiertos por el sector público, y otros países que tienen financiación privada para instalaciones o servicios específicos. Por otra parte, en algunos países, las condiciones económicas para el desarrollo y/o el mantenimiento de elementos AtoN se han establecido en coherencia con un programa de autofinanciación, basado en tarifas o tasas específicas aplicadas a los usuarios (sistema pagado por el usuario). En otros países encontramos un apoyo económico muy importante procedente de un organismo o administración pública, vinculado al sistema fiscal general, sin que deba ser cubierto por los usuarios un cargo específico (sistema no pagado por el usuario). También existen varias iniciativas para crear diferentes tipos de fondos de fideicomiso o similares, implicando a varios países para resolver algunas áreas marítimas específicas o estrechos que comparten dificultades especiales para la navegación. Por el momento no es frecuente el uso de programas de colaboración entre socios públicos y privados.

El modelo español de financiación de AtoN es un ejemplo interesante debido al hecho de que cubre todo el litoral con un impuesto específico aplicado a todos los usuarios (siguiendo un sistema pagado por el usuario). Las Autoridades Portuarias están implicadas en este modelo, gestionando el tramo de costa adjudicado a cada una y trabajando al mismo tiempo en un sistema común. El objeto de este trabajo es comparar diferentes sistemas de financiación de elementos AtoN (instalaciones y servicios), no solo en relación con las fuentes (fondos públicos y privados; entidades de financiación o proveedores), sino también con el tipo de cargas (impuestos, tarifas...) y el modo de aplicarlas, con el fin de extraer lecciones de la experiencia y también para identificar tendencias para el futuro.

Les aides à la navigation sont actuellement financées de façons très diverses, fonds publics et privés, partout dans le monde. Le cadre économique et légal de chaque pays est crucial pour déterminer les conditions du financement des aides. Dans beaucoup de pays le financement des équipements et des services (investissements et/ou autres coûts) dépend du service public ; dans d'autres pays, certains services particuliers sont financés par des organismes privés. De plus, dans quelques pays, les coûts de développement et/ou d'entretien des aides à la navigation suivent un schéma d'autofinancement basé sur des tarifs ou taxes payées par les utilisateurs. Dans d'autres pays, on trouve un important soutien économique d'une organisation publique ou d'une administration en lien avec le système public général, sans charge spécifique pour l'utilisateur. Il y a aussi de nombreuses initiatives tendant à créer différentes sortes de regroupements impliquant plusieurs pays pour partager des difficultés de navigation liées à des zones spécifiques. Actuellement on ne voit pas beaucoup de cas de collaboration public/privé.

Le modèle espagnol est un exemple intéressant du fait qu'il couvre toutes les côtes avec une taxe spécifique levée sur tous les utilisateurs (selon le système de l'« utilisateur-payeur »). Les autorités portuaires sont impliquées dans ce modèle, chacune gérant la portion de côte qui lui a été attribuée mais travaillant aussi dans un système commun. Le but de ce travail est de comparer divers systèmes de financement des aides à la navigation (équipements et services), non seulement en fonction des différentes sources (public/privé), mais aussi les différentes charges applicables (taxes, tarifs) et la façon dont elles s'appliquent, afin d'en tirer des leçons et d'identifier les tendances futures.

Development, maintenance and provision of AtoN services – Who pays for them?

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1. THE PRESENCE OF THE PUBLIC SECTOR IN ATONS: HISTORICAL OVERVIEW

To start off with, we will raise the following question: are aids to navigation (AtoN) inevitably public? Or turning that same question around, can they solely be in the hands private organisations?

Wherever it is deemed that AtoNs belong to everyone, it can be construed that they are "public". However, if they are transferred to private entities with the power to appropriate them on an indefinite basis, to transfer them according to their will or even to decide on their features, performance and use in keeping with their own interests, it must be construed in many places that AtoNs are "private".

In Justinian Roman law the coastline formed part of those things that had already been catalogued as public things (*res publicae*). Hence, the coastline could not be traded (*res extra commercium*) due to its "natural" essence. Like water and air, it was considered that nobody could appropriate it. The coastline was also included under that other category of things known in the Roman world as communal, which in terms of use also meant that they were available to all (*res comunes omnium*).

From this open and at the same time egalitarian view on the coastline, the free use of the coastline by anybody – be it a person or a people – could therefore be deduced (*usus publicus*). With it, the issue of use came to be a determining factor for the coastline's identification as a public thing, even though Roman law assumed that freedom of use was not total, but rather restricted to anybody who was a Roman citizen. However, it is clear that the mere allusion to this condition also responded to an explicit recognition of the principle of equal rights regarding the enjoyment of natural resources or elements.

Some ancient civil codes regulated an aspect of use that later provoked much debate, regulation and control. These civil codes specifically stated that the public nature of the coastline did not entail for interested parties a right to unlimited use of a portion of the coastline, but rather another more "adjusted" right of use, which was limited to a right that did not impede or disturb the right of any other party from a similar use. In another area of ethics, this condition already set out a differentiation between liberty and profligacy. This implied, among other things, forbidding an individual from appropriating for himself and at his own risk a part of the coastline to reserve for himself the right of admission to it or the private use of it, and to occupy and exploit it exclusively at his own whim. For instance, it was not possible to colonise the coastline without any further ado.

In 13th century Spain, one of the *Partidas* (a section of a law) of Alfonso X, the Wise is very illustrative in this regard. It stated the following: "*the things that communally belong to all creatures that live on this world are these: the air and the rainfall and the sea and its coasts, as any creature that lives may use any of these things according to their needs, and hence all men may take advantage of the sea and of its shores, fishing and sailing and doing there all the things they deem may be to their advantage*" (3rd *Partida*, Title XXVIII, Law 3).

When the coastline was untouched, its classification as a "public good" had some conceptual logic because it possessed a totally natural quality.

However, when man-made elements began to be placed on the coastline, like signals, lighthouses and artificial ports, the question rapidly arose whether such man-made goods, whose scope was sufficient to transform the coast, were really in keeping with the open view originally expounded by Roman law focusing on the natural environment.

Firstly, it should be pointed out that many of the ancient facilities built during the classical world along the coastline, like the ones that served to warn mariners of the presence of dangerous places or help ships reach landfall at ports, could not be built by any kind of initiative that was not made by the public sector.

The Alexandria Lighthouse was commissioned by Ptolemy II and the Roman port of Ostia by the Emperor Claudius in the image of the former, who apparently also devised the Tower of Hercules, although the decision to finally build it is attributed to Trajan. At that time, only authorities in power and equipped with tax-collecting capacity were able to raise the necessary resources to turn the coastal infrastructures and facilities they decided to design from time to time into a reality. The coastline was therefore modified by a power that exercised its *imperium* over it.

It is probable that navigation along the Guadalquivir River to the port of Seville in ancient Al Andalus was properly marked out by the Muslims who lived in the Iberian Peninsula. This surely continued under the reign of the Castilian king Alfonso X after defeating the Muslim king of Niebla, Aben Mehafut, and reaching the river's mouth near the town known today as San Lúcar de

Barrameda. In some ancient texts like the anonymous *portulano*, or port chart, known as the *Compasso di Navigare*, which dates back to the second half of the 13th century, references to several buoys and markings along this river are to be found, which some consider as the oldest for which there is proof. All of them were commissioned by order of the governing authority of the time.

As all these primitive AtoN facilities were of artificial origin, it could be immediately supposed that they had lost their nature of being *res publicae* or *res common omnium*. Someone who held an almost absolute power had commissioned them. He was therefore in a position to claim ownership over them and exercise an exclusive privilege of use. However, there is no clear indication whatsoever that such a thing ever happened either in Roman law or any of its subsequent re-editions, at least for some specific goods. As they were built by public authorities, it is most likely that the quality of being "public" persisted for them concerning ownership and even the adjective "communal" regarding their use, though this latter attribute had to be nuanced later.

Such qualities hypothetically required overcoming the engrained notion of "free use" inherent to the natural condition by means of an explicit statement made by the public power setting forth which man-made goods, like the ones which served as AtoNs, belonged to all, as in the case of streets and theatres in cities. One cannot discard the possibility that any kind of coastal facility was expressly designated as public property through such an administrative action in certain periods of ancient Rome.

Likewise, one cannot discard thinking that the determining factor of a public nature was not so much making available and operating ancient AtoNs, which were logically tasks that had to be restricted to experts, but rather their public utility; that is to say their condition of serving as a universal guide, in this case to all mariners, citizens and foreigners alike without any distinction whatsoever. To sum up, light was conceived as thing belonging to all.

This condition of free access to their use did not, however, free AtoNs from regulation and control, given that precisely such condition had to be safeguarded and, of course, that the proper running of AtoNs had to be ensured to thus guarantee the aim of the service, which consisted, let us not forget, of contributing to safe navigation.

It is precisely in this area of public control where the notion of jurisdiction (*jurisdictio*) lay, as somehow it was necessary to create a space where the management and operation of AtoNs conceived as a public good could be regulated and, in general terms, where the authority could administer the justice connected to them. This necessitated an active presence of some kind of the governing authority at the AtoN facility with a view to at least protecting (*protectio*) fulfilment of the Law. From there, it is in turn possible to derive the notion of dominion (*dominum*), not so much as ownership in the strictest meaning of the word, but as a sphere in which the authority is present to duly exercise regulation and protection.

It was in Medieval and Renaissance Europe that the concept of dominion was most strikingly developed, especially during the long era of large feudal estates, principalities, kingdoms and empires. It was construed from some sectors interested in social ethics that the rise of growing dynastic powers with a thirst for appropriation jeopardised the public nature of certain goods, including AtoNs. The question was how to reconcile the existence of "public or communal things" with the fact that they were increasingly subject to the reigning power's dominion, which decided who, where and when they would be developed and what scope they would have and the type of service they would provide.

The same thing was happening in Asia, where successive dynastic lineages in the different territories also exercised absolute courtly power, despite having to subsequently surrender part of that power to local forces when building, maintaining and operating lighthouses and other facilities aimed at serving as AtoNs. Nonetheless, the ultimate decision seems to have resided in the centralised power and was materialised in some kind of permit or authorisation, which imposed the way the corresponding taxes were to be collected.

From the Tudor dynasty in England to the Tokugawa shogunate in Japan, marine signals – like the ones installed along the English coastline in the 16th century or lighthouses like the one in Cape Omaezaki built in the 17th century on the coast of the Japanese province of Totomi – were being built by order of the governing authority, which had the last word.

During the heyday of the great European monarchies, even the sea itself was at times not considered as free to use as a result of its "natural", "immaterial" or "divine" nature, but rather as of restricted use to what the Crown would decree, shamelessly exercising its absolute dominion over it. A debate thus arose about the free use of the sea (*liberum*) and the limited or closed use of it (*clausum*) imposed by public powers. This debate was kept alive in Europe right up to the Enlightenment at the end of the 17th century. It was then recognised that the sea should remain as a universal reserve geared at free use and free navigation, which today is set forth in the right of innocent passage approved in the United Nations Convention on the Law of the Sea of 1982. This was not the case for coastal facilities, which became the property of the king or a "royal prerogative", as the Spanish jurist, Hevia y Bolaños, stated in the 17th century for example. It was therefore this authority which determined their use.

At the beginning of the Enlightenment, Cardinal de Luca made an effort to clarify the notion of dominion in a legal compendium published in Rome. According to this cardinal, the seas, lakes and navigable rivers were owned by nobody with regards to ownership and were for everybody regarding their use. Up to this point, de Luca did not contradict Roman law. Nevertheless, he added, with regard to dominion, any human actions on the coasts belonged to the "sovereign Prince", which was the reason why he was empowered to tax anyone who made use of them.

This was a significant step, as actions along the coastline, like ports and AtoNs, came to be conceived and also regulated from a terrestrial viewpoint. When the modern notion of a nation later began to be conceptualised well into the Enlightenment, artificial elements built on the coastline were rapidly included in this new way of conceiving societies. The idea of an ever more exacerbated dominion exercised by the Crown over the coastline was left behind and a new conception of a wider dominion emerged, which was to be assigned to the nation-state.

A good example of this is what the Swiss jurist, Emer de Vattel, expounded about the coastline in his extensive work on the right of peoples or the principles of natural law, which was published in 1758. Vattel literally affirmed the following: "the shores of the sea undeniably belong to the nation which owns the country to which they belong and are among the number of public things". With this, the "domain of the nation" was underlined, which was to be one of the seeds for what would later be the "public domain", a notion that was firmly set forth in the different civil codes of southern European countries after the French Revolution.

Without going any further, in Spain, where the monarchy survived with some slight interruptions, the none too arduous task remained of separating the specific domain of the Crown, as the state's highest authority, from that other domain which had recently been coined as public and administered by the "state apparatus", which nobody could appropriate in as much as it was managed by some public authorities which acted to defend the public interest.

The difficulty of differentiating spheres of dominion subject to different titles was served. However, the seed of the "public domain" had already been planted and it would germinate in a new code that would last until today in countries with a Latin influence.

In these countries, the entire coastline rapidly came to form part of the public domain, which was characterised by not belonging to anybody whilst being for open use by the people, where sovereignty resided. It consequently no longer belonged to the king, prince or feudal lord and passed on to be administered by public authorities representing the state. This was therefore a view that was coherent with the mark left on France by the Revolution.

A "controlled" use would prevail for artificial elements. Unlike the coastline's natural elements, the facilities made with a specific aim in mind, like the ones destined to serve as AtoNs, had to be built and operated by technical experts in keeping with another incipient concept, that of public or civil servants, among whose functions prevailed that of at least ensuring these facilities' public utility, so that they could be enjoyed by any mariner. This clearly delineated the public authorities' direct intervention.

In line with this requirement, the incipient state or federal governments of the 18th century progressively took over the administration and development of lighthouses and other marine signalling facilities. A good example of this was the United States, whose federal government ascribed all lighthouses to itself in 1789. These came under the responsibility of the Secretary of the Treasury, while control over them and the responsibility for collecting funds for them fell to a body of superintendants designated for such purpose dependent on the Customs and Excise Service. Another much later example can be seen in Japan during the Meiji era, where the imperial public authorities decided to order the construction of a series of new lighthouses and take over the administration of all coastal signalling facilities.

The transition from the 18th century to the 19th century was characterised by a strong presence of public authorities in the promotion and administration of lighthouses in response to the spectacular growth in sea trade. Public organisations specialising in lighthouses were set up as technology developed. Their aim was to put forward technical design criteria for different lighthouse elements, particularly light sources and optics that projected light over the sea.

In 1810, the General Lighthouse Authorities of the United Kingdom and Ireland (Trinity House, the Northern Lighthouse Board and the Commissioners of Irish Lights) decided to join efforts in order to act in a coordinated fashion. A little later, the lighthouses that remained in private hands joined them. Napoleon created a Lighthouse Commission in 1811, whose purpose was to improve "the lighthouses of all the Empire's coasts". It was comprised of nine members, among them Augustin Fresnel, inventor of the revolutionary catadioptric lens with circular rings that replaced traditional lenses.

After the fall of the Napoleonic Empire, the different European countries set up their own lighthouse commissions. The first Lighthouse Commission in Spain was set up on 22 February 1842 and played an important role in the first "General Maritime Lighting Plan for the Coasts and Ports of Spain and its Adjacent Islands" approved in 1847, which contemplated designing no less than 126 lighthouses. This Commission remains active to this day.

For its part, the US Federal Government had already created a similar body in 1837 called the Lighthouse Board, which also had nine members from a variety of positions and backgrounds.

The echoes of technological development in the West were felt in Asia and many Asian countries also promoted centralised bodies in charge of maritime and coastal signalling. As a result of the efforts made by the English civil servant Sir Robert Hal, who was appointed as a customs inspector in China, a Maritime Customs Department was established in China in 1868 to hold responsibility for the incipient national AtoN system.

Thus, the public sector's presence in AtoNs became almost unquestionable in all countries during the 19th century. The public sector was therefore provided with the relevant legal support, especially in countries on the shores of the Mediterranean.

It should be remembered that the Napoleonic civil code approved in 1804 explicitly assigned to the "shores, inlets and bays of the sea" as well as to "ports, coves and roadsteads" and any other facilities not susceptible of private ownership the condition of being goods in the public domain (Article 538). This condition was then extended to the first civil codes of its surrounding countries, such as the Italian civil code of 1865 (Article 427), the Portuguese civil code of 1867 (Article 380[2]) or the Spanish civil code, whose enactment was delayed until 1888-1889 (Article 339[1]), probably because of the difficulty of making the local rights (*derechos forales*) of some territories compatible with it.

More specifically, any goods "destined for public use, such a roads, canals, rivers, torrents, ports and bridges built by the State, riverbanks, beaches, roadsteads and other similar goods" were set forth as "goods in the public domain" in this first Spanish civil code.

In Latin countries, any facilities located on the coastline, such as lighthouses or beacons, were henceforth included under the new notion of "public domain", which was generally materialised through a process of encumbrance. Goods in the public domain are different from the rest of state-owned goods, in as much as they cannot be transferred or sold, if it is not by means of a prior process of disencumbrance. This process tends to be constrained by a series of reservations, among which is the obligation of demonstrating that the goods being disencumbered have lost the condition of being a public utility or in the general interest.

In countries which have not incorporated the notion of public domain into their legal systems, facilities aimed at serving as AtoNs were simply catalogued as goods for public or communal use either directly or because they were allocated to provide a service deemed as a public service.

In this respect, it should be indicated that the idea of public service, whether or not it is linked to a public domain, allows one to better understand the public essence of AtoNs, as it is the use made of them by mariners that may be considered as open and universal. Such use is what therefore provides them with their public nature and not the direct handling of the goods that comprise them, which from a public perspective has to be done by public or private experts. The latter are subject to an exclusive-use regime subject to the appropriate approval, authorisation or licence.

The intended "public use" of the facilities that comprise AtoNs, construed as directly operating or handling them, is not any kind of use, but rather a use that technically serves the specific intrinsic aims connected to their *raison d'être*. AtoNs are facilities located on the coastline and intended to ensure the safety of maritime shipping. In so far as such intention is deemed to be a public utility or in the public interest, it is therefore coherent to consider that the public sector is legitimated to lay down the relevant controls, especially to give them a specific use and safeguard that this is the case.

The aspect that makes the public sector especially present in certain public domains, such as AtoNs, is that it is construed that the purposes such AtoNs are entrusted with are of public utility or in the general interest rather than in response to discretional individual or private interests. The latter can be accommodated to the extent by which they respect public objectives as being prevalent. Taking on the condition of being a public utility or in the general interest will ultimately determine whether or not the public sector is the owner of or responsible for the goods which comprise AtoNs.

Whatever may be the case, AtoNs construed as public goods encumbered or not to a public domain ended up in many states forming part of their respective public resources.

Now then, it was not always clear how to administer such public resources. In many countries, a controversy arose between the civil and military jurisdictions when setting out the task of promoting and operating AtoNs. For centuries, towers and ports equipped with bastions or which served as arsenals or for the purposes of military defence were ascribed to the military, while those destined to sea trade were assigned to bodies of civil servants. A large stretch of the coastline was left over and in principle seen as nobody's land, where the civil and military jurisdictions vied for the right to signal it. Even today in countries like Portugal, the administration of lighthouses remains in the hands of the navy, although in many others the competent authority is a civil agency.

The conflict between the military and civil jurisdictions was not only limited to the already known coastline, but was extended to newly chartered coasts after new shipping routes were opened up and consolidated. Many lighthouses located in remote places were built in the 19th century at the initiative of military authorities, especially navies. A good example of this is the San Juan de Salvamento Lighthouse, the first ever built in the southern waters of Argentina at the orders of commodore Augusto Lasserre (1884).

It is clear that over the last few centuries many lighthouses and other marine signalling elements formed part of the public sector, the best example of which was their relatively recent incorporation into the state's resources as goods in the public domain.

In Spain, it was not until democracy was re-established in the last 25 years of the 20th century that specific legislation on AtoNs was enacted. For a start, Article 149.1(20) of the Spanish Constitution of 1978 sets forth that the state holds exclusive competence over "coastal lights and maritime signals". Furthermore, Article 132.2 of the Constitution sets forth that the legal framework for goods in the public domain shall be governed by Law, stating that they shall be "inalienable, non-forfeitable and unattachable".

By virtue thereof, both the Coastline Act of 1988 and the Act on Ports of the State and the Merchant Marine of 1992 encumbered coastal and port land as well as the goods located therein to a specific type of public domain, which meant that such goods came to be considered in accordance with the constitutional principles.

For such purpose, the notions known as the "marine-terrestrial public domain" and, as part of it, the "port public domain" were set forth and regulated.

The incorporation of the Spanish coastline into the notion of the public domain strengthened the condition that the coastline could not by definition be private property. This was in keeping with the original idea of the public domain set forth in the famous Decree-Law of 1790 enacted in revolutionary France, which pioneered and inspired subsequent civil codes, and stated that goods in the public domain were distinguished by the fact that they "were not susceptible of being under private ownership".

In Spain, the land, works and facilities of AtoNs came to form part of the port public domain and administered by the port authorities in 1992. The main use recognised for these goods is marine signalling. The possibility of other complementary uses is allowed, however, provided these do not affect the main use and are of public utility or in the general interest. This main use is directly linked to the recognition that the provision of a public service is carried out through them (Paz, 2008), in this case called marine signalling, the purpose of which is "*the installation, maintenance, control and* *inspection of active or passive visual, acoustic, electronic or radio devices aimed at enhancing the safety of shipping and the movements of vessels along the Spanish coast and, as appropriate, to confirm the position of navigating vessels*".

Summarising the issues dealt with up to this point, it is possible to conclude that, in the countries which have incorporated into their respective civil codes the legal concept of public domain and which have furthermore encumbered their AtoNs to this notion, it is clear that the goods and rights that make up these AtoNs are mainly linked to the public sector. This does not mean that the public sector is literally the owner of the same. What should be construed by this is that they form part of the public resources and consequently that sector has been ascribed with them or is the holder of them, though solely for the purposes of ensuring fulfilment of the Law with regard to the public domain's qualities.

However, not by all means is this public presence in AtoNs so notorious in all countries and not even is the fact of being included in the public domain synonymous of an unequivocal involvement of the public sector in matters connected with them. The legal doctrine based on the recognition of the public domain for AtoNs involves a very specific way of regulating them, which is possibly a legacy from the classical world transfigured with a new name by the Napoleonic civil code and subsequently adopted by a number of countries of mainly Latin origin or influence.

In countries where a private or mercantile-oriented culture has prevailed, the notion of a public good is more restricted and tends to be associated to anything which the market in itself cannot provide or which it provides in a limited way. This is a more economically based approach to the concept.

As a matter of fact, renowned economists like Paul Samuelson (1954) have explicitly referred to AtoNs as examples of a public good or, more specifically, of a public service. According to Samuelson, AtoNs meet two of the most significant conditions of a public good or service as seen from their consumption or use side:

- They are non-exclusive (non-exclusion); in other words, when the service is provided, it is provided for all without distinction so that anyone who does not pay for the service cannot be prevented from using it.
- Their consumption is not subject to competition (non-rivalry in consumption), given that the fact of a mariner making use of the AtoNs does not reduce the good's quantity and therefore does not diminish the ability of other mariners from likewise benefitting from the service.

In some economists' view, these two features make the intention of having the market meet the demand for AtoNs vain because users will tend not to pay for the service (that is to say they will become free riders) and hence supply will become insufficient or simply disappear altogether. The public sector will therefore be obliged to take over the service and be justified in covering its costs through general taxation or by charging a levy or tax on the real or potential population benefitting from the service.

This conclusion is today nuanced by other economists who point out that there are numerous goods or services provided by the market that include "positive externalities" not paid for by their consumers or users, and this does not necessarily confer upon them the quality of being a public good. When the public sector is involved in providing a good funded by general taxation as a result of the features of a public good mentioned above, a distancing from the market's optimal state can come about, which can be mitigated if the charging mechanism is done through a specific toll or levy that is as close as possible to the target market directly connected with, in this case, AtoNs.

Lastly, a line of reasoning stands out which is frequently used to support the public nature of AtoNs, which is based on what would happen if these aids did not exist of if they suddenly ceased to exist.

Two types of complementary interpretations in this respect can be developed:

- AtoNs are necessary for navigational safety. If they did not exist, the number of collisions by vessels against the coastline's features and obstacles would increase and, as is well known, these are in themselves one of the most significant causes of marine accidents.
- AtoNs – and more specifically lighthouses – are perceived by society as goods of high historical and cultural value and so, if they did not exist, the result would be viewed as a considerable loss of architectural, archaeological and industrial heritage.

Both interpretations are the bases of the arguments that are usually used to justify a common way of funding AtoNs today, which consists of two kinds of funding sources:

- Public funds, usually provided through general taxation, to cover the operating costs needed to provide the AtoN service which is directly related to the safety of maritime shipping,

- Additional resources provided by public or private third-party stakeholders that are useful to maintain the facilities used to support AtoNs, essentially lighthouses. These resources can be collected by charging for complementary uses, taking advantage of the historical and cultural value of said facilities.

In this funding scheme, which is common in many countries around the world, private initiative comes about as a complementary part of the main AtoN service, which remains in public hands. Now then, has this been the predominant model over the centuries?

2. THE PRESENCE OF THE PRIVATE SECTOR IN ATONS: HISTORICAL OVERVIEW

The historical evidence known to date reveals the existence of many lighthouses and AtoN facilities that came about as a result of private initiatives. In principle, they are therefore private in keeping with the above.

It must nevertheless be said that the further we go back in history, the more difficult it is to distinguish between the public and private realms.

Throughout the centuries, there is a never-ending list of civil, military and even religious authorities that have taken over many kinds of coastal facilities (ports, lighthouses, etc.) and in the interior of territories in order to submit them to interests that were in reality more specific than general because these interests preferentially corresponded to the defence, expansion or perpetuation of some kind of hegemonic power in a certain territory. Since time immemorial, the coastline has always been seen as a place of defence or as a beachhead for authorities. Coasts have therefore always been catalogued by those in power as strategic because they contributed to their *imperium*, the two-fold notion that encompassed both power and sovereignty.

This led to the first conceptual dispute between the public and private realms dating back to antiquity. Governing powers have, for centuries, been characterised for converting anything that could in principle be public into a good or right owned by them or ascribed to their own specific domains, and therefore into something private. From this point of view, the core of the question about whether AtoNs are public or private will then depend on the reading we make of the regime in power behind them, on whether it is an imposed or representative power.

If we go back to feudal, monarchical or imperial societies dominated by an incontestable power attributed with recurrence to divine designs, very present in the past in all parts of the world, we can see in any available chronicle that the government of the entire territory, along with its coastline, does not seem to serve any other purpose other than consolidating certain dynastic rights, which were mainly indifferent to the interests of the population. This kind of biased endogamous administration immediately turned all goods into hostages of a few unfailingly private interests. In other words, AtoNs became the private property of the feudal lord or king. He was the one who set the rules and directly granted privileges or rights of use over them.

There is a generalised feeling in many societies that we are before a process of appropriation or "privatisation" of goods – including lighthouses, beacons and coastal facilities – subjected to the power of public authorities when these act without taking citizens into account, no matter how they may twist the reasons for it. The claim made by some administrations that they operate public AtoNs only makes sense if they are dedicated to exercising an authority open to dialogue, which is construed as having been delegated by all citizens whom they represent, without making any kind of distinction, instead of projecting themselves as a self-imposed, self-sufficient power.

In reality, only in democratic societies endowed with public sectors conceived as a legitimate expression of "private power" can a public conception of AtoNs fit in, and even their dilution into the private sphere. Where public authorities are not construed as an origin or an end in themselves, but rather as a means of serving society (and thus comprised of "public servants"), AtoNs will be viewed as things belonging to each and every individual. They will therefore be public and, in a certain sense, also private at the same time.

Despite having a certain formal coherence, this utopian line of reasoning is, however, based on some complex subtleties having nothing to do with reality.

What is indeed undeniable over the last few centuries is that the view of AtoNs as private goods is associated with the fact that they are at the service of a particular interest no longer attributable to a feudal lord or a dynastic family acting without regard for the population's interests. This view arises instead from the adoption of a liberal (or free-market) perspective.

Whatever the circumstances surrounding AtoNs may be, what truly allows a single concept of the private sphere to materialise in the world today is the condition of belonging, in the broad sense of the word, to an individual. Put in another way, AtoNs will be private when the public sector's presence in them is scarce or totally lacking, this presence being limited as much as possible to ensuring fulfilment of legal principles of a very general scope.

In highly advanced societies where a defence of the private sphere has taken root, this option of fully handing over marine signalling to specific interests would not seem out of place, if it were not for their consideration as a public good closely tied to the notion of safety.

Now then, does this type of private conception on AtoNs only correspond to the contemporary era?

The truth is that it does not seem to be the case.

In medieval China, lighthouses were built to guide shipping and at the entries of age-old ports like Quanzhou, Guangzhou and Xiamen in response to the growth of maritime shipping in Asia, especially at the height of the Southern Song dynasty in the 12th and 13th centuries. It could be supposed that the decision on the construction of these lighthouses was taken by the dynasty's mandarins, but it is not so clear they had a direct influence on the building and operation of the lighthouses, as a large complex civil service structure tending towards decentralisation took form in that era. Some experts therefore affirm that coastal facilities were built and financed by local forces with a solid private presence, which only required a permit from the central authorities.

Something similar could have happened in Europe, despite the obscurity of the Middle Ages. Due to the royal authority's lack of financial capacity to take on new port and lighthouse building activities, the chronicles reveal a variety of reactions of both local fiefs and the civil forces in the coastal towns and cities to tackle the construction of these facilities and also, more importantly, to operate them.

It is no trivial matter that all these initiatives had to count on the Court's approval, but this did not restrict possible private initiatives in this sphere.

In 16th century England, both Henry VIII and Queen Elizabeth I issued decrees to grant the Trinity House Corporation all matters connected with the aims and costs needed to design, build and place into operation coastal signalling facilities in order to ensure the safety of maritime shipping along a significant stretch of coastline. The monarch was thus recognised to hold decision-making powers over AtoNs.

Nevertheless, their management and development was ceded to a group of "people of the sea". Despite requiring the Crown's authorisation or of the bodies it had delegated to, many lighthouses could still be built by individuals in post-Renaissance England. This is what the British economist Ronald Coase (1974) affirmed, who found that most English lighthouses had been built by private individuals right up to the 19th century.

The greater or lower private presence in making lighthouses available had to do with the technology that was available at any particular time. There were historical periods in which private initiative was responsible for technological innovation. Once an advanced lighting system had been devised, however, it was the public authorities who exercised their influence for centuries through an exclusive position to grant patents and rights over property and use.

There are numerous examples of lighthouses built over the 17th and 18th centuries which were devised in this context of an ever-present central power by private initiatives and funded by resources financed by individuals that were either recovered or not depending on the possibility of applying levies on vessels. At times, these were in response to an interest in setting up a business, but on many other occasions it was at the initiative of mariners who aimed to avoid marine accidents.

The Casquets Lighthouse on the island of Guernsey in the English Channel between England and France is often cited as the oldest example of this. The initiative arose from ship-owners, who had had enough of suffering collisions against the rocks off the island of Alderney. They requested Thomas Le Cocq, the rocks' owner, to build a lighthouse which the mariners themselves would fund (IALA, 1998).

The possible reasons for private initiatives are many, all of which are to a greater or lesser extent due to a confluence of a need that arises on the demand side and a business opportunity detected on the supply side. Theoretically, however, they can be grouped together into three types:

- *Reaction from the demand side*: it is the ship-owners who associate themselves to contribute funds to help finance lighthouse projects and thus ensure the safety of their own ships. Should such lighthouses end up being operated by the ship-owners themselves, we are before a case of self-provision of the AtoN service.
- *Reaction from the supply side*: individual investors also arise as developers of lighthouse projects aiming to provide a commercially-oriented AtoN service based on in-house technology that is to be covered by the tolls paid by mariners who would benefit from the lighthouse.
- *Reaction from the social milieu*: at times, the above-mentioned individuals get together in more or less robust mercantile associations or organisations linked to port cities, which provided the funding.

The lighthouse development schemes which arose from port cities are particularly interesting, as private and public initiatives were intermingled in them.

As was indicated in the preceding section, the civil authorities of coastal city-states in central Europe were in charge of building lighthouses and signals on their own stretches of coastline and navigation channels for centuries. They operated under a permit, authorisation or privilege granted by a count, prince or king, who ended up almost completely yielding the infrastructures and facilities' maintenance and management, and only kept the tax receipts of the corresponding tax.

Few harboured any doubts about the power of the highest ranking authority, but it was also clear that the construction of infrastructures and the control over AtoN operations were in the hands of the surrounding population's local authorities, which led that population to believing that these were their own. It is easy find examples in the 14th and 15th centuries of ports and AtoN facilities whose physical and functional elements were subject to the control of port cities, such as Calais, Dunkirk, Bruges, Antwerp, Ghent, Hamburg, Gdansk, Lübeck, etc.

This does not mean to say that these cities acted alone. It is true that they at times competed among themselves for commercial reasons, but it is no less true that they also established alliances. A good example of this was the Hanseatic League, set up in the 13th century by port cities. Its hub was in Lübeck, which was recognized as an "imperial city". Subsequently, Bruges, London, Bergen, Hamburg, Bremen, Danzig, Visby and Riga joined, to mention just some of the most significant.

The aim was to promote trade on the basis of safe navigation in shared strategic waters. In order to achieve this, agreement needed to be reached on the way lighthouses and other signals had to be located and operated. For such purpose, its governing body, known as the Diet (*Hansetag*), reached agreement by consensus on general location and design criteria. Nevertheless, each city then held responsibility for the development and operation of its own ports and navigation channels, along with the AtoNs that surrounded them. The civil authorities of the port cities not only collected taxes for, funded and executed the necessary works, they also regulated or were directly in charge of providing the corresponding services.

There is a certain similarity between decentralisation and corporatisation with a hint of the private sphere. At times, when the local element prevails, it is rooted in the territory where public and private forces intermingle, which then act together to defend the territory. This happened at the time of the European city-states. As a matter of fact, there are many examples of privately-built lighthouses in the 17th and 18th centuries constructed under a permit issued by the reigning power and promoted with funding through taxes throughout the European coastline. Perhaps one of the most emblematic is the Genoa Lighthouse (known as the *Laterna*), one of the oldest in Europe. In 1413, the Consulate of the Sea of this Italian city, made up of the bourgeoisie involved in shipping and sea trade, set up a special fund to ensure the proper operation of an emblematic lighthouse.

Whatever the cause for private development may have been in the past, the truth is that private initiatives were to a certain extent subordinated to the each territory's established power at any one moment. Coase's thesis, which tends to highlight the private sphere's preponderance in lighthouses, was subsequently nuanced by other authors like David Van Zandt (1993). The objections were supported by documentary evidence which showed that private stakeholders that developed such facilities could not do without public support due to several reasons.

Firstly, this is because such private developers required a permit or authorisation granted by the governing authorities, even if it was to obtain a patent for new technological products. This revealed the existence of a certain underlying public nature in the performance of the activity on which the viability of the private business depended. Moreover, it was because they required public aid, at least for fund raising activities. This corroborates the fact that in reality the funding and development schemes of the investments allocated to providing an AtoN service were similar to a kind of public-private partnership.

Consequently, the intended private AtoN business did not escape "official" consideration of their elements as public goods, which could be limited to the activity itself or affect the physical elements needed to perform it, including the land and the goods made available by the private stakeholder. This consideration in turn leads to the current debate about the possible coexistence of public and private elements with regard to AtoNs, which is of unquestionable interest for the purposes which interest us here.

As is commonly known, experience has shown that the fact that AtoNs have a public nature does not necessarily mean that their development and operation cannot be in private hands, even in countries with a "Roman" influence. This possibility, however, has been subject to wide-ranging debate from time immemorial.

As an example of this debate, we should recall the words of the renowned Juan de Hevia y Bolaños expressed in his *Curia philipica*, which recognise a conflict between the free use of a port and its private appropriation. In such work the author specifically states that "*the use of a sea port: as the sea is communal for all people of the world, apart from the first occupier, without another being able to attach it whilst he occupies it, as set forth in civil and royal law. Hence, as Baldo says, if the sea port were to be built by the wit of man, the building belongs to he who built it according to a text, but the port belongs to all, as the water is communal according to another text*" (Jordá, 2008).

The problem detected by Hevia y Bolaños and other jurists of his time takes on real meaning when private stakeholders are in charge of placing AtoNs into operation and additionally need to make a significant investment with the commitments and expectations with regard to risks and profitability they entail. Apart from the difficulties attributable to the private business itself, the debate arises about whether ownership of the goods resulting from such investment should be public or private.

Today we know that classifying an AtoN as a public good or even encumbering it to a public domain does not prevent it from receiving investments from a private stakeholder that will later be in charge of providing a service. On the contrary, there is no contradiction between the public nature of the AtoN and its assignment to a private stakeholder to make "private use" of it, at least during the time period needed to make the investment viable, provided such stakeholder fulfils a series of conditions which are compatible with the general interest. At the end of that time period, it is possible to require the reversion, or return to the competent public authority, of the fixed infrastructures and facilities built by the private stakeholder. However, there may also be cases where the private stakeholder may retain ownership over them and may take them away, especially in the case of facilities which can be disassembled.

All of this gives rise to an extensive interconnection of links between the public and private sectors that is usually resolved in the field of administrative and economic-financial law through an authorisation or concession model, which will be dealt with below.

For the moment, what is of interest to highlight here is that there will be elements which will be private in some way, at least during a period of time, when private stakeholders are given access to the area of AtoNs to make investments and earn profits from them based on the provision of a series of remunerated services.

In the case of ports, concession periods can be very long. In Europe, for instance, average concession periods granted for the handling of merchandise at port terminals range from 20 to 40 years according to the European Sea Ports Organisation (ESPO). In other countries, concessions cover the entire port, including all its signalling, and can last even longer. As a matter of fact, it is well known that most of the world's ports are publicly owned, regardless of whether or not they are based on the notion of public domain. Nevertheless, most of the investments made in them are mainly private, as is their operation.

When this happens, the questions raised at the start about the public or private ownership of an AtoN facility arise once more. Those facilities which are state resources or encumbered to a public domain in accordance with the legal system will mainly be under public ownership in the wide sense and from a theoretical perspective. However, when the main presence at a facility for an extended period of time is of stakeholders acting in keeping with private interests, we can say that they have *de facto* fallen into private hands.

To sum up, today it is perfectly possible to clearly differentiate between public AtoNs – construed as those belonging to everyone – and private AtoNs – construed as those which are in private hands – despite the conceptual complexities. This is an issue that dates back to antiquity and remains alive to this day. However, we view it today in a different light from our ancestors, starting off with the classical world, where old debates about this issue had already arisen.

3. MANAGEMENT AND FUNDING MODELS APPLIED TO ATONS

AtoN planning, development, administration and control tasks are almost entirely and exclusively attributed to the public sector in most countries of the world. This is also the case when it comes to maintaining, operating and providing AtoN services despite the fact that these latter tasks can be outsourced, as happens in many other sectors of activity.

Without going further afield, in other coastal facilities like ports it is well known that the involvement of the public and private sectors has in recent years tended towards a transformation from public service or "tool port" models – similar to the ones which predominate for AtoNs – to others classified as "landlord" models and even towards outright privatisation in some cases.

According to the first two models mentioned above, the public sector is in charge of developing and managing all elements of the supply side, ranging from the land and the services, infrastructures and facilities. This involves earmarking public resources for all the necessary investments and costs in human and material resources. For its part, in the landlord model the public sector reserves for itself the aspects which are most closely connected with public utility or the general interest – that is to say, the aforementioned tasks of planning, development, administration and control –, while a large part of the activity connected with service provision is transferred to private hands.

It is clear that the current transition between models is nothing more than a privatisation process, by means of which the competent public agency provides and land and also invests in anything that would be difficult for private initiatives to assume – essentially what is known as "basic infrastructure" in Europe. There will therefore be private operators in the port space which are specialised in their respective fields (pilotage, towage, mooring, handling merchandise, etc.) in order to provide the corresponding services and thus run their own businesses. These operators can take over goods assigned by the public sector (leasehold) or keep them (freehold).

Although there are myriad administrative modalities that formalise the relationship between the public and the private sectors, it is possible put forward a non-exhaustive classification from an administrative standpoint:

- Service contracts and subcontracts, by means of which the public sector retains ownership of and responsibility for the services and then provides them under an indirect management scheme through a company that it contracts or subcontracts. This occurs when the public sector lacks resources with the necessary degree of specialisation. These tend to be for a short time period. The public sector deals directly with customers and compensates the private sector for the costs incurred with an amount usually set forth in the contract.
- Management contracts, by means of which the public sector also retains ownership but transfers responsibility to the company which provides the AtoN services. In these cases, the company does not take on any business risk since it is the public sector which deals with customers and applies the relevant fees. Furthermore, the company is compensated through a payment that can be fixed or variable depending on the costs incurred and/or the service provision’s efficiency/efficacy.
- Licenses and authorisations, through which the public sector grants to companies the right to provide services whose nature is private and these take on the risks and venture, or with certain guarantees. In this case, the companies deal with customers and apply the necessary fees to make their business viable. Any compensation they may receive from the public sector is usually only related to the obligation of providing certain services deemed to be in the general interest.
- Rentals or leases, through which the public sector assigns the private sector the right to use public assets, usually facilities or superstructures, so that the company can provide the services entrusted to it and charge for them by applying a fee. The term of the lease tends to be relatively short. The company must pay the public sector some duties, levies or public fees for leasing the assets.

- Concessions, which are used to allow companies to occupy land and infrastructures and make the necessary investments in order to provide the services they are in charge of. The term for this kind of contract tends to be medium/long and justified by the size and types of investment made by the concessionaire, among other factors. As in the previous case, the company deals directly with customers and applies the corresponding fee to them. The company must pay the public sector some duties, levies or public fees for leasing the assets.
- Sale. The public sector sells the elements of an AtoN facility to a private operator, either gradually or not.

Where the landlord model applies and private investment reaches a certain amount, the administrative relationship governing the rights and obligations of each party tends to be laid down in an administrative concession. As is known, the public sector's competent body grants to a private operator through the concession the exclusive use of public assets – for instance, one or several AtoN facilities – at some specific terms and conditions during a period of time, so that the operator in its capacity as a concessionaire can build the infrastructures under its responsibility, install the equipment and recruit the human resources needed to provide the relevant services.

A shared interest in providing an AtoN service with the widest possible scope is materialised through the concession relationship. Such interest will supposedly be incorporated into each stakeholder's (public and private) respective planning instruments, which in principle will be subject to a coordinated strategy and aims. More specifically, the stakeholders will coincide in making an effort to ensure that the AtoNs give efficient and effective support to all mariners, so that they become a safety element that provides the greatest possible utility to its users.

Nevertheless, this interest shared by the private and public stakeholders ties in with a series of viewpoints that may differ. It is therefore convenient to clearly set forth the terms and conditions that will appear in the concession contract or title the parties will sign.

The public sector is in charge of safeguarding the common good or the general interest. Thus, it not only represents the interests of the private parties that compete to provide AtoN services with a legitimate interest to maximise their profits and profitability, but above all it has to reflect the needs and feelings of at least part of the population that may be directly affected.

In this regard, it is common for the public sector to include AtoNs under the framework of industry-specific policies of a wider scope in addition referring to principles such as equality or sustainability, which are not necessarily compatible with the private initiative's interests.

The general guidelines governing the public sector are frequently transferred to AtoNs through some kind of body, agency, corporation or state-owned company, which acts as an authority on the matter, two kinds of which stand out:

- A maritime or coastal authority, which is normally in charge of the safety of maritime shipping.
- A port, customs or border authority, whose role also tends to be of utmost importance in many countries for both the facilities' management and as a collection instrument.

For its part, the private sector will provide AtoN services with the well-known aim of boosting its profits. As has been mentioned before, it is to be expected that it will also take charge of more basic tasks, like maintaining and operating the elements that comprise those aids.

As in the case of the public sector, it is possible to find different kinds of private stakeholders interested in activities connected with AtoNs. Thus, certain complementary services, such as the ones which serve to boost the value of lighthouses for society, can be provided by several companies specialising in the area. It is also possible to think that other private companies will be in charge of supplying technical materials and supplies. Lastly, it is usual to outsource financial and legal management and risk insurance, among other matters. All of these give rise to a more or less extensive group of private stakeholders acting around AtoNs.

In spite of this, it is of interest to highlight a visible leader or head, in the form of an AtoN operating company, to achieve greater clarity. This operator will be bound to the public, maritime, port or customs authority by some kind of administrative relationship, like the aforementioned concession, which lays down the terms and conditions under which the main AtoN service will be provided. In that case, the AtoN operator is clearly identified as the private sector party responsible for operating the facilities.

In order to clarify the analysis, we can sum up by stating that there are two main clearly differentiated figures in any offer to open up AtoNs to private participation to a greater or lesser extent:

- The maritime, port or other kind of public authority
- The AtoN operator

There are very different ways in which the public authority and the AtoN operator can organise themselves to ensure the services mariners demand are suitably provided.

It is entirely feasible to maintain an eminently public authority and attribute operational matters to the private sector, either because this would increase efficiency or also to overcome a possible lack of public resources. This possibility does not necessarily involve a progressive replacement of the public sector by the private sector, but rather positive collaboration. A certain degree of privatisation is not incompatible with a robust public presence, which is firstly materialised in the setting of rules (a regulatory framework) and in its control and supervision in order to guarantee the general interest, especially if the coastline is catalogued as public.

The experience of Oman can be mentioned as an example.

In 2003, the government of the Sultanate of Oman granted the exclusive right to provide the AtoN service in the country to a private company called AMNAS (Arabian Maritime and Navigation Aids Service) under a concession scheme for an extended period. Since then, AMNAS plans, maintains and operates a broad range of facilities (lighthouses, beacons, buoys, AIS and global positioning services, among others) along a coastline measuring approximately 3,600 km. In order to do so, it was granted the right to apply certain tolls on ships navigating through the Sultanate of Oman's jurisdictional waters, which were initially set by the government and whose review it reserves the right to approve.

In view of the fact that privatisation processes may be extended across the globe, three kinds of AtoN funding schemes are set out below which somehow predetermine who will be the main AtoN developer:

- Public funding mainly charged to some kind of general or specific charge or tax in the country, which may or may not be set up as an ad hoc fund that may or may not be attributed to the public authority in charge of AtoNs.
- Mixed funding arising from the joint participation of the public and private sectors in the development and operation of AtoNs. Private initiative will contribute its capital and the public sector will do the same with its tax resources in a proportion that will depend on the degree of each party's involvement and the funding model's design.
- Private funding; that is to say through the contribution of solely private resources, which can be recovered through the revenue received for the services provided to direct and indirect users. It is possible to give public support to a private funding scheme through certain guarantees or limited aid.
- In many countries, there is a single public authority in charge of AtoNs that is fully embedded in a highly centralised state administration. In many others, there is a structure divided into several public authorities having more or less independence and management autonomy. These are jurisdictionally divided according to competencies and functions (for instance, by separating development and promotion from supervision and inspection and in turn from maintenance and operations) or directly according to territories or maritime areas following a decentralised model.
- In practice, this leads to the deployment of a large variety of ways to organise both solely public funding and public-private partnerships. The way to attract private initiative to an AtoN service traditionally managed by the public sector is usually conceived as mixed funding. As has been indicated above, the public sector reserves matters of general interest to itself and the role of operator is transferred to private stakeholders, usually through the granting of a concession.

Concession possibilities in turn lead to the following options:

- Private AtoN operator with the participation of the public authority holding competence in the matter, either by holding a stake in its capital or in its governing bodies (board of directors). The public authority will thus have the possibility of gaining better inside knowledge on the conditions under which the private operator works when operating AtoNs, and even have an impact on some its decisions to protect the general interest. Nevertheless, the risk of sharing a business with a private operator means that the public authority may loss objectivity in its role of safeguarding the public interest. It should be noted in this respect that the percentage stake in public hands of a business model designed to be carried out by a private operator is a determining factor. More specifically, a small stake could mitigate the problem of interferences between the public and private spheres and would at least partially offset the information asymmetry which tends to exist between the public and private sectors.

- Entirely private AtoN operator and totally independent from the public authority in terms of capital or internal governance, which are solely bound by the concession contract in keeping with a pure landlord model. The advantages of this model from a management standpoint reside in the fact that the competencies and functions of each party are clearly separated. From a financial standpoint, this same advantage entails that both the risks and the anticipated profits or profitability are more clearly delimited and assigned.

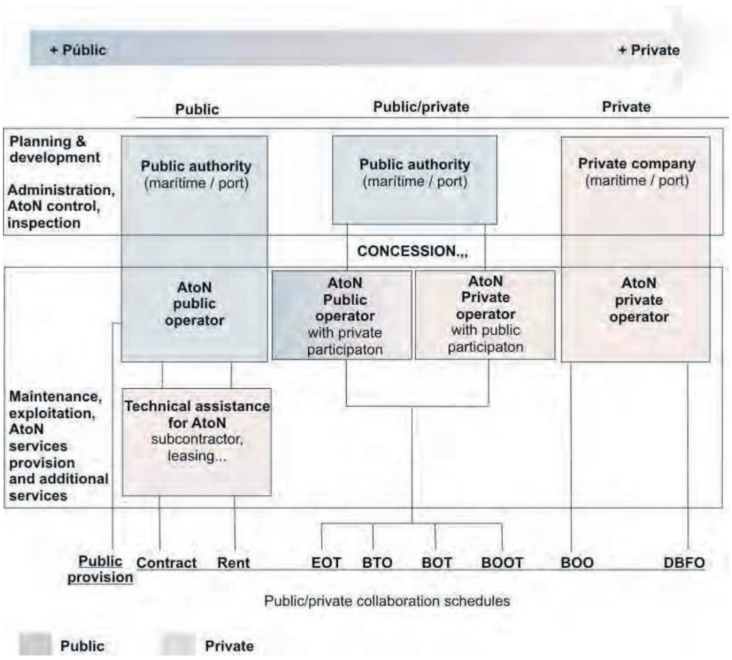

Figure 1: Funding schedules depending on the public and private sectors' participation in AtoNs

In line with this and delving a little bit further into the above from a financial viewpoint, it is possible to differentiate the following public-private partnership models, which are ordered in accordance with the intensity of the private sector's involvement:

- Subcontract granted by the public sector to the private sector. The former retains ownership over of the land, infrastructure and even the AtoN services to be provided.
- The public sector leases the land and assets for the private sector's use or operation.
- EOT (Equip, Operate and Transfer): the private sector provides the AtoN equipment, operates it and transfers it to the public sector after a certain time period.
- BTO (Build, Transfer and Operate): the private sector builds the AtoN facility at the expense of public funding and, at the end of the works, transfers ownership of the same to the public sector. The operation of that facility is done on the basis of a right of use over it granted by the public sector, which expires after a predetermined time period that is not very long (medium/long).
- BOT (Build, Operate and Transfer): the private sector builds, funds and operates the facility, retaining a certain ownership right over it during a predetermined time period, which is usually long. After its expiry, the aforementioned right reverts back to the competent public sector authority. At times, the right of use over the property is a lease with or without a purchase option. It would then be called BROT (Build, Rent, Operate and Transfer) or BLOT (Build, Lease, Operate and Transfer).
- BOOT (Build, Own, Operate and Transfer): the private sector builds and funds the facility, of which it becomes the legal owner once the works are completed. It is then in charge of operating it under its ownership and, once a lengthy predetermined time period has elapsed, transfers ownership to the public sector.
- BOO (Build, Own and Operate): the private sector builds, funds and operates the facility under its ownership for an indefinite time period. This type of modality would usually be associated to AtoN projects whose main assets' estimated useful life runs approximately in parallel with the anticipated time period for their operation and financing.
- DBFO (Design, Build, Finance and Operate): the private sector designs, builds, funds and operates the facility under its ownership for an indefinite time period.

Subcontracting and leasing are two very light forms of private sector participation that correspond to a type of public sector development and funding for AtoNs. As a matter of fact, they fit in with a "tool

AtoN" model according to which the public sector leads the entire decision-making process related to the facility's development and operation.

The last kind of funding mentioned above is at the other extreme and represents a private AtoN development and funding model in keeping with systems entirely managed by the private sector.

In the cases designated as intermediate, especially where the letter "T" (Transfer) appears, the transfer of the AtoN facilities to the public sector is set forth at a specific time. This obliges private operators to limit the assessment they must make on their business's viability to a certain time period, generally in terms of two factors: profitability and risk.

When a project to promote a set of AtoN facilities and place them into operation is tackled, the first thing that should be noted is that the resources needed to turn it them into a reality will probably be high, given that it is possible that new infrastructures will have to be made or refurbished and highly sophisticated technological equipment will have to be ordered and incorporated to serve as light sources and optics.

It should also be recalled that many investment projects of many kinds in the last few decades have been based on high borrowing levels up to the point of exceeding admissible solvency levels. Investment partners and credit institutions then suffer from the risks resulting from the project's inability to meet the obligations it has undertaken with them. At the end of the day, when a liquidity problem arises to face a maturity date, not only is the private sector which has financed the project affected, but also the public sector, which is frequently obliged to intervene and suffers the corresponding losses that are then transferred to society as a whole. In the specific case of AtoNs, the consequences of a sudden economic and financial problem in any of their development stages has a direct negative impact on the safety of maritime shipping, leading to an immediate need to intervene in order to remedy the situation.

From the standpoint of private initiative, the key to avoid these risks in practice is having knowledge about how demand will behave. The success of a private AtoN system development project is based on the principle of involving as much marine traffic as possible. The necessary revenues will therefore be obtained to meet the commitments undertaken with each investor or creditor. As in any other investment project, the cause behind the most significant risk affecting AtoN development projects can therefore be attributed to failures in demand; in other words, the possibility that traffic will in the end be lower than expected or that special difficulties are encountered to obtain the anticipated revenues. Information on this issue is essential.

A demand-side outlook on AtoN projects is fundamental to identify, classify and assess any associated risks in great detail. In addition to this, the stakeholders involved are also affected by numerous AtoN supply-side risks, which are related to the infrastructures and equipment as well as to their operation. There can be no doubt that special attention should be placed on financial risks because these include both internal risks affecting the partners and investors of projects and external risks resulting from unstable markets or other factors. This entire process of risk identification, classification and assessment is intimately intertwined with the different levels of responsibility delimited in the public-private partnership scheme.

The following classification of risks is put forward for financial purposes:

- Revenue risks, which are divided into those connected with demand and the ones having to do with the charges or prices to be applied. The need to pay special attention to demand has already been mentioned. On an *a priori* basis, it is advisable to use of the most advanced techniques to gain as much in-depth "macro" and "micro" knowledge as possible to reliably determine the potential traffic volumes that can benefit from AtoNs. Forecasts have to be prudent and be submitted to sensitivity analyses. For its part, the charge or price of AtoNs not only conditions revenue collection capacity, but can even exert a direct influence on demand, particularly in scenarios where competition exists.

- Infrastructure and equipment investment risks. Unforeseen situations are commonly encountered during the execution of works or when ordering equipment that lead to project modifications with significant extra costs on the initially contracted price. These situations frequently result from technical issues that have not been sufficiently analysed in preliminary studies. An unforeseen rise in investment costs would greatly affect the financial viability of AtoN development projects. Delays in execution time scales for building works and equipment supplies must be added to the risk of extra costs. These can alter commitments among the stakeholders involved and jeopardise the entire project's viability. The building, environmental and safety permits and licences needed to turn an AtoN project into a reality cannot be forgotten either, as these may lead to significant delays and the performance of new and totally unforeseen actions or corrective measures, which are to be incurred by either the public or the private sector. Examples of this are the encumbrance of areas, protected species or the sudden appearance of archaeological remains (wrecks, artefacts, etc.) which entail the suspension of works and the treatment of the remains.

- AtoN operating risks. Poor initial design or the faulty execution of infrastructural elements leads to extra maintenance costs for them and the equipment supported by them or lower service performance levels. Some special risk factors have been identified in this area which have to be taken into account such as the ones caused by nature or accidents (safety) and even the ones resulting from illegal or anti-social actions (security) such as theft or vandalism.

- Financial risks. The high gearing ratio with which some AtoN development and operation projects are designed is in itself an implicit risk. Many loans are granted on the basis of interest rates subject to financial market fluctuations, which can become particularly pernicious when they rise due to industry-specific reasons or the economic situation. Experience has shown that many projects have failed as a result of problems that do not arise from supply and/or demand conditions, but rather from failures in the complex financial arrangements behind them that have turned out to be particularly fragile in the face of the markets. Two key risk factors stand out in these complex arrangements: loan interest rates and foreign exchange rates, where the debt is materialised in a currency other than the one in which anticipated revenues will be paid.

The risk assessment for an AtoN project will depend on the sharing out of responsibilities between the public and private sectors, and among the different stakeholders involved within each of them. This sharing out ultimately exerts an influence on the project's viability, as it will shed light on the extent to which good coverage for all the risks identified has been achieved. However, the real determining factor for such viability is the project's ability to generate sufficient resources based on the business, which leads us on to a more detailed analysis on the way to achieve anticipated revenues.

4. IS SELF–FUNDING POSSIBLE?

Regardless of the public or private nature of the AtoN assets and services, what is indeed possible is to identify two opposed funding models, which are differentiated by the way in which they transfer their costs. These models serve to delimit the extremes of a complex mechanism, which will be discussed regarding this specific matter.

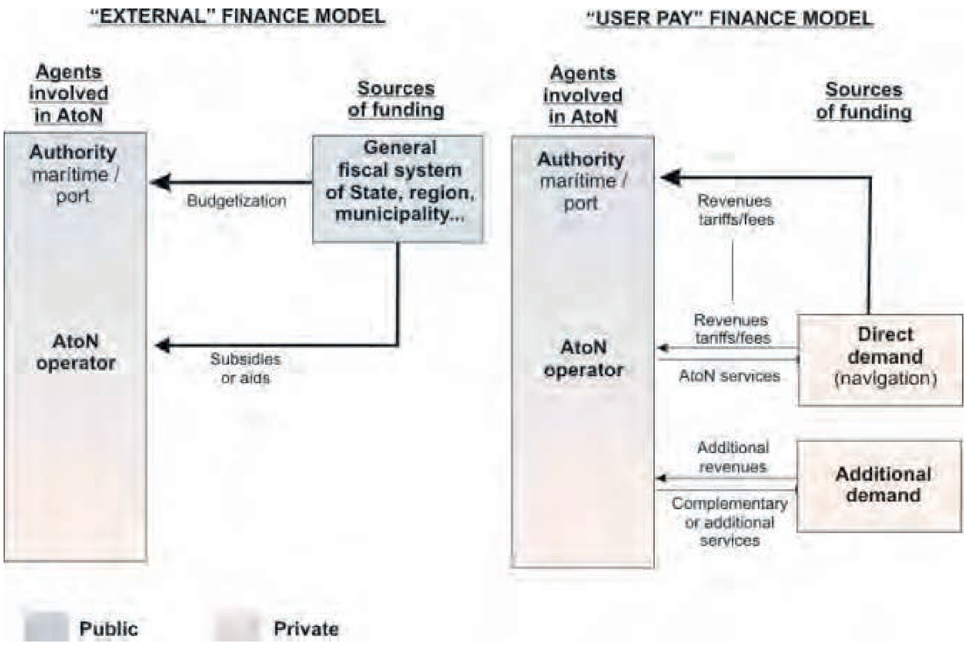

Figure 2: AtoN funding models based on the way capital is recovered

The two models are as follows:

- A funding model that is totally external to the AtoN service, which is charged to contributions made by third-party stakeholders that, in principle, have nothing to do with its use. In this case, these contributions commonly come from budget items allocated from the general tax collection system of a country, region or municipality. AtoNs would be paid for by taxpayers in such a case. Non-recoverable contributions made by a private stakeholder which acts as a patron or similar is much less common today.

- A self-funding model; in other words, the recovery of the investments and costs linked to AtoNs from the revenues generated by the direct application of certain charges – be they fees, levies or tolls – on those demanding the relevant services, mainly those dedicated to maritime shipping. In the latter case, the model is based on the user-pays principle, as it is the service's recipients who in reality end up paying for it.

As has just been mentioned above, in practice there are a wide variety of funding schemes which would fit into an intermediate model or mix of both models.

To start off with, it is necessary to differentiate among three kinds of AtoN facilities that can be funded by different stakeholders

- AtoNs which serve to approach, gain access to and navigate through ports that are commonly assigned to the ports themselves and subject to their funding scheme.
- AtoNs located outside port limits, which have for some time been under the responsibility of the public sector in order to ensure maritime shipping, mainly in areas where there are natural hazards. Classic lighthouses of a certain age and the most important networks used to issue or transmit visual, acoustic or radio signals or signals based on information and communications technologies (ICT) of the different countries form part of this second block.
- AtoNs, such as beacons or buoys, which have to be developed to mark out relatively recent artificial hazards caused by public or private stakeholders. Many of these are funded by such developers.

As of this point, it is of interest to focus our attention on the second block mentioned above because it is the most costly and precisely where a heated debate on how AtoNs should be funded has arisen in many countries, especially regarding the opposition between the two aforementioned models: totally external funding for AtoNs (generally charged to general taxation) and self-funding designed on the user-pays principle.

Reality, of course, has shown us that intermediate funding models exist. At times, the building and maintenance of the most relevant AtoN infrastructures are funded by general taxation, while any variable costs directly connected with operations are paid from the revenues generated by the application of some kind of toll or levy.

For a start, such variety obliges us to define which items or costs – construction, maintenance or operation – are the most relevant when developing and providing AtoN services.

In principle, these items are as follows:

- The possible construction of an infrastructure of certain size, such as a new lighthouse or another relevant fixed AtoN facility, or the replacement or enlargement of an already existing one.
- The acquisition of the facilities and equipment needed to provide the AtoN service. It is common knowledge that there is a fully developed industry for this that operates around the world and which has progressively assumed most of the R&D effort over time.
- Raising capital from the financial sector through some kind of product or asset, the most common being a loan granted by a banking institution at a specific term and interest rate, among other terms and conditions.
- Covering the risks described in the preceding section, which can be summed up as those attributable to revenue (demand and collection), investments and operations, and those of a financial origin arising from the notion of prior cost.
- The service's operating costs. That is to say the costs of the human and material resources needed. These costs tend to progressively fall in the long term as a result of the automation of the processes inherent to AtoNs.
- The maintenance and conservation of all the assets destined to serve as AtoNs. This aspect usually gives rise to a high expenditure outflow, which usually increase over time due to the deterioration caused by the sea and weather and sea conditions which such assets withstand, among other reasons.

In principle, it can be imagined that these are all the costs that need to be covered through the funding model in question, either through the collection of other resources or through the revenues generated by the service itself.

As we have seen up to this point, a preliminary question arises about the wide variety of funding models applied across the world, which can be raised as follows: is the public or private nature of AtoNs a determining factor for the funding model to be used?

More specifically: does a public notion of AtoNs necessarily mean they have to be covered by the public tax resources of a country and which therefore have nothing to do with the service? Does transferring them to private hands involve the adoption of the user-pays principle?

We will first analyse some cases in more detail in order to put forward a response.

When an AtoN system is entirely in the hands of the public sector (from its planning, regulation and control to its operation), it is to be expected that the public sector will undertake to cover all anticipated investments and costs.

In principle then, it would be usual to earmark a budget item to a public authority in charge of AtoNs – that may or may not be endowed with a centralised structure –, which will be responsible for dealing with all cost items, ranging from the costs connected with building infrastructures and acquiring equipment to the costs needed to operate and maintain them, including all financial and insurance costs of course.

In many countries, the public conception of AtoNs is not incompatible with the participation of private companies in each of the aforementioned cost items. As a matter of fact, many outsourcing processes can be observed for very specific activities in each of these items, which have traditionally been carried out by the public sector and over which it retains responsibility, which is hardly irrelevant.

Less than a century ago, the construction of lighthouse infrastructures in many developed countries was carried out by management centres belonging to a public department or ministry allocated with public funds and technically

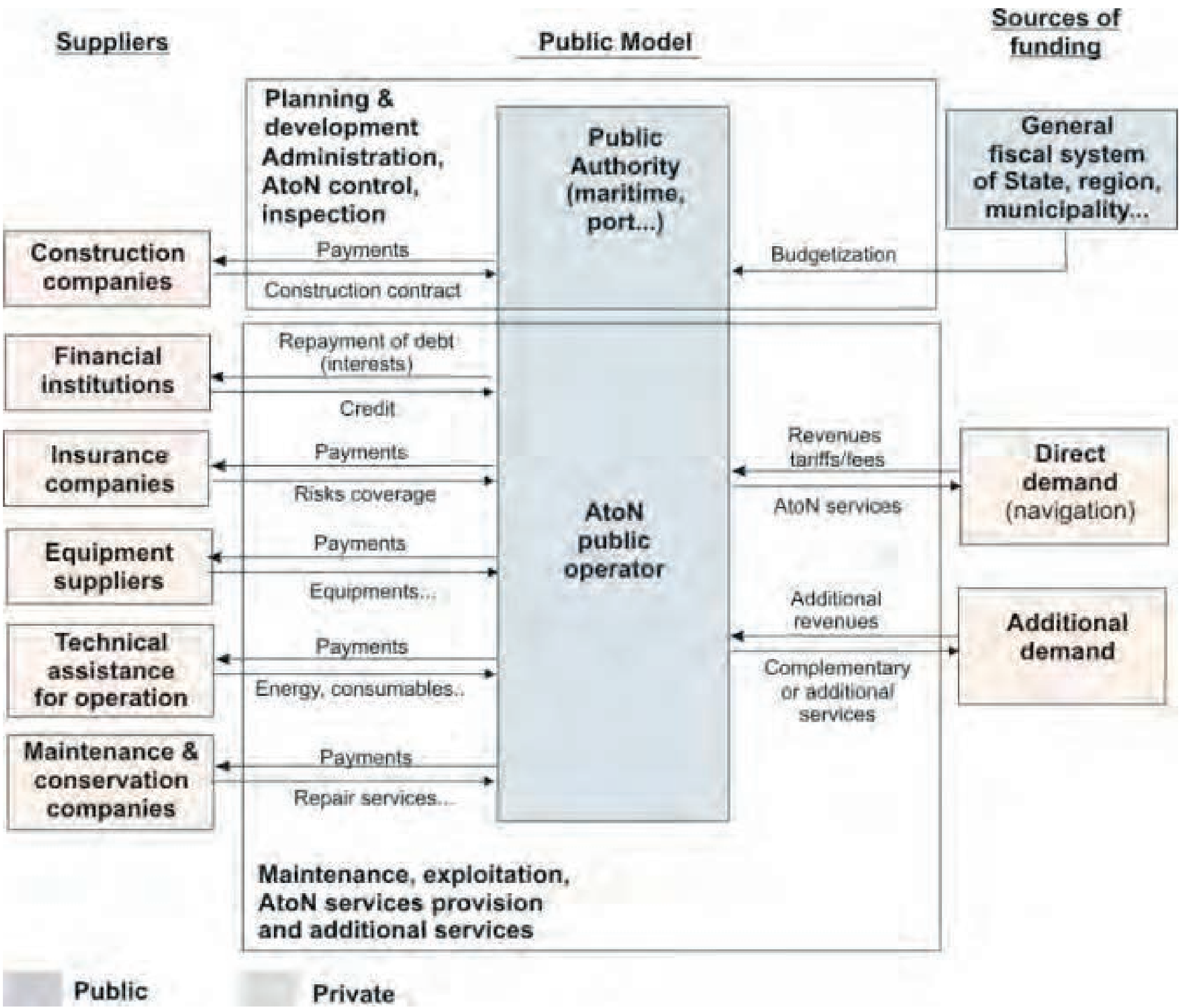

Figure 3.1: Cost and revenue items with a public funding model

qualified civil servants. Today, however, this kind of task is commissioned to private companies contracted for such purpose. This privatisation process affecting both of the drawing up of infrastructure projects and the execution of the corresponding works has become an open door for the private sector's participation, even if it does not entail the possibility of private companies later being in charge of operating such infrastructures as a private business at their own risk and peril.

The involvement of private companies in this kind of outsourced activities is of course usually subject to the regulations laid down in each country on public works, procurement and technical assistance contracts, which are preferably based on the principles of free competition, transparency, objectivity and proportionality.

What is important to highlight here is that the fact that private companies in this funding scheme not applying and charging fees for the provision to AtoN services does not mean that the public sector cannot do so.

There are many well-known examples of public charges (be they tolls, public fees or levies) imposed by the relevant authorities on mariners for the use of lighthouses and marine signals. Their origin dates back many centuries and they are fully in effect today. Furthermore, their amounts are such that they end up creating funding models that entirely conform to the user-pays principle; that is to say, they do not need any additional resources to ensure their economic and financial viability or sustainability.

To start off with, where the system works under a totally public scheme, it is more than likely that any charges for the use of AtoNs that can be imposed will also share in that public nature. These will generally be imposed on maritime shipping without any kind of distinction, regardless of whether the use is potential or real, and in keeping with some predetermined amounts.

Countries like the United Kingdom, Ireland, India or Spain have this type of self-sufficient funding model for their AtoNs, according to which the costs of the service are recovered by applying certain "charges".

The United Kingdom and Ireland share a funding system which is materialised through a common fund known as the General Lighthouse Fund administered by the UK Department of Transport on behalf of both countries. This fund is financed by some "light dues" which are applied to the vast majority of vessels that anchor at British ports based on their tonnage and port calls, up to a maximum of seven. The fund finances three authorities – Trinity House, the Northern Lighthouse Board and the Commissioners of Irish Lights – which have to limit themselves to covering the operating costs, including fixed asset depreciation, of all the AtoNs under their responsibility in their capacity as non-profit organisations.

The English/Irish system is objective and transparent. Apart from some specific territorial adjustments, it efficiently covers most of the costs associated to AtoNs. Moreover, the unit charge per tonne has progressively been falling over the last few decades (relative to the CPI) due to the lower investment effort in new large lighthouses and the automation of many elements connected with the service.

A similar economically self-sufficient system has been put into place in India for all the country's lighthouses, which is administered by the Directorate General of Lighthouses and Lightships. This public management centre covers most of the costs incurred by the AtoN service from the amounts collected in the country's ports by applying light dues on ships, which are similar to the ones imposed in the Anglo-Saxon maritime context.

There is a public funding system in Spain which is also based on the user-pays principle. It is exclusively managed through the Spanish port system which acts as the public authority in matters having to do with AtoNs. For facilities located outside port limits, this system is funded through the application of AtoN levies.

Consequently, even where the public sector plays a dominant role in the provision of the AtoN service, it is possible to do away with funding from the general tax system and design funding models that are based on the user-pays principle.

As the service is progressively privatised, it is easy to observe how the difficulties increase in recurring to the centralised tax system to obtain public funds from it. It is commonly known that in many relatively advanced market economies the allocation of public resources to private companies is obviously limited, restricted or even prohibited, seeing as it entails a distortion of free competition.

This, for instance, is the case within the European Union, where the Treaty on the Functioning of the European Union (Treaty of Lisbon) prohibits any public aid that may affect free competition, like commercial services provided by private companies in a free market, and sets forth a series of highly specific exceptions (Article 107; formerly Article 87 of the TEC). It is nonetheless possible to grant public aid to private companies that contribute to the attainment of some kind of aim of public utility or in the general interest, in which case they have to be subject to certain industry-specific regulations and have obtained the relevant authorisation from the European Commission.

It is worth setting out the European experience in ports concerning this matter. As is known, port management has been evolving towards a landlord type model over the last few decades. In this model, the public sector retains ownership over the land and allocates its resources to so-called "basic" infrastructures, while the private sector provides port or other services under a licence, authorisation or concession scheme and has to contribute the human and material resources needed to do so.

This process of transferring services to private companies does not necessarily involve a self-funding model designed around the user-pays principle, as it leaves open the possibility of certain infrastructures of a certain dimension being covered by the taxes of the state, region or municipality where the port is located.

It is admissible within the European Union to consider the works to build shelters (breakwaters and seawalls), quays, embankments and communal areas, along with dredging and road works in ports as "basic" infrastructures. The rest of the facilities which can be classified under the heading of

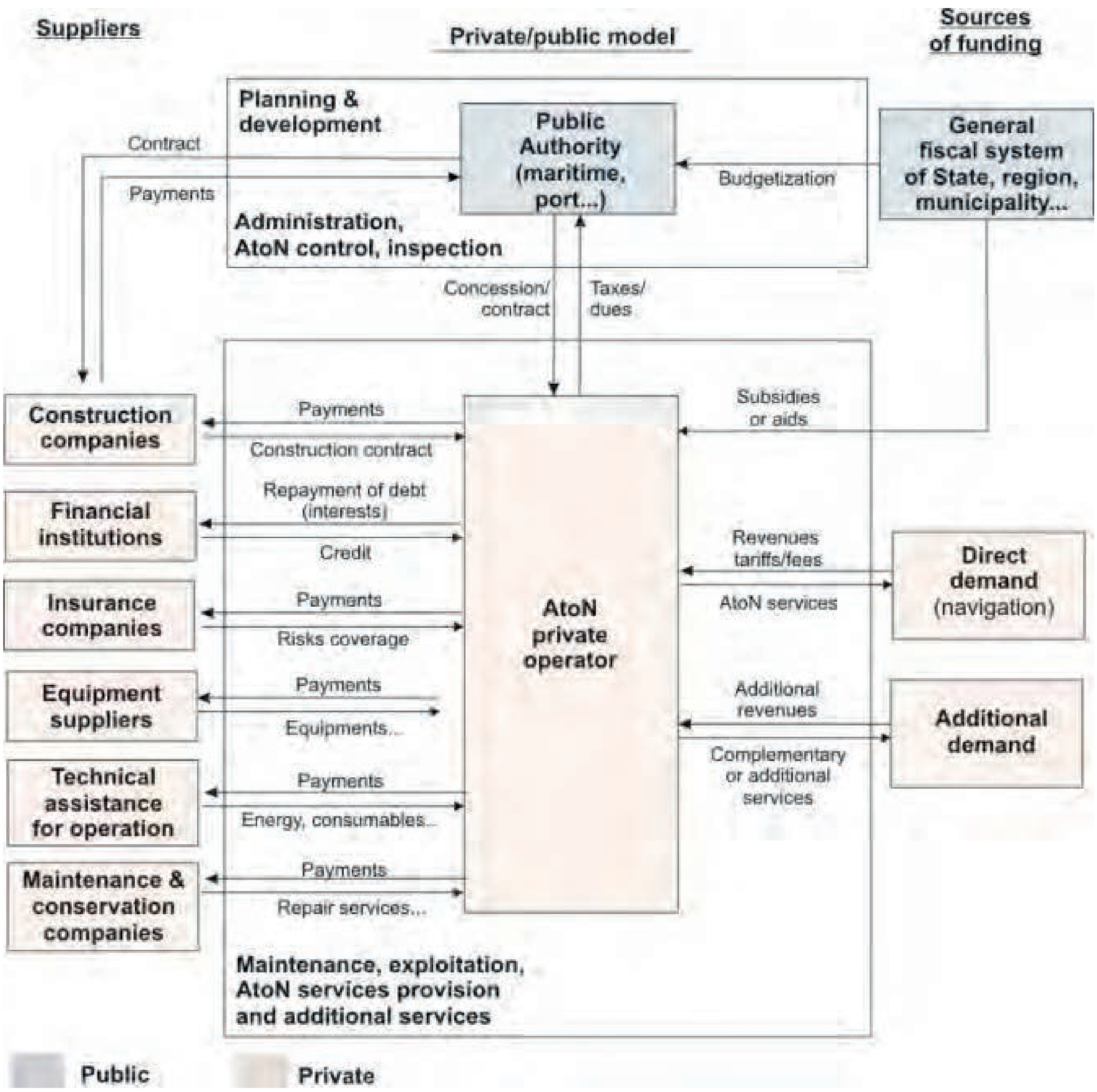

Figure 3.2: Coast and revenue items with a mixed public/private funding model through a concession

superstructure – such as quay and overhead cranes, goods handling machinery, industrial buildings, warehouses, silos, tanks and other elements – have to be made available and paid for by private stakeholders at their own risk and peril. Some elements like filling and paving works, along with certain kinds of quays and jetties in port areas assigned to private companies under an authorisation or concession scheme have remained in a sort of no man's land and are therefore the subject of permanent debate.

Nonetheless, the fact that basic infrastructures are paid for by the public sector does not necessarily mean that they should be funded by the taxes of all citizens. It is also possible to design public port charges of a sufficient amount to ensure that port users end up paying for all the port's elements. Self-funding can therefore be attained through these charges and the fees set by private companies.

This economically self-sufficient public-private partnership scheme, which transfers all the costs to direct demand, can be fully assimilated to AtoNs, especially where the mechanism for charging the relevant public and private charges is carried out through ports as points where vessels end up anchoring and where the agents representing them go.

Where private initiative is directly in charge of all AtoN services, the possibilities of receiving direct public funding become more difficult, though this

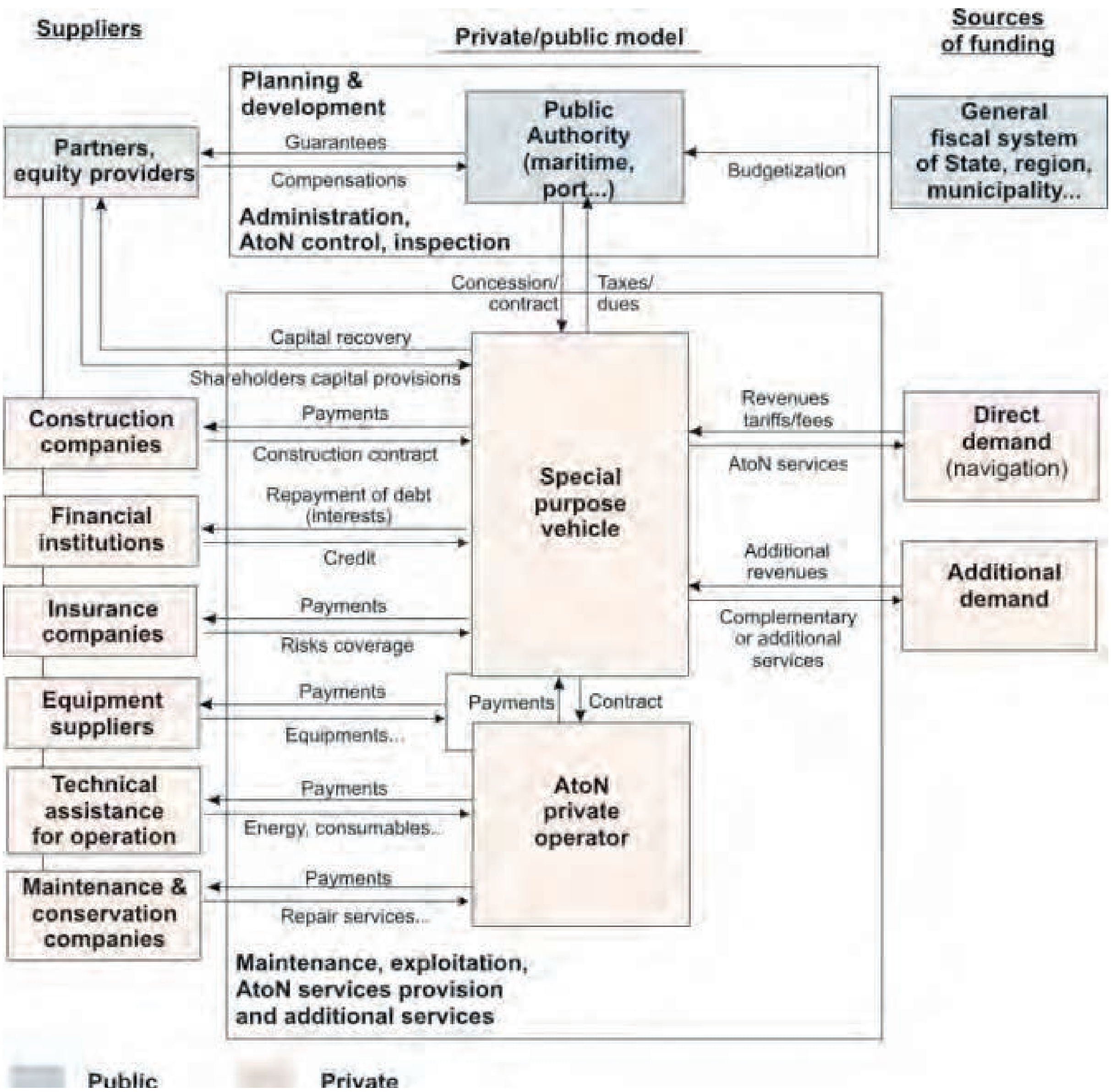

Figure 3.3: Cost and revenue items with a public-private partnership model and funding based on the project itself

does not mean that public aid will entirely disappear.

Public-private partnership projects are common in all realms of activity. In them the public sector assumes certain undertakings or guarantees and the private stakeholders act as private developers, thereby reducing their risks, and in reality conceal different kinds of public aid.

Typical examples of this kind of partnership are those whose funding is based on the project itself (project finance). These are organised around special-purpose vehicles (SPV) for the project which manage the capital provided by its developer-members, apart from another kind of capital in the form of commercial loans granted by financial institutions and loan agencies.

All the capital provided by both to the project's SPV has to be returned by it, so that creditors can get a return on their investment and credit institutions can recover their principal along with the interest. This company therefore assumes any financial risks linked to the cumulative debt, which obliges it to actively promote, fund and place into operation the AtoN system. It may, nevertheless, outsource the tasks having the greatest technological or operational component.

The difference between these two types of creditors resides in the fact that the kind of debt the project's SPV assumes from its developer-members is subordinated to the commercial debt borrowed from credit institutions. The capital of the latter therefore has senior status and dominates over that of the developer-members, which are relegated to an equity holding position, which means their stake can be assimilated to the purchase of shares in the project's SPV.

Having a senior position over the debt is the main and apparently only advantage financial institutions have, as in principle they cannot rely on any direct individual guarantees from the developers. In other words, if an AtoN project organised in the way mentioned above ends up failing, the financial institutions involved cannot claim the corresponding assets or cash flows from each of the developers. Their relationship with the project starts and ends with the SPV. If the loan's principal and interest are not paid back to them, they can only recur to that company's capital as a guarantee. They therefore have to believe in it, at least more so than if it were a loan backed by solid guarantees.

The project's SPV is the key element in the implementation of this kind of scheme. To begin with, such company must have a legal personality which is independent of its developer-members' legal personality and it should act with wide-ranging management autonomy, so it may allocate the service's anticipated revenues as efficiently as possible. Furthermore, it is advisable for it to be a corporation in order to limit the developer-members' liability to the shares they have subscribed in the SPV.

Before incorporating an AtoN project SPV, it is important to attract the attention of all stakeholders interested in taking part in the project. Though it takes up a lot of time, this stage of attracting members ends up being vital to ensure the project's viability. In addition, it is not uncommon to hire a series of advisors at this stage to resolve any technical and legal uncertainties which may arise along the way.

It should also be indicated that these kinds of funding models having a high private-sector component are designed with a high gearing ratio at the start. It is precisely here that the main risk of this kind of operation resides. Obviously, the higher the amount of equity contributed by the developer-members, the more ease of mind there will be for the financial institutions involved.

The public sector can take part in this kind of project finance scheme as yet another member. However, the truth is that these are schemes specifically designed to get around the need for direct public contributions charged to general taxation and even to avoid charging demand with public charges, thereby leaving only the private fees to be applied in this case by the project's SPV for the provision of the AtoN service as the only revenue-generating mechanism

It would therefore be a private user-pays model.

Now then, should there be a lack of sufficient contributions by equity investors and members and if the traditional financial sector is reluctant to grant loans, the temptation exists of covering the risk resulting from a potentially large debt with public sector guarantees. This is where the most serious drawback of these schemes lies because, if the project's SPV fails to meet its initial debt undertakings, it is to be expected that the public sector will be obliged to come to the rescue by starting to make such guarantees effective before the AtoN service is suspended. This will probably mean the socialisation of the problem's inherent obligations and extra costs in the long run.

In any event, it should be noted that the number of AtoNs catalogued to date as public is so generalised that there are no specific cases that clearly reflect this kind of public-private partnership model.

Notwithstanding this, what is indeed perceived as a fact is that the age-old debate between the models which transfer costs to users and the models which are funded by general tax resources remains open in many countries.

When the United States decided to do away with the light dues inherited from the English colonial era in 1789 and pass on all AtoN costs to the National Treasury, the reason given by the US Lighthouse Board stated that "*light should as free as air, because it is not only in the interest of trade, but also to the benefit science and humanity*" (attributed by Foldvary to Johnson, 1890). The conception of AtoNs as public goods at the reach of anybody was thus intensified. This conception has survived to our day and has finally led to the centralised management of AtoNs by the US Coast Guard in 1933 with funding from the Treasury's tax resources.

In view of the technological advances in on-board navigational systems on vessels and the possible obsolescence of some AtoNs, many today are, however, asking how to shift the burden of maintenance costs of lighthouses and other AtoN facilities onto demand once again. In other words, the aim is to directly charge beneficiaries and interested parties for the US Coast Guard service instead of American taxpayers continuing to fund it through the public Treasury (Foldvary, 2003).

In the 1990s, the European Commission openly defended the recovery of AtoN costs by charging their direct beneficiaries, like public or private ship-owners and shipping agents, the relevant charges. The user-pays principle was precisely what it defended in the communications entitled *A Common Policy on Safer Seas* (1993) and *Green Paper on Sea Ports and Maritime Infrastructures* (1997).

The main argument put forward by the Commission to defend economic self-sufficiency was based around the need to avoid transferring onto society the costs of a service that in reality benefitted mariners, many of which navigated along territorial waters and therefore had little to do with the countries that placed this service at their disposal. In other words, taxpayers had to be freed from paying for something they did not use on a day-to-day basis, even though they could suffer a direct or indirect long-term cost as a result of possible ship accidents in the sea if AtoNs did not exist.

In those years, the European Commission additionally recognised the need for generalising a single model – specifically the model associated to the user-pays model – because the coexistence of different models could alter free competition between ports. According to the statistics of the European Sea Ports Organisation (ESPO), there are two extremes in Europe:

- Countries which cover all AtoN costs, including both investment and maintenance, through general taxation like, for instance, Germany, the Netherlands, Belgium, Poland and Italy.
- Countries that apply some specific charges or fees collected at ports through a more or less centralised system, so that AtoN users fully pay for them, such as the United Kingdom, Ireland and Spain.

The alteration of free competition comes about when demand reacts (or is elastic) in the face of what it perceives as cost differences between ports, which are can be attributed to the funding schemes in each country. To be more precise, ports in countries which have implemented the user-pays principle will be more expensive than the others. Some authors like Asteris (2006) insist on the distorting effect resulting from the existence of both systems, particularly in situations of fierce competition between English and continental ports located on the other side of the English Channel. Some more practical studies, however, minimise this impact, indicating that it is other port levies and especially port service fees, such as technical and nautical service fees, which exert an appreciable influence on demand in price competition among ports.

This section should be brought to an end by indicating that no direct correlation exists today between the public or private consideration of AtoNs and the way in which costs are transferred to society. There are countries, which today are a majority, with public AtoN systems that obtain resources to sustain such systems from general taxation. There are also others, however, which transfer their costs to users through specific levies. This diversity could lead to a certain distortion of free competition in prices among ports, a fact that would make working towards attaining a greater degree of similarity in the models worthwhile.

However, it seems that such distortion does not in any event have serious effects.

5. THE SPANISH CASE

Like many other models around the world, the Spanish model for the development, availability and operation of AtoNs is essentially public. This is not only due to an economics-based view of these aids as public goods but, as was already indicated in the first chapter, also as a result of the legal recognition that both the land on which they are located and all their elements form part of the state's resources as goods in the public domain.

It is also an economically self-sufficient model. In other words, it is in keeping with the user-pays principle, according to which the public authority in charge of such aids imposes a series of levies on the direct beneficiaries of AtoNs, thereby allowing it to collect sufficient revenues to cover their costs.

There have been few examples in Europe of self-sufficient economic schemes which transfer their costs to users in the last few decades. Aside from the Spanish AtoN system, these are the United Kingdom and Irish systems which, as has been mentioned before, share the same funding scheme.

Though small in number, the maritime relevance of these countries should nonetheless be highlighted, as they have very long coastlines. More specifically, the United Kingdom coastline measures 12,430 km, Spain has a coastline of almost 7,880 km and Ireland has 1,450 km of coasts. Together they account for approximately 1/3 of the European Union coastline's total length.

The Spanish self-funding model is similar to the one in place in the United Kingdom and Ireland, in as much as the costs associated to AtoNs are passed on to demand for the service; in other words, to vessels and on the basis of their tonnage. All three apply specific levies known as light dues or AtoN levies.

It should be pointed out that the revenues from the aforementioned levies cover the costs of public AtoNs in charge of signalling natural hazards along the coastline which are outside port limits. These AtoNs mainly include lighthouses, buoys, beacons, racons and different kinds of transmission networks.

It should be recalled in this regard that in Spain the AtoNs belonging to ports are covered by a so-called vessel fee, which are solely applied by the corresponding port authority, while the AtoNs located outside port waters and in charge of signalling any artificial facilities which could be an obstacle or danger for shipping are financed by direct contributions made by the developers of such facilities, be they publicly owned or private.

Referring henceforth to only the AtoNs which are generally in charge of signalling natural hazards, it should be indicated that the basic variables used to determine the AtoN levy in Spain are a vessel's tonnage (GT) and its port calls. Additionally, the number of port calls in Spain which may be affected by the levy is limited to three per year for merchant ships and to only one per year for other vessels, unlike the seven port calls per year in the United Kingdom. The Spanish and English/Irish levies obviously differ regarding both certain circumstances as well as their basic amounts because they are set in relation to the costs to be covered in each area of application.

Nonetheless, the most striking differences between these countries which have implemented the user-pays principle are of an organisational nature and can be summed up in two major differences:

- On the one hand, there are no public authorities solely dedicated to AtoN-related matters in Spain, as opposed to what is the case in the United Kingdom and Ireland. The Spanish authority holding responsibility for this matter is the general-interest port system itself, which is made up of the public agency Puertos del Estado and a set of 28 port authorities in charge of 44 ports, all of which depend on the Ministry of Public Works. Aside from these bodies, the Spanish AtoN system has an advisory body known as the Lighthouse Commission, which dates back to 1842. It issues opinions on marine signalling and is made up of the organisations and associations most involved in maritime matters and more specifically with shipping.
- Moreover, revenue collection is not carried out solely through a specific fund like the General Lighthouse Fund shared by the United Kingdom and Ireland. In Spain, an inter-port compensation fund is used, which receives 80% of the revenue collected by the port authorities in AtoN levies (on the basis of vessel traffic) that is later shared out among them in keeping with a reasonable-cost criterion. This criterion used to share out the fund is agreed upon by a committee set up for such purpose by the Law, which is comprised of the Chairmen of Puertos del Estado and each of the 28 port authorities. The resolutions taken within this committee are

usually based on the number and type of AtoN facilities located on each of the stretches of coastline assigned to the port authorities.

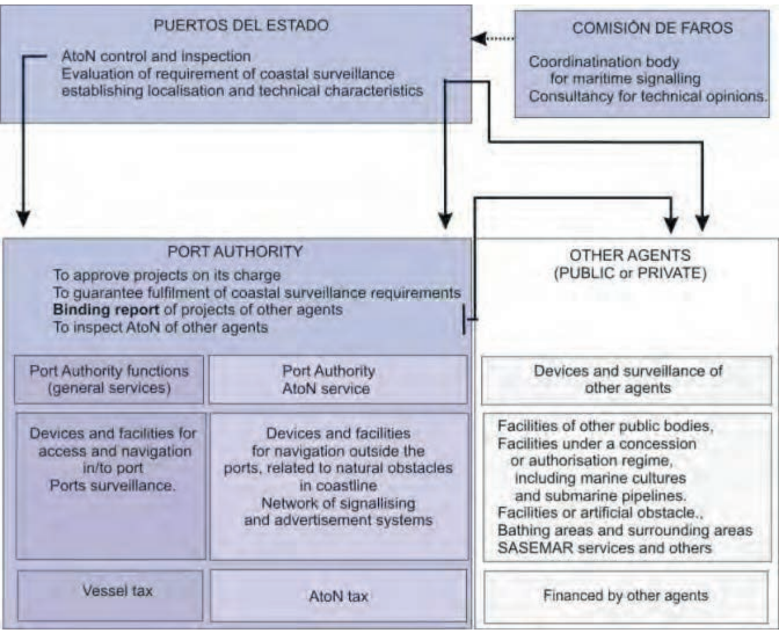

Figure 4: The Spanish case – Organisational model

The aim of self-economic sufficiency has been reached with regard to the main basic AtoN operating costs mainly due to the high degree of automation the service has attained. As a matter of fact, it should be recalled that the body of lighthouse keepers was extinguished in 1992. There are only 50 lighthouse keepers left today, who have been integrated into the respective port authority workforces.

Nevertheless, the Spanish experience shows that the application of the AtoN levy does not fully cover all the maintenance and conservation costs of facilities having a certain size, like the buildings which house lighthouses and other ancillary buildings attached to them. This deficit is aggravated when such buildings acquire sufficient historical value to form part of Spain's cultural heritage or when they are declared as assets of cultural interest. There are numerous international charters or conventions on the preservation of heritage which impose very specific conservation requirements, such as the European Charter of the Architectural Heritage of 1975. It must not be forgotten that many lighthouses are located in protected areas for environmental or other reasons, which also make it necessary to take special care of the interaction between the surroundings and the lighthouse and its uses. It is also possible that some highly relevant facility or lighthouse may even be declared a world heritage site, in which case it will be subject to very strict maintenance requirements that oblige the corresponding public authorities to assume high costs that can hardly be passed on to demand for AtoNs.

For instance, many lighthouses have been declared as assets of cultural interest in the Canary Islands, like the Pechiguera and Alegranza Lighthouses off the island of Lanzarote (built in 1866), the Maspalomas Lighthouse in Las Palmas or the Orchilla Lighthouse on the island of El Hierro, requiring the port authorities in charge of them (the Las Palmas and Santa Cruz de Tenerife Port Authorities) to incur a series of additional costs for their conservation. For its part, there is also the Tower of Hercules in the Iberian Peninsula, the oldest active lighthouse in the world located in La Coruña that was declared a world heritage site by UNESCO in 2009, which requires particularly expensive maintenance and care.

A series of complementary uses have been put forward in Spain, as in other countries of the world, to cover the high maintenance and conservation costs of the most vulnerable and oldest lighthouses and AtoN facilities in order to generate additional resources for such purpose.

Maintaining lighthouses as assets of historical value is a task which many countries have seriously begun to tackle at a national level and additional channels of funding have been opened for such purpose. An allusion to complementary funding was already reflected in the Lighthouse Conservation Manual published by IALA (2006).

In practice, different ways can be found to obtain the additional extra resources needed to properly conserve lighthouses, which include the following:

- Signing agreements or covenants with local authorities or public organisations and agencies holding responsibility for such matters and interested in organising possible complementary uses at the AtoNs, such as guided tours which are booked in advance or by invitation, interpretation centres, exhibitions or museums open to the general public. On the basis of the interest shown by such public stakeholders in using the facilities for such purpose, regular aid is contributed that can be allocated to conservation and maintenance.

- Setting up a cooperation fund comprised of the direct contributions made by all public and private stakeholders interested in maintaining the historical value of lighthouses in exchange for implementing possible complementary uses in them and having the chance of taking advantage of them at some time.

- Granting a concession scheme to a private firm or company to operate part of the building or the facilities attached to the lighthouse for complementary uses, not only as a centre for visits, but also for catering or accommodation activities. In which case, said company can run its own business by applying the relevant fees for the service linked to such uses with the obligation of properly maintaining the facilities.

There are many diverse practical experiences across the world in which private initiative has a presence to add value to a lighthouse, thereby allowing maintenance and conservation costs to be covered at that business's expense.

In some countries, the extent of such initiatives has lead to the creation of some kind of umbrella group in charge of setting harmonised standards and procedures to attract the public to the corresponding offers and thus generate interesting economies of scale.

For example, the United States Lighthouse Society should be cited as point of reference. It is a non-profit organisation having over 10,000 members which is responsible for bringing in funds from visits and making them compatible with maintaining the historical value of lighthouses in the United States.

This association informs about the possibility of being a "light keeper" on its website (see www.uslhs.org) through a variety of accommodation options at a series of lighthouses, which are suitably described and located in over fifteen states, from Alaska to Florida and from California to Maine. The accommodation options range from bed & breakfast type stays to longer stays. All of them offer features of a higher or lower standard.

Another similar organisation is called Lighthouses of Australia Inc., which offers guided tours by land and air (by helicopter) to visit historic lighthouses located on the Australian coast and on nearby islands. This organisation contributes to financing AtoNs in Australia, which are today managed by the Australian Maritime Safety Authority, jointly with the contributions made by local authorities, maritime museums or natural parks.

There are many isolated initiatives in numerous European countries aimed at reconditioning highly emblematic lighthouses for complementary uses, especially as residential accommodation (see for example www.lighthousesofeurope.com).

Today Portugal and Spain are two of the few European countries which stand out for currently not having any kind of residential activity in their lighthouses.

It should be recalled that Portuguese lighthouses are administered by the Navy of Portugal, a circumstance which has led to them being closed to the general public for many years. The first sign of an opening up in this country was detected in 2011, when six historic lighthouses in the Algarve were made available for visits by the public.

For its part, the strong public nature of lighthouses in Spain has also led to there being no kind of residential activity in them, apart from serving as accommodation for lighthouse keepers. However, there are many examples of lighthouses having some kind of complementary use which contributes to their upkeep. An extensive list of Spanish lighthouses having complementary uses can be found on the website of the Spanish public agency Puertos del Estado (www.puertos.es). More specifically, the following stand out among such uses:

- As places to visit in natural landscapes or along tourist trails
- Nature interpretation centres, observatories
- Art centres, museums and exhibitions
- Cultural, training or conference centres
- Catering centres (restaurants, cafés, etc.)
- Shops (shops selling handicrafts, etc.)
- Aquarium
- Telecommunications station

However, Puertos del Estado launched a project in 2013 known as *Faros de España* (Lighthouses of Spain) aimed at strengthening these uses and in particular promoting new residential uses.

It is a nation-wide project aimed at identifying all possible complementary uses in Spanish lighthouses, which places special emphasis on residential uses, in order to place into practice specific projects in a progressive fashion that can be borne by the private sector through a concession scheme.

Due to the consideration in Spain of AtoNs as goods in the public domain and because they are also located on the Spanish coastline, which is likewise catalogued as a maritime-terrestrial public domain, putting into practice a residential activity is subject to a very strict legal and administrative procedure, which comes to an end with each project's approval by either the Ministry of Public Works or by the Cabinet, depending on the location of each lighthouse.

Taking into account that the public agency in Spain holding responsibility for lighthouses is the port system itself, Puertos del Estado has promoted the creation of a working group with the port authorities which is aimed at diagnosing the state and ability of each of the AtoN facilities that may house complementary uses and to promote projects which may be in the interest of private initiative.

In the terms which concern us here, the interesting thing regarding the funding of AtoNs is that an effort is being made through this initiative to complement the current public funding model based on the user-pays principle with the contribution of resources that could come from adding value to lighthouses and other AtoN facilities by taking advantage of the possibility of equipping them with complementary uses. Hence, the low levies mariners are charged for AtoNs can be maintained, which is additionally in tune with the process of automating the service, without failing to cover the conservation and maintenance needs required by these facilities due to their historical and cultural value.

6. CONCLUSIONS

To sum up, it can firstly be concluded from all of the above that most of the AtoN systems in the world today are deemed as public, either because they are attributed with an economically-oriented quality of being public goods or because the governing legal systems deems them as such. In this regard, a public presence cannot be avoided in most of the European countries with shores on the Mediterranean due to the fact that all the elements which comprise AtoNs, including the land on which they stand, are considered as goods in the public domain and because they are also used to provide a public service.

Nevertheless, this fact does not determine the funding model for AtoN systems. Despite AtoNs being considered as public systems, two different models survive in the world today to transfer their associated costs:

- The model through which AtoN costs are covered by the general tax system of the country, region or municipality where they are located, which means that AtoNs are paid for by the taxpayers of the territory thus affected. This model is the most widespread in the world.

- The model based on the user-pays principle, through which some specific levies (light dues or similar) are applied and collected in the ports of the relevant country for the provision of the AtoN service. By means of this model, the mariners who benefit from the service pay for AtoNs instead of all taxpayers. This model is not as widespread at the one above, but is common in countries having an Anglo-Saxon influence, as well as in some others like Spain in keeping with the principle implemented that each port should be self-sufficient.

The presence of private initiative in the full provision of the AtoN services is relatively rare in the world. It is limited to certain private company concessionaires of a full-scale national AtoN system, as well as to the outsourcing of very specific highly advanced technological

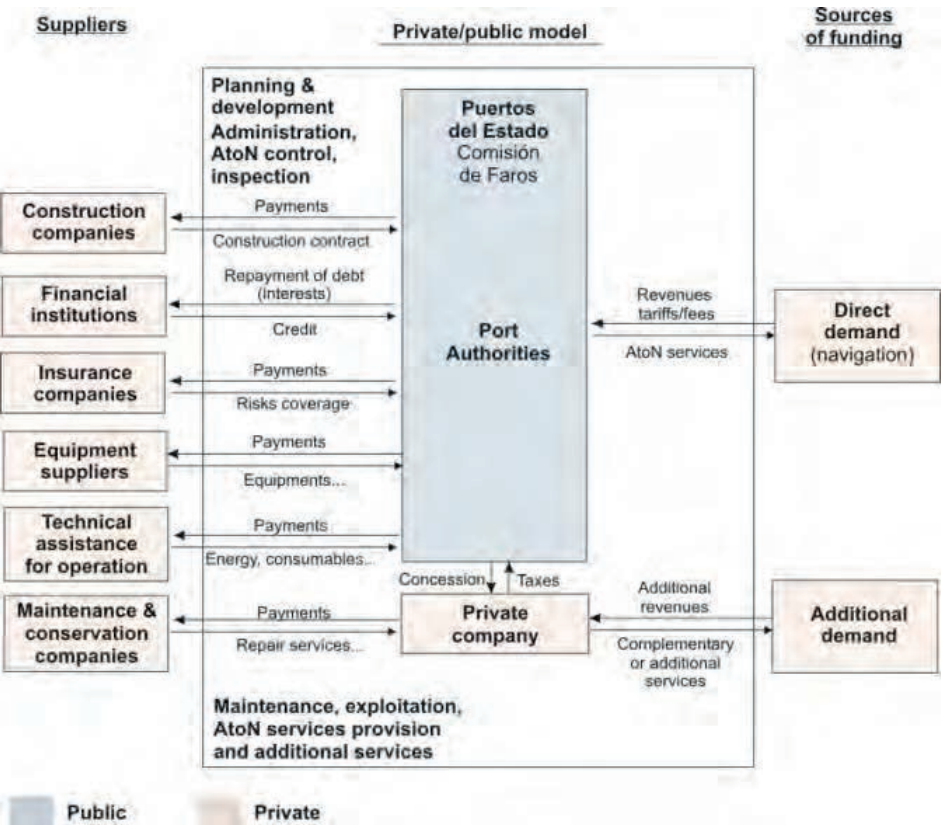

Figure 5: The Spanish case – Cost and revenue items with a public user pays model with possible additional funding based on complementary uses/services

elements or items, such as the construction of unique building infrastructures, the supply of equipment or the maintenance and upkeep of the corresponding assets.

Although sufficient information is still unavailable on this point, it could also be concluded that it is more than likely that there will be trend towards funding models based on the user-pays principle as AtoN systems are progressively privatised. However, rather than applying levies, commercial fees will be charged, which will possibly be directly regulated or approved by the public sector.

Nonetheless, if more sophisticated funding like project finance models are used, it is possible that a certain contribution of public resources will still be necessary in the form of undertakings or guarantees to cover some of the risks associated to the projects. In such cases, it is necessary to clearly set out the role to be played by the public and private sectors to properly allocate costs and, above all, their anticipated recovery through the revenues obtained from the application of fees.

As the processes linked to the provision of the AtoN service are automated, their associated operating costs will fall. This will facilitate a possible transition to the user-pays principle, given the scarce impact the application of some specific levies would have on maritime shipping.

However, the maintenance and conservation costs of the elements that make up AtoNs tend to rise over time as a result of the harsh weather and sea conditions they have to bear, which turn out to be especially serious if these elements have a historical or cultural value. In such case, it would perhaps be advisable not to charge AtoN users for these costs and subject them to a steep rise in levies. It would be better instead to explore new sources of funding based on taking advantage of the facilities for complementary uses of social or commercial interest.

These uses can be promoted and handled by public agencies, associations or public-private partnerships, as well as by private companies granted a specially designed concession for such purpose. These turn out to be very interesting options in funding terms for both AtoNs funded by general taxation and the ones paid for by users through a specific levy (user-pays). In the long-term, the aim is to obtain valuable additional resources that are generally allocated to conserving and even increasing the economic value of AtoNs, particularly lighthouses, while limiting or even mitigating the tax burden.

This line of work has already begun in many countries and there is in fact a wide range of highly different complementary uses for AtoNs across the world. The AtoN system in Spain is not oblivious to this reality and today offers the possibility of making use of some facilities as cultural, art, tourist, leisure or catering centres. Furthermore, a project known as *Faros de España* (Lighthouses of Spain) was launched in 2013 in response to the need to add value to the country's most emblematic and adaptable lighthouses. It aims to promote the conversion of certain facilities into accommodation centres equipped with some standard minimum features through suitable concessions granted to any private companies that submit economically viable projects that are coherent with the public aims being sought. ■

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74 QUANTITATIVE RISK ASSESSMENT AND THE COMPLIMENTARY USE OF IWRAP

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Risk Assessment to ensure that the most appropriate mitigation measures are in place to ensure any new and existing dangers to the Mariner are provided for, is essential. The two main methods of Risk Assessment, that is the quantitative and qualitative approaches, must be used to enable full consideration of possible and proposed control measures. Routing Measures: All routing measures begin with a form of risk assessment but often rely on the qualitative expertise of those carrying out the assessment. The IALA Waterway Risk Assessment Program (IWRAP Mk II) has now being developed to a level where we can use the tool to clearly demonstrate change in risk when considering and implementing a routing measure. A quantitative answer to some of the basic questions, supporting the proposal can be given – for example:

- How wide should the lane be?
- Does the TSS provide for sufficient separation of the traffic?

When submitting a proposal to the IMO for a new routing measure quantitative data will significantly support any case that is being made and assist those making their assessment of the values of the proposal. Offshore Developments: Internationally there is a huge increase in proposals for offshore renewable energy developments. Particularly when assessing two or more adjacent sites the use of IWRAP to demonstrate change in Risk caused by the proposals can significantly support the assessment of, for example, the corridor width required. It is very evident that disproportionate weight is being given to issues surround these developments and we are now able to use IWRAP to ensure that Safety of the Mariner is assured in any considerations. Protection of a particular species, for example, will sometimes cause the boundary of a wind farm to be shifted, to the detriment of navigation safety. My presentation and paper will, using the IWRAP tool, graphically demonstrate the benefits of quantitative assessment.

La evaluación de riesgos es fundamental para garantizar que se estén aplicando las medidas de atenuación más adecuadas para garantizar que cualquier peligro nuevo o existente para los marineros esté cubierto. Los dos métodos principales de evaluación de riesgos, los enfoques cuantitativos y cualitativos, se deben utilizar para poder valorar todas las medidas de control posibles y propuestas. Medidas de enrutamiento: Todas las medidas de enrutamiento comienzan con un tipo de evaluación de riesgos pero con frecuencia confían en la experiencia cualitativa de aquellos que llevan a cabo la evaluación. El programa de evaluación de riesgos de navegación fluvial IALA (IWRAP Mk II) se ha desarrollado hasta un nivel en el que podemos utilizar la herramienta para demostrar claramente el cambio en el riesgo si se tiene en cuenta y se implementa una medida de enrutamiento. Se puede dar una respuesta cuantitativa a algunas de las repuestas básicas apoyando la propuesta.

Por ejemplo:

- ¿Qué longitud debe tener la ruta?
- ¿Proporciona el TSS una separación suficiente para el tráfico?

Al enviar una propuesta al IMO para una nueva medida de enrutamiento, los datos cuantitativos apoyarán significativamente cualquier caso que se produzca y ayudará a aquellos que estén realizando su evaluación de valores de la propuesta. Desarrollos mar adentro: A nivel internacional hay un gran aumento de propuestas de desarrollos de energías renovables mar adentro. En concreto, al evaluar dos o más lugares contiguos, el uso de IWRAP para probar el cambio del riesgo causado por las propuestas puede apoyar significativamente la evaluación de, por ejemplo, el ancho del pasillo necesario. Es muy evidente que se le otorga un peso desproporcionado a asuntos alrededor de estos desarrollos y que ahora somos capaces de utilizar IWRAP para garantizar que la seguridad del marinero esté asegurada en cualquier situación. Por ejemplo, la protección de especies concretas hará a veces que se desplacen los límites de un parque eólico en detrimento de la seguridad en la navegación. Mi presentación y ponencia mostrará gráficamente, mediante la herramienta IWRAP, los beneficios de una evaluación cuantitativa.

L'évaluation du risque est essentielle pour s'assurer que les mesures d'atténuation les plus appropriées sont en place face aux dangers nouveaux ou existants menaçant le marin. Les deux méthodes principales d'évaluation du risque, l'approche quantitative et l'approche qualitative, doivent être utilisées pour considérer en totalité les mesures de contrôle possibles et proposées. Mesures de séparation de trafic: Toutes les mesures de séparation de trafic commencent par une forme d'évaluation du risque mais dépendent souvent de l'expertise qualitative de ceux qui procèdent à l'évaluation. Le programme de l'AISM d'évaluation du risque dans les voies maritimes (IWRAP Mk II) a maintenant atteint un niveau de développement qui lui permet d'être utilisé pour démontrer clairement un changement du risque lors de l'étude et de la mise en place d'une séparation de trafic. Une réponse quantitative à quelques-unes des questions de base peut être apportée en appui au changement proposé – par exemple:

- *Quelle doit être la longueur du couloir?*
- *L'organisation du trafic prévoit-elle une séparation suffisante du trafic?*

Lors de la proposition à l'OMI d'une nouvelle mesure de séparation de trafic des données quantitatives appuieront de façon significative la proposition et aideront ceux qui en évalueront le bien-fondé. Développements offshore: Il y a, au niveau international, une augmentation impressionnante des propositions d'installation de production d'énergie renouvelable en mer. L'utilisation d'IWRAP pour démontrer la modification du risque provoquée par ces propositions peut apporter une aide précieuse à l'évaluation, par exemple de la largeur du couloir, notamment lorsque deux sites ou plus doivent être évalués.

Il est évident qu'un poids disproportionné est attribué à ces questions et nous sommes maintenant capables d'utiliser l'IWRAP en toute circonstance pour assurer la sécurité du marin. La protection de certaines espèces, par exemple, peut parfois exiger le déplacement des limites d'un champ d'éoliennes, au détriment de la sécurité de la navigation. Ma présentation et mon rapport vont, à l'aide de l'outil IWRAP, démontrer de façon graphique les avantages d'une évaluation quantitative.

Paper not available

82 PRACTICAL ASPECTS IN THE IMPLEMENTATION OF MESSAGE 8 IN AIS AtoNs

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Hidrovía SA is a private firm that since 1995 has a concession from the Ministry of Public Works to realize the dredging and maintenance of Aids to Navigation in a stretch of the main waterway of Argentina from the Ocean to Corrientes (Argentina) situated 1487 Km upstream.

Message 8 is a very important AIS message. It allows transmitting additional information like meteorological information using the AIS system.

The implementation of transmission and reception of Message 8 can be done in different ways.

- The supplier supplies AIS equipment with associated transducers for measurement of different physical variables in a turnkey basis
- The User develops an interface for the transducer/transponder
- Work is done between Supplier and User to develop an adaptation of the AIS transponder to the used transducer
- Interfaces developed by third parties are used

The objectives of this paper are:
a) To share knowledge on practical aspects and difficulties of implementing transmission of meteo/hydro information via Message 8.
b) To present advantages and disadvantages of the different implementation possibilities.

Hidrovía S.A. es una empresa privada que tiene desde 1995 una concesión del Ministerio de Obras Públicas para realizar el dragado y el mantenimiento de Ayudas a la Navegación en un tramo de la principal vía navegable interior de Argentina, desde el Océano a Corrientes (Argentina), situada 1487 km aguas arriba.

El Mensaje 8 es un mensaje AIS muy importante que permite la transmisión de información adicional, como la información meteorológica, utilizando el sistema AIS.

La implementación de la transmisión y recepción del Mensaje 8 puede realizarse de diferentes modos.
- El Proveedor suministra equipos AIS con transductores asociados para la medición de diferentes variables físicas llave en mano
- El Usuario desarrolla una interfaz para el transductor/transpondedor
- Proveedor y Usuario trabajan conjuntamente para desarrollar una adaptación del transpondedor AIS al transductor utilizado
- Se utilizan interfaces desarrolladas por terceros

Los objetivos de esta ponencia son:
a) Compartir el conocimiento sobre los aspectos prácticos y las dificultades de la implementación de la transmisión de información meteorológica/hidrológica vía Mensaje 8.
b) Presentar las ventajas y desventajas de las diferentes posibilidades de implementación.

HIDROVIA SA est une société privée qui a depuis 1995 une concession du Ministère des Travaux Publics pour le dragage et l'entretien des aides à la navigation le long de la principale voie navigable de l'Argentine, de l'Océan jusqu'à Corrientes, à 1487 km en amont.

Message 8 est un très important message AIS. Il permet de transmettre des informations supplémentaires, par exemple météorologiques, par AIS.

L'installation de l'émission/réception du Message 8 peut se faire de différentes façons :

- *Le fournisseur vend l'AIS avec les transducers associés qui permettent de mesurer différentes variables physiques dans une turnkey basis*

- *L'utilisateur développe une interface pour le transducer/transponder*
- *La tâche entre le fournisseur et l'utilisateur est de développer une adaptation du transponder AIS au transducer utilisé.*
- *Utiliser des interfaces développées par un troisième partenaire.*

Les objectifs de ce rapport sont :
a) Partager les connaissances sur les aspects pratiques et les difficultés d'installation de la transmission d'informations météorologiques ou hydrographiques par Message 8
b) Présenter les avantages et inconvénients des différents moyens d'installation.

Practical aspects in the implementation of Message 8 in AIS AtoN

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INTRODUCTION

Hidrovía SA is a private firm that since 1995 has a concession from the Ministry of Public Works of Argentina to realize the dredging and maintenance of Aids to Navigation in an stretch of the main waterway of Argentina (Figure 1) that is part of the Paraná – Paraguay waterway from the Ocean just in front of Montevideo (Uruguay) to Santa Fe (Argentina) situated 800 km upstream where deep draught ships sail and since 2006 from Santa Fe (Argentina) to Corrientes (Argentina) situated another 640 Km upstream where the navigation is done mainly by convoys of big barges.

The company has gained great experience implementing electronic AtoN and has been very active installing AIS equipment on floating devices in the mentioned waterway. Additionally, jointly with the Argentine Navy, HIDROVIA S.A. has started in 2012 the operation of the first AIS-AtoN in the Antarctica, as published in IALA Bulletin 3-2013.

This paper is as a follow up of the paper presented at the XVIIth IALA Conference held in Cape Town, South Africa in 2010 "Practical aspects of the use of AIS information".

Figure 1: Location of project area in South America

AIS INTRODUCTION

This short introduction to AIS has been extracted from IALA A-126 Recommendation and mentions to Message 8 has been highlighted

Automatic Identification System (AIS) is an autonomous broadcast system, operating in the VHF maritime mobile band. It exchanges information between mobile and fixed stations. It handles multiple reports, using different type of messages.

Primary purpose of an AIS AtoN is to promote and enhance safety and efficient navigation. One of the stated purposes is to provide weather, tidal, and sea state data.

AIS–ATON TYPE

There are three classifications of an AIS AtoN station, with different functionality

Type 1: This AIS-AtoN Station is a transmit-only station, operating in FATDMA mode. Hence the slots used by the Type 1 AIS-AtoN Station need to be reserved by a competent authority using Message 20, transmitted from an AIS base station in the coverage area. The Type 1 unit must be configured to use the slots reserved for it before being placed into service.

Type 2: This AIS-AtoN Station is not in common use but is similar to a Type 1. It has, in addition, an AIS receiver of limited capability which allows the Type 2 Station to be remotely configured via the AIS VDL. This receiver operates on a single AIS channel.

Type 3: This AIS-AtoN Station is more complex than the Type 1 and is therefore capable of:

- Autonomous operation, not requiring slot reservations (RATDMA);
- Autonomous operation using slots reserved by a competent authority, using message 20, transmitted from another AIS Station in the coverage area (FATDMA);
- Receiving and relaying AIS messages, including control and configuration messages for itself or for other AIS AtoN stations in a chain.

Message 8 can be transmitted using either AIS Type 1 or AIS Type 3 Stations.

According to our experience is recommended to use AIS Type 3 to realize the transmission due higher probabilities of having successful events.

MESSAGES

The standard messages are approved by ITU for use by AIS and the message 21 is the common navigation report.

In addition of message 21, an AIS AtoN may also transmit Messages 6, 7, **8**, 12, 13, 14, and 25. .

Msg ID	Message name	Message description	Application examples
6	Binary Addressed message	Binary data for addressed Communication	Monitoring of AtoN lantern Power supply, etc.
7	Binary acknowledge message	Acknowledge of addressed binary message	
8	**Binary Broadcast Message**	**Binary data for broadcast communications**	**Meteorological and hydrological data**
12	Addressed Safety Related Messages	Safety related data for addressed communication	Warn AtoN malfunctioning
13	Safety related acknowledge message	Aknowledge of addressed safety related message	
14	Bradcast Safety Related Message	Sfety related data for broadcast communication	Warn AtoN malfunctioning
21	AIS AtoN message		
25	Single slot binary message	Binary data for addressed or broadcast communication	Status report
26	Multiple slot binary message	Using SOTDMA	

Table 1: Summary of optional AIS AtoN Station messages

Amongst the functionality associated to the AIS system, an AtoN AIS can be used through its message 8 for additional services, such as providing meteorological and wave data which can be included in the electronic navigation platform. of stations

For AtoN Services that have meteorological networks this capability offers the possibility of transmitting data with very low cost of transmission. It is obligation of HIDROVIA SA to maintain a network of 36 telemetric water level measuring stations. Currently, transmission of water level data and condition is done via cellular phone and via communications satellite with their high associated costs.

Figure 2: Parana – Paraguay waterway

ALTERNATIVES OF IMPLEMENTATION

Four different ways of implementing transmission of hydro/meteo data using Message 8 have been attempted and are described below.

Alternative 1 – The supplier provides AIS equipment with associated transducers for measurement of different physical variables in a turnkey basis.

As an example, AtoNis from Automatic Power receives and transmits only signals from sensors supplied by this firm. This alternative could be a good solution for AtoN services that are beginning with the measurement and transmission of water levels and/or other meteo information. It is also a possibility when the number of measuring stations is low. For already installed important networks this situation is not convenient due to several reasons that are mentioned below

- Difficulty and costs of changing transducers. This implies not only the costs of buying new transducers but also installation costs in remote stations some of them far from the coast

- Technical staff in workshop and AtoN technicians on buoy tenders should be re-trained on new transducers characteristics, data loggers and their configurations.
- The hydro meteorological network is part of a Quality Management System. Therefore migrating to new equipment will lead to modifying most of the documents involved
- The change may have implications in fully or partly updating the current hydro meteorological network because the transmitting system runs through a management software that cannot "see" the AIS protocol.
- From a reliability point of view and due to the criticality of the level of service of this hydro meteorological network the decision of a massive replacement of equipment would imply important risks

This is the case of HIDROVIA where 36 water level measuring stations are already functioning and they include other types of transducers. Therefore Alternative 1 has been considered not suitable in our case

Figure 3: Water level/meteorological measuring stations – 24 stations from Santa Fe to the Ocean

Alternative 2 – The User develops an interface for the transducer/transponder.

One actual problem to use this AIS capability is that AIS transponders as usually supplied by providers do not interface easily with physical transducers.

One of these companies (Sinequanon) requires that the interface is designed and built by the user. Other suppliers require additional software to be developed.

In all cases an important development of software and in some cases hardware has to be done in-house.

During the 2009-2012 period HIDROVIA has tried Alternative 2 with the idea of implementing a specially designed interface to capture the transducer signal and to translate it into the Met/Hydro information that the AIS transducer should receive to be in order of retransmit it. The result after numerous trials was not successful due to the complexity of making compatible different operative protocols of each transducer.

Figure 4: Water level/Meteorological measuring stations – 12 stations from Santa Fe to Corrientes

Alternative 3 – Joint work is done between AIS Supplier and User to develop an adaptation of the AIS transponder to the types of transducers currently in use.

Since 2011 HIDROVIA has been working in this approach in conjunction with Kannad (Orolia Group).

As part of the program, six Type 3 AIS – AtoN from Kannad and one ultrasonic speed and wind direction transducer from AirMar were bought and the technical specs and communication protocols were provided by the supplier.

The transponders were fully analyzed in our workshop having a permanent contact with the supplier for the various evaluations performed related with functionality for meteo data transmission.

Despite that in the beginning of these tests no satisfactory results were achieved, further exchange with Kannad and the transducer´s manufacturer allowed to prove its functionality that was determined independently of a connection to the AIS transponder.

After confirming the reliability of the sensor and the data integrity, works for connecting transducer and transponder were started.

Up to this point, HIDROVIA S.A. had no specific software for monitoring Message 8 parameters. So, in the preliminary testing phase and due to supplier´s advice a tool included in the transponder configuration software package was used. With this tool every AIS message could be viewed and the meteorological messages could be parted.

It is to mention that usual programs for AIS visualization like SHIPPLOTTER are of low cost but they do not allow the visualization of Message 8. For this purpose it is necessary to acquire specific software programs like Vigie AtoN Supervision System of Kannad or similar that have values of around Euros 15,000.- This amount has to be considered in the economic evaluation of the project.

The image on the bottom left shows the detail of a decoded Message 8 with the default parameters (when no transducers are connected to the transponder).

```
AIS channel:1
Message ID=8
Repeat Indicator=0
Source ID (MMSI)=997011017
Spare=0
Binary Data
    Application identifier=0x005F(95)
        DAC=1(International)
        Function identifier =31(Reserved for international operational applications)
    Application data:
Longitude=0x3586E2(058°027.938 W)
Latitude=0x1FAD91(34°036.049 S)
Pos. acc.=0
Date and time=0xF387(30 14h07m)

Average wind speed=0x7F(127 kts)
Wind gust=0x7F(127 kt(s))
Wind direction=0x168(360 degree(s))
Wind gust direction=0x168(360 degree(s))
Air temperature=0xFFFFFC00(-102.4 degree(s) Celcius)
Relative humidity=0x65(101percent)
Dew point=0x1F5(50.1 degree(s) Celcius)
Air pressure=0x1FF(1310 hPa)
Air pressure tendency=0x3(3(Not available))
Horizontal visibility=0x7F(12.7 NM)
Water level=0xFA1(30.01 m)
Water level trend=0x3(3)
Surface current speed=0xFF(25.5 kts)
Surface current direction=0x168(360 degree(s))
Current speed #2=0xFF(25.5 kts)
Current direction #2=0x168(360 degree(s))
Current measuring level #2=0x1F(31 m)
Current speed #3=0xFF(25.5 kts)
Current direction #3=0x168(360 degree(s))
Current measuring level #3=0x1F(31 m)
Significant wave height=0xFF(25.5 m)
Wave period=0x3F(63 Sec)
Wave direction=168(360 degree(s))
Swell height=0xFF(25.5) m
Swell period=0x3F(63 Sec)
Swell direction=0x168(360 degree(s))
Sea state=0xD(13 Beaufort)
Water temperature=0x1F5(50.1 degree(s) Celcius)
Precipitation=0x7(7 according to WMO)
Salinity=0x1FE(51.0 permil)
Ice=0x3(3)
```

After successfully connecting the AIRMAR PB150 WeatherStation transducer, it was confirmed that meteorological messages of speed and wind direction were transmitted, as highlighted in the next image.

```
AIS channel:1
Message ID=8
Repeat Indicator=0
Source ID (MMSI)=997011017
Spare=0
Binary Data
    Application identifier=0x005F(95)
        DAC=1(International)
        Function identifier =31(Reserved for international operational applications)
    Application data:
Longitude=0x3586E4(058°027.940 W)
Latitude=0x1FAD94(34°036.052 S)
Pos. acc.=0
Date and time=0xF3D9(30 15h25m)

  Average wind speed=0x6(6 kts)
  Wind direction=0x29(41 degree(s)
  Air temperature=0xA5(16.5 degree(s) Celcius)
  Relative humidity=0x65(101percent)
  Dew point=0x1F5(50.1 degree(s) Celcius)
  Air pressure=0xE4(1027 hPa)
  Air pressure tendency=0x3(3(Not available))
  Horizontal visibility=0x7F(12.7 NM)
  Water level=0xFA1(30.01 m)
  Water level trend=0x3(3)
  Surface current speed=0xFF(25.5 kts)
  Surface current direction=0x168(360 degree(s))
  Current speed #2=0xFF(25.5 kts)
  Current direction #2=0x168(360 degree(s))
  Current measuring level #2=0x1F(31 m)
  Current speed #3=0xFF(25.5 kts)
  Current direction #3=0x168(360 degree(s))
  Current measuring level #3=0x1F(31 m)
  Significant wave height=0xFF(25.5 m)
  Wave period=0x3F(63 Sec)
  Wave direction=168(360 degree(s))
  Swell height=0xFF(25.5) m
  Swell period=0x3F(63 Sec)
  Swell direction=0x168(360 degree(s))
  Sea state=0xD(13 Beaufort)
  Water temperature=0x1F5(50.1 degree(s) Celcius)
  Precipitation=0x7(7 according to WMO)
  Salinity=0x1FE(51.0 permil)
  Ice=0x3(3)
```

In the next step, and considering the advances made with the Airmar transducer and the transmission of Message 8, an interface was developed for converting analogic signals (from water level transducers currently in use by Hidrovía S.A. in the meteorological station network) into digital ones, that could be recognized by Kanaton3 transponder and sent as meteorological AIS messages (Message 8) .

Next page is shown an image of capture and decoding of water level data sent through the AIS transponder as Message 8. Water level data are highlighted

IMPLEMENTATION OF ALTERNATIVE 3

During this phase of the Project, several troubles had to be solved, concerning: usage of transducers from different manufacturers, disparity among

```
AIS channel:1
Message ID=8
Repeat Indicator=0
Source ID (MMSI)=997011017
Spare=0
Binary Data
   Application identifier=0x005F(95)
      DAC=1(International)
      Function identifier =31(Reserved for international operational applications)
   Application data:
Longitude=0x3586E2(058°027.938 W)
Latitude=0x1FAD95(34°036.053 S)
Pos. acc.=0
Date and time=0xF447(30 17h07m)
Average wind speed=0x7F(127 kts)
Wind gust=0x7F(127 kt(s))
Wind direction=0x168(360 degree(s))
Wind gust direction=0x168(360 degree(s))
Air temperature=0xFFFFFC00(-102.4 degree(s) Celcius)
Relative humidity=0x65(101percent)
Dew point=0x1F5(50.1 degree(s) Celcius)
Air pressure=0x1FF(1310 hPa)
Air pressure tendency=0x3(3(Not available))
Horizontal visibility=0x7F(12.7 NM)
Water level=0x730(8.40 m)
Water level trend=0x3(3)
Surface current speed=0xFF(25.5 kts)
Surface current direction=0x168(360 degree(s))
Current speed #2=0xFF(25.5 kts)
Current direction #2=0x168(360 degree(s))
Current measuring level #2=0x1F(31 m)
Current speed #3=0xFF(25.5 kts)
Current direction #3=0x168(360 degree(s))
Current measuring level #3=0x1F(31 m)
Significant wave height=0xFF(25.5 m)
Wave period=0x3F(63 Sec)
Wave direction=168(360 degree(s))
Swell height=0xFF(25.5) m
Swell period=0x3F(63 Sec)
Swell direction=0x168(360 degree(s))
Sea state=0xD(13 Beaufort)
Water temperature=0x1F5(50.1 degree(s) Celcius)
Precipitation=0x7(7 according to WMO)
Salinity=0x1FE(51.0 permil)
Ice=0x3(3)
```

communication protocols of sensors and AIS equipment, adaptation of transducer signal to NMEA protocol, and connection layout and shape.

Regarding existing transducers re-usage, transducers with NMEA interface make an easier integration to AtoN AIS.

NEXT STEPS

In the period November 2013 – March 2014 following activities will be performed:

- Validation of the development of the interface
- Functional test of the interface – sensor – AIS at workshop
- Computations of energy consumption and working current of sensor
- Installation in the field and test of prototype

If results are positive the program will continue to incorporate the rest of the water level measuring stations.

With the functioning of this alternative reduction in transmission costs will be evaluated comparing the actual situation with the new situation. It is foreseen that an important saving in transmission costs will be achieved

CONSIDERATIONS ABOUT THE DEVELOPMENT:

Connections between sensors, interface and computer have to be carefully studied so as to prevent conflicts, because communication modes refer to different regional standards.

Also, communication speed and computer port compatibility can generate disconnections and "hang" some devices.

The various types of transducers to be connected to the interface can complicate its development from the hardware as well as the software point of view.

To make the interface apt for working in marine conditions is crucial because any fault that might occur can lead to a complete failure of the station, due to a short-circuit.

ALTERNATIVE 4

We have recently acknowledged that the Spanish Company Mediterráneo Señales Marítimas has developed its own interface for connecting analog/digital sensors to the input protocol of an AIS AtoN.

Consequently, two of these interfaces have been bought to be evaluated.

TRANSMISSION PHASE

In order to generate intermediate transmission nodes, spar buoys or similar structures had to be deployed. This type of AtoN can accommodate more installed power and have plenty of space for installing masts and VHF antennae.

Coastal reception stations had to be installed to ensure the link to the AIS data coming from the network. These stations allow data collection and to retransmit them via internet.

Also a program for ensuring operation and maintenance of coastal stations was developed, due to the conditions they have to endure: vandalism, settlement proximity, atmospheric discharges, power supply, etc.

The Meteorological data received by the AIS network comes in a different format to the one from the original network and, consequently, to the general database which collects information from digital and satellite mobile phones. This implies reconfiguring the data in order to have the right input to the generic database.

ADVANTAGES

Reliability of the installed equipment has increased because the water-tightness and durability are guaranteed by their extreme environmental exposure design. An implementation on a satellite modem does not meet those standards.

From the economic point of view, one of the advantages in transmitting meteorological data through Message 8 is that it is free of charge. On the contrary, the trimestral cost of transmissions via satellite is equivalent to a Type 3 AIS AtoN.

CONCLUSIONS

Implementing the use of hydro/meteo data through the use of Message 8 is not an easy task for Services that have already installed networks

Implementing message 8 for sending meteorological data synergizes waterway navigation safety, allowing users to get real time weather conditions.

The reduction in costs associated to traditional meteorological data transmission vs. the amounts required for implementing message 8 is really significant. This situation is directly related to the size of the hydro meteorological network.

Investigation, development and implementation of new technologies generate an incentive with direct impact in the technical staff associated with the project. ■

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83 ATLANTIC COAST PORT ACCESS ROUTE STUDY AND COASTAL MARINE SPATIAL PLANNING

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One mission of the U.S. Coast Guard is to preserve navigational safety, even as new ocean uses emerge along the coastal regions of our waters, such as offshore renewable energy installations. The U.S. Coast Guard is conducting an Atlantic Coast Port Access Route Study to study the navigational uses off the Atlantic Coast in support of the rapidly developing renewable energy industry, especially wind farms and to provide data to support future Coastal and Marine Spatial Planning efforts. The entire Atlantic Coast from Maine to Florida including those waters located seaward of the existing port approach systems within the Exclusive Economic Zone are being studied. This paper will identify the various impacts that require a thorough understanding of the interrelationships of shipping and other commercial uses, recreational uses, and port operations.

Una de las misiones de la Guardia Costera de Estados Unidos es mantener la seguridad de la navegación, aun cuando surjan nuevos usos del océano a lo largo de las regiones costeras de nuestras aguas, tales como las instalaciones de energías renovables mar adentro. La Guardia Costera de Estados Unidos está realizando un Estudio de Rutas de Acceso a Puerto en la Costa Atlántica para estudiar los usos náuticos de la Costa Atlántica como apoyo al rápido desarrollo de la industria de las energías renovables, especialmente parques eólicos, y para proporcionar datos para apoyar futuros programas de Planificación Espacial Marina y Costera. Se está estudiando toda la Costa Atlántica desde Maine hasta Florida, incluyendo las aguas localizadas hacia el mar de los sistemas de acercamiento a puerto existentes dentro de la Zona Económica Exclusiva. Esta ponencia identificará los diferentes impactos que requieren una profunda comprensión de las interrelaciones del tráfico marítimo y otros usos comerciales, usos recreativos y operaciones portuarias.

Une des missions de la Garde côtière des Etats Unis est de préserver la sécurité de la navigation, alors que de nouvelles utilisations de la zone côtière, telles que l'installation de sources d'énergie renouvelables, apparaissent. La Garde côtière des Etats-Unis a entrepris une étude des routes d'accès aux ports atlantiques concernant l'utilisation de la zone côtière atlantique pour aider dans le développement rapide de l'industrie de l'énergie renouvelable, particulièrement les champs d'éoliennes, et fournir des données à l'appui des efforts de planification future de l'environnement maritime et côtier. Toute la côte atlantique depuis le Maine et jusqu'à la Floride est concernée, y compris les systèmes d'approche d'un port dans la Zone Economique Exclusive. Le rapport identifie les différents impacts qui demandent une compréhension des interactions entre la navigation et les autres utilisations commerciales, celles de la plaisance et des opérations portuaires.

Atlantic coast port access route study and coastal marine spatial planning

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PURPOSE OF THE ATLANTIC COAST PORT ACCESS ROUTE STUDY

The purpose of the Atlantic Coast Port Access Route Study (ACPARS) is to identify all current and anticipated new users of the Western Atlantic near coastal zone, and determine what impact the siting, construction and operation of proposed alternative energy facilities may have on these users and whether vessel routing measures should be created to ensure the safety of navigation. To ensure safety of navigation, the U.S. Coast Guard (Coast Guard) needs to fully characterize the impacts of rerouting maritime traffic, funneling traffic, and placement of structures that may obstruct navigation. Some of the impacts may include increased vessel traffic density, more restricted offshore vessel routing (seaward of pilotage areas), fixed navigation obstructions, underwater cable hazards, a larger need for more and varied types of aids to navigation, and other economic impacts.

One mission of the Coast Guard is to preserve navigational safety, even as new ocean uses emerge along the coastal regions of our waters, such as offshore renewable energy installations (OREIs). These installations may be facilities that harness wind, currents, tides, and hydrothermal energy to generate electricity. OREI development is new in the United States and may present unanticipated marine and navigational safety challenges.

In order to justify and support the establishing of new or adjusting existing traffic separation schemes

(TSSs) and shipping safety fairways as well as creating other types of routing measures, the Coast Guard is conducting the ACPARS.

The ACPARS Workgroup (WG) was chartered in May 2011 and was created to address the potential navigational safety risks associated with the development of OREIs (primarily wind farms) and to support future marine spatial planning efforts. The WG was given three objectives to complete which are to -

1) Determine whether the Coast Guard should initiate actions to modify or create shipping safety fairways, TSSs or other routing measures;
2) Provide data, tools and/or methodology to assist in future determinations of waterways suitability for proposed projects; and
3) Develop, in the near term, Automatic Identification System (AIS) products and provide other support as necessary to assist Districts with all emerging coastal and offshore energy projects.

The study is still in progress because the modeling and analysis identified at the beginning of the study, and further reinforced as the study has progressed, as being critical to evaluating changes in navigational risk, has not been completed.

BACKGROUND

The ACPARS was initiated to study the navigational uses off the Atlantic Coast in support of the Bureau of Ocean Energy Management (BOEM) "Smart from the Start" initiative and provide data to support future Coastal and Marine Spatial Planning (CMSP) efforts. The study area includes the entire Atlantic Coast (Maine to Florida), but not focused on the port areas from the sea buoy into the port like a typical port access route study. It is focused on those waters located seaward of the existing port approach systems within the Exclusive Economic Zone (EEZ). The intent of the ACPARS is to identify all current and anticipated new users of the Western Atlantic near coastal zone, and determine what impact the siting, construction and operation of proposed alternative energy facilities may have on existing near coastal users and whether routing measures should be created to ensure the safety of navigation. Analyzing the various impacts requires a thorough understanding of the interrelationships of shipping and other commercial uses, recreational uses, and port operations.

BOEM's "Smart from the Start" wind energy initiative for the Atlantic Outer Continental Shelf (OCS) was launched in November 2010 to accelerate siting, leasing and construction of new projects. In a Department of Interior (DOI) press release, BOEM Director Michael Bromwich was quoted as saying, "This accelerated and focused approach to developing the nation's Atlantic Wind resources will encourage investment while ensuring projects are built in the right way and in the right places."[1]

Up to now, Wind Energy Areas (WEAs) have been identified or considered off the coasts of Maine, Massachusetts, Rhode Island, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina. WEAs are offshore locations that appear most suitable for wind energy development. Coincidently, the identified WEAs are located at or near the entrances to major ports because the wind energy potential in these areas is suitable for possible commercial exploitation. The depth of water is adequate for wind farm construction and there is landside electrical energy infrastructure within acceptable distances to connect to the wind farms. The locations of some of the identified WEAs are at or near the seaward terminus of existing TSSs. Other WEAs are located in or very near the traditional routes used by vessels in foreign trade and on Atlantic coastwise transits. The impact to safe and efficient navigation appears to be significant; although not yet characterized.

STUDY APPROACH

The Coast Guard workgroup is conducting the ACPARS. The core group consists of waterways management specialists from Coast Guard's Headquarters, Atlantic Area and Districts One, Five and Seven, but at times also includes other personnel from supporting offices throughout the Coast Guard, and from other government agencies such as the National Oceanic and Atmospheric Administration (NOAA) and the Maritime Administration (MARAD).

The WG created a four-phase Project Management Plan. The first two phases are essentially complete, but are refined as new data are identified. Phase Three has been started and is still in progress. Phase Four will be started once Phase Three is complete. Each of the Four Phases, their major action items, and progress to date are explained further:

Phase 1 – Data Gathering

In Phase 1, the WG gathered data on existing and future waterway usage. This was accomplished by -

- Determining traditional shipping routes using available Automatic Identification System (AIS) data and any other available data on maritime traffic patterns.
- Combining AIS and other available data then analyzing the data to determine existing shipping routes and displaying routes in a geospatial format.
- Gathering additional data and information to identify existing and future waterways usage through public comments.
- Conducting stakeholder outreach through industry organizations and port level committees.
- Gathering maritime transportation system information from other federal agencies.

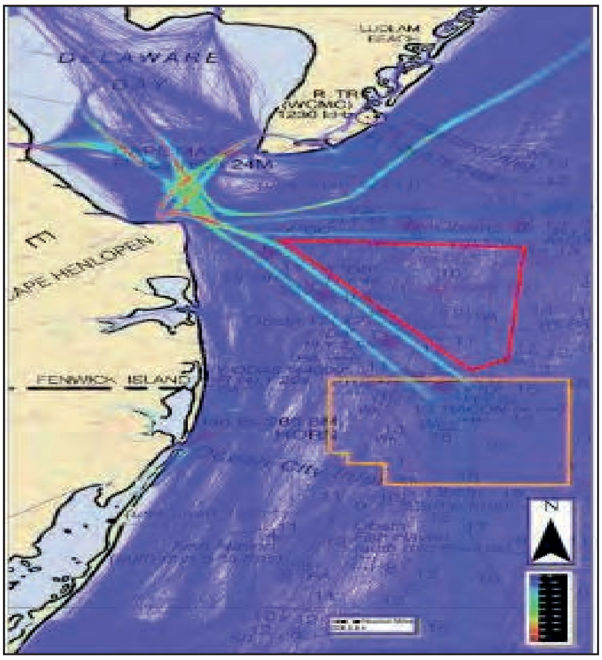

Figure 1: Heat Map of the Delaware Bay Entrance[2]

AIS data is the primary source of vessel transit data available to the Coast Guard and the WG. The WG initially discovered that the Coast Guard AIS database was designed to store large amounts of historical AIS data, not to extract and analyze the data. The ACPARS was the first effort by the Coast Guard to analyze AIS data on such a large scale. As a result, the Coast Guard did not have the capability to process the AIS data as desired and the WG was not able to characterize vessel traffic to the extent that was needed. The Coast Guard was able to produce some AIS products that enabled the WG to compare vessel traffic to proposed wind energy areas.

Available in the AIS data are several information fields including, but not limited to, the vessel type, speed, direction, length, draft, and a time/date stamp. The heat maps and density plots produced by the Coast Guard were primarily limited to only depicting all vessels for a one year period. What the WG needed was the ability to process the AIS data by each of the individual information fields.

Once the shortfall was identified, a GIS specialist was contracted to develop methodologies and processes to analyze the AIS for the ACPARS and produce more extensive and refined products. The methodologies included GIS Analysis with AIS Data from Marine Cadastre, Data Processing and Analysis with Coast Guard provided AIS Data, and Operational Performance Analysis.

In the first methodology, visual geospatial products were created from AIS data publically available on the Marine Cadastre. This data was already processed into a geospatial format and ready for immediate analysis. The GIS specialist developed geoprocessing scripts to create maps showing broadcast point characteristics (such as direction), tracklines, average direction of tracklines, and traffic density maps. Because the data was pre-processed, there were some limitations as to how the data could be used and what conclusions could be drawn.

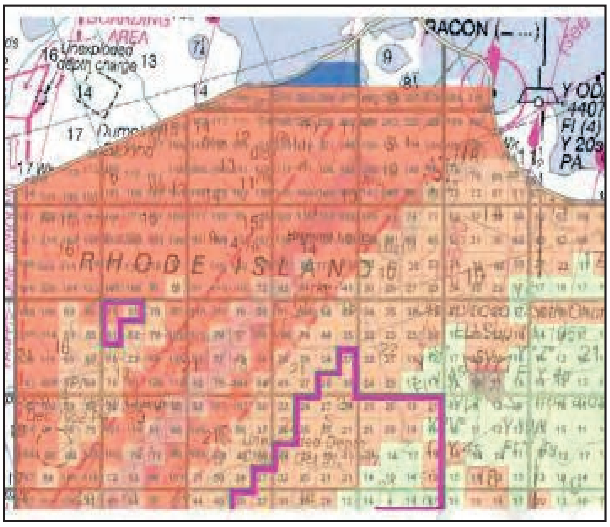

Figure 2: Density Plot of the Entrance to Buzzard's Bay[3]

A second methodology and scripts were also developed to process Coast Guard historical AIS data into a geospatial format. The GIS specialist developed an automated methodology for converting the comma separated value (CSV) format AIS data to spatial formats. In addition, the specialist created Python geoprocessing scripts to automate the production of maps showing tracklines by month, kernel density of tracklines by month, and tracklines by vessel type.

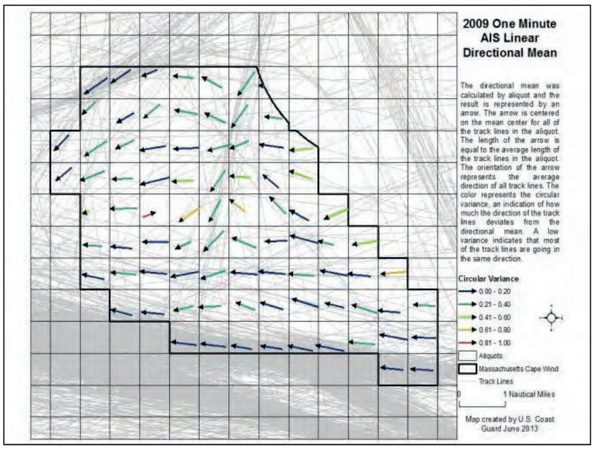

Figure 3: Example of Linear Direction Mean

The cartographic products can only be as good as the data from which they are produced. In order to gauge the data integrity, a methodology to measure the quality of the AIS datasets was developed. The operational performance of Nationwide AIS (NAIS) was measured by determining the number of messages that were expected to be received by NAIS receivers and comparing this to the number that were actually received. Areas where a large number of AIS messages were missing indicated areas of poor NAIS performance. The performance of the system must be considered as conclusions are drawn about historical vessel traffic because the performance affects the number of AIS broadcast messages received. In areas of poor performance, it is important to avoid concluding that vessel traffic is low based only on the lack of data.

The Coast Guard published two formal requests for comments through the U.S. Government's *Federal Register*. Twenty six (26) submissions were received to the ACPARS docket during the first comment period and 103 submissions were received in the second comment period for a total of 129 submissions. Of the 129 submissions, 57 (45%) were determined to be outside the scope of the ACPARS and 3 others were duplicate submissions.

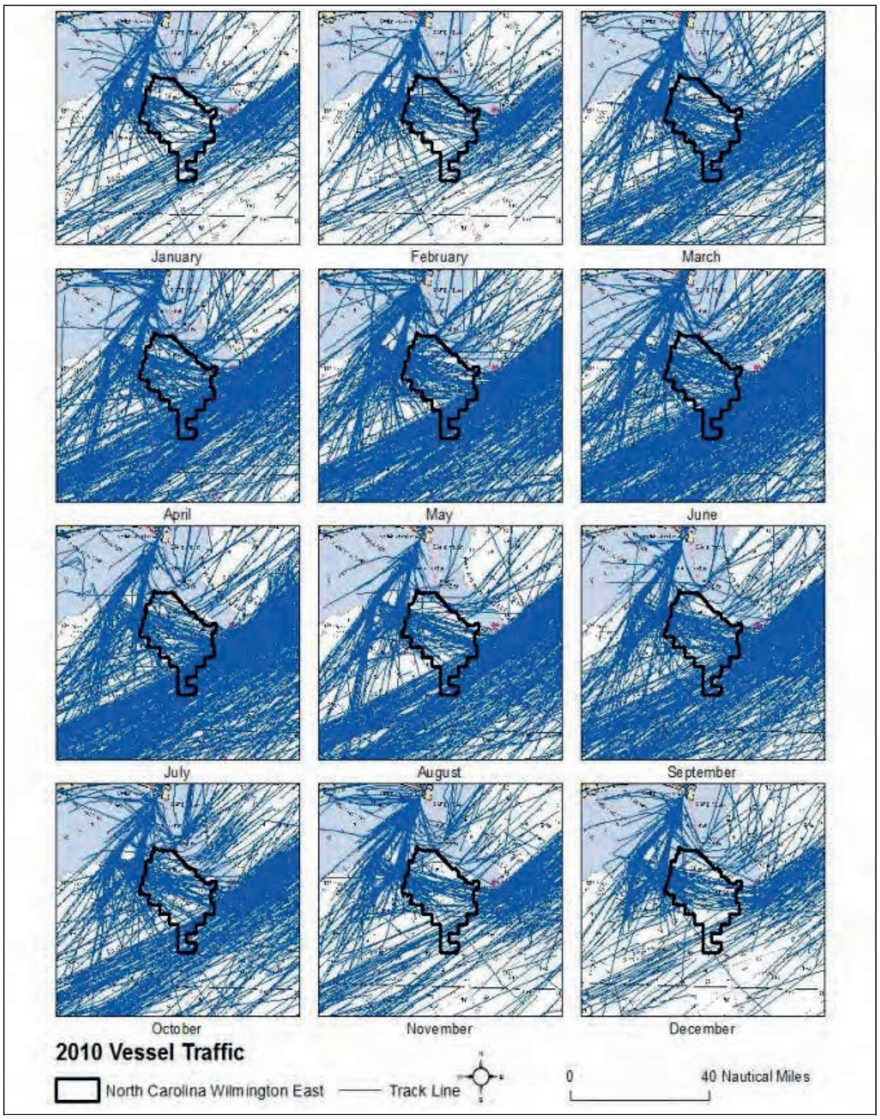

Figure 4 - Example Tracklines by Month Maps for Wilmington East WEA

The remaining submissions were reviewed and specific comments and/or recommendations identified, resulting in a total of almost 300 individual comments. These comments were grouped into categories such as - Anchorage, Assistance, Buffer/Buffer Zone/Separation Distance, Cost Benefit Analysis, Environmental Impacts, Hazards, Navigational Aids, Precautionary Areas, Routes, Routing Measures, Risk Assessment, Siting, and Watchstanding (shipboard).

In addition to the requests for public comments, the WG has engaged and continues to engage in an extensive outreach campaign seeking participation from local, regional, national and international port and industry stakeholders. To achieve this, the WG has taken several approaches to ensure the widest audience is reached. The approaches include:

Leveraging existing regional partnerships and relationships between local Coast Guard units and local port partners to encourage input to the study; Conducting targeted outreach to the towing vessel community;

- Sending letters to industry organizations to ensure awareness of the ACPARS study;
- Developing a website[4] to better communicate to all potential stakeholders to bolster their outreach efforts; and,
- Conducting national level outreach by Coast Guard Headquarters to ensure partner agencies and national level organizations were engaged.

As part of the data gathering phase the WG explored the social and economic benefits of the many uses of the waters off the Atlantic Coast including maritime trade, commercial fishing, recreational fishing, tourism and recreation. In understanding the many varied uses of the Marine Transportation System (MTS), it is important to consider future trends, particularly as they pertain to balancing multiple uses. The WG identified three major areas that may impact future uses of the Atlantic Coast waters including the expansion of the Panama Canal, the MARAD's America's Marine Highway Program, and future exploitation of energy resources on the OCS.

Phase 2 – Apply Suitability Criteria

In Phase 2, the WG used the shipping routes identified in Phase 1 and applied the best available guidance (such as United Kingdom (UK) Maritime Guidance Note MGN-371) to identify areas within the study area that are:

- Unsuitable for OREIs because of proximity to or location within existing routes;
- Potentially suitable for OREIs but require further study and analysis to determine if mitigation measures can reduce the navigational safety risk to tolerable levels; or,
- Potentially suitable for OREIs based on available data that suggest the navigational safety risk is acceptable without additional mitigation measures.

The original intent in Phase 2 was to make an analytical determination of existing shipping routes by analyzing the AIS data to determine routes that encompassed 95% of the traffic (+ or- 2 standard deviations) traveling in the same or opposing directions.[5] The WG applied the Red-Yellow-Green (R-Y-G) methodology to make an initial determination of where there is high, medium or low conflict for the entire study area. Due to the limitations in the ability to process and analyze the AIS data, the WG was unable to conduct the analytical determination of vessel routes and was also unable to conduct an initial R-Y-G determination for the entire Atlantic offshore waters. As a result the WG made subjective determinations (visual) using the AIS products described in Phase 1 to apply the R-Y-G methodology to the proposed WEAs. The WG still considers it important that an analytical determination of traditional routes be completed as a starting point for determining potential conflicts with vessel traffic.

Red–Yellow–Green Methodology

As part of Phase 2 the WG developed a methodology based primarily on the UK Maritime Guidance Note 371 to make preliminary determinations of suitability of proposed wind development areas with regard to navigation. MGN 371 provided three break points between WEAs and vessel traffic routes that were thought to be most significant and useful to this determination:

- 1 NM - The minimum distance to the parallel boundary of a TSS. At this distance there would still be S band radar interference and an Automatic Radar Plotting Aid (ARPA) is affected. This is also the boundary between High/Medium navigational safety risk.
- 2 NM – The distance where compliance with Collision Regulations (COLREGS) becomes less challenging, mitigation measures would still be required to reduce risk As Low As Reasonably Practicable (ALARP). This is also the boundary between Medium/Low navigational safety risk.
- 5 NM –The distance where there are minimal impacts to navigational safety and risk should

be acceptable without additional mitigation. This is also the boundary between Low/Very Low navigational safety risk.

Distance	Factors	Risk	
<0.25 NM	Inter-turbine spacing = only small craft recommended	Very High	RED
0.5 NM	Mariner's high traffic density domain	High	RED
1.0 NM	Minimum distance to parallel boundary of TSS	Medium	YELLOW
1.5 NM	S band radar interference - ARPA affected	Medium	YELLOW
2.0 NM	Compliance with COLREGS becomes less challenging	Medium	YELLOW
>2.0 NM	But not near a TSS	Low	YELLOW
5.0 NM	Adjacent wind farm introduces cumulative effect Distance from TSS entry/exit	Very Low	GREEN
10.0 NM	No other wind farms	Very Low	GREEN

Figure 5: Application of UK Maritime Guidance Note 371 for Red-Yellow-Green Methodology

The WG selected the transition points where risk went from High to Medium (1 NM) and from Low to Very Low (5 NM). Note there is still radar interference at 1.5 NM and compliance with COLREGS is described as challenging out to 2 NM. The reason for not taking a more conservative approach with larger separation distances was the desire to initially leave as much of the proposed areas as available for consideration by WEA developers early-on in the process with the understanding that it would be an iterative process and more area could be removed at a later time. For the "Smart from the Start" process, once lease blocks or aliquots were removed from consideration they could not be added back to the WEA.

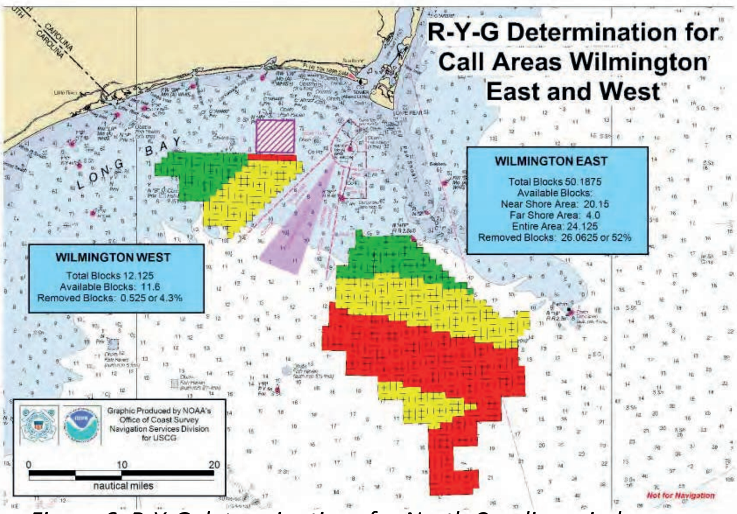

Figure 6: R-Y-G determinations for North Carolina wind energy areas (Graphic courtesy of NOAA)

To date, R-Y-G determinations have been completed for Maryland, Massachusetts/Rhode Island Area of Mutual Interest, Virginia and North Carolina. The majority of the areas, that remain for consideration, have been designated as Yellow, and therefore, require additional analysis to determine if impacts to navigational safety risk can be mitigated to within acceptable limits.

Phase 3– Modeling and Analysis

The WG recognized the need to conduct modeling and analysis to predict changes in traffic patterns and determine the change in navigational risk due to the complex interactions of the various factors that would impact navigational safety. The tasks to be accomplished in Phase 3 were beyond the technical capabilities and capacity of the WG and Coast Guard resources. Phase 3 would include:

- Developing a Geospatial Information System (GIS) based model to predict traffic density and traffic patterns that would incorporate the UK methodology[6] or equivalent to determine the resultant navigational safety risk given alternative siting scenarios and mitigating measures. The model should be able to identify the individual and cumulative effects on the MTS along the Atlantic Coast;
- Assessing the resultant navigational safety risk associated with potential wind development areas with and without changes to routing measures or other navigational safety measures (pilotage, separation distances, regulated navigation areas, etc.);
- Conducting analyses of potential mitigating measures to determine if modifying existing or creating new routing measures, or implementing other navigational safety measures (pilotage, separation distances, regulated navigation areas, etc.) are necessary to reduce risk to within acceptable levels and to minimize overall impacts to the MTS;
- Evaluating options for the creation of coastwise routing measures and make recommendations for the creation of a system of routing measures that would ensure navigational safety remains within acceptable limits while having the ability to accommodate multiple uses today and in the future; and
- Publishing a final report.

From the beginning of the ACPARS effort, the WG understood that for the Coast Guard to make appropriate recommendations to BOEM with regard to impacts to navigation, a modeling solution must be employed that examines how the dynamics of marine transportation would change in response to a wind farm project installation. The WG surveyed the European markets and looked for guidance from the more mature projects' regulators and developers. The science of navigational impact assessments has evolved in Europe to match pace with the advancing OREI environment. The UK methodology, "Guidance on the Assessment of the Impact of Offshore Winds Farms: Methodology for Assessing the Impact of Wind Farms" was identified as the best available guidance.

Knowing that the modeling and analysis were beyond the capabilities of the Coast Guard, a Statement of Work (SOW) was drafted that incorporated the concepts of the assessments being conducted in Europe and was provided to BOEM for consideration. The Coast Guard articulated the need for modeling and analysis to DOI and BOEM at a meeting in March, 2011. DOI/BOEM acknowledged the need and agreed to identify the funding to accomplish Phase 3 modeling and analysis.

BOEM would fund the contract directly, using one of the Department of Energy (DOE) National Labs. BOEM received proposals from the labs and after review by both the WG and BOEM staff; BOEM selected Pacific Northwest National Lab (PNNL) to conduct the modeling and analysis portion of the study.

Although the intent of Phase 3 was to develop a GIS based model to predict changes in traffic patterns and determine the resultant navigational safety risk in order to evaluate options for routing measures, the WG made an attempt to identify preliminary recommendations for routing measures. NOAA hosted the WG and provided assistance with displaying AIS data for the entire study area. Given the available AIS data and comments from the public, the WG strove to identify fundamentally apparent routes along the Atlantic Seaboard and into major port areas.

A very broad summary analysis indicates, in the current unimpeded environment, vessels take roughly the same routes into major port areas, but outside of the harbor approach areas, the vessels take divergent routes depending on their destination and various factors that impact safety, such as type (size) of vessel, and route characteristics such as depth of water, weather, sea state, etc., resulting in many well-traveled, distinct offshore routes.

Viewing heat maps of the entire Atlantic Coast, the WG was able to identify numerous distinct routes and other large areas of high density. The WG attempted to document the myriad of routes and quickly realized it would not be possible to capture every traditional route. The WG found that if routes were to be combined to reduce the total number to a manageable level, it would increase vessel density and also result in the mixing of previously segregated vessel types (combining of slow moving and fast moving vessels).

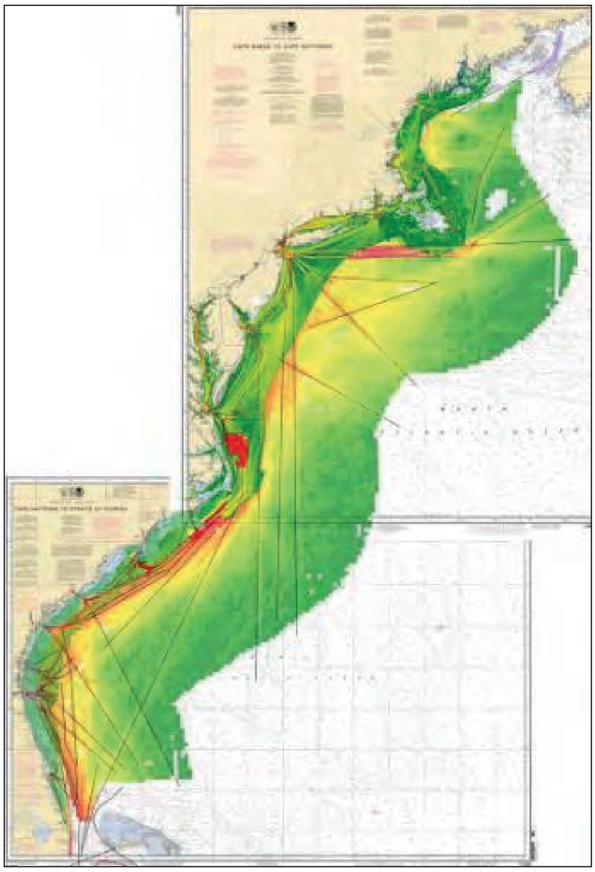

Figure 7: Atlantic Coast heat map with black lines depicting the center of traditional routes

The WG acknowledged that it did not have the capability to evaluate and quantify the impacts to navigational safety without the modeling and analysis described in Phase 3. A conservative approach to designating routing measures would quickly remove most of the wind energy areas already being proposed, which is not in the interest of facilitating other uses.

The WG came to the conclusion that it would be inappropriate to propose even preliminary routes based on incomplete AIS data and a rudimentary evaluation that has been completed to date. The modeling and analysis portions of Phase 3 are necessary to determine if routing measures would be appropriate.

Phase 4 – Implementation of Study Recommendations

Phase 4 cannot be started until the completion of Phase 3 and will consist of reviewing the final ACPARS report from Phase 3 to determine:

- If additional information is needed;
- If changes to routing measures or creation of new routing measures are recommended; or,
- Whether other actions are necessary such as documentation of traditional routes, changes in Coast Guard processes to determine suitability of proposed siting or updates to the Coast Guard Navigational Vessel Inspection Circular for OREIs.

If no additional information is needed, the Coast Guard will issue a Notice of Study Results, however, if additional information is needed, the Coast Guard will reopen the docket through a Federal Register notice and conduct outreach and public meetings as necessary.

Should the report recommend creating or amending routing measures, the Coast Guard will initiate regulatory and/or International Maritime Organization (IMO) processes as required.

SUMMARY

Impact to Shipping

The placement of structures on the Atlantic Coast OCS, where previously no structures existed, increases risk of a vessel allision (with a fixed object), and may increase risk of collision between vessels and/or groundings. The risks are increased as a result of vessel traffic density being increased through funneling and decreased sea space for maneuverability. Density plots and heat maps calculate density over a given period of time. For instance, density plots created by the Coast Guard might show that 320 vessels transited through a specific aliquot over the period of a year. What the plots do not reflect is how often two or more vessels pass within close range of each other, referred to as an encounter. The number of encounters is directly related to the risk of a collision. Rerouting (displacing) traffic may also increase the weather related casualty risk to smaller vessels engaged in coast-wise shipping by forcing them further offshore where they will be subjected to larger sea states, and where their transits will be commingled with deep draft vessels moving much faster.

Establishment of Wind Energy Areas

The R-Y-G Methodology provides a defensible process to evaluate proposed WEAs. The methodology leaves areas with moderate conflicts available for further study and potential leasing for site assessment and site characterization activities which is consistent with BOEM's desire to leave as much area available for further study, because once removed, areas cannot be added back in during this round. A full navigational safety risk assessment will be conducted later in the process during the approval of the Construction and Operations Plan (COP).

Risks of Postponing Assessment of Navigational Impacts

The "Smart from the Start" leasing process has accelerated and modified the traditional review process for projects. The conflicts between WEAs and shipping traffic appear to be significant, but will not be fully analyzed until later in the process. Given the management decision to take a less conservative approach and leave as much area available for further study until later in the process, the WG is concerned that this gives the public and developers a false sense that the WEA has in fact been approved and the siting of a WEA is fully acceptable for wind development. Unfortunately under BOEM's plan, the impacts to vessel traffic would not be fully evaluated until the preparation of an Environment Impact Statement (EIS) during the approval process of the COP. The Coast Guard has recommended that the potential impacts to navigation from the construction of wind farms be addressed as soon as possible for any area contemplated for development. The complexities of determining the impacts of the interaction of vessels and wind farms, the effects of increased vessel density and the impacts of decreased sea room require an analysis beyond what has been done to date. Only the site assessment and site characterization activities are currently being evaluated prior to issuing a lease and not the impacts of the actual construction and operation of the wind farm.

Other Offshore Energy Installations

Although the current emphasis off the Atlantic Coast is for offshore wind energy, other exploration and exploitation activities that may occur in the study area in the future must be considered, such as hydrokinetics or traditional oil, gas and mineral extraction. The Administration's[7] and the Nation's desire for energy independence, all point to further exploration and exploitation of the vast energy potential available from the Atlantic OCS.

Tug and Barge Routes

Many factors affect the routes vessels take, but generally they take the most direct and safest route. Smaller and slower moving vessels tend to transit closer to shore, whereas larger and faster moving vessels tend to transit in deeper water further offshore. Based on initial evaluations, the highest conflict tug and barge routes and proposed WEAs are the coastwise routes. Their routes vary based on weather, sea state and depth of water necessary for the catenary to clear the bottom when towing astern. In many cases proposed WEAs, such as at the entrance to Delaware Bay, would force them to transit further inshore or offshore from their traditional routes. The offshore route would take them approximately 35 miles offshore and into routes used by larger deep draft vessels. This is much farther than they would normally transit, especially the smaller units. The alternative would force them inshore across the entrance to the bay at the convergence of the TSSs and pilot boarding areas, increasing traffic density and complicating crossing situations.

Deep Draft Routes

Deep draft vessels on coastwise routes appear to have less conflict with proposed WEAs. However, the coastwise routes are located in prime areas suitable for the next round of wind development in deeper water. It appears the biggest conflicts with deep draft vessels will be when entering and leaving major port areas where wind farms are proposed at or near harbor approaches. In the case of the proposed WEA for Virginia, a significant number of vessels currently transit through the proposed area and alternative routes would need to be evaluated.

Cumulative Impacts of Wind Farms

One of the driving concerns that led to conducting the PARS for the entire Atlantic Coast was to address the cumulative impacts of multiple winds farms. In the vicinity of the Delaware Bay entrance there are three proposed WEAs and each of them would displace vessel traffic. The result of which would funnel vessel traffic into smaller areas, increasing vessel density with concurrent increased risk of collision, loss of property, loss of life and environmental damage.

Evaluating the cumulative impacts are also important to understand the cascading effects of one wind farm that may change the routes and approaches to the next port or the next wind development area. Determining how vessels would alter routes given new obstructions and quantifying the resultant change in navigational risk remains beyond the capability of the WG.

RECOMMENDATIONS AND CONCLUSION

The Coast Guard will continue to engage with DOI/BOEM to ensure the modeling and analysis necessary to evaluate the impacts the proposed wind energy areas will have on other users of the near coastal area, impacts to navigation safety, and the effectiveness of any proposed routing measure will be completed.

With GIS analyst support, the ACPARS WG should

- Compare AIS data to the routing measures recommended in the public comments to determine if they are representative of traditional routes, and
- Explore the possibility of developing recommended routing measures that reflect existing routes.

The WG was given three objectives in its initial charter. The first objective, to determine whether the Coast Guard should initiate actions to create or modify routing measures, cannot be met without further analysis. The WG determined that modeling and analysis beyond the capability of the WG is required to make these determinations. The second objective to provide data, tools and/or methodology to assist in future determinations has been partially met with the R-Y-G Methodology, but can be further advanced with the envisioned modeling and analysis tools from Phase 3. The third objective, to develop AIS products and support Districts with emerging coastal and offshore energy projects, has been met to the best of the ability of the WG. ■

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- United Kingdom Department of Trade and Industry (DTI) "Guidance on the Assessment of the Impact of Offshore Winds Farms: Methodology for Assessing the Impact of Wind Farms."

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[1] DOI Press Release dated 23NOV2010, "Salazar Launches 'Smart from the Start' Initiative to Speed Offshore Wind Energy Development off the Atlantic Coast" http://www.doi.gov/news/pressreleases/Salazar-Launches-Smart-from-the-Start-Initiative-to-Speed-Offshore-Wind-Energy-Development-off-the-Atlantic-Coast.cfm

[2] "Heat map" is a term used for a depiction of line density or point density where the "hotter" color reflects a higher density.

[3] "Density Plots," refer to the number of vessels that transited through a defined area (such as an aliquot[3] or lease block) over a defined period of time.

[4] http://www.uscg.mil/lantarea/acpars/

[5] United Kingdom Department of Trade and Industry (DTI) Guidance on the Assessment of the Impact of Offshore Winds Farms: Methodology for Assessing the Impact of Wind Farms, p.97.

[6] United Kingdom Department of Trade and Industry (DTI) "Guidance on the Assessment of the Impact of Offshore Winds Farms: Methodology for Assessing the Impact of Wind Farms."

[7] http://www.whitehouse.gov/sites/default/files/email-files/fact_sheet_obama_administration_92s_all_of_the_above_a_windows_approach_to_american_energy.pdf

88 LIGHT MEASUREMENT OF TOWER OF HERCULES LIGHTHOUSE

Malcolm Nicholson, Link Powell. General Lighthouse Authorities, United Kingdom and Ireland

The Research and Radionavigation Directorate of the General Lighthouse Authorities of the UK and Ireland have, for many years, carried out 'in-situ' field light measurements of lighthouses in order to ascertain the light intensity performance upon re-engineering or a change in navigational requirement. A 'live' demonstration of the techniques used by R&RNAV will be given one evening during the conference with the present and a potential replacement light sources measured at the Tower of Hercules Lighthouse. Following the measurement, during the conference, the results will be presented along with a description of the techniques used and the common problems associated with conducting measurements of this nature.

La Dirección de Investigación y Radionavegación de las Autoridades Generales de Faros del Reino Unido e Irlanda ha realizado, durante muchos años, mediciones de luz in situ de faros para determinar el rendimiento de la intensidad lumínica tras la reingeniería o el cambio de los requisitos de navegación. Se hará una demostración en directo de las técnicas utilizadas por el R&RNAV una noche durante la conferencia con las fuentes de luz actuales y una potencial sustituta medida en el Faro de la Torre de Hércules. Tras la medición, durante la conferencia, se presentarán los resultados junto con una explicación de las técnicas utilizadas y los problemas habituales asociados con la realización de mediciones de este tipo.

La Direction de la recherche et de la radionavigation de l'Autorité générale des phares du Royaume Uni et d'Irlande (R&RNAV) effectue, depuis longtemps, des mesures « in situ » de la lumière des phares pour évaluer les performances d'intensité après une réorganisation technique ou un changement des prescriptions de navigation. Une démonstration « live » des techniques utilisées par R&RNAV sera effectuée l'un des soirs de la Conférence et d'éventuelles sources lumineuses de remplacement seront mesurées à la Tour d'Hercule. Après ces mesures, pendant la Conférence, on en présentera les résultats accompagnés d'une description des techniques utilisées et des problèmes communément associés à la conduite de mesures de cette nature.

Light measurement of Tower of Hercules Lighthouse

Malcolm Nicholson
&
Link Powell

General Lighthouse Authorities
UK & Ireland

IALA·2014·AISM
XVIII Conference · A Coruña · Spain

INTRODUCTION

"The recommended way of determining the intensity of the beam is by direct photometric measurement on a suitable measuring range as referred to in E200-3.

Section A *gives details of a method for the approximate calculation of the peak luminous intensity of a beam from an aid-to-navigation light, i.e. the intensity at a maximum of its distribution in space, usually in the direction of the optical axis of the beam projection system.*

This type of calculation is intended for use when direct photometric measurement is not possible and when the data required for the methods of Section B *are not available.*

Section B *describes methods by which it is possible to obtain better estimates of luminous intensity for a given source-optic combination, than those obtainable by the methods of* Section A, *provided that measured data are available for an identical optic with other sources or for an identical source with other optics.*

This type of calculation is preferred to that of Section A, *where possible."*

Many Members will be familiar with the above introduction, taken from IALA Recommendation E-200-5. What is less familiar are the limitations of the calculations. As a 'real' example, using the calculations in E-200-5:-

Io = h*d*L*k
Where,
Io= peak intensity
h= height of lens (m)
d= width of light source (m)
L= luminance of light source (cd/m^2)
K= correction factor for lens collection angle

Therefore:-

Io = 0.5*0.024*7,000,000*0.55
Io = 46,200cd

Ie = Io*t/(0.2+t)

Where t = 1s (flash duration)

Ie = 46,200*1/(0.2+1)
Ie = 46,200/1.2
Ie = 38,500cd

When the above lens was measured 'in-situ' a result of less than 16,000cd effective intensity was realised. There were a number of reasons for this, each one with its own contribution to the poor 'real' performance of the light as follows:-
Lamp Voltage
Lamp Blackening/Aging
Lamp Size
Focussing
Lens degradation
Quoted Luminance

Only by measurement can these reasons be identified and either corrected or the 'real' performance of the light reported to the mariner.

GENERAL PHOTOMETRIC MEASUREMENT METHODS

There are two general methods for determining the intensity of a light. The first is to measure the illuminance in lux of a light at a known distance and calculate the intensity by multiplying the illuminance by the square of the measurement distance in metres – this is known as the inverse square law or photometric distance law method. The second is to measure the illuminance in lux of a light at an arbitrary distance and then substitute that light with another of known intensity – this is known as the substitution method. The measured illuminances of known and unknown lights are used as a ratio, which is applied to the known intensity to calculate the unknown intensity.

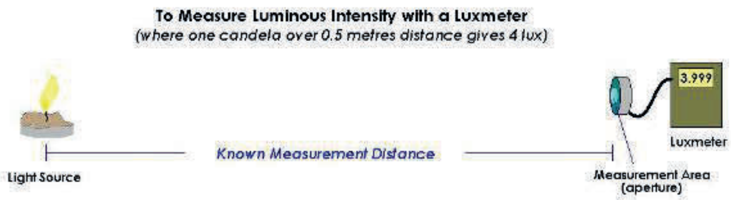


Figure 1: 'Inverse Square' Method of measuring Intensity

The photometric distance law method is useful at short distances, up to one hundred metres or so, but at greater distances, the measurement uncertainty can increase due to the effects of atmosphere. This is significant when determining the intensity of a lighthouse lens because the intensity can only be measured beyond the crossover point, which is the point at which the beam is fully formed. For a large lens, the crossover point can be several hundred metres from the lens.

For this reason, the substitution method is the method of choice for lighthouse intensity measurements because they are usually carried out over large distances, either to get beyond crossover or because topography dictates the measurement distance. When comparing the measurements of known and unknown lights, both are measured over the same atmospheric path and any atmospheric losses, provided they are consistent, are cancelled out when the ratio is derived.

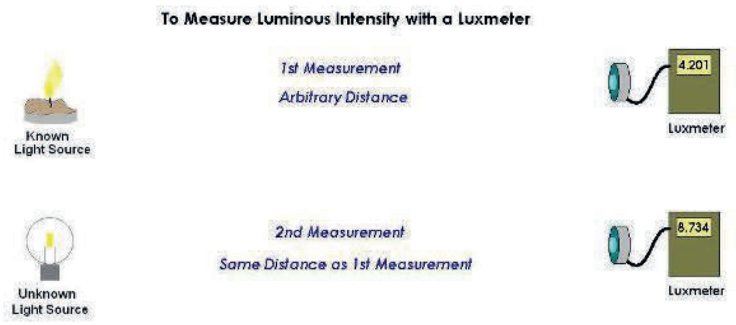


Figure 2: 'Substitution' Method of measuring Intensity

R&RNAV METHOD OF FIELD LIGHT MEASUREMENT

An existing method of measuring the intensity and rhythmic character of AtoN lights in situ is described in IALA Recommendation E-200-3. It uses the substitution method of measuring intensity because of the extreme measurement distances sometimes encountered.

The process has two distinct parts: one to determine the intensity profile with respect to time of the lighthouse beam or beams; the second to plot the vertical intensity profile with respect to elevation angle of the beam.

The intensity profile with respect to time is used to determine:

- the flash duration of each flash;
- the eclipse period between each flash;
- the rhythmic character from the above;
- the effective intensity; and
- the nominal range.

Plotting the vertical beam profile is important to ensure:

- that the beam is pointing in the right direction (i.e. to the horizon); and
- to calculate the beam centre intensity if the measurement site is not at the beam centre.

Lighthouse Setup

The lighthouse team ensures the AtoN light is functioning correctly. They also fix a reference light source (one that is calibrated so that its intensity is known absolutely) to the gallery of the lighthouse. The reference light source, usually a sealed beam lamp, is directed towards the measurement site.

A further task of the lighthouse team is to place a frame between the optical apparatus and the measurement site. The purpose of this frame is to hold prisms which are used to refract the beam up and down in discrete steps.

If the optical apparatus is rotating and there is more than one lens panel, each lens panel should be identified so as to inform the measurement site personnel which panel is pointing their way.

Measurement Site Setup

The measurement site team need to ensure that the optic or the part of the optic that they are measuring is representative of the whole optic. They often need the help of the lighthouse team to do this. The measurement site must also be at the correct elevation to be within the beam of the light, fairly close to the beam centre. It must also be far enough from the light for the beam to be fully formed – this point is known as the 'beam crossover point' and it may be determined by calculation.

A telephotometer is fixed to a pan and tilt head, which in turn is fitted to a tripod. The telephotometer is aligned and focussed so that its measurement aperture encompasses the optic and reference light being measured. This is best done before the onset of darkness. The analogue output of the telephotometer is connected to a fast analogue to digital (A/D) converter, which in turn is connected to a recording program.

Figure 3 Setting up the measurement site at Rubha Cadail

When the measurement commences, the lighthouse team need to tell the measurement team which lens panel is which and when the character period is about to commence. This is to identify each lens panel individually and to minimise recording time.

The operator needs to record at least one complete character period and ask for the reference light to be switched on at the appropriate time in order to get a representative sample of the light being measured and to be able to compare it with the reference light. If there is too large a difference in intensity between the reference light and the AtoN light, the gain range on the telephotometer may need to be altered during the recording. In **figure 4** below, there is a gain range difference of times ten between recording the three flashes and the reference light. Three flashes can be seen superimposed on the reference light recording but at a lower level than when recorded on the left of the plot.

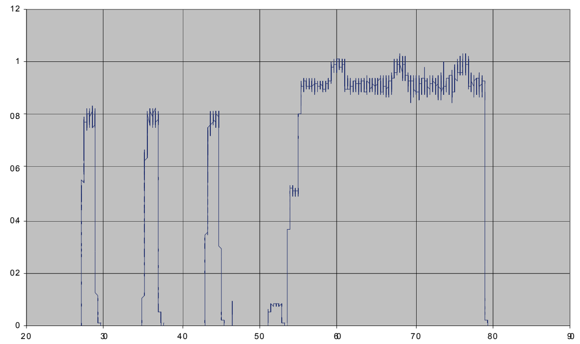


Figure 4: Typical recording of flashes and reference light

Once recordings have been taken, it is a relatively simple matter, using proprietary software, to measure the height of the flashes and the height of the reference light and calculate the intensity of the AtoN light from the known reference intensity. If the results are transferred to a spread sheet, the required parameters of flash duration, eclipse period, and effective intensity can be determined.

EQUIPMENT

Reference Light

R&RNAV use a series of sealed beam lamps for their reference lights, typically mounted on a lighthouse gallery rail.

Figure 5: Left: Outline drawing of a typical sealed beam lamp; Centre GE Q4559X; Right: 'Red' reference light mounted on gallery

These are directional lamps and therefore have to be pointed at the measurement site and adjusted for a maximum reading on the telephotometer. The sealed beam lamps used are all GE types as follows:

Colour code	Lamp type	Voltage (V)	Power (W)	Approximate intensity (cd)
Yellow	PAR 46 H7614	12	50	1,500
Blue	PAR 46 4412	12	35	10,000
Green	PAR 46 4596	24	250	100,000
Red	PAR 64 Q4559X	28	600	500,000

Table 1: R&RNAV Field Reference Lamps

All lamps are housed in a steel box with mounting nut and bolt and supplied with regulated DC power supplies. The reference light is designed to be mounted on a pan and tilt head for easy alignment with the measurement site. All lamps are calibrated on the R&RNAV light range before use.

Prism Frame

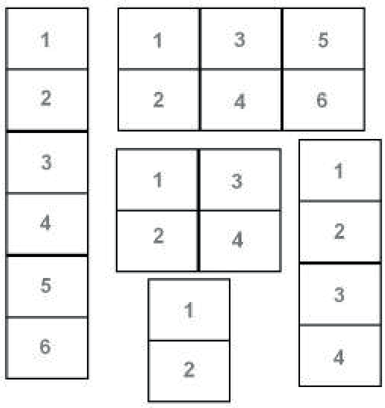
This aluminium frame is lightweight and collapsible for easy handling to a lighthouse and into the lantern room. It can be assembled to make a variety of different shapes to suit the optic being measured and can hold up to six prisms when assembled.

Figure 6:

Three part prism frame collapsed for transportation

Figure 7:

Different arrangements of prism frame



Once assembled, the frame is placed between the optic and the measurement site. It is usually fixed to the lantern glazing by suckers. Blanking is placed around the frame to ensure that only light through the frame reaches the measurement site.

Figure 8:
Left: A prism frame attached to the glazing by suckers; Right: The same prism frame with the surround blanked and a ladder for access

The area of the frame usually covers only a part of the optic area. The area covered should be in the centre of the lens as far as practicable.

Prisms

Acrylic prisms are used to refract the light beam from the optic, up and down in half degree steps. For each measurement of prism deflection, each hole of the frame (up to six) should contain identical prisms with the same prism orientation.

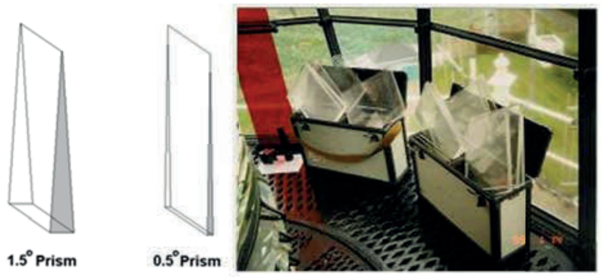
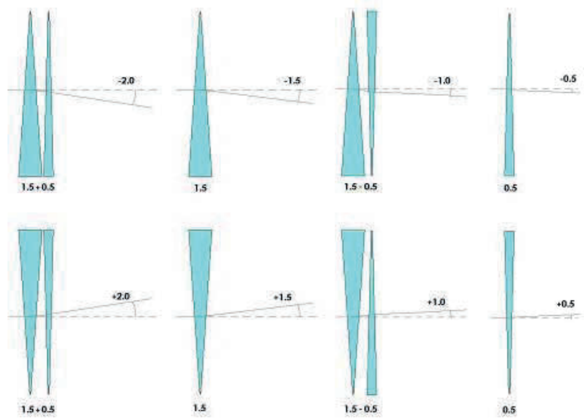


Figure 9: Left: Two types of acrylic prism used; Right: Prisms and their carrying cases in a lantern



Photometric Equipment

For the majority of field light measurements, where the measurement site is relatively close to the lighthouse being measured, a Hagner S3 or S4 universal photometer is used in luminance mode. This provides an optical instrument coupled to a photodetector with a measurement field limited to one degree. When the measurement field is filled or overfilled, the luminance of a light source in candelas per metre squared (cd/m²) can be measured. However, when the measurement field is underfilled the photometric quantity measured is illuminance; but it is only a relative, not an absolute, value. In this underfilled mode, the luminance meter becomes, in effect, a telephotometer. Used in this mode, a reference light is required to scale the relative illuminance value obtained.

Figure 11: Hagner S4 universal photometer

The photometer has an analogue output with a range of 0-2VDC which is proportional to the measured photometric value. This output mimics the digital and analogue meters that can be seen on the side of the S4 (**figure 11**).

Recording Equipment

A fast A/D converter and logger is used to record the variations of the analogue output from the photometer with respect to time. The device of choice is the Data Translation DT 9803, a 16 bit A/D converter capable of recording 100,000 samples per second.

← *Figure 10: Prism configurations to give ± 2º beam refraction in half degree steps – no prisms = 0º*

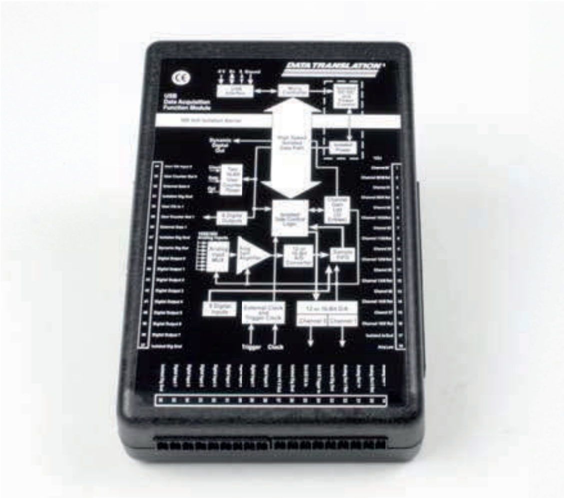


Figure 12: Data Translation DT 9803 fast A/D converter.

The A/D converter is plugged into a laptop computer and operated via bespoke software written for R&RNAV. This software not only records data from the DT 9803 but also has a flash analysis function that may be used to determine such parameters as peak intensity, effective intensity and flash duration at three different percentages of the peak value.

EXISTING R&RNAV MEASUREMENT PROCEDURE

A team is required in two places: one at the lighthouse; and another at a measurement site some distance away. The following criteria should be observed:

- the measurement site must be within the arc of utilisation of the AtoN light being measured;
- the measurement distance (i.e. from the light to the measurement site) should be beyond the beam crossover distance;
- the measurement site must be close to the vertical centre of the beam – in other words roughly level with the light;
- good verbal communications between the lighthouse and the measurement site are essential;
- relatively good weather, in particular consistent visibility, is necessary;
- during the measurement process ambient light levels must be low enough to be insignificant when compared with the light level being measured, complete darkness is preferable;
- however, setting up equipment in preparation for measurement is best done during the hours of daylight.

During daylight

The measurement site team find a suitable site making sure that it is in full view of the optic, within the arc of utilisation and vertically within ± 1° of the horizon. The photometer is aimed at the lighthouse and aligned so that the whole light plus reference light is within the measurement field.

Figure 13: Left: Setting up the photometer; Right: A typical view through the eyepiece of the Hagner S4, the dark centre is the measurement field

In **figure 13**, the horizon can be observed cutting just below the optic in the lantern of the lighthouse. This is a good indicator of correct measurement height.

The lighthouse team observe the proposed measurement site from the lantern and:

- ensure the measurement site can see an unobstructed view of all parts of the optic within the arc of utilisation;
- gauge the elevation of the measurement site with respect to the horizon – this can be done by eyeing the horizon with respect to the site or by using a theodolite;
- using the assembled prism frame, fix it securely to the lantern glazing ensuring that its area encompasses a representative area of the optic being measured and is directly between the optic and the measurement site;
- blank around the prism frame to ensure that the only light passing from the optic to the measurement site does so through the frame;
- fix a calibrated reference light of appropriate intensity (preferably within an order of magnitude of the expected intensity of the

optic being measured) to the gallery of the lighthouse;

- align the reference light with the measurement site by eye or rifle sight.

The lighthouse team should also ensure that the light source and optical apparatus to be measured are working correctly, that the light source is correctly focussed within the optic and that lamp voltages, for example, are correct at the lamp terminals.

At onset of darkness

When it is dark enough and the AtoN light is switched on, blanking plates should be placed in the prism frame to ensure that no light from the optic passes to the measurement site. To test the blanking, the measurement site team should observe the lighthouse to ensure that it is adequate. Any noticeable glints of light around or through the frame and blanking should be covered.

With the blanking in place, the reference light should be switched on whilst the measurement team observe the photometer reading. They should direct the lighthouse team to adjust the reference light pan and tilt head for a maximum photometer reading. The reference light can then be switched off.

On removal of the blanking plates from the prism frame, a series of measurement can be carried out with different prism configurations as detailed in **figure 10.** Each measurement should be done with the same prism configuration in each of the frame panels and with the lighthouse team well clear of the optic so as not to obstruct the beam. Each measurement recording should contain at least one representative sample of the rhythmic character and a sample of reference light. More samples of the character should be taken if conditions (e.g. scintillation) dictate. If the optic is a rotating type with several lens panels, a recording of all lens panels should be taken.

Once the prism runs have been completed, the blanking, prisms and prism frame should be removed. Several measurements of the unblanked optic should then be carried out. Each recording should contain at least two samples of rhythmic character; this is to ensure that the character period can be measured.

Processing measurement results

The measurement results can be used to determine an absolute intensity profile of each measurement run in candelas with respect to time:

$$I_f = I_{ref} \times \frac{V_f}{V_{ref}} \times \frac{G_f}{G_{ref}} \qquad \textit{Equation 1}$$

where: I_f is the intensity of the flash in candelas

I_{ref} is the intensity of the reference light in candelas (calibration certificate)

V_f is the photometer reading of the flash in volts

V_{ref} is the photometer reading of the reference light in volts

G_f is the photometer gain setting for the flash measurement

G_{ref} is the photometer gain setting for the reference measurement

A typical output of the A/D recorder would comprise a text file with two columns: one of time and a second of voltage, an example of which is shown below with a sample period of 2ms or 500 samples per second.

Time (s)	Voltage (V)
0.000	0.001
0.002	0.002
0.004	0.001
0.006	0.004
0.008	0.005
0.010	0.005
0.012	0.007
0.014	0.008
0.016	0.011
0.018	0.011
0.020	0.011

Such a file can be input to a spreadsheet and the formula in equation 1 used to calculate intensity for a particular set of results on a particular day.

Station A 14th March 2010

Times (s)	Vf	If	Iref	Vref	Gref	Gf
			10000	1.345	1	10
0.000	0.001	101				
0.002	0.002	141				
0.004	0.001	61				
0.006	0.004	262				
0.008	0.005	383				
0.010	0.005	343				
0.012	0.007	504				
0.014	0.008	625				
0.016	0.011	787				
0.018	0.011	787				
0.020	0.011	787				

Values input from measurement

Calcuated intensity values

Figure 14: Example of part of an analogue recording input to spreadsheet

From this data array, a graph of intensity versus time can be plotted.

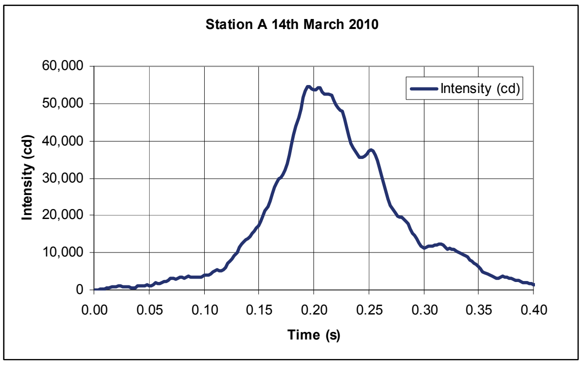


Figure 15: Flash profile plotted from spreadsheet results

Results of measurements with prisms

From each of the prism measurements, the peak intensity value for each flash can be taken and used to plot a graph of intensity versus angle of elevation – a vertical beam profile. However, the intensity value from each measurement will only represent the amount of light measured through the frame with blanked surround and not the whole optic. Therefore this is only a relative intensity value. The usual method of displaying such a plot of the vertical beam profile is to normalise the graph to give a percentage of maximum.

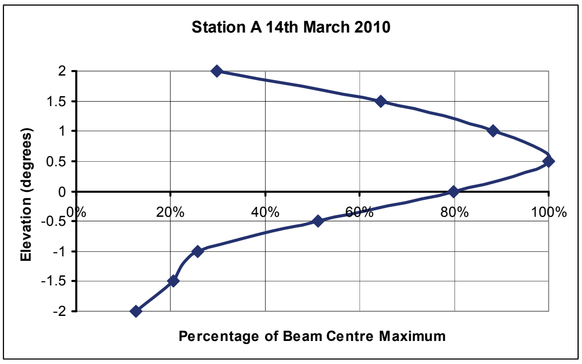


Figure 16 Vertical beam diagram plotted from results of nine prism measurements

There is a transmission loss associated with each prism and this affects the measurements of intensity through the prisms. Transmission through a 1.5° prism is 89%, and through a 0.5° prism is 91%. For the prism configurations shown in **figure 10**, the transmission factors are shown in **Table 2**.

For a ±3.0 degree deflection, two 1.5 degree prisms should be used – the transmission factor for both prisms will be 0.79.

Elevation (degrees)	Prism Configuration	Transmission Factor
-2.0	1.5 + 0.5	0.81
-1.5	1.5	0.89
-1.0	1.5 – 0.5	0.81
-0.5	0.5	0.91
0	None	1
+0.5	0.5	0.91
+1.5	1.5	0.89
+2.0	1.5 + 0.5	0.81

Table 2: Prism Transmission Factors

Results of measurements of whole optic

From the measurements of the whole unblanked optic, absolute values of intensity in candelas versus time can be realised. From the flash profile, values of peak intensity, flash duration and effective intensity can be obtained. However, if the measurement site is not in the beam centre – either because the beam direction is high or low due to poor focussing or because the measurement site is not in line with the horizon – then the beam centre value may be derived by using the vertical beam diagram. Taking **figure 16** as an example, the intensity value from the measurement site (at 0°) of the unblanked optic can be divided by 0.8 to derive the beam centre intensity.

CONCLUSIONS

The light measurement techniques described above are not beyond the scope of the average engineer. Although the subject may not be within their normal remit, given adequate equipment and training, an engineer should be able to carry out this task satisfactorily. The main requirement of the engineer carrying out the task, apart from adequate experience, is care. Once a number of 'in-situ' measurements have been taken a database of the results can be made. Future performance can be better estimated using the ratio technique described in E-200-5.

101 OUTSOURCING OF ATON MAINTENANCE SERVICES. INNOVATION IN TENDERING, CONTRACTING AND MANAGING THESE SERVICES IN AUSTRALIA

Gerry Brine, David Jeffkins. Australian Maritime Safety Authority, Australia

The provision of Aids to Navigation (AtoN) maintenance is widely outsourced by aids to navigation authorities within Australia at the national, state and individual port authority level.

The Australian Maritime Safety Authority (AMSA) has outsourced its AtoN maintenance service since 2001. In outsourcing this service AMSA has faced numerous challenges in ensuring ongoing value for money, meeting IALA's AtoN availability levels and managing contractor performance. AMSA has had the same contractor over two separate, long term contract periods and has completed a third tender process in 2013/14 for its next maintenance contract which has seen AMSA re-engage the incumbent contractor. With each tender process, AMSA has undertaken research and analysis in order to enhance the cost effectiveness of its AtoN network through reviewing service model and maintenance regime options. This paper will highlight the key learnings from these tender processes.

AMSA has also evolved its contract management model and processes in seeking to achieve an optimal balance between allowing the contractor the autonomy and flexibility necessary for them to be made fully accountable for the maintenance task, while fostering an in-house technical capability necessary to enable robust scrutiny and assessment of the contractor's performance and to maximise the economic life of AMSA's AtoN assets. This paper examines how AMSA is achieving this balance and potential enhancements in the future.

AMSA's latest tender process was characterised by extensive review of AtoN service levels, asset maintenance needs and cost analysis. An example of key issues considered was whether the existing fixed price contract model was still the most appropriate for a mature service delivery arrangement. Extensive market consultation was undertaken to help ensure a competitive tender process.

Many other Australian AtoN authorities have outsourced the provision of AtoN maintenance services utilising varying service model. Some of their experiences are also discussed in this paper.
In summary, this paper identifies the lessons learnt, successful maintenance strategies and practices, the pros and cons of various service models and strategic and operational issues expected to impact AtoN authorities' outsourced services in the future.

El suministro del mantenimiento de Ayudas a la Navegación (AtoN) está ampliamente subcontratado por las autoridades de ayudas a la navegación dentro de Australia a nivel nacional, estatal y de autoridad portuaria independiente.

La Autoridad de Seguridad Marítima Australiana (AMSA) ha subcontratado su servicio de mantenimiento AtoN desde 2001. Al subcontratar este servicio, AMSA ha afrontado numerosos desafíos para garantizar una rentabilidad permanente de su dinero, cumpliendo los niveles de disponibilidad AtoN de IALA y gestionando el rendimiento del contratista. La AMSA ha tenido el mismo contratista durante dos periodos de contratación a largo plazo separados y ha completado un tercer proceso de licitación en 2013/2014 para su próximo contrato de mantenimiento en el que AMSA recontratará al contratista actual. En cada proceso de licitación, AMSA ha hecho una investigación y análisis para aumentar la rentabilidad de su red AtoN revisando el modelo de servicio y las opciones de régimen de mantenimiento. Esta ponencia resaltará los principales conocimientos adquiridos en estos procesos de licitación.

La AMSA también ha desarrollado su modelo y procesos de gestión de contrato para alcanzar un equilibrio óptimo entre el otorgamiento de autonomía al contratista y la flexibilidad necesaria para ser totalmente responsable de la tarea de mantenimiento a la vez que fomenta una capacidad técnica interna necesaria para permitir un examen y evaluación enérgicos del rendimiento del contratista y maximizar la vida económica de los activos AtoN de AMSA. Esta ponencia examina cómo la AMSA consigue este equilibrio y mejoras potenciales en el futuro.

El último proceso de licitación de AMSA se caracterizó por una revisión amplia de los niveles de servicio AtoN, las necesidades de mantenimiento del activo y el análisis de costes. Un ejemplo de los asuntos clave tenidos en cuenta fue si el modelo de contrato de precio fijo existente todavía era el más apropiado para un acuerdo madurado de entrega de servicio. Se realizó una amplia consulta de mercado para ayudar a garantizar un proceso de licitación competitivo.

Muchas otras autoridades AtoN australianas han subcontratado el suministro de los servicios de mantenimiento AtoN haciendo uso de diferentes modelos de servicio. Algunas de sus experiencias se tratarán también en esta ponencia.

En resumen, esta ponencia identifica las lecciones aprendidas, las estrategias y prácticas de mantenimiento exitosas, los pros y contras de los diferentes modelos de servicio y los asuntos estratégicos y operativos que se esperaba que afectaran a los servicios subcontratados por las autoridades AtoN en el futuro.

L'entretien des aides à la navigation est largement sous-traité par les autorités australiennes de signalisation maritime, que ce soit au niveau national ou au niveau des autorités portuaires particulières.

L'Autorité de sécurité maritime australienne (AMSA) sous-traite les services d'entretien des aides à la navigation depuis 2001. En sous-traitant ce service, AMSA a fait face à de nombreux défis pour continuer à recevoir un service au niveau du prix payé, maintenir les niveaux de disponibilité requis par l'AISM et superviser la société sous contrat. AMSA a fait appel à la même société pendant deux longues périodes différentes et a terminé en 2013/14 un processus d'appel d'offres pour la prochaine période, qui a abouti au réengagement de la société sortante. A chaque processus d'appel d'offres AMSA a mené recherches et analyses pour accroître la rentabilité de son réseau d'aides à la navigation par une révision de son modèle de service et de ses options d'entretien. Ce rapport mettra l'accent sur les principaux enseignements de ces processus d'appel d'offres. AMSA a fait évoluer son modèle de gestion des contrats en recherchant le meilleur équilibre entre donner au contractant l'autonomie et la souplesse nécessaires à l'entière responsabilité des tâches d'entretien, et assurer une capacité technique « maison » qui lui permet de faire face aux inspections et évaluations des performances du contractant tout en optimisant les actifs d'AMSA. Ce rapport explique comment AMSA réalise cet équilibre et présente des améliorations potentielles pour l'avenir.

Le dernier processus d'appel d'offres d'AMSA s'est caractérisé par une revue détaillée des niveaux de service des aides à la navigation et une analyse des besoins en entretien et des coûts. A titre d'exemple des questions clés, il s'est agi de savoir si le modèle de contrat à prix fixe était toujours le mieux adapté au rendu d'un service mature. Une consultation du marché a été entreprise pour un assurer un processus d'appel d'offres compétitif.

Beaucoup d'autres autorités australiennes d'aides à la navigation ont sous-traité leurs services d'entretien en utilisant divers modèles de services. On présente aussi quelques-unes de leurs expériences.

En résumé, le rapport identifie les leçons retirées, les stratégies et pratiques d'entretien satisfaisantes, les pour et les contre de divers modèles de service et les questions stratégiques et opérationnelles susceptibles d'avoir dans l'avenir des conséquences sur les services sous traités par les autorités de signalisation maritime.

Outsourcing of AtoN maintenance services

Innovation in tendering, contracting and managing these services in Australia

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INTRODUCTION

The Australian Maritime Safety Authority (AMSA) is responsible for the operation and maintenance of the Australian government's coastal marine aids to navigation (AtoN) Network. AMSA AtoN network consists of some 500 AtoN at approximately 400 sites around the Australian coastline (refer **Figure 1**).

Figure 1: Location of AMSA Aids to Navigation Network

AMSA's AtoN generally lie outside port limits and serve the phases of navigation that are described as landfall, coastal navigation and port approach. AMSA's AtoN sites are situated on a range of different types of locations including headlands, promontories, offshore islands, sand cays, drying reefs and coastal waters generally less than 20 metres deep.

AMSA aims to provide a cost effective system of marine AtoN to the commercial shipping industry in accordance with Regulation 13, Chapter V of SOLAS obligations and international best practice (e.g. IALA guidance).

AMSA's responsibilities in this regard are also prescribed in domestic legislation (Navigation Act 2012). The costs of performing this function are recovered from the commercial shipping industry through the Marine Navigation Levy.

AMSA'S ATON MAINTENANCE SERVICE DELIVERY MODEL

AMSA's decision to outsource its AtoN the maintenance services was an outcome of an extensive internal business review process covering corporate and operational functions. These business reviews were in response to whole of government policy of contestability of government services involving benchmarking internal service delivery with the option of delivery by the private sector.

AMSA's objectives of outsourcing included reduction in overall costs whilst improving quality of service delivery, increased flexibility, meeting industry expectations of cost effective use of funding generated by the Marine Navigation Levy and access to specialist skills and expertise.

AMSA outsourced the delivery of AtoN maintenance services from July 2001 to Australian Maritime Systems Limited (AMS) following an open tender process. AMSA also sold its AtoN maintenance vessel to P&O Maritime and re-contracted the vessel for the same role from July 2001 for a similar period as the initial AtoN maintenance contract.

AMSA re-tendered the AtoN maintenance service in 2005 following a review of the service model. The frequency of the planned maintenance services was changed by extending maintenance intervals for some sites from one year to two years. However, the scope of the maintenance services remained largely unchanged

Figure 2: Emergency Towing Vessel Pacific Responder

AMSA also modified its approach to providing a vessel for AtoN maintenance whereby the sole AtoN maintenance vessel was discontinued. Instead the AtoN maintenance contractor would now be responsible for sourcing suitable vessels for AtoN maintenance around the Australian coast where required. The key exception to this approach was within the northern region of the Great Barrier Reef and in Torres Strait where AMSA's new, dedicated emergency towing vessel would be made available for AtoN maintenance for a minimum of 100 days per year.

During 2012/13 AMSA undertook a review of the service model for the delivery of AtoN maintenance services in preparation for tendering its next maintenance contract which needed to commence on 1 July 2014. This review encompassed:

- review of the current arrangements in light of technology changes;
- the outcomes of nautical reviews;
- new environmental and workplace health and safety requirements;
- consultation with other AtoN authorities on their service models; and
- a study to identify and assess the pricing impact of existing and future cost drivers.

To inform the development of the service model and help ensure a competitive tender process, AMSA also undertook an extensive marketing phase involving contacting potential service providers and providing extensive background information and conducting one-on-one meetings with these organisations. Input sought from potential tenderers covered aspects such as:

- what the next service model should comprise;
- what current aspects of the service model were most likely to impact risk pricing in their tender response;
- fixed versus variable pricing;
- the use of thresholds for major maintenance and unforeseen events; and
- the condition of the existing asset base.

Following the review there was only one change to the broad scope of the maintenance services from the previous contract. This change involved including the maintenance of communications devices purchased by AMSA and located at third party AIS sites (ports). This equipment enables AMSA to incorporate third party AIS data in its vessel tracking systems. However, some fundamental changes to the service model were reflected in the tender specification that was released to the market in April 2013 including:

- Provision for annual cost increases based on a combination of labour, equipment and transport cost indices.
- A reduction in the major maintenance threshold from $220,000 to $150,000.

The tender process was completed at the end of 2013 with the contracting of the incumbent provider (Australian Maritime Systems Ltd) for a further ten years.

A comparison of key aspects of AMSA's AtoN maintenance contracts are summarised in **Table 1** below:

Contract	Contract term (years)	Annual price ($m)	Prices basis	Scope of service				Major maintenance threshold $'000
				Planned	Corrective	Fault & failure	Other	
2001/02 – 2005/06	3+1+1	7.5	Fixed	Y	Y	Y	• AMSA funds vessel support Australia wide. • AMSA funds consumables. • AMSA funds new and replacement assets (>$3000)	100
2006/07 – 2013/14	8 (no option to extend)	9.5	Fixed	Y	Y	Y	• Contractor funds vessel support outside ETV area. • Contractor funds consumables. • AMSA funds new and replacement assets (>$3000)	220
2014/15 – 2023/24	10 (no option to extend)	12.9	Fixed	Y	Y	Y	• Contractor funds vessel support outside ETV area. • Contractor maintains data communications equipment at 3rd party AIS sites. • Contractor funds equipment upgrades (buoys, lighting, remote monitoring, AIS) including installation. • AMSA funds new and replacement assets (>$3000).	150

Figure 1: Comparison of AMSA's AtoN maintenance contracts

CONTRACT MANAGEMENT

AMSA employs a small team of engineering and other specialist staff to perform its AtoN management functions. Their prime responsibilities are management of the AtoN network in accordance with IALA Recommendations and Guidelines and defined industry standards through contract and project management, strategic and operational planning, development of AtoN policy, liaison with the commercial shipping industry and liaison and participation in regional and international standard setting organisations such as IALA and the IMO.

AMSA's current AtoN maintenance service contract is a fixed price contract that includes the delivery of AtoN preventive and corrective maintenance, fault and failure response and inventory management.

The contractor's performance is monitored and measured through a range of activities and reporting requirements, including:

- detailed reporting – monthly, quarterly and annual;
- monthly meetings;
- quarterly and annual performance review meetings;
- AtoN site audits;
- desktop process audits; and
- Key Performance Indicator (KPI) framework.

The contractor must meet or exceed the agreed KPI's to access an at-risk component of the contract price (annual performance payment). The annual performance payment is made to the contractor following an annual review process. The KPI's are based generally on the following areas and have clearly defined targets and timeframes for deliverables:

- AtoN availability;
- quality;
- safety;
- environment;
- heritage;
- innovation;
- information management; and
- reporting.

AMSA and the contractor review and agree KPI's on an annual basis. This provides an opportunity to tailor the KPI's for the following year to address any emerging issues e.g. introduction of new technology, management of specific hazards or safety concerns.

The monthly reporting process provides AMSA with a detailed view of all AtoN maintenance activities undertaken for the month and any fault and failure rectification activities. AMSA meets with the contractor on a monthly basis to discuss the monthly report and any issues that have been experienced in delivering the AtoN maintenance services. In addition to the annual AtoN program, the monthly reporting and meeting process is seen as a critical process for ensuring compliance with the contract and confirming that the required quality, safety and environmental outcomes are being met. It also provides the contractor with a regular opportunity to discuss areas of concern with AMSA, confirm requirements and align expectations.

The contractor is required to identify risks and plan for contingencies that may affect the provision of the AtoN maintenance services (such as unavailability of resources and situations of emergency) throughout the contract term. The contractor must identify, manage and mitigate all risks associated with delivery of the AtoN maintenance services. Detailed risk assessments must be undertaken for all work undertaken under the contract.

The Contractor must develop and maintain detailed AtoN site risk assessments for each AtoN site that take into consideration, at a minimum, the nature of work being performed, known AtoN site hazards, topography, flora and fauna, and be updated as risks become apparent or local conditions change.

Over the course of the outsourced maintenance service arrangements the contractor has performed at a high level on a consistent basis, achieving well in excess of 90% of the agreed performance targets. AMSA has strengthened its performance management regime over time with the benefit of experience and in response to changing legislation and community expectations. This has been achieved through a variety of measures including through annually reviewing KPI's, enhanced auditing practices and requiring more substantial deliverables in terms of strategic asset management, workplace health and safety, environmental and heritage compliance.

The Contractor must eliminate or mitigate identified risks and implement appropriate risk management strategies. Some of the key risks for AMSA and the contractor and therefore an area of high focus in contract management activities include:

- potential for reduction and capability gaps in contractor resources;
- major refurbishment or replacement of assets inside useful life;
- potential injury to contractor's staff, AMSA staff or third parties e.g. other contractors, general public; and
- potential environmental incident.

INNOVATION

Since AMSA embarked on outsourcing of AtoN maintenance it has had a strong focus on innovation and continuous improvement in delivering the AtoN maintenance service.

In addition to AMSA identified innovations, AMSA's contract arrangements call for the contractor to proactively identify and propose innovations to AMSA throughout the contract term. To date, the following improvements have been made:

- a number of AtoN Sites and equipment have been upgraded to enable the service intervals to be extended from annual to biennial;
- in many cases low voltage light sources have replaced the mains powered 1000 watt lamps in heritage lenses;
- use of LED beacons;
- a number of mild steel towers have been replaced with modular fibreglass towers;
- changes to buoy maintenance have resulted in a doubling of the service intervals for most buoys;
- obsolete equipment such as old back-up diesel generators, optic drive motors and switch boards have been removed from the network;
- implementation of polyethylene buoys instead of steel buoys in open waters (where feasible); and
- trialling of AIS AtoN technology.

AMSA is also very conscious of safety and the environment. The AtoN maintenance contractor is required to proactively propose innovations in these areas. Improvements to date include:

- identification of AtoN site hazards;
- establishment and ongoing maintenance of detailed hazard registers, for example, for asbestos, radiation, lead and mercury;
- removal of hazardous substances from AtoN sites; and
- improvements to safety for AtoN site access, improved walkways, ladders and the introduction of fall arrest systems.

Requiring the AtoN maintenance contractor to innovate and continuously improve has allowed AMSA to share some of the risk of the introduction of new technology. The contractor bears the risk of responding to AtoN faults and failures for all AMSA AtoN equipment.

Over the next five to ten years AMSA will continue to refine its AtoN network through the introduction of:

- LED lights both sectored and non-sectored for medium range lights;
- LED light sources for large heritage flashing and rotating optics;
- replacement of steel buoys with polyethylene buoys;
- development of a next generation remote monitoring system;
- expanding the coverage of its AIS base station network; and
- the targeted introduction of AIS AtoN for specific applications.

All of the above enhancements with the exception of AIS AtoN deployments will be funded by the maintenance contractor. These enhancements will be implemented within the next five years with the exception of the replacement of AIS base stations which will occur progressively over 10 years. Benefits to AMSA include reduced capital expenditure and project resource effort and more timely implementation than if it was to implement these innovations itself.

ASSET MANAGEMENT

Due to the nature of their locations, AtoN sites and infrastructure are subject to severe sea and weather conditions which require a range of asset management strategies in order to keep them operating at the required levels and maximise their useful life.

In addition to the AtoN structures and equipment, an AtoN site may include other infrastructure and improvements such as fencing, retaining walls and roads.

AtoN sites are mostly serviced on an annual or biennial basis depending on their nature and specific maintenance requirements. Publicly accessible heritage lighthouses are visited by the contractor every six months as are the five radar sites which support operations of the coastal vessel traffic service in the Great Barrier Reef and Torres Strait (REEFVTS).

AMSA's maintenance service contract calls for the contractor to develop, implement and review detailed asset management strategies for each AtoN site. The site asset management strategies must be reviewed and updated at least every two years or following any major changes to the AtoN site infrastructure or environmental conditions.

Figure 3: Clerke Island – Modular Fibreglass AtoN structure

The asset management strategies for each AtoN site include the following information:

- general overview of the site including;
  - AtoN site establishment date and major events / modifications;
  - navigational objectives;
  - AtoN characteristics;
  - property details, leases, land ownership, access etc.;
- list of assets on the AtoN site e.g. structure, AtoN equipment, fencing, roads etc.;
- design life estimates for each asset;
- performance requirements for each asset;
- factors identified which affect access or maintenance tasks e.g. restrictions, climate, environmental controls, traditional land owners, heritage listings etc.;
- asset maintenance regimes for each asset including rationale for maintenance intensity and frequency;
- reference to job plans (work method statements) applicable to maintenance regime for each individual asset;
- proposed disposal/recycling approach for each asset; and
- forward outlook for replacement of each asset, including timing and options.

AMSA operates a computerised asset management system (Maximo) for managing and recording maintenance on its AtoN assets. Maximo is used for the following:

- recording all assets and spare parts and their location in the AtoN network;
- tracking the movements of assets in the AtoN network;
- recording faults and failures with AtoN assets;
- calculating AtoN availability;
- recording planned maintenance and corrective maintenance activities;
- storing preventive maintenance schedules for assets;

Figure 4: North Reef Lighthouse after major refurbishment in 2011

- storing job plans (work method statements) for maintenance activities; and
- storing individual AtoN site information registers – site specific information e.g. site contacts, hazards etc.

The contractor is required to ensure that Maximo is updated when changes occur due to undertaking the AtoN maintenance services, new AtoN site installations or decommissioning of AtoN sites. This occurs through an integration process between the contractor's information systems and AMSA's Maximo system.

Maximo is AMSA's master database or central repository for AtoN asset information. Other AMSA systems draw information from this data base for other applications e.g. issuing of maritime safety information (MSI) and GIS applications.

The AtoN asset management strategies detail the core requirements for AtoN asset maintenance; they are also one of the planning tools that are used for providing input into AMSA's capital works program for the replacement and major upgrades of AtoN assets.

AN ALTERNATIVE OUTSOURCED SERVICE MODEL

The outsourcing of Western Australian Department of Transport's (DoTWA) AtoN maintenance services has been driven by the state government's policy on private sector delivery which has sought greater private sector involvement in the provision of government-funded services, long term relationships/partnerships, innovative agreements, better overall management of assets i.e. asset management over whole of life of assets. The ultimate objective was and remains value for money.

The outsourced AtoN maintenance service for WA Department of Transport covers 1,382 AtoN, comprising buoys, 650 lit beacons/leads, 602 unlit beacons and 37 marine facilities.

DoTWA first outsourced the maintenance of their AtoN and other marine facilities in 1995.

DoTWA's first contract (with Transfield) was essentially a "labour hire" contract which involved paying the contractor a management fee which covered the contractor's staff, corporate overheads, profit, insurance, office costs etc. All work was carried out by work order only. The management fee and labour rates were reviewed annually.

The second contract with Transfield (August 2001-November 2010) involved an increase in scope to include inspections, condition assessments, development of maintenance strategies, planning, budgeting and annual programming. The basis of the management fee largely remained as per the first contract although the schedule of rates was expanded to encompass plant and equipment. Materials were to be supplied at cost. The contract was also expanded to include new works up to a value of $100,000.

The current contract (also with Transfield) runs from 2010-2019 subject to performance at an estimated value of $140 million. There are three main areas of service delivery; Asset Management Services, Maintenance Services and Project Delivery Services (up to a maximum value of $5 million per project).

Asset Management Services is a precursor to the delivery of maintenance services and involves: condition assessments, analysis of maintenance history and costs, development of whole-of-life asset management strategies and planning and budgeting. The contractor must also update the asset register and AtoN register, develop and update annual maintenance programs and budgets and provide 10-year asset management plans and budget forecasts for the Government.

Maintenance Services comprises Routine Maintenance, Programmed Maintenance (which comprises larger period works for example: buoy change outs, repainting of light houses and large beacons) and Reactive Maintenance which comprises urgent and unforeseen activities for example: vandalism and damage caused by severe weather events.

Project Services involves the contractor undertaking works up to a maximum $5 million per project for upgrading existing assets or delivery of new assets, for example installation of new AtoN. DoTWA issues a project brief for the contractor to quote on. If DoTWA determine the proposal represents value for money. .

The WA government was seeking long term relationship-based contract management models rather than the usual adversarial type of contract. The contract management approach involves a two-layered structure:

1) A joint **Agreement Leadership Team** who operate at the strategic level providing guidance, driving improvement and change in culture and reviewing performance.

2) A joint **Agreement Management Team** who implement the agreement, deliver services, meet monthly. DoTWA and the contractor have equal representation.

The contract management approach also includes integrated teams including co-location of personnel, decisions must be unanimous and issues are resolved jointly.

Cost transparency is achieved through 'Open Book' accounting and defined at-risk corporate overhead and profit percentages which are reviewed and adjusted annually. Performance management is covered in the contract price through the Incentive Scheme. The Incentive Scheme is designed to:

- focus the contractor on achieving excellent outcomes for both contractor and principal;
- reward the contractor for outstanding performance; and
- determine whether the Agreement is to be extended (Performance is assessed at end of years 2, 4 and 6 to determine extensions for years 7, 8 and 9).

The contractor's performance is assessed in three key result areas (KRA's) using the agreed key performance indicators shown in **Table 2** below:

KRA 1 **Agreement Management**	**KRA 2** **Asset Management Services**	**KRA 3** **Maintenance Services**
KPI's • Health of relationship survey • Financial management • Safety • Environment • Innovation	KPI's • Quality & efficiency in development of asset management plans • Annual budgets • Input into Transports systems	KPI's • Monthly budget performance • IALA Performance • Timeliness in delivery • Backlog maintenance

Table 2 – Key Result Areas and key performance indicators

Performance will determine increase or decrease in profit and overhead components of Management Fee.

Lessons learnt to date include:

- relationship contracting requires change in culture to ensure success;
- co-location and embedment of staff in the same office is highly beneficial;
- pursuing continuous improvement is a strong motivator in a team environment; and
- ageing infrastructure and developing appropriate asset management strategies will be a key challenge moving forward.

CONCLUSION

There are various outsourced contracting models that can be used to deliver AtoN maintenance services. Aspects such as the scope of services, pricing basis, performance management regimes can vary depending on an organisation's AtoN infrastructure maintenance needs, asset management strategy, funding, stakeholder expectations etc.

It is worth noting that the nature, challenges and risks associated with maintaining AMSA's AtoN network can be different in some areas from those of other AtoN providers such as ports and state marine safety authorities where the logistics for servicing, prevailing climatic conditions, funding source and the specific needs of users may warrant or enforce a different service model to that used by AMSA.

AMSA is very confident that its outsourced AtoN maintenance arrangements have served it well since inception in 2001. The fixed price, all inclusive nature of the two contracts to date has provided a high degree of certainty in budgeting and actual costs for delivering the AtoN maintenance services.

The outsourced arrangement works for AMSA in a number of ways. For example, AMSA is not able to supplement its revenue base through tendering for other work due to Government competition policy which reduces the opportunity for an insourced arrangement to be more cost effective. Also, by not having to manage a large workforce, internal AtoN resources can focus solely on strategic asset management and innovative, cost effective delivery of maintenance services.

Taking into account its experience gained in the course of the previous contracts, AMSA has some key future challenges in relation to its outsourced AtoN maintenance services. AMSA needs to ensure the required value is extracted from the new contract over a contract term two years longer than its existing eight year contract and twice as long as its original maintenance contract. AMSA also needs to maintain a fully effective working relationship with the contractor over this period noting that the new contract will have a much higher at-risk performance component than the existing contract. AMSA also needs to ensure the significant longer term maintenance efficiencies inherent in the innovation deliverables of the next maintenance contract are thoroughly assessed and then harvested through the pricing of future contracts.

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38 E-NAVIGATION STARTS WITH E-VOYAGE PLANNING

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Considering the balancing of data/information flow needed in NextGen Navigation (e-Navigation) and decision support already in the VoyagePlanning phase.

The navigational world is getting more and more complex. And the need for intelligent solutions to handle the workflow processes both onboard, to ship-ship and shore-ship collaboration, are in high demand. This includes all tasks; from the information collection in the voyage planning and optimization process, to reporting regimes and berth to berth safe navigation based on up to date and real time situation awareness.

Not only to get more data out to the mariners whom are taking navigational and other operational decisions, but to enhance cooperation or "co-navigation" happening between other ships, and shore side support – from VTS and SAR, to dedicated routing service, presented as Intelligent Integrated Information. One of the main hazard to (e)-Navigation is the availability of good data that is presented and compiled in an "unintelligent" way. The same goes for the workflow for the operators: the process from Planning, Optimizing and Reporting, to berth to berth navigation is only as good as the weakest link of all the marine operators: be it the VTS or SAR operator, Pilot, Captain or the Lookout. And with no integrated tools to handle this workflow, the risk for misunderstanding, fatigue and human errors is very much present.

I will in my paper present three central challenges and potentials in the voyage towards eNavigation: 1) More optimized and safer navigation based upon closer ship-ship and ship-shore collaboration and 2) a concept for voyage planning, optimization, collaboration and reporting processes. 3) The impact of e-Navigation on Polar Navigation.

The paper is presenting current status from different test beds, as well as IMO and industry alignment, to ensure that the harmonization and enhancement set forward in the e-Navigation visions are being realized. Stressing the need for good solutions that take into account intelligent information exchange between all marine stakeholders, from the onboard navigators, shore side VTS and SAR operators and the ship operators.

Consideración del equilibrio del flujo de datos/información necesario en la navegación NextGen (e-Navegación) y respaldo a las decisiones ya existentes en la fase de planificación del viaje.

El mundo de la navegación es cada día más complejo y la necesidad de soluciones inteligentes para manejar los procesos de flujo de trabajo a bordo, colaboración barco a barco y costa a barco, va en aumento. Esto incluye todas las tareas, desde la recopilación de información en la planificación del viaje y el proceso de optimización hasta regímenes de información y navegación segura de amarradero a amarradero basados en el conocimiento actualizado y en tiempo real de la situación.

No se trata únicamente de obtener más datos de los marineros que están adoptando decisiones operativas y de navegación, sino de mejorar la cooperación o «conavegación» que tiene lugar entre otros barcos, y apoyo del lado costa, desde VTS y SAR hasta servicio de enrutamiento especializado, presentado como Información Integrada Inteligente. Uno de los principales riesgos de la e-Navegación es la disponibilidad de datos de calidad presentados y compilados de un modo «poco inteligente». Lo mismo sucede con el flujo de trabajo de los operadores: los procesos de Planificación, Optimización e Información para la navegación de amarradero a amarradero son solamente tan buenos como el eslabón más débil de entre todos los operadores marinos, sea el operador del VTS o SAR, el Piloto, el Capitán o el Vigía. Y sin herramientas integradas para manejar este flujo de trabajo el riesgo de malentendidos, fatiga y errores humanos está muy presente.

En mi ponencia presentaré tres importantes desafíos y potenciales en el camino hacia la e-Navegación: 1) Navegación más optimizada y segura basada en una colaboración más estrecha entre barco y barco y entre barco y costa 2) Un concepto de procesos de planificación de viaje, optimización, colaboración e información. 3) El impacto de la e-Navegación sobre la navegación polar.

La ponencia presenta el estado actual de diferentes bancos de prueba, así como la alineación de la IMO y la industria, para garantizar que la armonización y la mejora avanzan en los proyectos de e-Navegación que se están realizando, recalcando la necesidad de buenas soluciones que tengan en cuenta el intercambio inteligente de información entre todas las partes interesadas marinas, desde los navegadores a bordo, los operadores SAR y VTS en tierra y los operadores del barco.

Considérant l'équilibre du flux données/informations nécessaire à la navigation de future génération (e-Navigation) et l'aide à la décision déjà dans le Plan de Voyage, la navigation mondiale devient de plus en plus complexe. Et le besoin de solutions intelligentes pour traiter le flot de procédures, tant à bord que de navire à navire et de navire à terre, est très important. Il comprend toutes les tâches ; de la collecte des informations pour le plan de voyage et son optimisation, les règles concernant les comptes rendus, la sécurité de la navigation de quai à quai, basés sur une connaissance de la situation à jour et en temps réel. Non seulement pour avoir plus de données à passer aux navigateurs qui ont à prendre des décisions opérationnelles, mais aussi pour améliorer la coopération, ou « co-navigation », entre navires, services à terre (VTS et SAR), avec le service de routage présenté comme une information intégrée intelligente. L'un des risques les plus importants menaçant la e-Navigation est la présence de bonnes données, qui sont présentées et classées de façon non intelligente. Même problème avec les tâches des opérateurs : la procédure Plan, Optimisation et Rapport sur la navigation de quai à quai est seulement aussi bonne que le plus faible maillon de tous les opérateurs maritimes, qu'il soit opérateur de VTS ou de SAR, pilote, commandant ou veilleur. Et sans aucun outil intégré pour effectuer les tâches; le risque d'incompréhension, de fatigue, d'erreur humaine est très présent.

Mon rapport présentera trois défis à relever sur la route de la e-Navigation : 1) Une navigation plus optimisée et plus sûre basée sur une meilleure collaboration navire-navire et navire-terre ; 2) Un concept pour les procédures de planification du voyage, d'optimisation, de collaboration et de rapports ; 3) Impact de la e-Navigation sur la navigation en région polaire.

Ce rapport présente les résultats actuels de différents bancs d'essais, ainsi que l'alignement OMI-Industries permettant à l'harmonisation et l'amélioration prévues par la e-Navigation de se réaliser. Il insiste sur la nécessité de bonnes solutions qui prennent en compte l'échange d'informations intelligentes entre toutes les parties prenantes maritimes, navigateurs à bord, opérateurs VTS et SAR du côté terre et opérateurs de navires.

e-Navigation starts with e-VoyagePlanning

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1. INTRODUCTION

As the shipping world is truly moving into the "Digital Ship", international organizations and industry do a joint effort to ensure that the safety and security of both the seafarers and society are maintained and improved.

Saying that "e-Navigation starts with e-VoyagePlanning", one have to look at what information vision IMO has for the Marine Community. The proposed solutions were drafted in IMO NAV 58, annex 4 and 5. Some of the system requirements concerned user-friendliness, automation and graphical integrations, and some functional requirements where information and reporting management, VTS service portfolio, Search and Rescue, and route and voyage plan exchange.

A key consideration is how this information is collected and presented to the marine operators; be it onboard for the mariner, or shore side for a marine VTS/SAR coordinator or manager. Also considerations work to be done to data compilation and compression, and the "postman"; communications.

The work to prepare and execute a voyage plan, is described on high level in IMO Res. A893; "Guidelines for Voyage Planning". Starting with the appraisal, collection of relevant information, updating of charts (be it paper or digital official ENC), publications, and ship particulars are key. Going into planning process, manual or digital tools are available to collect and plan use of navigational aids, weather, and port information etc. Coming into actual execution, the process of navigation begin with maneuvering and ship handling; where one react to changing elements and situations, including COLREG and severe weather, ice and all other conditions that cannot been mitigated in the risk analyzing done in the Passage planning process. Finally for verifying; aids to monitor the process like radar, ECDIS, and most important; lookout need to be used.

The Voyage Plan is sometimes referred to as the "tactic", as it is done usually days or hours ahead of starting the voyage. The process of "e-Navigation" could probably be referred to as "wheel" or a circle; a continuous process of managing nautical information, preparing voyage and passage plans, maneuvering and navigation, optimizing especially in Transocean passages, reporting and voyage analyzing. Looking into the offshore industry; the process is the same, the only difference is that the ports are at sea; complicating the operations further (but mitigated i.e. with use of dynamic position systems).

The process should all collect in the all important voyage plan being available on the bridge. Taking into account more information being available – the risk of "information overflow" is becoming more present. The aviation industry has taken this into account, where Jeppesen has been in the lead to replace the traditional aviation charts with digital means. While in the marine industry; paper charts and publications are still to be maintained in a painstaking process. How do we ensure that the transformation to the digital information age in marine, thus e-Navigation, is happening as effective and user-friendly as possible?

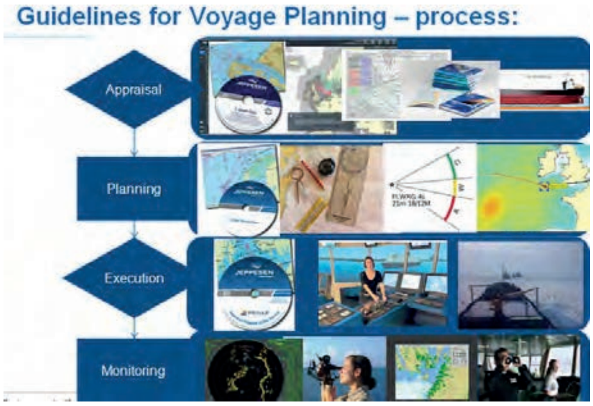

Figure 1

2. IMO E–NAVIGATION DEVELOPMENT.

For IMO, the visions of e-Navigation are developing into a reality. Even if the current ECDIS is under rigid performance standards, it is considered a key waypoint towards the realization, as part of the "INS" (Integrated Navigational System).

Some of the proposed e-Navigation solutions address potential for integration, graphical display, exchange of "Marine Service Portfolio" information (such as SAR and VTS), route segment exchange between ships (intended route), and collaboration on voyage plans (for authorized parties) for seaside and shore side operators. For the ship operators, the return of investment lies in safer and more efficient operations, and for the global society greener and safer ship operations with reduced risk of accidents – as well as increased transport efficiency.

The "BLAST" (Bringing Land and Sea together" project newly ended. The projects objective was 1) a harmonized model for data across land-sea. Together with a prototype for land/Sea interoperability between multiple sectors. 2)

Improved solutions for North Sea Navigation, including improved ENC harmonization, maritime data collection system, 3d port model, Digital Mariners Guide, and Harmonization of Nautical Information. As well as Marine Traffic Harmonization and Climate Changes in Coastal Zones. "SafeSeaNet" could also be considered a result of this project. And we are now seeing Nautical Publication Information, including Temporary and Prelimenary NTM's, are being integrated into the ENC or as separate layers.

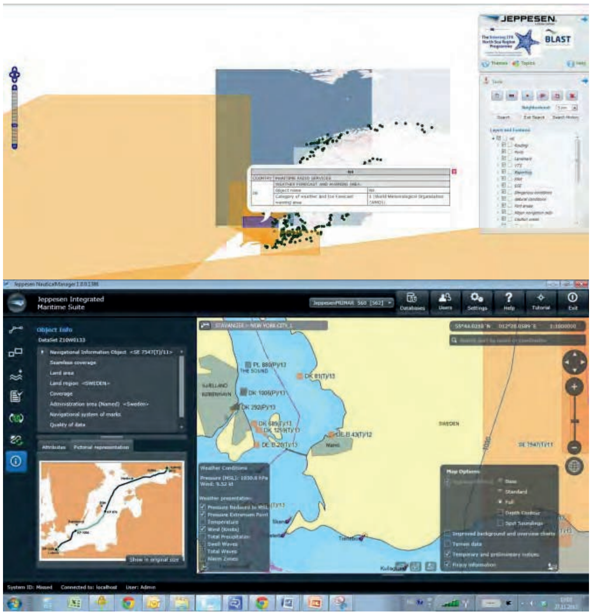

Figure 2: Results from BLAST and how implementation is done to workable solutions.

The **need for a common "language" on information exchange** has been solved with the development of the International Hydrographic Organization (IHO) "S100 GI registry" – which in contrast to the current "S57" format is an "open" registry. Meaning that organizations may submit new or improved standards, and is open for the industry to develop, adopt and improve solutions in the registry. This concept is being maintained by cross-organizational work between i.e. IHO, IALA, CIRM and so on –where industry members such as has leading positions and expertise.

Some of the potential for such solutions has already been proven: in 2011 the "EfficienSea" project was closed with a practical demonstrator on VTS and Ship collaboration chaired by the Danish Maritime Authority. In April 2012, as part of the "Marine Electronic Highway" project, a joint sea trial on real time information exchange of MSI (Maritime Safety Information), METOC and Notice to Mariners (NTM) was carried out in the Singapore straight. Systems involved were a Jeppesen eNav prototype based on a Navigational Kernel (SDK) and Kongsberg Norcontrol VTS – "C-Scope system. The sea trial was done on the request from IMO, chaired by Norwegian Coastal Administration and with close support from the Singapore MPA. The process was later replicated under an IMO workshop. It proved that AIS could be one potential carrier for "real time" short range navigational information from i.e. a VTS. In combination with efficient data compilation for NTM (Notice to Mariners) over minimum "internet" access such as WiMax – "S100" can work as a common framework for information exchange (Portrayal and data structure). Based on the project, the "S100" was adopted by IMO as a framework for e-Navigation data exchange.

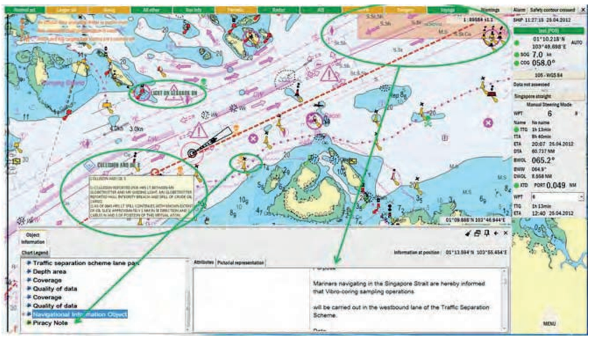

Figure 2. (From Singapore sea trials on "S100").

Currently the joint EU funded project "MonaLisa2" is being established with the industry as vital contributors. The first waypoint for the project will to be establish of a common route (and potential voyage plan) format, and infrastructure to handle such exchange and collaboration between marine stakeholders. It also aligns with the IMO proposed e-Nav solutions for "exchange of route segment between ships and VTS", and "voyage plan exchange and collaboration for authorized parties". Questions has been raised, especially on "voyage plan exchange and collaboration" – however this is already being done between ship and specialized weather routing services. The Monalisa project will look into how more services and expertise can be made available through common platforms for the onboard navigators and shore side operators (marine coordinators/ship operators) to ensure effective collaboration with safer and more efficient marine traffic handling. The objective for the project is to go from "surface based operations" to "voyage based operations". And most likely we will see a "handshake" alternative from Pilot (alternative Pilot exception ceritificate is used>VTS>Shore side oceanic routing>VTS>Pilot. Norway has already started work on a "electronic Pilot Exception Certificate" as part of SafeSeaNet. In Monalisa2, it is a joint industrial, academic and governmental contribution.

3. INDUSTRY ALIGNMENT

It is several companies that already are aligning with the need for improved routing and information exchange; it exists databases of recommended industrial routes, which can be updated align with normal ENC Notice to Mariners update.. For the end user, it reduce time for route planning from hours to seconds, freeing more time available to do quality assurance of the voyage plan. Also additional data such as Tides and Currents, SAR and GMDSS areas, and other information needed for improved voyage planning (Value Added Data) are available as supplementary layers to official ENC (like JeppesenPrimar) and derivated chart databases. To further support the need for improved voyage planning and operational support, Jeppesen is working on an integrated program in line with Monalisa2 to solve some severe painpoint in onboard VoyagePlanning and shore side support. Being another example how technology may help addressing all the aspects that are being involved in the voyage planning process.

As the ECDIS mandate is coming into effect for the IMO mandated fleet, more ship-owners and onboard operators are coming more familiar how technology can help them both to reduce cost and maintenance compared to traditional paper charts management, and improved safety. In parallel, development is being done to help support the transition. Jeppesen's "NauticalManager" and Chartco's "Passage Planner" are just some of the solutions becoming available to minimize manual work for digital chart ordering and maintenance with highly automatic processes. Last year's partnership between these two companies highlights the industrial efforts to ensure effective and cost effective transition.

For the navigational officer, effective distribution and loading of officials ENC's and other marine information such as Weather forecasts raise issues due to general communication and performance restrictions. Joint industrial-private efforts has achieved distribution of Official ENC's in type approved SENC formats, while weather and other marine information can be exchanged safe, effectly and secure using modern technology to ships. And probably improvements on the "S100" standard will further mitigate the risk and optimize the transition to the "Digital Ship".

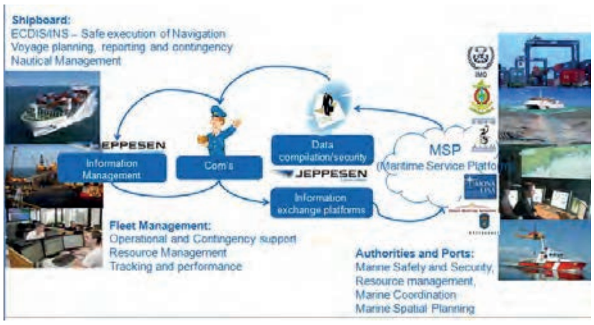

Figure 3. Industrial alignment in the e-Navigation infrastructure.

4. E–NAVIGATION AND POLAR NAVIGATION

In parallel with IMO e-Navigation, the IMO Polar Code is going from a vision to reality as the Polar Regions are being opened for commercial shipping. Questions are raised about the challenges and possible solutions for navigation safety in the areas.

Potential for both improved natural/fossil resource extraction, considerably shorten the Europe – East Asia route, as well as avoiding high security threat areas such as the Indian Ocean are just some of the incentives making shipping and oil and gas operators aware of the potential now opening up. However, marine operations in Polar Regions are facing considerable challenges. Remote areas, communication, icing of vessels, technology development, and access to information and so on, are just some of the issues that need to be addressed. As not only cargo shipping, but also tourist cruises are increasing in numbers.

5. POLAR CODE STATUS

In parallel with the work done on e-Navigation, mandates and regulations are being developed to ensure protection of both human life and environment in the regions under the Polar Code. Today IMO has issued the "Guidelines for vessels operating in polar waters" (2009) as an important mile stone towards a mandatory code.

This code cover the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles.

The obvious challenge is ice coverage in general; a traditional ship with "V-shape" bow will be stuck in the ice attacking it from head on. Today this is solved in ice covered areas such as the Baltic Sea, northern Russia and so on with the support from specialized Ice breaker services. Some ship-operators, such as Knutsen OAS, has contracted specialized LNG carrier vessels to be able to sail the North East Passage route (LNG/C "Ribera del Duero" – classed DNV ICE-1A (up to 0,8 m of ice thickness). However, they still will need help from ice breakers in some of the areas. A more direct approach is i.e. the "Norilskiy Nicke" working in Siberian waters, sailing traditional "bow first" in open waters, but with a special designed rear, going "aft first" up to 1,5 m thick ice.

Another well-known problem sailing in Polar Regions is the icing of the vessels, reducing the stability due to higher center of gravity (CG) For vessels risking this, dynamic stability calculation and mitigation with use of i.e. deck steam are important, as well as solutions for calculating risk of icing.

If an accident happens, both Search and Rescue, evacuation of personnel, as well as environmental impacts are great challenges. Pr. Today the IMO "Guidelines for voyage planning for passenger vessels operating in remote areas", has escort/"tandem" sailing as one of the considerations. Also use of dedicated ice navigators is recommended. Another long term impact is a potential oil spill; as the oil will be trapped inside the ice, oil recovery is practical impossible – and may have greater environmental impact than ever seen before in very vulnerable environments. Norway and Russia have been cooperating to mitigate these potentials, with the "Barents Watch" program. The "Barents Ship Reporting System", coming in effect 1. Of June 2013 are one of the results impacting the marine operations in the Artic as one potential solution to improve Vessel Traffic Services (VTS) in the region.

Taking into account navigational issues – hydrographic surveys and charting is in its nature extremely challenging in these areas, and need special charts. ENC coverage to be used in the "ECDIS" is improving especially due to Norwegian and Russian collaboration, however is still a challenge due to projection issues and quality of data. Organizations like BSH and The Arctic and Antarctic Institute, are distributing special charts and ice coverage predictions, and navigational data providers such as Jeppesen ensures that the data is available in as efficient means as possible – such as through the "dkart IceNavigator". The Norwegian "Hurtigruten" is one of the pioneers in Arctic/Antarctic tourist cruising. Their vessels doing polar tourist cruises use solutions such as official ENC charts and decision support tool "OceanView" software both from Jeppesen, in combination with a portable survey solution mounted on a tender boat when sailing in unsurvyed areas. Also specialized radars are being developed to ensure better situational awareness sailing in ice covered areas.

For areas surveyed, another issue arise with regards to Aids to Navigation (AtoN) – buoys are well known to drift, and taking into account the heavy forces drifting ice represent and maintenance for short range shore side systems, such solutions are practical impossible. Under the "e-Navigation" development, solutions such as "Virtual Aids to Navigation" and "specialized route exchange and advisory" are only some of the possible solutions that may arise.

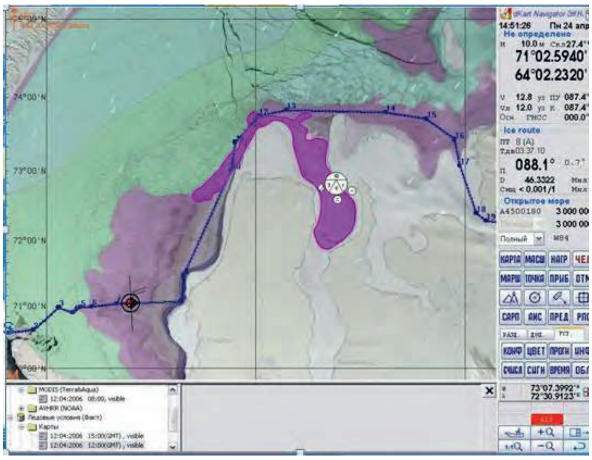

Figure 4. IceNavigator using official ENC and updated Ice information overlay.

If e-Navigation is going to be used as a potential solution for polar navigation, communication has to be improved. In an IMO eNavigation workshop in Haugesund, Norway, results from a sea trial of VSAT coverage done aboard MV "Hurtigruten Fram" in September – coordinated by Nor. Coastal Admin, showed large variations on coverage even within the "A3" area.

Today most SOLAS vessels are under GMDSS "A3" regulations to ensure communication especially for distress situations. For vessels sailing in Polar Regions the GMDSS "A4" regulations will apply. Today this is mostly covered by HF (High frequency – short wave) voice radio carriage, but is subject to effects such as frequency shift throughout the day, atmospheric disturbance and voice/language issues in general. The Iridium system is another available option, but not covering

A4 carrier requirements. From the Norwegian hosted workshop, it became clear that both efficient compilations of navigational data, as well as improved communication infrastructure are critical to ensure e-Navigation in the regions.

6. THE WAY FORWARD

As much work are being done in IMO and supporting organizations such as IHO and IALA, with support from the industry, it is clear that navigation in general will change from reaction to changing elements, to better preparation, planning and mitigation of risks. Work is being done to ensure a shared minimum framework in the "S100". It is clear that e-Navigation improve *voyage based operations* through better *voyage planning*. Seafarers will still need to be able to react to changing conditions, but probably technology can help in the processes of risk management and planning both for seagoing and shore side personnel. Information need to be available as early as possible.

Polar navigation represent a new frontier, and will maybe be the ultimate test of e-Navigation solutions for information exchange such as weather and ice forecast, recommended routes, maritime service information and so on.

The industry has already available solutions for efficient data handling, information exchange and management - mitigating risk of system failure or loss of data, and ensuring situation planning and awareness for all marine stakeholders. Be it for the ship side navigators or shore side operators and managers.

Probably the largest challenge lies in communication infrastructure (the "postman") – where joint industrial effort in combination with international collaboration are underway.

Taking all these considerations into account is a huge task. Marine traffic are increasing, and demand for safer and more efficient operations put the whole marine industry under pressure; from the onboard navigators and shore side marine VTS/SAR coordinators, to the Fleet Managers and Authorities.

Simple standards to exchange the knowledge and information between all stakeholders is a necessity and has always been done some way or the other. The change is that e-Navigation will require extended situational awareness. And situational awareness starts with proficient planning and preparation.

That's why "e-Navigation starts with e-VoyagePlanning". ■

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115 REAL-TIME RISK ASSESSMENT FOR AIDS TO NAVIGATION USING FUZZY-FSA

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In order to appreciate the risk level of the aids to navigation (AtoNs) in a navigation channel and to provide some decision-making suggestions for the AtoNs Maintenance and Management Department, the risk assessment index system of the AtoNs was built considering the advanced experience of IALA. The quantitative standard of each factor was presented, and the weight of each factor determined by means of experts-consultation combing with analytic hierarchy process (AHP) method. Under the Formal Safety Assessment frame, taking the advantages of the fuzzy comprehensive evaluation method, the fuzzy-FSA model of risk assessment for aids to navigation was established. The data needed for the model was classified into three types, which are basic fact data, real-time data and external data. And the data source of each type was determined. The model was implemented for the assessment of aids to navigation in Shanghai area. The real-time data were extracted from the existing information system of aids to navigation, and the real-time risk assessment for aids to navigation of the chosen channel was performed on platform of the three-dimensional simulation system of aids to navigation, with the risk assessment software. Specifically, taking the deep-water channel of the Yangtze River estuary as an example to illustrate the general assessment procedure, related risk assessment results and risk control suggestions were given. The method proposed presents practical significance and application prospect on the maintenance and management of the aids to navigation.

Keywords: Real-time risk assessment; aids to navigation; fuzzy –FSA; AHP; Yangtze River estuary deep-water channel

Para apreciar el nivel de riesgo de las Ayudas a la Navegación (AtoN) en un canal de navegación y proporcionar algunas sugerencias de toma de decisiones al Departamento de Gestión y Mantenimiento de AtoN se elaboró el sistema de índice de evaluación de riesgos de las AtoN considerando la experiencia avanzada de la IALA. Se presentó el valor cuantitativo de cada factor y se determinó la ponderación de cada factor por medio de consultas a expertos combinadas con el método de Proceso Jerárquico Analítico (AHP). En el marco de Evaluación de Seguridad Formal, tomando las ventajas del método de evaluación exhaustivo difuso, se estableció el modelo de evaluación de riesgos «fuzzy-FSA» para las ayudas a la navegación. Los datos necesarios para el modelo se clasificaron en tres tipos, a saber, datos reales básicos, datos en tiempo real y datos externos, y se determinó la fuente de datos de cada tipo. Se implementó el modelo para la evaluación de ayudas a la navegación en el área de Shanghái. Los datos en tiempo real se extrajeron del sistema de información de ayudas a la navegación existente, y la evaluación de riesgos en tiempo real de las ayudas a la navegación en el canal escogido se realizó sobre la plataforma de un sistema de simulación tridimensional de ayudas a la navegación, con el software de evaluación de riesgos. Específicamente, tomando el canal de aguas profundas del estuario del río Yangtsé como ejemplo para ilustrar el procedimiento de evaluación general, se dieron los resultados de evaluación de riesgos relacionados y sugerencias de control de riesgos. El método propuesto presenta trascendencia práctica y perspectivas de aplicación en el mantenimiento y gestión de las ayudas a la navegación.

Palabras clave: evaluación de riesgos en tiempo real; ayudas a la navegación; fuzzy-FSA; AHP; canal de aguas profundas del estuario del río Yangtsé

Pour apprécier le niveau de risque des aides à la navigation dans un chenal navigable et donner quelques suggestions de prises de décision au service de gestion et d'entretien des aides à la navigation, un système d'évaluation du risque a été élaboré en prenant en compte l'expérience avancée de l'AISM. Chaque élément a été évalué et son poids déterminé par des consultations d'experts combinées à la méthode de hiérarchisation analytique (AHP). Dans le cadre de l'évaluation formelle de la sécurité (FSA), en tirant avantage de la méthode fuzzy d'évaluation détaillée, on a développé le modèle fuzzy-FSA d'évaluation du risque pour les aides à la navigation. Les données nécessaires au modèle ont été classées en trois types : données factuelles de base, données en temps réel et données externes. Et la source des données de chaque type a été

déterminée. Ce modèle a été utilisé pour l'évaluation des aides à la navigation de la région de Shanghai. Les données en temps réel ont été extraites du système d'information existant et l'évaluation en temps réel du risque pour les aides à la navigation du chenal choisi a été réalisée sur une plate-forme de simulation tridimensionnelle, à l'aide du logiciel d'évaluation du risque. Pour illustrer cette procédure et prenant pour exemple le chenal en eaux profondes de l'estuaire du Yangtze, les résultats de cette évaluation et des suggestions de contrôle du risque ont été donnés. La méthode proposée et son application à l'entretien et la gestion des aides à la navigation a de l'avenir.

Real-time risk assessment for aids to navigation using fuzzy-FSA

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1. INTRODUCTION

A marine aid to navigation is a device or system external to vessels that is designed and operated to enhance the safe and efficient navigation of vessels and /or vessel traffic (IALA, 2001).

The AtoNs system marks a navigational channel, so the risk level of the AtoNs not only reflects the navigation service level of this system also indicates the ship navigation safety level in this channel. After the real-time risk assessment of the AtoNs system, some suggestions can be given to the administrators to improve the navigation service level and guarantee the ship navigation safety.

The Aids to Navigation Administration Department has the duty to plan, construct and place appropriate aids in the channel according to the navigation ships, ship density and other requirements. Then, some daily maintenance should be taken to the aids to keep them work well and guarantee their efficacy to low the navigation risk of the ships.

During the whole lifecycle of an aid, the risk assessment for marine aids is always necessary. But, at present, the AtoNs risk assessment mainly depends on the subjective judgment of the administrators or experts, or relies on some indirect suggestions from related aids to navigation information systems. These methods cannot produce real-time, accurate and systematic assessment results. So, making full use of the existing advanced information systems in the administration department, extracting real-time, accurate and comprehensive data from the systems, then carrying on real-time risk assessment for aids to navigation in chosen channel, is very significant to improve the service level of the AtoNs system. By this means, the risk assessment can run through the whole procedure of an aid including plan, placement, construction, operation, maintenance and management, and can decrease subjective judgments, which can provide more useful, comprehensive and real-time information and advices for the administrators.

The index system for AtoNs risk assessment was established by exploring experience from IALA and consulting many related experts. Then, under the framework of the Formal Safety Assessment (FSA) method, the fuzzy comprehensive assessment method was introduced into the work to build a Fuzzy-FSA model to realize the risk assessment for the AtoNs. Besides, the real-time risk assessment for aids to navigation of the chosen channel was performed on platform of the three-dimensional simulation system of aids to navigation, with the risk assessment software. Specifically, the deep-water channel of the Yangtze River estuary was taken as an example to illustrate the general assessment procedure, the final risk assessment results and risk control suggestions were given to the administrators for better maintenance and management of the aids to navigation.

2. INDEX SYSTEM FOR ATONS RISK ASSESSMENT

A marine aid to navigation, as an individual part in the channel, is very easily influenced by external environment, including the navigation vessel conditions, traffic conditions, channel conditions, hydrological conditions, meteorological conditions and so on. Frequent abnormal conditions happened to a marine aid maybe: damage, abnormal light, shifting, lost, etc. These all will have obvious harmful effects to the navigation service level for the ships and the navigation safety, even may lead to ship collision, ship grounding or collision between ships and buoys.

Therefore, the risk assessment for marine aids is necessary and covers so many factors, such as navigation ships, traffic, channel, environment, accidents history and so on. After drawing lessons from the <IALA Aids to Navigation Guide> and consulting some related experts on aids to navigation maintenance and management (from Aids to Navigation Administration Departments, Aids to Navigation Plan and Design Departments, Pilot Stations and Aids to Navigation Repair Stations), also, considering the operability of the real-time assessment on the aids to navigation three-dimensional simulation system, the index system for AtoNs risk assessment was established in **Table 1.** The index system can be categorized into five aspects: traffic volume, ship traffic condition, navigational condition, Waterway configuration and Accident conditions. Each aspect also was further subdivided into several factors.

Besides, some factors having relationships with the risk of AtoNs may be excluded from the index system because of their tiny and negligible effects comparing to other factors in the system, for example "channel length" in "waterway configuration", or the meanings of them have been embodied into other factors in the system, for example "ship size" embodied into "traffic mix" via statistics. In a word, the built index system for AtoNs risk assessment is relatively complete and feasible.

Risk assessment for AtoNs	
1. Traffic Volume	Deep draught
	Shallow draught
	Commercial fishing vessels and other boats
	Hazard cargoes
2. Ship Traffic Conditions	Traffic mix
	Traffic density
	Ship speed
3. Navigational conditions	Visibility
	Wind
	Current and wave
	Obstructions conditions
	Aids to navigation condition
4. Waterway configuration	Channel width
	Channel curvature
	Waterway complexity
	Channel depth
	Channel structure
5. Accident conditions	Accident frequency
	Injuries to people
	Property damage
	Hazardous material release
	Emergent rescue equipment condition
	Emergent rescue system level

Table 1: Index system for AtoN risk assessment

3. FUZZY-FSA MODEL

3.1 Introduction of Formal Safety Assessment (FSA)

FSA is a structured and standardized safety assessment method. In the 20th century, for promoting and improving the maritime safety, the International Maritime Organization (IMO) encourages Member States to apply this advanced safety assessment to special research on the safety of vessels. So far, FSA has been widely applied into safety rule making, ship design and ship management and other related fields. It provides some decision-making proposals to improve the navigation safety level and reduce or avoid marine risk. FSA method has five formal steps shown in **Fig 1,** including identity risks/hazards, assess risks, specify risk control options, make a decision and take action.

Comparing to other methods, the steps in FSA are much more reasonable and comprehensive. Also, it can be integrated into some comprehensive evaluation methods to analyze the risk and influence. This method will propose corresponding decision-making suggestions from both the quantitative and qualitative angle. Then, the evaluation results will be much more scientific, making the suggestions on risk control more practical and feasible.

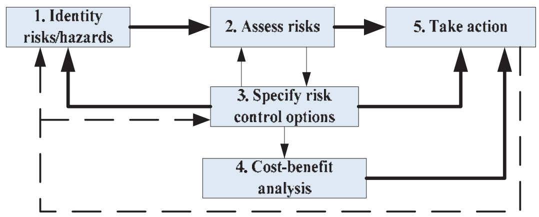

Figure 1: Steps of FSA method

3.2 Introduction of Fuzzy-FSA model

Fuzzy comprehensive evaluation method (Fuzzy) applies fuzzy transform principle and the maximum membership degree law, and considers factors associated with the target to make a comprehensive evaluation. The evaluation results can reflect the actual conditions of the evaluated target comprehensively after analyzing from multi-factor and multi-level. Now, Fuzzy method has been widely used in various fields.

The general steps of the Fuzzy comprehensive evaluation method are as follows:

1. Building the risk evaluation index system with hierarchical structure based on the characteristics of the target to be evaluated;
2. Determining of the weight set of the index system by expert consulting and AHP method;
3. Building of the evaluation matrix of each factor according to the determined quantitative standard;
4. Calculating the final fuzzy relation matrix for the target based on the weight set;
5. Obtaining the quantitative and qualitative evaluation results through the defuzzification of the results.

Fuzzy-FSA model is built by introducing the Fuzzy comprehensive evaluation method under the framework of FSA method. The qualitative and quantitative risk level will be achieved by building the index system and fuzzy assessment. Fuzzy evaluation method is obvious in steps 1, 2, 3 and step 5 of FSA method. Because of considering too many economic and political factors, the step 4 of FSA, cost-benefit analysis is excluded here. FSA provides overall assessment ideas while the Fuzzy method provides evaluation technique and evaluation index. These two methods combined together to make the evaluation idea more clear and the evaluation results more persuasive and feasible. **Fig 2** shows the general steps of Fuzzy-FSA method.

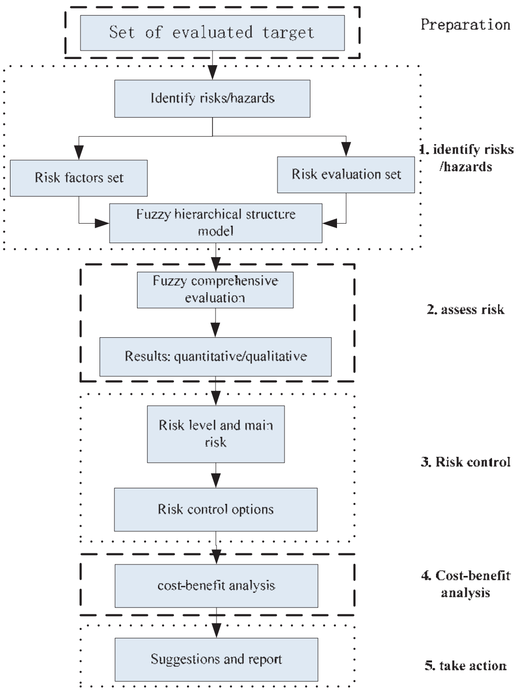

Figure 2: General steps of Fuzzy-FSA method

3.3 Quantitative Standard of Each Factor

In order to realize the real-time risk assessment of the AtoNs, each factor in the index system should be analyzed to determine one corresponding quantitative standard. The standard must be so accurate as much as possible that can represent the actual meaning of the factor, and also should be feasible making sure the value of the factor is easy to get.

The meanings of some factors in Table 1 are obvious and clear, so the quantitative standards of them can be determined easily according to their literal meanings, for example, "traffic mix", "current and wave", "channel depth" and "accident frequency".

While some factors can be quantified into a percentage, for example, using "the proportion of large ships per day (%)" to indicate the "Deep Draught", using "the proportion of over-speeding ships per day (%)" to indicate the "Ship Speed", the same to the other three factors: "Shallow draught", "Commercial fishing vessels and other boats", "Hazard cargoes".

"Injuries to people" and "property damage" can be quantified by straight data, which are "the number of people injured" and "the economic lost" respectively.

While some factors are qualitative, such as, "channel structure", "aids to navigation condition", "hazardous material release", "emergent rescue equipment condition" and "emergent rescue system level". These factors can be quantified by means of a score (from 0~10) determined by the administrators or investigation results.

Because of lacking of intuitive and appropriate judgment criteria, or no direct data, the other factors (visibility, wind, channel width, channel curvature, obstructions condition, waterway complexity) cannot be quantified according to the superficial meanings, needs further analysis. Taking the "visibility" as an example, even one channel may have different visibilities every day, so it is very inconvenient to collect the data and unsuitable to compare between different channels if just using the "the distance of the visibility" to qualify it. Therefore, after further analyzing the factor and making reference to related research, "the days per year with the visibility less than 1km" is determined as the quantitative standard for "visibility". This kind of quantitative standard is easy to understand and the value of it is easy to get. Also, the quantitative standards of "wind", "channel depth", "channel curvature" and "waterway complexity" all have been determined by this means. The quantitative standard of every factor is shown in **Table 2**.

Risk assessment for AtoN		Quantitative Standard	Weight
1. Traffic Volume	Deep draught	The proportion of large ships per day (%)	0.055
	Shallow draught	The proportion of small ships per day (%)	0.037
	Commercial fishing vessels and other boats	The proportion of commercial fishing vessels and other boats per day (%)	0.037
	Hazard cargoes	The proportion of ships with hazard cargoes per day (%)	0.055
2. Ship traffic conditions	Traffic mix	Average ship numbers per day	0.102
	Traffic density	Smoothness level: Score (0~10)	0.077
	Ship speed	The proportion of over-speeding ships per day (%)	0.077

Risk assessment for AtoN		Quantitative Standard	Weight
3.Navigational conditions	Visibility	The days per year with the visibility less than 1km	0.021
	Wind	The days per year with wind stronger than 6 grade	0.038
	Current and wave	Speed of cross current(m/s)	0.034
	Obstructions condition	Distance to the channel centerline (m)	0.021
	Aids to Navigation condition	Score (0~10)	0.034
4. Waterway configuration	Channel width	The length of the largest ship/ the most narrow width of the channel	0.097
	Channel curvature	The largest turning angle of the channel (Deg)	0.049
	Waterway complexity	Numbers of traffic special points in the channel /channel length	0.025
	Channel depth	Channel depth (m)	0.021
	Channel structure	Score (0~10)	0.021
5. Accident conditions	Accident frequency	Average Accident frequency per year	0.034
	Injuries to people	The numbers of people injured	0.033
	Property damage	The economic lost	0.033
	Hazardous material release	Pollution degree: score (0~10)	0.033
	Emergent rescue equipment condition	Score (0~10)	0.033
	Emergent rescue system level	Score (0~10)	0.033

Table 2: Quantitative standard of each factor and the weight index

3.4 Weight of Each Factor

The weight of each factor is also very important to the risk assessment results. For making sure of the accuracy and acceptability of the assessment results, on the basis of the related project from Shanghai Aids to Navigation Administration Department, the weight index was acquired by integrating Delphi method and Analytic Hierarchy Process (AHP) method. During the project, the expert questionnaire was complied and sent to 48 experts from Aids to Navigation Administration Departments, Aids to Navigation Plan and Design Departments, Pilot Stations and Aids to Navigation Repair Stations and some related departments. The questionnaires were all replied back. Fully considering all the experts' comments and suggestions, the judgment matrix based on AHP method was established. The weight of each factor was calculated by square root rule, and passed the consistency check. The detailed calculation procedure will not be repeated here.

Besides, the weight index should also be dynamic and adjustable in coincidence with the changes in channel or port or government policy. Because with the development of port and channel and the continuous construction of AtoNs, the risk may face will also be changed. The weight index is also shown in **Table 2.**

Owning to limited time and resources, the number of the sent questionnaires may be not enough. But the experts chosen are all very experienced and representative in the field in China. Their persuasive comments and suggestions can generally guarantee the objectivity and accuracy of the assessment results.

4. REAL-TIME RISK ASSESSMENT FOR AIDS TO NAVIGATION USING FUZZY-FSA ON THE PLATFORM OF AIDS TO NAVIGATION THREE-DIMENSIONAL SIMULATION SYSTEM

Till now, the AtoNs administrators mastering and assessing the AtoNs risk mainly resorts to measurements by practical ship trail. It is time-consuming and cost expensive. The most important is that the results by technical measurements only can reflect the conditions of the aids observed under the environment condition at that time, but not comprehensive and real-time. Besides, the results measured are easily affected by the technical level, the distance from the target, the testers and the environment conditions and some other factors.

Now, China Aids to Navigation Administration Departments have been equipped many useful AtoNs information system to help mastering the real-time conditions of the AtoNs in the water areas under the jurisdiction, such as AIS AtoNs system, Aids to Navigation Three-dimensional Simulation System, Aids to Navigation Telemeter and Telecontrol System, and so on. Especially, the Aids to Navigation Three-dimensional Simulation System is a comprehensive system, integrating with other information systems, which can display the surrounding conditions in real time, including the aids to navigation and nearby ships' information under the pre-set environment conditions. So, it is an optimal platform to realize the real-time risk assessment for aids to navigation.

4.1 General Procedure of the real-time risk assessment for aids to navigation

If all the values of the influencing factors of aids to navigation risk were input or determined manually, the risk assessment system would be meaningless. So, an AtoNs risk assessment module was developed on the platform of the Aids to Navigation Three-dimensional Simulation System. It was embedded into the simulation system, also, can run independently.

The real-time risk assessment for aids to navigation is realized by extracting the needed real-time data from the aids to navigation three-dimensional simulation system. And also, some additional external database and expert experience knowledge will be supplemented to the system. The data can be updated real-timely according to the chosen targets and assessment conditions. In this module, the important real-time information was extracted to determine the value of the factors in the built index system, then, activating the fuzzy-FSA model to carry out the risk assessment for chosen aid or channel. The results can reflect the real time risk level of the aids to navigation in the channel, which can provide more helps for the aids to navigation administrators and be useful for improving the navigation service level and ship navigation safety level. And, the results can be displayed on the three-dimensional simulation system, also can be saved as an excel table to be printed, which is very convenient to compare and analyze in future.

The general procedure of the assessment is shown in **Fig.3**.

4.2 Preparation of data

The data needed in the assessment includes the values of the factors and their weights. The weight index was established in section 3.4.

Then, according to the built risk assessment index system and the quantitative standards, the value of each factor can be classified into three types, which are basic fact data, real-time data and external data (Table 3). It is obvious that the navigational conditions and the channel conditions of one channel are often constant in a long time, while the ship conditions, ship traffic conditions and the accidents conditions are mainly dynamic. Besides, some other data, such as the aids to navigation service, emergent rescue equipment conditions and emergent rescue system level, rely on external input or judgment. This classification is helpful to the data preparation before risk assessment.

Different types of data are from different sources, shown in **Table 3**. The Aids to Navigation Three-dimensional simulation system, as the foundation platform, is certainly the first data source. Particularly, its bottom aids to navigation database and channel database will provide some precious data for the risk assessment. Meanwhile, the database can be supplemented and perfect according to requirements. Besides, the basic fact data and the real-time data can be complied into a database for the direct use in the three-dimensional simulation system. And, this is helpful to data modification and data update, guaranteeing the timeliness and accuracy of the evaluation result.

4.3 Design Results of the Real-time risk assessment module

Based on the ECDIS, using Visual C++ and Database Management technology, the real-time

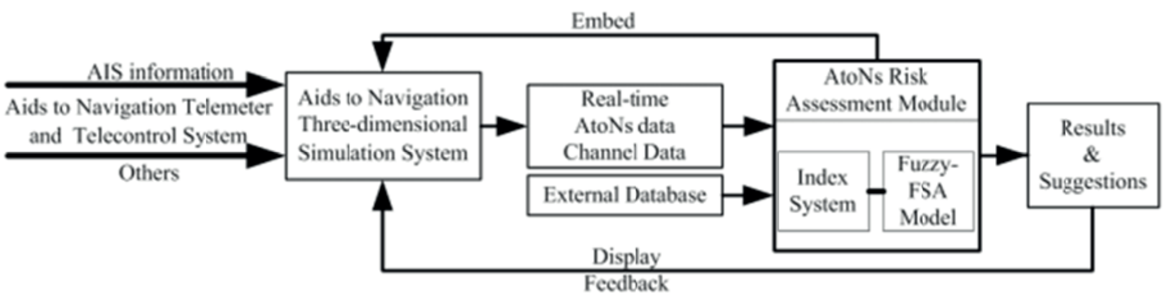

Figure 3: General Procedure of the real-time risk assessment for aids to navigation

risk assessment system for aids to navigation on Three-dimensional simulation system was achieved and taken into actual use in Shanghai Aids to Navigation Department. This module can run with the simulation platform, or, run independently. When choosing one evaluated aid or channel on the ECDIS of the three-dimensional simulation system, the "Aids to Navigation Risk Assessment" module is activated to realize the risk evaluation for the chosen target (Fig.4). All the indexes and their values are all displayed in the evaluation window. And the evaluation results displayed in the window includes risk value of each aspect and the value and level of the total risk, also some risk control suggestions **(Fig.5)**.

Classification	Data needed	Data source
Basic fact data	Navigational conditions	Statistic materials, such as sailing guidelines
	Channel conditions	Channel database and the supplement in the simulation system
Real-time data	Traffic volume conditions	AIS data in three-dimensional simulation system
	Ship traffic conditions	AIS data in three-dimensional simulation system
	Accident frequency; Injuries to people; Property damage; Hazardous material release	Accident statistics materials
External data	Aids to navigation condition	Evaluation results from the administrators
	Emergent rescue equipment conditions; Emergent rescue system level	Actual conditions and expert judgments

Table 3: Data classification and data source

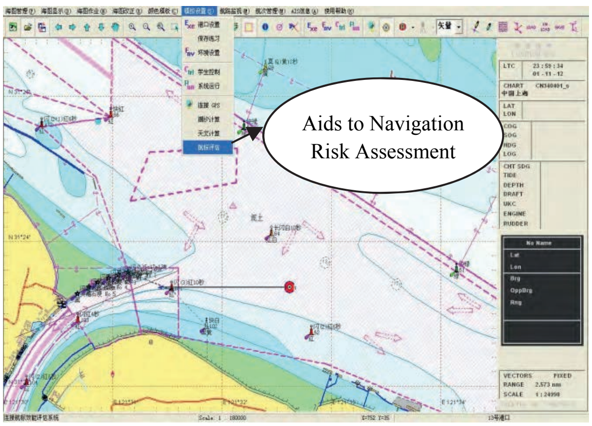

Figure 4: Activating the "Aids to Navigation Risk Assessment" module on Three-dimensional system

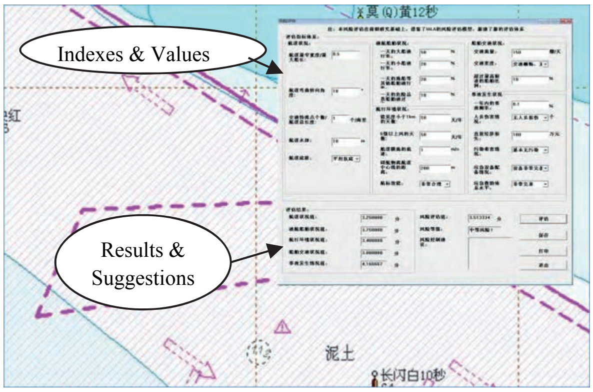

Figure 5: Evaluation effects of the chosen channel

The evaluation process and the final results can be saved into a database called "Assessment Record" for future study or comparisons between different targets or assessment conditions.

5. REAL-TIME RISK ASSESSMENT FOR AIDS TO NAVIGATION IN YANGTZE ESTUARY DEEP-WATER CHANNEL

Taking the deep-water channel of the Yangtze River estuary as an example to illustrate the general assessment procedure, then, related risk assessment results and risk control suggestions will be given at last.

5.1 General conditions of the deep-water channel

After the third-phase project, the depth of the deep-water channel is kept at 12.5m, and the ship flux increased steadily. But the navigation environment of the deep-water channel is very complicated. Many heavy wind days occur and last a long time. And the days with poor visibility may account for 5% of the total year. With the development of Shanghai International Shipping Center, much larger numbers of ships with various types navigate in this water area. Even the maximum speed limitation is set to be 15kn, still many large ships navigate beyond it, bringing higher risks to the whole navigation safety. Fig.6 shows the average speed distribution condition in this channel in 2013. Almost 29.1% ships are over-speeding.

Analyzing the AIS data in the three-dimensional system, it is found that the average ship flux in the deep-water channel is 251 per day in recent years, in which, large ships (draft>10m) account for 10.3%, while the small ships account for about 31.9%. Most of the ships are commercial ships and other boats, occupying 57.8% of the total numbers. And 15.8% ships carry hazardous cargoes.

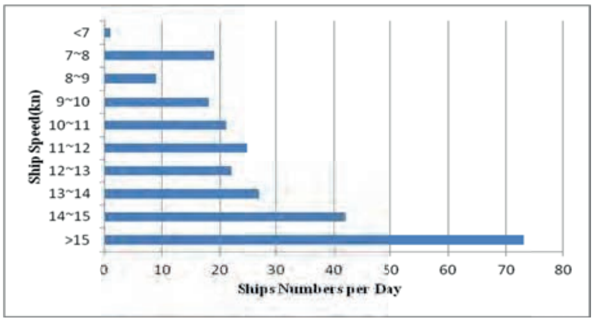

Figure 6: Ship speed distribution condition in deep-water channel

5.2 Risk assessment for AtoNs in deep–water channel

After activating the "Aids to Navigation Risk Assessment" module on Three-dimensional system, then choosing the deep-water channel in the ECDIS, the window of the real-time risk assessment for AtoNs in the deep-water channel will be appeared, like Fig.5. The blanks in the window are filled with the values of each index as in Table 4. The meanings of each data were illustrated in Table 2, and also the weight of each index.

Certainly, if the chosen targets or the assessment environments were changed, the values of each index would be changed correspondingly and real-timely. That is how the real-time assessment be achieved.

Risk assessment for AtoNs in deep-water channel		Index values
1. Traffic Volume	Deep draught	10.3%
	Shallow draught	31.9%
	Commercial fishing vessels and other boats	57.8%
	Hazard cargoes	15.8%
2. Ship Traffic Conditions	Traffic mix	251
	Traffic density	8(0~10)
	Ship speed	29.1%
3. Navigational conditions	Visibility	18.25
	Wind	31
	Current and wave	0.7
	Obstructions conditions	570
	Aids to navigation condition	9(0~10)
4. Waterway configuration	Channel width	0.914
	Channel curvature	12
	Waterway complexity	0.08
	Channel depth	12.5
	Channel structure	8(0~10)
5. Accident	Accident frequency	0.02%
	Injuries to people	0
conditions	Property damage	15
	Hazardous material release	8(0~10)
	Emergent rescue equipment condition	8(0~10)
	Emergent rescue system level	8(0~10)

Table 4: The values of each index for deep water channel

Click the "Assessment" in the window, the results will be displayed in the window (Fig.5). It was illustrated in **Fig.7**.

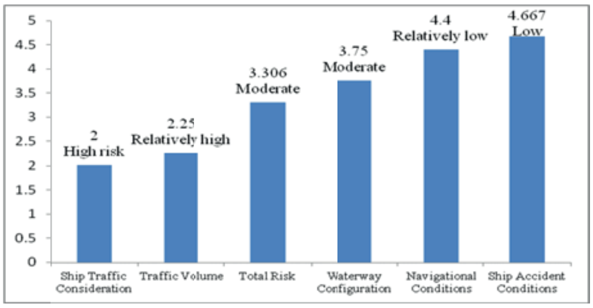

Fig.7 Risk condition of the AtoNs in deep-water channel

(**Attention:** 0~2, High Risk; 2~3, Relatively High Risk; 3~4, Moderate Risk; 4~4.5, Relatively Low Risk; 4.5~5, Low Risk)

Fig.7 shows that the overall risk level of the AtoNs in Yangtze estuary deep-water channel is moderate (score: 3.306). The main risks are caused by ships conditions and the traffic conditions with high risk level, with the score of 2 and 2.25 respectively. In the deep-water channel, the types of the ships are various, with many small ships and commercial fishing vessels or boats. And, many over-speeding ships and ships with hazardous cargoes navigate in the channel. These all lead to high risk level. However, the channel conditions, aids to navigation conditions and the navigational environment are all very good to the ship navigation, which can reduce the navigation risk to some extent. In conclusion, the overall risk level of the channel is moderate.

To the Yangtze estuary deep-water channel, some risk control suggestions were proposed based on the above evaluation results:

1. Standardizing the ship navigation orders, warning and guiding the small ships and commercial fishing vessels to obey the rules; Warning the over speeding ships timely to keep safety speed;

2. Placing safe water markings or leading lines in the water area with big ship flux to guide the ships past this area quickly and safely;
3. Making full use of the visual aids and radio aids to build one comprehensive navigation aid system to provide accurate and timely navigation information and warnings for the ships;

The results were reviewed and approved by the administrators and experts from Shanghai Aids to Navigation Department. And, the risk assessment can be real-timely changed in coincidence with the chosen targets and the assessment environments.

6. CONCLUSIONS

In order to improve the risk assessment level for AtoNs, one real-time risk assessment module was completed based on built index system and fuzzy-FSA model. Comparing to the traditional AtoNs risk assessment method, the real-time risk assessment for aids to navigation using fuzzy-FSA on the platform of aids to navigation three-dimensional simulation system can provide real-time, more scientific and comprehensive results for the chosen targets. And the risk assessment results would be changed real-timely if the targets and the assessment environments were changed. Besides, after practical using in the Yangtze estuary deep-water channel in Shanghai, the assessment results were approved by the administrators and experts from Shanghai Aids to Navigation Department. The method proposed presents practical significance and application prospect on the maintenance and management of the aids to navigation. ■

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116 RISK ASSESSMENT OF NEW DANGEROUS WRECK WARKING

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A new dangerous wreck which often has burst and critical characteristics, pose a great threat to ships. IMO approved IALA Recommendation O-133 in November, 2006, which introduces a new emergency wreck marking buoy(EWMB). The latest revised MBS bring into EWMB and stipulates that marking a new danger using appropriate marks such as Lateral, Cardinal, Isolated Danger marks, or equally using EWMB. This paper introduces the actual situation on new dangerous wreck marking worldwide since 2006, including the use of virtual AIS AtoN. This paper use risk assessment for marking new dangerous wreck which combined with typical cases. Finally, in order to ensure safety of navigation and the prevention of pollution of sea, this paper suggests how to better marking new dangerous wreck in future.

Un nuevo naufragio peligroso que frecuentemente reúne características explosivas y críticas supone una gran amenaza para los barcos. La IMO aprobó en noviembre de 2006 la Recomendación O-133 de la IALA, que presenta una nueva Boya para el Balizamiento de Emergencia de Naufragios (EWMB). La última revisión del Sistema de Balizamiento Marítimo (MBS) introduce la EWMB y estipula que puede señalizarse un nuevo peligro utilizando marcas apropiadas como las marcas Lateral, Cardinal, Peligro aislado, o igualmente usando EWMB. Esta ponencia presenta la situación real sobre la nueva señalización de naufragios peligrosos en todo el mundo desde 2006, incluyendo el uso de AIS AtoN virtuales. Esta ponencia analiza la evaluación de riesgos para la señalización de nuevos naufragios peligrosos combinada con casos típicos. Finalmente, para garantizar la seguridad de la navegación y la prevención de la contaminación marina, esta ponencia sugiere cómo señalizar mejor los nuevos naufragios peligrosos en el futuro.

Une nouvelle et dangereuse épave, souvent démantelée, est une menace pour les navires. L'OMI a approuvé la Recommandation O-133 de l'AISM en novembre 2006, qui introduit une nouvelle bouée de balisage d'urgence des épaves (EWMB). La dernière version du Système de Balisage Mondial (MBS) introduit les EWMB et stipule que le balisage d'un danger nouveau doit s'effectuer avec les marques appropriées : cardinales, latérales, danger isolé, mais aussi avec l'EWMB. Ce rapport expose la situation réelle du balisage de nouvelles et dangereuses épaves dans le monde depuis 2006, y compris l'utilisation des aides à la navigation AIS virtuelles. Il utilise l'évaluation du risque pour le balisage d'une nouvelle et dangereuse épave, combiné avec des cas typiques. Enfin, pour assurer la sécurité de la navigation et prévenir la pollution de la mer, ce rapport suggère des moyens de mieux baliser les épaves nouvelles et dangereuses à l'avenir.

Risk assessment of new dangerous wreck marking

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XVIII Conference · A Coruña · Spain

1. IMO AND IALA'S REGULATIONS ON NEW DANGEROUS WRECK MARKING

In 2002, some ships collided with the wreck Tricolor, although it had been marked by conventional buoy after it sank in the Dover Strait, which brought into sharp focus the effective responses required to adequately and quickly mark such new dangers and prevent collisions. The collisions also made IALA rethink profoundly on the effectiveness of conventional new dangerous wreck markings (lateral, cardinal marks, and isolated danger marks) and finally introduced the EWMB.

1.1 IMO approved the IALA Recommendation 0–133, which brought up the use of new EWMB

IMO pointed out in its Notice SN.1/Circ.259 on EWMB:

- The Maritime Safety Committee, at its eighty-second session (29 November to 8 December 2006), at the request of IALA and with a view to improving the safety of navigation, approved the circulation of a recently adopted IALA Recommendation O-133, which introduces, on a trial basis, a new emergency wreck marking buoy that could be used in addition to the IALA Buoyage System.

- Member Governments are invited to bring the information contained in the IALA recommendation annexed to the present circular to the attention of masters of their ships.

The IMO notice designated that the EWMBs have been recommended all around the world.

Trinity House also sent the Notice to Mariners of using EWMB on 17th May, 2005.

1.2 The IALA Buoyage System revised in 2010 brought into the use of EWMB. The system stipulates,

"New Dangers" are newly discovered hazards, natural or man-made, that may not yet be shown in nautical documents and publications, and until the information is sufficiently promulgated, should be indicated by:

- marking a new danger using appropriate marks such as; Lateral, Cardinal, Isolated Danger marks, or equally
- using the Emergency Wreck Marking Buoy (EWMB)

If the competent authority considers the risk to navigation to be especially high at least one of the marks should be duplicated.

Marking of a new danger may include use of a Racon coded Morse "D" (- ●●) or other radio transmitting device such as automatic identification systems as an Aid to Navigation (AIS as an AtoN).

Marking of a new danger may be discontinued when the appropriate competent Authority is satisfied that information concerning the "New Danger" has been sufficiently promulgated or the danger has been resolved.

2. APPLICATION OF EWMB AROUND THE WORLD

The author of this paper has the first-hand data for the use of EWMB around the world, as he was required to report twice a year the use and the problems of EWMB around the world at the IALA AtoN Management committee (ANM) meeting as a Rapporteur of Use of the IALA Emergency Wreck Marking Buoy from 2006-2010. In August and September of 2013, the author sent out questionnaires to all the delegates to ANM Committee and obtained some new information. According to the feedback provided by the questionnaires, the EWMB application around the world is as follows,

Seven countries have used EWMB: China, UK. Denmark, Latvia, Australia, Korea and Ireland

All the competent Authority that had used EWMB unanimously claimed that it is a very good system, or a good solution, which is manifested in the following:

- The use of the EWMB has been proved to be a successful alternative to the traditional buoys.

- All Mariners from Commercial to Fishing and Leisure are advising that the different conspicuity of the Blue and Yellow light and buoy are proving to provide the necessary warning for a new dangerous wreck.

Eight countries and regions are ready to use EWMB: Netherlands, Scotland, Belgium, Sweden, Poland, Argentina, Norway and Hongkong.

Four countries have explicitly expressed that they would not use EWMB: US, Canada, Germany and Portugal.

The reason why US and Canada did not want to use EWMB is that the blue light has been used on ships of law enforcement. US generally use lateral marks to mark new dangerous wrecks, but they feel the EWMB is distinctive and well designed, and it can be used to good purposes in many parts of the world. Canada relies on traditional ways (isolated danger buoys, cardinal buoys, lateral buoys) to mark new dangers.

Germany and Portuguese did not want to use EWMB because until this moment they didn't feel the need to use this buoy. The situations they faced were perfectly solved with the use of cardinal marks/isolated danger marks/ lateral marks.

3. ANALYSES OF TYPICAL CASES

After a new dangerous wreck happens, the competent Authority should select an adequate solution for deploy a number of buoys according to the specific situation of the wreck, the environment, trafficking. In view of our investigation, the number of EWMBs to be deployed at the time of a new dangerous wreck should be 1-4. The following is analysis of typical cases.

3.1 One EWMB Deployment – Great North East Channel Torres Strait, Australia

On Saturday 12 September 2009 a 17m steel fishing trawler sank after its nets became entangled on a seabed obstruction in approximately 30m of water in the vicinity of the Two-Way Route at Great North East Channel, Torres Strait, Northern Australia. Two crewmen were safely rescued by helicopter.(See **Figure 1**)

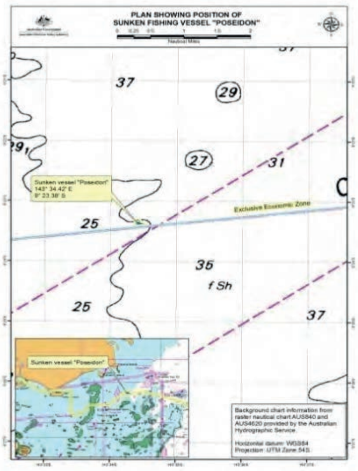

Figure 1: Map for the wreck in Torres Strait

In view of the proximity of the dangerous wreck to the shipping channel, Australian Maritime Safety Authority (AMSA) issued Safety Broadcasts and marked the position with a wreck marking buoy (See **Figure 2**). The buoy was deployed by AMSA's dedicated Great Barrier Reef / Torres Strait Emergency Towage Vessel (ETV) Pacific Responder (See **Figure 3**).

Figure 2: The EWMB deployed by Australia

Figure 3: The Pacific Responder, the emergency towage vessel

3.2 Two EWMBs Deployment –West Coastal Sea of Korea

According to the IALA Recommendation O-133, Korea introduced the EWMB in November 2008 and the first installation of EWMB for new dangerous wreck was on March 7th, 2009 at the west coastal sea of KOREA.

The tugboat (Namkwang 2, 18 dwt) sank in the vicinity of Incheon Port anchorage. (See **Figure 4**). The competent Authority deployed two EWMBs during the time of 7th to 31st March 2009.

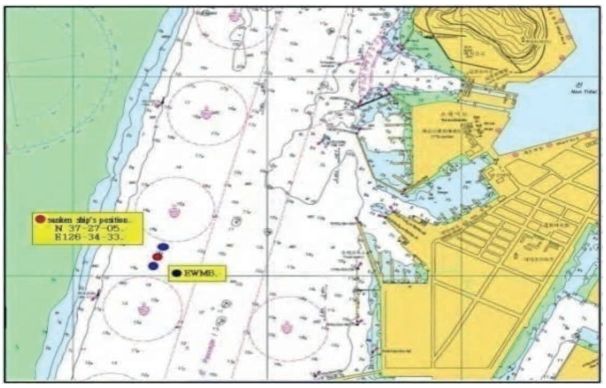

Figure 4: The wreck and the EWMBs in Incheon Port

Figure 5: The EWMB deployed by Korea

3.3 Three EWMBs Deployment – Changtu Port of Eastern China Sea

In Changtu Port of Eastern China Sea, three EWMBs were deployed for one new dangerous wreck on 3rd October, 2007.

The 45 m long cargo ship MV Zhedai 286 sank in the vicinity of the entrance channel of Changtu Port, which constituted a threat to the safety of navigation (See **Figure 6**). Three EWMBs were deployed on 3rd October, 2007 and they are still there now (See **Figure 7**).

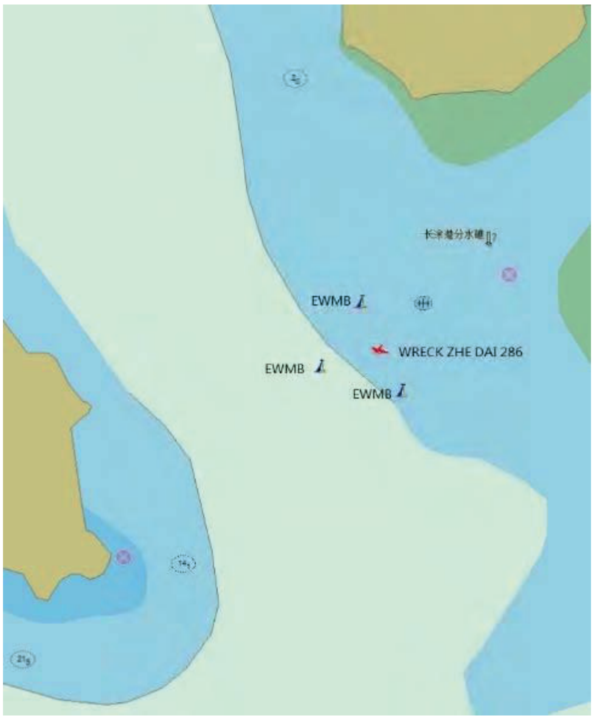

Figure 6: The wreck and the EWMBs near Changtu Port

Figure 7: The EWMB deployed by China

3.4 Four EWMBs Deployment – Territorial Waters of UK

The wreck MVJork, (3167 gt bulker, 95 m long, 4.7 in draft, carrying grain) stuck an unmanned gas production platform and finally sank at Latitude 53° 26'.015N Longitude 02 ° 08'.39E with the surrounding depths in initial reported to be 11.6 m (See **Figure 8**). It was marked by 4 EWMBs from 4th to 6th August 2007, (See **Figure 9**) after which it was marked by 5 cardinal buoys, the duplicate west cardinal was a Racon Coded Morse "D".

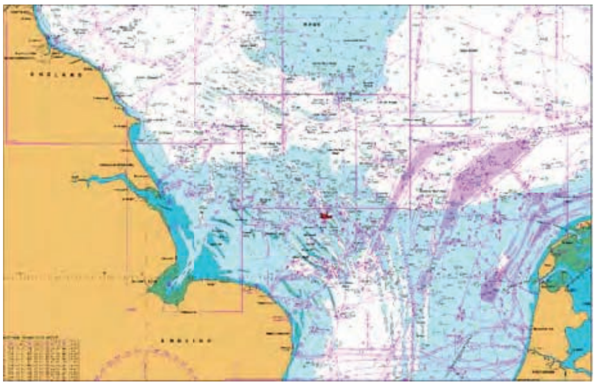

Figure 8: The wreck Jork and its position in British territorial waters

3.5 Using virtual AIS AtoN before anything else—Yangtze River Estuary, East China Sea

As early as 0038, August7, 2013, the China flag Haihongda, carrying 13,500 tons of iron ore, collided with Panama flag the Tourist and sank. 16

crewmen were rescued with the other 2 missing. The wreck posed a serious danger to safe navigation.

At 0500 of the same day, Shanghai Maritime Safety Adminstation, after being informed of the accident, sent buoy tender Haixun 167 to the spot at full speed. At the same time it used one virtual AIS AtoN (see **Figure 10**). After that, the passing ships began to avoid the marked position. At 14:50 that day, the Haixun 167 arrived at the spot and deployed four EWMBs.

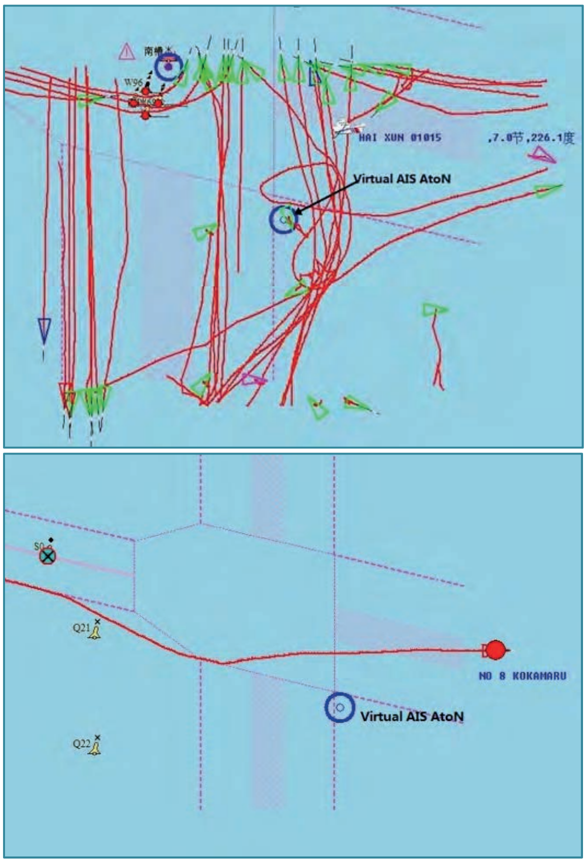

Figure 10: AIS virtual AtoN at the position of the wreck

3.6 Analysis

In view of the case analysis, combined with the answers to our questionnaire, we conclud that:

- Although the competent Authority always broadcast Safety message of new dangerous wreck via NAVTEX or VHF immediately, there still might not be known by quite a lot of vessels which are transiting through or will transit through. So the deploy of AtoN including virtual AIS AtoN in time is key important.
- In respect of the choice of marks, the EWMB become the first choice for most of the

Figure 9: The EWMB used in UK

countries as its high impact and be designed to special for new dangerous wrecks.

- In respect of the pattern of deployment, it is generally deployed on the side where the wreck is near the navigation channel when one EWMB is used; when 2 EWMBs are used, they are deployed in such a way that the wreck is on the center of a virtual line by connecting the EWMBs; when three or more are used, the wreck is deployed within the virtual lines formed by the EWMBs.
- In respect of the period of establish, some countries' regulate 2 weeks ,some others 2 months, some others 6 months. In practice, the shortest period is 1-3 days, while the longest, more than one year. When the period is short, it means the wreck is quickly cleared away or the EWMB is immediately replaced by conventional marks. In case of the longer period, it means in general, the competent Authority would wait until the new dangerous wreck information is issued in Notice to Mariners and all the navigators might have received such or until the wreck has been marked on relevant chars.
- In respect of the size of the EWMB, it was decided by the environment of the place where it should be deploy, small size buoys for shallow waters, while large and medium sized ones for deep water.
- In respect of the application of AIS virtual AtoN, It will be considered by competent authorities when it is impossible to deploy an EWMB due to some objective factors, such as the meteorological conditions, or when the wreck is too far to reach in time, so that the warning can be sent out as early as possible. Sometimes the virtual AIS AtoN are withdrawn after the buoys are deployed. But in

most cases, the virtual AIS AtoN are retained, even after the wreck has been marked on the charts.

- In respect of the discontinue of the use of EWMB , the EWMB is withdrawn generally when the wreck has been cleared, or when it has been marked on relevant charts after the detailed information has been obtained after careful survey and when the permanent marking are deployed.

4. RISK ASSESSMENT AND RISK MANAGEMENT ON THE NEW DANGEROUS WRECK MARKING

The diagram in **Figure 11** provides a guide to the steps involved in the IALA Risk Assessment and Risk Management process.

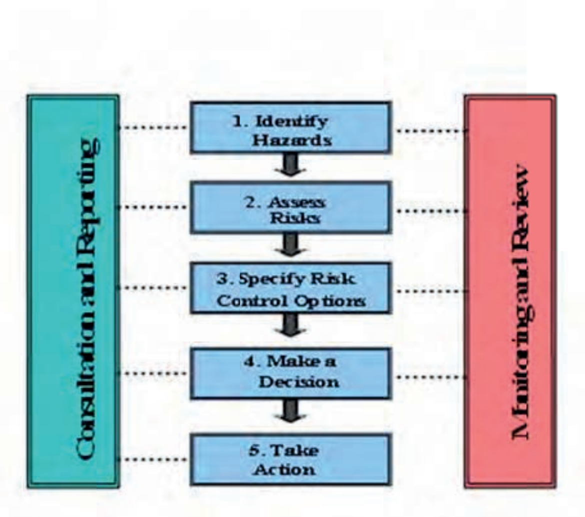

Figure 11: The Risk Assessment and Risk Management process

4.1 Identification of hazards

New wrecks are characterized as happening suddenly, and are described as follows,

- The wreck is totally submerged in water, or totally submerged in high tide, without anything to be observed or
- Part of the wreck is above water, which can be observed in daylight, but not at night;

New wreck , that not yet be shown in nautical documents and publications, is highly dangerous to passing ships, sometime, due to the failure to receive information about the new dangerous wreck, the passing ship may be faced with the great hazards of collision with the wreck. Many of the wrecks caused a great deal of maritime accident or pollution and even injuries of people in history.

4.2 Risk assessment

After receiving information about a new wreck, the competent Authority should effect risk assessment on the new dangerous wreck in terms of the hazards it caused to navigation, relying on charts and other maritime publications, based on the AIS Traffic volume analysis, taking into consideration the environment of the navigable waters, ships types, navigation density and characteristics, the depth of navigable waters and navigation rules, and other related factors.

The risk level is determined by how serious an accident, and the probability of an accident. The matrix in **Figure12** shows the basis by which the risks are ranked.

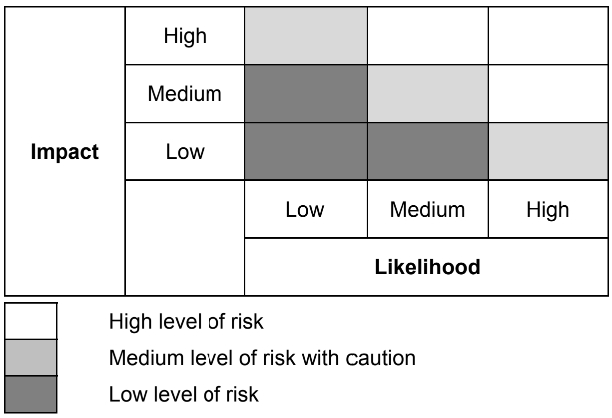

Figure 12: Risk matrix

Our research shows that the impact of the hazard can be expressed by **Table 1**.

Impact	Seriousness of the accident
High	Major injuries of personnel, serious oil spills and discharge of dangerous chemical material due to a collision between the wreck and large and medium sized special ships, such as passenger ships, dangerous cargo ships and tankers, etc. that caused serious biological destruction or damage to fishery resources.
Medium	Injuries of personnel, fuel oil spills and lose of property due to a collision between the wreck and large and medium-sized ships, exclusive of passenger ships, dangerous cargo ships and tankers, etc. that caused biological destruction or damage to fishery resources.
Small	Personnel injuries, fuel oil spills and loss of property caused by collisions between the wreck and small ships, exclusive of passenger ships, dangerous cargo ship and tankers.

Table 1: Factors that have impact on the accident

Our research proves that the probability of accidents may be expressed in **Table 2**.

Probability	Traffic situation
High	The middle of the busy channel or Ship Routing
Medium	Waters where traffic is busy
Low	Other navigable waters

Table 2: Factors that may have impact on the probability of accidents

The risk level of a new wreck can be assessed by combining the impact and probability.

4.3 Specify risk control options

Our research proves that the option for risk control that may be adopted based on the risk level of the new dangerous wreck is shown in **Table 3**.

Measures to control the risks	Low level of risk	Medium level or Risk with caution	High level of risk
Immediate broadcast of initial Safety message (navigational warning) concerning the new dangerous wreck.	Yes	Yes	Yes
Obtain as much information as possible about the new wreck.	Yes	Yes	Yes
Consider deployment of a Guard ship on the location of the new wreck	No	Yes	Yes
Consider whether temporary VTS is necessary on the new danger wreck.	No	Yes	Yes
Consider AIS applications.	Yes	Yes	Yes
Initial marking of the wreck position and the number of the EWMB	Yes, but generally only one	Yes, two in general	Yes, 3 or more in general
Survey the wreck and Issue updates.	Yes	Yes	Yes
Consider whether continuation of temporary VTS is necessary.	No	No	Yes
Consider whether removal of the wreck is necessary.	No	No	Yes
Identify steps to take if the wreck is not to be removed—Marking the wreck in charts.	Yes	Yes	Yes
Identify steps to take if the wreck is not to be removed -- Consider the permanent marking of the wreck.	Generally no	Generally AIS virtual mark is used	Generally both physical mark and AIS virtual mark

Table 3: Solutions for risk control

4.4 Decision and implementation

It is a must to mark a new dangerous wreck that poses threat to passing ships. But the meteorological and sea conditions, and lack of information of the wreck, etc., would impede the timely marking of the wreck. However, the wreck must be marked in time, irrespective of such factors. It is important that passing ships are informed of the position of the new dangerous wreck. After the decision to deploy a mark is made, the relevant procedure should be commenced as soon as possible and consider the following factors:

- Whether the base or the buoy tender has the right type and number of marks;
- The position of the nearest on-site monitoring ships (with EWNBs) or buoy tender;
- Whether the weather and the sea conditions permit such operation? Generally, the sinking of a ship happens due to a collision in poor visibility or sink due to rough weather. Moreover, it takes some time for a ship to arrive at the spot. So it is recommended that AIS virtual marking first be used.

5. CONCLUSION AND RECOMMENDATION

- Except for some countries that have used the blue light on Law enforcement ship, most of countries that have proper experience in EWMB expressed satisfaction on the effect of EWMB. Therefore it is suggested that IALA continue to sum up the experience of EWMB and promote the application of EWMB.
- In view of the fact that the service cycle of EWMB are different from country to country, it is recommended that IALA regulate the cycle of service. In principle, the cycle should be consider the time needed to be widely known by receive Notices to Mariners and is marked on charts. Generally, it could be 6 months.
- Because of the effectiveness of AIS virtual mark under rough weather and poor visibility and its characteristics of being quickly used, it is suggested that the competent Authorizes consider the immediate use of AIS virtual mark and retain it as long as possible when the meteorological conditions or depth of water is not favourable or the wreck is too far away so it is impossible to deploy an EWMB in time.

Recommend that competent Authorities make full use of AIS tool in marking a new danger wreck, as ship historical data are useful for judging the degree of risk of new dangerous wreck. ■

References

[1] IALA NAVGUIDE
[2] IALA Recommendation O-133 On Emergency Wreck Marking Buoy
[3] IALA Guideline No. 1046 On Response Plan for the Marking of New Wrecks

2014

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