IALA SEMINAR ON

on

THE HERITAGE ISSUES OF INTRODUCING NEW TECHNOLOGIES IN AIDS TO NAVIGATION

23-26 June 2009

Santander, Spain

Final Report

Executive Summary

The seminar was held at the Palacio de la Magdalena, and was attended by 60 delegates from 20 countries. It was supported by the International University Menendez Pelayo, Santander Port Authority and Puertos del Estado

The seminar looked at the impact of new technology on both fixed and floating aids to navigation and some of the consequences for their preservation. Although there was a significant focus on traditional lights and lenses, including the impact of LED lamps, the seminar also considered the need to conserve early radio navigation systems. Structural issues were not forgotten and consideration was also given to the effects of de-manning and the need for sound documentation.

Three technical visits, to Castro Urdiales, El Pescadore and Cabo Mayor lighthouses were included in the programme.

The seminar provided an excellent opportunity for delegates to achieve the seminar's stated objective of sharing expertise and exchanging information during the professional and social parts of the programme.

The seminar identified 14 conclusions and 14 recommendations (see ANNEX 5).

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1. INTRODUCTION

The IALA seminar on the heritage issues of introducing new technologies in aids to navigation was held from 23-26 June 2009 in Santander, Spain, at the Palacio de la Magdalena. It was attended by 60 delegates from 20 countries.

The objective of the seminar was to share expertise and exchange information.

Day One – Tuesday 23 June

2. SESSION 1 - OPENING OF THE SEMINAR

The opening was chaired by Ómar Frits Eriksson, Danish Maritime Safety Administration (DaMSA), Denmark, Chairman of the IALA EEP Committee.

2.1 Welcome

The Vice-Chancellor of the International University Menendez Pelayo, Mr Salvador Ordóñez, co-ordinated the welcoming remarks made on behalf of his university, Santander Port Authority and Puertos del Estado. The port was represented by Javier de la Riva, its General Manager, and Puertos del Estado by Álvaro Rodriguez Dapena, its Director of Planning and Development.

2.2 Welcome by IALA

Marie-Hèléne Grillet, Administration Manager of IALA, made the following remarks:

On behalf of IALA I would like to thank Santander Port Authority, the Municipality of Santander, the International University Menendez Pelayo, and Puertos del Estado. They have spared no effort in organising this Seminar here in Santander and the co-operation between them and IALA during its preparation has always been very efficient and friendly.

I am pleased to welcome all participants to the Seminar and hope it will meet their expectations.

The delegates who are gathered here today come from many parts of the world, some of them have travelled from the other side of the planet, from places as far away as Australia and Vietnam to hear the latest news regarding Aids to Navigation conservation. This demonstrates that the issue of conervation arouses interest all over the world and that all Aids to Navigation Authorities are facing similar problems, which they try to solve very often in close co-operation with their Heritage administrations and conservation organisations.

In this particular field IALA does not have all the skills needed and has to call upon external resources. We thank the professionals who have made the trip to Santander bringing with them their expertise and experience to share with us.

This Seminar is the third in a series, which started in the year 2000 in Norway. Some might find it very strange that interest in conservation came on the scene at the start of a millennium, which seems to be driven by new technologies and people sometimes have the feeling that what they see on their computer's screen is "more true" than what that they could see in their physical environment, if they would only take the time to look around them.

Actually, it is the power of the technology that led us to start worrying about the conditions in which the aids to navigation ancestors, the lighthouses, are left, now that their keepers are gone and just their lights continue to work, in the loneliness of an automated lantern. A cry for help was received for the first time in the 1990s when the Norwegian Aids to Navigation Authorities realised that the policy of full technology implementation was a serious threat to its many lighthouses. Why should they continue maintaining these buildings when only the lights were needed, and perhaps not for long? Thus, why should they be given money to do it? Big savings are to be made with cuts in lighthouse maintenance budgets. IALA at that time hesitated to jump into this venture. The issue wasn't in its Constitution and part of the Council was reluctant because they too were convinced that the future lay with new technologies.

Yes, but. But Aids to Navigation Authorities are responsible for keeping the lights on. And what will happen to the light if the building underneath falls to pieces, due to a lack of maintenance? Those who have taken part in the field trip at the second Seminar in Gothenburg have experienced that lighthouse decay smells bad, too. And people living in the vicinity of a lighthouse love their lighthouse. They have always lived with it. It is part of the town, of the village, the coast. This lighthouse hasn't been built here by coincidence. It's been built here because accidents have happened, in which men have lost their lives. It is the witness of the efforts made to improve the safety of life at sea. And: what will they put on their postcards if the lighthouse disappears?

These aspects however are not taken into account by those who so cautiously allocate budgets Independent solutions had to found for lighthouses to remain in existence; they had to survive by themselves.

The first initiative was to find them other roles and IALA came up with the concept of alternative or complementary use. Thus the first Seminar was devoted to identifying what the alternatives might be, according to the location, accessibility, resources available in the vicinity and, most importantly, the laws governing the lighthouse. In some countries, legislation did not allow the Aids to Navigation Authorities to give a lighthouse a role other than that of being an aid to navigation. We worked hard on that too and, as a result, the first IALA Guidelines on conservation were issued.

Once it was widely accepted that lighthouses should be given the chance of a second life, care needed to be taken of their physical condition. The second Seminar looked at this. With the help of building professionals, it scrutinized the techniques available to restore the structures, techniques that were quite different from lighthouse to lighthouse, according to the material they are built from and the environmental conditions. Listening to the presentations I discovered, to my great surprise, that concrete is something much more complex than a funny mud resulting from the mix of sand, stones and tiny grey particles. That was fascinating.

In the meantime the Panel that IALA had created to give constant support to the conservation project (known as PHL) was continuing its work with the development of the IALA Lighthouse Conservation Manual. The Manual was launched in 2006. Here, I must mention that Spain was always closely involved, never failing to give support, sharing with us the benefit of their experience in Heritage initiatives. It is also thanks to Spain that the Conservation Manual exists in both English and Spanish.

The Panel is now part of the IALA EEP Committee, under the dynamic and efficient leadership of Omar-Frits Eriksson, but the aim remains unchanged.

This time we'll go up to the lantern; the reason for the lighthouse. The technology is available, with new light sources. The large Fresnel optics are often taken out and placed in museums being replaced with complete LED systems. We'll hear that this is not always necessary and that the new technology can adapt to the lighthouse and not the opposite way round, without spending more money, possibly even less.

However lighthouses, although they are the most spectacular, are not the only aids to navigation under threat from technology; lightvessels, fog horns and early radionavigation systems have all played a prominent role on the maritime scene. We won't forget them.

I sincerely hope that you will enjoy the presentations, which, no doubt, will be fascinating and benefit from the technical visits.

Thank you again to all who have come here to share their skills.

I wish you a good, fruitful Seminar.

2.3 Chairman's welcome - Ómar Frits Eriksson

Ladies and Gentlemen, I also want to welcome you to this seminar on the Heritage Issues of Introducing New Technology in Aids to Navigation here in the beautiful city of Santander, and indeed at this spectacular venue; the Palace of Magdalena.

I spend a lot of time working with IALA and one of my responsibilities is to be the chairman of the Engineering, Environment and Preservation Committee; the EEP Committee.

In my spare time, I work with the Danish Maritime Safety Administration where I now am the head of the Innovation and Projects division.

IALA has its roots in the requirements and technology for lighthouses – indeed it is an organization that was born to serve the needs of lighthouse authorities. Although discussion on the possible formation of an association for heads of lighthouse and marking services began in 1926, the organization formally began taking shape in 1955, and the International Association of Lighthouse Authorities (IALA) was formally established on July 1st, 1957.

At that time, in 1957, the need for large lighthouses and lighthouse structures was still increasing, and technology developed at a tremendous rate.

IALA therefore became the forum where members could share their knowledge; learn together how to efficiently apply cutting edge technology to the world of Aids to Navigation.

IALA formed technical committees to deal with the challenges of how best to harvest the benefits of the electronic revolution.

For decades, this has been the revolving point of the activities of the EEP committee.

At some point in time, in the second half of the last century, the consequences of these technological advancements started to give us new engineering challenges. The de-manning of lighthouse stations resulted in new engineering challenges such as how to maintain these structures properly.

Recent developments in optics and new light sources in the first decade of this century have given us new concepts that outperform the older concepts with higher performance, reliability and efficiency.

In 2002 the PHL panel became a part of the EEP committee. This made it possible for the EEP committee to take a holistic view on all technical aspects of Aids to Navigation.

The trick is now to strike the balance between harvesting as much as possible from new technology and making sure that we take proper care of our Aids to Navigation heritage.

As you all know this balance is a very difficult one, and this seminar is an important part of this work.

This week we hope to shed some light on a balanced approach to Aids to Navigation conservation, recognizing the value of our heritage while at the same time embracing new technology.

On behalf of the EEP committee, I welcome you and wish you a very successful Seminar.

2.4 Key Note Speech - Impact of Modernisation-Advances in Technology and the Conservation of Historic Lighthouses and Aids to Navigation (Bob McIntosh, Northern Lighthouse Board, Scotland)

Good morning Ladies and Gentlemen,

I would like to add my welcome and hope that you enjoy participating in the seminar over the next four days. I am particularly appreciative of your efforts to attend this event in view of the difficult financial problems which have affected everyone in some way and I hope that by the end of the week you will feel that it has been very worthwhile.

I am here today in my role as Chairman of IALA's working group on Heritage and Conservation matters relating to Historic Lighthouses and other Aids to Navigation and Equipment. I have been involved in the work of this group now for about 9 years. I feel that the experience gained in my post with the Northern Lighthouse has provided me with a suitable background. For over twenty years I have been responsible for maintenance and project work at many of our 100 Historic Lighthouses dating from the 18th and 19th centuries.

For those of you unfamiliar with the work of IALA and in particular of our working group I would like to give you some background of how we reached this point.

The group has been in existence since 1996 and during this time we have produced many guidelines to assist IALA members in particular, with some of the options available to them. The first issue of the IALA Lighthouse Conservation Manual, published in 2006 incorporated many of these guidelines and included much useful information on this subject and is a very good starting point for authorities faced with the task of looking after these historic buildings.

In addition to the manual, a report has been published of the proceedings of a workshop, held in Kristiansand in May 2000 on The Alternative Use of Historic Lighthouses.

In August 2005 a seminar was held in Gothenburg, Sweden on the Practical Aspects of Lighthouse Preservation. The Seminar provided an opportunity for discussion on issues surrounding all aspects of the conservation of lighthouses, including historic lighthouses. The Seminar provided examples of practical solutions to the diverse problems facing aids to navigation authorities when dealing with building maintenance in remote and harsh environments. The presentations provided the latest in research and developments in paint solutions, mortar options and conservation and preservation techniques. The local project which was covered in some detail was the project to repair and reinstate the cast iron lighthouse of Pater Noster and on Thursday morning we will receive an update.

We consider that this seminar will be the next logical step in the process and it will investigate one of the major challenges faced by the Maritime Administrations around the world in the past but still today – the problems associated with changing technology in historic Lighthouses and other Aids to Navigation and how they can help to conserve these important parts of the world's maritime heritage.

As you will have read in the programme, the objective of the seminar starts by saying:

- **To share expertise** – we have here a mixture of experts in the fields of lighthouse conservation, lighthouse engineering, lighthouse museums lighthouse societies and many directly involved in projects to safeguard the future of Historic Lighthouses have travelled to be here from around the world.
- Also **to exchange information** – this we have tried to do with a balanced programme of presentations on a variety of Aids to Navigation
- Day 1 continues by talking about different aids to Navigation such as buoys, radio aids and how modern technologies can be managed. Sessions 3 and 4 deal with possibly one of the most emotive issues of Lighthouse Heritage and that is the impact of modernisation on traditional lenses and how can this be achieved to minimise the impact on these icons.
- Day 2 we have called Santander Day when we hear about local projects which have adapted lighthouse sites for complementary use with presentations on renovation of the buildings, management of the sites and links with the local authorities. Then we will be taken to visit several of the lighthouses discussed before the official dinner tomorrow evening which will be held in the Cabo Mayor Art Centre.
- Day 3 will start with several case studies of major lighthouse projects followed by session 10 when speakers will deal with the problems and hopefully some solutions to the problems of building conditioning in remoter sites with limited power sources. We will then hear from various groups outwith the lighthouse authorities who will tell us about their involvement in the conservation of lighthouses and other aids to

navigation and the day will be finished off with the presentations on the involvement of heritage authorities, museums and about recording of the changes in technology

- But we also hope that this will be a two way exchange and that your contributions through discussions will be just as important.
- and thirdly **to identify best practices on the impact of modernisation to historic lighthouses, associated buildings and all Aids to Navigation equipment.** It is anticipated that this will be identified in the final report of the seminar and in its conclusions and recommendations.

By working together to achieve these objectives we should demonstrate a balanced approach to Aids to Navigation conservation recognising the traditional heritage versus the modern day technological solutions.

It is anticipated that conclusions and recommendations from the seminar will provide guidance for heritage and aids to navigation authorities and that they may provide indicators for the work of IALA in the 2010-2014 work term.

I have tried to consider some of the problems which have been identified in Scotland but also from my meetings with representatives from other countries and I hope that through these presentations and discussions we may identify others but equally we may be able to identify some solutions to these problems

- Ongoing advancements in technology and the trend in many countries towards downgrading the range of lights, generally require smaller installations to provide the equivalent Aid to Navigation. For example more efficient solar modules, batteries and LED lanterns which reduce the area or the number of buildings required to support the Aid to Navigation
- The resulting lower equipment costs but ever increasing maintenance costs of historic lighthouse buildings can lead to difficulties in justifying the budget submissions.
- The redundancy of some AtoN's e.g. Fog Signals and Radio Beacons which produce a reduction in space requirements or most likely redundant buildings with the ongoing maintenance burden. Often these are more modern additions but are they still part of the heritage of the Lighthouse site?
- Ultimate disposal of the historic site when the Aid to Navigation is no longer required. How can the authorities help protect the future of these sites, or do they need to?
- De-manning has resulted in reduced regular building maintenance and a loss or reduction in heating and ventilation particularly at remote sites which may increase the response time to maintenance issues such as water leaks.
- General staff and funding reductions as well as low maintenance equipment requires reduced maintenance time on site and a subsequent reduction in the number of visits per year.

And now possibly a few thoughts of solutions to the problems:

- The use of alternative light sources in traditional lenses;
- Re-use of redundant property for appropriate complementary use;
- Retention of redundant equipment on site with the establishment of on-site exhibitions and improving the visitor experience;
- Or removal of equipment to an off-site museum

I think it is clear that the previous efforts of our working group continue to be relevant but also that this seminar must be seen as a stimulus to IALA to carry on with this work supported by its members using the knowledge we have gained so far to assist in the transfer the information around the world.

During this seminar I hope that you will gain from the knowledge and experiences of our speakers but also through the time available between presentations and in the evenings to ask questions to broaden your learning experience from this event.

I would ask all the attendees to consider as they are listening to the speakers and enjoying their presentations, what are the most important matters in the Heritage Issues of Introducing New Technologies in Aids to Navigation and to put these opinions forward to me so that we can arrive at a consensus of the problems and solutions to the topics discussed this week.

I hope that you all enjoy this seminar and I would like to take this early opportunity to thank all those from our hosts Santander Port Authority, my Steering Committee, Puerto del Estados and IALA staff who have brought this seminar from concept to fruition. It is now up to you the attendees to make this seminar the success it should be after all the hard work to date.

The seminar draw to a close on the final day with discussion on what has been presented, possibly what needs further research and the presenting of the conclusions and recommendations of this event which will bring together the thoughts of representatives from the 20 countries represented here this week.

3. SESSION 2 - NEW TECHNOLOGIES IN AIDS TO NAVIGATION - A NEW CHALLENGE

This session was chaired by Álvaro Rodriguez Dapena, Puertos del Estado, Spain.

3.1 The consequences of changes in floating aid technologies, (Adrian Wilkins, Pharos Marine, United Kingdom)

Early mentions of buoys are incidental in documents such as sailing directions in the 13th century. Detailed information on buoy construction does not appear until the 18th century. An 18th century chart also provides details of the first lightvessel. The introduction of iron construction in the 19th century enabled larger buoys to be built and consequently their numbers increased rapidly. Many technologies were investigated to provide lighted buoys: sound signals also proliferated. The introduction of the Lanby buoy paved the way for the automation of large floating aids in the 20th century. Finally the impact of solar power and LED lighting technology is considered.

The notes used by Adrian Wilkins are at Annex 6.

3.2 The new technologies in Aids to Navigation and alternative ways of management (Juan Francisco Rebollo, Puertos del Estado, Spain)

New technologies are causing a certain effect on the organizations responsible for marine aids to navigation, although the effects can be managed. This leaves the question are the new technologies a cause or an effect?

In fact, the new technologies, especially those coming from other sectors bring with them a new way of doing things, based on efficiency, and a significant reduction of resources,. This makes it necessary to know the possible effects on different issues in order to convert risk into opportunities, which will ensure the sustainability of the service quality and form a world-wide and multi-modal approach in a changing and globalised environment.

A paper accompanying the presentation is at Annex 7.

3.3 Evolution of Radio Aids to Navigation (Eoghan Lehane, Commissioners of Irish Lights, Ireland)

When considering lighthouse heritage, there is a tendency to consider the lighthouse tower and traditional aids to navigation systems such as large revolving lights and pneumatic fog signals. However, there is a long tradition of radio aids to navigation going back to early in the 20th century. Over the years, these radio aids have become increasingly important in the battle to ensure safe navigation and clean seas. The presentation looked at the history of radio aids to navigation and how these aids can be displayed as heritage items. Topics covered included:

1 Radio Aids to Navigation;

2 Safe navigation;

3 Lighthouse heritage.

A paper accompanying the presentation, written by James Doyle, Commissioners of Irish Lights, is at Annex 8.

3.4 Questions

In response to the question "How long has Puertos del Estado Knowledge Management System been in place?", Juan Francisco Rebollo replied that the "System has been in place for 2 years but despite numerous e-mails to the 28 Port Authorities he had had no response to his request for information on problems encountered by the authorities with their Aids to Navigation.

On the conclusion of the session a group photograph was taken.

4. SESSION 3 – TRADITIONAL LENSES AND MODERN LIGHT SOURCES

This session was chaired by Christian Lagerwall, Swedish Maritime Administration, Sweden.

4.1 History and evolution of Fresnel lenses (Fernando Romero, MSM, Spain)

The Fresnel lens was invented in 1822 by Augustin Jean Fresnel (1788–1827), a French mathematician and physicist. Until 1950's, quality Fresnel lenses were made from glass by the same grinding and polishing techniques developed in 1822. Cheap Fresnel lenses were made by pressing hot glass into metal moulds. In the past forty years, the advent of optical plastics, compression and injection moulding techniques, and computer-aided manufacturing have significant improved the optical quality and broader the applications of Fresnel lens. Modern computer-controlled machining methods can be used to cut the surface of each cone precisely so as to bring all paraxial rays into focus at exactly the same point, avoiding spherical aberration. Better still, newer methods can be used to cut each refracting surface in the correct aspheric contour.

4.2 Adapting new light sources to traditional lenses (Ian Tutt, General Lighthouse Authorities of United Kingdom and Ireland)

Many lighthouse services today are removing or decommissioning traditional optics and installing new, smaller, self-contained devices. There are often good economic reasons for doing this but sometimes there is a need to retain large traditional optics. Some reasons for retaining these optics are:

- High luminous range requirement;
- Optics with complex characters or sectors;
- Managing future strategy; and

- Heritage.

If a traditional optic is retained, the choice of light source to use with it is important. Fitting a modern ‘off the shelf’ lamp in a large optic can produce poor results, so care must be taken in choosing a suitable lamp.

Over the last few decades, in a drive to reduce energy requirements, some modern lamps have been temporarily installed in a variety of large optics to see how the combination performed. In some cases the small size of the light source has caused problems of poor performance including short flash duration and low intensity. Various techniques such as light diffusers and lamps clusters have been used to enhance the performance of modern low power light sources in order to optimize their use within traditional optics. The results of various light measurements are shown in this paper, together with details of problems encountered during the experiments.

4.3 History and use of LED's in Aids to Navigation (Xavier Kergadallan, CETMEF, France)

In his absence, the presentation prepared by Xavier Kergadallan was made by Ian Tutt (General Lighthouse Authorities of United Kingdom and Ireland).

The presentation introduced the optics and lamps mainly used in France and then dealt with the introduction of LED technology, the benefits to be derived and emphasising that it is possible to retain the existing optics. It then looked to possible future developments.

4.4 Questions

During discussion it was stated that maintenance work on traditional lenses does give an extra burden, however they will last a long time; possibly another 100 years. It was also remarked that there is a need to look 10 years ahead. A large fixed lens requires little maintenance. Although requiring more maintenance, rotating lenses have been with us for a long time and can be expected to continue to be so. The key disadvantage is health and safety issues due to mercury but correct equipment and procedures will cope with this. On balance, keep the existing, traditional lenses.

In response to the question ‘What is available for performance lenses with LED’s?’ It was replied that it is difficult to focus more than one or two layers of lensed LEDs. It was also said that we are at the beginning of LED (multi-LED), performance is now increasing but numbers decreasing. Whilst the range is longer with new lamps there are no fallbacks; should there be an alternative?

The question ‘Is much use being made of MSM modern traditional lens equivalents’, prompted the response that there is the possible production of 400 mm focal length lens soon. It is undergoing development and could possibly be on display at the Cape Town conference.

Initially there were 30 elements in an LED, now usual to find 1 LED with varying levels of intensity elements. Variations in levels of intensity are monitored. However, development of LED is still at its inception and progress with the technology can be expected, noting that the topic is very complex.

With regard to the level of monitoring, it was said that, up to now, LED had mainly been used for buoy lights, which are not generally monitored and gradual failing was not noticed until complete failure. Monitoring is increasing and the failures are being noticed. However, delegates were urged to specify their user requirements to cover concerns over aspects of failure, as manufacturers generally listen to their customers.

5. SESSION 4 – TRADITIONAL LENSES AND MODERN LIGHT SOURCES (CONTINUED)

The session was chaired by Bob McIntosh, Northern Lighthouse Board, Scotland.

5.1 Identifying the challenges of mercury removal in lighthouse optics (Bert Frame, Pelangi International Ltd, United Kingdom)

The presentation was intended to describe the usage of mercury in lighthouses, identify the objectives of lighthouse modernisation, and detail how these can be best achieved. It was aimed at both casual observers wishing to gain an overview of the subject, and at professional engineers who are preparing to embark upon such a project themselves.

Firstly, the common types of mercury pedestals still in use today were described, and the mercury within each quantified. The overall objectives of modernisation were identified, with some brief examples of recent partial modernisations.

A typical modernisation project involving the removal of mercury was then discussed in detail. Topics covered included planning ahead, storage and access, mercury safety, mercury bath removal and decontamination, bearing replacement, clockwork mechanisms and weights, and drive replacement.

Finally, an example of a Museum installation was discussed.

On question “Isn’t it possible to clean the mercury bath and reinstall it in the lighthouse?” it was answered that the bath is only 5 to 6 millimetres in depth leaving just enough space for the bearings. Reinstallation of the mercury bath would require the creation of a new bath. The problem of evaporation was also mentioned. However the problem would be avoided if the mercury bath is sealed.

5.2 Heritage Conflicts between traditional and LED lenses and other aspects (Knut Baar Kristoffersen, Kystverket, Norway)

1. Introduction of the heritage status in Norway.
2. Aspect concerning heritage.
3. Conflicts between traditional lenses and LED-lenses.

The maritime infrastructure and aids to navigation are important parts of Norwegian heritage. Norway has an extremely long coastline, and most of the population lives spread along the coast. The larges industries have traditionally been fishing and shipping. Therefore safety seaways have been very important to communication and trade, as well as that it made it possible to establish Norway as an independent nation.

When the lighthouses were de-manned we had already produced a heritage plan. After de-manning we established partnership with other bodies or organisations that were capable of taking care of the lighthouses and make new alternative use of them. Principles for this will be discussed.

Lighthouses are symbols which are attractive for many people. How can this be published and broadcasted in a way of “story telling” that gives more funding for better maintenance.

Conflicts when new technologies are implemented; good and bad examples when LED-lenses replace traditional lenses. Do we need LED-lenses instead of traditional lenses?

Is it too expensive to take heritage responsibility or is it more expensive to not? Anyway keep contact with heritage authority.

A paper accompanying the presentation is at Annex 9.

5.3 Upgrading a Traditional Lens with a Modern Light Source at the Cape du Couedic Lighthouse, Australia (Lyndon O'Grady, Australian Maritime Safety Administration, Australia)

Extensive upgrade works were recently undertaken to the historic (built in 1909) Cape du Couedic lighthouse (built in 1909), which is situated on Kangaroo Island in the state of South Australia.

The current historic 3rd Order lens and lamp arrangement benefited from the Australian Maritime Safety Authorities (AMSA') recent experience and similar application with excellent results.

The presentation outlines the mains power supply and battery back-up arrangements, including the remote monitoring which was installed and utilises GSM SMS messaging to alert AMSA of any faults.

There was a description of the conversion with photographs and relevant schematic drawings further explaining the upgrade process. It then outlined the advantages of conversion to extra low voltage including the installation of new lamps and lampchanger, power supply and switchboard.

Finally there was a discussion of the many benefits of modernisation at the site including: ongoing maintenance cost reductions, reduced on-site hazards to personnel and the reduced cost of ownership to the AtoN provider.

In the discussion at the end of this session the following points were made:

Mercury ceases to be a hazard when it is known about. It was not a problem with lighthouse keepers but without their knowledge, the mercury baths when opened are a hazard. However, they can be made safe by being cleaned and the covers put back.

Australia has organised a system of volunteer keepers / guides. The volunteer movement has spread throughout Australia and continues to grow. However, more visitors means more maintenance but the revenue they generate is not rising to keep pace with costs. The coverage of guides is also patchy but there is an AMSA training scheme in place.

5.4 Questions

Unfortunately, technical difficulties with one of the presentations precluded the asking of specific questions following this session.

5.5 Wrap up of day, discussions.

There was a brief question and answer session following which the practical details of the next day's technical visits were covered.

END OF DAY

Day Two – Wednesday 24 June

6. SESSIONS 5 TO 8 – LOCAL RESTORATION PROJECTS: AUTORIDAD PORTUARIA DE SANTANDER

In the absence of Christian Manrique, President of Autoridad Portuaria de Santander, Spain, the sessions were chaired by Ómar Frits Eriksson, DaMSA. The day was broken down into:

1 Three presentations;

2 Technical visit to Castro Urdiales Lighthouse (see ANNEX 4);

3 Technical visit to El Pescador Lighthouse (see ANNEX 4);

4 Technical visit to Cabo Mayor Lighthouse (see ANNEX 4).

6.1 Complementary activities and management of Cabo Mayor and La Cerda Lighthouses (Javier de la Riva, General Manager of Autoridad Portuaria de Santander, Spain)

The presentation covered recent developments at two lighthouses administered by the port authority. Automation has removed the need for lighthouse keepers and brought forward remote monitoring. This led to the adaption of the premises for other purposes. La Cerda light has been developed, in conjunction with two local universities, into a study and training centre. Cabo Mayor light has been developed into a visitor centre and gallery for a local artist, with the gallery being adaptable for other functions. Both adaptations have benefited from the proximity of the city of Santander

6.2 The renovation of Cabo Mayor and La Cerda Lighthouses (Ignacio Pereda and Cesar Barrios, Architecture Studio, Santander, Spain)

Through a comprehensive set of photographs, this presentation covered the processes involved in renovating the La Cerda and Cabo Mayor lights. It covered the difficulties encountered as the old fabric was stripped away and the issues involved in restoring what could be saved and the choice of materials used where replacement was necessary.

6.3 Agreements with local council authorities (José Luis Zatarain, Autoridad Portuaria de Santander, Spain)

Santander Port Authority (SPA) is in charge of nine lighthouses working automatically through appropriate software and radio links. Therefore, SPA undertook a process to improve the maintenance of this heritage providing different uses by its own budget or promoting agreements with local authorities. This presentation deals with the cases of San Vicente de la Barquera, Suances, Santoña y Castro Urdiales Lighthouses. Suances is completed, and it is working as an environmental hall for courses and conferences, Santoña is also completed and serves as a landmark of INTERREG III-B “AT-LIGHTS” program and subsidiary museum, San Vicente de la Barquera is on the way to implement a marine museum, and Castro Urdiales is suffering varied problems to handle the castle restoration. The author explains the set of agreements on these Aids to Navigation made with the different local authorities.

The presentations were followed by three technical visits (see ANNEX 4).

6.4 Questions

Ionna Papayianni raised the question of using new products on old materials. She reported her experience in Greece where the use of new technology materials had led to the destruction of the original material. Carlos Calvo answered that the Spanish lighthouses’ renovation had used only natural products similar to the original ones. Only concrete was added to the structures with special additive to protect it against sea water. Painting used water based paint.

END OF DAY

Day Three – Thursday 25 June

7. SESSION 9 – CONSERVATION PROJECTS: REAL EXAMPLES

The session was chaired by Jo van der Eynden, Norwegian Lighthouse Museum, Norway.

7.1 Pater Noster Project – Sweden (Agneta Olsson with Anders Eydal, State Property Board, Sweden)

Pater Noster, lighthouse and buildings, are situated on the west coast of Sweden. Though fishing in the local communities has long since declined, the traditions and memories of days gone by are the biggest features of the area's cultural heritage. The restoration of one of the most famous lighthouses, Pater Noster has thus been a massive contribution to the preservation of the area's cultural heritage.

Pater Noster was built in 1868 and is held in deep affection by local people and is a strong cultural symbol. After being taken ashore in 2002 the voluntary association 'Friends of Pater Noster', the Swedish National Property Board and the Museum of Bohuslän came together with the Swedish Maritime Association, the National Heritage Board, the Västra Götaland regional authority, Tjörn municipality and a main sponsor and industrial partner in Pharmadule Emtunga AB. The partnership applied for Leader+ funding as part of the project.

26 September 2007 was Pater Noster alight again, the structure restored to near new condition and a new era has begun for Pater Noster!

7.2 Damage to Historic Lighthouse Buildings and their appropriate repair (Ionna Papayianni, Aristotle University of Thessaloniki, Greece)

Most of the old lighthouse buildings have been constructed with stones or bricks connected with lime-based mortars. In many cases they were also covered with thick renderings. After the Second World War, they were repaired by using concrete elements and cement-based mortars. Nowadays, the original masonry of these buildings has deteriorated because of secondary problems presented after interventions. Concrete members, which have replaced old lantern bases, also suffer from corrosion. Therefore, it is necessary for any preventive intervention to select suitable materials which should be compatible to the old structure and resistant to the marine environment. Based on these two requirements repair materials and techniques of application are proposed for a number of common faults in historic Lighthouse buildings.

7.3 Processes and Problems in the reuse of redundant rooms of the Balearic Islands Lighthouses (Javier Peréz de Arévalo, Autoridad Portuaria de Baleares, Spain)

1 Lighthouse automation process

2 Adaptation of redundant rooms made by different entities than the port authority

3 Portopí lighthouse

In this presentation the aim was to show the evolution of Balearic navigation aids, and the influence of this evolution over the current situation concerning the reuse of redundant rooms of historical lighthouses, making special mention of Portopí lighthouse and its Maritime Signals Exhibition, as well as the Historical Archives stored inside.

8. SESSION 10 – IMPACT ON BUILDINGS OF DE-MANNING AND CONSEQUENCES ON HISTORIC BUILDING MANAGEMENT

The session was chaired by Eoghan Lehane, Commissioners of Irish Lights, Ireland.

8.1 Impact of de-manning on building conditioning (Belinda Colston, Lincoln University, United Kingdom)

Beginning with the vagaries of the marine environment, including the effect of salt water damage it was emphasised how necessary it is to understand the building before conducting a non-destructive survey. Several techniques were discussed, drawn from electro-magnetic, nuclear and acoustic methods. The presentation concluded with the warning that constant environmental monitoring is required. Perhaps somewhat 'tongue in cheek' the final point made was that given the cost of restoration, might it not be cheaper to employ a lighthouse keeper?

8.2 Low Powered Building Conditioning (Ron Blakeley, Trinity House, United Kingdom)

Lighthouses are an important component of the construction heritage and many of them are of historical significance. Initially staffed by teams of resident lighthouse keepers, the trend in recent decades has been towards automation in order to reduce running costs while maintaining an efficient service for mariners. The presence of resident attendants ensured good internal conditioning through a rigorous day-to-day maintenance programme. However, since automation internal conditioning has suffered with resultant deterioration of building components. Investigation has been undertaken into alternative methods of improving internal conditioning of unoccupied structures: this presentation outlines the problems and highlights the necessity of using renewable energy or self-contained energy systems to provide such conditioning.

8.3 Questions

In discussion it was revealed that, as a result of the need to secure the lighthouses they have been locked up and as a result ventilation has been restricted. Belinda Colston said that natural ventilation could be a good thing but is also likely to attract warm moist air which can cause condensation when it meets cold surfaces. There was an additional comment from floor, to the effect that you have to be aware of addressing problems of pockets of stagnant air which may gather below underside of the staircase if the tower has a continuous stone staircase.

9. SESSION 11 – WHEN A SOCIETY BECOMES INVOLVED IN THE HERITAGE OF AIDS TO NAVIGATION

The session was chaired by Carlos Calvo, Autoridad Portuaria de Santander, Spain.

9.1 Nomination of Hercules Tower for UNESCO World Heritage Status (Fernando González Laxe, Puertos del Estado, Spain)

In the absence of Fernando González Laxe, this presentation was made by Carmen Martinez, of Puertos del Estado. An English translation can be found as a layer to the pdf representation of the presentation and is also at Annex 10.

9.2 The restoration of the lightvessel Texel (Lyda Voska, Foundation History of Aids to Navigation, Netherland)

By means of photographs covering the lightvessel Texel's life and restoration, the story was told of how this historic vessel had been saved by a band of determined volunteers, who had also created a visitor centre and associated museum.

9.3 Lighthouse transfers: Preservation successes and lessons learned (Henry González, US Lighthouse Society, USA)

In the year 2000, the United States Congress enacted the National Historic Lighthouse Preservation Act, or NHLPA. The purpose of this law was to enable and facilitate the transfer of historic lighthouse properties from the United States Coast Guard to other government agencies or to non-profit organizations that could preserve and maintain the property, while the Coast Guard focused on operating and maintaining the aids to navigation on the property. The presentation discussed the NHLPA, presented success stories of transfers to non-profit Societies, and shared lessons learned that could be applied in other countries.

9.4 Innovation in Italian Lighthouses heritage: documentation and restoration (Cristiana Bartolomei, Bologna University, Italy and Alessandro di Capua, Italian Navy)

Rehabilitating a lighthouse, within the Italian scenario, is a really complex challenge.

Many of the active Italian lighthouses (estimated at 160 lights) are at risk of decay; it's an ancient heritage where many lights were built more than 150 years ago.

The Italian Navy is supporting alternative re-use of buildings and conservation projects.

Capo Spartivento lighthouse, built in 1866 and located in the southern point of Sardinia, can be considered as a good example of such a project. At the end of the restoration works the lighthouse looks more comfortable, technological, eco- friendly and Mediterranean, but it also appeals to all our five senses in a perfect fit with the surrounding environment. The lighthouse can be seen as a best practice project in terms of architectural tuning and sustainable materials, energy saving and power production by way of renewables and sustainable design technologies.

9.5 Questions

On the involvement of individuals in lighthouse preservation it was remarked that enthusiasm may dry up in the long term but interest in lighthouses will continue to exist. Another question concerned the preservation decision: why protecting one lighthouse and not the other one, perhaps older? The answer was that there was also a need to preserve also the current history of the lighthouse. Finally, there was a criticism about a very modern restoration of an Italian lighthouse, to turn it into a hotel. It was noticed that the result may be too modern for a historic place. Here the answer was that it was a compromise: the external character of the place had been kept but the interior totally refurbished. This was the only way to restore a building, which was totally abandoned.

10. SESSION 12 – DOCUMENTATION PROCESS (WHAT TO SAVE AND HOW TO ACHIEVE IT?)

The session was chaired by Ron Blakeley, Trinity House, England & Wales.

10.1 The role of Heritage Authorities (Jo Van der Eynden, Norwegian Lighthouse Museum, Norway)

Based on the experience gained, culminating in becoming the director of the Norwegian Lighthouse Museum, the presentation illustrated the work involved in developing a lighthouse museum, the issues that can arise and the satisfaction that can be gained from preserving such important heritage artefacts.

10.2 Documentation prior to alteration work (Christian Lagerwall, Swedish Maritime Administration, Sweden)

The presentation ran through the reasons why documentation of artefacts, actions taken with respect to them and any changes made is so important. It then went on to itemise what should be documented before illustrating the points made with several case studies. The documentation process used by SMA was then illustrated with a further case study.

10.3 The fascination of lighthouses (Virginia Mayes-Wright, Museum of Scottish Lighthouses, Scotland)

The starting point was that, in preserving a lighthouse we are preserving for people in the future and that in the UK museums can no longer be thought of as a good thing on its own, but as a place that connects people to the history and stories we tell. Thus the presentation looked at lighthouse heritage from the point of view of the customer; the visitor. It sought to answer who visits lighthouses and why. Drawing on experience from the Museum of Scottish Lighthouses and with other lighthouses in Scotland, the need to explore alternative uses and encourage visitors was covered. The presentation ended by asking just what is meant by lighthouse heritage and urging constant vigilance to ensure that tomorrow's historical artefacts are identified and retained. There was also a plea for co-ordination of effort and not competition between bodies responsible for heritage preservation.

END OF DAY

Day Four – Friday 26 June

11. PRESENTATION – PORT AUTHORITY OF TARRAGONA

Lighthouses, lights and maritime traffic in Google Earth was an additional presentation provided by Miguel Ángel Sánchez Terry, from the Port Authority of Tarragona. This showed the port authorities innovative approach to the more rapid updating of details for charts and list of lights than the current official system provides. The use of Google earth not only allows almost instant depiction of updated information but also its representation in three dimensions. From this operational start, the project has been developed to include information about AtoN heritage issues. This is seen as a means of disseminating such information beyond the circle of professionals within which it currently tends to reside. The website used is found via www.porttarragona.es. The Port of Tarragona would be happy to assist other ports / authorities to develop similar functionality, including the provision of the necessary program code and training. A hard copy of the information available from the site can be downloaded for use by those not having constant access to the internet. Following the presentation, a demonstration of the capabilities of the site developed by the port was given.

Miguel Ángel Sánchez Terry can be contacted via mafsterry@gmail.com. The presentation that introduced the demonstration is part of the output of the seminar, which is available on the IALA ftp server.

11.1 Questions

It was suggested that the reliability of the service is dependent on the quality of the internet connection and so is this a problem, especially for mariners?

Miguel Terry said that at home and in the office broadband should be adequate and that a download capability is available for mariners, if required.

It was then asked if there are their liability issues involving provision of a service concerning AtoN?

Miguel Terry said that the Port of Tarragona is the releasing authority and so can certify that the data is correct.

It was then asked what the project had cost? To this, Miguel Terry replied that it was the labour of two lighthouse keepers for four months and approx. €400 for some software.

There was a final question about the cost of downloading the books illustrated in the presentation? Miguel Terry said that all are freely available, as they either belong to the Port Authority or have been donated by the authors. Arrangements are being made to provide a direct link to IALA, for anyone interested in purchasing the Spanish language version of the Preservation Manual.

12. SESSION 13 – GENERAL DISCUSSION

The session was chaired by Omar Frits Eriksson (DaMSA).

12.1 Discussions from floor – items not yet covered. Additional matters of interest and issues requiring further debate

Is the Swedish approach to conservation, as presented by Christian Lagerwall – documenting and then sealing off – a good route to take? The Spanish view was that the structure and fabric is essential. In the USA, two camps, save all, not practical to save all. Impossible to save all but representative samples should be maintained, employing the enthusiasm and labour of volunteer groups. Sadly, some structures have to be removed, rather than be left to fall into a state of disrepair.

The imaginative use of liaison with industry, as shown by the Pater Noster project, may be viable in ‘good times’ but what about the current financial climate? There is expected to be a downturn in the enthusiasm of industry for such ventures but it should be recalled that the relationship is based on both sides gaining and that the industrial contributions are largely non-financial. As no one else appeared to be using such an approach, it was suggested that this might be an idea to consider.

This gave rise to the comment that in the USA a viable approach is to diversify the sponsorship, aiming for a number of smaller benefactors. However, there has been a noticeable downturn in the availability of government capital grants.

Can tax exemption be a factor? In the USA historic preservations attracts tax exemption and tax credits.

Corporate social responsibility, which companies wanting to be seen as sponsors of social causes will have a policy for, can be use to good effect.

What about advertising on the lighthouse structures? This has been attempted in the USA, for instance by hanging a banner between the masts of a light vessel and in support of events.

13. SESSION 14 – PRESENTATION OF THE CONCLUSIONS OF SEMINAR. IDENTIFICATION OF RECOMMENDATIONS

The session was chaired by Bob McIntosh, Northern Lighthouse Board, Scotland.

A draft set of Conclusions and Recommendations, produced by the Seminar Steering Group, were reviewed. This resulted in some amendments and additions, after which the Conclusions and Recommendations at Annex 5 were agreed.

14. SESSION 15 – CLOSING OF THE SEMINAR

This session was chaired by Virginia Maqueira, pro-vice-Chancellor of Universidad Internacional Menendez Pelayo.

14.1 Award of Diplomas

Diplomas were awarded by the Universidad Internacional Menéndez Pelayo (UIMP) to all delegates, in recognition of their participation in the seminar.

14.2 Remarks by IALA

Bob McIntosh thanked all those involved in the organisation of the Seminar: the University, which gave IALA the use of wonderful facilities and Santander Port Authority, which gave its full support. He particularly thanked Carlos Calvo for his efforts and apologised for the participants that had to leave before the closing session, due to travel arrangements.

14.3 Remarks by UIMP

Mrs. Virginia Maqueira said that it had been an honour for the University to host the Seminar.

14.4 Remarks by Santander Port Authority

Christian Manrique, President of Santander Port Authority, thanked the participants and the University. He said that Santander Port Authority had been happy to give its support to an event related to the sea and technology. He wished that another opportunity would be given to his organisation to host an IALA Seminar or Workshop. He added that the final conclusions and recommendations would be helpful to the future of the Spanish ports.

14.5 Remarks by Puertos del Estado

Juan-Francisco Rebollo, on behalf of Puertos del Estado, thanked the University for their excellent work, the speakers for their high level presentations, and the attendees. He said that the Seminar was an open exchange of experience, a key to the success. He was grateful to IALA for having supported preservation and organising the event. He added that Puertos del Estado would continue to support this initiative.

14.6 Closure

Ómar Frits Eriksson concluded proceedings by thanking everyone for their participation and wishing them a safe journey home. He then declared the seminar closed.

END OF SEMINAR

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ANNEX 2 Seminar Programme

Day 1 - Tuesday 23 June 2009

Time	Activity	Chair	Presenter
0830 -0930	Registration / welcome coffee		
0930 -1030	Session 1 – Opening of the Seminar		
	Welcome from hosts	Ómar Frits Eriksson (DaMSA)	University Menéndez Pelayo Santander Port Authority (SPA) Puertos del Estado
	Welcome from IALA		IALA – Marie Helene Grillet Ómar Frits Eriksson
	Administrative Details, flow of events for week		SPA – Marta Cano
	Keynote Address – *"Impact of Modernisation – Advances in Technology and the Conservation of Historic Lighthouses and Aids to Navigation"*		Bob McIntosh
	Thanks for keynote address / adjourn for coffee		Ómar Frits Eriksson
1030 - 1100	Coffee		
1100 - 1230	Session 2 – New technologies in Aids to Navigation – a new challenge		
1100 - 1130	The consequences of changes in floating aid technologies	Sr. Alvaro Rodriguez	Adrian Wilkins
1130 - 1200	The new technologies in Aids to Navigation and alternative ways of management		Juan Francisco Rebollo
1200 - 1230	Evolution of Radio Aids to Navigation		Eoghan Lehane
1230 - 1400	Official photo		
1400 - 1530	Session 3 – Traditional Lenses and Modern Light Sources		
1400 -1430	History and evolution of Fresnel lenses	Christian Lagerwall	Fernando Romero
1430 – 1500	Modern light sources in traditional lenses		Ian Tutt
1500 – 1530	Recycling optics by replacing the lamps with LED light sources		Xavier Kergdalen / Eric Vassor
1530 - 1600	Coffee		

Time	Activity	Chair	Presenter
1600 - 1730	Session 4 - Traditional Lenses and Modern Light Sources (cont.)		
1600 – 1630	Identifying the challenges of mercury removal in lighthouse optics	Bob McIntosh	Bert Frame
1630 - 1700	Conflicts between traditional lenses vs. LED lenses, and other aspect concerning heritage		Knut Baar Kristoffersen
1700 – 1730	Upgrading a Traditional Lens at the Cape du Couedic Lighthouse		Lyndon O'Grady
1730	Wrap up of day, discussions Programme for tomorrow		

Free Evening

Day 2 – Wednesday 24 June 2009

Time	Activity	Chair	Presenter
	Sessions 5 to 8 Local Renovation Projects (Santander Day)		
0900 – 0930	Complementary activities and management of Cabo Mayor and La Cerda Lighthouses	Ómar Frits Eriksson (DamSA)	Javier de la Riva
0930-1000	Renovation of Cabo Mayor and La Cerda Lighthouses		Ignacio Pereda and Cesar Barrios
1000 -1030	Agreements with local council authorities		Jose Luis Zatarain
1030 – 1100	Coffee		

Visit arrangements:

1100	Coach from Palacio de la Magdalena to Castro Urdiales
1215	Technical visit to Castro Urdiales Lighthouse
1300	Coach to Berria Beach, Santoña
1330	Lunch at Berria Beach
1600	Technical visit to El Pescador Lighthouse, Santoña
1800	Return to hotels

19:30 Visit and Official Dinner – Cabo Mayor Art Centre

2330 Return to hotels by bus

Day 3 – Thursday 25 June 2009

Time	Activity	Chair	Presenter
0900 - 1030	Session 9 – Conservation projects		
0900 -0930	Pater Noster Project - Sweden	Jo van der Eynden	Agneta Olsson / Anders Eydal
0930 – 1000	Damage of old lighthouses and their repair		Ioanna Papayianni / Vasiliki Pachta
1000 - 1030	Processes and Problems in the reuse of redundant rooms of the Balearic Islands Lighthouses		Fransesc Triay Llopis
1030 - 1100	Coffee		
1100-1230	Session 10 – Impact on buildings of de-manning and consequences on historic building management		
1100 -1130	Impact of de-manning on building conditioning	Eoghan Lehane	Belinda Colston
1130 – 1200	Low Powered Building Conditioning		Ron Blakeley
1200 - 1530	Session 11 – When a society becomes active in Heritage of Aids to Navigation		
1200 – 1230	Instituto de Estudios Torre de Hércules: 7 años de compromiso para el reconocimiento de bien patrimonio de la Humanidad	Carlos Calvo	Fernando Gonzalez Laxe / Carmen Martinez
1230 - 1400	Lunch (1.5 hrs due to expected number of participants)		
1400 - 1430	Museum Lightvessel Texel	Carlos Calvo	Lyda Voska Foundation History of Aid to Navigation
1430 -1500	Lighthouse transfers: Preservation successes and lessons learned		Henry Gonzalez, Vice President US Lighthouse Society
1500 – 1530	Innovation in Italian Lighthouses heritage		Cristiana Bartolomei / Alessandro di Capua
1530 - 1600	Coffee		
1600 - 1700	Session 12 – Documentation Process (What to save and how to achieve it?)		
1600 - 1630	Role of Heritage Authority	Ron Blakeley	Jo Van der Eynden
1630 - 1700	Documentation prior to alteration work		Christian Lagerwall
1700 - 1730	The fascination of lighthouses		Virginia Mayes-Wright

1830 Visit by boat to the Port and Bay of Santander

Day 4 – Friday 26 June 2009

Time	Activity	Chair	Presenter
0930 - 1045	Session 13 – General Discussion		
	Discussions from floor – items not yet covered	Ómar Frits Eriksson	
0930 -1000	Lighthouses, lights and maritime traffic in Google Earth		Miguel Ángel Sánchez Terry
	Additional matters of interest and issues requiring further debate		
1045-1115	Coffee		
1115-1230	Session 14 – Conclusions		
1115-1210	Presentation of conclusions of Seminar / identification of recommendations	B McIntosh	
1210 - 1230			
	Seminar Closing		
	Presentation from IALA – Hosts		
	Closing Remarks – IALA / Hosts		

ANNEX 3 Social Events

1 On Wednesday, 24 June 2009, following the technical visit to the Cabo Mayor Lighthouse, there was an opportunity to visit the co-located Art Centre, before the seminar's Official Dinner took place. This was hosted by the Port Authority of Santander.

2 On Thursday, 25 June 2009, the Port Authority of Santander organised a visit by boat so that delegates could view the AtoN in the port and bay of Santander.

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ANNEX 4 Technical Visits

1. VISIT TO CASTRO URDIALES LIGHTHOUSE

This provided the first of three opportunities to view the renovation of lighthouses for alternative use, whilst still acting as an Aid to Navigation. In this instance a well developed visitor centre, including a lift and cafeteria, had been integrated into the fabric of the building.

The tour of the facilities was led by the local mayor.

2. VISIT TO EL PESCADOR LIGHTHOUSE, BARRIO

The development of this lighthouse includes a small museum and visitor centre, with two screens for the display of video material.

3. VISIT TO CABO MAYOR LIGHTHOUSE

For this site an attractive and spacious art gallery had been attached to the tower, which also permits other uses, such as a recent car model launch and dining. Other facilities, such as coffee and gift shops are close by, with an extensive car park.

ANNEX 5 Seminar Conclusions and Recommendations

CONCLUSIONS

1 Change is inevitable. Ideally, changes made during the development of an historical AtoN site, should be reversible and in all cases properly documented.

2 Conservation and renovation of AtoN is not possible without making compromises. Modern products and materials must be used with caution because they could potentially damage the original fabric of a site if not tested. The careful use of modern compatible materials may have to be accepted when authentic materials are not available for the renovation of structures. If you think holistically, there can be a successful combination of heritage and modern technology.

3 There is a need to document the history of floating aids to navigation.

4 Radionavigation aids were an important part of AtoN technology in the 20^{th} Century. There is a need to document and disseminate this aspect of AtoN heritage.

5 Mercury baths for traditional optics are currently considered safe provided appropriate protection and procedures are used during maintenance and removal. However, there is a need for guidance on methods for removing mercury baths, when this is required.

6 Preservation and documentation of AtoN should focus on whole sites and include technical equipment and related human experience. Documentation should include the experiences and recollections of those involved in operating AtoN, as well as those involved in their conservation.

7 When developing an existing AtoN site for public use, consultation with other bodies, National Heritage and Environmental Authorities may be necessary in any significant changes during AtoN conservation, including the modernisation of technical equipment.

8 Operational, traditional lighthouse lenses are significant, historically valuable lighthouse objects. They can be used to provide high intensity lights that are useful in overcoming high levels of background lighting and provide a practical and effective intensifier for new efficient light sources. They also make it possible to retain the characteristics of sectors and rhythmic characters familiar to the local mariner.

9 An increasing number of volunteer groups are becoming aware of the historical value of AtoNs. Maritime, preservation and other authorities could collaborate with this emerging resource.

10 Using the internet, a culture of sharing information related to AtoN and making it available to the public is emerging in a growing number of countries. There may be a need for guidance about how this should develop.

11 There is a risk that the knowledge of technicians and other people involved in AtoN technology and preservation will be lost.

12 There are documented cases of alternative ownership of lighthouses, which have been successful in preserving the lighthouse whilst also allowing the lighthouse authority to operate and maintain the AtoN.

13 There is a need to establish classification criteria of AtoN sites when considering the order in which they should be conserved.

14 When contemplating building conditioning, monitoring of environmental conditions should take place prior to and post intervention.

RECOMMENDATIONS

1 IALA should advise its members that when modernisation of historic AtoN is necessary, reversible solutions should be adopted where reasonably practicable and that in all cases properly documented.

2 IALA should continue to advise its members to adopt a scientific approach in ensuring compatibility between old and new materials during maintenance and conservation.

3 IALA should document the history of floating aids to navigation, incorporating existing published information and historical data from individual authorities into an IALA historical record.

4 IALA should advise its membership to document and disseminate the history of radionavigation

5 IALA should provide guidance on the maintenance of mercury baths and methods of their removal.

6 IALA should continue to provide guidance to its members on how to collect documentation concerning conservation / preservation, in order to ensure accumulation of information on best practice on the proper management of historic AtoN.

7 IALA should encourage its members, when developing an existing AtoN site for public use, to co-operate with other bodies and involve national Heritage and Environmental Authorities in all significant changes during AtoN conservation, including the modernisation of technical equipment.

8 IALA should encourage its members to keep traditional lighthouse lenses in operation and to make use of their potential, in relation to the integration of new light sources and the retention of the characteristics of the light familiar to the local mariner.

9 IALA should consider encouraging its members to consider collaborating with the emerging resource provided by volunteer groups.

10 IALA should encourage its members to share information about heritage issues related to AtoN via the internet.

11 IALA should advise its members to develop strategies in order to retain the knowledge of technicians and other people involved in AtoN technology and preservation.

12 IALA should advise its members to consider alternative ownership of lighthouses as a method of preserving the lighthouse whilst also allowing the lighthouse authority to operate and maintain the AtoN.

13 IALA should request its members to provide information on heritage classification criteria of AtoN sites.

14 IALA should advise its members that when contemplating building conditioning monitoring of environmental conditions, should take place prior to and post intervention.

ANNEX 6 The consequences of changes in floating aid technologies, Adrian Wilkins, Consultant with Pharos Marine, UK

1. SAILING SHIPS WITH BUOY

There were probably some forms of floating marks moored to dangerous rocks far back in history, possibly simply pieces of wood moored by rope to a block of stone. The first mention of buoys in Europe was here in Spain, in sailing directions of 1295 for the river leading to Seville. The buoys being somewhere near Chipiona. There is no record of the construction of these buoys or their moorings.

2. 2 BUOYS 1675

By the early 16th C. there were 43 buoys around the Zuider Zee and the buoyage of the English coast is particularly mentioned in the Elizabeth 1st charter to Trinity House. This is the earliest illustration that I have found of wooden buoys of this period. They were constructed in a similar fashion to a barrel. Staves of wood, usually oak, were fitted close together and bound together with hoops of iron. Although some buoys were exactly like barrels and floated on their sides the majority of navigation buoys tapered almost to a point to allow the fixing of a substantial iron mooring eye. Typical size was in the order of 1.5m diameter and 3m long.

3. 1790 CONICAL BUOY

These buoys were also constructed in a bi-conical form presumably to provide a better daymark. The technology of wooden buoy construction seems to have been more developed in Holland and Germany, as there are records of the Hull Trinity House buying buoys from Holland in 1621 and Hamburg in 1682. It would be interesting to know why the considerable expense was justified to import what seem to be very simple products.

4. STONE SINKER

Buoys were moored with specially made square stone sinkers or with old, worn mill stones. Some were moored with rope, that must have had a very short service life, but many were moored with chain. This is 250 years before chain came into general use for mooring ships. Developments in chain technology for buoy moorings eventually lead to chain suitable for lightvessels and then ship use.

5. SINKER WITH CHAIN

The chain used was very different to modern chain. It was of course entirely hand forged and the individual links were very long. In some cases the links were up to ½ m long and in the form of rods with an eye at each end rather than oval links. Long links provide faster and hence cheaper construction for a given length of chain and reduce the number of welded joints that were the weakest areas of the chain.

6. NORE CHART DETAIL

This is an inset from a 1732 chart that illustrates the first lightvessel. Sea trade was increasing and a lighted aid was required to enable ships to establish their position, at night in the featureless estuary of the Thames. Personnel were required to tend the lights and so a small coasting vessel was converted for the purpose.

7. NORE CHART

This chart was produced one year after the light vessel was established and shows the lightvessel pictorially and a buoy.

8. NORE MODEL

This is believed to have been an accurate model of the vessel that set a large flag as a daymark and candle lanterns at the ends of the yard at night. The crew tended the rope moorings and sailed the vessel when the mooring failed. Lightvessels increased in number as their effectiveness became apparent. Their AtoN technology generally followed that used in lighthouses, i.e. light and fog signals. I will only comment on lightvessel specific technologies.

9. TRINITY HOUSE WHARF

Moving ahead rapidly to the late 19th Century, ships have become larger, deeper draft and faster. There is the need to identify the deep-water channels and to navigate restricted waterways at night and in poor visibility. Buoys have become larger and more numerous. Trinity House had 40 buoys in 1796 and 400 by 1860! Top marks and flags are in use but these are essentially the same wooden buoys as were in use 200 years before.

10. TRINITY HOUSE BUOY STORE

As wooden buoys were made larger they had to be made from increasingly thick timber to be sufficiently strong and hence became heavier. The shapes that could be made by this cooperage process were also very limited. As we move into the 1800's the technology of manufacturing iron storage vessels and ships hulls developed at a rapid pace and this technology was soon used to make iron buoys.

11. TRINITY HOUSE IRON AND WOOD BUOYS

The fist riveted iron buoys followed the shape of wooden buoys but they would have been lighter and hence could support more mooring weight. The ability of iron to be worked into many complex shapes allowed a variety of buoy shapes to be developed that in some cases included the daymark shape in the buoy body and allowed the buoy to be sub-divided with bulkheads in case of collision damage. This drawing shows a variety of buoy types in use by Trinity House in the mid 19th Century when Britain seems to have been at the forefront of developments. Note that a bell buoy is included. These quickly came in to use as they provided the only means of providing warnings in restricted visibility.

12. FRENCH WOOD AND IRON BUOYS.

There was a French lighthouse service visit to Trinity House in 1855 to inspect developments in iron buoys and this resulted in their development of a standard buoy and a bellbuoy.

13. FRENCH BELL BUOYS

There had been a visit to TH by the US service in 1845 when it was noted that standard shapes and colours were used for buoys throughout the UK. Buoys remained on station usually for 6 months. They were moored to stone sinkers with chain moorings and ex-lightvessel chain was often used. We can infer that lightvessels were then usually moored with chain.

14. COURTNEY WHISTLE BUOY

In the US Mr Courtney (an English émigré) developed the automatic whistle buoy. The vertical motion of the buoy in the water drives air through a central tube to operate a whistle

15. GOODWIN SANDS LIGHTVESSEL. 1864

Lightvessels had developed into substantial vessels with large daymarks and lanterns that were hoisted up the masts at night. Lighting was provided by Argand lamps with individual reflectors that were positioned around the mast and individually gimballed. The start of the 19th C had seen many developments in artificial lighting using oil, gas, and electricity but the problems associated with operating any system on a buoy continually moving around at sea were considerable.

16. PINTSCH

The first major success was by a German, Julius Pintsh who had developed a gas lighting system for railway carriages. He distilled a stable gas from a mixture of vegetable and mineral compounds and compressed this into the buoy body. The gas (called oil gas) was burned in an open flame burner that would have produced a continuous, yellowish flame. The first lighted buoys were produced in 1878 and by 1880 were in use in the Thames estuary.

17. NY ELECTRIC BUOY

Surprisingly in 1880 electrically lighted buoys were installed in New York harbour. These were spar buoys with ‘Swan’ filament lamps, only 2 years after the filament lamp had been invented! Coloured filters were used to identify individual buoys. Initially a DC supply was used but the voltage loss in over 6 miles of cabling must have caused serious problems. The system was changed to AC in 1895 but the buoys were changed to more reliable gas lights in 1904. A similar system was trialled on the river Jade in Germany in 1895.

18. TRINITY HOUSE BUOY

This is, I believe a Pintsh buoy that had a 30 day service period. These were soon in use around the world. A clockwork occulting mechanism was introduced in 1883, which reduced gas consumption and gave a 3-month service life.

19. MAN ON BUOY

Acetylene was discovered in 1892. It has the particular advantage that with a correctly designed burner it can burn in air to produce a white light. Approximately 7x the intensity of oil gas lights. It is capable of operating very fast flash times and hence gas consumption is greatly reduced when compared with oil gas. However acetylene is extremely explosive and liable to detonation in widely varying ratios of acetylene to air.

20. WILSON CARBIDE BUOY

The Wilson buoy from 1900 produced acetylene from the reaction of calcium carbide and water within the buoy. These were introduced by some services, particularly US and Canada. But there were several disastrous explosions and operational problems due to the water freezing.

21. AGA GAS CYLINDER BUOY

The major advance in the early 1900's was the work of the AGA company in Sweden and in particular the engineer Gustav Dalen in the safe storage of acetylene, dissolved in acetone absorbed in a porous solid within steel cylinders and the development of the very complex but very reliable gas flashers. The flasher mechanically reduced and regulated the gas pressure and fed pulses of gas to the burner so that the required flashing character can be produced.

22. AGA FLASHERS

The gas storage and the gas flashers provided the means to operate buoys and remote beacons, unattended usually for at least a year. These became the industry standard in many parts of the world and some are still in use today.

23. &

24. AGA LANTERN

This type of gas lantern remained in use for nearly 100years. Gustav Dalen received the Nobel Prize for Physics in 1912 for his contribution to the safety of navigation.

25. WIGHAM OIL LANTERN

This automatic oil lantern had a continuously moving wick burning paraffin oil provided a simple fixed light used on some sheltered buoy stations around the turn of the century.

26. 1912 MEETING DRAWING

Some countries continued to use oil gas until the 1930's with Authorities having their own gas distillation plants. Oil gas was gradually replaced with propane or butane that could be stored in liquid form at moderate pressure. Oil gas lanterns and flashers developed in similar ways to acetylene lanterns and incandescent mantles were introduced to provide a white light.The world's lighthouse services divided between the use of acetylene or propane/butane as the gas for their buoys for the next 70 years or so. This drawing is from the 1912 International Navigation Congress in Philadelphia where buoy lighting with various types of gas was a major topic. The buoys are essentially similar to tail tube buoys still in use. Note that one of the buoys has an under-water bell. This is an example of an almost forgotten area of floataid technology.

27. LEADSMAN

We forget that the fast steam vessels in the early 20th century had no on-board navigation aids besides their compass, sextant, chronometer and leadline. The picture shows a leadsman sounding the water depth on a battleship in 1904. Some assistance was provided with the introduction of submarine bells. These take advantage of the fact that sounds travels much faster in water than it does in air and the reflection and refraction problems that make sound propagation in air so uncertain have little effect on propagation in water. Large ships were equipped with underwater listening devices that could detect underwater bells at a range of 10 miles and make a good estimate of the direction of the bell.

28. LIGHTVESSEL UNDER-WATER SIGNAL

Buoy bells were operated by the rolling motion of the buoy and were thus dependant on sea state. Lightvessels had bells that were mechanically operated and later electrical oscillators. These could be synchronised with the lightvessel's fog signal (whistle, syren or diaphone). The approaching ship could then note the time difference between the reception of the airborne signal and the under-water signal and be able to accurately calculate, for the first time, their distance from the lightvessel. This principal was further developed when the underwater fog signals were synchronised with the first radio beacons.

29. MANNED LIGHTVESSEL

Lightvessel designs were refined until in the 1930's they had rotating lights, diesel generators, compressed air fog signals and radio beacons. The major difference that existed from one country to another was that some Authorities had self- propelled vessels and some had vessels with no propulsion machinery that had to be towed to station. Authorities with many floating AtoN needed a considerable fleet of support vessels to tow lightvessels to and from station, change crews over and to lay and re-gas buoys.

30. LANBY

This situation remained largely unchanged until the 1970's when the US Coastguard made the brave step of replacing manned lightvessels with automatically operated very large buoys. These LNB's were 13m diameter very shallow hulls with 13m towers, that were developed from a meteorological buoy. The hull contained fuel tanks, two long running diesel alternators to power the light and fog signal and a very large cabinet of electrical control equipment and radio systems. The original US buoys and those built later in the UK were extremely unreliable and very difficult to maintain.

31. LANBY FLOATAID 1984

The engineering effort that went into solving the problems highlighted by the first LNB's soon established confidence in the operation of remotely operated diesel power systems, remote control and monitoring systems and the unattended moorings of the LNB and lead to the steady automation of the manned lightvessel fleet and the offshore lighthouses.

32. TENDER WITH LV'S

In 1990 we see a tender removing one automatic lightvessel from station and about to replace it with a newly refitted vessel. Note that the buoys on deck have no lanterns fitted. The gas lanterns will be operating in the lantern test space on the foredeck to ensure their characters are correct and will only be fitted to their buoys just before laying. The sea time of the tender fleet will have been substantially reduced as they no longer have to carry crews and their supplies to lightvessels and offshore lighthouses as many of these have been automated but they are still re-gassing buoys and re-fuelling the lightvessels and maintaining moorings.

33. LAMP CHANGER

Some Services changed from gas buoy lights to primary battery powered electric lights in the 1960's and 70's. These required the regular replacement of primary battery packs. The small filament lamps, usually carried in automatic lamp changers were never entirely reliable at exposed buoy stations.

34. SOLAR CONVERTED GAS BUOY

The introduction of solar modules to recharge secondary batteries was probably the most significant step in buoy technology. There were progressive developments in the 1980's and the problems of mounting solar modules, charge regulation and choice of battery type were solved and confidence gained in the operation of solar systems. Gas buoys were then converted to solar power and electric lanterns removing the need for ships to change heavy gas bottles.

35. LED LANTERN

Solar systems soon demonstrated their reliability and the next development was the LED lantern. The LED provides a very efficient conversion of electrical power to light. The LED will last for many years and consequently the need to regularly replace filament lamps, on station has gone. There is the added advantage that the light output of coloured LEDs are equal or better than white LEDs, this is compared with coloured light produced by filtering white light where 30 to 50% of the light is lost in the filter. This has resulted in smaller solar modules being required for a given light output so that in many cases the lantern can be combined in one housing with the solar modules and battery.

36. PLASTIC BUOY

Many buoys are now made from some form of moulded plastic rather than steel, but most are moored in a similar way that which they were 400 years ago. The buoy, with solar powered LED lantern may remain on station for 5 or 6 years only requiring surface cleaning. The requirements for visits by servicing vessels is, therefore, significantly reduced.

37. SOLAR LIGHTVESSEL

The few remaining lightvessels have taken advantage of low powered AtoN technology and have also been converted to solar power. It will be interesting to see how many and what types of floating AtoN will remain at the end of this century.

38. DUBBELS, HENDRIK JAKOBSZ

(b. 1621, Amsterdam, d. 1707, Amsterdam)

Description

A dramatic portrayal of two Dutch East Indiamen, who may have returned from a journey overseas. The ship on the left, in distant port-quarter view, has a scene painted on her stern depicting a pavilion with trees, possibly palm trees and thus a reference to her exotic trade associations. Men are portrayed in the rigging, working on the sails. In the centre foreground, a smalschip sails into wind and six men can be seen in her stern. A smalschip, meaning narrow ship, took its name from its ability to negotiate locks on inland waterways. One of the men gestures towards the ship on the far right, seen in port-bow view with a carved figurehead of a lion. T he deck is laden with men busy on various tasks as it prepares to anchor. The two ships are flying Dutch flags and a plain red jack. In the far distance, a landscape can be seen on either side of the picture. To the far left, this includes a skyline of church towers, and to the right, the curved shape of dunes, suggesting this is an estuary scene or a channel between islands on the Dutch coast. Strong contrasts of light and dark dominate both sea and sky, and the striking formation of the clouds dominates the top-half of the image. The artist has signed his name on the buoy in the centre foreground.

Dubbels worked in Amsterdam as a painter of seascapes and winter landscapes from c. 1641 until his death.

ANNEX 7 **The new technologies in Aids to Navigation and alternative ways of management, Juan Francisco Rebollo, Puertos del Estado, Spain**

NEW TECHNOLOGIES IN AIDS TO NAVIGATION AND ALTERNATIVE WAYS OF MANAGEMENT

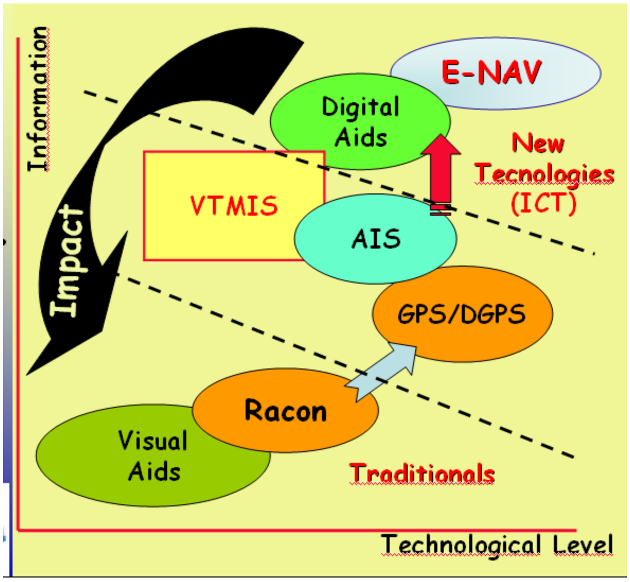
Juan F. Rebollo – Puertos del Estado, Spain

Firstly, let me thank this Seminar's organising committee for having taken this topic into consideration as part of the aspects that will be dealt with over the coming days. I would also like to thank Puertos del Estado for having let me give this presentation.

The title according the program is NEW TECHNOLOGIES IN AIDS TO NAVIGATION AND ALTERNATIVE WAYS OF MANAGEMENT but should be also understand as THE IMPACT OF THE NEW TECNOLOGIES ON PROVIDING MARINE AIDS TO NAVIGATION SERVICES.

The origin of this presentation is in the IALA ANM Committee, in which I have had the honour of acting as rapporteur on this subject for nine years, as well as in my article entitled "The Impact of New Technologies on Providing Marine Aids to Navigation Services", published in the 2006/1 issue of the IALA Bulletin. I would like to thank the Committee's members for all their contributions throughout this time.

Far from aiming to provide Guru-style recommendations, an effort is made in this presentation to put forward some ideas whose appropriately developed would facilitate changes in the management models for marine aids to navigation (AtoN) services, which are apparently, arise from the new technologies. Or is it just an excuse?



The aids to navigation systems have progressively evolved from traditional or short-range systems to today's systems now more related to the information and communications technologies. Marine signals have moved on from physical devices to becoming "bits" of information ready for use of mariners when necessary as an aid to their decision-making. This could sometimes mean the disappearance of the sense of "signal", as occurs in the aids applied to Marine Electronic Highways (MEH) or in intelligent applications for traditional aids, using information from AIS systems.

Let's start off then by establishing a common framework of reference that will help us define the following terms:

Impact: We understand this to mean an influence or effect that involves some kind of change. In principle, it has a neutral perception, but with a certain positive bent.

New technologies: We can consider these involve the use of new equipment and systems, as well as new ways of doing things.

Provision: We understand the selection and acquisition of devices, the tasks connected to its maintenance and availability, as well as the service's management.

Service: User-driven, establishing systems that meet the user needs and expectations, so as to help us prioritise our resources and actions.

As examples of "New Technologies" we could include: ECDIS, ENC charting, GPS/DGPS positioning, AIS devices and networks, LED equipment, plastic buoys, elastic mooring systems, remote control and information systems, and the new “e-systems”

Lastly, there are as many definitions for the term “**management**" as authors who have written on this subject. However, it could be understood to mean a set of actions which are capable of providing a high-quality response with an appropriate cost through the planning, deployment and application of available resources and knowledge, without forgetting that we are in a changing environment and globalised.

The following table highlights some of the present and future impacts that have been identified:

Present Impacts	**Future Impacts**
• Reduction in traditional Aids to Navigation. Is this sure? • Reductions in costs and maintenance tasks • Redistribution of authorities in charge of Aids to Navigation • Subcontracting of maintenance tasks • Use of solar panels for Aids to Navigation • Increase in navigation safety • Appearance of aspects connected to security • Need for updated and reliable digital charting • Risk of losing "knowledge"	• Possible ongoing reduction in traditional Aids to Navigation • Nautical importance of lighthouses placed into question • End of some systems like LORAN-C • Reduction in the frequency of Aid to Navigation maintenance, especially buoys • Increase in subcontracting and appearance of ADS[1] • Change in the definition of Aids to Navigation and integration of ship's external-internal areas, as well as integration of the safety-security duality • Blurring of competencies between IALA-IMO and IHO in the new "e-environments"

As well as, among others, the following risks and trends:

Risks	**Trends**
• People and knowledge. New cultures, new backgrounds, new challenges • Transferences from aeronautical or terrestrial sectors • Technological dependence • Market-driven research; loss of basic knowledge • Legal aspects and liabilities	• Local redundant (backup) systems (in terrestrial positioning systems) • Efficiency improvements • Environmental considerations • World-Wide and multi-modal or multi-type nature • Complementary/ Alternative use of lighthouses strategies for idle or out-of-service facilities.

[1] ADS: Alternative delivery service.

Back to the reduction in traditional AtoN, it was identified in the surveys conducted by the IALA-ANM Committee, but not in a significant way. It is perhaps more relevant in the case of buoys. We should take into account that new technologies, especially those coming from other sectors which are in widespread use, produce an important reduction in costs and lower levels of energy consumption. Hence, an increase in signals, especially short-range signals, could come about by taking advantage of the new technologies, as they can be cheaper and easy to install.

Briefly, I would like to comment on what I have called "Transferences from other sectors". This involves the use of new technologies or ways of doing things coming from the aeronautical or terrestrial sectors (mainly the aeronautical) in an effort to transfer their experiences to the marine sector. Perhaps this is due to the number of consultants or new-experts coming from these sectors.

Concerning the alternative (I prefer complementary) uses of the lighthouses, will be the subject of other papers, this strategy assumes that lighthouses and other visuals AtoN are necessary for navigating, especially without instruments, and as a reserve or backup system for the new technologies. Moreover, they are an outstanding logistical platform to symbiotically install new technologies, without forgetting that they constitute a piece of cultural and technical heritage that should be preserved and permit the integration on the society.

The normal effect of new technologies is to replace the before existing ones, but in our case, the new technologies coexist with traditional (old) technologies. This can be due to various causes, for example the coexistence of different kinds of users, some of them without any kind of technical know-how; the lack of any overall regulation and control for all of them, some have no regulation at all or the regulation is difficult to apply; also a certain lack of co-ordination among regulatory authorities concerning navigation safety from the vessels point of view and those in charge of aids to navigation systems.

It should also be taken into account that the requirements of coastal navigation are different from ports approaches and restricted waters navigation. While for the coastal navigation new technologies can be a more efficient alternative, they are not for other kinds of navigation in which, due to the difficulties dealt with an adequate charting, traditional mark are very necessary and, perhaps, can't be replaced by any other system.

Without forgetting legal and environmental liabilities as background "noise", the following are some of the **causes** that are generating the greatest effects on AtoN service provider:

- Technology
- Other ways of doing things.

Concerning technology, we have to take into consideration specific developments in the aids to navigation sector and the application in this sector of new technological developments coming from other sectors.

In addition, management criteria based on efficacy and efficiency are being applied. These are focused on the user needs and expectations, as well as on using resources — mainly public resources — in a responsible way. This means that, like for other services, the Authorities involved are focused on the user in a high-quality environment. Although efficacy is guaranteed, the new management challenges are focused on the efficiency, based on cost-benefit analyses, but in some cases directly on cutting the available budget.

These causes lead to **effects** in:

Infrastructure: The most significant effect is the need to preserve Heritage, not only for lighthouses as an infrastructure but also for the associated technical equipment and historical documentation, including technical, construction-related and administrative documentation. In many cases the preservation of such Heritage is a heavy cost for the AtoN service provider without this cost improving the safety. So, complementary uses are an ideal tool to maintain this heritage without it becoming a burden for the ever more limited resources destined for the service.

Technical devices: The progression from mechanical to electro-mechanical systems and later to electronic and now to intelligent (computer) systems means that the core of the organisations no longer resides in equipment maintenance and repairs. New technologies provide integrated equipments that are difficult to repair, and damaged elements have to be replaced. Systems integration clearly improves reliability, but reduces reparability.

Stock management is essential in the new management of aids to navigation. Although the most reliable equipments and despite having low maintenance needs, it should not be forgotten that repairs will be difficult when a fault arise. An additional investment in "full-device" spare parts is therefore necessary. In themselves new technologies do not guarantee better availability of service without taking into account an appropriate spare parts policy and technical training.

One new effect of the new technologies have on our area is the technical obsolescence of equipment, especially when we are using technologies that originally came from other sectors. This is due to the rapid evolution of these technologies, as well as to the lack of spare parts needed to guarantee the service after a short period of time. In addition, new developments do not ensure technological compatibility with the previous ones. If lighthouses have working for hundreds of years, LED systems have developed several generations in just a few years. The same can be said for radioelectric aids and positioning systems.

People: People are the most important elements of any organisation. New technologies are having a significant effect on people, along with new ways of doing things under criteria of efficiency. New technologies require new professional backgrounds, new skills and new attitudes.

The use of new technologies from other sectors limits the need for technical experts to improve research and development, now only innovation. In addition, with the reduction in the equipment's reparability, the replacement of damaged parts has made easy the outsourcing of the tasks, which have been essential for our technician some time ago.

Now then, the AtoN service provider needs better trained technicians in charge of the service, with a greater degree of technical authority and competencies. Such staff should have knowledge about a wide variety of fields, as the new technologies will come from different sectors.

The culture of contracting-out produces a reduction of personnel from their technical structures, in many cases based on the age. This is causing considerable harm to the knowledge, which passes from the competent authorities to private companies. But, in fact, companies are not interested in the knowledge either, these using young talents for an important new project, but then leave the company shortly after, usually more quickly as younger and more promising talent they are.

However, refusing the outsourcing is not a guarantee of keeping on the work groups and conserving knowledge either. The, apparently, inevitable reduction of personnel in technical areas means that organisations need to restructure themselves by assigning people to new tasks, thus also breaking up work teams inside the organization. The effects of this are similar to the effects of outsourcing. We should not forget the notion of the internal provider, subject to the same risks that the external providers, but more difficult to replace because the organisation probably will not replace them.

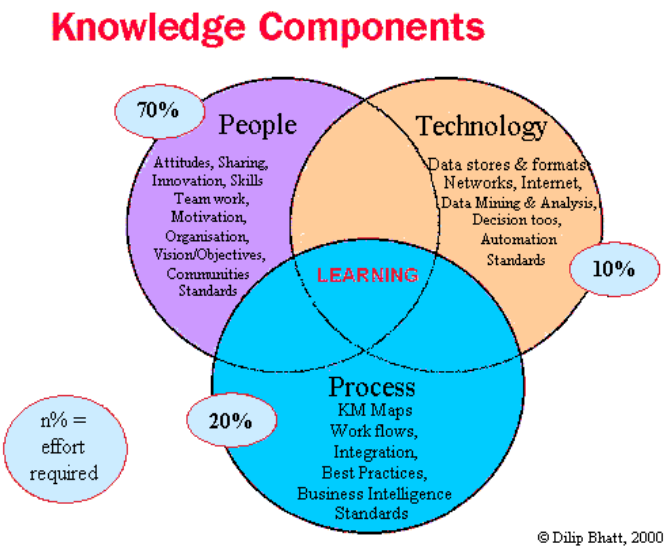
Tasks: As has been mentioned before, organisations focus on maintenance tasks will disappear. Devices are more reliable, remote control systems exist and information can circulate cheaper and easily. Making repairs is almost no longer possible. Instead complete elements have to be replaced, which in some cases can be done more cheaply by subcontracting.

Now the trend of the tasks is more directly related to control, service quality and the service, spending more time to the continuous improvement of processes, in order to improve the efficiency. This involves teamwork as opposed to solitary work; new technologies, sometimes not very well-known, as opposed to specialisation. The new tasks require new backgrounds from people, in all case with open-mind. When we have difficulties of finding suitable people for the new tasks and provide them the necessary training is slowly and costly, the contracting-out can be the easy solution.

An extreme case of subcontracting is Alternative Delivery Services (ADS). In this case, the companies contracted takes charge of all the service's aspects, including the provision of aids to navigation, their maintenance and archive the service quality according with the standard parameters. The competent authority loses an important part of its knowledge and only have the function of monitoring the service's quality and pays for it. The authority lacks infrastructures and will even lose all its technical capacity within a short period of time.

Technological return for the organisation should be ensured in outsourcing or ADS with people capable of absorbing, maintaining and transmitting the knowledge generated outside the organisation but paid for it.

Knowledge: Knowledge is not only the way of doing things (know-how) but also the safekeeping of a company's culture over the time, as well as of its technical competence and its evolution. The main challenge is involving people. Any kind of management over people has an effect on knowledge. Knowledge is the differential value of the organizations: let's take care of it. If we lose knowledge, we become...nothing.



From a historical standpoint, it could be considered that knowledge in the marine aids to navigation has developed within two scenarios, one centralised and other dispersed scenario. The first one is made up of organisations' technical centres, which have traditionally been centralised, where theoretical knowledge resided and research, development and innovation activities were performed. The latter was focused on maintenance tasks and comprised of operational knowledge. While the first was documented and the staff was older, with technical expertise, the latter was based on oral transmission from one technician to the next of how to do things, usually younger, which over the course of time could provide people to an organisation's headquarters.

This wheel of knowledge has today been broken. This is mainly due to the reduction in the people dedicated to performing technical tasks within organisations. At the beginning the outsourcing was in charge of repetitive tasks having little added value, but progressively begins to include more and more added value tasks, moving on the knowledge, at least operational knowledge, from the organisation to external groups.

This reduction in technical resources can cause that the technicians, who having theoretical and even operational knowledge, are moved on to other areas of activity in the organization. Hence, the organisation's basic knowledge at its headquarters is also lost.

The experience we at Puertos del Estado have undergone shows how difficult this matter is. People who have knowledge are not usually willing to share it. A cultural change aimed at encouraging the ways of sharing knowledge as a win-win activity that drives forward the development of the whole organisation through the experience of individuals is therefore necessary.

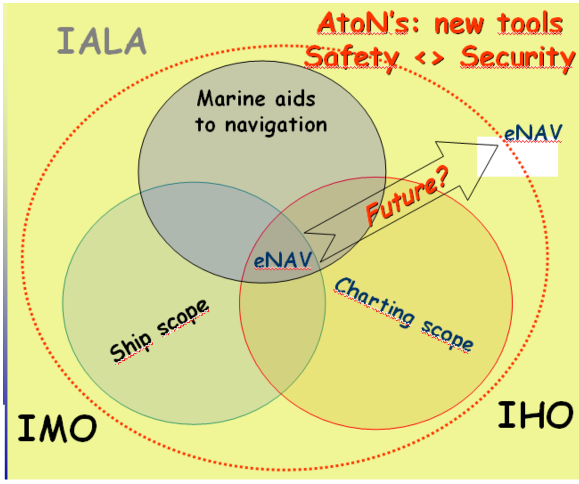
New needs: New platforms are sometimes required to ensure new technologies can fully develop their benefits. A case requiring special care is nautical charting. The new technologies based on accurate positioning and information systems require the availability of geographical support having similar accuracy. For instance, the availability of updated quality charts can be a limitation for the new positioning systems and the development of e-navigation. Something similar happens with the availability of faster communications for information systems.

In most cases, these new needs are competence of other authorities; thereby the co-ordination among all of them is essential.

An ongoing need is training on the new technologies. However, as was mentioned before, as AtoN is a service, there is a "transmitter" and a "receiver". Training in the new technologies must go hand-in-hand for both. Organisations in charge of marine aids to navigation have been making significant efforts to train their personnel and apply more efficient, better quality new technologies of offer greater safety to navigation. However, have "receivers" of marine aids to navigation — ownership, shipping companies and mariners — made similar efforts?

A consequence of this possible difference in efforts has an impact on the provision of the service under safe conditions, making its parallel development is necessary. Any potentially negative impact should be assessed before taking the decision to implement new technologies, although we should not forget that technological innovation activities are the driving force for development.

The spheres of marine environment, those involved in AtoN, in the vessel scope and those having to do with charting, are overlapping more and more, leading to blurring the competencies held by the different competent authorities. The increase in the number of overlapping points means that the contents of the core element will expand. This core could be e-navigation, but also can be understand like the joint management, of the three spheres above mentioned. The new technologies can be the tools of e-navigation: digital aids and the so-called "e-technologies": e-Loran, e-ANSI, e-…



A new effect of new technologies is the deployment of e-navigation at two levels: safety and security. The latter is new to the scope of marine aids to navigation and may possibly require some modification to the definition of "aid to navigation" in the IALA Constitution.

We won't go into the effects of the competition for leadership in new technologies in the marine area among international organisations like the IMO's e-navigation and the EU's e-maritime. Are really co-ordinated?

Summarizing:

- The aids to navigation systems that have progressively evolved from traditional or short-range systems to today's systems now are more related to the information and communications technologies. Marine signals have moved on from physical elements to becoming "bits" of information ready to mariners when necessary as an aid to their decision-making. This could sometimes mean the disappearance of the notion of "signal", as occurs in the aids applied to Marine Electronic Highways (MEH) or in intelligent applications for traditional aids, using information from AIS devices.

- As examples of "New Technologies", we could include: ECDIS, ENC charting, GPS/DGPS positioning, AIS devices and networks, LED equipment, plastic buoys, elastic mooring systems, remote control, information systems and the new “e-systems”

- Impacts:
  - ✓ Present Impacts: Reductions in cost and maintenance tasks; an increase in subcontracting, along with the need for new, better trained technical backgrounds; an increase in safety (greater reliability and availability); start security matters.
  - ✓ Future Impacts: End of some systems like the LORAN-C and the arrival of new ones like e-Loran; an increase in the blurring of the competencies held by the IALA, IMO, IHO; a possible reduction in some types of marine signals, more for coastal navigation, as long as the charting were adequate.
  - ✓ Risks: New cultures, new profiles, new challenges; technological dependence; the loss of basic knowledge; new needs, especially charting and trained people in both sites: AtoN and vessels.
  - ✓ Trends: World-Wide and multi-modal or multi-type nature; complementary use of lighthouses spaces strategies; maintenance of terrestrial positioning systems combining satellite-based system; a progressive reduction in Organizations' workforce and technical capacities.
- Independently of the possible loss in the value of lighthouses as navigational devices, especially for coastal navigation, making them available to society and as logistical platforms for the placement of new technologies are excellent strategies to preserve heritage.
- It must not be forgotten that new technologies provide highly efficient solutions that can guarantee the survival of lighthouses, because the cost-benefit relationship is now more advantageous.
- Marine aids to navigation somewhat more than lighthouses, although these and, in general terms, traditional aids can become reserve or backup systems for the new technologies as regards coastal navigation, but the traditional ones may be the main system in approaches to the coast or restricted waters.
- The normal effect of new technologies is replacing the old technologies, but in our case, the new technologies coexist with traditional technologies.
- Like in other kinds of services, authorities are customer driven within a high-quality environment. Although efficacy is guaranteed, the new management challenges are centred around efficiency, which is based on cost-benefit analyses or directly on the cutting the available budget.
- Concerning new technology effect, we have to take in consideration specific developments in the aids to navigation sector and the application in this sector of technological developments coming from other sectors, along with other ways of doing things, without forgetting legal and environmental liabilities as background "noise.
- We can identify effects on:
  - ✓ Infrastructures: Defending heritage from vandalism and from infrastructure degradation. New technical uses to promote the placement of new technologies.
  - ✓ Technical devices: Appearance of computer-based intelligent systems. Lack of reparability and risk of not reaching availability levels. Need to invest in spare parts. Rapid technological obsolescence, especially regarding developments coming from other sectors.
  - ✓ People: Continuous fall in the number of technical staff. Subcontracting of external and internal providers. Need for continuous training and new backgrounds.

- ✓ Tasks: Increase in the subcontracting of more tasks. New tasks connected with management. ADS. Technological return for the organisation should be ensured in outsourcing or ADS with people capable of absorbing, maintaining and transmitting the knowledge generated outside the organisation but paid for by it.
- ✓ Knowledge: The circle of knowledge is broken. Knowledge is an organisation's greatest asset, but the organisation lacks it. Transfer of knowledge to external sectors, more exactly to external people who will lose it once the subcontracting has come to end.
- ✓ New needs: Updated and accurate WGS-84 Datum charting. Availability for faster communications in remote places. Co-ordination among competent authorities in some areas. Digital aids as e-navigation tools. New "e-technologies".

- Marine aids to navigation will enter the area of security. Will amending the IALA Constitution and the definition of "Aid to Navigation" be necessary?
- The urgent need for training, but in a co-ordinated way among "transmitting" organisations (Aids to Navigation) and "receiving" organisations (centred around vessels).
- Any potentially negative impacts should be properly assessed and could possibly be turned into opportunities or as driving forces for technological development.

Now in **key words or highlights** is shown a summarized set of ideas without any order of preference:

1 Changing environment and globalised.

2 Efficiency. Quality Assessment and process improvement.

3 Usability. No reparability.

4 Safety and Security.

5 “e-technologies” as tools in the new e-navigation.

6 Less resources and less budget.

7 New Technologies are easy to install, chipper and low maintenance needed.

8 Now it is easy to improve the range of visual aids, so why not maintain it or install even more?

9 Traditional Aids are necessary for reserve or backup of the new technologies and should maintain as main aids in areas not well charted, port approaches and restricted waters.

10 The new technologies don’t remove the existing ones.

11 Complementary uses of lighthouses are a good strategy for to preserve the Heritage as well as add value to the society.

12 New needs: Charting and training in both parts: AtoN service provider and in the Vessels scope.

13 Legal liabilities and environmental culture.

14 Transferences from other sector (mainly aeronautical); blurring between competent Authorities; Knowledge is transferred to private companies, first but after will be lost.

15 Faster technical obsolescence, especially of technologies comes from other sectors.

16 New skills for people, more wide competencies and open-mind.

17 People are the success key and the knowledge is the key for Organizations.

18 Outsourcing or contacting-out or subcontracting of external provider, but the same effect can occur with the internal provider.

19 Technological return for the organisation should be ensured in outsourcing or ADS with people capable of absorbing, maintaining and transmitting the knowledge generated outside the organisation but paid for by it.

20 AtoN for World-Wide and multi-modal or multi-type user.

To finish off, allow me to make a comment on the new technologies we are deploying in Spain in the area of marine aids to navigation. An **e-ANSI or AtoNIS information system** based on our remote control systems, AIS-AtoN systems, Internet communications, and other non-automated information, we will generate an automatic updating of our database and broadcast it to users through Internet and AIS networks, following the IALA trends.

A **knowledge management system** made up of two Web-based tools, one of which is a forum for open, rapid queries and the other is a knowledge database, in which experiences and best practices (both positive and negative) can be stored. This database is accessible through our website and is open to all through the following link:

(http://www.puertos.es/AtoNBDC/index.jsp (user: guest; password: guest)

Finally, we should not forget what Nils Gustaf Dalen, the Nobel award in Physics, said, **"The lights should never be turned off",** although we have to take into account that marine aids to navigation are much more than lighthouses, but all of them should not be "turned off" either.

ANNEX 8 Evolution of Radio Aids to Navigation, James Doyle, Commissioners of Irish Lights, Ireland

When considering lighthouse heritage, there is a tendency to consider the lighthouse tower and traditional aids to navigation systems such as large revolving lights and pneumatic fog signals. However there is a long tradition of radio aids to navigation going back to early in the 20th century. Over the years these radio aids have become increasingly important in the battle to ensure safe navigation and clean seas. This paper looks at the history of radio aids to navigation and how these aids can be displayed as heritage items.

1. INTRODUCTION

Over the past century there has been a quite revolution in the ability of mariners to determine their position accurately and thus ensure that the movements of vessels are safe, expeditious and cost effective and at the same time protect the environment. This revolution in marine navigation has been driven by the relentless development of radio Aids to Navigation (AtoN). And just as lighthouse lights became part of our valued heritage, so to radio systems pass into the annals of history and become part of our heritage. The objective of this paper is to look at the history of radio aids to navigation and how these aids can be displayed as heritage items.

2. DAWN OF RADIO

Ignoring the discovery of electricity by Benjamin Franklin with his famous kite flying experiments in 1752, it all started with the discovery of "radio waves" - electromagnetic waves that have the capacity to transmit music, speech, pictures and other data invisibly through the air. James Clerk Maxwell, the Scottish physicist, was born on 13th June 1831, in Edinburgh. He was very interested in Michael Faraday's work on electromagnetism. In 1855 he produced a paper which built on Faraday's ideas, and in 1861 developed a model for a hypothetical medium, that consisted of a fluid (the ether) which could carry electric and magnetic effects. He also considered what would happen if the fluid became elastic and a charge was applied to it. This would set up a disturbance in the fluid, which would produce waves that would travel through the medium. Maxwell finally published this work in his 'Treatise on Electricity and Magnetism' in 1873. Thus the theory of radio was born.

In 1888 German physicist Heinrich Hertz made the sensational discovery of radio waves, a form of electromagnetic radiation with wavelengths too long for our eyes to see, confirming Maxwell's ideas. He devised a transmitting oscillator, which radiated radio waves, and detected them using a metal loop with a gap at one side.

When the loop was placed within the transmitter's electromagnetic field, sparks were produced across the gap. This proved that electromagnetic waves could be sent out into space, and be remotely detected. These waves were known as 'Hertzian Waves' and Hertz managed to detect them across the length of his laboratory.

Italian born Guglielmo Marconi was fascinated by Hertz's discovery, and realised that if radio waves could be transmitted and detected over long distances, wireless telegraphy could be developed. He started experimenting in 1894 and set up rough aerials on opposite sides of the family garden. He managed to receive signals over a distance of 100 metres, and by the end of 1895 had extended the distance to over a mile. He approached the Italian Ministry of Posts and Telegraphs, informing them of his experiments. The Ministry was not interested and so his cousin, Henry Jameson-Davis arranged an interview with Nyilliam Preece, who was Engineer-in-Chief to the British Post Office.

Marconi came to England in February 1896 and gave demonstrations in London at the General Post Office Building. His transmissions were detected 1.5 miles away, and on 2nd September at Salisbury plain the range was increased to 8 miles. In 1897 he obtained a patent for wireless telegraphy, and established the Wireless Telegraph and Signal Company at Chelmsford. The world's first radio factory was opened there in 1898. On 11th May 1897 tests were carried out to establish that contacts were possible over water. A transmitter was set up at Lavernock Point, near Penarth and the transmissions were received on the other side of the Bristol Channel at the Island of Holm, a distance of 3.5 miles. The Daily Express was the first newspaper to obtain news by wireless telegraphy in August 1898, and in December of that year communication was set up between Queen Victoria's Royal yacht, off Cowes and Osborne House. The Queen received regular bulletins on the Prince of Wales' health, by radio, from the yacht, where he was convalescing.

The lighthouse service was quick to take advantage. In December of that year, wireless communication was set up between the East Goodwin light ship and the South Foreland lighthouse. On 3rd March 1899 Marconi obtained a lot of publicity when the first life was saved by wireless telegraphy, which was used to save a ship in distress in the North Sea. By the summer cross channel communication had been established and the first ocean newspaper published bulletins sent by wireless.

3. RADIO COMMUNICATIONS

About this time Marconi began to develop tuned circuits for wireless transmission, so that a wireless can be tuned to a particular frequency, to remove all other transmissions except the one of interest. He patented this on 26th April 1900, under the name of 'Tuned Syntonic Telegraphy'.

On Thursday 12th December 1901, Marconi and his associates succeeded in transmitting a signal across the Atlantic Ocean. He sailed to Newfoundland with G.S. Kemp and P.W. Paget, and received a transmission from Poldhu, Cornwall. The transmission was received at Signal Hill using a kite aerial. The British government and admiralty were greatly impressed and many people wanted to invest in the new technology.

Demand grew and large numbers of ships carried the new apparatus, which saved many lives at sea. One of the most famous occasions was when the Titanic sank. Signals transmitted by its Marconi wireless summoned help and saved many lives.

Although not strictly an Aid to Navigation, radio communication was a quantum leap forward in the management and safety of marine navigation. As time went on, radio systems were developed to assist with identifying the position of ships.

4. RADAR

Strictly speaking, radar is a navigation aid fitted on the ships bridge rather than an Aid to Navigation provided from outside the bridge. However, it is sufficiently important to safe navigation to warrant a place in the history of radio AtoN.

Radar (RAdio Detection And Ranging) is a system based on the detection of backscatter of transmitted radio energy from an object. The targets are displayed in such a way that their bearing and range are continuously available. The frequencies used are in the 3GHz (S band) and 9GHz (X band). The history of radar began in the 1900s when engineers invented simple uni-directional ranging devices.

In 1904 Christian Huelsmeyer gave public demonstrations in Germany and the Netherlands of the use of radio echoes to detect ships so that collisions could be avoided. His device consisted of a simple spark gap aimed using a multipole antenna. When a reflection was picked up by the two straight antennas attached to the separate receiver, a bell sounded. During bad weather or fog, the device would be periodically "spun" to check for nearby ships. The system detected presence of ships up to 3 km, and he planned to extend its capability to 10 km. It did not provide range information, only warning of a nearby object. He patented the device, called the telemobiloscope, but due to lack of interest by the naval authorities the invention was not put into production.

In the autumn of 1922, Albert H. Taylor and Leo C. Young of the U.S. Naval Research Laboratory (NRL) were conducting communication experiments when they noticed that a wooden ship in the Potomac River was interfering with their signals; in effect, they had demonstrated the first continuous wave (CW) interference radar with separated transmitting and receiving antennas. In June, 1930, Lawrence A. Hyland of the NRL in the U.S. detected an airplane with this type of radar operating on 33 MHz.

Robert Watson-Watt, working at a meterological outstation at Aldershot, in Hampshire, Britain, developed the use of radio signals generated by lightning strikes to map out the position of thunderstorms. The difficulty in pinpointing the direction of these fleeting signals led to the use of rotating directional antennas, and in 1923 the use of oscilloscopes in order to display them. An operator would periodically rotate the antenna and look for "spikes" on the oscilloscope to find the direction of a storm. At this point the only missing part of a functioning radar was the transmitter.

On February 26, 1935 Watson-Watt and AF Wilkins demonstrated a basic radar system to an observer from the Air Ministry Committee the Detection of Aircraft. The previous day Wilkins had set up receiving equipment in a field near Upper Stowe, Northamptonshire, and this was used to detect the presence of a Handley Page Heyford bomber at ranges up to 8 miles (13 km) by means of the radio waves which it reflected from the nearby Daventry shortwave radio transmitter of the BBC, which operated at a frequency of 6 MHz. This convincing demonstration, known as the Daventry Experiment, led immediately to development of radar in the UK.

Shortly before the outbreak of World War II several radar stations known as Chain Home (or CH) were constructed along the South and East coasts of Britain, based on a successful model at Bawdsey by Watson-Watt. As one might expect from the first radar to be deployed, CH was a simple system. The broadcast side was formed from two 300 ft (100 m) tall steel towers strung with a series of antennas between them. A second set of 240 ft (73 m) tall wooden towers were used for reception, with a series of crossed antennas at various heights up to 215 ft (65 m).

The CH system was very large and used for coastal surveillance. A successful programme by Edward George Bowen in 1936 developed a miniaturized radar system suitable for aircraft, the so-called Airborne Interception (AI) set.

The early radars worked at a frequency of about 30MHz with pulse power of 750kW. The next major development in the history of radar was the invention of the cavity magnetron by John Randall and Harry Boot of Birmingham University in early 1940. This enabled generation of frequencies at 3000Mz with pulse power of 30kW. The combination of the magnetron, the duplexer switch, small antennas and high resolution allowed small high quality radars to be installed in aircraft. Over the years the miniaturisation of electronics has reduced the size of radar systems to the small units in use today.

Fitted on every ship and most aircraft, radar is an indispensable on board system that allows crews to see what is around them in daylight, fog or night time.

5. RACONS

A Racon (RAdar beacon) is a type of radar transponder commonly used to mark maritime navigational hazards. When a racon receives a radar pulse, it responds with a signal on the same frequency which leaves an image on the radar display. This takes the form of a short line of dots and dashes forming a Morse character radiating away from the location of the beacon on the normal plan position indicator radar display. The length of the line usually corresponds to the equivalent of a few nautical miles on the display.

They are used to mark structures of significance to navigation such as lighthouses and navigation buoys, positions on inconspicuous coastlines, navigable spans under bridges, offshore oil platforms and other structures, and environmentally-sensitive areas such as coral reefs. Their characteristics are defined in the ITU-R Recommendation M.824, Technical Parameters of Radar Beacons (RACONS). Racons usually operate on the 9320 MHz to 9500

MHz marine radar band (X-band), and most also operate on the 2920 MHz to 3100 MHz marine radar band (S-band).

During the 1960s, racons such as Kelvin Hughes URSA MINOR and Marconi Major emerged. With developments in electronic miniaturisation from valves to transistors, the size of these units quickly reduced to units that were portable by the 1970s.

Older racons such as the Marconi Seawatch 2A and 2B operate in a slow sweep mode, in which the transponder sweeps across the X-band over 1 or 2 minutes. The racon only responds if it happens to be tuned to the frequency of an incoming radar signal at the moment it arrives, which in practice means it responds only around 5% of the time.

In 1980 Marconi developed the X-band Accord frequency agile racon, which had a wide-band receiver that detects the incoming radar pulse, tunes the transmitter and responds with a 25 microsecond long signal within 700 nanoseconds, thus responding to every scan of the interrogating radar. Modern racons such as the Eriksson Ericon, the Tideland Seabeacon and the Pharos Marine Phalcon are frequency-agile on both X and S-Bands.

To avoid the response masking important radar targets behind the beacon, racons only operate for part of the time. In the United Kingdom, a duty cycle of about 30% is used - usually 20 seconds in which the racon will respond to radar signals is followed by 40 seconds when it will not, or sometimes 9 seconds on and 21 seconds off (as in the case of the Seven Stones Light Vessel). In the United States a longer duty cycle is used, 50% for battery-powered buoys (20 seconds on, 20 seconds off) and 75% for on-shore beacons.

In 2007 New Technology (NT) S-Band radars using coherent transmissions with very low power non magnetron transmitters began to emerge. IMO Resolution 192(79) removed the requirement for S-Band Radars to trigger racons from 2008. Thus, while the NT radars had much improved performance, they no longer work well with S-Band racons. The way forward is uncertain.

6. RADIOBEACONS

Radio beacons first appeared in the 1920s. The first UK marine radio beacon began broadcasting from Kinnaird Head on 20th March 1929. This was an attempt to improve upon fog signal apparatus that had been introduced in 1902 and ran on compressed air. The signal was broadcast in Morse code allowing mariners to fix bearings. The concept was to broadcast radio signals to ships during bad weather that would enable them to steer clear of dangerous areas.

Radiobeacons transmit in the frequency band of 285–315 kilohertz. The technology is much simpler that radar using simple transmitters and receivers with loop type receiver antenna to enable direction finding. In a characteristic signal lasting one minute, the station identification, in Morse code, is transmitted two or three times, followed by a period of continuous transmission during which a bearing can be measured by a ship’s direction-finding receiver. Bearing accuracy averages better than 3°. The frequency of transmission varies in different parts of the world. Knowing the transmitting station from the identification morse code and the direction from the direction finder, the bearing to the transmitting station could be plotted. Taking and plotting such a bearing from two or three stations then provides ships position.

In the busy waters of Europe, radio beacons transmit continuously on a number of different channels within the allotted frequency band. A world wide system was set up as a network of chains with the transmitters in each chain transmitting sequentially for 1 minute in every 6 minutes. This was published in the Admiraly list of Radio Signals.

The U.S. Marine Radiobeacon System is typical of the development of radiobeacons. The US system first became operational with three transmitter sites and a handful of users in 1921 under the jurisdiction of the Lighthouse Service of the Department of Commerce. The system grew rapidly from the time of its inception. By 1939, when the Coast Guard assumed system responsibility, the number of transmitter sites had grown to 141 with an estimated 4,000 users. By January of 1982, the system consisted of 198 transmitter sites with an estimated 423,000 users, most of whom were pleasure boat owners.

Since the development of satellite-based positioning systems in the 1970s and ’80s, the early importance of radio beacons as an aid for marine navigators has largely ceased. However the transmitters have acquired a second important role in broadcasting corrections for improving the accuracy and integrity of the satellite systems using the IALA Differential GPS system (DGPS).

7. CONSOL

Developed in Germany by Dr. Ernst Kramar, working at Standard Elektrik Lorenz in 1938, the Sonne system is an example of a 'collapsed' hyperbolic system (see Loran) wherein the baseline between the transmitting aerials is made so short that the hyperbolae degenerate into radials at a very short distance and the system becomes a bearing system rather than a hyperbolic one.

During WWII, the British captured some Sonne charts and took them to Group Capt Dickie Richardson, who was the navigation officer for Coastal Command at Northwood. Capt Richardson then found a receiver and tuned in getting a good bearing on his location. He ordered the RAF map department to manufacture charts to British specifications. Dickie called the system CONSOL meaning "by the sun".

Sonne/Consol used three aerials spaced on a line 1.5 miles long, or about three wavelengths at the operating frequency of 300 kHz. An identical signal was fed to all three aerials but at one outer aerial, it was delayed by 90 degrees of phase while at the other outer aerial it is advanced by 90 degrees. Multiple lobes with deep nulls between them were produced by the interaction of the three aerials. By steadily changing the phase shift in the two outer aerials so that it interchanged every 30 seconds, these lobes were caused to sweep. They were also switched at a very much faster rate in synchronism with a Morse pattern of dots and dashes, the effect being that each lobe carried only either dots or dashes and was replaced by its complement over the 30 second period.

The navigator only needed an ordinary radio receiver tuneable to 300 kHz in order to use the system. He heard a series of dots slowly merging into a steady tone and then becoming a series of dashes (or dashes becoming dots). He simply had to count how many dots or dashes he could hear before the steady tone and then plot his position line on a suitably overprinted map. There were multiple ambiguities in the system since there was no inherent way of distinguishing between one lobe and another. At its narrowest each lobe was only about 7.5 degrees wide. They were resolved either by approximate knowledge of position or by taking a loop bearing on the station. For this purpose, a steady tone was transmitted for a few seconds before each sweep, from the central aerial only. One station did not provide a fix, of course, but it was a very useful system requiring little expertise to use and only simple equipment. In effect Consol operated like a radio compass and main application was for landfall. For Atlantic travellers, the combined use of Echo sounder to identify the 100 fathom continental shelf and a bearing from Consol provided an accurate position.

Consol had a range of up to 1,000 - 1,200 miles and an accuracy of bearing of around one-sixth of a degree (3 miles at 1,000 miles range). It used the principle of "collapsed hyperbolic" for operation. Consol suffered from all the usual propagation problems of these frequencies of night-time skywave and static. Station LEC located at Stavenger Norway and operating on 319 kHz, was the last Consol station to go off the air sometime after 1991.

8. LORAN-A

Loran (LOng RAange Navigation) is the first of the hyperbolic radio positioning systems. From the 1950s to 1990s there was a proliferation of hyperbolic navigation systems and of necessity, only the major systems are considered here.

Loran provided facilities whereby ships and aircraft derived their position at long distances. The system required at least three transmitting stations for each 'chain', and the observer used a special Loran receiver. A chain consisted of one master and two slave stations. Differences in the arrival time of pulses from a pair of stations was measured and displayed on the face of a cathode ray tube. Each fix required two observations and the operation normally took about five minutes. The readings were then transposed to a Loran lattice chart and position could be plotted. In some cases readings were referenced to special Loran tables. Because Loran-A signals were pulsed and not continuous transmissions, tremendous peak power levels could be achieved by a relatively small transmitter. The maximum reliable range for Loran-A was 700 miles by day and 1,400 miles at night.

The US Army Signal Corps Technical Committee, at a meeting on 1 October 1940, wrote a specification calling for a precision radio navigation system with an accuracy of at least 1000 feet at a range of 200 miles. This was adopted as 'Project 3 (or C)' by the Microwave Committee and initial orders for Loran A equipment were placed in December 1940. The first Loran-A pair on frequency 1.95 MHz was on the air permanently by June 1942 (Montauk Point, NY, and Fenwick Is, Del.), and by October there were additional stations along the Canadian east coast. The system became operational in early 1943, and late that year stations were established in Greenland, Iceland, the Faeroes and the Hebrides to complete the North Atlantic cover, some being operated by the Royal Navy. At the request of the RAF, another station was put into the Shetlands to cover Norway and coverage was extended to the Pacific. Loran-A had an average expected accuracy of 1 percent of the distance between the navigator and the stations and provided an easy-to-use, accurate navigational system required to remove the need for highly skilled celestial navigators and weather dependency.

Developments of Loran A as Loran-B at 2MHz and Loran-D for short range high accuracy applications did not result in widespread deployment.

9. LORAN-C

Loran-C, the successor to Loran-A, was originally developed to provide US Navy radionavigation service for U.S. coastal waters.

The driver for Loran-C was the need for greater range than provided by Loran-A. Loran-C operates in the 90 to 110 kHz band providing greater range, uses pulse-time and phase-difference as its operating principle and the day/night range is 1200/2400 NM typical. Loran-C provides better than 0.25 nautical mile (460 meters) absolute accuracy for suitably equipped users within the published areas.

In 1946, the Sperry company proposed a navigation system called Cyclan which would use phase comparison and operate at two frequencies of 180 and 200 kHz, the difference between them being used to resolve ambiguities. It was tested by the USAF in 1948 using 160 and 180 kHz and later reduced to one frequency and renamed Cytac for possible use as a military tactical navaid. The project eventually did not proceed until the US Navy resurrected it in 1956. Tests showed a daytime ground wave range of 2,250 miles, nighttime ground wave of 1,650 miles and skywaves out to 3,000 miles. Time difference accuracy was estimated at 0.15 microseconds. Loran-C was born. Transmitters were installed to provide US coastal coverage and coverage was later expanded to include complete coverage of the continental U.S. as well as most of Alaska.

The US Navy established transmitters in the north-eastern Atlantic and the Mediterranean during 1957, followed by many others in the Pacific and elsewhere. In the Far East, the Chayka system equivalent to the Loran-C system was established.

While the accuracy of Loran-C was a few hundred meters, it was prized by fishermen for its repeatable accuracy- users could return to previously determined positions with an accuracy of 18 to 90 meters using Loran-C in the time difference repeatable mode.

New technology has allowed automation of the stations, mainly in Europe. The application of new receiver technology has improved the usability of the system. A majority of the 1.3 million Loran sets in use worldwide are for mariners. Loran-C was greatly appreciated by the US general aviation community with some 80,000 aircraft equipped with the system.

In recent years, receiver technology has driven the development of enhanced Loran (eLoran), in which the same transmitters are used but the receiver measures distance to the transmitter in the same way as GPS receivers and thus making the system more resilient. Absolute accuracies of 8-20 meters using eLoran for harbour entrance and approach are possible. eLoran can function as an independent, highly accurate source of Universal Time Coordinated (UTC). The development of the Navstar GPS has relegated Loran to near obsolescence. However GPS is vulnerable to interference because of the very weak signals received from satellites and eLoran is seen by many as a viable complementary system to provide position, navigation and timing signals in the event of GPS outage or interference. Users can anticipate integrated eLoran/GNSS receivers in the near future for a variety of applications.

10. DECCA NAVIGATOR

The Decca Navigator system found its origins in the United States but was later developed into an operational system by Decca Radio and Television Ltd. of London. Originally it was conceived by an American, Bill J O'Brien between 1936 and 1939 as a method of measuring the ground speed of aircraft undergoing trials and was simply named ‘Aircraft Position Indicator'. With no interest in the USA, O’Brien offered the idea to the British Air Ministry at the outbreak of the war through his friend H. F. Schwarz, an American working in London for the Decca Record Company.

O'Brien and Schwarz, with support from Decca, then tested a prototype system in California using a master transmitter at 300 kHz and a slave at 600 kHz. Comparison was made at 1200 kHz and the accuracy of the system was demonstrated in a car. It proved the basic viability of the system and was a major departure from earlier proposals by using harmonically related radio frequencies for transmission. This solved the problems of identification and phase comparison at the lowest common multiple of the carrier waves without needing any sort of modulation. It was a neat solution and had the additional advantages of occupying a very narrow bandwidth and only using low power for the transmissions. It did not however, eliminate the problem of "ambiguity" or lane slip. Although Gee, used widely by the RAF, and Decca were similar in broad principles only, Decca was more accurate than Gee and in modern parlance, more 'user-friendly' because the results were presented directly on clock dials called "decometers" instead of a cathode ray tube as was done in Gee. Decca was first used in the 1944 Normandy landing.

In 1945, the Decca Navigator Co, Ltd was formed and the first commercial chain of stations established in south-east England in 1946. The problems of ambiguity were never far away and a system of lane identification was introduced in 1947 which was still only a partial solution and did not completely resolve matters. It was not until the mid-1950's and the introduction of the ' Multipulse' technique that reliable lane identification out to the same range as the basic pattern almost completely removed ambiguities.

In the 1960's, a very considerable effort was mounted by Decca to get it adopted by ICAO as the standard airborne navaid in preference to VOR/DME. It was a very serious initiative which even included setting up special chains in the USA at Decca's expense, but the considerable investment already made in VOR/DME, the technical problems of ambiguity and precipitation static interference, both worse for aircraft than for ships, counted against it, and there was also the fact that, with a reliable range of about 200 miles, a single Decca chain needing four transmitters covered little more area than a single VOR/DME installation.

When the service first became commercially available, users would rent a receiver from the Decca Navigator company. In 1973, the factory near Raynes Park in South West London turned out one marine receiver every hour. By the early 1980s the widespread availability of low cost microprocessors made inexpensive Decca receivers available for purchase. The loss of rental revenue caused Racal Electronics, which by then had acquired Decca Navigator, to inform the Government that it could no longer afford to operate the system without financial support. From then onwards, the Decca Navigator Service was funded by the UK and Ireland General Lighthouse Authority (GLA) and Racal continued to operate it on the Authority's behalf. In 1992 an agreement was signed between the GLA and Racal-Decca Marine Navigation Ltd that the 18 Decca stations that had not already been modernized would be updated to reduce operating costs. This multi-million pound investment was completed by Racal in June 1994 by which time the entire system had been fully automated. Large buildings filled with tube technology transmitter equipment built in the 1960's were replaced by automated solid state units housed in small transportable containers. A new Supercontrol centre was opened in Edinburgh from which the entire UK Decca system could be monitored. Staff numbers were reduced from 64 to 19 and running costs were reduced by 40 per cent.

Decca Navigator was used throughout the world. At its peak there were chains in all of the principal shipping areas of the world and an estimated 200,000 Decca users in Europe alone.

Despite the system operating within its reduced budget and successfully maintaining Decca Navigator's 99.95 per cent performance reliability, the writing was on the wall for the service. The advent of GPS navigation satellites slowly made the service superfluous. During 1999, the GLA announced the final shutdown of the service at midnight 31st March 2000 following over 50 years of successful operation.

11. PULSE-8

Pulse-8, also known as AccuFix, became Decca Survey's name for their short-range Loran-C system. It was designed for offshore survey and had a design range of only 300 miles although it got out much further than that. There were eight transmitters around the North Sea alone in the late 1970's and many others abroad, and it was in use during the 1970's through to the mid/late ‘90's.

It operated in the low frequency band, and radiated a pulse transmission very similar to Loran-C. It was a hyperbolic system using time-of-flight techniques, with station identification by means of pulse pattern recognition and PRI timings.

The transmitting equipment was manufactured by Megapulse Inc. and used an unusual technique of magnetic compression. Large value capacitors were charged up and at set times their energy was released into L-C transformer networks in a set manner and through to the antenna matching coil.

The first receiver used in 1976 by the then Decca Survey was produced by Internav, called the S501, was large and heavy. This could be set to receive three ranges and to display any two of them at one time.

The next receiver to be deployed was the Mk4, designed in-house in Decca Survey it was smaller and lighter and better, it could display 3 range measurements continuously and give output data via several parallel ports.

The last widely used receiver was the Mk7, a tiny unit full of microprocessors and it was again a double unit. The unit could track up to 5 Ranges in each of two chains, display these and drive a track plotter.

12. OMEGA

John Alvin Pierce, the "Father of Omega," first proposed the use of continuous wave modulation of VLF signals for navigation purposes in the 1940's. Working at the Radiation Laboratory at the Massachusetts Institute of Technology, he proved the viability of measuring the phase difference of radio signals to compute a location solution. Pierce originally called this system RADUX. After experimenting with various frequencies, he settled on a phase stable, 10 kHz transmission in the 1950's. Thinking this frequency was the far end of the radio spectrum Pierce dubbed the transmission "Omega," for the last letter of the Greek alphabet.

The OMEGA radionavigation system, developed by the United States Navy for military aviation users, was approved for full implementation in 1968 and promised a true worldwide oceanic coverage capability and the ability to achieve a four mile accuracy when fixing a position. Initially, the system was to be used for navigating nuclear bombers across the North Pole to Russia. Later, it was found useful for submarines. The system was a long range system and evolved into a system used primarily by the civil community.

The system is comprised of eight continuous wave (CW) transmitting stations situated throughout the world operating in the 10kHz band and providing an accuracy of 2 to 4 NM. Omega achieved full eight station implementation in 1983 and was used by several airlines flying long range routes over water as well as by military forces. Towards the end of its service life, the Omega system was upgraded with new timing and control equipment. With the Global Positioning System (GPS) being declared fully operational, the use of OMEGA dwindled to a point where continued operation was not economically justified and OMEGA was shut down precisely at 0300Z on 30 September 1997 - the end of another era.

13. SURVEY SYSTEMS

A number of local hyperbolic type systems were developed for specific applications such as fishing and surveying. The following are a sample. Most have been superceded by GNSS, mainly GPS.

13.1 RANA

The Rana system was developed for fishing purposes on the French Atlantic coast. It was intended to provide a good repeatable accuracy and with no ambiguity in fishing areas, some hundred miles offshore, using cheap and reliable receiving equipment. The French chain covered the whole Bay of Biscay from Normandy to the Spanish coast. As with most hyperbolic systems, the advent of GPS spelled its end.

Rana is a medium frequency (283.5 – 415 kHz) hyperbolic radionavigation system using narrow band, low power signals. Each station transmits 10 CW timeshared signals on 10 frequencies and one permanent CW signal on a dedicated specific frequency. Position information is obtained by measuring the relative ephase difference between signals received from different transmitters. Accuracy is 350m with a repeatable accuracy of 50m and range of 400NM in daytime and 200NM at night.

13.2 TORAN

TORAN was a radio system for high accuracy survey and navigation developed in France. It allows mobile stations equipped with receivers, to determine their accurate location by means of hyperbolic coordinate patterns. Its principle is based on the measurement of the phase of an audio frequency beat, realised between two frequencies radiated by fixed transmitters. TORAN chains originated around the 1950s and was another casualty of the GPS era.

TORAN operates in the MF (300-3000 kHz) band providing long range at low atmospheric noise and providing an accuracy of 50m at 250NM in daytime and 120NM at night-time. High accuracy modern GPS renders the system unnecessary.

13.3 SYLEDIS

Syledis (SYstem LEgere pour mesure le DIStance) was a terrestrial radio navigation system designed for survey and hydrographic purposes. The system operated in the UHF segment of 420-450 MHz. Operational during the 1980s and until about 1995, it provided positioning and navigational support for the petroleum sector in the North Sea. The system provided accuracy of 1-3m at range of 2 to 3 times radio horizon distance – about 40NM.

Syledis uses time domain multiple access with long pulses transmission and phase shift modulation. Data auto-correction provides an effective increase in peak power, allowing a good trans-horizon coverage with a low or medium transmitter power of the order of 10 watt. The system was usually set up for a specific project and recovered on completion of the project. Use of the system declined in the 1990s.

13.4 DECCA HI-FIX

Decca Hi-Fix was operated by Decca Survey, of Leatherhead, Surrey in UK. A number of Hi-Fix Systems operated at about 1.9MHz and produced very distinctive signals in the 160 metre Amateur Band in the UK up until late 80’s.

Hi-Fix, as can be ascertained from the name was a high accuracy surveying tool and not intended for general navigation, and although permanent chains did exist, one being for navigation on the lower reaches of the River Thames and another for the North Sea, most were temporary and set up for a particular surveying exercise.

14. TRANSIT

The TRANSIT system, also known as NAVSAT (for Navy Navigation Satellite System), was the first satellite navigation system to be used operationally. The system was primarily used by the US Navy to provide accurate location information to ballistic missile submarines, and was also used as a general navigation system by the Navy, as well as hydrographic and geodetic surveying. It was also used for civilian general navigation s for marine users principally in the ocean phase.

The system was developed by the Johns Hopkins University Applied Physics Laboratory for the US Navy. Inspired by Doppler shift measurements from the Sputnik transmissions on 4 October 1957, development of the system began in 1958, and a prototype satellite, Transit 1A, was launched in September 1959. That satellite failed to reach orbit. A second satellite, Transit 1B, was successfully launched on 13th April 1960. The first successful tests of the system were made in 1960, and the system entered Naval service in 1964. The satellites (known as OSCAR or NOVA satellites) used in the system were placed in low polar orbits, at an altitude of about 600 nautical miles (1,100 km), with an orbital period of about 106 minutes. A constellation of five satellites was required to provide reasonable global coverage. While the system was operational, at least ten satellites – one spare for each satellite in the basic constellation – were usually kept in orbit.

The orbits of the TRANSIT satellites were chosen to cover the entire Earth, and their orbits crossed-over the poles and were "spread out" at the equator. Since only one was usually visible at any given time, fixes could be made only when one of the satellites was above the horizon. At the equator this delay between fixes could be up to several hours. At mid-latitudes the delay was more typically an hour or two. With later improvements, the system provided single-pass accuracy of roughly 200 meters, and also provided time synchronization to roughly 50 microseconds.

The TRANSIT system satellites broadcast two UHF carrier signals that provided precise time hacks (every two minutes), plus the satellite's six orbit elements and orbit perturbation variables. The orbit ephemeris and clock corrections were uploaded twice each day to each satellite from one of the four Navy tracking and injection stations. This broadcast information allowed a ground receiver to calculate the location of the satellite at any point in time. Use of two carriers permitted ground receivers to reduce navigation errors caused by ionospheric refraction. The critical information that allowed the receiver to compute location was a unique frequency curve caused by the Doppler effect. The Doppler effect caused an apparent compression of the carrier's wavelength as the satellite approached the receiver, and stretching of wavelengths as the satellite receded. The spacecraft travelled at about 17,000 mph, which could increase or decrease the received carrier signal by as much as 10 kHz. This shift in frequency and knowledge of the satellite position allowed calculation of position.

The TRANSIT system was made obsolete by the Global Positioning System, and ceased navigation service in 1996. After 1996, the satellites were kept in use as spaceborne 'mailboxes' and for the Navy's Ionospheric Monitoring System.

15. GPS

The NAVSTAR Global Positioning System (GPS) is a global navigation satellite system (GNSS) developed by the United States Department of Defence. It a worldwide GNSS and can be used freely by anyone, anywhere, and is often used by civilians in every facet of life for positioning, navigation and timing purposes. It uses a constellation of between 24 medium Earth orbit satellites that transmit precise radiowave signals, which allow GPS receivers to determine their current location, the time, and their velocity.

In 1972, the US Air Force Central Inertial Guidance Test Facility (Holloman AFB) conducted developmental flight tests of two prototype GPS receivers over White Sands Missile Range, using ground-based pseudo-satellites. In 1978 the first experimental Block-I GPS satellite was launched. By December 1993 the GPS achieved initial operational capability. By 17th January 1994 a complete constellation of 24 satellites was in orbit. Full Operational Capability was declared by NAVSTAR in April 1995. Satellites currently in service are Block IIA and Block IIR and IIR-M. Modernisation and satellite replacement is on-going on a system that is truly global and all encompassing.

The space segment comprises 24 orbiting GPS satellites or Space Vehicles (SV) in six planes with four satellites each. The flight paths of the satellites are tracked by ground segment monitoring stations around the world and the tracking information is sent to the Air Force Space Command's master control station at Schriever Air Force Base in Colorado Springs. The ground segment contacts each GPS satellite regularly with a navigational update to synchronize the atomic clocks on board the satellites to within a few nanoseconds of each other, and adjust the ephemeris of each satellite's internal orbital model.

A GPS receiver calculates its position by precisely timing the signals sent by at least four of the GPS satellites high above the Earth. Each satellite continually transmits messages containing the time the message was sent, precise orbital information (the ephemeris), and the general system health and rough orbits of all GPS satellites (the almanac). The receiver measures the transit time of each message and computes the distance to each satellite. Geometric trilateration (measurements from at least three satellites) is used to combine these distances with the location of the satellites to determine the receiver's location. The position is displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units also show derived information such as direction and speed, calculated from position changes.

When originally launched, GPS was deliberately degraded by using selective availability to produce an accuracy of 100m. SA was removed on 2nd May 2000 and GPS now provides an accuracy of 20m.

Since it became fully operational on April 27, 1995, GPS has become a widely used aid to navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance, and hobbies.

Also, the precise time reference is used in many applications including the scientific study of earthquakes and as a required time synchronization method for most forms of communications. In 2004, the United States Government signed an agreement with the European Community establishing cooperation related to GPS and Europe's planned Galileo system.

16. GLONASS

GLONASS (GLObal'naya NAvigatsionnaya Sputnikovaya Sistema; "GLObal NAvigation Satellite System" in English) is a radio-based satellite navigation system, developed by the former Soviet Union and now operated for the Russian government by the Russian Space Forces. It is an alternative and complementary to the United States' Global Positioning System (GPS), the Chinese COMPASS Navigation System, and the planned Galileo positioning system of the European Union (EU).

Development on the GLONASS began in 1976, with a goal of global coverage by 1991. Beginning on 12th October 1982, numerous rocket launches added satellites, initially Block I Uragan satellites, to the system until the constellation was completed in 1995. A fully operational GLONASS constellation consists of 24 satellites, with 21 used for transmitting signals and three for on-orbit spares, deployed in three orbital planes. The three orbital planes' ascending nodes are separated by 120° with each plane containing eight equally spaced satellites. In contrast to the single frequency GPS system, GLONASS uses different frequencies from each satellite.

The ground control segment of GLONASS is entirely located within former Soviet Union territory. The Ground Control Centre and Time Standards is located in Moscow and the telemetry and tracking stations are in Saint Petersburg, Ternopol, Eniseisk, Komsomolsk-na-Amure.

Following completion, the system rapidly fell into disrepair with the collapse of the Russian economy. Beginning in 2001, Russia committed to restoring the system, and in recent years has diversified, introducing the Indian government as a partner, and accelerated the program with a goal of restoring global coverage by 2009.

GLONASS was developed to provide real-time position and velocity determination, initially for use by the Soviet military for navigation and ballistic missile targeting. It was the Soviet Union's second generation satellite navigation system, improving on the Tsiklon system which required one to two hours of signal processing to calculate a location with high accuracy. By contrast, once a GLONASS receiver is tracking the satellite signals, a position fix is available instantly.

17. GALILEO

Named for the Italian astronomer Galileo Galilei, Galileo is a global navigation satellite system (GNSS) currently being built by the European Union (EU) and European Space Agency (ESA). The €3.4 billion project is an alternative and complementary to the U.S. Global Positioning System (GPS) and the Russian GLONASS. On 30th November 2007 the 27 EU transportation ministers involved reached an agreement that it should be operational by 2013. There is as strong body of opinion that 2015 is more likely.

Two satellites are in orbit. GIOVE-A is the first GIOVE (Galileo In-Orbit Validation Element) test satellite. It was launched on 28th December 2005. Operation of GIOVE-A ensured that Galileo meets the frequency-filing allocation and reservation requirements for the International Telecommunication Union (ITU), a process that was required to be complete by June 2006. GIOVE-B has a more advanced payload than GIOVE-A. It was successfully launched on 27th April 2008.

When in operation, it will have two ground operations centres, one near Munich, Germany, and another in Fucino, 130 km east of Rome, Italy. Since 18th May 2007, at the recommendation of Transport Commissioner Jacques Barrot, the EU took direct control of the Galileo project from the private sector group of eight companies called European Satellite Navigation Industries, which had abandoned this Galileo project in early 2007.

Galileo is intended to provide more precise measurements than available through current GPS or GLONASS (Galileo will be accurate down to the metre range) including the height (altitude) above sea level, and a better positioning services at high latitudes. The political aim is to provide an independent positioning system upon which European nations can rely even in times of war or political disagreement, since Russia or the USA could disable use of their national systems by others (through encryption).

Like the US GPS, use of basic (open) Galileo services will be free for everyone. However, more qualified services will be accessible with pecuniary or military restrictions.

18. DGPS

All GNSS suffer from an inherent integrity problem. If a satellite transmits incorrect information, the position output by the receiver can be seriously in error. Differential systems provide an integrity warning and accuracy improvement service that overcomes this problem.

Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount. The correction signal is typically broadcast on the medium wave radio frequencies between 285 kHz and 325 kHz originally used for radiobeacons and using the same transmitters in many cases.

A reference station calculates differential corrections for its own location and time. Users may be up to 200 nautical miles (370 km) from the station, however, and some of the compensated errors vary with space: specifically, satellite ephemeris errors and those introduced by ionospheric and tropospheric distortions. For this reason, the accuracy of DGPS decreases with distance from the reference station. The IALA Recommendation on the Performance and Monitoring of DGNSS Services in the Band 283.5–325 kHz cite the United States Department of Transportation's 1993 estimated error growth of 0.67 m per 100 km from the broadcast site but measurements of accuracy in Portugal suggest a degradation of just 0.22 m per 100 km.

DGPS is broadcast near major waterways and harbours where integrity and accuracy are essential. Co-ordinated by IALA DGPS systems were installed worldwide during the 1990s and remains in operation today.

19. SPACE BASED AUGMENTATION - EGNOS / WAAS / MSAT

Differential signals can also be transmitted from space and a number of such systems are in operation, principle of which are EGNOS, WAAS and MSAT. These systems are very similar and are interoperable, using Inmarsat satellites.

Using three geostationary satellites, the deployment of the European Geostationary Navigation Overlay Service (EGNOS) covers a large area and involves various countries and partner organisations. EGNOS is a project of the Tripartite Group whose members are ESA, the European Commission and Eurocontrol, the European organisation for the safety of air navigation.

The EGNOS signal is transmitted by three geostationary satellites: two Inmarsat-3 satellites, one over the eastern part of the Atlantic, the other over the Indian Ocean, and the ESA Artemis satellite above Africa. By correcting Global Positioning System (GPS) signals, EGNOS gives an accuracy of down to 2 metres, compared to the less accurate 15 to 20 metres provided by GPS alone. EGNOS achieves this through a network of ground elements installed throughout Europe. The elements that make up the EGNOS system include: Ranging and Integrity Monitoring Stations (RIMS) which pick up GPS signals, Master Control Centres (MCCs) to process the data delivered by the RIMS, and uplink stations which send the signal to three geostationary satellites to then relay it back to users on the ground. By 2007 EGNOS was fully deployed and in its pre-operational phase. The system will undergo certification for safety-of-life applications before becoming fully operational.

In the USA, the Wide Area Augmentation System (WAAS) is an air navigation aid developed by the Federal Aviation Administration to augment the Global Positioning System (GPS), with the goal of improving its accuracy, integrity, and availability. Essentially, WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches to any airport within its coverage area. WAAS uses a network of ground-based reference stations, in North America and Hawaii, to measure small variations in the GPS satellites' signals in the western hemisphere. Operation is similar to EGNOS. The WAAS specification requires it to provide a position accuracy of 7.6 meters or better (for both lateral and vertical measurements), at least 95% of the time. Actual performance measurements of system at specific locations have shown it typically provides better than 1.0 meters laterally and 1.5 meters vertically throughout most of the contiguous United States and large parts of Canada and Alaska. With these results, WAAS is capable of achieving the required Category I precision approach accuracy of 16 m laterally and 4.0 m vertically.

The original two WAAS satellites, named Pacific Ocean Region (POR) and Atlantic Ocean Region-West (AOR-W), were leased space on Inmarsat III satellites. These satellites ceased WAAS transmissions on 31 July 2007. With the end of the Inmarsat lease approaching, two new satellites (Galaxy 15 and Anik F1R) were launched in late 2005. Galaxy 15 is a PanAmSat, and Anik F1R is a Telesat. As with the previous satellites, these are leased services under the FAA's Geostationary Satellite Communications Control Segment contract with Lockheed Martin for WAAS geostationary satellite leased services, who is contracted to provide up to three satellites through the year 2016. Since 23rd September 2008, the ranging data that Galaxy 15 and Anik F1R transmit have been flagged as "Precision Approach."

With initial satellite launch in 1995, MSAT, short for Mobile Satellite, is a satellite-based mobile telephony service developed by the National Research Council of Canada. Supported by a number of companies in the US and Canada, MSAT hosts a number of services, including the broadcast of DGPS signals. The MSAT satellites were built by Hughes (now owned by Boeing) with a 3 kilowatt solar array power capacity, sufficient fuel for a design life of twelve years. TMI of Canada referred to its MSAT satellite as MSAT-1, while American Mobile Satellite Consortium (now SkyTerra) referred to its MSAT as AMSC-1, with each satellite providing backup for the other. On 11th January 2006, Mobile Satellite Ventures (MSVLP) (now SkyTerra) announced plans to launch a new generation of satellites (in a 3 satellite configuration) to replace the MSAT satellites by 2010.

20. AUTOMATIC IDENTIFICATION SYSTEMS (AIS)

Automatic Identification System (AIS) is a system that makes it possible to monitor ships from other ships, and from shore based stations. AIS equipped ships continuously transmit a short message on 161.975 MHz or 162.025 MHz containing information of position, course over ground (COG), speed over ground (SOG), gyro course (heading), etc. Ships equipped with AIS meeting anywhere on earth will be able to identify and track each other without being dependent of shore stations.

Shore stations receive the same information from AIS equipped ships within the VHF area of the station when monitoring the coastal areas and the ports. The AIS uses a broadcast and interrogation technology that operates ship-to-ship and ship-to-shore including limited communication capabilities.

AIS includes an AtoN message in which the position and station identification are broadcast. Additional information such as the status of other AtoN on a lighthouse or buoy can be broadcast as well as information about tide, wave and wind conditions. Overlaid on an electronic chart, AIS provides a total picture of the sea, land and surrounding vessels on a single chart with position accurate to a few metres – a truly awesome integration of all available information into a single display. The performance of these systems is now such that there is a growing fear that bridge crew will forget to look out the bridge window.

The mandatory fitting of AIS to new SOLAS vessels came into effect from 1st July 2002. This extended to tankers, passenger vessels and other SOLAS vessels in stages over the following few years.

21. HERITAGE DISPLAYS

None of us are getting any younger and AtoN systems are no different. As anyone who has visited a lighthouse museum will testify, it is important to retain examples of our heritage for future generations. Systems light structures and lights are relatively easy to display as their purpose and function are obvious. However, radio systems are just “black boxes” and their functioning is not clear.

Some imagination is therefore required to exhibit radio systems in museums. Animated displays using computer systems or models alongside the exhibit are far more effective than wall boards full of “dull” reading.

Local automatic audio explanations can also be helpful but language difficulties can arise. Powerpoint displays with overlaid audio explanation can be particularly effective if kept short and focused. Computer control laser pointers that highlight particular parts of a display add immediate interest and focus. The essential point is to inform the visitor of the function and operation of the system or unit within less than a minute with minimal effort on the part of the visitor. And make it enjoyable.

22. CONCLUSION

Over the space of a single century, radio systems have evolved from simple communications systems, using Morse to the fully integrated displays of AIS, in which all information about the ships position and its surroundings is presented on a single display with accuracy of a few metres. With such a rate of evolution, one cannot imagine what the next one hundred years will bring.

ANNEX 9 Heritage conflicts between traditional and LED lenses and other aspects, Knut Baar Kristoffersen, Kystverket, Norway

1. INTRODUCTION

I am asked to say something about the conflicts between traditional lenses and LED-lenses, as well as discuss other aspects concerning heritage according to lighthouses and other aids to navigation. First I will give you a short introduction of the status and some facts about Norway. So my contribution will contain these four parts: (2.slides)

If we take a look at the map (3.slides) you can see Norway in the very north of Europe. The country is not so big and the population is low, but the coastline is (as you can see) extremely long. The total distance that belongs to the coastline is about 83.000 kilometres, including the islands and fjords – that means more than twice the distance around equator. To imagine the size we can (as a virtual experiment) turn the country up side down, and then, ironically, we touch down in Santander. (4.slides)

A multitude of fjords and unpredictable archipelagos represent hazards and making voyages along the coast challenging and difficult. Nevertheless (5.slide), the majority of the population has always lived by the coast, and therefore most of the nation's wealth and industry has been created and based there, not least through the fisheries. The sea was the most important transport artery for both goods and people, and provided the main means of trading with other counties. Moreover, the fairways along the coast linked Norway together.

For the sake of the population living on the coast, as well as to enable Norway to develop as an independent nation, it was essential to improve the maritime infrastructure. The lighthouses and other aids to navigation provided opportunities and safety for a significant increase in shipping, and hence more trade between different parts of the long stretched country as well as with other nations. And these enable Norway to break out of the unions with Denmark and Sweden, and be an independent fishery and shipping nation. Therefore the maritime infrastructure has been and is an important part of the nation's heritage. (6.slide)

- There is built ca. 230 manned lighthouses;
- 154 of them have been in operation at the same time;
- Last lighthouse was de-manned in 2006;
- 83 lighthouses are listed according to The Act of Heritage.

The listed lighthouses shall be taken care of in an authentic way. And the Government has concluded that the lighthouses shall be own by us as (the lighthouse authority) and opened and accessible for the public as far as possible, based at long term leasing contracts with local authorities or Non-Governmental Organisations. Today about seventy-five 75 lighthouses are available for visitors in different kinds of alternative use. Alternative use is the best way to take the heritage responsibility.

2. TRADITIONAL LENSES Vs LED-LENSES

But at the same time that we are imposed to take care of the heritage of lighthouses and open those for the public, most of the lighthouses are still in operation, and that can often involve different conflicts and problems and now we are finely close to the key items for this presentation.

When new technology is introduced it can be a challenge for the heritage aspect. For some years ago we started to established LED lenses. Most of them are not implemented at classical lighthouses, but we have some examples that are. Because of optical reasons we cannot put the LED-lens inside the traditional Fresnel lens.

(7.slide) Bøkfjord lighthouse (in the north-east of the country, close to the Russian border, this lighthouse was the last that was de-manned in Norway). At Bøkfjord lighthouse I think we handled too fast when we just throw out the traditional lens and replace the Led-lens like this (8.slide).

The critical issue in cases like that is how far the heritage resolution goes. Is it just the exterior that is protected by the heritage law or is the interior protected as well? Or maybe it is not clear if the lens is part of the exterior? In our heritage resolution it was not clear whether the traditional lens was protected by the heritage law. And we interpret another sentence in the law that seemingly served us; that was that the heritage protection should not be an obstacle to the origins function of the lighthouses. Therefore we act in good faith when we did that, and we did it in the same way a couple of other places.

While the work at Bøkfjord was going on, we created some documentary films about the history of lighthouses for television, in cooperation with Norway's biggest television company (NRK). When the documentary was broadcasted in prime time, lots of TV-visitors were indignant and angry, when they saw the old lens at Bøkfjord was striped down. Many people consider the lens as the heart of the lighthouses. The Norwegian Lighthouse society contacted the Heritage authority, and the Heritage authority instructed us to re-allocate the old lenses. We didn't accept this decision immediately, because those particular lighthouses were extremely difficult to arrive and almost impossible to open for the sake of alternative use for the public.

After some discussions with the Heritage authority we agreed to let it be like this, on condition that we in the future made better solutions. As well as we promised that we always should contact and involve the Heritage authority in every case when considerable change or implementing of new technology is going to be introduced.

(9.slide) So when we once again did a new attempt to replace a LED-lens, we paid a visit at the Heritage authority and agreed about a solution at Utsira lighthouse at the south-west coast. Bay the way; this lighthouse was our case study in the EU's interreg program called Pharos, which was finished two years ago.

(10.slide) As you can see, we placed the LED-lens at the top of the tower, and did no interference at the traditional lens, other than turn off the electricity. The lighthouse society as well as local community (which is the smallest commune in Norway with about 200 citizens) was not happy with this solution. They missed the symbol that the rotating sweep from the traditional lens represented. But the old technology is potential intact and as a compromise we agreed to let them see the old sweeping light some few times a year.

(11.slide) I think a discussion about the necessity of replacing LED-lenses like this is needed. Maybe it is better to establish the the LED-lantern at another location. In what degree the classical lighthouses shall operate in the traditional way has to be a discussion too. Any way I think we obviously have to save a number of them into traditional operation, if we are going to take our heritage responsibility seriously. At least the lighthouses that are most visited.

3. OTHER ASPECTS CONCERNING HERITAGE OF LIGHTHOUSES

3.1 Environment and surroundings

(12.slide) There are of course many other aspects concerning heritage we have to act in accordance with, for example when new alternative use is going to be established at a de-manned lighthouse, there will often be needs and desires concerning reconstructions and expansion of the number of buildings at the lighthouse area. There can be turn on changing frontage, new interior floor plan, solutions for fire safety, information centre and sanitary conditions etc. In some cases it can be of interest to construct new buildings in order to satisfy visitors and tourists. In such instance there will often be restrictions regarded to the preservation regulations linked to the lighthouses, as well as the environment and surroundings. Many lighthouses are located at surroundings that are protected for the reason landscape, environment and animal / birds life. Therefore we have to seek solutions that are as discreet as possible and incorporated into the existing buildings or the whole area, in a way that the interventions don't represent any obstacles. I will give you some bad and good examples from Norway.

3.2 Kvassheim lighthouse – bad example

(13.slide) Kvassheim lighthouse is located at the south-west coast. Originally it was a small third order lighthouse with the light integrated in the top of a three floor wooden building. Now the light is replaced a hundreds meters outside the lighthouse area. (14.slide) The lighthouse is not in our ownership any more, and the new owners have done unacceptable changes (15.slide) at the frontage as well as made an annex that doesn't fit the rest of the buildings. The lighthouse is not listed, but still we as Lighthouse authority never would give permission to this kind of changes.

3.3 Lindesnes lighthouse – good example

(17.slide) Some of you were at a similar IALA workshop nine years ago at Lindesnes in Norway. That was some years before we got a break through in according to our heritage effort. Since the workshop in 2000, lots of things have occurred in the matter of heritage. Lindesnes has been an official Lighthouse museum and the infrastructure facilities at the lighthouse have been developed in very good way, and are an example of best practice of how to do changes discreet on the heritage premises. The lighthouse area looks quite similar as it did before, but if we look closer lots of things are changed without big intervention at the buildings or the surroundings. The place is now equipped with different kinds of facilities, I will show you some pictures:

(18.slide) The tower (unchanged), accommodation, office and administration

(19.slide) Public centre, museum shop, WC

(20.slide) Rock/ stone hall (outside)

(21.slide) Rock/ stone hall (inside I): Cafe, gallery,

(22.slide) Rock/ stone hall (inside II): Auditorium for 200, exhibition rooms

(23.slide) Over all photo

Lindesnes is the best and largest example of alternative use in Norway, but Lindesnes has been an inspiration for other cases, and as a National lighthouse museum they bring their experience and knowledge into other project. And we have many other interesting projects around the coastline. I will give one more example - a case that is in the planning stage.

3.4 Alnes lighthouse – example for the future

(24.slide) Alnes lighthouse at the vest coast is a listed lighthouse located in an area that the landscape is preserved and regulated for building. One of Norway's most famous painters – Ørnulf Opdahl - has his gallery at Alnes. To day his paintings are located in the tower, but we plan to build a public art centre and gallery into the ground like this (25.-28.slides).

4. STORYTELLING AND HISTORY

(29.slide) When I in the introduction spent some time to figure out the situation of the history of lighthouses in Norway, some of you may be considering that as outside the key items of this presentation. But history and storytelling are important aspect of the heritage work according to lighthouses. As I mention, the history of lighthouses is a considerable part of the developing of our Nation – I am sure there is similar condition in other nations too.

Often at IALA committee meetings we hear that there are problems to carry out heritage projects because of the lack of money and recourses. It seems that it is too expensive to take heritage responsibility. But I will put it in the opposite direction. It is expensive to NOT put the effort on heritage. If we succeed to take heritage responsibility, that may be a benefit to the ordinary conduct of maritime infrastructure. In Norway we have experienced that it is so.

We have tried to put some extra effort to the maritime heritage field in Norway and during the last few years we have changed the condition of maritime heritage in general and for the lighthouses especially. Through offer adventures at alternative use, as well as spread of knowledge through museums, books and all kind of media we have succeed to reach the wide public. That has maid us to a public corporation that people in general know better, relying on and is engaged in. And remember, what people in general is engaged in, is mostly the same that the politicians and decision-making bodies are engaged in. One reason that lighthouse authority and lighthouse service has got increasing budgets the last years is a result of our priority of heritage and focus on history. The best way to argue to get more resources to develop new technology is to convince how important navigation had been through the history. What I am trying to say is that there is profitable to spend money at heritage. There is no real conflict between heritage and modern technology; there can be a win-win situation.

I could give you many examples, but I confine myself to mention one thing brand new date. During the proceeding financial crisis, the Government has this spring displayed a retrenchment package. In competition with many other good initiatives, several millions were earmarked for preservation of lighthouses. That happened in addition to an already increased economy to the sake of heritage of lighthouses.

5. CONCLUSIONS

- Keep lighthouses in authority ownership as far as possible;
- Co-operate with other bodies about alternative uses for the public;
- Involve the Heritage Authority in all significant changes;
- Adjust development in accordance with the environment and surroundings;
- Document the (inter)national and local history of a lighthouse and disseminate it via museums, books and media;
- Think holistically; there is a win-win situation between heritage and modern technology.

ANNEX 10 Instituto de Estudios Torre de Hércules: 7 años de compromiso para el reconocimiento de bien patrimonio de la Humanidad

1. SLIDE 1

Torre de Hércules Institute. Seven years of compromise to be recognized as World Heritage

2. SLIDE 2 - HERCULES TOWER

From its construction by the Romans, Hercules Tower lighthouse was a memorial worthy of mention. So collected chronicles and Roman sources until later today.

Your singularity made that the tower were transformed in the symbol of La Coruña city. It was assumed for all the neighbours and institutions.

Now, the oldest lighthouse in the world still in operation, which lit with its presence or its light to thousands of peoples in the hundreds of years of its life, aspire to be recognize as Lighthouse and World Heritage at the same time

3. SLIDE 3 - HERCULES TOWER INSTITUTE. 7 YEARS OF COMPROMISE

In September 2001, a group of friends, led by Dr. Vázquez Iglesias, sensible to the defence of the historical legacy of the Hercules Tower make to themselves the purpose to organize a strong, solid and consistent project in order to present the candidature of the UNESCO world heritage.

It also decided to organize them to secure the claim.

Born Institute for Studies Torre de Hércules (IETH) as a body that brings together various professionals, very easy to build and very agile for achieving the objectives

4. SLIDE 4 - MOBILIZATION OF CONSCIENCES

They participate in many debates, mobilizing consciences and highlighting the historical importance of the monument

The public opinion describe them as "visionary" and the official authorities at this time gave little credit to their intentions (they were only 62 people and without external funding)

5. SLIDE 5 - AND…THE JOURNEY BEGINS

They organized social events involving the Coruña society: Examples: a) a cantata (a composition of classical music) on the Hercules Tower; a running around the tower; a fashion show called “Footbridge Hercules Tower " and a constant presence in newspapers, radio and TV.

Later on, a meeting is arranged for joining the Tower of Hercules with the park of the Statue of Liberty in New York as brothers, the only cultural institution that has that range.

And they connect with other cities that host monuments declared World Heritage Sites to give knowledge of their intentions and to learn from their experiences.

6. SLIDE 6 - ORGANIZATION STEPS

Since 2002 they proceeded to draft a comprehensive historical study, about heritage, maritime buoyage and shipping that is their memory-base. The process ends in 2005 and the dossier weighs a total of fifteen (15) kilos.

They handed to the Mayor of the city. After to the Ministry of Culture of the Xunta de Galicia (Regional Government).

At the end of 2006 they learn that UNESCO will open the time of admission to new requests.

A period of hope is beginning

7. SLIDE 7 - THE WAY TO BE RECOGNIZED

They redouble their efforts and impulses. When Mr. Cesar Antonio Molina is appointed to Minister of Culture, the light its opened.

They send the dossier to the deputy director of the Ministry of Culture.

They stopped to be considered as "visionary“. They were increasingly convinced, and then… they have the support of the minister.

In September 2007 they get that the Spanish Government submitted the dossier to UNESCO

The third phase is begining

8. SLIDE 8 WE ARE JUST INTO THE “CULTURE WORLD LEAGUE

.The final sprint begins. But they are not experts in international marketing, nor specialists in boost "brands.“

They are mobilizing consciences, stirring emotions, revulsive commitments and, in short , winners of alliances

9. SLIDE 9 - THE CRITERIA FOR SELECTION

10. SLIDE 10 - JUSTIFICATION OF THE HERCULES TOWER LIGHTHOUSE

It’s a Roman lighthouse still in operation maintaining its primary function as aid to navigation. Of the other two in the world, Dover lighthouse and the Libyan Leptis Magra lighthouse, only its ruins remain.

Hercules Tower Lighthouse retains its functionality, and at the same time, the concern for its constant maintenance is notorious.

It’s a signed lighthouse. On foot of the HerculesTower an inscription which denotes the importance of the monument has been found. Among the historic lighthouses, only lighthouse of Alexandria is signed.

Its location is unique. Located on a promontory, with difficult communication, but in a basic navigation point, despite being located away from areas of richness.

11. SLIDE 11

On Saturday, this Saturday we expect the verdict.

But we know that all who have sailed, who have used their signals at sea, the art scholars, the readers of the history, the pilgrims, the migrants, the immigrants, ... all want to succeed of a historical legacy transmitted from generation to generation, which serves as a message of solidarity and that the society take care of it and show it with pride.

12. SLIDE 12

Thank you so much for your attention.

ANNEX 11 The role of Heritage Authorities, Jo van der Eynden, Norwegian Lighthouse Museum, Norway

1. INTRODUCTION

First of all let me thank, and congratulate IALA and the local organisers with a splendid seminar both in regards to physical environment, professional content, and the social and cultural context.

Many important topics have been covered by competent colleagues, such as:

- Maintenance and the consequences of de-manning on building conditioning and management
- Alternative use and additional use of buildings
- Questions regarding traditional lenses and modern light sources
- And now: The documentation process

And all this in relation to the main topic:

The impact of technological modernisation to the protection and conservation of historical lighthouses and other aids to navigation.

I have been asked to say something about the role of the Heritage Authorities in this context. Although I have been placed in the documentation session, I will take the liberty of speaking in a wider and more general perspective. I will try to say something about why we protect and preserve historical monuments, buildings and artefacts. And why, in particular, it is important and necessary to preserve our lighthouse heritage.

My main focus will not be on the buildings as such, but rather on the challenges and dilemmas we are faced with, when a decision to preserve a historical building has been made, i.e. the dilemma of preservation in relation to maintaining a functional use. And here I will mainly concentrate on the questions and challenges related to old lenses and the introduction of the new LED-light technology.

Finally I will try to relate this to the concept and methods of documentation, as understood by museums and heritage authorities, before Christian Lagerwall will present more specific examples of documentations on lighthouses in Sweden.

2. MUSEUMS AND HERITAGE AUTHORITIES

As I mentioned: I now work with the Norwegian Lighthouse Museum, and I have to say a few words about what we are and how we work.

In Norway, every governmental body has an obligation to document and preserve important aspects of their own history. This means:

- Keeping historical archives;
- Documenting main historical developments/achievements;
- Preserving important historical buildings, equipment etc.

From 2008 the Norwegian Lighthouse Museum was formally established as a governmental museum, financed by the Department of Coastal Affairs. It is organised as a network with 4 co-operating museums that together shall cower the whole country and the whole range of the governmental activities and responsibilities concerning lighthouses and other aids to navigation, the pilot service, the harbour developments and the present day traffic surveillance. The 4 museums shall provide the National Coastal Administration and the general public with competence, know-how and facilities to enable us to document, preserve and present important aspects of the national maritime infrastructure to future generations.

I have been asked to talk about the role of the heritage authorities, but I work with museums. In Norway, and I think in most countries the role and the focus of the two are slightly different. World-wide, the functions of the museums are:

- Preservation of historical objects and artefacts;
- Documentation: To collect information (written, spoken, drawn, photographed…);
- Research (scientific investigation to produce new knowledge);
- To present/mediate historical information to the public. (Accessibility, education, enjoyment).

Heritage authorities work within the same field, but their role are somewhat more specific:

Their focus is more on the physical object/building/environment. Which buildings and sites should be preserved as monuments and protected by heritage laws? And how should they best be conserved and used for public enjoyment?

Once a building or site is protected by heritage laws, it is up to the heritage authorities to define what must be done to conserve it in a best possible way, what alterations or modernisations that can be accepted to enable alternative or additional use and so on.

Sometimes, in some countries the heritage authorities also has money to share with the owners of protected monuments and site.

Usually an extensive documentation of both the building and its function is required before it is listed as a historical monument. This documentation forms the base for all the decisions that has to be made after it is listed, also the later use.

- The construction of the building (materials etc.);
- The technical condition of the building (what has to be done?);
- The history of the building (plans, drawings, earlier alterations etc.);
- The use of the building (social, cultural content – representation);
- An evaluation of the importance and qualities of the building in an broader context;
- A feasibility study for the future use of the building.

Ultimately, one might say that the role and challenges of the heritage authorities is impossible:

To stop the time, prevent changes and stop all physical decay and deterioration.

In the practical world, this always calls for compromises.

3. SO WHY PRESERVE ANYTHING AT ALL (AND LIGHTHOUSES IN PARTICULAR)?

Change is inevitable. More than anything else, history is a study of changes through time: Technically, economically, socially and culturally.

The value and importance of history and heritage is that it can enable us to understand those changes, and thereby to understand ourselves and our environment today (how it came about).

The historical perspective is important when we shall define who we are, both as individuals and as communities/societies. And to a large extent – this is a choice (personally and politically). Who we are is therefore partly defined by what we choose to preserve from the past. What we define as being important enough to protect from deterioration. This is called historical identification.

Today the concept of “globalisation” is often presented as something new and modern. It is “hip” and threatening at the same time – almost like Columbus must have felt when he set out for China and hit America on the way. Everybody working with maritime history knows that "globalisation" is a process going way back through the ages.

- The Romans imported tons of pepper from India more than two thousand years ago.
- The tower of Alexandria was erected to guide mariners from the Mediterranean to this important harbour, where goods from the Orient were exchanged for European valuables.
- Maritime trade has been an important part of the history and economic development of more or less every coastal nation all over the world for thousands of years. (We don't know quite how they managed, but we know they did! i.e. Vikings to Vinland more than a thousand years ago. The spice-race starting in the 15th Century. The trade route between the North Sea and the Baltic – with more than 50,000 ships in the Skagerrak every year (1875)).
- To safeguard and guide all those ships, men and values have been an important, challenging and expensive enterprise the world over.
- Today, most historical ships have sunk, rotted and rusted. Only a few "lost and lonely ones" have been preserved by museums and stubborn people, and a few replicas have been built.
- Historical harbours have been developed and moved according to changing needs and new markets.
- But a lot of lighthouses, beacons and other aids to navigation are still standing (or floating), and they are even still functioning. Some of these installations bear and represent an essential part of our maritime history. They should be viewed, treated and respected as important monuments of local, regional, national and global heritage. In other words: They should be protected according to their historical significance.

I believe we all would like that – but the next question is: How do we do it?

4. THE IMPACT OF TECHNOLOGICAL MODERNISATION ON THE PRESERVATION OF HISTORIC LIGHTHOUSES

(Lindesnes lights)

Technological development has been a continuous process through the history of navigation. This is also the case with lighthouses. The driving force of change and modernisation has been to maximise safety and to cut running costs.

In most countries the question of preservation of lighthouses has been triggered by the automation and de-manning of the stations. In this process, lighthouse authorities all over the world were left with a lot of redundant buildings, and naturally had to face the question of what to do with them: preserve, sell or demolish.

They also had to face the fact that a lot of different stakeholders had strong opinions of what the lighthouse authorities should do. In many countries it soon became clear that most of the lighthouses had such a strong symbolic, cultural and social value that demolition would be unthinkable. Most of the lighthouses are also situated in coastal environment that are attractive to the general public. So the idea of preservation by alternative or additional use was born.

From the point of view of the Heritage Authorities though, all kinds of alternative use has to be adapted to the demands and limits of preservation. The potential for alternative use is not in itself a reason for preservation. It should be looked upon as a means to achieve the goal of preserving lighthouse heritage.

In a way, you can say that the superior reason for preservation is documentation.

The reason why we want to preserve lighthouses is to document the heritage that these buildings and installations represent. They may have many different values and qualities, but it is their historical function and their role as mediators of maritime culture that is essential, when we want to preserve and protect them.

As a consequence of this, the best way of preserving a lighthouse is usually to preserve its function as an ATON.

When we worked with the national preservation plan for the lighthouses of Norway, three main guidelines were followed:

- Preferably whole stations should be preserved, not only single buildings or towers. This of course is because living quarters, store rooms and technical rooms form an important part of the social and technical documentation of lighthouse culture.
- Whenever possible, technical equipment should be preserved intact at the stations, for historical documentation, presentation and education of technical development.
- The preservation of the lighthouses should not prevent their future use as ATONs.

This sounds all very well, but still it confronts us with serious dilemmas when the functional use of the lighthouse is actually dependent upon modernisation and replacement of valuable historical equipment. As far as I can see, we have 4 options:

4.1 Remove the function (AtoN)

(Songvaar lighthouse)

At Songvaar Lighthouse in Norway, the ATON was moved out of the old lighthouse and placed in a new beacon. This was accepted by the Heritage Authorities, because Songvaar is not a listed lighthouse. The old lens was removed of security reasons and placed at the lighthouse museum at Lindesnes. After some time though, a local organisation got a long term lease-contract for the lighthouse, and they wanted to present some of the old lighthouse equipment to visitors. Therefore the lighthouse authorities and the museum agreed to move the lens back for display.

But in my mind – a lighthouse without a light is a self-contradiction. It’s like a cathedral without an altar. In general I think that too much focus been on the towers when we have been discussing preservation of lighthouses, and too little on the function and the technical heritage of lighthouses.

4.2 Remove the old equipment to give room for modernisation and the preservation of the function as an ATON

(Display of artefacts at Torungen Lighthouse)

This has been the traditional way of doing it. I it certainly not desirable from a preservation point of view, but safety demands, environmental considerations or even economical reasons may force us to accept such changes, even in a preserved lighthouse.

The demand from the heritage authorities, then, would usually be that the changes are as few and as minor as possible, that the replacement process is properly documented, and that the old equipment is stored or displayed in a proper way (not sold or demolished).

The documentation process should be systematic and as detailed as possible. It usually consists of description, measurements and photographs:

- Of the situation before starting;
- Of every object you remove;
- Of the replacements;
- And it should give information of what you have done with what was removed, and where to find it again.

Often we divide between reversible and irreversible changes in a historical building, and whenever possible one should try to find solutions that at least in principle are reversible.

As in the example with the replacement of lenses with LED-lights in Norway that has earlier been referred to by Knut Baar Kristoffersen, the arguments for finally accepting this change was two-sided:

- Safety-considerations made it preferable to place the LED-lanterns inside the lanterns in all three lighthouses;
- None of these lighthouses were accessible to the public. Only the seagulls would benefit from seeing the lenses.

If and when the question arises of removing lenses from lighthouses that are public attractions, and where the presentation of lighthouse technology is an important part of the lighthouse experience, then at least I would fight very hard to find other solutions.

4.3 Add new equipment but preserve the old in functional order

This is the preferable way to do it, when a change to new technology is demanded. And this was the compromise made at the Lighthouse at Utsira in Norway, shown by Knut Baar Kristoffersen.

But as he mentioned: Local people complained of losing the old lens-light. People identified with the rotating corona of light-beams. It had become part of their identity and the "genius loci" of the place and the community.

I never saw an economical calculation of how much was saved in running costs by changing to LED-light, but since the old lens-light was powered by cable electricity, perhaps it might have been possible to save it?

4.4 Preserve and use old equipment as long as it does not threaten maritime safety or the environment

This, of course is the preferred alternative, because it enables us to preserve and present the technology as an integrated part of the protected monument.

But it demands the will and obligation to protect, preserve and present, even though it costs a bit more, and may represent an inconvenience compared to more modern technology.