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XVIII Conference · A Coruña · Spain

25-31 May 2014

AIDS TO NAVIGATION KNOWLEDGE AND INNOVATION

From the Torre de Hercules to e-Navigation and beyond

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PROCEEDINGS

Aids to Navigation Provision

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AIDS TO NAVIGATION PROVISION

Aids to Navigation Provision

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SUMMARIES AND PROCEEDINGS

84 EFFECTIVE INTENSITY – IS IT EFFECTIVE?

Malcolm Nicholson. General Lighthouse Authorities, United Kingdom and Ireland

Since the invention of flashing signal lights, the question of how a flash of light compares with a continuous ('fixed' or 'steady') light has been pondered. The increase in intensity or efficiency, as a result of focussing or switching the light source, is offset by the fact that a flash of light is not seen so effectively by the observer due to the inertia of human visual perception.

The currently recommended method of quantifying the effects of a flashing light on human visual perception is a photometric quantity called effective intensity, which is the 'fixed light equivalent' of a flash of light. The definition of effective intensity intends the flash to be viewed at the threshold of visual perception, but that is not how marine aid to navigation (AtoN) lights are viewed. By international agreement, the range of marine AtoN lights is calculated from an observer illuminance above the threshold of perception. Therefore, the use of effective intensity is not valid for determining the range of a marine AtoN flashing light.

Experimental work carried out in the 1930s studied flashing lights above the threshold of visual perception (supra-threshold). Further scientific studies carried out in the 1930s and 1960s suggested modifying the Blondel-Rey model for effective intensity so that it could be used at supra-threshold levels by linking the value of illuminance at the observer to a time-constant for visual inertia (often known as a) in the equation for the Blondel-Rey model. Since the term 'effective intensity' is only valid at the threshold of visual perception, it is suggested that the term assigned to perception of a flash above threshold be 'apparent intensity'.

The use of apparent intensity should enable lighthouse authorities to model the effect of different flash profiles at levels of illuminance from 0.2 microlux (currently recommended for AtoN lights at night with no background lighting) to higher levels of illuminance. This is particularly pertinent for leading lights and lights with minor and substantial background lighting.

To that end the General Lighthouse Authorities of the United Kingdom have been collaborating with Leeds University to carry out a repeat of the original 1930s experiment of Toulmin-Smith & Green extending the scope of the experiment to higher levels of illuminance and looking for models with a better fit to the experimental data.

An assessment of the results will be given and the impact of moving to an apparent intensity model will be outlined and explained.

Desde la invención de las luces de señalización intermitentes se ha planteado la cuestión de cómo puede compararse un destello de luz con una luz continua («fija» o «constante»). El aumento de la intensidad o la eficiencia, como resultado de enfocar o cambiar la fuente de luz, queda compensado por el hecho de que un destello de luz no es visto de forma tan eficaz por el observador debido a la inercia de la percepción visual humana.

El método actualmente recomendado para cuantificar los efectos de una luz intermitente sobre la percepción visual humana es una cantidad fotométrica denominada intensidad efectiva, que es el «equivalente a la luz fija» de un destello de luz. La definición de intensidad efectiva pretende que el destello sea visto en el umbral de la percepción visual, pero así no es como se ven las luces marítimas de Ayudas a la Navegación (AtoN). Por acuerdo internacional, el alcance de las luces marítimas AtoN se calcula a partir de la iluminancia en un observador por encima del umbral de la percepción. Por lo tanto, el uso de intensidad efectiva no es válido para determinar el alcance de una luz marítima intermitente AtoN.

Trabajos experimentales realizados en la década de 1930 estudiaron las luces intermitentes por encima del umbral de la percepción visual (supraumbral). Otros estudios científicos llevados a cabo en las décadas de 1930 y 1960 sugirieron modificar el modelo Blondel-Rey para la intensidad efectiva de modo que pudiera utilizarse a niveles de supraumbral vinculando el valor de iluminancia en el observador a una constante temporal para la inercia visual (a menudo conocida como a) en la ecuación para el modelo Blondel-Rey. Dado que el término «intensidad

efectiva» solo es válido en el umbral de la percepción visual, se sugiere que el término asignado a la percepción de un destello por encima del umbral sea «intensidad aparente».
El uso de la intensidad aparente debe permitir a las autoridades de faros modelar el efecto de diferentes perfiles de destello a niveles de luminancia de 0,2 microluxes (actualmente recomendado para luces AtoN por la noche sin iluminación de fondo) a mayores niveles de luminancia. Esto es particularmente pertinente para luces de enfilación y luces con iluminación de fondo escasa y considerable.

Con esa finalidad, las Autoridades Generales de Faros del Reino Unido han estado colaborando con la Universidad de Leeds para repetir el experimento original de la década de 1930 de Toulmin-Smith y Green ampliando el alcance del experimento a mayores niveles de iluminancia y buscando modelos que se ajusten mejor a los datos experimentales.

Se proporcionará una evaluación de los resultados y se expondrá y explicará el impacto del cambio a un modelo de intensidad aparente.

Depuis l'invention des feux à éclats, la question se pose de savoir comment un feu à éclats est perçu par rapport à un feu fixe (ou continu). L'augmentation de l'intensité, ou de l'efficacité de la source lumineuse est annulée par le fait qu'un éclat de lumière n'est pas perçu de façon aussi efficace par l'observateur en raison de l'inertie de la perception visuelle humaine.

La méthode actuellement recommandée pour mesurer les effets des éclats sur la perception humaine du feu est une mesure photométrique, appelée intensité effective, est « l'équivalent d'un feu fixe » d'un éclat de lumière. La définition de l'intensité effective suppose que l'éclat est vu au seuil de la perception visuelle, ce qui n'est pas le cas de la perception du feu d'une aide à la navigation. Suite à un accord international, la portée des feux des aides est calculée pour un observateur au dessus du seuil de perception. Donc, l'intensité effective n'est pas valide pour déterminer la portée du feu à éclats d'une aide à la navigation.

Les expériences faites durant les années 1930 portaient sur des feux à éclats au dessus du seuil de perception (supra-seuil). Des études scientifiques faites dans les années 1930 et 1990 ont suggéré de modifier le modèle de Blondel-Rey pour l'intensité effective pour pouvoir être utilisé en supra-seuil en liant la valeur de la luminance à l'observateur à l'inertie visuelle à temps constant (souvent appelée a) dans l'équation du modèle de Blondel Rey. Puisque le terme « intensité effective » n'est valide qu'au seuil de perception, il est suggéré d'appeler la perception d'un éclat au-dessus du seuil de perception « intensité apparente ».

L'utilisation de l'intensité apparente devrait permettre aux services de signalisation maritime de modéliser les effets des différents profils des éclats à des niveaux de luminance de 0,2 microlux (actuellement recommandé pour les feux des aides à la navigation, de nuit, sur fond sombre) à plus niveaux hauts. Ceci est particulièrement pertinent pour les feux d'alignement et les feux vus sur fonds éclairés.

Pour ce faire, les « General Lighthouse Authorities of the United Kingdom », en collaboration avec l'Université de Leeds, a décidé de refaire les expériences de Toulmin-Smith & Green des années 1930 en en étendant le champ d'action à des luminances plus élevées et en cherchant des modèles mieux adaptés aux données expérimentales.

Une évaluation des résultats sera donnée et l'impact du passage à un modèle d'intensité apparente sera détaillé et expliqué.

Effective intensity – Is it effective?

Malcolm Nicholson

R&RNAV, General Lighthouse Authorities

UK & Ireland

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Malcolm Nicholson, R&RNAV, General Lighthouse Authorities, UK & Ireland

INTRODUCTION

In 2012, the Research and Radionavigation Directorate of the General Lighthouse Authorities implemented a project aimed at repeating the experiments of Toulmin-Smith and Green. The aim was to assess the usefulness of the successive brightness matching method for modelling the conspicuity of marine aid to navigation lights in order to quantify, and thereby improve, performance and efficiency.

Initial work was undertaken by Peter Rhodes of Leeds University in 2013 using an observer illuminance of 0.2 µlux. Results were compared with those of Toulmin-Smith and Green, who used 0.194 µlux, but there were distinct differences. Rhodes found that variations in the performance of his six observers were considerably greater than those of Toulmin-Smith and Green's two or three observers. Results also showed that, on average, Rhode's observers judged the brightness of flashes to be greater than did Toulmin-Smith and Green's observers.

THE ORIGINAL TS&G EXPERIMENT

The original experiments conducted by Toulmin-Smith and Green (1931a and 1931b) consisted of two phases. The first of these attempted to establish whether there was any difference between observations made with one or two eyes (Figure 1). From the outset it should be noted that there is a degree of ambiguity in their descriptions and also a lack of detailed raw data reported in their results.

The second phase used a clockwork-driven sector disc mechanism to generate a series of light pulses. The observer was able to alternate between flashing and steady light by pressing a key. The intensity of the flashing source was then manipulated by adjusting the position of a variable transmission wedge until a visual match was obtained. A block diagram (Figure 2) illustrates the main elements.

According to their results, TSG involved only a very limited number of observers (possibly as few as two or three) and many of their smooth curves which plot apparent intensity mask experimental noise. The mechanical set up as described would certainly lead to variations in timing and there was insufficient data to reach a conclusion over the typical variability of observers and the robustness of the conclusions.

REPEATING TS&G

Hardware

Due to the unique nature of this experiment, no off-the-shelf solution was available. With the assistance of Bentham Instruments, bespoke apparatus was designed to reproduce similar conditions to those used by TSG but using updated technology. A cross-sectional view of the resulting ILFD20QH unit is shown in **Figure 3**.

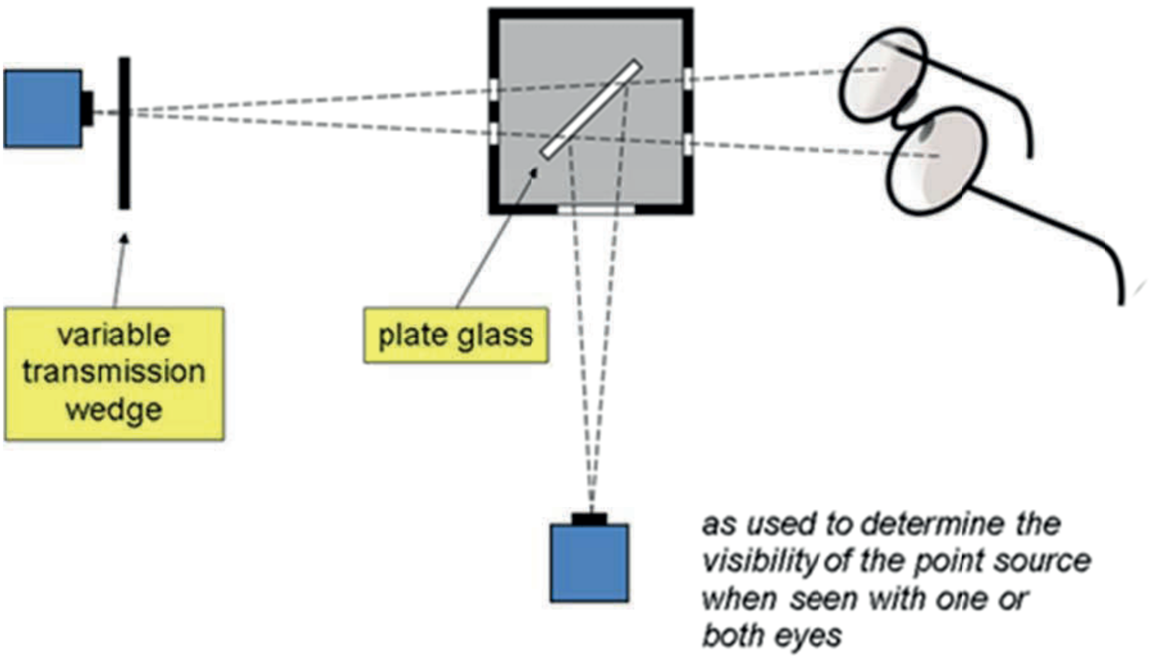


Figure 1: TSG experiment initial phase

Not shown here is the photopic matched photodiode at the surface of the integrating sphere which was used to measure light output.

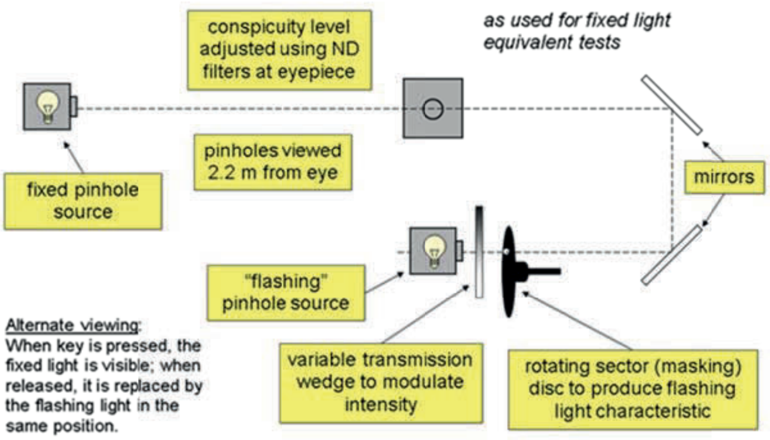


Figure 2: TSG second experimental phase

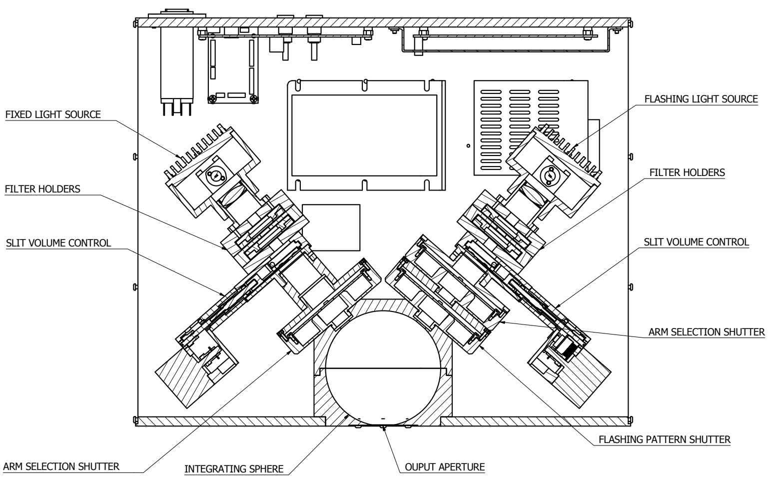


Figure 3: Bentham ILFD20QH

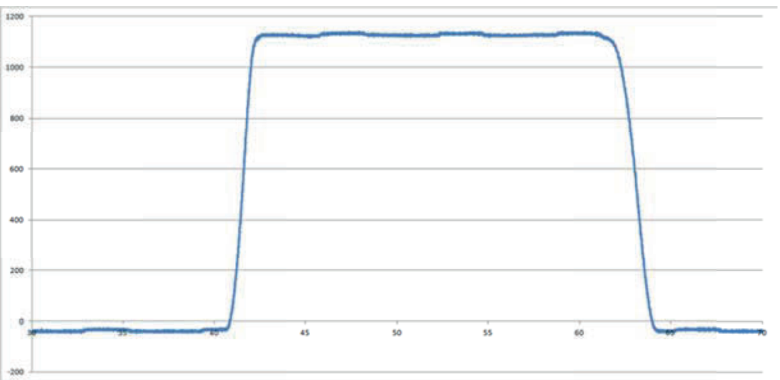


Figure 4: Shutter output rise and fall times

The switching characteristics of the electromechanical shutter used to module the flashing light were assessed by Bentham prior to supplying the finished apparatus. A typical 20 ms pulse is shown in **Figure 4** which exhibits a rise/fall time of within 2 ms. The shutter itself is capable of operating over sustained frequencies ranging from 10 Hz to dc.

Bentham also estimated the measurement uncertainty as being 2.5% on average during the unit's spectral calibration.

Software

A PC linked to the ILFD20QH source via USB ran software provided by Bentham (2013) having the following functionality:-

- *calibration* – to manually set the slit width or aperture, select or measure the light source (flashing or steady) and to re-calibrate the slit
- *flashing profiles* – graphically configure the duration in ms of the on and off times within a cycle for the flashing source
- *experiment profiles* – set the steady light intensity and assign multiple flash profiles which are to be used as stimuli in an experimental session
- *run experiment* – begin, pause or abort the execution of an experimental profile

Once an experiment had begun, each observer was then able to interact via a game controller (see **Figure 5**) which had buttons for toggling between the steady and flashing sources and also for changing the brightness of the flashing source. The brightness of the steady source was always that specified in the experiment profile. Each new stimulus began with a zero intensity flashing light. It was *not* possible for observers to adjust this to the same level each time simply by tapping the up button a certain number of times.

Figure 5: Controller used by obsevers

Based on experience from the pilot study, the "next" button was disabled as it proved all too easy to press this by mistake with no easy way of recovering. Instead, the experimenter advanced stimuli via the PC user interface once the observer was satisfied with the match. After a session, the results were stored to a CSV file which included the date, observer name (if recorded), measured illuminances of the steady and flashing sources (in µlux) together with details of the flashing profiles used.

EXPERIMENT

Due to ambiguities in the description of the original TSG study, a small-scale pilot study was completed to validate the set up. Both experiments were conducted in complete black out conditions with observers seated 2.2 m away from a pinhole aperture, leading to a < 1' arc visual angle. The pinhole was positioned at roughly the same height as observers' eyes. The ILFD20QH unit's two integrated 30W quartz halogen lamps required a ten-minute warm up before beginning and observers typically needed at least 15 minutes to acclimatise to the darkness – longer if coming from a bright environment. A further refinement was added to the software to add a switching delay, preventing instantaneous toggling between steady/flashing lights.

Pilot Study

Achieving a completely black environment initially proved challenging, in part because the equipment emitted stray light from power indicators, etc. These were concealed, however it soon became apparent that total darkness created significant problems for observers. Without anything else to look at, the visual system rapidly "lost interest" in between flashes, and most people found it difficult to locate and re-focus the eyes during the brief instant that a flash was emitted. To remedy this, a very dim "reference" light was added so that they had something else to fixate on in between viewing the pinhole source. This reference light was constructed by shining a Kingbright L-7113SEC-E 5 mm orange LED light driven at 1.83 V into a 10 cm integrating sphere having a 2 cm aperture which was positioned at the same distance but above and to the right of the pinhole. The final set up is shown in Figure 5. Even with this light, the conditions were close to the limits of vision leading to the potential for considerable visual fatigue. To minimise this, each session was limited to around 45 minutes (excluding acclimatisation).

For this experiment, only one brightness level was used for the steady light: 0.2 µlux. Using an eclipse time of 1000 ms, the following 19 different on-time flash profiles were used as stimuli (in ms units).

For this experiment, only one brightness level was used for the steady light: 0.2 µlux. Using an eclipse time of 1000 ms, the following 19 different on-time flash profiles were used as stimuli (in ms units).

50	75	100	125	150	175	200	225	250	275
300	325	350	375	400	425	450	475	500	x

The results from this experiment were eventually combined with those of the main experiment, and so will be discussed in the next section. Some adjustments were subsequently made to the range of flash durations in light of the initial findings.

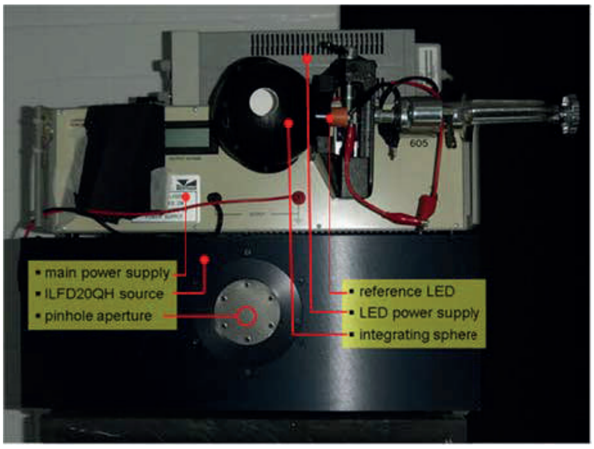


Figure 6: Experimental stimulus generation

Main experiment

Extending the groundwork laid in the previous section, a further four off-time flash durations were added covering intervals both longer and shorter than the pilot. Each of these four phases included the following sixteen flash durations (in ms) which were again compared with the same 0.2 µlux steady reference:-

25	50	75	100	125	150	175	200
225	250	275	300	350	400	450	500

A total of six observers took part in each phase, although not all observers took part in all phases. Each observer was required to make four observations of each set of stimuli, this being done on different occasions. A new visual acuity test was added based on a modified Snellen chart (1862) which was redesigned to be viewed at the same 2.2 m distance as the light sources. Observers attained scores equivalent to the range 20/16 to 20/25 with vision corrected where applicable.

A list of the participants and the phases they took part in is given below. They were a mixture of professional staff from Trinity House and the University of Leeds.

Observer	Eclipse Time (ms)				
	250	500	1000	1500[1]	2000[1]
Chris			✓		
David	✓		✓		
Gavin		✓			
Link	✓	✓			
Malcolm	✓	✓	✓		
Neal	✓	✓	✓		
Peter	✓	✓	✓		
Sophie	✓		✓		
Travis		✓			

Before their first session, observers were allowed to practice with a few test stimuli to familiarise themselves with both the task and the controls. They were instructed to make the match in the central part of the vision. Although flashing lights are significantly more conspicuous in peripheral vision, early findings from the pilot study showed that this was not a reliable way of judging brightness. Observers were also encouraged to rest their eyes whenever vision became "fogged" with after images. The reference light proved to be very helpful in this regards.

RESULTS AND DISCUSSION

After some practice, the majority of observers seemed to adopt the strategy of increasing the brightness of the flashing stimulus until it was just visible before comparing it with the steady light and then switching back to fine tune the match. Several cycles of toggling back and forth between steady and flashing stimuli were usually required; however it should be noted that if a match could not be obtained within a few minutes, the task became progressively harder due to visual fatigue.

Two other observers were excluded from the experiments because their results were found to be highly non-repeatable and "noisy". Performance did not appear to be related to age, experience or visual acuity; although further work would be needed to establish this conclusively. A key finding from this work is the typical variability of observers, which is important in establishing tolerances around the overall trends that were uncovered. The TSG experiments seemed to pay very little attention to this aspect.

Based on the matching data recorded by the experimental software, the ratios of steady to flashing intensity were calculated. These were plotted against flash duration for each of the phases. To better understand the robustness of the results, standard error bars were included. Since the occasional incorrect result was inevitable due to the highly challenging nature of the task, the median was used when averaging an observer's results as this statistic is not influenced by outliers.

Observer Reliability

A comparison was made between individual observer's results and the mean results from all observers. Detailed plots can be made available where the size of the error bars signifies the magnitude of individual variation (i.e. *precision*). For an observer to be *accurate*, their error bars should encompass the mean overall data (red bars) for a given stimulus.

From these graphs, the following points can be identified:-

- qualitatively, the spread of results seems greater than that found by TSG
- the typical standard error for observers was around 0.06 however certain individuals (i.e. Chris and Sophie) exhibit a very much greater variation
- some observers produce either higher matches (e.g. David) or lower matches (e.g. Peter) than average, whilst for others (e.g. Malcolm) this seems to vary according to the interval between flashes
- contrary to expectations, shorter flashes seem to be judged more consistently than brighter ones

To improve overall precision, either more observers would need to be used or alternatively the existing observers could complete more repeat judgements. It is also possible to selectively exclude some observers or specific observer data, however this would need to be justified on the basis of it being anomalous as opposed to representative of the typical human variation for this task.

Overall Results

Figure 7 summarises the overall results from each of the three phases that have been completed. It can be seen quite clearly that the flash duration time has the biggest impact on apparent intensity, with flashes lasting 250 ms or more being perceived in the same manner as steady sources.

This does not seem to be affected significantly by the interval between flashes, although observers found longer off periods much harder to judge. Separate plots for each of the three phases can be provided in which the spread of individual observer median results can be seen.

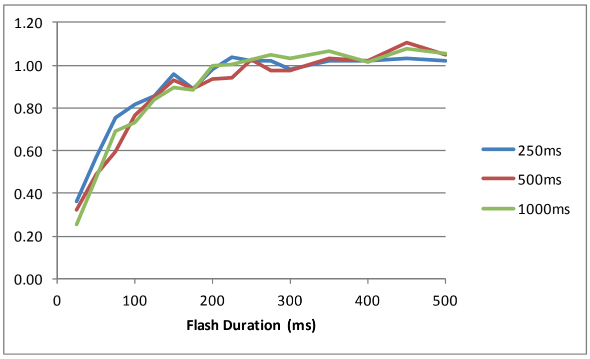


Figure 7: Overall results for each dark time series

CONCLUSIONS

The findings presented here reveal a definite trend from the observers: for durations of less than 250 ms, flashing stimuli are perceived to be dimmer than steady lights. This means that a flashing light needs to be made progressively more intense as it becomes shorter in duration in order for it to be judged as equivalent in brightness to a steady light. In addition, it has been possible to fully define the experimental procedure and investigate observer variation – both of which go beyond the results of Toulmin-Smith and Green.

Aside from the number of observers used, one possible limitation here is that stimuli were always presented in the same order (i.e. ascending flash length). While this could potentially lead to bias, the intention here was to help reduce the considerable visual fatigue by making the task seem progressively easier. Judging the brightness of such brief and dim sources is at the limits of human vision and not a task that most of us are used to doing.

Further work should be considered to look at different intensities for the steady light before moving on to the impact of colour of light. In the longer term, the further complexity could be added by adding different coloured (or even moving) backgrounds together with rival lights. This would closely mimic the real world scene experienced by mariners close to land.

FURTHER WORK

During the course of his experiment, Rhodes used a dim orange reference light above and to the right of the pinhole exhibiting the flashing and steady white lights being matched. This was found to provide a resting place for the observer's eye in the darkened room, alleviating observer fatigue. However, CIE observers voiced concern over the use of this method, arguing that such a reference light within the field of view of the observer could influence results.

Figure 8 shows the comparison of the Leeds results compared to the original experiment. A decision was made to repeat Rhodes' experiment in Harwich, using the same Bentham ILFD20QH equipment and, where possible, the same observers but in complete darkness without any reference light. Attention would be paid to observer fatigue and varying the order of flash profiles in line with conclusions from the Leeds report. Furthermore, system calibration would be checked by means other than the Bentham equipment's internal calibration system.

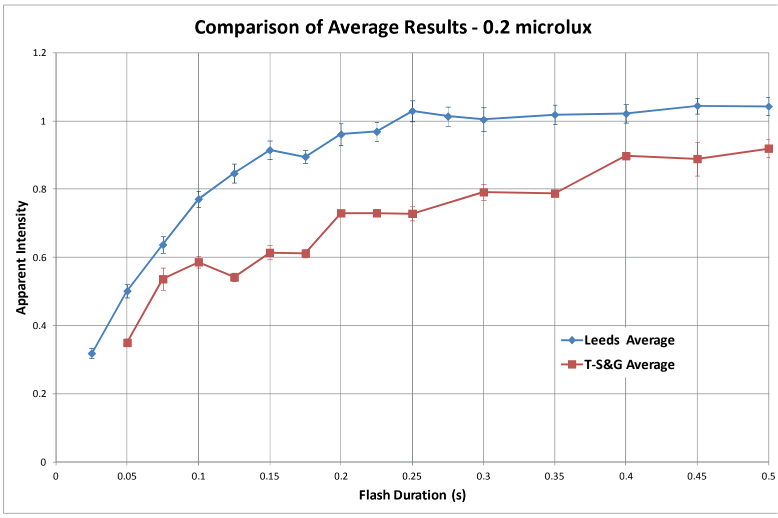


Figure 8: Comparison of Leeds and Toulmin-Smith and Green Average Results

The objective of the experiment was to check the calibration of the Bentham ILFD20QH equipment, repeat the experiment of Leeds University in complete darkness and compare results with those of Leeds and Toulmin-Smith and Green. Further observations were to be carried out at illuminance levels of 0.077 microlux and 0.77 microlux, results of which were also to be compared with those of Toulmin-Smith and Green. A fixation light was to be used for additional comparative tests or when the observer could not carry out the task of foveal brightness matching in complete darkness (see **figure 9**).

Fixation Light

Although the majority of observations were carried out in complete darkness, a fixation light was used for a few observations in order to study the difference in behaviour of observers with and without fixation.

A light source was constructed that consisted of a sheet of 5mm thick clear cast acrylic sheet with a 60mm diameter hole in its centre. One side of the hole was given a slight 45 degree chamfer. At either side of the sheet, the edge was drilled with a 3mm diameter hole into which a 650nm red LED was fitted. The whole of the surface of the sheet was blackened except for the chamfer. The LEDs were wired in series and supplied from a variable current power supply. The sheet was then placed directly in front of the Bentham ILFD20QH such that the pinhole was at the centre of the 60mm hole in the sheet.

When lit, the fixation light formed a thin annular red light around the pinhole. At the observer distance of 2.2 metres, the subtense angle of the fixation light was approximately ±0.8 degrees of arc.

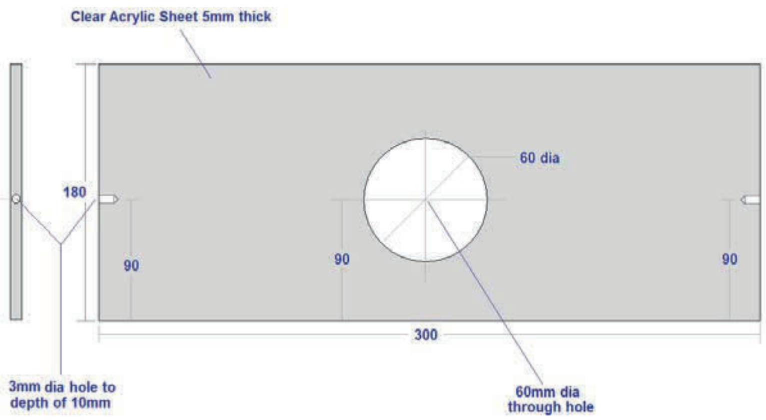


Figure 9: Fixation light drawing

Observers

Seven observers were used for the Harwich experiment as shown in **Table 1**.

Five of the seven observers, G, L, M, N and P, participated in the Leeds experiment.

Method

Independent Calibration Check

Before commencement of experiments, the Bentham ILFD20QH was set to a fixed intensity using the experiment profile page of the program and the flashing profile was set to 5s on and 10ms off. A luxmeter was placed at a fixed distance from the pinhole and an illuminance measurement taken of the steady light. This was found to be the expected illuminance within the combined uncertainty budget. Next, the game controller was toggled so that the flashing profile was output from the pinhole and the brightness control adjusted to give the same reading as previously obtained from the steady light. Values of fixed and flashing illuminance recorded by the Bentham program were checked and found to be identical.

Name	Observer reference	Age last birthday	Other details
Gavin	G	32	
Jim	J	50	Corrective glasses
Ian	I	62	
Link	L	25	
Malcolm	M	42	
Neal	N	36	
Peter	P	46	Corrective glasses

Table 1: List of Observers

Experimental Procedure

The equipment was switched on and allowed to stabilise for ten minutes. The observer was seated and his position adjusted until he was comfortable and in the correct position with his forehead resting on the padded area of the hinged bar. The programmed experiment was initiated by pressing the 'Run' prompt and the VDU screen was switched off. All lights were switched off and the room checked for stray light.

The observer and experimenter then waited fifteen minutes to achieve dark adaptation of vision. After a final check for stray light and ensuring the observer was comfortable, the task of brightness matching commenced.

The observer toggled back and forth between steady and flashing lights, adjusting the brightness of the flashing light until he was satisfied that a brightness match was obtained. He then told the experimenter who advanced the program to the next flash profile using the remote mouse.

Experiment Profiles

0.2 microlux

At the illuminance level of 0.2 microlux, four different experiment profiles were programmed. Each profile began with two steady lights followed by eight different flash durations. The eclipse period between each flash was one second. The purpose of matching steady lights was twofold: firstly to accustom the observer to the experiment setup and its controls; secondly to assess the ability of the observer to carry out the task of successive brightness matching. Experiment profiles were as follows:

1st Half Forward Steady, Steady, 0.025, 0.075, 0.125, 0.175, 0.225, 0,275, 0.35, 0.45

2nd Half Forward Steady, Steady, 0.05, 0.01, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5

1st Half ReverseSteady, Steady, 0.45, 0.35, 0,275, 0.225, 0.175, 0.125, 0.075, 0.025

2nd Half Reverse Steady, Steady, 0.5, 0.4, 0.3, 0.25, 0.2, 0.15, 0.01, 0.05

Upon completion of up to two of each of the above profiles at 0.2 microlux, the annular red fixation light was turned on and adjusted so that the observer could just see it when looking directly at it and that it could not be seen in peripheral vision.

Further observations of some experiment profiles at 0.2 microlux were carried with the fixation light being adjusted for each observer. Observers were asked to adjust the brightness of the steady light for threshold detection instead of brightness matching. Specifically, observers were asked to increase the brightness level of the steady light so that it could be clearly seen, then reduce the brightness until it disappeared, then increase the brightness slowly until it could just be seen. The fixation light ensured that threshold detection took place in foveal vision.

0.77 microlux

At an illuminance level of 0.77 microlux, two experiment profiles were programmed as follows:

Forward 0.025, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, Steady

Reverse 0.5, 0.4, 0.3, 0.25, 0.2, 0.15, 0.1, 0.075, 0.05, 0.025, Steady

The number of flash profiles were reduced in order to save time and the observers, being accustomed to such tests, did not need to begin with steady light matching. Tests took place in complete darkness.

0.077 microlux

At 0.077 microlux, close to achromatic threshold, a flash appears much brighter to the dark-adapted eye in peripheral vision. The effect is much more noticeable at this low level of illuminance level than at higher levels. In complete darkness, there is no guarantee of the flash being viewed in foveal vision because the flash is difficult to see when viewed directly and the observer's eye direction wanders in the eclipse period between flashes. For this reason a fixation light was used for all tests at the 0.077 microlux illuminance level. Otherwise, the same format was used for 0.077 microlux as was used for 0.77 microlux.

Results

Results of steady versus steady brightness matching were tabulated for each observer showing maximum and minimum percentage differences as well as mean and standard deviation.

Results for flashing versus steady brightness matching were normalised by dividing the steady illuminance by the flashing illuminance to obtain a fixed light equivalent or apparent intensity value. Plots of the average of all observers as well as groups of observers are shown below along with graphs comparing the results of this experiment with those of the Leeds and the Toulmin-smith and Green experiments.

Absolute threshold illuminance values are shown in microlux for each observer along with a measurement uncertainty.

0.2 microlux

Steady versus Steady

Over a number of observations, observers were asked to match the brightness of two steady lights by successive brightness matching. **Table 2** shows the percentage difference between actual illuminance and perceived illuminance for each observer.

Observer	Maximum	Minimum	Average difference	Standard deviation	No. of observations
G	60%	-11%	11%	22%	12
I	5%	-21%	-6%	11%	8
J	16%	-20%	-3%	13%	12
L	15%	-10%	1%	8%	12
M	44%	-10%	10%	16%	10
N	33%	-11%	9%	14%	10
P	32%	-10%	10%	12%	12

Table 2: Steady versus Steady Brightness Matching at 0.2 microlux

Flashing versus Steady

Average plots for each observer of flash duration against apparent intensity for 0.2 microlux are shown in **Figure10**. The graph in **Figure 11** shows the average of all observations for each of the three experiments: Harwich 2014, Leeds 2013 and Toulmin-Smith and Green 1933.

Trend lines have been added, the T-S&G trend line is that published in Toulmin-Smith and Green's paper for 0.194 microlux, observer results being taken from figure IV of the Air Ministry report.

By studying **Figure 10** it can be seen that the Harwich observers fall into two similarly performing groups, G, I, N & P in one group and J, L & M in the second.

A comparison of an average of the group with the lowest performance, GINP observers, with an average of Toulmin-Smith and Green observers is shown in **Figure 12**.

0.77 microlux

Steady versus Steady

Over a number of observations, six observers were asked to match the brightness of two steady lights by successive brightness matching. **Table 3** on the next page shows the percentage difference between actual illuminance and perceived illuminance for each observer.

Flashing versus Steady

Average plots for each observer of flash duration against apparent intensity for 0,77 microlux are shown in **Figure 13** on the next page.

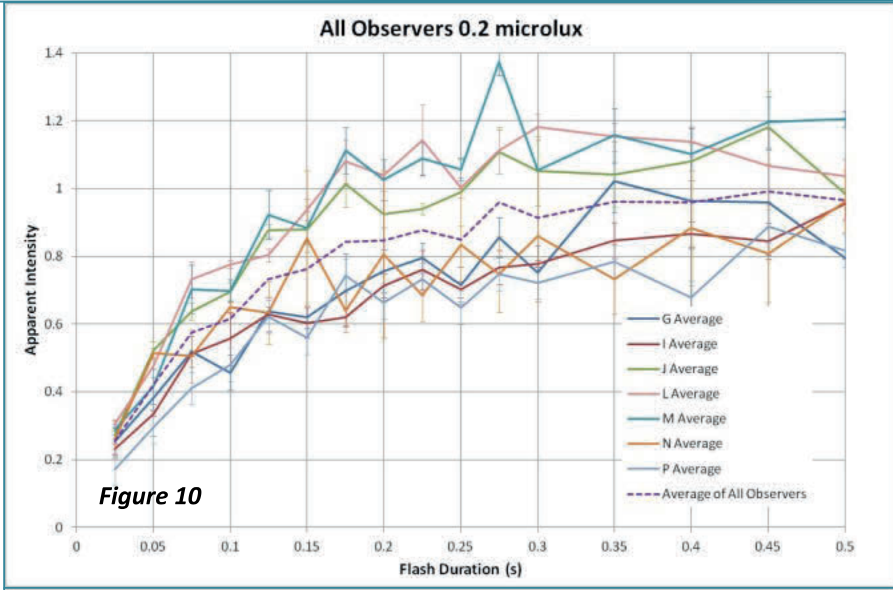
0.077 microlux

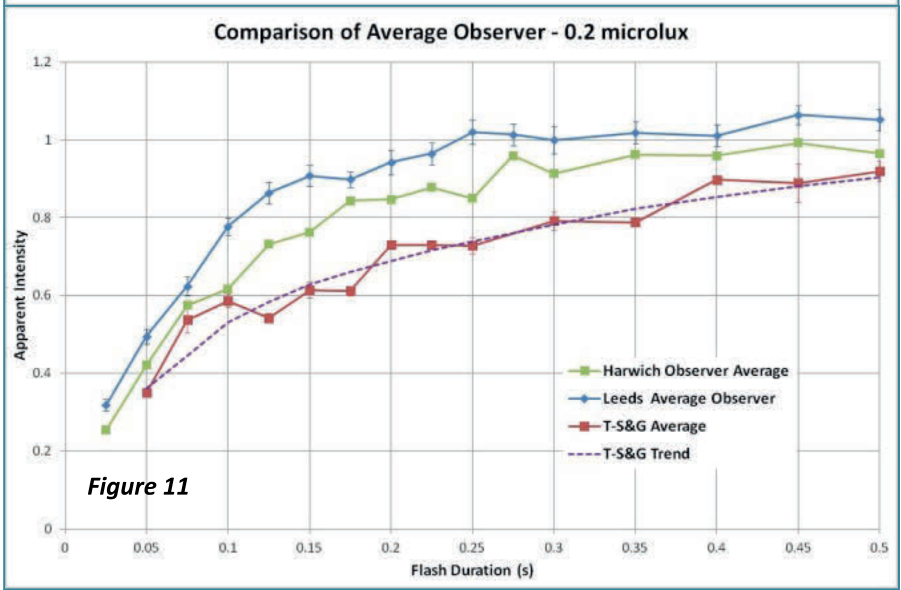
Steady versus Steady

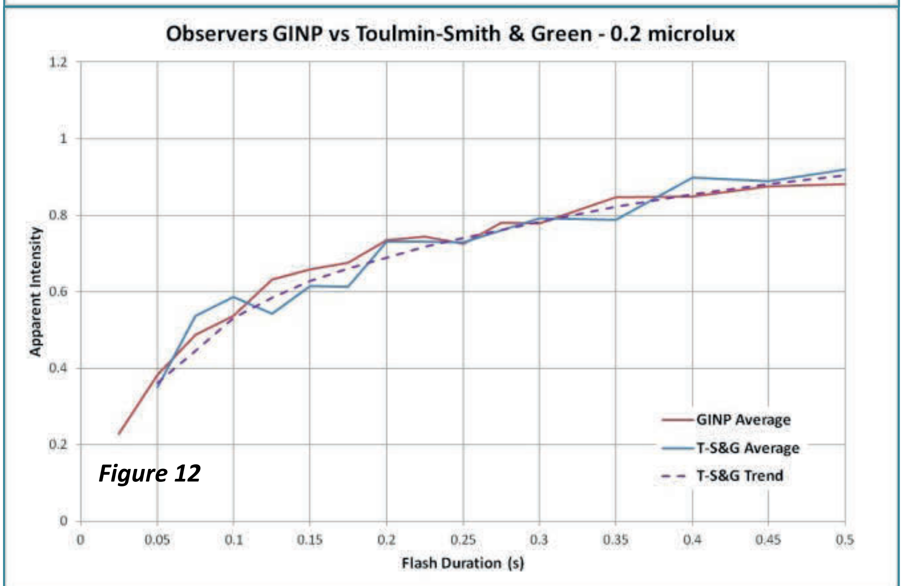
Over a number of observations, four observers were asked to match the brightness of two steady lights by successive brightness matching. **Table 4** on the next page shows the percentage difference between actual illuminance and perceived illuminance for each observer.

Flashing versus Steady

Average plots for each observer of flash duration against apparent intensity for 0,077 microlux are shown in **Figure 14** on the next page.







Figures 10 to 12:
10 - An Average Apparent Intensity Plot of Each Observer at 0.2 microlux
11 - Average of All Observations for each Experiment
12 - Harwich Observers GIN &P compared with Toulmin-Smith and Green

Observer	Maximum	Minimum	Average difference	Standard deviation	No. of observations
G	16%	9%	12%	5%	2
I	0%	-14%	-5%	8%	3
J	14%	-14%	-4%	13%	4
L	4%	-1%	1%	3%	4
M	14%	-1%	6%	8%	4
N	3%	-10%	-3%	7%	3

Table 3: Steady versus Steady Brightness Matching at 0.77 microlux

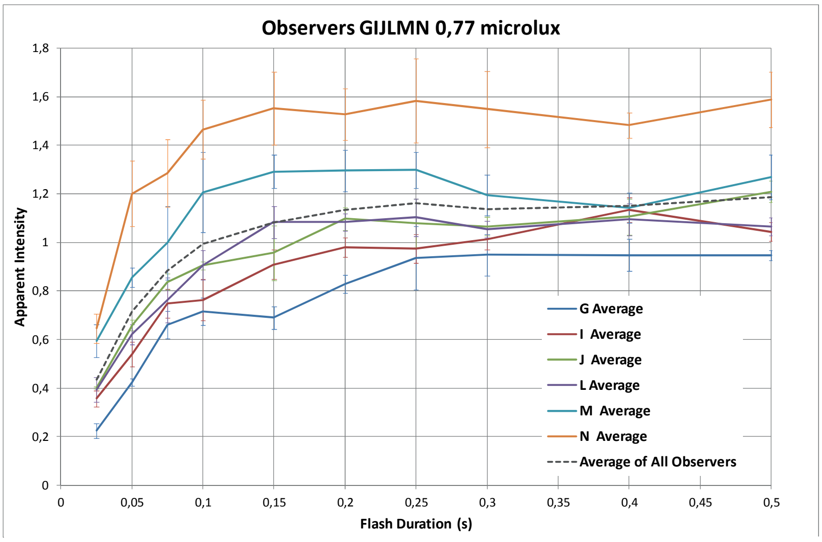


Figure 13: An Average Apparent Intensity Plot of Each Observer at 0,77 microlux

Observer	Maximum	Minimum	Average difference	Standard deviation	No. of observations
I	29%	-38%	4%	30%	4
J	22%	-13%	12%	16%	4
L	22%	0%	10%	11%	4
M	11%	0%	4%	6%	3

Table 4: Steady versus Steady Brightness Matching at 0.077 microlux

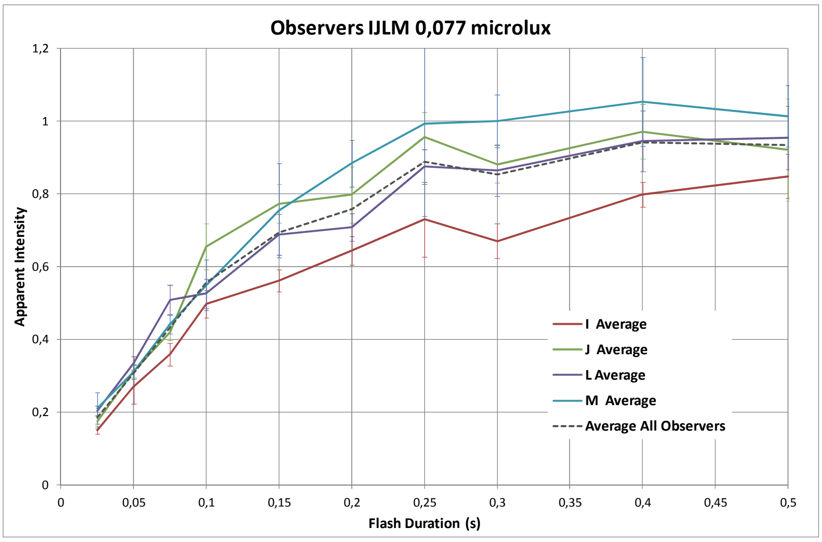


Figure 14: An Average Apparent Intensity Plot of Each Observer at 0,077 microlux

DISCUSSION

It is clear from results and from observers' comments that brightness matching of point sources is a difficult visual task. Furthermore, with successive brightness matching, the observer has to match the brightness of a point source with his memory of the previously viewed point source. Toulmin-Smith and Green's results were plausible but they were achieved with few observers, probably only one observer in some cases.

In Leeds and Harwich, more observers were used and the spread of results was much greater than for Toulmin-Smith and Green, although only complete results for 0.194 microlux are available from the latter. Differences between observers is the likely explanation for the greater spread of results and when smaller groups of similarly performing observers, or individual observers, from Harwich are studied, results comparable to Toulmin-Smith and Green's can be obtained.

For successive brightness matching of point light sources to be made viable, it seems necessary to select appropriate observers. Observers chosen need to be consistent performers and, with marine aid to navigation safety in mind, they need to have a comparatively slow reaction time to flash perception. These criteria should apply at all levels of illuminance being considered. A larger number of observations, probably around ten, for these selected observers would reduce uncertainty. But a larger number of observations necessitates observer availability, which may be difficult to guarantee.

The difference between results from Leeds and those from Harwich can possibly be explained by the use of fixation. Of the five Leeds observers used in the Harwich experiment, two showed a distinct difference in results when a fixation light was used. This difference in two observers could move the average Harwich results closer to those obtained in Leeds if fixation were used. The use of a fixation or reference light considerably reduces observer fatigue, and at low illuminance levels observations were extremely difficult without it.

There is a distinct difference between results obtained from even the lowest performing observers for 0.2 microlux in Harwich and the currently recommended effective intensity model, Blondel-Rey. At 0.077 microlux, the lowest performer trajectory was well above that of the Blondel-Rey when the time-constant of a = 0.2 seconds is used, but were comparable when a value of a = 0.1 was used. The use of the Blondel-Rey model with a = 0.2 seems unduly pessimistic for an observer illuminance of 0.2 microlux.

Results so far suggest that for white flashing lights with a rectangular flash profile, a Blondel-Rey formula with a visual time-constant value of a = 0.1 seconds would be a more suitable model for determining the range of a marine aid to navigation light. The impact of using such a model would be to enable the flash duration of lights to be reduced, without reducing the published nominal range. Savings could therefore be made in energy consumption resulting in reduced costs, or longer maintenance or redundancy periods. A reduction in flash duration for solar powered aids to navigation in higher latitudes, such as cardinal buoys that use white LED lights, would substantially improve the winter minimum figure.

CONCLUSIONS

- The Leeds experiment highlighted some of the short comings of the original TS&G experiment.
- The repeat of the Leeds experiment, in Harwich shows closer agreement with the original TS&G experiment.
- Successive brightness matching is a difficult visual task.
- For 'white', rectangular flash shapes the 0.2 microlux apparent intensity curve yields a visual inertia value of approximately 0.1s.
- The experimental result forms the baseline for further experiments.

The Impact of Moving to an 'Apparent Intensity' Model

If the apparent intensity model at supra-threshold illuminance levels is validated and used to evaluate the performance of white, rectangular flash shape lights instead of the existing effective intensity model, then shorter flashes will be favoured. This means that a short flash will have a greater apparent intensity compared to its effective intensity – or that the flash can be shortened to maintain the same range thereby saving energy.

As a general rule of thumb, for flashes up to 0.5s, the flash duration can be halved to achieve the same nominal range.

Further Experiments

Further experiments will be conducted covering the following aspects in due course:-

- Higher illuminance levels;
- Different colours;
- Different flash profiles;

Different levels of background lighting. . ■

Acknowledgements

Dr Peter Rhodes of Leeds University for his valuable insight into the preliminary design of the equipment and experiment. And for conducting the first experiment.

Mr Ian Tutt (Retired) for his continued interest in this subject. And for conducting the second experiment.

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[1] Experiments for the 1500 and 2000 ms were not conducted.

602259 INTEGRATED AtoN INFORMATION SYSTEM (I-ATONIS SERVICE) AND ADDED VALUE APPLICATIONS

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The integration of procedures that enable the almost immediate availability of information generated locally in a unified database (accessible over the Internet) and its distribution through AIS-AtoN messages is what we have called the "I-ATONIS Service".

Advances in the integration of remote monitoring information from different devices of equipment and the use of these information systems to generate synthetic AIS-AtoN messages in buoys are presented in this paper.

A new remote monitoring system that enables information to be connected to other of the organisations' internal management systems – like the unified nation-wide AtoN information systems and service status transmissions via AIS-AtoN messages – is also presented in this paper.

La integración de procedimientos que permiten la casi inmediata disponibilidad de información generada localmente en una base de datos unificada (accesible a través de Internet) y su distribución a través de mensajes AIS-AtoN es lo que denominamos «Servicio I-ATONIS».

En esta ponencia se presentan los avances en la integración de información de control remoto de diferentes dispositivos de equipamiento y el uso de estos sistemas de información para generar mensajes AIS-AtoN sintéticos en boyas.

En esta ponencia también se presenta un nuevo sistema de control remoto que permite conectar la información a otro de los sistemas de gestión interna de las organizaciones, como los sistemas de información AtoN unificados a nivel nacional y transmisiones de estado de servicio a través de mensajes AIS-AtoN.

L'intégration de procédures permettant l'obtention quasi immédiate d'informations produites localement dans une base de données unifiée accessible par internet et sa diffusion par des messages AIS-AtoN est ce que nous appelons le service « I-ATONIS ».

La présentation décrit les progrès de l'intégration d'informations de télésurveillance de différents matériels et équipements et l'utilisation de ces systèmes d'informations pour produire des messages synthétiques AIS-AtoN sur les bouées.

Elle présente également un nouveau système de télésurveillance permettant de connecter l'information à d'autres systèmes de gestion interne à l'organisation – tels que les systèmes d'information nationaux unifiés et les émissions d'information sur l'état de fonctionnement par messages AIS-AtoN.

Integrated AtoN information system (I–ATONIS Service) and added value applications

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Spain

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

INTRODUCTION

The Integrated AtoN Information Service is aimed at optimising the procedures to process and spread information coming from a variety of different local sources at the level of the central point or node. At this central node a unique databases is generated and can be accessed by other systems. Thus enabling the provision of added value services to external user (mariners and other interested parties or stakeholders) and internal users (corporate users).

A programme aimed at developing and implementing a single remote AtoN control and monitoring system was initiated in Spain in the 1980's. Over time and due to technical needs, each Port Authority (AtoN service providers) has transformed this single system in different ways with off-the-shelf market solutions and by taking advantage of monitoring technologies used in other industrial sectors. The interchange and distribution of information at a national level has, however, been standardised.

The Integrated AtoN Information System covers two areas: **an inventory** of aids and **service status**, integrating three elements or systems. These include the **remote monitoring systems** at a local level (Port Authorities), the **PORTAL-AtoN** application, which contains the inventory and service status of each of the AtoNs at a central level (Puertos del Estado) and the **AIS-Port** network, which broadcasts status information as AIS-AtoN, in addition to providing its own functions as an AIS system.

This status information broadcasting system provided through AIS-AtoN messages is also available at a local level for other Port Authority management applications and as a backup system for the centralised system.

Integration involves standardisation. Hence, protocols and applications have been developed on the basis of the different remote monitoring systems to standardise the information on marine AtoNs (inventory and status) and make it available to users in a centralised way over the Internet or through AIS-AtoN messages.

This paper presents two examples of how communication systems and data formats have been integrated. It also shows how information from Remote Monitoring Systems (RMS) can be used in added value applications. In the case of the Barcelona Port Authority, the system has been designed to enhance its connectivity with the Port Authority's other systems and with systems belonging to external agencies, such as Puertos del Estado, whilst the Santander Port Authority is using RMS to generate Synthetic-AIS information on buoys.

In no way, however, does this integrated information service aim to replace mandatory means of communication on the status of AtoNs through navigational warnings or notices to mariners. It has been conceived instead as an added value service for seafarers and other interested parties.

INTEGRATION OF THE PORT OF SANTANDER'S AtoNs INTO A SINGLE GRAPHIC AND INFORMATION INTERFACE IN AIS FORMAT.

The constant technological advances of the last few years and more specifically advances in the area of AtoNs have led to the replacement of older equipment by other more innovative and fuel-efficient equipment.

The installation of a remote monitoring system, which initially covered only eight lighthouses, began in the 1990's. This was an important step because it meant that not only were the lighthouses automated, but also that the AtoN Department of the Santander Port Authority had real-time information available on what was happening at each lighthouse.

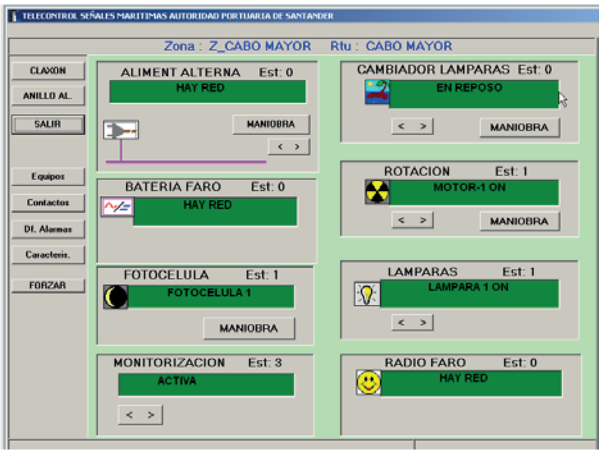
Visual control could therefore be easily exercised through a single screen over all the lighthouses under the Santander Port Authority's responsibility.

In order to get more detailed information, one only had to click on the name of each lighthouse to gain access to all its specific pieces of equipment.

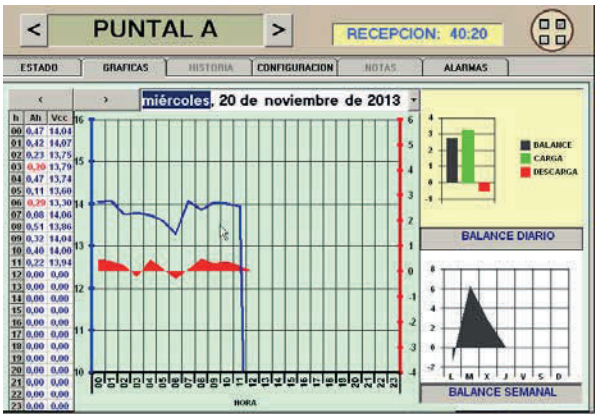
This information provided data that went beyond service status data (in service, out of service).

Battery chargers, generating sets, photocells and generator diesel fuel tank levels in the event of emergencies, among others, were also monitored.

Another significant advantage, aside from the ones mentioned above, was that there were no communication costs at all due to the fact that the information was transmitted by radio (163.725 MHz).



Naturally enough, no system is perfect and this one wasn't either. Given the peculiarities of its port, which is located inside a bay, most of the marine signals in this Port Authority are buoys, which were not included in the Remote Monitoring System's initial phase. A decision was therefore taken to conduct a second phase that would include the main buoys and some other important signals like the leading lines into the port.



Due to the power constraints in these kinds of signals, a radio transmission system was carefully designed to take this aspect into account, so that it consumed as little power as possible. In this regard, the number of messages was limited to a maximum of four per hour, and one per hour was set by default. The capturing and transmission of analogue status signals was also implemented in order to know in advance the status and evolution of battery charges, so as to be in a position to conduct preventative maintenance and pre-empt any possible breakdowns due to power failures. The system was also equipped with current measurement devices, which provided us with information on the performance of the solar panels and wind turbines that were incorporated to offset the low levels of winter sunlight in the Cantabria region, located in the north of Spain.

The small wind turbines partly offset insufficient charges on cloudy days, as it is precisely during these weather conditions when there happens to be wind.

Finally, we had to redesign the entire system with the arrival of LEDs as a light source to replace incandescent lamps. Both the wind turbines and the external photovoltaic panels were progressively phased out, because the new self-contained beacons came equipped with their own panels.

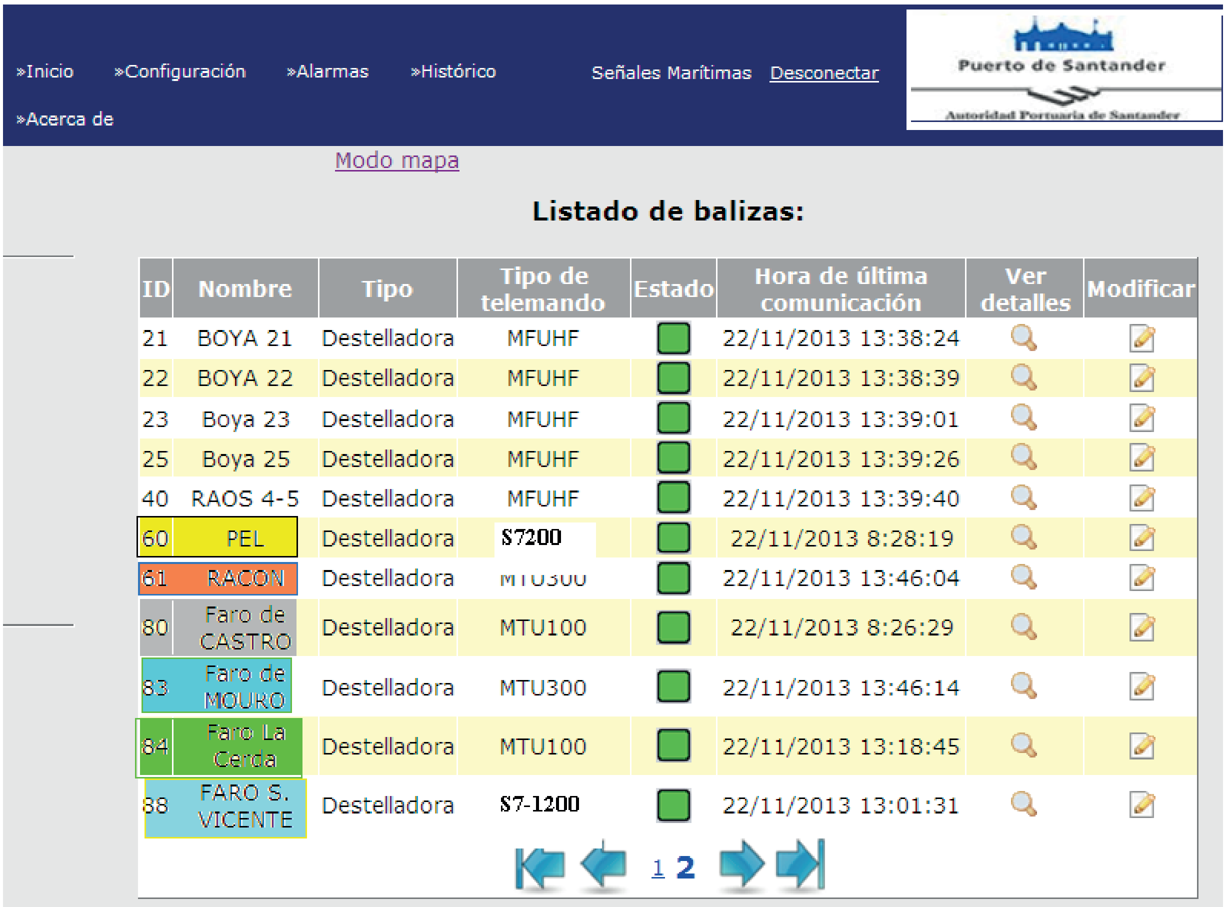
One of the aims of the technical staff at the Santander Port Authority's AtoN Department was to standardise as much as possible the equipment in marine signals progressively. Each time a piece of equipment was replaced by more technologically advanced equipment in recent years, an effort was made to consider it as a point of reference for other similar AtoNs when these also had to be renovated.

However, despite this standardisation policy, devices from different manufacturers have continued working properly and have remained installed. These have therefore not needed replacement.

Furthermore, the economic crisis has underlined the always advisable aim of reducing costs as much as possible. In this regard, we realised that it was not always necessary to replace the oldest devices, but rather that it was preferable and sufficient to perform work to integrate them with new products.

Such integration enables data from equipment having different technical characteristics and/or from different manufacturers to be transmitted and displayed, an aspect we wish to set out in this part of the paper.

When the most important buoys of the main entry channel into the Port of Santander's quays were replaced in 2010, it was deemed suitable to upgrade



»Inicio »Configuración »Alarmas »Histórico Señales Marítimas Desconectar
»Acerca de

Puerto de Santander
Autoridad Portuaria de Santander

Modo mapa

Listado de balizas:

ID	Nombre	Tipo	Tipo de telemando	Estado	Hora de última comunicación	Ver detalles	Modificar
21	BOYA 21	Destelladora	MFUHF		22/11/2013 13:38:24		
22	BOYA 22	Destelladora	MFUHF		22/11/2013 13:38:39		
23	Boya 23	Destelladora	MFUHF		22/11/2013 13:39:01		
25	Boya 25	Destelladora	MFUHF		22/11/2013 13:39:26		
40	RAOS 4-5	Destelladora	MFUHF		22/11/2013 13:39:40		
60	PEL	Destelladora	S7200		22/11/2013 8:28:19		
61	RACON	Destelladora	MTU300		22/11/2013 13:46:04		
80	Faro de CASTRO	Destelladora	MTU100		22/11/2013 8:26:29		
83	Faro de MOURO	Destelladora	MTU300		22/11/2013 13:46:14		
84	Faro La Cerda	Destelladora	MTU100		22/11/2013 13:18:45		
88	FARO S. VICENTE	Destelladora	S7-1200		22/11/2013 13:01:31		

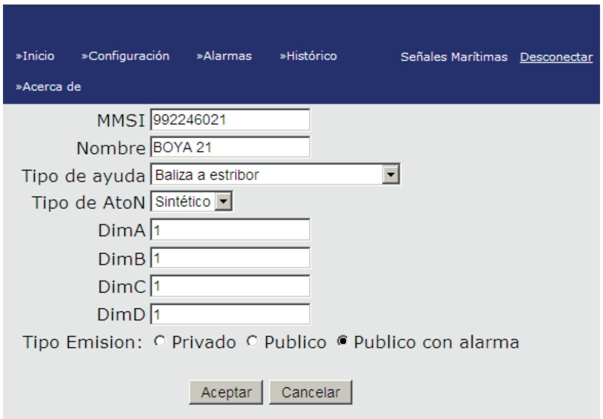
1 2

In this illustration, we have coloured the AtoNs equipped with different devices, which have nevertheless been integrated into the same Remote Monitoring System.

the former remote control system, which had been designed for buoys equipped with external power feed systems (solar panels and wind turbines) and independent communication systems. The new self-powered lanterns included an integrated communication system, which allowed for several options, such as: GSM, GPRS or free frequency UHF. We chose the latter option for the buoys and used the other options for the AtoNs located in distant sites.

We requested the remote control system's manufacturer to provide us with an open modular system, so it could be modified or incorporate other signals not initially foreseen; in other words, a system that would allow the inputs and outputs that had to be viewed at each marine signal to be configured. In order to achieve flexible communications, we also requested the manufacturer to provide us with the format in which the data would arrive at the control centre in order to adapt the marine signal data from other manufacturers' equipment.

All the data from analogue or digital AtoN signals were therefore packaged into a single SMS message measuring 120 bytes to ensure that this encoded



information was coherent with the data received from that manufacturer's equipment and consequently processed and dealt with in a similar fashion.

This integration allowed the data coming from any AtoN be recorded in the remote control system and be displayed in the same graphic interface, regardless of the means of communication chosen or the hardware used by each manufacturer.

Finally, another important step was taken in the integration process. The Santander Port Authority

had already been equipped with an AIS Base Station since 2007, the initial aim of which was to exercise greater control over existing traffic in the area and in the port, as well as to provide the possibility of transmitting relevant information in case of need and also leave the door open for the inclusion AIS AtoN information (AIS-AtoN).

The chance for this arose after the acquisition of the flexible and configurable Remote Control System mentioned above in 2010, which allowed our marine signals to be processed as synthetic AtoN; in other words capable of transmitting their status to ships in the area without the need of being equipped with an individual transponder. To do so, some selection tabs were added to each signal's configuration page that enabled one to choose whether or not its data would be "posted" and whether such transmissions on its position and status would be permanent or only in the event of an alarm. In our case, we only chose to "post" on a permanent basis the two main buoys at the entrance to the bay and the Mouro lighthouse. The rest are only activated in the event of an alarm.

This option is justified by the large number of AtoNs in a relatively small area. Simultaneously posting of all them under normal circumstances would produce an unnecessary excess of information.

This is a first level of integration at a local level capable of unifying information from beacons made by different manufacturers in a single monitoring system, in addition to transmitting the most relevant AtoNs as Synthetic AIS (access to the Port of Santander's entry channel), including the buoys which are not equipped with a physical AIS device, by using these beacons' real positioning information provided by the Remote Monitoring System for Synthetic AIS-AtoN messages on these buoys.

MANAGEMENT AND INTEGRATION SYSTEM OF THE PORT OF BARCELONA'S AtoNs (IMS–AN)

In the Barcelona Port Authority's Remote Monitoring System, which is presented below, its connection to added value applications covering other areas of port activity (external users) and the automated generation to the PORTAL-AtoN application (Puertos del Estado) of the status-change messages it handles, also in a semi-automated[1] way, should be highlighted.

Remote control and monitoring systems for AtoNs enable the service provided to mariners to be enhanced by optimising available resources. However, they generally lack the necessary development flexibility to adapt to the new requirements that the various areas of port management demand on a day-to-day basis.

Taking heed of these needs, the Barcelona Port Authority (APB from "Autoridad Portuaria de Barcelona") broached the development of a remote monitoring system (RMS) for marine signals that would be capable of integrating all currently available AtoN facilities, while at the same time providing a response to the demand for information of the different management systems of the Port of Barcelona's services.

The technical upgrading of the remote AtoN monitoring system also guarantees the system's high level of availability – comparable to the availability levels undertaken for marine signals –, data interchange between the different software applications comprising the port's organisational network and development flexibility that would enable us to build an extensive application based on the initial core.

To sum up, the IMS-AN was designed to be a system open to the effective and transparent interchange of information. Its advantages can be summed up as follows:

- Integration of the Port of Barcelona's information systems; this is not a local control and monitoring system, but rather hierarchical information management. The IMS's architecture was implemented over the Port of Barcelona's core hardware and is compatible with its in-house software and tools. It also allows for the transparent transversal use of information and databases by any of the organisation's users and departments. Integration with the LDAP service converts any person, group or customer included in the Port Authority's organisational network into a potential user.

  In the strict sense of the IMS-AN's design, it is an application built according to the Service-Oriented Architecture (SOA) philosophy and implemented in an environment based on flexible reusable models aimed at optimising code. It consists of a Kernel (MS0-AtoN) and five modules, which are interconnected via Web services through the standard SOAP 1.1 protocol.

  All this allows for the availability of a system that is sufficiently open to guarantee its future growth and easy integration with other systems, while the Web services define a remote monitoring API for the systems integrated into it from any external application, regardless of the operating system.

- Implementation of the functionality that allows synthetic AIS-AtoN messages to be transmitted automatically when a marine signal included in the system is out of service or turned off.
- Communications redundancy to ensure the integrity and reliability of the availability data provided by the APB to the AtoN system, which has been implemented at all remote backup communication channel stations by combining all available systems, such as GPRS, SMS, ADSL, radio, AIS and fibre optic cable, with the most suitable configuration in each case.

Among others, the system enjoys the following advantages over off-the-shelf systems.

- User interface customised for the Port of Barcelona according to the APB style guide.
- The system allows for remote mobile clients, both via Web as well as through a specific application (App) designed for tablet/mobile devices
- Simultaneously sending critical alarm SMS messages to up to ten users.
- Scalable modular system that enables new elements and systems from any manufacturer to be added.
- Storage of information in an Oracle database for subsequent use in reports and statistics.
- Information displayed over the following charting systems: S-57/S-63, direct ENC and Google Earth.

Application for mobile devices. Source APB

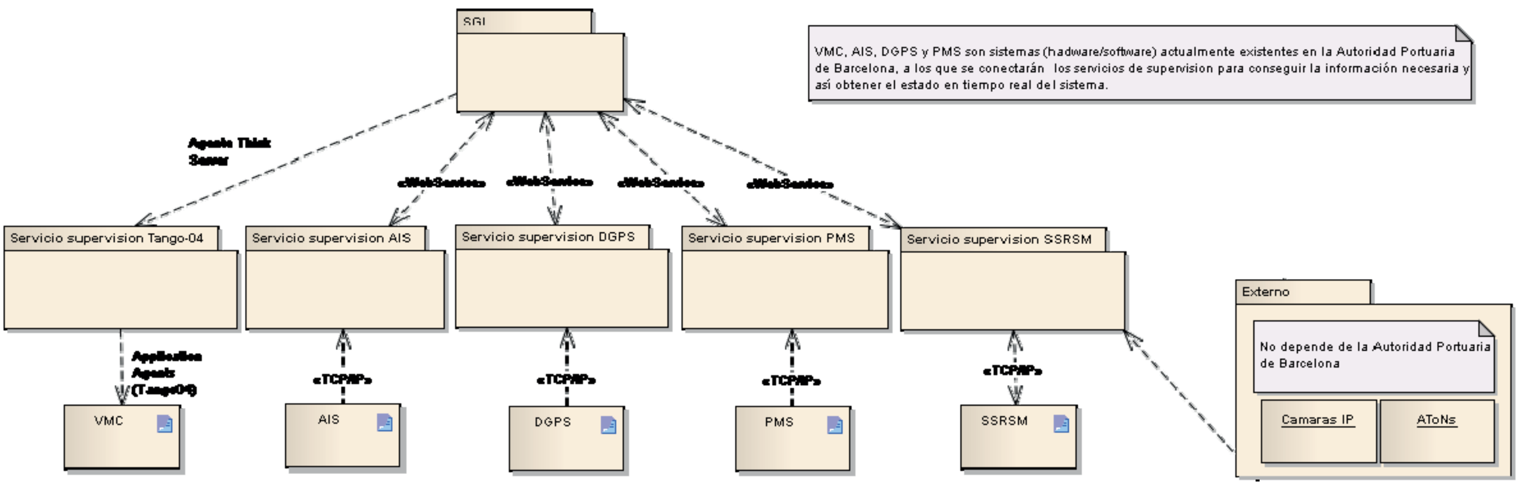
- Integration in the user interface of real-time video images from light cameras.
- User management and access to the integrated system via the APB's LDAP server.
- Sending configuration information needed to transmit synthetic and virtual AIS-AtoN to the local control unit via Web services and RPC.
- Remote configuration of DGPS stations.
- Access to e-mail mailbox from the user interface.
- Access to folders containing system and procedures information.
- The system allows for the integration of anti-intrusion alarm systems or other security devices installed at the different stations.
- Editing window for technical notes.
- Change of language.

To finish off, we will now present the most relevant GIS-AtoN functionalities developed by the Barcelona Port Authority:

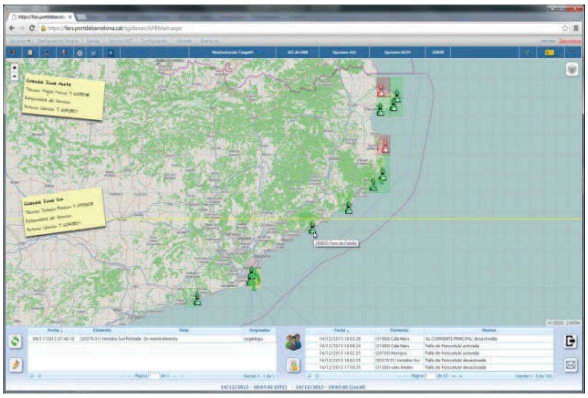
- AtoN Control and Monitoring System: The main aim of the remote monitoring system is to monitor, supervise and remotely control distant stations (lighthouses, beacons and buoys).

  The AtoN control and monitoring system is currently applied to twelve lighthouses, eight significant beacons and five buoys.

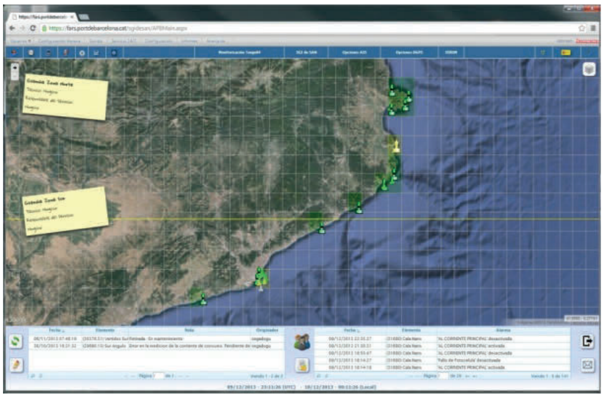
- Monitoring system for DGPS stations under the APB's responsibility. It implements remote monitoring of the two DGPS stations that are



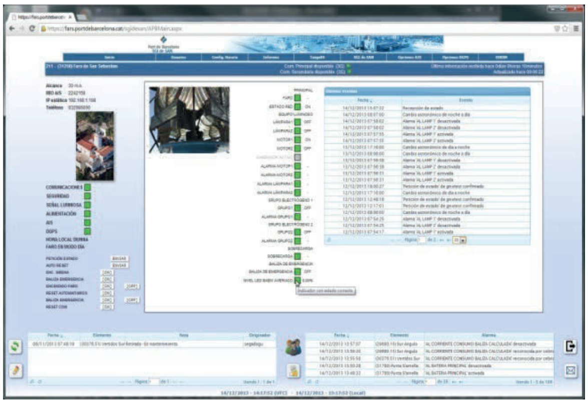
Functional architecture



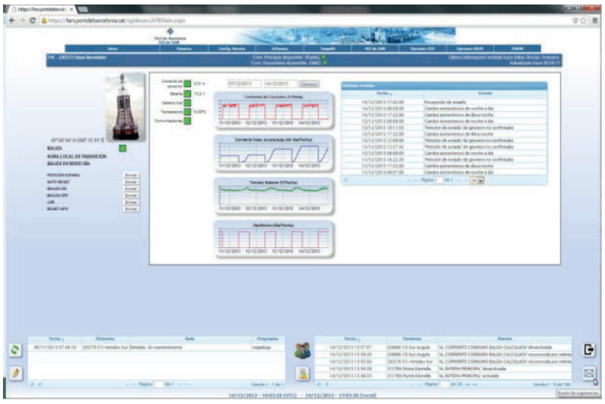
Main window with OSM charting.



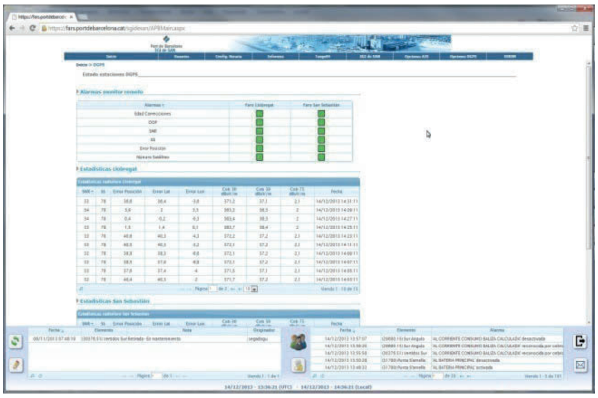
Main window with Google Earth charting.



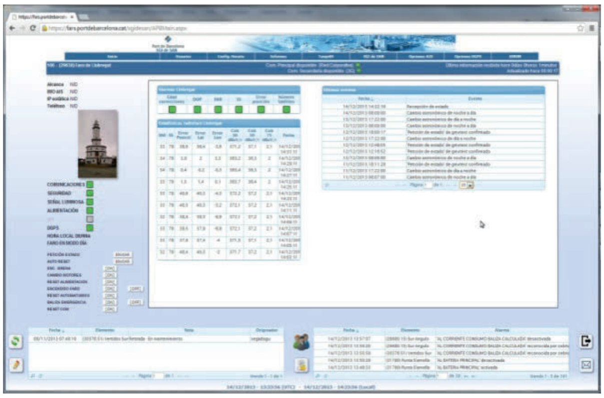
Window displaying details of the indicators on a lighthouse's light signal system



Window main displaying a beacon's details.



General DGPS system monitoring window

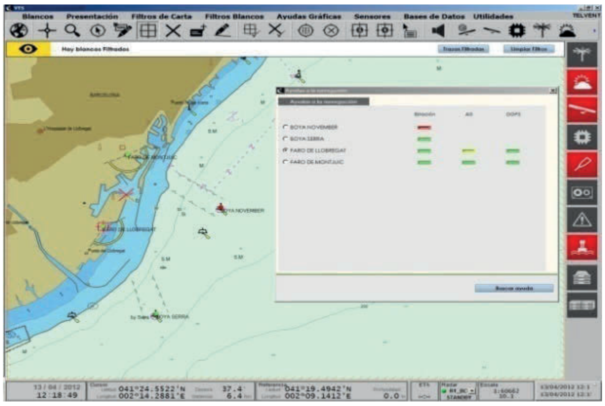


Window displaying details of the indicators on a DGPS station's system.

managed and administered by the Barcelona Port Authority.

- **Automated data interchange with Puertos del Estado's I-ATONIS Integrated Service**, including status data on the AtoNs belonging to the systems dependent on the APB, so the data can be displayed and broadcast through centralised channels, such as the PORTAL-AtoN application and the AIS-Port Network.

- AIS Station Control and Monitoring System, which includes the Barcelona Port Authority's AIS base stations and AIS network, real AIS of the Port of Barcelona's signals and synthetic and virtual AIS located along the coastline under the APB's responsibility.
It is currently applied to three AIS base stations, four physical AIS-AtoN stations, seventeen synthetic AIS-AtoN signals and a virtual AIS-AtoN.



Window for displaying data on the PMS AtoNs system. Source IDOM

- Interchange of status data with the Marine-Port Management System (PMS) of the Port of Barcelona's "Control Tower". The GIS provides status data on the signals it monitors in real time to the marine traffic management system (PMS).

  The system implements an interrogation protocol with the PMS to verify on a continuous basis that the exchange of data is being conducted properly.

- Data interchange with the APB's Business Services Monitoring and Management System (TANGO/04). The system is monitored by the TANGO business management services, which are in charge of constantly monitoring that the Remote AtoN Monitoring, AIS and DGPS systems, along with the database storage servers and the system's communications are running properly. Any incidents reported are dealt with and managed by the APB Helpdesk.

- Shortcut from the user interface to the ShipLocus application that displays AIS targets and to the Port of Barcelona and Puertos del Estado websites.

- The system is equipped with specific information on facilities, like their location, access, contact people and telephone number, along with any other information to ease the task of operators.

- High degree of parameterisation, thus allowing for the possibility of creating customised statistical reports, managing any alarms set, sending notices via SMS or e-mail depending on the kind of alarm, whether manual or automated, and programming commands between dates and times. The execution or status request command should automatically run at the time set.

- The application features several operating environments and allows sound and/or visual alarms to be set on the basis of their type/criticality, incidents with a diagnosis, resolution and closure to be recorded, the real-time detection of buoy positions and alarms to be triggered should there be breakage in their chains. MMB02 non-intrusive monitoring system at the beacon/lighthouse to be monitored and data transmission protection system through encoding or passwords.

Added value applications which will connect the Remote Monitoring System to other Barcelona Port Authority departments will be developed in the future, such as:

- Data interchange with the Conservation Department's Management System, including inventory, registration and incident data at the signals monitored by the IMS-AN, which will in the future allow the economic management of the AtoN services to be exhaustively monitored. This project is pending the Conservation and AtoN Department's Management System (GISCONSER).

- Data interchange with the corporate website, which will enable us to offer the APB clients real-time information on the status of AtoNs via the Port of Barcelona corporate website.

As has already been mentioned, this Remote Monitoring, System includes several external connections to other of the Barcelona Port Authority's applications and to those of other agencies, such as Puertos del Estado's Spanish Integrated AtoN Information Service (I-ATONIS).

PUERTOS DEL ESTADO'S I–ATONIS SERVICE AS THE SPANISH AtoN INFORMATION SERVICE

It should firstly be stated that I-ATONIS is a service and not a system. However, the coordination of various systems and the automation of information interchange procedures, whenever possible, are necessary in order to access this service

The aim of the I-ATONIS service is to place at the disposal of users an updated inventory of all existing marine AtoNs in Spain, along with an indication of their service status over the Internet and through synthetic AIS-AtoN signals by automating the process from an incident's detection in the Remote Monitoring System to transmission by the AIS network via a single database: PORTAL-AtoN[2].

We will begin by presenting the PORTAL-AtoN Web application (http://portalaton.puertos.es/portalAton), the basic tool for the AtoN service's integrated management by Puertos del Estado. However, for the purposes of this paper, we will only focus on the **inventory** and **change of status notification** functionalities, which are updated by the people holding responsibility for each AtoN by accessing the application through a username and password.

At a national level, the inventory is public and can be accessed freely from the Puertos del Estado website (www.puertos.es – Aids to Navigation (AtoN) – Data Centre – Service Status) or from the PORTAL-AtoN URL. The hierarchical structure of the information is as follows:

- Geographic Unit (set of different installations in the same area that be marked jointly)
- Installation (port and other elements that should be marked jointly and have a unique responsible)
- Site (place of an Installation; place that provide the coordinates)
- Aids (each of the different AtoNs existing in the same site)

Service status is set out as follows:

- In service (green)
- Out of service (red)
- Reduced service/other (yellow)
- Temporary withdrawal (purple)
- Scheduled incident (blue)
- Abandoned or destroyed (grey)

In addition to notifying changes of status once these have come about, the application allows for the notification of scheduled actions which will affect the service (scheduled incidents).

Updating the inventory is done automatically through the "New, Deletion and Other Changes" functionality in the "Incidents" tab (only for registered users - managers) via the PORTAL-AtoN application. An alternative way consists of these changes in the inventory being sent by those holding responsibility by fax or e-mail to Puertos del Estado, which would then be in charge of updating the inventory in such cases.

Likewise, service incident notifications (changes of status: additions and withdrawals) are notified by those holding responsibility for the AtoNs to the PORTAL-AtoN system through the "Change of Status Management" functionality. As has been indicated above for the updating of the inventory, those holding responsibility can also send notifications by fax or e-mail, in which case Puertos del Estado will be in charge of entering such status changes into the computer application.

For both these cases, we are making an effort to use only the PORTAL-AtoN application for this kind of notifications, thus eliminating fax or other sorts of unintegrated communication.

Once the information on new aids, withdrawals, changes of status has been entered in the PORTAL-AtoN application by those responsible for the aid (or by the Puertos del Estado operator), the information is automatically transferred by electronic means through a standard e-mail to the same person holding responsibility (as confirmation), the relevant port authority (as appropriate, or manager in general), the inspection agency corresponding to the aid and the Marine Hydrographical Institute, so that it can be published in Notices to Mariners or other nautical documents.

This information is also sent through an FTP service to the SASEMAR agency, which holds responsibility for Marine Safety, so that it can be broadcast through navigational warnings. SASEMAR automatically incorporates such information into its local and coastal navigational warning management application.

Apart from accessing inventory and service status information through the PORTAL-AtoN URL, a KMZ file can be downloaded free. This KMZ file connects to the database each time it is opened. Hence, it always provides up-to-date information on both the inventory and service status, along with a photograph of the site. Furthermore, access can be gained to the detailed data contained in the inventory and change od status database.

Up to this point, we have presented how to access information on AtoNs in Spain via the Internet.

The new functionality that completes the I-ATONIS service covers two areas:

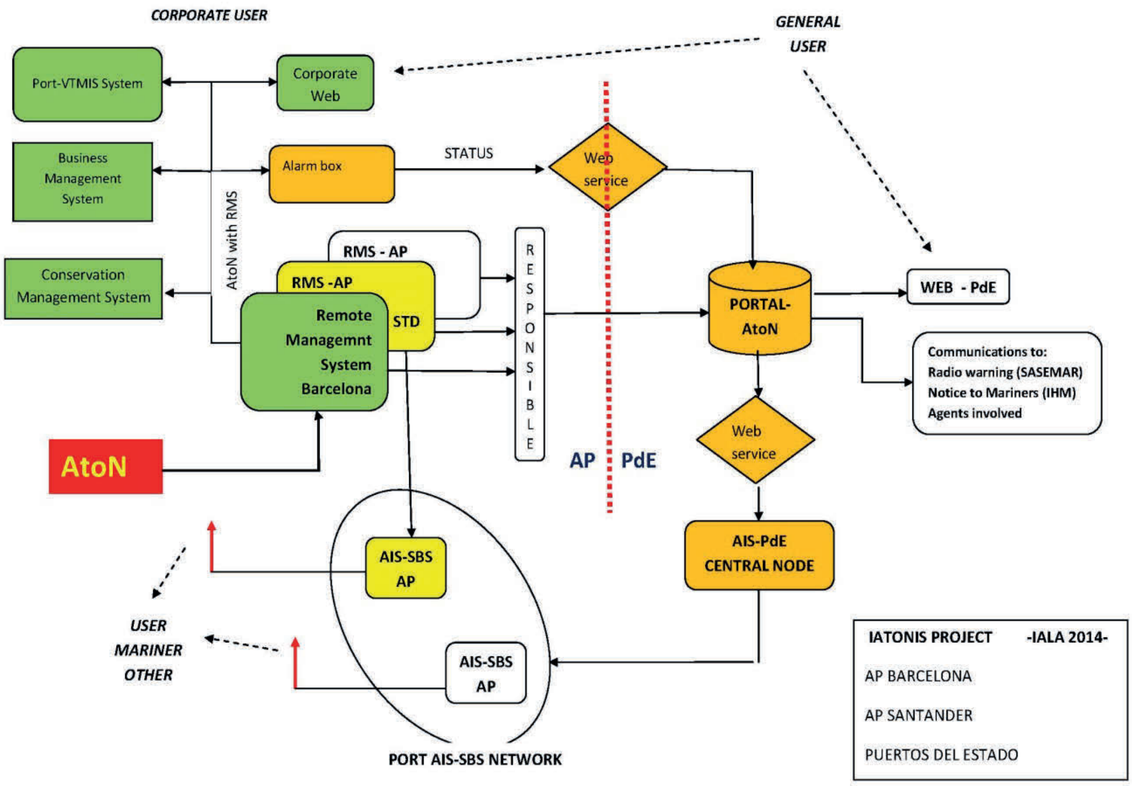
- On the one hand, changes of status notifications generated in a Remote Control and Monitoring System (as in the case of the Barcelona Port Authority) will be automatically (or semi-automatically) transferred by computerised means to the PORTAL-AtoN service and, whenever possible, the manual inputting of incidents into the PORTAL-AtoN Web application by those responsible for aids will be eliminated.
- On the other, any status (and inventory) information available in the PORTAL-AtoN database will be broadcast through AIS-Port

shore stations (Puertos del Estado) via synthetic AIS messages.

In both cases, Remote Monitoring System → PORTAL-AtoN communications and PORTAL-AtoN → AIS Network communications will be established through Web services, which will also incorporate continuous communication verification mechanisms.

AtoN status broadcasting through the AIS network will be done from the Puertos del Estado central node, where AIS message #21 and an AIS text message (#14-broadcast) will be configured according to IALA Recommendation A-126 and Guideline 1029.

In order not to affect the AIS Network's efficacy and to provide only relevant AIS information,



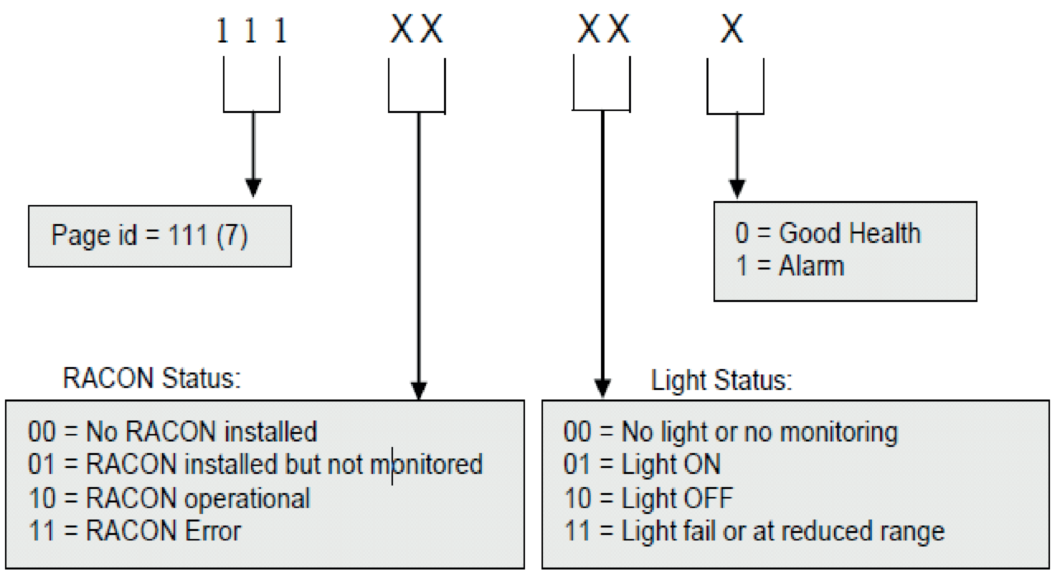


Figure 3 Recommended use of AtoN status bits

solely information on Category 1 (according to the IALA categorisation) Coastal Network aids will be transmitted (no port aids or aids on man-made obstructions), at least in an initial phase.

The functionality's other technical characteristics are as follows:

- PORTAL-AtoN will send status information according to:
  - Alarm position ON/OFF on floating AtoNs
  - RACON Failure
  - Light Failure
  - AtoNAlarmFlag
  - AIS Status Table

RACON STATUS	
0 .- No RACON	If there is no racon on the site
1.-	Will not be used
2.- Operational	In service
3.- Racon error	Out of service, reduced service, temporary withdrawal, abandoned

LIGHT STATUS	
0.- No light	If the site has no light or not in service
1.- Light on	Will not be used
2.- Light off	Will not be used
3.- Light failure or reduced	Out of service, reduced service, temporary withdrawal, abandoned

AtoNAlarmFlag will be alarm (1), where RACON is 3 or LIGHT is 3. Otherwise it will be 0 (Good Health)

- Table of Mark Types

Code - Definition	To send
1 - LIGHTHOUSE	5
2 - COASTAL BEACON	5
3 - SECTOR LIGHT	6
4 - DIRECTIONAL LIGHT	6
5 - LEADING LINE	7 = Front / 8 = Rear
6 - STARBOARD HAND MARK	14 = Fixed / 25 = Floating
7 - PORT HAND MARK	13 = Fixed / 24 = Floating
8 - Lateral mark modify, preferred channel to starboard	16 = Fixed / 27 = Floating
9 - Lateral mark modify, preferred channel to port	15 = Fixed / 26 = Floating
10 - NAVIGABLE WATER (LANDFALL)	18 = Fixed / 29 = Floating
11 - ISOLATED DANGER	17 = Fixed / 28 = Floating
12 - SPECIAL MARK	19 = Fixed / 30 = Floating
13 - WRECK	19 = Fixed / 30 = Floating
14 - CARDINAL NORTH	9 = Fixed / 20 = Floating
15 - CARDINAL EAST	10 = Fixed / 21 = Floating
16 - CARDINAL WEST	12 = Fixed / 23 = Floating
17 - CARDINAL SOUTH	11 = Fixed / 22 = Floating
18 - HORN	
19 - OTHERS	
20 - UNKNOWN	0
21 - SEMAPHORE	
22 - DIRECTIONAL SECTOR LIGHT	6

- PORTAL-AtoN sends any incident (change od status) that may come about at any time or any change in active incidents to the AIS Network.
- The AIS Network transmits the corresponding message on a periodic basis (every 3 minutes – configurable) to vessels.
- PORTAL-AtoN transfers data on all active incidents to the AIS Network once a day.
- The AIS Network updates incident data and verifies the status of all AIS-AtoN.
- When there are no incidents in an AtoN, the AIS Network does not transmit any message (except the AIS-AtoNs that are transmitting on a permanent basis).
- In order to ensure there is a connection between both systems, both will conduct still alive verifications every 30 minutes, record them in a log and send a warning e-mail in case of failure. The verifications will be conducted in an overlapping way: PORTAL-AtoN at 0 and 30 minutes of every hour and AIS Network at 15 and 45 minutes. Such warnings will be sent by

each system to the e-mail addresses designated for both systems.

- AtoN Status: status field: RACON + Light. Both will be dealt with jointly when they are in the same site (same coordinates). The status of both will always be sent in the same message.

  When the Racon and Light coordinates are different, they will dealt with as two different aids; Racon and Light should have a different MMSI.

The AIS message management system (#21 and text) at Puertos del Estado defines for every AtoN the shore base station (SBS) through which AIS messages should be transmitted and checks that this is not being transmitted at a local level.

Details on the format for AIS message #21 → AtoNs data interchange are set out in the tables below.

This service model, which based in an old idea of IALA's known as e-ANSI, manages to attain greater efficiency and coherence in AtoN status information in Spain through the integration and automation of procedures. It avoids duplication in the different procedures involved and applies the "single data" principle whenever possible.

CONCLUSIONS

AtoN service levels, like the quality levels undertaken, can only be ensured if reliable and efficient information systems are available.

The connection between original data in the local node and the database in the central node should be as automated as possible through Web services to ensure the integrity of the information.

This service (and inventory) status information should be notified as soon as possible to mariners and other interested parties, including organizations' internal customers. In order to achieve this, the most efficient ways are through Internet access to a single database or via AIS-AtoN messages, in addition to Web services for communications with other added value applications.

The integration of procedures that enable the almost immediate availability of information generated locally in a unified database (accessible over the Internet) and its broadcasting through AIS-AtoN messages is what we have called the "I-ATONIS Service". ■

[1] "Semi-automated" here means that it can either be automated or after prior validation by an operator.

[2] Developed by PORTEL Servicios Telemáticos, S.A. as per Puertos del Estado specifications.

AIS Network - MESSAGE #21 - Aids to Navigation Message

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Message ID	6	Identifier for this message: 21					
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. Refer to §4.6.1; 0 - 3; default = 0; 3 = do not repeat any more.					
ID	30	MMSI number	Number format 99224xxxx. Example: 992240001	<MMSI>992240001</MMsI>	MMSI ("AIS network identifier"), new field that will bein the site	int	numb er
Type of Aid-to-Navigation	5	0 = not available = default; refer to appropriate definition set up by IALA; refer to Table 34bis.	Two-number code according to table 34 bis / table 6.2 below; Example: 14 = Starboard hand mark	<tipoAtoN>14</tipoAtoN>	Type of AtoN will be sent according to "Table of Mark Types" in PORTAL-AtoN	int	code

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Name of Aid-to-Navigation	120	Maximum 20 characters 6 bit ASCII, "@@@@@@@@@@@@@@@@@@@@" = not available = default.The name of the Aid-to-Navigation may be extended by the parameter "Name of Aid-to-Navigation Extension" below.	AtoN name Example: "FINISTERRE LIGHTHOUSE Fl[1]W"	<name>BOYA NORTE</name>	We will send the name of the site.It is convenient to indicate the same name as in chart	String	name
Position accuracy	1	1 = high (10 m; Differential Mode of e.g. DGNSS receiver) 0 low (10 m; Autonomous Mode of e.g. GNSS receiver or of other Electronic Position Fixing Device); Default = 0	1 - If position is received from the Port Authority through an automated monitoring system and accuracy is better than 10 metres 0 - If it is a position obtained manually or if the position has been received from the Port Authority but accuracy is worse than 10 metres. For the moment, I feel we should always use 0	<posAcc>0</posAcc>	Include it in messages with low value = 0.	int	0.1

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Longitude	28	Longitude in 1/10 000 min of position of Aids-to-Navigation (±180 degrees, East positive, West negative. 181 degrees (6791AC0 hex) = not available = default)	± xxx.xxxxx minimum 5 decimal numbers which correspond to 1 thousandth of a minute Examples: - 006.12345 = 6.12345 West 001.12345 = 1.12345 º East	<longitude>XXX,XXXXX</longitude><longitude>-XXX,XXXXX</longitude>	OK	double	degrees
Latitude	27	Latitude in 1/10 000 min of Aids-to-Navigation (±90 degrees, North positive, South negative, 91 degrees (3412140 hex) = not available = default)	± xx.xxxxx minimum 5 decimal numbers which correspond to 1 thousandth of a minute Examples: 40.12345 = 1.12345 º North (we will have negative values = South)	<latitude>XX.XXXXX</latitude><latitude>-XX.XXXXX</latitude>	OK	double	degrees
Dimension/Reference for Position	30	Reference point for reported position; also indicates the dimension of Aid-to-Navigation in metres (see Fig. 18 and § 3.3.8.2.3.3), if relevant. (1)	Dimensions A, B, C and D according to figure 18 and A.126, Section 4.8.3PORTAL-AtoN will generally not have this data. Where unavailable, 0, 0, 0 .0. Where available, they will be whole numbers in metres. If buoy diameters are available, A = B = C = D=1 or 2 or 3... can be determined Quantities = diameter divided by 2	<dimension>1,0,2,1</dimension>	Include it in messages with value = 0,0,0,0.	TipoDimension	[metres]

The fields in this colour should be sent by PORTAL-AtoN	
The fields in this colour the will be generated by the AIS Network	

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Type of Electronic Position Fixing Device	4	0 = Undefined (default); 1 = GPS, 2 = GLONASS, 3 = Combined GPS/GLONASS, 4 = Loran-C, 5 = Chayka, 6 = Integrated Navigation System, 7 = surveyed. For fixed AtoNs and synthetic/virtual AtoNs, the surveyed position should be used. The accurate position enhances its function as a radar reference target. 8 – 15 = not used.	If this information is available because it has been received from a Port Authority through an automated monitoring system, the corresponding value will be indicated. If the data is not available, send 0 or 7, as appropriate.	<posDevice>1</posDevice>	Include it in messages with value 0.	int	code
Time Stamp	6	UTC second when the report was generated by the EPFS (0 –59,or 60 if time stamp is not available, which should also be the default value,or 61 if positioning system is in manual input mode, or 62 if Electronic Position Fixing System operates in estimated (dead reckoning) mode,or 63 if the positioning system is inoperative)					

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Off-Position Indicator	1	For floating Aids-to-Navigation, only: 0 = on position; 1 = off position; NOTE – This flag should only be considered valid by receiving station, if the Aid-to-Navigation is a floating aid, and if Time Stamp is equal to orbelow 59. For floating AtoN the guard zone parameters should be set on installation.	Indicator on whether the aid is in the correct position or not (only for floating aids). 0 - If the position is correct; and 1 - If it is notIf the aid is not a floating aid, PORTAL-AtoN will send: 2	<offPosition>1</offPosition>	0 - If the position is correct; and 1 - If it is notIf the aid is not a floating aid, PORTAL-AtoN will send: 2	int	code

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Reserved for regional or local application	8	Reserved for definition by a competent regional or local authority. Should be set to zero, if not used for any regional or local application. Regional applications should not use zero.	This is the field where the status of the AtoN appears according to Recommendation A.126, pages 14-18. 8 bits distributed in the following way from left to right: bits 1-3: Are always 111 bits 4-5: Indicate RACON status: 00 = No RACON installed 01 = RACON installed but not monitored 10 = RACON operational 11 = RACON Error Bits 6-7: Light signal status - We will only use 00 and 11 depending on status 00 = No light or no monitoring 01 = Light ON 10 = Light OFF 11 = Light fail or at reduced range Bit 8: General Status - general status considering RACON and Light 0 = Good Health (both OK) 1 = Alarm (any of the two not OK)	The value of bits 4 to 8 should be indicated in all AtoNs sent to the AIS Network. <status>0,1,0</status>No Racon installed, Ligth ON, Good Health	- Racon status, Light status, General status	TipoEstado Ais	code
RAIM-Flag	1	RAIM (Receiver Autonomous Integrity Monitoring) flag of Electronic Position Fixing Device; 0 = RAIM not in use = default; 1 = RAIM in use)					

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Virtual AtoN Flag	1	0 = default = real AtoN at indicated position; 1 = no AtoN =ATON does not physically exist, may only be transmitted from an AIS station nearby under the direction of a competent authority. (2)					
Assigned Mode Flag	1	0 = Station operating in autonomous and continuous mode =default1 = Station operating in assigned mode					
Spare	1	Spare. Not used. Should be set to zero.					
Name of Aid-to-Navigation Extension	0, 6, 12, 18,24, 30, 36, 84	Combined with the parameter “Name of Aid-to-Navigation” at the end of that parameter, when more than 20 characters are needed for the Name of the Aid-to-Navigation. This parameter should be omitted when no more than 20 characters for the name of the A-to-N are needed intotal. Only the required number of characters should be transmitted, i. e. no @-character should be used.					

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
Spare	0, 2, 4, or 6	Spare. Used only when parameter "Name of Aid-to-Navigation Extension" is used. Should be set to zero. The number of spare bits should be adjusted in order to observe byte boundaries					
Number of bits	272–360	Occupies two slots.					

ADDITIONAL FIELDS

Type of transfer			Indicates the type of PORTAL-AtoN -> AIS Network transfer [1] Entry of incident (1 AtoN) Type + Data gatherin (see Excel) [2] Change of incident (1 AtoN) Type + Data gathering (see Excel) [3] Withdrawal of incident (1 AtoN) Type + MMSI [4] Transfer all (1 per day) (study and decide) [5] Transfer the inventory (1 per day)				

The fields in this colour should be sent by PORTAL-AtoN
The fields in this colour the will be generated by the AIS Network

Parameter	Nº bits	Descrption	Observation: Data to be provided by PORTAL-AtoN	XML - format	PORTAL-AtoN	Type of data	Data unit
AtoN Category			Indicate AtoN category 0 - Not classified 1 - Category 1 = Lighthouses and RACONS 2 - Category 2 = coastal network beacons 3 - Category 3 = rest of AtoN Only categories 1 and 2 will be transmitted	<categoria>1</categoria>	OK	int	code
Data from of a RMS			Indicate whether the status and position data come from an automated monitoring system or whether they have been provided manually 0 - Manual 1 - From RSM	<origenSSRSM>14</origenSSRSM>	Include it in messages with value 0.	int	code

19 CONVERSION OF LIGHT BUOYS IN THE NORTH AND BALTIC SEA ON COMPACT LIGHTING UNITS WITH LED AND SOLAR TECHNOLOGY, AIS AND REMOTE MONITORING

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The German Waterways and Shipping Administration (WSV) operates nearly 1500 light buoys in the North and Baltic Sea. For decades gas lamps or incandescent lamps were used as light source. Since 2004 these light buoys have been converted to LED- and solar technology. As a consequence the luminosity was reduced on two main classes of solar lanterns. For large light buoys the so-called "SKA" ("solar compact unit"), which was a proprietary development of the WSV, is in use. It consists of a solar energy source in a compact housing and an external LEDlantern. Mid size light buoys are equipped with the "IPSL" (Integrated Power System Lantern), the development of which was based on functional and design specifications of the WSV taking into account the following IALA papers: IALA Guideline No. 1064: Integrated Power System Lantern, IALA Recommendation A-126: AIS in Marine Aids to Navigation Services, IALA Guideline No. 1069: Synchronisation of Lights In addition to the LED- and solar technology the IPSL includes further features such as "Aids to Navigation" via AIS, remote monitoring (condition of the technology, position monitoring), astronomical clock and synchronisation of light.

The presentation describes both, the conversion itself (preparatory work, engineering, procurement and impact on the operation of the workshops and the buoy tenders) as well as experience up to now. Furthermore, it gives an outlook on the future developments in the areas of lighting, solar technology, batteries and additional systems to be expected on light buoys. Also the further optimization of operation and maintenance is considered, especially in context with conversion to plastic buoys and the demand for ice strength.

La Administración Alemana de Navegación Fluvial y Transporte Marítimo (WSV) opera cerca de 1500 boyas luminosas en el Mar del Norte y el Mar Báltico. Durante décadas se utilizaron lámparas de gas o lámparas incandescentes como fuente de luz. Desde 2004 estas boyas luminosas se han convertido a tecnología solar y LED. Como consecuencia, la luminosidad se redujo a dos tipos principales de linternas solares. Para las boyas luminosas grandes, se utiliza la llamada «SKA» («unidad solar compacta»), un desarrollo patentado por la WSV formado por una fuente de energía solar dentro de una carcasa compacta y una linterna LED externa. Las boyas luminosas de tamaño mediano están equipadas con «IPSL» (Linterna con Sistema Integrado de Energía), cuyo desarrollo se basó en especificaciones funcionales y de diseño de la WSV teniendo en cuenta los siguientes documentos de la IALA: Directriz N.º 1064 de la IALA: Linternas con sistema integrado de energía, Recomendación A-126 de la IALA: Uso de AIS en servicios marítimos de ayuda a la navegación, Directriz N.º 1069 de la IALA: Sincronización de luces. Además de la tecnología solar y LED, la IPSL incluye otras características como las «Ayudas a la Navegación» mediante AIS (Sistemas de Identificación Automática), control remoto (estado de la tecnología, control de posición), reloj astronómico y sincronización de luz.

La presentación describe tanto la propia conversión (trabajo preliminar, ingeniería, adquisición e impacto sobre el funcionamiento de los talleres y buques balizadores) como la experiencia obtenida hasta ahora. Es más, proporciona una perspectiva sobre los desarrollos futuros en el ámbito de la iluminación, tecnología solar, baterías y sistemas adicionales previsibles para boyas luminosas. También se considera la mayor optimización del funcionamiento y el mantenimiento, especialmente en el contexto de la conversión a boyas de plástico y la demanda de resistencia al hielo.

L'Administration allemande de la navigation et des voies navigables (WSV) entretient environ 1 500 bouées lumineuses dans le nord de la mer Baltique. Depuis des décennies on utilisait, comme source lumineuse, des lampes au gaz ou à incandescence. Depuis 2004 ces bouées ont été converties aux LEDs et à l'énergie solaire. En conséquence, la luminosité de deux importantes classes de lanternes solaires a été réduite. Sur les grandes bouées lumineuses on utilise des

SKA (Solar Compact unit), développées par la WSV. Elles comprennent une source d'énergie solaire dans un compartiment compact et une lanterne LED extérieure. Les bouées lumineuses moyennes sont équipées d'un IPSL (Integrated Power System Lantern) développé suivant des spécifications de la WSV, en accord avec les documents suivants de l'AISM: Guide n° 1064 - Integrated Power System Lantern, Recommandation A- 126 - AIS in Marine Aids to Navigation Services, Guide n°1069 Synchronisation of Lights. Outre les LEDs et la technologie solaire le IPSL contient d'autres aspects tels que les aides à la navigation par AIS, la télésurveillance (état de la technologie, surveillance du positionnement), horloge astronomique et synchronisation du feu.

La présentation décrit à la fois la conversion elle-même (préparation, ingénierie, achat et impact sur le fonctionnement des ateliers et des baliseurs, ainsi que l'expérience réalisée jusqu'à présent.

De plus, il introduit les futurs développements en matière d'éclairage, de technologie solaire, de batteries et autres systèmes utilisables sur des bouées lumineuses. Il évoque enfin la future optimisation du fonctionnement et de la maintenance, en particulier dans le contexte de conversion vers les bouées en plastique et des exigences de résistance à la glace.

Conversion of light buoys in the North and Baltic Sea on compact lighting units with LED and solar technology, AIS and remote monitoring

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Introduction

The German Waterways and Shipping Administration (WSV) operates approximately 4000 floating aids to navigation in the North and Baltic Sea. Nearly 1500 of them are lighted (light buoys, light vessels). The gas technique, which had originally been used for lighting, and electric incandescent systems installed meanwhile have been replaced consequently by LED and solar technology since 2000. With two classes of luminosity and the compact photovoltaic-powered carrier systems “Solarkompaktaufsatz” (SKA, i.e. solar compact unit) and “Integrated Power Sys-tem Lantern” (IPSL) about 95 % of the lighting requirements of the German coast have been accomplished. Also on inland waterways and ports these systems are used. In addition to the LED and solar technology further functions such as AIS and remote monitoring have been implemented. The individual development and conversion steps are described as follows.

Photovoltaic Energy Supply

The photovoltaic energy has proven as a reliable and low-maintenance power supply for buoys. In the WSV (Waterways and Shipping Administration) it was first introduced in the late

Figure 2: Gas lantern with solar supplied flasher (1988), large solar buoy (1990), small solar buoy (1992)

1980s on large numbers to supply electrical flashers of gas lanterns. In the early 1990s some large light buoys and a lot of small light buoys have been equipped with photovoltaic energy. The lighting technology consisted of incandescent electric lamps in conjunction with changers. Maintenance intervals up to 1.5 years were possible. But this light source was relatively inefficient, because the required light colour (red, green, yellow) had to be filtered from the white light of the incandescent

Figure 1: Buoys with IPSL and SKA

lamp. Nearly 80% of the original brightness got lost. So relative many solar panels and large batteries were required. The photovoltaic components were mounted on and inside of the buoy. This type of distribution and a high number of electrical connections caused a relatively trouble-prone system compared to today's requirements.

LED Technology

Developed in the early 1960s, LED technology has been used for decades only as display element, mainly on account of poor luminosity. In the mid of the 1990s the luminosity increased and the application range of this durable and maintenance free technology expanded also to navigation marks. Compact LED marine lanterns have been developed, a maintenance free operation for more than 10 years was expected. Equipped with microprocessor the flasher was implemented and advanced functions such as parameterization via infrared interface and wireless remote diagnosis were possible.

A special advantage of LED technology is the generation of light directly in the required colour, which decreases the electrical power consumption significantly. In comparison to the gas technology also a more uniform light distribution and a higher vertical dispersion were realised. In addition the flash characters are represented very clearly because of rapid switching between 0 % and 100 % of brightness. After various tests and trials the WSV decided in 2000 to convert all light buoys to LED and solar technology. Coast wide uniform

Figure 3: Compact LED marine lanterns

components and standards should be used for easier handling, stocking of spare parts and training of the employees.

"Solarkompaktaufsatz" (SKA, Solar Compact Unit) for Large Light Buoys

The standard gas-powered light buoy type "LT81", which was introduced in West Germany (Federal Republic of Germany) in 1981, constitutes the biggest number (800 units) of WSV light buoys. The main areas of application are the exclusive economic zone (EEZ), territorial sea and estuaries of rivers. The body is made of steel, has a diameter of 2.5 m, a total height of about 9 m and a weight of nearly 5 tonnes. With the integrated 300 kg gas barrel the gas lantern operated up to 1.5 years.

At the same time East Germany (German Democratic Republic, GDR) introduced the comparable type "TWT76" (deep water buoy) and the "FWT" (flat water buoy).

All these three buoy types had comparable photometric parameters. Therefore the coast-wide conversion to LED and solar technology was started with these buoys.

The new specifications had to adopt the photometric parameters of the gas powered light buoys. The vertical light distribution was defined corresponding to ***figure 4***. The maximum values (100 %) for the different colours are:

- red/green: 40 cd
- yellow: 35 cd
- white: 120 cd

Merchantable LED marine lanterns with red, green and yellow light had an electric power consumption of approximately 3.6 W for the aforementioned luminosities. Lanterns with white light were not available with sufficient luminosity and suitable power consumption. Conversion white light for the buoys was held back to benefit from the ongoing improvement of white LED design, resulting in lower power consumption.

Based on the small power consumption of 3.6 W the main components of photovoltaic energy supply, i.e. solar panels and battery, could be minimized to fit all components in a compact plastic housing. So the "SKA" ("Solarkompaktaufsatz", i.e. solar compact unit) was designed by the "German Traffic Technologies Center" (GTTC / FVT, Koblenz). For sizing the photovoltaic power supply the following IALA-guidelines were considered:

- 1039: Designing Solar Power Systems for AtoN (solar sizing program)
- 1042: Power Sources for AtoN
- 1044: Secondary Batteries for AtoN

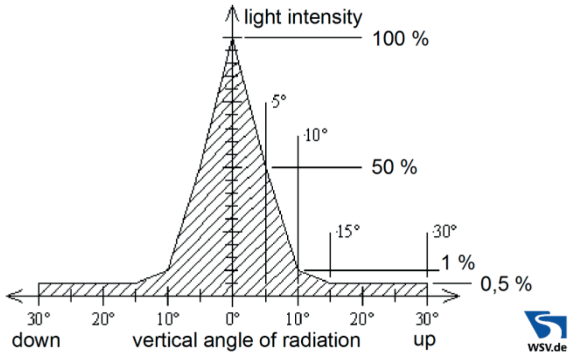

Figure 4: Specification of photometric parameters

The energy is generated by 4 solar modules with each 30 W peak power. They are mounted nearly vertically on the SKA housing. The solar battery consists of 6 in series connected single lead-acid cells, each with 2V and 240Ah. A charge controller manages the energy flow between solar modules and battery and prevents it from overcharging. All other functions have been integrated into the LED marine lantern. These are:

- LED light source
- flasher (parameterized by an infrared programming device)
- dusk switch for switching light source on and off
- battery deep discharge protection (gradual reduction of luminosity up to total switch-off)
- remote monitoring: functional test from the buoy tender by radio-diagnostic device (start the flasher and query parameters of the solar supply)

The SKA housing is an own development of the WSV and consists of 2 parts. The upper housing holds all external attachments and is made of polyethylene (PE) by rotational moulding. The mould is owned by the WSV.

The housing base is assembled by welding polyethylene plates. It serves as the base plate and carrier for the inner parts of the SKA, such as battery, solar charge controller, DC-distributor, etc.

Figure 5: SKA

Figure 6: Mould for upper housing

For a better daytime visibility all upper housings were manufactured in coloured plastic at the beginning of the conversion. Securing long-term colour stability, especially for red, needed special UV stabilization of the colour pigments and the plastic. After initial difficulties (fading) the result was satisfactory. Measurements on some, now more than 10 years old housings confirm this.

A uniform grey upper housing is easier to manufacture and simplifies the procurement and stocking of spare parts, especially on the buoy tenders. After tests with regard to the visibility, grey housings on " LT81 " and "TWT76" buoys were acceptable. Due to the smaller viewing area of the "FWT" buoy only this type still needs a coloured upper housing.

Also the labelling of buoys with SKA was unified coast-wide. The 50 cm x 50 cm big marker boards are mounted below the solar modules. Colour, font, font size, possible texts, etc. were specified in detail.

The IP67-protected DC distributor connects all electrical system components and includes also surge arresters as well as circuit breakers for the separation of the solar battery. For a high reliability plug connections were avoided. The above-described "simple" design of the SKA has been proven in large numbers over a period of more than 10 years now. In the fault and failure statistics only a few technical failures are recorded, most of them are related to the LED marine lantern.

By 2005 LED performance increased resulting in lower power consumption of 5.5 W and a luminosity of 120 cd in white colour. The maximum light to dark ratio of the flash characters used at white light is about 50%. So it was possible to convert the buoys with white light (coast wide about 120 pieces) into SKA-operation too.

Specifications of the SKA

diameter:	1000 mm
height:	1320 mm
weight:	240 kg
battery type:	lead-acid battery, maintenance free, life period 15 years
rated voltage:	12 V (6 cells a 2 V)
nominal capacity:	240 Ah (100-hour)
solar panels:	4 x 30 Wp, 36 cells in each panel
LED marine lantern:	"MB3", manufacturer "TWE"

Figure 7: Comparison of LT81 with coloured and grey housing, FWT with coloured housing

Mounting the SKA on buoys

In the North Sea a screwed fastening is used for fixing the SKA on a buoy. Originally with gas technology equipped buoys were modified so that a flat mounting plate and 4 stud bolts are available. For collision protection a protective ring is mounted. Optional a top mark attachment can be fixed.

For the shallow waters in the Baltic Sea a "quick release" was developed. It locks and opens automatically. A ships crane lands or removes the SKA. During this the buoy stays in the water. The demand for this development was given by the often rapid and widespread occurrence of ice in the shallow waters. In this case, all SKA must be removed quickly to prevent total loss. After removing the SKA only the buoy stays on position. By using the quick release also smaller ships, which cannot take a complete buoy on deck, can be used for operation and maintenance of SKA.

Figure 8: Standard SKA mounting with screws and via quick release

Introduction of the SKA

The introduction of the SKA was started under administration of the Waterways and Shipping Office Emden (WSA Emden) in collaboration with the German Traffic Technologies Center (GTTC / FVT, Koblenz) and further coastal Waterways and Shipping Offices. After the estab-lishment of the „Central Engineering and Maintenance Office for Maritime Traffic Technology" (Bündelungsstelle Maritime Verkehrstechnik, BüMVt) in 2006, the tasks were taken over by this organization, which is mainly located at the Waterways and Shipping Office Wilhelmshaven (WSA Wilhelmshaven).

Beside the procurement of the SKA via EU-wide call for tenders other activities were important, such as:

- determination of the numbers of buoys
- determination and declaration of the necessary budget
- coordination with the coastal Waterways and Shipping Offices
- preparation of a concept for the technical operation and maintenance
- organization and implementation of spare parts supply
- training the staff of the maintenance workshops
- maintenance workshops: modification and new equipment
- system support: adaptation of the SKA to current technical developments, transaction of warranty cases, fault and failure statistics.

After preparatory work a budget of approximately € 7 million was available in the beginning of 2001. To avoid additional costs for buoy tender operations, the rebuilding of the nearly 1200 buoys has been integrated into the normal maintenance cycle and the procurement was done over several years. The total number of LED marine lanterns – excluding white lights - was commissioned at the beginning in order to get coast-wide uniform lanterns, parameterization devices and radio diagnostic devices. Result of the tender was the LED marine lantern type "MB3" (manufacturer TWE) and the assembly of the SKA by Pintsch-Bamag. The delivery of the lanterns was parallel to the respective production cycles of the SKA. Following procurements were done for the German coast from 2001 to 2009:

- 27 SKA for test purposes (coloured housings, 2001/2002)
- 100 SKA (coloured housings, 2003/2004)
- 20 SKA with quick release for test purposes (grey housings, 2004)
- 350 SKA (grey housings, 2005)
- 230 SKA (grey housings, 2006)
- 220 SKA (grey housings, 2007/2008)
- 210 SKA with quick release (grey housings und coloured housings, 2008/2009)
- technical equipment for maintenance centres (chargers, etc.)

Operation and maintenance

The main advantages of the SKA in terms of operation and maintenance are:

- long lifetime of the components: LED marine lantern greater than 10 years, photovoltaic energy source greater than 15 years

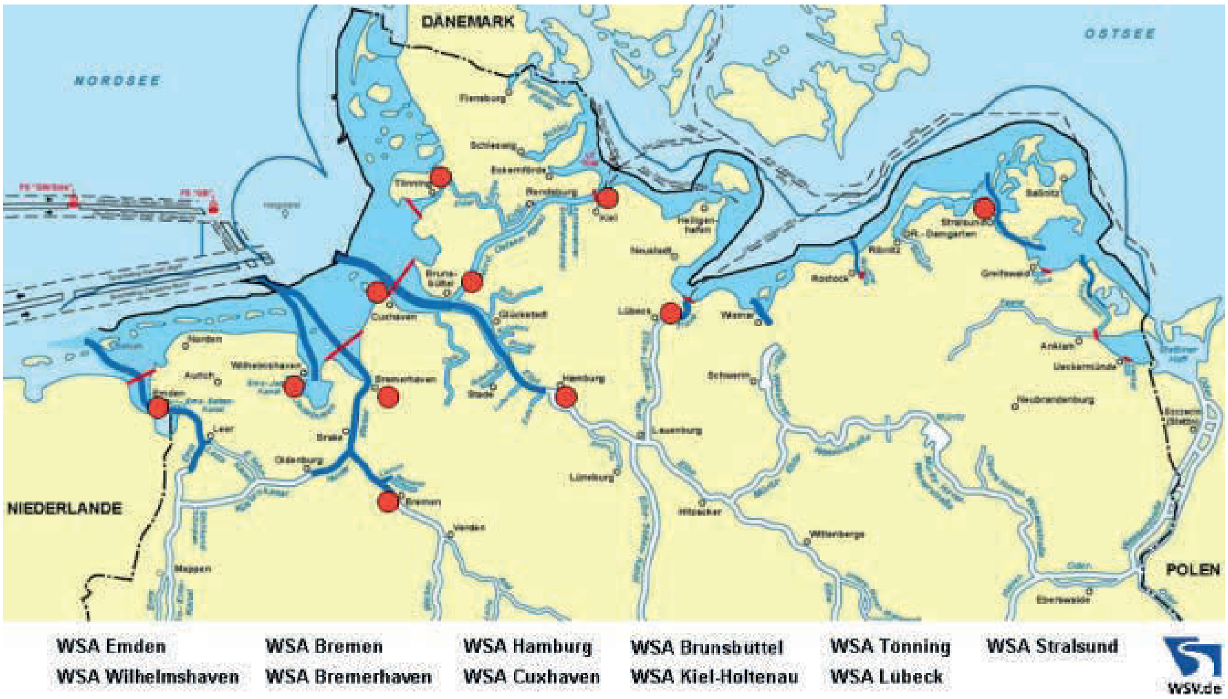

Figure 8: Standard SKA mounting with screws and via quick release

- reduced maintenance: the LED marine lantern is maintenance-free, maintenance of photovoltaic energy supply every 5 years
- possibility of quick SKA change on board of the buoy tender (no loosening of cabling, etc.)
- SKA with quick release: processing with small, inexpensive ships, rapid disassembly when the risk of ice is threatening
- remote monitoring of system parameters via radio from the buoy tender
- optimization of safety: no staff on top of the buoys.

For the operation and maintenance of SKA the profession for the staff changed from mechanics to electricians. Therefore different trainings with the following content were required:

- LED technology in marine lanterns
- fundamentals of photovoltaics, solar storage batteries, solar charge controller
- energy balance and system components of a photovoltaic energy supply
- test and measurement for photovoltaic systems
- mechanical assembly and handling of SKA
- exercises to the mounting variants of the SKA

Also the workshops for maintenance were redesigned while the SKA introduction. Both the design and the technical equipment were planned coast-wide uniform. The basic configuration of a SKA workshop contains the following rooms with appropriate equipment:

- mechanical assembly hall
- electronics laboratory
- battery charging room

After carrying out the previously mentioned works the coast-wide uniform conversion of large light buoys was completed in 2009. The SKA is also used by WSV on inland waterways and some port operators, for example "Hamburg Port Authority" (HPA). Up to now nearly 1500 units were produced.

Cost savings

The consequent conversion to LED and solar technology allowed significant cost savings concerning personnel costs and non-personnel costs. The main costs were saved by:

- reducing the procurement costs for the light source
- reducing the number of operations and maintenance employees to less than 50%
- elimination of costs for the provision of energy
- reduce the number of ship operations through greater reliability

Developments during the operation time

Because of the consistently positive experience the operation time of the SKA is planned up to 2025.

Already during the conversion phase (2001 to 2009) there were some technical advancement, such as the availability of AIS transponders with low energy consumption. Furthermore switching on and off the light by an astronomical clock, flasher-synchronization and the integration into remote monitoring systems were new navigational or operational requirements. In 2011 the procurement of a retrofit module was done, to improve the SKA by adding following features:

- astronomical clock
- synchronization of flash characters
- position monitoring by GPS
- remote monitoring via GSM
- control of an AIS transponder: Aids to Navigation (message 21), remote monitoring (message 6)

Integration to Maritime Traffic Technology System

The new „Maritime Traffic Technology System“ (“System Maritime Verkehrstechnik“, “SMV”) is currently replacing the existing traffic systems on the German coast. It has a coast-wide uniform design and supports both the nautical traffic control in the VTS-centers as well as the technical operation. Among others it consists of decentral outstations (like floating or fixed visual aids to navigation, radar stations, maritime radio, etc.) and 3 interconnected data centres at different locations. Inside the data centres data is processed, replicated and deployed. The concept of the “SMV” divides the maritime system in different “technical services”, whereby the floating aids to navigation are provided by the service "ViS" (Visuelle Schifffahrtszeichen, schwimmend).

Up to now only some very important light buoys have been remote monitored by the technical operation. With the new technical possibilities of the “SMV”, a variety of communication ways and optimized power consumption of system components, all light buoys of the WSV can be integrated into the remote monitoring. Both, operational state of the SKA (for example state of light and solar energy) as well as data related to the buoy (type, position, time on actual position, next repair, etc.) can be captured. The data transferred to the “SMV” will be available via an appropriate user interface (MMI) and may enable further optimization of the technical operation, especially with regard to the cost intensive buoy tender fleet. The system concept is illustrated in ***Figure 10***.

The technical implementation can be done during the replacement of the LED marine lantern type “MB3”, which is required now. This lantern has been introduced at the beginning of the conversion and was designed for 10 years maintenance-free

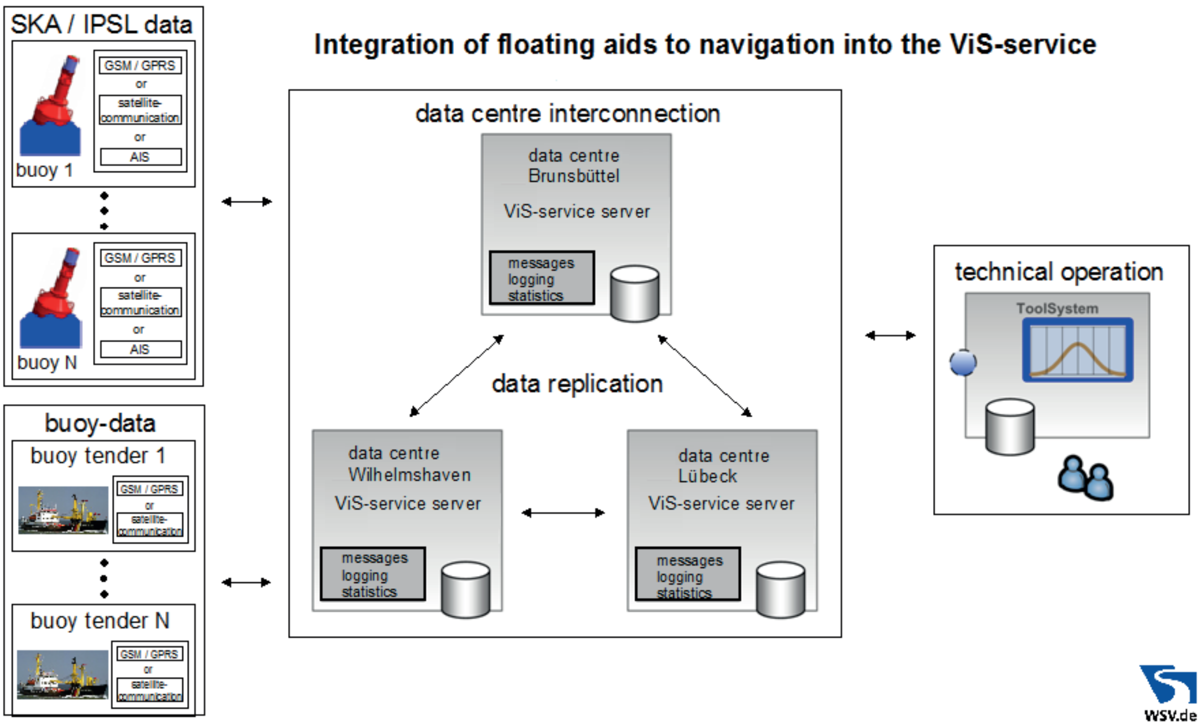

Figure 10: Integration of floating aids to navigation

operation. Those lanterns, which have been delivered at first, have already exceeded this time. The photometric parameters are still fine, but some lanterns have hairline cracks on the plastic lenses. A repair is uneconomical. Therefore, these lanterns have to be replaced gradually. The lantern type "MB3" has now been discontinued by the manufacturer and is obsolete. Currently the procurement for a replacement model is in preparation. In addition to the functions of the "MB3" and the retrofit module the new lantern model will provide an interface for remote monitoring. Depending on the availability of the type of wireless networks at the position of the buoy different data transfer modules can be connected to the interface. The following transmission ways are possible:

- GSM / GPRS
- Satellite communication
- AIS

In the meantime the energy consumption of merchantable marine lanterns has roughly halved, so that the electric energy required for data transfer can be provided by the SKA.

„IPSL" for small light buoys

For total replacement of gas technology also the conversion of approximately 200 small light buoys (type "LT140") to LED and solar technology was required. Those buoys have a diameter of about 1.4 m, a height of nearly 4 m and a weight of 1 ton. They are mainly used in the following areas:

- lower stretch of rivers
- main fairways in the wadden sea

For conversion of the "LT140" to LED and solar technology in 2009 the "IPSL" (Integrated Power System Lantern) was introduced according to the IALA Guideline No. 1064. In contrast to the SKA, which is an own development of WSV, the "IPSL" was procured by a mostly functional tender. Only a few hard design specifications were included.

Before creating the design specifications the photometric parameters had to be specified. While the SKA is equipped with luminosities of 40 cd (colour) and 120 cd (white), luminosities of 10 cd (colour) and 20 cd (white) have been established for the "IPSL". The curve of the vertical luminosity distribution is identical to that of the SKA (***figure 4***).

After providing the budget (nearly € 1 million) the tender for the "IPSL" was carried out with the following requirements:

Figure 11: Comparison between tender and execution

- mechanical dimensions: max. Diameter of 500 mm, max. height of 600 mm
- height of light: 450 mm to 600 mm
- weight: max. 50 kg
- fixing on the buoy by screwing
- sizing of the photovoltaic power supply according to IALA Directive in 1039, confirmation by the contractor
- detailed specifications for the battery, the solar modules, the function of the charge controller and the flasher were included.
- detailed description of the main constructive parameters, such as housing construction, mechanical protection of solar modules, etc. were included.
- integration of astronomical clock and dust/dawn switch
- execution of all parameterization and radio remote diagnostics analogous to the SKA under use of the same equipment
- GPS position monitoring
- remote monitoring via GSM-radio module
- preparation for integration of a Type 3 AIS aids to navigation transponder according to IALA Recommendation A-126 and IEC 62320-2
- transmission of AIS aids to navigation message (message 21) and monitoring message (message 6

- configuration of the AIS –transponder via message 18
- Retrofit AIS transponders were included with 10 % of the "IPSL" number into the tender.

Result of the tender was the „IPSL" type "SC155-2 IPSL" (manufacturer Sabik). Because of the already built-in GSM radio module it is possible, to integrate each „IPSL" into the remote monitoring of the "SMV" according to ***figure 10***.

To achieve a coast-wide uniform appearance of the "LT140" the so-called "lantern chair", which is the connecting piece between the buoy body and the "IPSL", was newly designed and put into the tender as a separate lot. ***Figure 11*** shows a comparison between the specification by the tender and the execution later on.

Specifications IPSL

diameter:	500 mm
height:	650 mm
height of light:	582 mm
weight:	37 kg
solar module:	3 x 11 Wp
battery type:	lead-acid battery, maintenance free
lifetime:	min. 10 years
rated voltage:	12 V
nominal capacity:	60 Ah (100-hour)
manufacturer, model:	Sabik, SC155-2

Conversion to plastic buoys

With reference to technical progress and strategic personnel requirements the buoy system of the WSV is still under optimization in terms of economy. In this context the potential of optimization by the coast-wide conversion from steel to plastic buoys was analysed. For small and medium buoys with diameter less than 2.5 m the conversion to plastic is cost-effective. Therefore approximately 4000 plastic buoys in different sizes have to be procured. An essential requirement on these buoys is the durability in ice so that changes of buoys in winter times can be omitted in future. Furthermore an extension of inspection intervals and optimizing the anchor system are required. Also the small light buoys type „LT 140", which were equipped with the "IPSL" in 2009/2010, are part of the plastic buoy conversion. The functions of the „IPSL" must be integrated into an ice-withstanding design. Furthermore the results of the economical studies show, that the large light buoys (types "LT81", "TWT76" and "FWT") which are equipped with SKA, should stay in steel. The steel maintenance is to centralize in a few locations. Nevertheless, there are already 4 large plastic buoys, equipped with a SKA, in the testing.

109 LASER TECHNOLOGIES FOR VISUAL AIDS TO NAVIGATION

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The paper describes results into the expediency and efficiency of laser technology application for use as aids to navigation (AtoNs), the development of commercial samples of qualitatively new kinds of aids to navigation having performance advantages and reduced cost of system maintenance.

Our approach is based on laser beams scanning with the radiation of divergence, which equals several minutes of arc. It enables to increase the detection distance on 25 - 30 % as compared with the known solutions and conventional AtoNs. Differences even more increase at the visibility decrease. Besides usage a small optical diameter of the laser beam allows to elaborate the one position leading light. This circumstance in a number of cases is solving.

Long-term sea tests, the empirical exploitation and the comparative analysis of characteristics display the following. The set-up of the laser ranges considerably improve requirements of the coastal navigation especially at low visibility and in unfavorable for observation of lights and marks requirements.

In the paper the dichromatic one position laser beacon is listed which is the most perspective experimental prototype.

In summary, the problems of operational use, the further development perspectives and an expediency of laser ranges application are discussed.

Keywords: aids to navigation, aerosol scattering and extinction, laser leading beacon

La integración de procedimientos que permiten la casi inmediata disponibilidad de información
La ponencia describe los resultados respecto a la conveniencia y eficiencia de la aplicación de la tecnología láser en el uso como Ayudas a la Navegación (AtoN) y el desarrollo de muestras comerciales de nuevos tipos de ayudas a la navegación con ventajas de rendimiento y coste reducido del mantenimiento del sistema.

Nuestro enfoque se basa en haces láser que escanean con la radiación de divergencia, que es igual a varios minutos de arco. Permite aumentar la distancia de detección en un 25-30 % en comparación con las soluciones conocidas y las AtoN convencionales. Las diferencias se incrementan todavía más a medida que decrece la visibilidad. Además, el uso de un pequeño diámetro óptico del haz láser permite elaborar la luz de enfilación de una posición. Esta circunstancia está resolviendo algunos casos.

Las pruebas en el mar a largo plazo, la explotación empírica y el análisis comparativo de características muestran que la configuración del alcance del láser mejora considerablemente los requisitos de la navegación costera, especialmente con baja visibilidad y en circunstancias desfavorables para la observación de luces y señales.
En la ponencia se detalla la baliza láser dicromática de una posición, que es el prototipo experimental con mayor perspectiva.

En resumen, se analizan los problemas de uso operativo, las futuras perspectivas de desarrollo y la conveniencia de la aplicación de gamas láser.

Palabras clave: ayudas a la navegación, dispersión y extinción de aerosoles, baliza láser de enfilación

Le rapport donne des résultats concernant l'opportunité et l''efficacité de l'utilisation de la technologie laser pour les aides à la navigation, le développement de prototypes commerciaux de nouveaux types d'aides de qualité offrant des avantages en matière de performance et de moindre coût d'entretien du système.

Notre approche repose sur le balayage de rayons laser avec une divergence de radiation qui atteint plusieurs minutes d'arc. Il permet d'augmenter la distance de détection de 25-30% par rapport aux solutions connues et aux aides conventionnelles. Cette différence augmente même lorsque la visibilité décroît. En outre, le faible diamètre du rayon laser permet de trouver la position du feu d'alignement. Ce qui, dans de nombreux cas, est LA solution. Des essais en mer sur une longue durée, l'exploitation empirique et l'analyse comparative des caractéristiques ont montré que l'installation de feux laser améliore considérablement la navigation côtière, surtout par faible visibilité et mauvaises conditions d'observation des feux et marques.

Le rapport présente le prototype de feu laser dichromatique expérimental le plus prometteur. En bref, on y discute les problèmes d'utilisation opérationnelle, les perspectives de développement et l'opportunité d'utiliser les feux laser.

Laser technologies for visual aids to navigation

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1. Introduction

In spite of the progress of radio-electronic systems, the importance of visual aids to navigation (AtoN) in the field of safety and regularity of navigation in a coastal zone does not decrease. Moreover, there is an imperative need of constant improvement and creation essentially new visual AtoN. First, it connected with complex navigating conditions in seaports, in connection with growth of a turnover of goods, the tonnage of ships and their speeds, which occurs at continuous increase of requirements to safety and reliability of navigation. Besides, sea activity, leisure become very popular among usual people, considerably changes a picture of movement in a coastal zone. These navigators require the simple and clear navigating information, which does not demand special preliminary preparation.

These changes require perfecting visual AtoN both for increasing visibility range and conspicuous light sources, increase in service life and reduction of expenses at operation, and for creation of essentially new kinds of AtoN, which allow using a sea surface effectively. Now the direction is set to a vessel by navigational range, which has luminous head, and rear range, and accuracy of orientation increases with increase in distance between them. The range sets a line, which shows a safe route of movement to a mooring. In conditions of sharply crossed coastal zone, for example, at presence of mountainous coasts and a narrow way in the channel, there is no opportunity to carry head and back ranges at necessary distance. Besides, front and rear ranges can be strongly carried by height. In these conditions to take a direction with necessary accuracy is difficult enough. The situation even more becomes complicated at reduction of visibility in the atmosphere.

Now the unique decision of similar problems of coastal navigation connected with the development of laser technologies. The marine community that confirmed with many publications including XIVth and XVth IALA Conferences, 1998, 2002 where to this problem was devoted US, Japan, Canada Coast Guards and Russia reports [1-8] recognizes it.

All this means, that the market of essentially new, economic visual AtoN with service of one time in 7 years in the near future will be open, that sharply reduces operational expenses.

2. Our approach

Our approach is based on scanning of laser beam into orientation zone with the divergence of radiation equal to several angular minutes. It allows increasing in comparison with known decisions and traditional visual AtoN the detectable distance at least on 25 - 30 %. Distinctions even more grow at low visibility conditions in the atmosphere. In twilight, the limiting visibility range always two and more times is larger, than at regular fires at equal

Table 1 – Specification of the laser leading beacons

The name of characteristics	Two position	One position	One position Two colours
Character of navigation information	Flash, 0.2 – 0.7 Hz; Pause 1-3 s One colour	Flash with pause 1 – 10 s One colour	Flash with pause 1 – 10 s Dichromatic
Quantity sectors	One	Three	Three
Adjustment angle in zones, degree	Azimuth – 0.5-5 Angle of elevation 0.5-3	Azimuth – 0.1-3; 0.1-1.2; 0.1-3 Angle of elevation 0.5-5	Azimuth – 0.1-3.5; 0.1-1.2; 0.1-3.5 Angle of elevation 0.5-5
Output power, mW	4-10	15-25	45
Detectable distance: Day Night	 1 V *) 2 V	 1.5 V 2.5 V	 1.5 V 2.5 V
Accuracy of pilotage, angle minute	3-7	1 near a channel edge at the 3σ	1 near a channel edge at the 3σ
Power consumption, W	550	Average – 30	100
Environmental, C°	40; - 40	35; - 50	40; - 50
MTBF, hours	5000	3500	25000
Mass, kg	76 – one position	180	---
Construction	Two position	One position	One position

*) V – meteorological range of visibility, km

power consumption. It is actual for Russia at maintenance of navigation in the Arctic Seas where twilight are long, especially during the spring and autumn periods. Besides, narrow laser beams allow one to use simple and cheap methods to carry out redistribution of light energy in a zone of orientation, increasing thus detectable distance.

3. Development of laser AtoN

At the end of 80's and the beginning of 90's years a number R&D organizations of Russia has been developed domestic samples of laser visual AtoN, the majority of which should be attributed to laser leading beacons. In the ***Table 1*** their features are given.

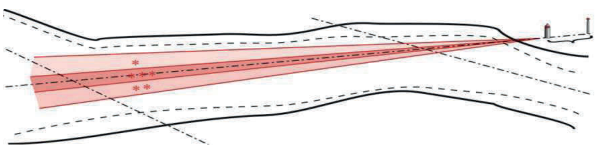

Figure 1: Nizhneudinskii laser leading beacon

In the majority of our decisions, the laser beacon has one position site.

Some pre-production models of one position laser leading beacon, fulfilled by the order of the Ministries for Transport custom-made the Hydrographic Enterprise, have been established in ports Dudinka and Providence Bay. The typical location plan of the given beacon in rivers mouth of the Siberian Rivers is given in ***Figure 1*** for a mouth of the river Ob'. Conditions of navigation here are the following: extended up to 15 and more miles and narrow channels are available. Navigating maintenance of such channels with visual means in some cases is complicated due to a complex relief of land. Therefore the equipment of the given waterways one position laser leading beacons is the single decision. In these specific climatic conditions our Laser Ranges have operate more than 6 years. For some cases where visibility of Front Range is limited by irrational port building, two position laser leading beacons are developed.

4 Detectable distances of AtoN

Aerosols of the marine and coastal atmospheric surface layer basically limit the detectable distances of AtoNs. It is important for the forecast connected of the performance assessment of laser AtoNs working in coastal environments. Allard's Law is used to calculate visibility. Although the distance at which the light can no longer be seen is subjective, the true visibility lies within a small distance span. Allard's Law discraibs the relationship between the illuminance produced at the observer's eye, the luminous intensity of the light source and the atmospheric transmissivity:

$$E=\frac{I}{D^2}T$$

where: E - illuminance at the observer's eye; I - effective intensity of the light source; T - atmospheric transmissivity which equal $T= e^{-\alpha(\lambda)D}= e^{-3.5D/V}$., D - distance between the light source and the observer; V = meteorological optical range.

For *a(λ)* calculation the empirical microphysical and optical model MaexPro of marine and coastal aerosol was developed [9-11]. The model (code) MaexPro (**Mar**ine **Ae**rosol **Ex**tinction **Pro**file) was developed on base of wide experimental date of particle size distribution *N(r)/dr* receiving in different arias and in different meteorological conditions and the complex optical indexes of refraction. Here *N* – number of aerosol particles, *r* – aerosol particle radius.

Using known Mie decisions for spheres [12-15], microphysical model MaexPro allows one to make calculations of the aerosol extinction coefficients spectral profiles

$$\alpha(\lambda) = \int_{r=0}^{r=\infty} K(\rho(m))\frac{dN(r)}{dr}\pi r^2 dr$$

Here $K(\rho(m))$ is the particle extinction efficiency factor, as a function of the complex optical index of refraction m, ρ is parameter Mie, and λ is the optical wavelength.

In ***Figure 2*** the main menu of the code MaexPro 5.0 is submitted. Here aerosol extinction

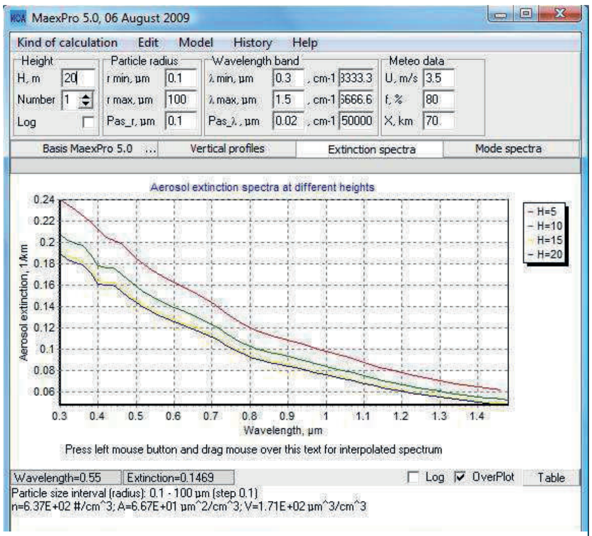

Figure 2: Main window of the code MaexPro 5.0

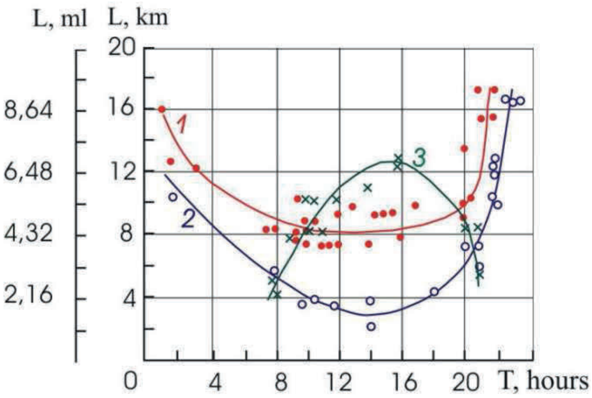

Figure 3: Results of comparison experimental detectable distances at marine observations (dots, circles and crosses) of the laser AtoNs (1), regular marine lights (2) and unlitmarks (3) as a day time function with MaexPro calculations (broken curves) at meteorological optical range equal 8 km.

coefficients for different colour and different heights under sea level are shown.

On the ***Figure 3*** results of comparison experimental detectable distances at marine observations of the laser AtoNs , regular marine lights and unlit marks as a day time function (crosses and circles) with MaexPro calculations (lines) receiving at V = 8 km are presented. Figure 4 shows essentially major detectable distances laser AtoNs in comparison with standard navigational range.

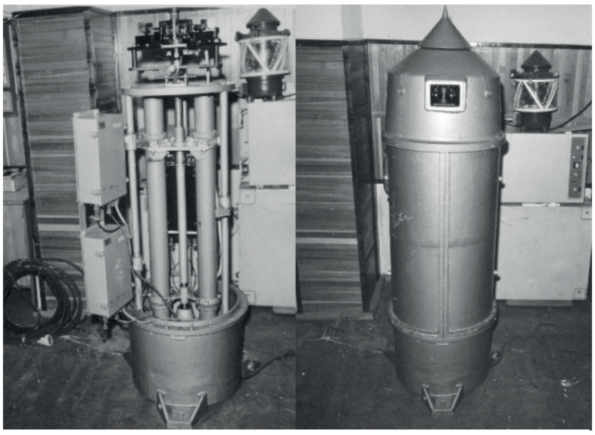

Figure 4: One colour, one position laser leading beacon : left – without mantle, - right – as an assembly

In ***Figure 4*** the appearance of the laser beacon without mantle and as ready-assembled is shown.

One of the laser leading beacon placing sites on Northern Sea Way is shown in ***Figure 5*** where it is resulted one-colour one-position laser leading beacon established on the front structure of the Lihachyvskii leading range of Providence Bay. Here at the left the beacon is located, the front lantern of the regular leading range MS-210 is on the right.

At the same time here it is necessary to note, that the rear lantern of the regular leading range is located on distance about 1 km. To place on the greater distance the rear lantern of the leading range for increasing an accuracy of the center line design the relief does not allow. The laser leading beacon solves this problem. For its accommodation needs the minimal area. Thus, high accuracy of the center line design is provided. The detection distance always on 25 - 30 % is

Figure 5: The laser leading beacon collocation on the front structure of the Lihachyvskii leading range of Providence Bay

more, and power consumption is less, than at the regular leading range.

One of latest domestic developments is the experimental sample of laser multi-colour leading beacon based on the use of semi-conductor lasers with electronic excitation, which allow refusing electromechanical scanners [16-19]. Another basic difference is the opportunity of obtaining practically any flashing characteristic. Principle of work the given laser range is based on the power transformation of an electronic stream to a semi-conductor monocrystal in optical radiation.

The location plan of Scanning Semi-Conductor Laser Range with Electronic Pump (SSCLEP) on coast and principle actions is similar two position laser leading beacon (***Figure 6***).

The appearance of one post of this laser beacon

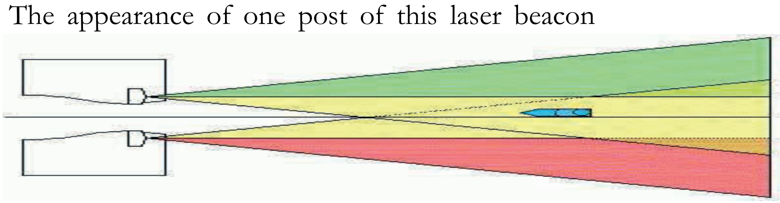

Figure 6: The operation principle of the semiconductor two position laser leading beacon

and the tube is given in and ***Figure** 7*. The tube is laser radiation source representing a hybrid of the semi-conductor laser with an electronic excitation and an electron beam tube forming scanning electronic beam.

5 Results of practical application

Numerous and long-term sea tests, pre-production operation and the comparative analysis of characteristics of the Table 1 shows the following:

1. In the common opinion, the installation of laser leading beacons considerably improves the conditions of navigation on range especially at the lowered visibility and in twilight when conditions of natural light exposure are adverse for supervision of fires and marks.
2. Light characteristics of zones are distinguished precisely and the side of evasion from a conducting zone is determined confidently.
3. In twilight the detectable distance of a laser light source is much higher, than regular fires and marks under any conditions of visibility. This circumstance is especially important for navigation in the Arctic seas where the twilight is long especially during the autumn and spring periods.
4. The exit on conducting zone in a distant part of the laser range at transition from one to another does not cause difficulties.
5. As a whole, the laser light source on the spectral intensity of radiation considerably surpasses other known light sources. However doubtless optimism causes that the time between failures of lasers, suitable for use in AtoN, constantly grows. Now it exceeds 50 thousand hours. Among other things, it gives significant economy on operating expenses.
6. It should be noted especially that all the domestic samples of laser beacons satisfy the National Safety Standards for Laser Products, which do not contradict the European Standards.

6 Summary

By present time the extensive nomenclature of methods and devises are developed, the various types of AtoN are tested. All of this allows to solve these or those problems at the navigating equipment of waterways. The question on expediency of AtoN application should be solved proceeding from concrete conditions of navigation and its maintenance of safety, at the all-round account of technical opportunities and economic efficiency of all AtoN. In some cases the greatest effect from laser leading beacons will be achieved at simultaneous their use with other kinds of AtoN.

One position laser range is expedient for establishing in those places where:

- the construction of back range is complicated or is impossible;
- for maintenance of the approach to moorages at performance of hydraulic engineering and dredging;

Figure 7: The one post beacon exterior (left) and tube (right)

- works;
- at a lining of cables;
- at exhibiting a protection to channels and waterways;
- in all other cases when high accuracy range guideline or fixations on a water table of lines, borders
- or local points is necessary. ■

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37 IMPLEMENTING A NEW MODULARLY DESIGNED RADAR SERVICE DURING CONTINUOUS NAUTICAL OPERATION

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The Traffic Services are an important element of the Maritime Traffic Technology System (MTTS). This especially includes the coast-wide Radar Services, the ship data processing as well as the traffic display in the Vessel Traffic Service centers (VTS centers). The Traffic Systems are being recapitalized. Here, technical and organizational challenges have to be met when the systems are developed, designed, tested and finally operated. At the German Coast, nine decentralized VTS centers are implemented. They are linked to each other via a communication interface. Data of 47 remote Radar stations will be processed in three Value-added Data Processing Centers (VTR) and will be distributed and displayed in the VTS centers. Main challenges of the project are: - To avoid any impact on the 7/24 operation of the VTS centers - To design a flexible and expansible system with open interfaces which is available at any time - A coast-wide use of the same technology - An early use of the displays while the radar antennas are still replaced The project is realized by a step-wise approach: 1. Dynamic design process including so-called Sprint-Tests every two months. Here, the customer and the designer will further develop and agree upon a detailed specification of the requirements for the final product. 2. During operation, the present systems and the new system are operated in parallel at the same time. Here, the real challenge is to operate the existing and the new radar sensors at the same time and to operate the communication interfaces of the present system. 3. The final operational capability and the removal of the existing systems start when the radar sensors have been replaced.

Los Servicios de Tráfico son un elemento importante del Sistema de Tecnología de Tráfico Marítimo (MTTS). Esto incluye, en particular, los Servicios de Radar costeros, el procesamiento de datos de barcos y la visualización del tráfico en los centros de Servicio de Tráfico de Buques (centros VTS). Los Sistemas de Tráfico están siendo renovados y, a este respecto, deben superarse los retos técnicos y organizativos cuando los sistemas se desarrollan, diseñan, ensayan y, por último, se ponen en funcionamiento. En la costa alemana se han implementado nueve centros VTS descentralizados, que están conectados entre sí mediante una interfaz de comunicación. Los datos de 47 estaciones de radar remotas se procesarán en tres Centros de Procesamiento de Datos de Valor Añadido (VTR) y se distribuirán y mostrarán en los centros VTS. Los principales desafíos del proyecto son: evitar cualquier impacto sobre el funcionamiento continuado de los centros VTS, diseñar un sistema flexible y ampliable con interfaces abiertas que esté disponible en cualquier momento, utilizar la misma tecnología en toda la costa y el uso temprano de las pantallas mientras se sustituyen las antenas de radar. El proyecto se realiza mediante un enfoque por etapas: 1. Proceso de diseño dinámico que incluye las llamadas pruebas de sprint cada dos meses. En este proceso, el cliente y el diseñador desarrollarán y acordarán una especificación detallada de los requisitos para el producto final. 2. Durante el funcionamiento, el sistema presente y el nuevo sistema se manejan en paralelo al mismo tiempo. Aquí, el desafío real es operar al mismo tiempo los sensores existentes y los nuevos sensores de radar, y operar las interfaces de comunicación del sistema presente. 3. La capacidad operativa final y la retirada de los sistemas existentes comienzan cuando se han sustituido los sensores de radar.

Les Services de Trafic Maritime sont un élément important du MTTS (Système de technologie du trafic maritime) qui comprend en particulier les services Radar côtiers, le traitement des données des navires et la représentation du trafic sur les écrans des centres de trafic (VTS). Les systèmes de trafic sont en restructuration. Ici il faut relever des défis techniques et opérationnels pour le développement, la conception, les essais et finalement le fonctionnement de ces systèmes. 9 VTS décentralisés sont installés le long de la côte allemande. Ils sont reliés les uns aux autres grâce à une interface de communication. Les données de 47 radars éloignés sont traitées dans 3 centres de traitement de valeur ajoutée (VTR) puis sont distribuées et affichées sur les écrans des centres VTS. Les principaux défis sont : a) éviter tout impact sur le

fonctionnement 24 heures sur 24 et 7 jours sur 7 des VTS ; b) concevoir un système flexible et extensible avec interfaces ouvertes, disponible en permanence ; c) une même technologie sur toute la côte ; et d) une utilisation des écrans possible dès que les antennes sont remises en place. Le projet est réalisé par étapes : 1. Conception dynamique avec essais rapides tous les deux mois ; à ce stade le concepteur et le client vont poursuivre en développant et mettant au point une spécification détaillée du produit final. 2. Au cours des opérations le système existant et le nouveau système fonctionnent en parallèle. Le réel défi est alors de faire fonctionner en même temps les nouveaux capteurs radar et ceux préalablement existants, et d'assurer le fonctionnement des interfaces de communication du système existant. 3. Le nouveau système a atteint sa pleine capacité et les systèmes existants sont retirés lorsque les capteurs radar ont été remplacés.

Implementing a new modularly designed radar service during continuous nautical operation

Functional chain of technical services for traffic data in VTS

Mark Thumann & Sascha Heesch

Federal Waterways and Shipping Administration, Germany

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Implementing a new modularly designed radar service during continuous nautical operation – Functional chain of technical services for traffic data in VTS

Mark Thumann & Sascha Heesch, Federal Waterways and Shipping Administration, Germany

Initial position

The German Waterways and Shipping Administration (WSV) operates nine Vessel Traffic Service(VTS)-centres along the 3,660 km German coastline. Each of this VTS-Centres has its own

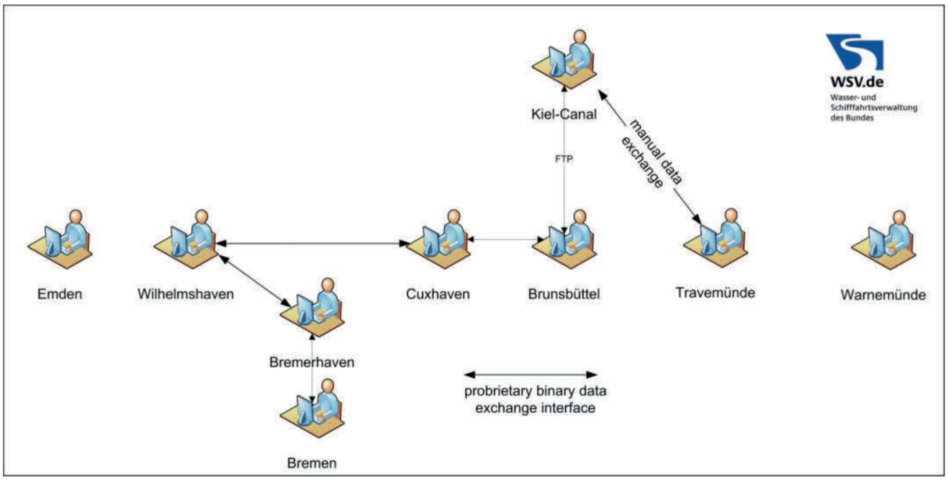

Figure 1: Interfaces

traffic related systems and infrastructure to fulfil their tasks of traffic survey and traffic safety. Classical VTS-systems to gather and display both, ship data and radar data, are playing an important rule. Each of these systems is optimized for the regions served by the VTS-centre. This means that the characteristics of rivers are equally included as the characteristics of surface areas. The systems in use are based on technical solutions of several manufacturers and different generations of technology. Some of the radar systems have been on duty for nearly 30 years! It is necessary to replace all VTS-systems along the German coastline.

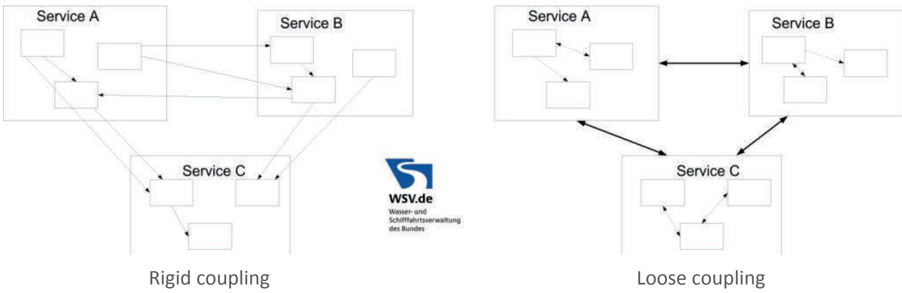

Figure 2: Rigid and loose coupling

Particularly important for the unobstructed operation of the German VTS-Centres is the data exchange between each other. To detect incoming traffic early and in a high quality five VTS-Systems are connected by a data interface. However, today only ship data is passed without identification of the radar tracks. Each traffic control centre has to identify incoming traffic objects in their area again by own radar tracks and to relink them with ship data.

As part of the implementation of the Maritime Traffic Technology System (MTTS) the existing VTS-systems will be replaced by the coastal-wide MTTS. It will be used in all VTS-Centres on the German coast and has to be designed in a way that all the area specifics are observed and the existing operative workflow is largely retained.

The idea of the MTTS – a flexible expendable system with open interfaces

The MTTS consists of about 30 independent services. Each of these services operates via open and standard interfaces. In that way it will be possible to release services without disturbing other tasks (loose linkage). This represents a particular challenge because the currently available systems usually have a very rigid coupling of software components (see ***Figure 2***). A loose coupling reduces the number of dependencies between services and functions to the essentials.

Implementation of the Traffic-Services in focus of the MTTS

The modular approach of the MTTS requires building five services simultaneously to achieve the functionality of the current VTS-systems (see ***Figure.3***, orange services). The services highlighted in grey are already implemented or are developed in parallel running projects, there won't be discussed here.

Data Collection and Transfer Services

The radar service (RAD) serves as a data collection service along the German coastline. All 47 radar

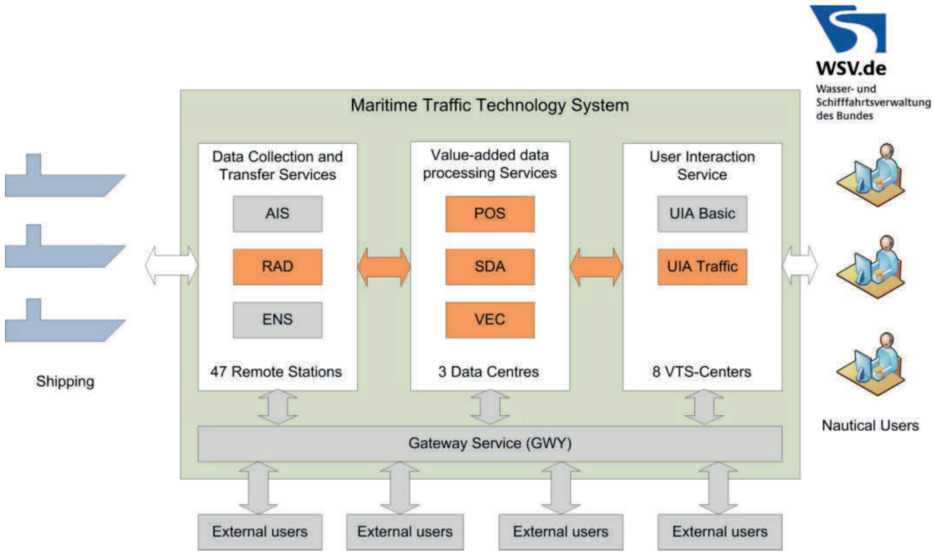

Figure 3: System image

stations will be equipped with new sensors. The data of the stations are coastal wide merged in the data centres called "nodes" and are available for all users.

Value-added data and processing services

The positioning service (POS) is used for a qualified and optimized detection of positions from various sources, e.g. radar and AIS. As all value-added data and processing services the positioning service is installed and used in the nodes only.

The ship data consistency service (SDA) is used to process and provide ship data. All required ship data is kept here and available to all users. This service is also installed only in the nodes.

The VTS-ENC-service is the third service realized within the Traffic Services. This service stores, updates and provides geographical data like ENC-charts, alarm regions etc. in the nodes for all users.

User Interaction Services

The user interaction service (UIA) is the main interface to the MTTS for the users in the VTS-centres. With the UIA all data for nautical operations are displayed, user data is put into the MTTS through the UIA and all necessary functionality for nautical operations in the VTS-centres are provided.

Project work

The main requirement while implementation is a minimal influence on the nautical operations in the VTS-centres. For this purpose a parallel connection to the existing radar stations is carried out, so that the current system can be operated while the new services of the MTTS can be developed and be tested with real data. Following this idea the procedure of implementation is divided in various steps.

Step 0: Award of contract for the whole project including the services in an open award procedure.

Step 1: Plan of execution and test system

- Workflow recording in the VTS-centres
- Specification of system design
- Realisation of a test system in the factory

Step 2: Parallel operations

- Several actions to be sure that the nautical operations are not influenced by the implementation
- Implementation of the new value-added data and processing services in the nodes (***Figure 3***)
- Parallel transmission of data from the radar sensors and feed this data into the new radar service
- Migration of existing ship data processing and coupling to the new ship data consistency service
- Parallel installation of the new user interaction service in the VTS-centres
- Test of the new services with live conditions and retention of the existing systems at the same time

Step 3: Installation of new radar sensors

- Exchange of the existing radar sensors

Currently step 2 is processed. The project termination is planned for 2015.

Step 1: Plan of execution and test system

Which approach ensures the success of the actions in Step 1?

As procedure model the "V-Modell XT" is used with an agile approach. While step 1 and step 2 the implementation is done incremental and iterative. This stepwise development of defined working packages is verified in so called "sprint tests" in an interval of eight weeks. This leads into a permanent coordination between the contracting parties. Because of this early coordination negative developments can be identified and can be corrected with low effort. Through working with the installed test system both contracting parties put in their expertise from the requirement-view and from the view of technical implementation. The result is a system which complies with all user requirements. ***Figure 4*** tries to illustrate the iterative method. It shows that the number of possible decisions is reduced in every iteration.

collaboration with each VTS-crew is necessary to tune the parameters of the new services for operational work. With this claim the system was tested by the users at the own desk.

- During all implementation and testing the existing systems have to remain running. In case of unforeseen difficulties with the new systems the operations can switch back to the old systems. For each VTS-centre a unique solution has to be found because of different space requirements at the desks of the users and in the technical environment.
- Because of a stepwise setting-up of operation of the VTS-centres it is necessary to implement the interfaces from the old VTS-

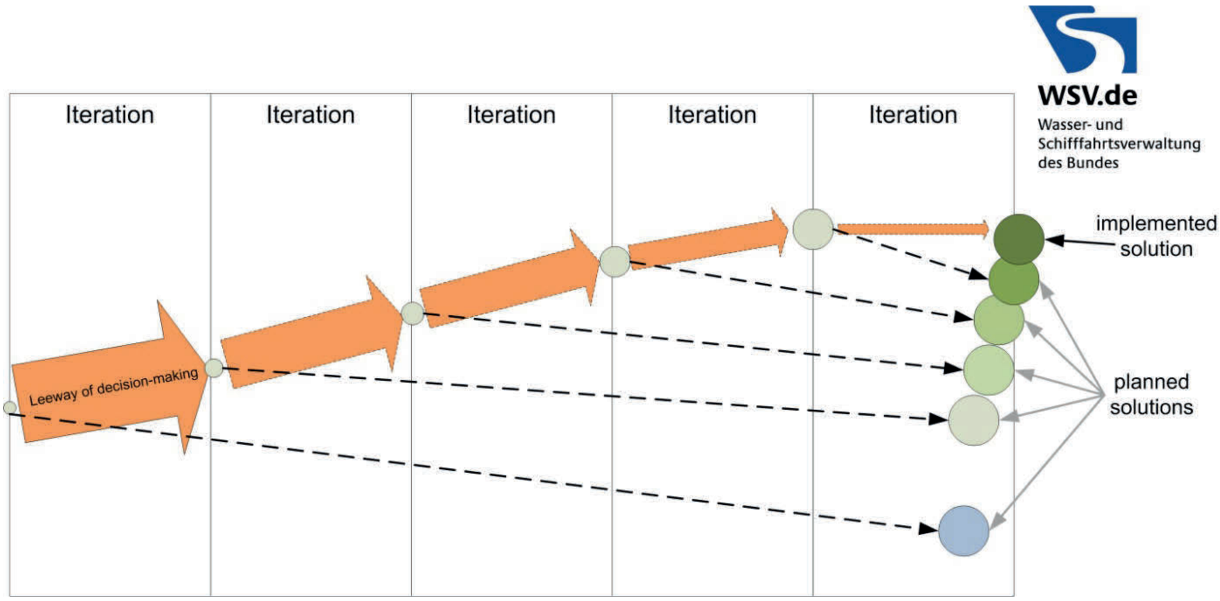

Figure 4 : Iterative implementation

Step 2: Parallel operations

During parallel operations radar data is picked from the existing systems and the systems of the MTTS-services are installed. With this method radar data is available in the existing systems and in the new services of the MTTS. The advantage of this method is that the normal operation can be done in the VTS-centres while the development, installation and test of the new services can be done with real data without any influence to the VTS operations. But there are several challenges to bring the new systems into operational work:

- In addition to the basic functionalities for all the VTS-centres the area specific characteristics have to be implemented as well. With this implementation a detailed test in the VTS-centres can be done. A close

systems to the new services of the MTTS. If one VTS-centres starts operation with the new services, a MMI feeds the existing system with data. With this method there is enough capacity for user support in each VTS-centre.

- The user training starts shortly before verification phase. A potential necessary refresh of training starts before test operations.

Which approach ensures the success of the actions in Step 2?

- Intensive cooperation with the user to understand his needs and to prohibit false development → verification phase
- Contemporary training of the users to give them the chance to find mistakes in the implementation in test operations.

- High availability and quality of the system to increase acceptance for users and technical operations

Step 3: Exchange of the radar sensors

After installation, test and start of operations in all VTS-centres the radar sensors can be exchanged. It is important that the user interaction service is accepted by the user because the new sensors are incompatible to the old systems.

Which approach ensures the success of the actions in Step 3?

- To ensure continuous flow of radar data the plan is to install a temporary radar sensor next to the radar site being exchanged. This opens a bigger time window for exchange of the sensor without influence to the operations in the VTS-centre. Unforeseen problems while installation of the new sensors won't take any effect.
- Some radar stations have a convenient location so radar data can be received through range extension of the neighbour radar site. AIS will help to ensure quality of the tracks.

Experiences

There are a large number of requirements from the nautical personnel. These requirements are partly very different. One of the big challenges it to cover all the requirements in one coastal-wide system. So from the beginning the main focus in design is placed in the possibility to configure the nautical workplaces for the needs of the users. The aim of a coastal-wide unified system is hard to achieve because of the different area characteristics. Many functions have to be configurable due to the fact that they are not needed in every VTS-centre.

Effects of the coastal-wide view can be seen e.g. in the ships database. To cover all requirements, there are about 160 attributes for every vessel. Each VTS-centre only needs a subset of this attributes. Since there is a high significance to the integrity of stored the ship data there will be a maintenance job which will update or correct wrong ship data.

The iterations while implementation leads to a common understanding between the WSV and the implementing company. The advantage is a requirement-driven and target-orientated implementation from the beginning on. The disadvantage is a higher effort for the purchaser.

The parallel operation of existing and new system was a good step. With this step it is possible to develop and test the new system over a longer time without influence to the nautical operations. In case of radar it is possible to see what the system is doing in extreme weather conditions like heavy rain or high waves at sea. Also it is possible to compare the old and the new system related in accuracy and correctness. Only the effort in survey of the workflow is tricky, here a close collaboration with the user is necessary.

The installation of a fallback solution while test operations takes a high effort. Notleast the design of the workplaces in the VTS-centres and the time of reaction for fallback causes a single solution in each VTS-centre.

The close cooperation with the users from the beginning leads in a system handling based on the existing systems. Hence, the introduction of the new system is easier. However, not all advantages might be taken, which could be realised with fundamental innovations, like new concepts of handling and area-overarching VTS-operations. ■

39 NEW LIGHTHOUSE AT THE NORTH ENLARGEMENT OF VALENCIA'S HARBOUR

Ignacio Pascual. Valencia Port Authority, Spain

From his initial conception, design, choice of materials and equipment, the project for the new lighthouse
at the port of Valencia, has been determined by the accomplishment of the following objectives:

- 1.- Self autonomy, with main supply by means of sustainable energy, with exterior supply only in case of emergency.
- 2.- Minimum energy consumption.
- 3.- Minimum cost of maintenance.

COMPONENTS.
The main components of the lighthouse are:
Reinforced concrete base-house, where the basic equipment for security, monitoring and supply, is been sheltered and protected.

Lattice tower, to reach the necessary height of 35 meters for the luminous signal, completely made of composite materials based on carbon and glass fiber, melted on a polymeric matrix, and conformed by eight cylindrical piers, five platforms and four octagonal braces.

Main light beacon, done by a LED lamp of 70 watts, with a meantime between failure (MTBF) of 100.000 hours and a stationary intensity of 1.300.000 candles. Giving a full beam, reaching the distance of 25 nautical miles.

Emergency light beacon, done by a LED lamp of 10 watts, with a MTBF of 100.000 hours, and a stationary intensity of 186.000 candles. Giving a distance reach of 20 nautical miles.

Main supply system, by means of solar and wind energy, produced by nine photovoltaic boards with ASI technology, of 12 volts and 80 watts, fixed on the tower structure. And a vertical axis wind generator (windside), of 24 volts and 9 amperes.

Lightning conductor, with a multiple non active tips, made of stainless steel, and a sea wire for a high discharge.

In the base concrete house, there are two banks of batteries, gel technology, with two chargers of 12 and 24 volts, to give enough capacity to store electric energy for six days of no wind at all or solar radiation. A control unit for the main and emergency beacon, another control unit for the energy chargers, a diesel power plant of 9,9/11,4 KVA., and a communication rack to the Emergency Control Center, for monitoring the state of the equipment.

La integración de procedimientos que permiten la casi inmediata disponibilidad de información Desde su concepción inicial, diseño y selección de materiales y equipamiento, el proyecto del nuevo faro en el puerto de Valencia ha estado determinado por el cumplimiento de los siguientes objetivos:

- 1. Autonomía propia, con suministro principal mediante energía sostenible y con suministro externo solo en caso de emergencia.
- 2. Mínimo consumo energético.
- 3. Mínimo coste de mantenimiento.

COMPONENTES
Los principales componentes del faro son:
Casa base de hormigón armado con equipamiento básico de seguridad, control y suministro resguardado y protegido.

Torre de celosía, que alcanzará la altura necesaria de 35 metros para la señal luminosa, completamente hecha de materiales compuestos basados en fibra de vidrio y de carbono, fundida en una matriz polimérica y formada por ocho pilares cilíndricos, cinco plataformas y cuatro soportes octogonales.

Baliza principal, hecha con una lámpara LED de 70 W, con un tiempo medio entre fallos (MTBF) de 100 000 horas y una intensidad estacionaria de 1 300 000 candelas, que proporciona un haz con un alcance de 25 millas náuticas.

Baliza de emergencia, hecha con una lámpara de 10 W, con un MTBF de 100 000 horas y una intensidad estacionaria de 186 000 candelas, que tiene un alcance de 20 millas náuticas. Sistema principal de suministro mediante energía solar y eólica, formado por nueve paneles fotovoltaicos con tecnología ASI, de 12 V y 80 W, fijados en la estructura de la torre, y un aerogenerador (windside) de eje vertical, de 24 V y 9 A.

Pararrayos, con múltiples puntas inactivas, fabricado con acero inoxidable y un cable adaptado al mar para altas descargas.

En la casa base de hormigón hay dos bancos de baterías de tecnología de gel, con dos cargadores de 12 y 24 V, que ofrecen suficiente capacidad para almacenar energía eléctrica durante seis días sin nada de viento o radiación solar. Además hay una unidad de control para la baliza principal y de emergencia, otra unidad de control para los cargadores de energía, un generador eléctrico diésel de 9,9/11,4 KVA y un bastidor de comunicaciones para el Centro de Control de Emergencias, para el control del estado del equipo.

Depuis le début du projet de ce nouveau phare du Port de Valencia, sa conception, les matériaux et les équipements à utiliser ont été choisis en fonction des critères suivants :

- *1.Autonomie, grâce à une alimentation principale assurée par des sources d'énergie renouvelables, avec alimentation extérieure uniquement en cas d'urgence,*
- *2.Consommation d'énergie minimale,*
- *3.Coût de construction et d'entretien minimaux.*

COMPOSITION
Les principaux éléments du phare sont les suivants :
Un socle en ciment armé dans lequel les équipements de base pour la sécurité, le contrôle et l'alimentation sont abrités et protégés.

Une tour en treillis de la hauteur nécessaire pour que le signal lumineux soit à 35 mètres de hauteur, fabriquée en matériaux composites carbone et fibre de verre fondus dans un moule polymère et renforcée par huit piliers cylindriques, cinq plates-formes et quatre embrasses octogonales.

La source lumineuse principale est une lampe LED, d'une durée de vie moyenne de 100 000 heures, d'une intensité stationnaire de 1 300 000 candélas et d'une portée de 25 milles nautiques. Le feu de secours est une lampe LED de watts 10 watts, d'une durée moyenne de 100 000 heures, d'une intensité stationnaire de 186 000 candélas et d'une portée de 20 milles nautiques.

Le système d'alimentation principal, par énergie solaire et éoliennes, comprend 9 panneaux photovoltaïques de technologie ASI, 12 volts et 80 watts fixés sur la tour, ainsi qu'une éolienne à axe vertical de 24 volts et 9 ampères (Winside).

Le câble de paratonnerre doté de multiples prises non activées est en acier inoxydable, comporte un câble pour forte décharge .Dans le socle en ciment se trouvent deux bancs de batteries de technologie gel, avec deux chargeurs 12 et 24 volts pour permettre de stocker suffisamment d'énergie pour six jours sans du tout de vent ni de rayons de soleil. Une unité de contrôle du feu principal et du feu de secours, une autre unité de contrôle des chargeurs d'énergie, un moteur diésel 9,9/11/4 kWA et un rack de communication avec le Centre de Contrôle d'urgence pour surveiller les équipements.

New lighthouse at the northern enlargement of Valencia harbour

Ignacio Pascual

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OBJECTIVES

From his initial conception, design, choice of materials and equipment, the project for the new lighthouse at the port of Valencia, has been determined by the accomplishment of the following objectives:

- 1.– Self autonomy, with main supply by means of sustainable energy, with exterior supply only in case of emergency.
- 2.– Minimum energy consumption.
- 3.– Minimum cost of maintenance.

COMPONENTS.

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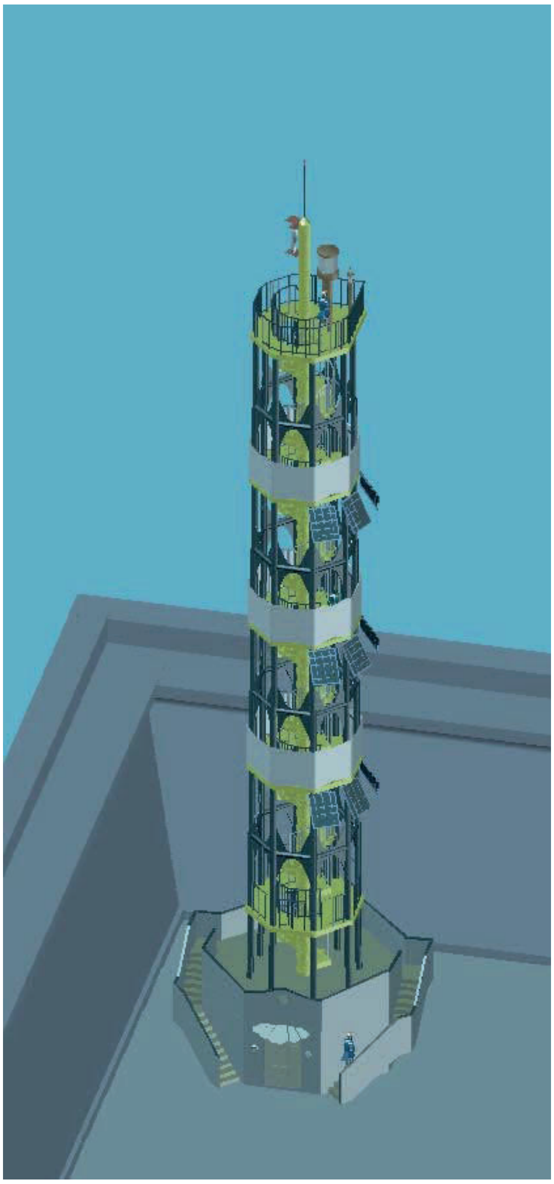

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1. Project objectives

In the development of the construction of the lighthouse, from its conception, design and selection of materials to employ, as well as the resources of the necessary equipment for it proper functioning; Lighting system, energy supply systems, etc., the project has been conditioned by the accomplishment of the following objectives:

- Self-sufficiency, using sustainable energy as main power without the necessity of outer energy supply, except in case of emergency.
- Minimum energy consumption whenever.
- Minimum or virtually non-existent maintenance cost.

The future lighthouse will stand at the northern corner of the new jetty, with a maximum height of 37 meters at its highest peak. This project includes two main activities, the base-house; which will serve as a base for both the foundation of the lighthouse as well as to stow the necessary equipment, and the lighthouse itself made entirely of composite material.

2. Project description

The new lighthouse is basically made up of two elements, the base-house which serves, firstly to stow the necessary equipment for the operation of the headlamp lighting system, and secondly, as a support element and foundation of the structure itself, which in turn serves as a support element of the lighting system, energy supply system and security system against lightning, as well as a ladder system which allows inspection and maintenance work.

Below is described each of the above elements, the ladder system, and the lighthouse equipment.

Base house

It consists of a seen reinforced concrete structure, with the shape of a prism of octagonal section possessing an exterior side of 3 meters and a height of 2.45 meters. The enclosure walls have a constant thickness of 40 cm. The roof is formed by a slab also of reinforced concrete of 0.35 meters maximum width and a slope of 2% on its surface for the departure of water from rainfall and from the jetty.

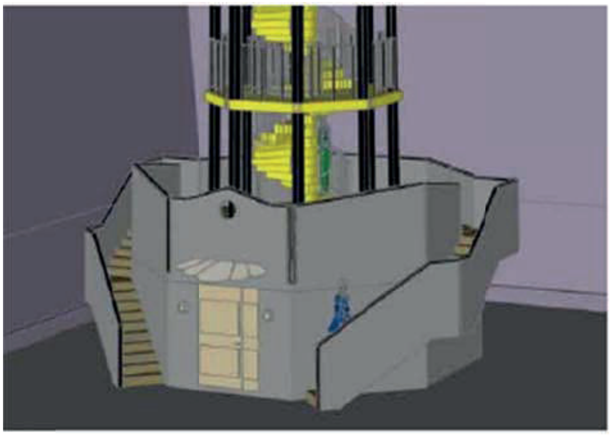
The foundation of the base-house consists of a reinforced concrete slab of 7,892 meters of double apothem octagonal floor and 1.10 meters thick. This slab, also serves as a foundation for the tubular structure of the lighthouse

There are two gaps on the walls of the base-house, one of them has 1.50 meters of width and 2.10 meters of height for the access door, and the other has 2.172 meters of width and 80 cm of height for the ventilation.

For the visitable access roof of the base-house, a set of stairs are available on both sides of the entrance door. These are supported by a slab of concrete of 15 cm thick which springs up in cantilever from the walls of the base-house.

Both, the stairs and around the perimeter of the roof, opaque reinforced concrete railings of 10 cm thick and a minimum height of 1.10 meters are featured.

Around the perimeter of the roof and at the foot of the parapet, a drainage channel is featured for the water to be evacuated through five gargoyles; the drain water is poured on the floor of the jetty, and due to the jetty slope, to the sea.



Base house

Structure of the lighthouse

The structure of the lighthouse consists of 8 tubular columns made of carbon fibre (C.F.) with a height of 31 meters, from a level of +2,00 from the base of the foundation of the base-house to a height of +33,00 from the upper platform of the lighthouse. The columns present a circular section with a diameter of 250mm and a thickness of 20mm. These columns are positioned on ground at the vertices of an octagonal inscribed in a circumference of 4,50 meters in diameter at its base and 4,00 meters of diameter at its crown.

The horizontal rigidification and connection between the eight tubes materializes by a double system. The first system consists of four horizontal rings with an octagonal shape, composed of glass fibre tubes (G.F.) of 190 mm in diameter and

20mm thick, which are set up every 6,00 meters at level +12,00 +12,00, +18,00, +24,00 y +30,00.

The second system consists of five horizontal octagonal shaped floor structures, formed with "sandwich" panels of 0,20 meters thick distributed with fibre glass skin and core material of low density (0,30 kN/m2), which are arranged every 6,00 meters at level +9,00, +15,00, +21,00, +27,00 y +33,00 meters.

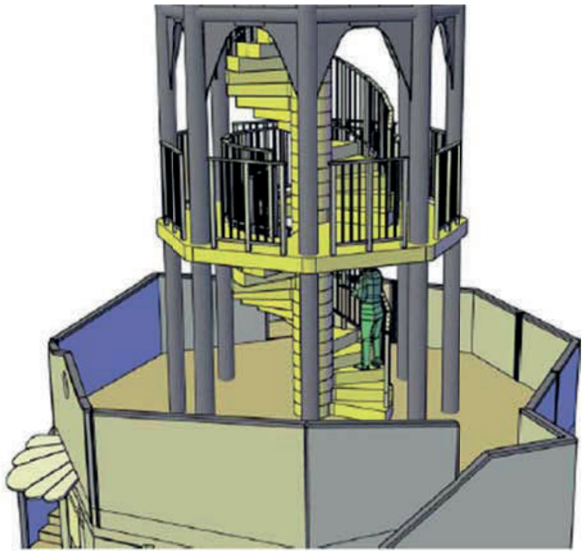
Both systems of rigidification and structural bracing, have the task to redistribute the strain of flexion and tension-compression. Additionally, the horizontal structures serve as platforms for the inspection and maintenance of the knots formed where the rings of horizontal rigidity and the eight tubes of the main structure meet. They rigidify, in turn, by 2.00 diagonal meter diamond shaped G.F. diaphragms set up vertically with a thickness of 24 millimetres.

The tubular structure is anchored into the foundation in eight niches of 0.75 meters in diameter made solely for this purpose; since the required length for the transfer of forces of the foundation structure is 2,00 meters, in order to not penalize the thickness of the foundation slab, reinforced concrete cylindrical plinths of 90 cm height and 75 cm in diameter are arranged. These plinths are attached to the niches using high resistance concrete mortars. The transfer of stress is accomplished with corrugated steel bars perpendicular to the tubes and helically arranged. The cementing of the cylinders and the interior of the main tubes is achieved by injecting grout from the inside of the tubes of 250 mm in diameter through the gap made for this exact purpose. It's important it be done this way to ensure the combined binding between the crossbars and C.F. tube

Spiral staircase

To carry out the inspection and maintenance labour, a spiral staircase of 2,40 meters in diameter is set up on the axis of the structure possessing a height of 27,00 meters from level +6,00 to level +33,00 and made from G.F. The steps are formed by a ring with an inner diameter of 60 cm where a platform with a trapezoidal floor of 90 cm length springs from it, the steps are made from "sandwich" type panels with a tread in the axis of 26 cm and the riser of 20 cm.

As landing platforms, the horizontal rigidity platforms of the structure are applied, and between them, similar landings to the steps with a tread in the axis of 1,047 meters are used.



Spiral staircase

The height placement of the steps with the rings, result in a central core of cylindrical shape which is filled in with reinforced concrete forming a rigid central core of the structure. This core is lengthened with a diameter of 60 cm from the roof of the base-house to the foundation. An unrecoverable formwork of C.F. is used to prolong the mentioned core.

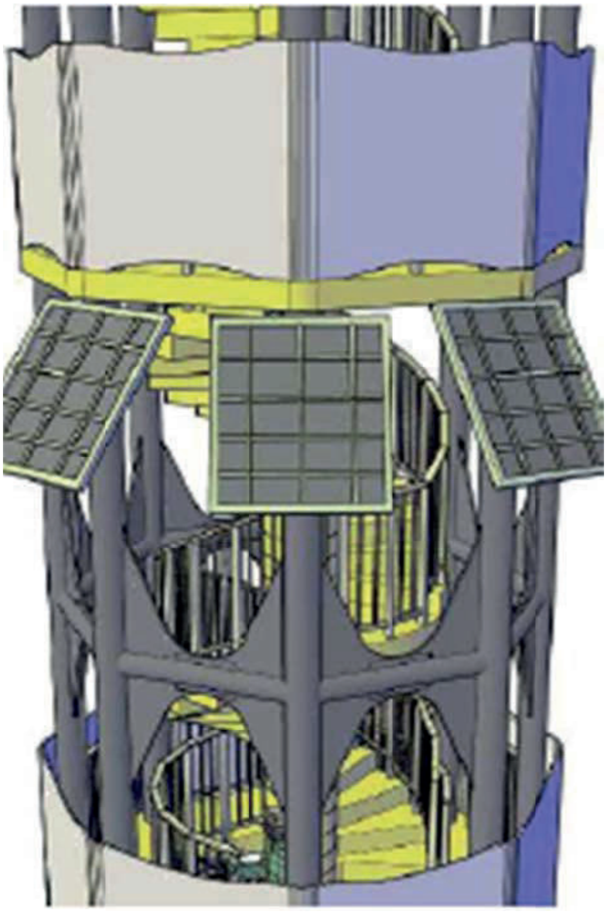
As an element of security for both the stairs, and the visitable platforms, a railing is placed made of V.F. of 1.20 meters high.

Both the intermediate platforms, as well as the stairs are covered with a top coat to ensure a non-slip and fire protection finish.

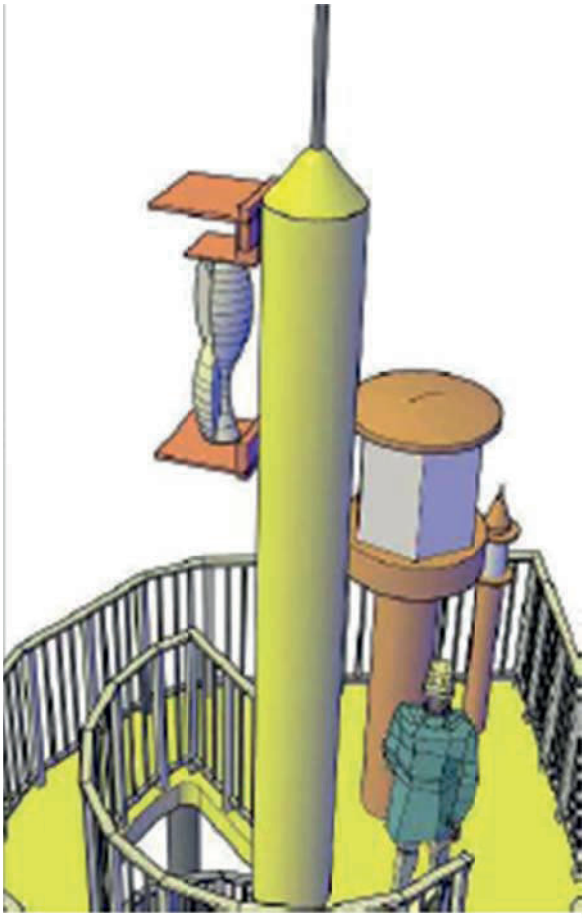
Equipment of the lighthouse

Below and in a brief manner, a list of said equipment is detailed.

- Lighting system, formed by:
  - Main Beacon of LED technology with a range of 25 nautical miles. 70 watts of electrical power.
  - Emergency Beacon of LED technology with a range of 20 nautical miles. 10 watts of electrical power.
- Control system to govern the main and emergency beacon.
- Lightning conductor system for the security of electrical apparatus.
- Main power system, formed by:
  - Solar Photovoltaic modules.
  - Vertical axis wind turbine.
  - Bank of batteries for 6 days self-sufficient



Structure of composite materials
Photovoltaic equipment and day signals



Light system and wind turbine generator

- Backup power supply system made up of a bank of batteries connected to the power grid.
- Emergency power supply system consisting of a generator connected to the side of the batteries backup power supply system

In order for the lighthouse to function as a daytime signal, it is equipped with identifiable elements in a visual position during the day, consisting of three strips of fabric permeable to wind, white in colour, measuring 1,50 meters high and with a surface of approximately 20 m2 per strip. Said strips will be arranged on the platforms situated at levels +15,00, +21,00, and 27,00; on the outside of the railing and secured to the eight tubes of the main structure of the lighthouse in 16 points, eight on the upper part and eight on the bottom part.

In order for the seabirds to not stain the lighthouse with their droppings, an ultrasound technological bird repellent system will be used. ■

20 THE PROCESSES IN THE MARITIME TRANSPORT CHAIN AND HOW TO LINK THEM

Dirk Eckhoff. Federal Waterways and Shipping Administration, Germany

One main reason for vessel traffic is to transport cargo from port A to port B. The world of transport has growing demands to maximise the throughput of the waterways.

In many regions of the world the first step to optimize the waterways´ throughput is to provide data to the stakeholder involved in the transport. By that many stakeholders know the status and maybe the planning of their neighbours´ processes.

But in many cases the stakeholder does not get required data. The stakeholders use different data sources, distribute data on separate networks, the data is not consistent and the planning and decisions are not transparent to other stakeholders.

But even if all these aspects were solved in a positive way and all stakeholders were interconnected and received the data they demand, would it help the single stakeholder to retrieve the needed information from that data? Is it sufficient just to exchange data to maximise the throughput of the waterway?

Are the stakeholders not heading for different aims? One stakeholder wants to optimize his own process to make more profit, the second one wants to provide more safety and another one wants to make customs more efficient. There may even be conflicting aims.

How to find and to achieve the maximum throughput of the waterway and still considering the different aims of the stakeholders? Do we need one overall system with supervisor or coordinator functions?

This paper will discuss ideas to optimize the maritime transport by respecting the different aims of the stakeholders.

Uno de los principales motivos del tráfico de buques es el transporte de mercancías de un puerto A a un puerto B. El mundo del transporte está sujeto cada vez a mayores exigencias para maximizar el rendimiento de las vías navegables.

En muchas regiones del mundo, el primer paso para optimizar el rendimiento de las vías navegables es proporcionar datos a la parte interesada implicada en el transporte. De esta forma, las partes interesadas conocen el estado y posiblemente la planificación de los procesos de sus vecinos.

Pero en muchos casos la parte interesada no consigue los datos requeridos. Las partes interesadas utilizan diferentes fuentes de datos, distribuyen los datos en redes separadas, los datos no son consistentes y la planificación y las decisiones no son transparentes para otras partes interesadas.

Pero, incluso si todos estos aspectos se resolvieran de forma positiva y todas las partes interesadas estuvieran interconectadas y recibieran los datos que requieren, ¿ayudaría esto a la parte interesada a extraer la información necesaria a partir de esos datos? ¿Basta con intercambiar datos para maximizar el rendimiento de la vía navegable?

¿No tiene cada parte interesada un objetivo diferente? Una parte quiere optimizar su propio proceso para obtener más beneficios, la segunda quiere ofrecer más seguridad y otra quiere aumentar la eficiencia de las aduanas. Los objetivos pueden ser incluso contradictorios.

¿Cómo podemos buscar y conseguir el máximo rendimiento de la vía navegable y al mismo tiempo tener en cuenta los diferentes objetivos de las partes interesadas? ¿Necesitamos un sistema global con funciones de supervisor o coordinador?

Esta ponencia analizará diversas ideas para optimizar el transporte marítimo respetando los diferentes objetivos de las partes interesadas.

Le but principal du trafic maritime est le transport de cargaisons d'un port A à un port B. Le monde du transport impose une demande croissante d'utilisation maximale des voies maritimes.

Dans beaucoup de régions du monde, la première étape pour optimiser la capacité des voies maritimes est de fournir des données aux parties prenantes du transport. Celles-ci peuvent ainsi connaître la situation et peut être le planning des processus de de leurs voisins.

Mais bien souvent la partie prenante ne demande pas ces données. Elle utilise différentes sources de données, les distribue sur des réseaux séparés, les données ne sont pas cohérentes, ses projets et plans de route ne sont pas transparents pour les autres parties prenantes.

Mais, même si ces inconvénients sont surmontés de manière positive, si toutes les parties prenantes sont interconnectées et reçoivent les données qu'elles demandent, une partie prenante sera-t-elle aidée par la donnée reçue ? Est-il suffisant d'échanger des données pour optimiser la capacité d'une voie maritime ?

Toutes les parties prenantes ont-elles les mêmes objectifs ? L'une veut optimiser son processus pour gagner plus, une autre désire améliorer la sécurité et une autre encore être plus efficace. Leurs objectifs peuvent même être contradictoires.

Comment trouver le moyen le plus efficace d'optimiser la capacité de la voie maritime en continuant à essayer de répondre aux attentes de toutes les parties prenantes ? Avons-nous besoin d'un système global avec des fonctions de superviseur ou de coordinateur ?

Le rapport présente des idées visant l'optimisation du transport maritime en tenant compte des différents objectifs des parties prenantes.

The processes in the maritime transport chain and how to link them

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Federal Waterways and Shipping Administration
Germany

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1. INTRODUCTION

Regarding commercial cargo shipping the aim of transport is the cargo flow. The optimisation of transport is cargo flow optimisation. For passenger transport the results of this paper can be used analogously.

More and larger vessels want to use waterways. At the same time the space of navigable water is decreasing due to other modes of use. It may not be assured that every vessel gets an unhampered passage to her terminal. This paper reflects an analysis of the processes involved in the maritime transport to achieve this goal. The analysis uses the methodology of process control and applies the theory to maritime transport and adjacent processes. It concludes measures that should be realized by IALA, the national competent authorities (NCA) or the VTS-authorities.

2. PARAMETERS FOR PROCESS OPTIMIZATION

The cargo flow follows the transport chain, that does not end when the vessel is berthing. For the improvement of cargo flow the adjacent processes ashore are also of relevance. The processes are linked in a chain. The connections are so tight, that the cargo flow would stop if one link fails.

Since transport at sea is facilitated by vessels, the vessel traffic, the vessel traffic services and connected services the processes must be considered for a good cargo flow.

In the field of shipping and waterway there are several parameters to optimize the cargo flow - but only few can be configured practically.

1) Waterway and fairway design

   The access to the port is limited by the geography. Many port states carry out measures (hydraulic engineering, major dredging) to improve the access to their ports, but in most cases the measures result in high costs or negative public response due to the environmental impact.

2) Visual Aids to Navigation (AtoN)

   Visual AtoN are a lower cost alternative, but they can improve the traffic flow only up to the limit the geography and the dimensions of the waterway allow.

3) Traffic requires space for movement. The sea and the coastal waters are not only used by marine traffic but or other enterprises like offshore wind farms, oil rigs etc. Therefore, the navigational space should be considered as a parameter as well.

4) Cargo

   The kind and quantity of cargo is defined by the market. Due to the growing environmental and security requirements the parameter ´hazardous cargo´ may become more relevant in the future.

5) Vessel

   Size and number of vessels is not ´steerable´ for the authorities. It is determined by the ship owners or the market. For economic reasons the nations' aim is to make the access to their ports attractive for all kind of vessels. On the other hand there are restrictions for certain kind of vessels due to safety, geographical or environmental reasons. Actually, only the vessel´s static and cargo-related parameters are steerable to improve the cargo flow.

The remaining parameters for transport optimization are the positioning and timing of a vessel. When considering all vessels in an certain area it is the vessel traffic. Hence, cargo flow optimization can be achieved by planning of the traffic, of the connected processes and marine spatial planning.

3. ANALYSIS OF THE TRANSPORT PROCESSES

For the cargo flow optimization this paper considers the processes when the vessel approaches a port up the berth. Three phases of cargo flow are distinguished, because different players with their own processes and aims are involved.

Sailing	: vessel and cargo is moving
Berthing	: vessel and cargo is not moving
Loading	: vessel is not moving, cargo is moving and linked to storage and transport ashore

The transport runs like on a virtual chain. The phases are closely like to each other. Some processes to facilitate one phase are directly linked to each other. Other processes are not directly linked to the chain but their performance has strong effects on the cargo flow. While the cargo flows sequentially along the transport chain the processes to enable the flow interact in a network.

Sailing phase:

The first phase is the vessel´s approach to the coast and sailing in an area where VTS may be provided. According to IMO Res. A.893(21) [1] each vessel makes her own plan for the entire voyage from berth to berth. The vessel´s plan is based on the information for several sources ashore and her own navigational capabilities.

The VTS has the focus on all vessels and the primary aim of safety of all vessels and efficiency of traffic. But traffic planning is applied only in the VTS area and only if traffic organization service is provided. The VTS has the task to bring the plans and the own predictions of all vessel into one schedule, so that no vessel should be hindered on her passage through the VTS area. However, the VTS may be not informed about the vessels planning and makes the plan based on data from other sources. If more and larger vessels want to use the navigable waters, the VTS may not be able anymore set up a plan without restrictions.

The VTS carries out a planning in respect to optimize maritime traffic flow to be able to provide traffic organisation service (TOS). The continuing cargo flow in the berthing or loading phase is not in the scope of the VTS.

The vessel´s plan is not only determined by the vessel herself but by those who are involved in the logistics or port business ashore. The aim of this stakeholders is that their ´own´ vessel meets schedule.

Berthing:

Other players like tugs, linesmen, port facilities are relevant for the processes in this phase. Mostly the coordination is not in one hand. The stakeholders have the primary aim to run their business and may not consider the traffic flow or the other vessels´ planning. The involved parties are mostly updated by the agents or the port.

Loading:

In this phase again other parties are involved. The process performance depends a lot on the port logistics and facilities . In respect to cargo flow the hinterland logistics may interfere with the loading. The port logistics focuses on a proper cargo flow e.g. the specific container must be loaded in time. But the vessel´s further voyage plan is of second priority, as long as the vessel arrives or departs the ´own´ terminal in time. The port logistic company expects an undisturbed traffic flow and plans for those vessel´s berthing at the own facilities. Without notice ahead the port may not find time and facilities to load/unload the cargo in time. This results also in plan changes to forward the cargo.

Furthermore processes auxiliary to the cargo flow are performed, like customs, port state control, supplies for the vessel etc. These processes may have an impact on the overall performance of the cargo or traffic flow process. The stakeholders for this task have their own aims, look for the single vessel but not necessarily for an efficient traffic or cargo flow.

Due to the organisational issues (shifts, handovers, less personnel..), there may be losses or misinterpretation of provided information.

Analysis results:

- There is no supervisory planning for the cargo flow.
- Stakeholder in the transport business make their planning to optimize their business.
- Not all parties directly or indirectly involved in the transport chain have the aim to improve cargo flow or maritime traffic flow
- The involved stakeholder have separate communication circles /networks which may result in inconsistent information.
- Feedback to changes in planning is not always exchanged to all parties that interfere with the cargo flow.
- The involved parties have different scope of planning:
  - organize entire traffic
  - plan for specific type of vessels
  - plan only for the ´own´ vessel.
  - focus on particular area or facility
- Neither for the processes in one phase nor for all three phases starting with approach of the vessel and finishes with loading it is planned by one co-ordinator.

4. MEASURES FOR CARGO FLOW OPTIMIZATION

Cargo flow optimization requires planning. Currently no supervising planning does exist for the entire transport chain in most of the areas of the world.

The first measure to improve the overall planning of the cargo flow is an instantaneous loop back of the process status and planning to the operators of all the processes directly or indirectly involved in the cargo flow. The IALA guidance concerning sharing data with other parties with the publications [2], [3], [4].

Strategic planning:

The strategic planning should aim for an optimum cargo flow. Hence, it should consider the entire transport chain. This planning should provide the aims for the region in respect to traffic, development of the port, foster specific kind of cargos / type of vessel e.g. LNG-tankers. Risk and restrictions for the traffic, environmental demands etc. should be assessed. The strategic planning should consider all the phases to optimize cargo flow. Arrangements should be negotiated with the stakeholders responsible for relevant processes in the phases. In the past IALA has made an attempt in respect to co-operation between stakeholder by drafting a framework for vessel traffic management.

If the maritime transport is confined by offshore or near shore installations it may be recommended to extend assessment on this areas. An example for marine spatial planning is the ACCSEAS project for a North Sea region [5].

The European organization for the safety of air navigation ´EUROCONTROL´ is setting up an air traffic management [6]. This is organized in three sectors:

a) air space management (ATM),

b) air traffic flow and capacity management and

c) air traffic control.

The analogy to sectors in the maritime world is obvious, although ATM covers save guidance in the air and on the ground.

Measures for Sailing phase /VTS Area

The density of the traffic or restrictions for the traffic may require to allocate a slot to certain vessels to achieve minimal delay for her passage. Currently the planning for all three phases is a self-organized process and covers mainly the sailing phase. No one does the overall planning for all the phases to find a slot for the vessel/cargo in the cargo flow.

The engineers invented a self-organized principle in technical systems like AIS called Self-Organized Time Division Multiple Access (SOTDMA). So why not copying the SOTDMA for the organisation of transport in the maritime domain. Each AIS transmitter reserves a time slots for transmission of the AIS message. This self-organization only works if enough slots are available. But transport planning is just required when the vessel cannot find a free slot in the traffic flow. In case all slots are occupied AIS can be switch to Fixed Access Time Division Multiple Access (FATDMA) transmission mode. The AIS-station in FATDMA mode gets fixed slots that guarantee for transmission of the message. FATDMA should only be used after coordination with other users. But what we can learn is, SOTDMA and FATDMA principle alone do not solve the problem of slot management. There is the need of previous organizational arrangements to make FATDMA work. The agreements should be made between the all parties who are affected by a slot management.

Traffic organisation:

Traffic planning is mostly confined to only one phase and to one VTS area. Those VTSs who provide Traffic Organisation Service (TOS) do traffic planning for the sailing phase of the transport chain. The phase is reached when the vessel approaches or transits the VTS area. The first step to improve the planning is to provide the observed traffic status and own planning to the operators who do the planning in the other phases or for auxiliary processes.

The strategic aims are the steering parameters for traffic planning process performed in the VTS.

The traffic organization should collect and evaluate the status and planning of the neighboured processes for the own planning. To include the other plans it is not necessary to know every internal step of the other processes. But there is a need to know about the status of link or overlap with the own process. Hence a proper interface to exchange information about the status and planning or prediction is recommended. Also the subordinated processes of ad hoc action like navigational assistance service (NAS) or information services (INS) should be provided with the up-to-date planning as a steering parameter.

The task to do the continuous planning may be supported by decision support to assess the multidisciplinary factors that have an impact on the planning. An example for the improvement of the tactical planning is the project MONA LISA [7]. The operational and legal issues like ´who may change the plans or route of a vessel?' or ´what is the latest possible change of a plan for the vessels to react in a safe way?´ were raised during the IALA workshop on portrayal [8].

Situational Awareness / ad hoc reaction

Ad hoc decisions have to be made here in the VTS like providing NAS to prevent collision or taking immediate measures to cope with incidents. Hence there is no time for planning or prediction. But any change in one or more vessel passages through the VTS sector may have impact on the traffic planning in other sector. Therefore an instantaneous loop back the process of TOS should be implemented.

Measures for Berthing / Loading Phase: Harbour approach and Port

The stakeholder for the phases should consider also an regime with the aim of improved cargo flow. Arrangements with the stakeholders within the phase and with the stakeholders of the adjacent phases should be negotiated. This includes the proper definition of the feedback information, the technical interfaces and particularly the ´steering´ parameters.

5. CONCLUSIONS

- The transport is a chain of processes which are closely linked.
- The planning of the transport requires a network of processes that feedback their own actual status and planning to the other process.
- There is no need for a superposed control process to optimize cargo flow. However, those responsible for the processes should find arrangements to achieve that aim of optimum cargo flow.
- IMO assigned a role in respect to Vessel Traffic Management to IALA [9].
- The IALA should use the role to support the measures for future transport planning by providing a forum for the relevant stakeholders and introduce a framework cooperation and arrangements for transport planning.
- The IALA should consult EUROCONTROL who is currently building up an air traffic management.
- The national competent authority (NCA) or VTS authority should cooperate with the stakeholders of the processes relevant for the cargo flow and find a regime for future traffic flow planning in the region.
- The NCA should use the methodology of a process to control and to analyse processes in the transport chain and invent a system that includes the transport planning from the sailing to the loading phase.
- The NCA should consider to support the task of traffic planning with the decision support tools (DST).

The NCA should foster the installation of data networks that exchange consistent und updated status, planning and feedback data of the involved processes. ■

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81 EVOLUTION OF REMOTE MONITORING SYSTEMS. EXAMPLES OF SYSTEMS AT A CORUÑA AND FERROL PORT AUTHORITIES (GALICIA REGION, SPAIN)

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As is known to all, the new technologies are advancing at dizzying speeds. In the case of Remote Control and Monitoring Systems in Aids to Navigation, it is confirmed so. Since the beginning with the automation of lighthouses and beacons until today, both data acquisition systems and communication ways have taken a big step. This development allows us to combine different types of remote stations and communication channels in the same system. A clear example can be seen easily here in Galicia, where lighthouses, buoys and beacons under the responsibility of Ferrol and A Coruña Port Authorities are using it. We can see how communications are made in a port by radio in order to minimize costs, but at the time of communication with the control center, remote stations can be linked via GPRS, ADSL or via satellite communication. Another development to note is the conjunction of the remote control and monitoring systems of aids to navigation with AIS systems. On the one hand, we see how it is possible through the GPS position of the buoy to link and transmit AIS signal to vessels, in such a way to take a double system performance. But where does this evolution remain? Through this presentation, we will give some brushstrokes on where this technology evolves to.

Como todos sabemos, las nuevas tecnologías están avanzando a una velocidad vertiginosa. En el caso de los Sistemas de Vigilancia y Control Remoto en las Ayudas a la Navegación, esto también se confirma. Desde que comenzó la automatización de faros y balizas hasta la actualidad, tanto los sistemas de adquisición de datos como las vías de comunicación han dado un gran paso. Este desarrollo nos permite combinar diferentes tipos de estaciones remotas y canales de comunicación en el mismo sistema. Podemos encontrar un ejemplo claro aquí, en Galicia, donde los faros, las boyas y las balizas bajo responsabilidad de las Autoridades Portuarias de Ferrol y A Coruña lo están utilizando. Podemos ver cómo se realizan las comunicaciones por radio en un puerto para minimizar costes, pero en el momento de la comunicación con el centro de control, las estaciones remotas pueden conectarse mediante GPRS, ADSL o comunicación vía satélite. Otro desarrollo que cabe destacar es la conjunción de los sistemas de supervisión y control remoto de las ayudas a la navegación con los sistemas AIS. Por una parte, vemos cómo es posible enlazar y transmitir señales AIS a buques mediante la posición GPS de la boya, de tal forma que se obtiene doble rendimiento del sistema. Pero, ¿en qué situación se encuentra esta evolución? A lo largo de esta exposición, ofreceremos algunas pinceladas sobre hacia dónde evoluciona esta tecnología.

Tout le monde sait que les technologies avancent à une vitesse vertigineuse. C'est confirmé dans le cas des systèmes de contrôle et de surveillance des aides à la navigation. Depuis le début de l'automatisation des phares et autres balises jusqu'à présent, les systèmes d'acquisition de données et de moyens de communication ont fait un grand pas en avant. Ce développement nous permet de combiner différents types de stations à distance et de canaux de communications dans un même système. On en trouve un bon exemple, ici en Galice, où les phares, bouées et balises sont sous la responsabilité des autorités portuaires de Ferrol et La Corogne. Nous pouvons voir comment les communications sont assurées dans un port par radio pour minimiser les coûts, mais lorsqu'il s'agit de communiquer avec le centre de contrôle, les stations éloignées peuvent être reliées par GPRS, ADSL ou par satellites. Un autre développement notable est la conjonction des systèmes de contrôle et de surveillance à distance des aides à la navigation avec des systèmes AIS. D'une part on voit comment il est possible, avec la position GPS d'une bouée de transmettre aux navires un signal AIS, doublant ainsi la performance du système. Mais où nous mène cette évolution ? Dans cette présentation nous esquisserons l'avenir vers lequel cette technologie évolue.

Evolution of remote monitoring systems

Examples of systems at A Coruña and Ferrol Ports Authorities (Galicia Region, Spain)

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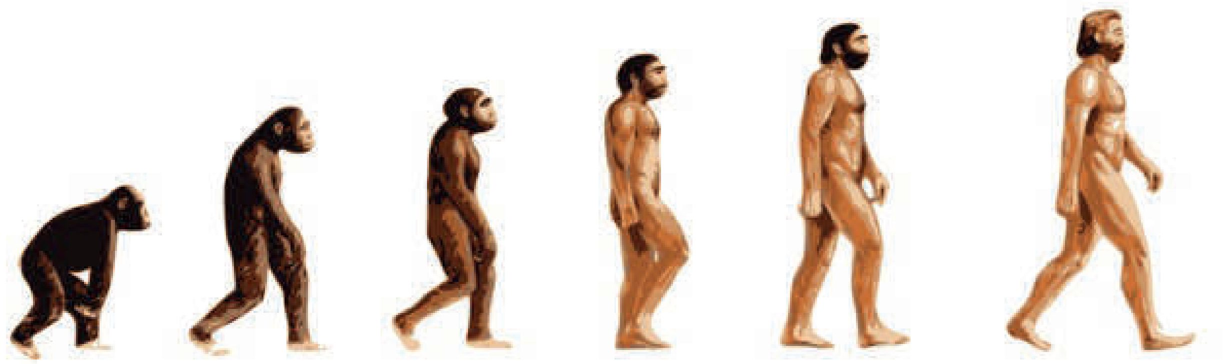


In this presentation, we will start with a review of the monitoring systems that have been implemented throughout the time here in Spain. It is important to know the beginnings of these systems to understand which the original idea was and which the aim to be achieved. We will see what types of communications were used at that time and the ones that can be used today. By analyzing the evolution, it will help us to keep in mind which factors of improvement can be used when designing a remote monitoring system, and also to conclude that the possibilities of analysis available today are endless compared with those we had twenty years ago. Following the evolution of these systems is following the technological revolution, as so far they have gone hand in hand. Becoming aware of where we started and how this field has been developing can give us an idea of how the future of these systems will be.

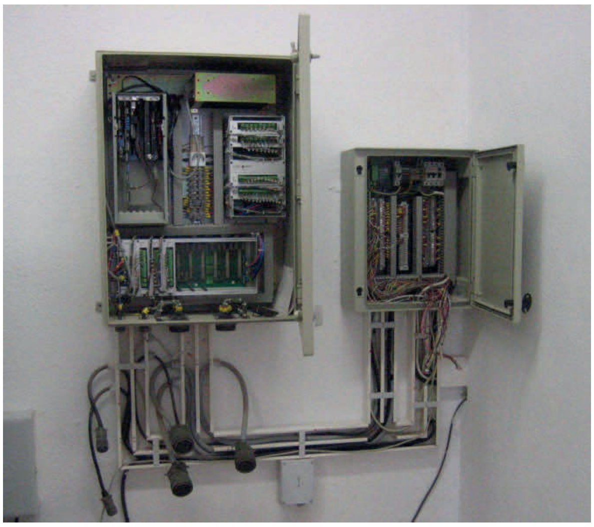
To get into this progress, we will take as an example one of the first lighthouse that was monitored, Punta Frouxeira Lighthouse, since this lighthouse has known the most clear and complete evolution on monitoring and control systems. This lighthouse is under the responsibility of Ferrol-San Cibrao Port Authority in Galicia Region. One of the characteristics of this Port Authority is its courage to be always at the forefront of the technology in its facilities. This lighthouse is the most extravagant of all the existing ones on the coast of Galicia. It is located on the headland of Frouxeiras, reason of its name (headland is “punta” in Spanish), it was built in 1992 with an avant-garde design, completely different from the traditional ones. The lighthouse became operational, for testing period, in June 1994, becoming permanent in November 1994. Its light beam is seen over 20 nautical miles away. It is about 30m height and originally its surface was all from glass. However, in 2008, it was almost fully walled, just leaving a small window at each height of stairs. The walls replaced the old glazing, and a bright blue colour gives this lighthouse a very distinctive look. The lighthouse is fully automatic and remotely monitored and controlled from the first day, so there has never been any “lighthouse-keeper” in Punta Frouxeira. We can also emphasize that it is the first lighthouse in Spain and perhaps worldwide that uses LED technology as lighting source.

The monitoring system consisted of a remote monitoring station installed in the lighthouse, which collected the different alarms and operating status from the command and control boards, and transmitted them to another symmetrical unit by using a VHF-frequency radio as link. Therefore, the control centre was formed by a remote monitoring unit equal to the one installed in the lighthouse that showed the same operating indicators (status and alarms) as the control board of the lighthouse itself. This monitoring system was successful because it was operating perfectly.

At first, this seemed a great achievement, because it supposed to have on real-time the same information as if we were on the location itself. However, at the time that other lighthouses were integrated, it was soon remarked that if a synoptic board was needed for each remote station to implement, they would not have enough room to accommodate all the synoptic boards in the same control centre. This led to take a step forward in the evolution, and then a big technological step was taken. A computer started to be used, which, linked to a single receiving radio station, would allow having all the information coming from all the remote stations in one same and only control centre. This would give way in the evolutionary scale to the first computerized control centre for lighthouses. The use of MS-DOS system (MicroSoft Disk Operating System) is an operating system for computers based on x86. It was the most popular of Microsoft DOS operating system family and the main system for personal computer compatible with IBM PC in the 80's and mid 90's decades. This control centre, based on MS-DOS, supposed to allow showing numeric data graphically in an interface that consisted of a line of commands received from lighthouse remote stations, which meant a transition from showing alarms and operating status using luminous indicators to being able to show them digitally on a computer screen.

The Port Authority implemented a monitoring system based on a control centre that utilised a HP 80386 PC, with the first existing software having user-machine interface for the control of several AtoN stations. This system abundantly fulfilled its functions until it was technologically replaced gradually by operating systems that offered a graphical user interface, in particular by several generations of Microsoft Windows. At late 90's and with the arrival of these operating systems as a complement to MS-DOS in response to the growing interest in graphical user interfaces, the first remote monitoring stations based on industrial PCs appeared. These stations consisted of one CPU unit and some circuit cards with digital and analogue inputs and outputs, which were in charge of collecting information from different lighthouse command and control boards.

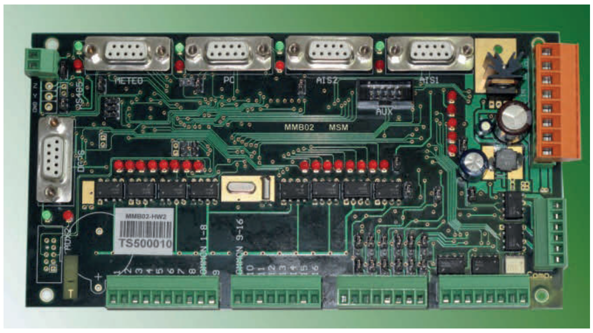
The CPU was running in MS -DOS environment, but the control centre formed by a PC was already provided with Windows operating system. It was already possible to show graphics and images, and it was also possible to analyse incidents that would be registered in the database to be analysed subsequently. In addition to the radio communications, the use of digital communication through telephone lines started. Although these stations based on industrial PCs were supplying enough information technologically to keep navaids monitored and controlled, whose concept was not very different to that used today, there was something that was making these units not give the expected results. Mainly, the marine environment was not the suitable one, the salinity of the environment and the vulnerability of these PCs to lightning caused lots of operating failures. The size and complexity of the equipment neither contributed to the equipment persisting in time, since the maintenance of the monitoring system was more complex than the one of the lighthouse control equipment in many installations. Moreover, if one of the main targets of monitoring and control systems was to reduce maintenance personnel and minimize failures, maintenance tasks increased considerably with these systems. At this stage, the first buoys started to be monitored, but the problem was the same, equipment too complex to control a beacon, beside much higher energy consumption than the one of the beacon itself, so that the solar systems needed to be over dimensioned.



Nevertheless, those devices were held until a new technological era flooded the industrial processes in the early 2000s, the "Microprocessor" era. With the arrival of the integrated circuit at the industrial world, made up of millions of electronic components at that is also described as the "computer brain", an important step is also taken in the development of remote monitoring and control stations for aids-to-navigation equipment. Besides being able to make millions of logic functions and analysis, it has as main advantages over PCs: small size, robustness and especially low energy consumption. These advantages, which have been progressively achieved over the last few years, have enabled that the remote monitoring stations can be nowadays installed even in the inside of a self-powered beacon.

The remote monitoring station installed now in Frouxeira Lighthouse is smaller than a calculator in size and has a power consumption of 50mA using GPRS communication.

Communication ways have also evolved significantly in recent years, and it has greatly enabled the monitoring of lighthouses off the beaten track, which it was unthinkable to remotely control and monitor few years ago because of its geographical location. The use of microprocessor-based systems, thanks to their multiple communication ports available, has allowed that any type of communication means can be utilised. At present, you can get information on real time from any AtoN station by using multiple connection link ways at very low operating costs. Radio frequencies in different bands, GSM / GPRS, ADSL, Satellite, optical fibre, Wifi,Wimax, can be used and best of all is that we can use different types of communication linked on the same network.



We next mention some examples on the use of those new link ways:

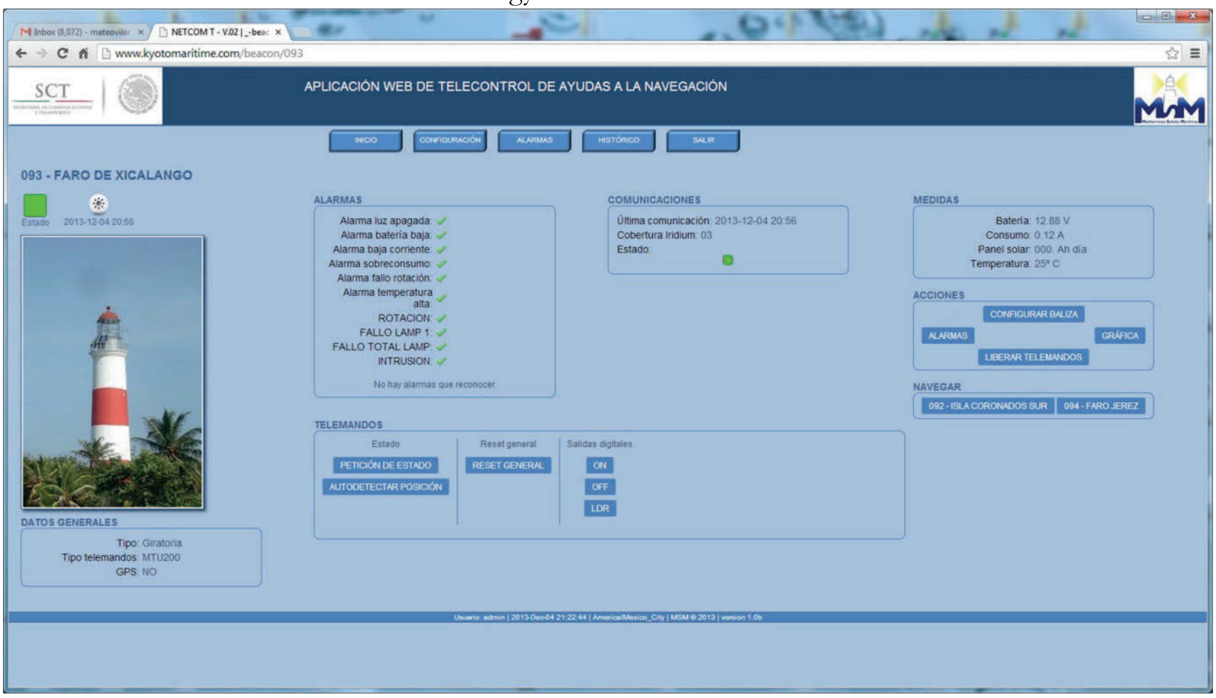
- Remote Monitoring and Control of *Columbretes Island Lighthouse*. This lighthouse, located at 50 km of the Castellon coast, Mediterranean Sea, has a remote monitoring station based on microprocessor, with consumption lower than 50 mA. The communication via used is Satellite, which allows having information available on real time at an operating cost lower than 1 USD a day. How much does it cost to move a boat/ship to that location, in order to know that the lighthouse is working properly?
- In the case of Ferrol-San Cibrao Port Authority, we can find an example of how a combination of several types of communication are used at the same time: In *Ria de Viveiro*, we have a certain quantity of buoys and beacons operating with self-contained lanterns that utilize remote monitoring station by radio communication, in order to minimize operating costs. The control

centre, located in Ferrol Port is located at 30 miles away from that estuary, therefore it was decided to utilize a remote monitoring station located in the estuary itself, which on the one hand interacted with each and every lantern and on the other hand established communication with the control centre by using a GPRS line. In this way, the Port Authority monitors and controls about ten AtoN stations with just the cost of a GPRS line.

- Barcelona Port Authority, wanting to have a safer system, decided that their lighthouses should operate with redundant communications system. Indeed, lighthouses utilise ADSL as main line and GPRS as secondary one, so that if the main communication line failed, the remote station would establish communication with the control centre through the secondary communication line. This has been only possible by using microprocessor-based remote stations of latest generation.
- In Valencia Port Authority, the bet on a remote monitoring and control system has also been strong. Besides controlling lighthouses digitally, the fact of using optical fiber lines and microwave link has empowered that video surveillance cameras are installed on the lighthouses, so that the status of command and rotating equipment can be monitored visually and on real time.

However, evolution does not end here, the revolution that the use of AIS technology has

meant in the world of sailing and especially in Aids to Navigation has enabled that this transmission device, normally used as an electronic aid to navigation, is increasingly used for remote monitoring and control of the navaids station where it is installed. With the use of the AIS AtoN, we not only control lighthouses and beacons, but



also we can send weather data to seafarers; being this one very useful information that progressively makes navigation safer. Best of all is the range (greater than 50 nautical miles) of this communication system to link to the control centre, and the zero cost of operating the VHF communications. Currently, it is now possible, thanks to the low power consumption of these AIS AtoN units, to integrate them into a self-contained lantern.

Likewise, control centres have evolved fast, and they have been doing it in parallel with computer operating systems. Today, the major advance has been the WEB control centres. The WEB concept enables that the information received from various remote stations can be viewed from anywhere with Internet access. The newest control centres offer the possibility of interconnection with AIS base stations, and so can generate virtual AIS AtoN signals from the data obtained/received from the different lights and beacons. They constitute by themselves authentic tools of prevention and surveillance, being possible to obtain consumption and voltage graphs, analysis of historical alarm reports and to set reports on each of the monitored signals. One of the most current analyses that these control centres of latest generation are able to establish is the "availability" status data of each one of the monitored AtoNs, in order to evaluate the operating condition of such navaids station.

As we have seen in the evolution of technological advancement, we are in a moment in which anything is possible in the world of remote monitoring. I find it difficult to know what the future in these systems will be; but, looking at the changes that have been taking place, I venture to guess that the next step is that the lighthouse control units and beacon control circuits (flashers) integrate the remote control and transmission system themselves, by reducing sizes, consumption and costs. Who knows? What I do see still difficult, but I do not know for how long, is that these systems can replace maintenance personnel.■

118 A-TO-N PROJECT MANAGEMENT FOR DEEP-WATER NAVIGATION CHANNEL AT YANGTZE RIVER ESTUARY

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The administration project of the deep-water navigational Channels at Yangtze River estuary, a world-class estuary control project, is the most difficult and largest waterway management project in the history of China's water-born transport, with the greatest investment. This project commenced in 1998 and terminated in 2010. It was carried out in three phases in terms of the channel depth, namely, Phase 1, 8.5 m.; Phase 2, 10 m; and Phase 3, 12.5m. The channels allow the all-tide two-way navigation of the third and the forth generations of container ships and 50,000DWT freighters (with a full drought ≤11.5 m). The fifth and sixth generations container ships and 100,000DWT freighters can also go in and out of the channels at Yangtze River estuary with high tides after the load is partially discharged.

The proposed channels totaled 92.2km (about 50 nautical miles) in length with a bottom width of 350-400m. In order to ensure the target water depth, the waterway had been dredged and an underwater structure with an overall length of about 120 km has been built, composed of distributary mouth, guiding dikes and T-shaped dike clusters. The construction of the mentioned project rendered great changes to the environmental conditions of this water area, i.e., increased volumes of larger ships, increasing of channel crossings, and the appearance of underwater structures, which makes the A-to-N management confronted with unprecedented challenges. This thesis offers a systematic introduction of the characteristics of the A-to-N project thereof with its focus on our solutions and experience concerning the following questions during the past 10 years and more:

- A-to-N deployment for compound channels
- A number of warning modes adopted for newly built guiding dikes under special navigational onditions
- Measures adopted for light beacon structures in case of uneven sedimentation of guiding dikes
- Solutions for drifting buoy
- Adjustment of light-buoy during long navigation channel dredging

El proyecto de administración de los canales navegables de aguas profundas en el estuario del río Yangtsé, un proyecto de control de estuarios de primera categoría, es el proyecto de gestión de vías navegables más grande y difícil en la historia del transporte marítimo de China, con la mayor inversión. Este proyecto comenzó en 1998 y terminó en 2010. Se realizó en tres fases en términos de profundidad de canal, concretamente, Fase 1, 8,5 m; Fase 2, 10 m; y Fase 3, 12,5 m. Los canales permiten la navegación bidireccional con todo tipo de marea de la tercera y cuarta generación de portacontenedores y cargueros de 50 000 TPM (con calado ≤ 11,5 m). La quinta y sexta generación de portacontenedores y cargueros de 100 000 TPM también puede entrar y salir de los canales del estuario del río Yangtsé con marea alta después de descargar parcialmente las mercancías.

Los canales propuestos sumaban una longitud de 92,2 km (aproximadamente 50 millas náuticas) con una anchura del fondo de 350-400 m. Para garantizar la profundidad objetivo del agua se ha dragado la vía navegable y se ha construido una estructura submarina con una longitud total de cerca de 120 km, compuesta por una desembocadura distributaria, diques guía y grupos de diques en forma de T. La construcción del proyecto mencionado representó grandes cambios en las condiciones medioambientales de este espacio acuático, es decir, aumento del volumen de grandes buques, aumento de cruces de canal y aparición de estructuras subacuáticas, lo que confronta la gestión de las AtoN con desafíos sin precedentes. Esta tesis ofrece una introducción sistemática de las características del proyecto AtoN centrado en nuestras soluciones y experiencia durante más de 10 años sobre las siguientes cuestiones:

- Implantación de AtoN en canales compuestos
- Diversos modos de advertencia adoptados para diques guía de reciente construcción en

condiciones de navegación especiales

- Medidas adoptadas para estructuras de baliza luminosa en caso de sedimentación desigual de los diques guía
- Soluciones para boya a la deriva
- Ajuste de boya luminosa durante el largo dragado del canal de navegación

Le projet de l'administration pour les chenaux en eaux profondes de l'estuaire du Yangtze, une voie de navigation de type international, est un des projets les plus difficiles et importants de l'histoire de la Chine pour ce qui concerne ses voies de navigation. Commencé en 1998 il s'est terminé en 2010. Il fut exécuté en trois phases, suivant la profondeur des chenaux : Phase 1 : 8,50 m, Phase 2 : 10 m et Phase 3 : 12,50 m. Ces chenaux permettent la navigation dans les deux sens et quelle que soit la marée, des porte-conteneurs de troisième et quatrième générations et des cargos de 50000DWT (d'un tirant d'eau maximal de 11,50 m. Les cinquième et sixième générations de porte-conteneurs et les cargos de 100 000 DWT peuvent aussi entrer et sortir de l'estuaire par marée haute et en charge partielle.

Les chenaux proposés avaient une longueur totale de 92,2 km (environ 50 milles nautiques) sur une largeur de base de 350-400 m. Pour assurer la profondeur d'eau désirée, la voie d'eau avait été draguée et on avait construit au fond une structure d'environ 120 km, constituée de bouches de distribution, de digues guides et de groupes de digues en forme de T

La construction d'un tel projet a entraîné d'importantes modifications environnementales dans la zone navigable : un trafic plus important de navires plus grands, plus de traversées de chenal, et un affleurement des structures sous-marines qui ont imposé aux gestionnaires des aides à la navigation un défi sans précédent. Ce rapport présente de façon méthodique les caractéristiques du projet d'aides à la navigation en se concentrant sur nos solutions et notre expérience des dix dernières années qui concernent les points suivants:

- *organisation des aides dans le réseau de chenaux*
- *signaux d'alerte adoptés pour les digues guides nouvellement construites dans des conditions de navigation particulières*
- *mesures adoptées pour les structures des balises lumineuses dans le cas, rare, de sédimentation des digues guides*
- *solutions pour les bouées dérivées*
- *adapter une bouée lumineuse pendant une longue période de dragage de chenal.*

A-to-N project management for deep water navigation channel at Yangtze River Estuary

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1. Introduction

Yangtze River Estuary, the estuary of Yangtze River, the longest river in China, appears trumpet shaped riverbed. The river runs into the sea through three stage tributaries and four estuaries, separated by Chongming Island at Baimao Estuary and downstream into two waterways: the North Waterway and the South Waterway. The former is further separated at the Wusong Estuary by Changxing Island and Hengsha Island into North Port Waterway and the South Port Waterway; while the latter is divided by Jiuduansha Wetland into South Passage and North Passage. The North Waterway, North Port Waterway, North Passage and South Passage are Yangtze River's four access to the sea. ***Figure 1*** shows the map of Yangtze River Estuary.

At the water area of Yangtze River Estuary, there are 511 A-to-N devices, including the traditional visual light vessels, light-buoys, light beacon and lighthouses, and radio A-to-N, such as racon and AIS responders, and virtual AIS A-to-N and warning notices according to the characteristics and demands for control project of deep-water navigation channel at Yangtze River Estuary. For details, see ***Table 1***.

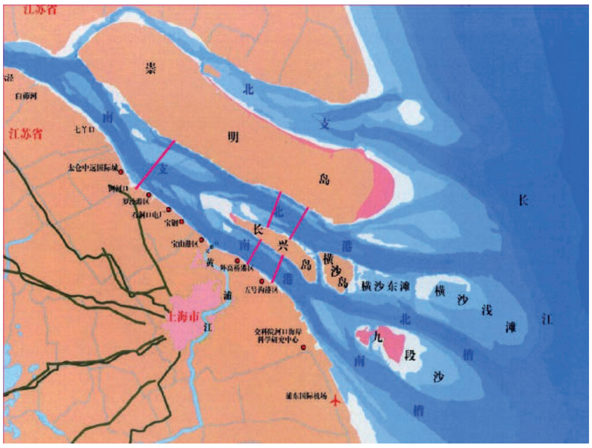

Figure 1: Map of Yangtze River Estuary

2. A-to-N Deployment for Compound Channels

In order to meet the navigation demands in the deepwater channels and ensure the safe navigation of ships while reducing the project investment, the A-to-N are mostly placed in the middle of the deep

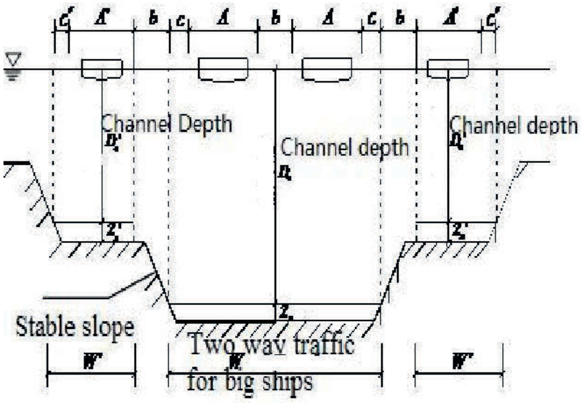

Figure 2: The cross section of compound navigation channels

water channels for two-way navigation (main channel) and the compound channels for one-way navigation of small ships (auxiliary channels), with the cross-section shown in ***Figure 2***.

The main channel, i.e., the deep water channel in the project, should be dredged and maintained so as to ensure the desirable channel depth. At present no international or domestic standards and regulations exist for this type of A-to-N, nor

Type \ Location	North Passage	South Passage	South Port Waterway	South Waterway	North Port Waterway	North Waterway	Subtotal
Light boats	2	3		2			7
Light buoys	58	73	29	58	54	30	189
Light beacons	52	6	13	28	9	2	8
Lighthouse	1				1		10
Warning signs				4			6
Virtual AIS AtoN	3	4	8	16	2		6
AIS responders	9	9	1	9	4	4	83
Racon	8	4	1	3	1		110
Total							511

Table 1: Number AtoN to be deployed in the Yantze River Estuary

relevant suggestion by IALA. According to the traditional visual A-to-N and the national standards, there are two modes (***Figure 3***):

Solution 1: A-to-Ns are placed only on the main channels but not on the auxiliary channels, which means to place compound A-to-Ns on both sides of the main channels to mark the limits of channels. This solution is simple and helpful for ship navigation, but it's only applicable to the auxiliary channels which have natural water depth and desirable the water depth at the outer side to allow adequate channel width.

berthed, go in and out of the anchorage and maneuver to avoid collision. After the project began, the deployment of A-to-Ns became a hard nut, for the ships were larger, the channels were to be dredged locally with the ship volumes continuing to increase and the big and small ships must be separated. If Solution 1 was to be adopted, the traffic in the main channels will be increased, for the smaller ships would be mistakenly led into the main channel. If Solution 2 was adopted, excessive light-buoys in a small area of water surface would become obstacles for ships entering and leaving the anchorage and the operation of

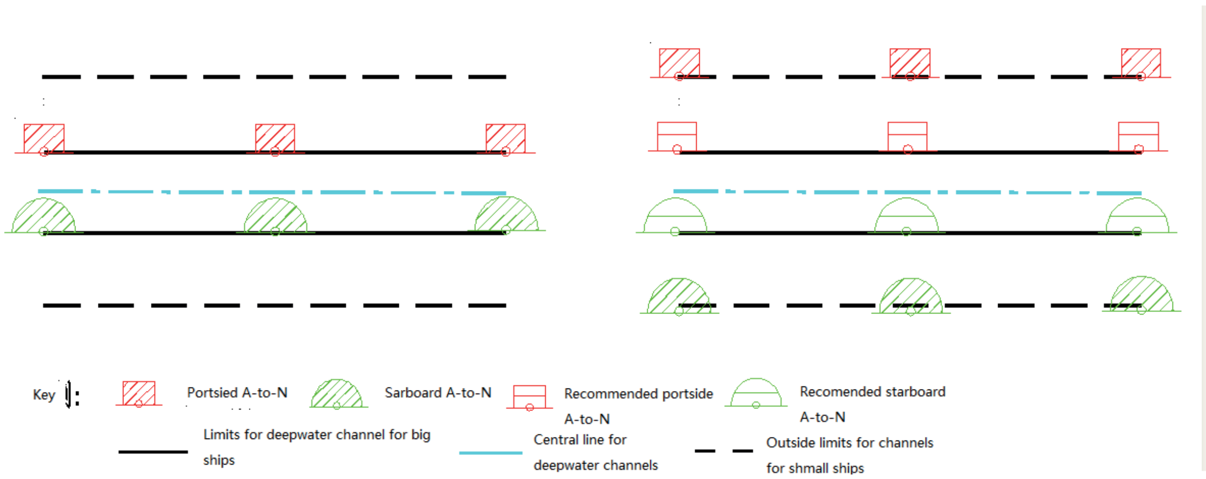

Figure 3: Two solutions to mark compound channels by visual AtoN

Solution 2: A-to-Ns are placed on both the main and auxiliary channels. The main channel is regarded as the recommended one, on both sides of which compound A-to-Ns are placed to direct the channels, while compound A-to-Ns are placed at single side of the auxiliary channels for one way traffic. This solution is clear and direct, but employs relatively more A-to-Ns. The light-buoys placed along the channels will occupy too much navigation resources and increase the channel construction investment; moreover, redundant A-to-N devices placed in the water will make it inconvenient for ships' maneuvering. Furthermore, it will be difficult for the ships to identify, thus affecting the safe navigation of ships.

In the South Port waters, i.e., from Yuanyuansha -- the main channel at Yangtze River Estuary upstream to its crossing with Huangpu River, the water depth was desirable before the project, with large ship traffic volume. By virtue of the anchorage to the north and Waigaoqiao Terminal to the south, ships here may turn round, get ships' berthing at Waigaoqiao Terminal. The conclusion is that neither Solution 1 nor Solution 2 should be adopted.

Currently, the land-based AIS along China's coastal areas has been basically completed, forming a continuous coverage at the waters along the Yangtze River Estuary. According to the 2002 revised edition of SOLOS, ships of and over 500DWT should be equipped with AIS before 2008. This means it was possible to deploy virtual AIS A-to-N. Therefore, Solution 3 came into being by combining the virtual AIS A-to-N with the traditional visual ones to mark the limits of compound channels, i.e., to replace the visual A-to-N in the main channel mentioned in Solution 2 with AIS A-to-Ns to mark the limits of the main channel and apply light-buoys to mark the limits of auxiliary channels. In this way, as for small ships, visual observation is adequate to identify the limits of auxiliary channels; while bigger ships can sail in the main channels along the ECDIS so as to meet the requirement of marking the limits of the main channel. ***Figure 4*** shows the application of this solution in South Port Waters.

In the South Port waters, i.e., from Yuanyuansha -- the main channel at Yangtze River Estuary upstream to its crossing with Huangpu River, the water depth was desirable before the project, with large ship traffic volume. By virtue of the anchorage to the north and Waigaoqiao Terminal to the south, ships here may turn round, get berthed, go in and out of the anchorage and maneuver to avoid collision. After the project began, the deployment of A-to-Ns became a hard nut, for the ships were larger, the channels were to be dredged locally with the ship volumes continuing to increase and the big and small ships must be separated. If Solution 1 was to be adopted, the traffic in the main channels will be increased, for the smaller ships would be mistakenly led into the main channel. If Solution 2 was adopted, continuous coverage at the waters along the Yangtze River Estuary. According to the 2002 revised edition of SOLOS, ships of and over 500DWT should be equipped with AIS before 2008. This means it was possible to deploy virtual AIS A-to-N. Therefore, Solution 3 came into being by combining the virtual AIS A-to-N with the traditional visual ones to mark the limits of compound channels, i.e., to replace the visual A-to-N in the main channel mentioned in Solution 2 with AIS A-to-Ns to mark the limits of the main channel and apply light-buoys to mark the limits of auxiliary channels. In this way, as for small ships, visual observation is adequate to identify the limits of auxiliary channels; while bigger ships can sail in the main channels along the ECDIS so as to meet the requirement of marking the limits of the main channel. ***Figure 4*** shows the application of this solution in South Port Waters.

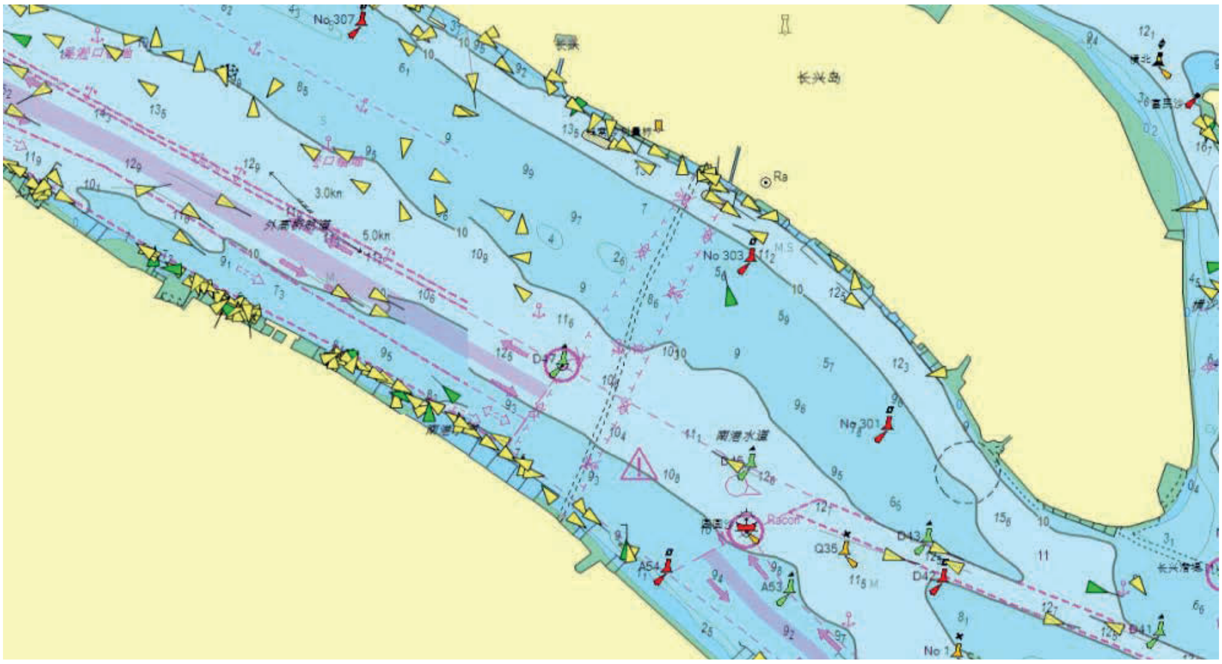

Figure 4: Deployment of AtoN at South Port Waters

excessive light-buoys in a small area of water surface would become obstacles for ships entering and leaving the anchorage and the operation of ships' berthing at Waigaoqiao Terminal. The conclusion is that neither Solution 1 nor Solution 2 should be adopted.

Currently, the land-based AIS along China's coastal areas has been basically completed, forming a

3. A Number of Warning Modes adopted for newly built guiding dikes under Special Navigation Conditions

The regulating structures for New Liuhe sand bar and Nanshatou Channel submerged dikes at the diverge of South Port and North Port deep water channels at the Yangtze River Estuary is composed of New Liuhe sand bar works and Nanshatou submerged dike works. The New Liuhe sandbar protection is composed of the Southern Dike, the Northern Dike, Round-up Dike and an submerged dike, with a total length of 8,610m, of which the total length for the first three dikes is 3,073m, with a top elevation of +2.0m; while the submerged dike is 537m in length and 2.0m in height. The Nanshatou Channel submerged dike is 2,390m in length, of which the transitory part connecting the Northern Dike is 500m in length, with a height of 2.0m and gradually reduced to -2.0 m. The main part of the submerged dike is 1,300m in length, with the top elevation of -2.0m. The transitory part connecting the Zhongyangsha Longitudinal Dike that runs along the channel for 590m, with the top elevation gradually rising from -2.0m at the main dike to +3.2m as high as that of the Zhongyangsha Longitudinal Dike.

According to relevant national design specifications, A-to-Ns shall be placed to identify the position and orientation of regulating structures. Light beacons shall be placed on the Southern Dike, the Northern Dike and the Round-up Dike. Besides, the submerged dikes are marked by a combination of light beacons and traffic warning signs, as the downstream part of the Nanshatou Channel where submerged dikes are constructed was originally a habitual navigation channel for a large volume of traffic for passenger boats, fishing boats and other small ships. After the navigation is prohibited in this area, many small ships may still sail in this area out of their habit. That is why the submerged dikes are noted on the warning signs with two Chinese Characters “qiandi”, so as to increase the ships' ability to identify the signs and to reinforce the warning effect. ***Figure 5*** shows the plan and structure designs.

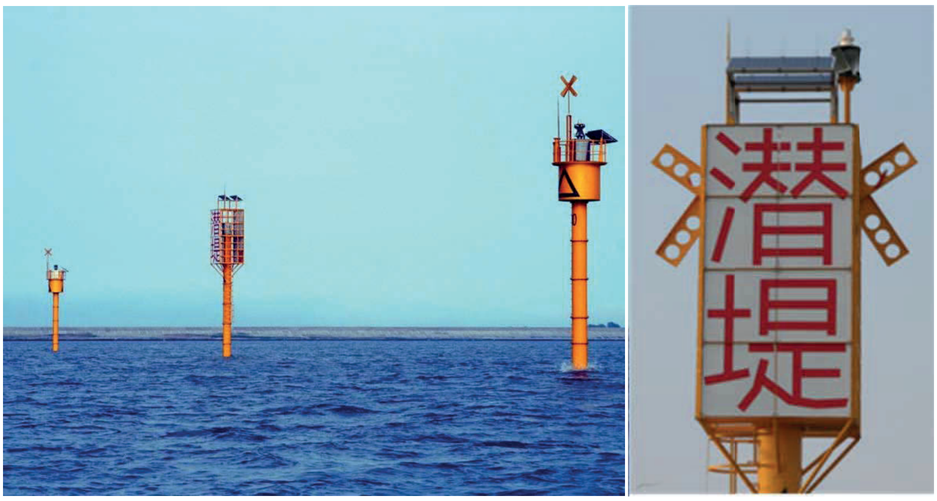

Figure 5: Installation of warning signs in guiding dikes

4. Measures adopted for light beacon structures in case of uneven sedimentation of guiding dikes

The total length of regulating structures for management of deepwater navigation channels at Yangtze River Estuary is totally 120 km long, including the guiding dikes in the north and the south, the T-shaped dikes, Changxing submerged dike and the protective dikes for the sand bars at the division mouth of the South Port and North Port. During the sedimentation observation period, some structures were found to sediment unevenly due to the special geologic environment and structural characteristics of underwater structures. As the base of light beacon was precast concrete ones with steel reinforcement and were constructed at the same time with the underwater structures. Therefore they would sediment unevenly accordingly, and if the sedimentation exceeds a certain degree, the functions of light beacons will surely be affected directly. Generally, it is required that the vertical tilt of light beacons should not exceed 3H/1000(mm), where H is the light beacon height. The maximum allowable tilt of the base can be calculated. Measures should be taken to correct the discrepancy for those light beacon bases that exceed the tilt limits before the upper structures of light beacon are installed.

The light beacons along the Yangtze River Estuary were all steel structures assembled in segments so as to facilitate operations on water. The upper structures of light beacons were installed to the base with bolts pre-buried in the base. However, considering the great differences of uneven sedimentation, it is difficult to forecast before operations, which means it would be an expensive operation to directly adjust level at the time of base construction. Therefore, the method to directly add the "leveling section" on the upper structures and the base is adopted for its easy and simple operations. See ***Figure 6***.

5. Solution for drifting buoy

There are three turning points along the North Passage Navigation Channel with the largest turning angle of 36°. The maximum angle between the channel tendency and the main current direction of ebb and flow is 25°, greatly exceeding the requirement that the design wind pressure difference of ships in the channels shall be less than 10°-15° recommended by IALA in its Guide to A-to-N. Besides the difficulty in controlling the ships' maneuvering, the setting, application, maintenance and management of light-buoys also increase the technical difficulties. As a result, we adopted a cross isometric deployment, i.e., deploying the light-buoys at equal distance on each side and symmetrically positioned on opposite sides, to nark the limits of the navigation passage, aid the shops to avoid buoys and facilitate the maintenance and management of light-buoys. However, after Phase 1 project was implemented, we found the light-buoys had drifted significantly. According to statistics, about 1/3 of the light-buoys drifted within two months after installation, with the light-buoys at the turning point of the external channel of North Passage drifting away for as many as three times. Analysis showed that, on the one hand, the dikes in the project restrain the flow, increasing the flow volume of water returning to the North Passage, accelerating the flow dynamics, building up the natural brushing to the channel, so as to deepen the channel, lead the flow and reduce the back silting. Data shows that after the project completion, the flow rate in some channel segments sped up from the original 0.5m/s- 1.0m/s to 2.0m/s-3.0m/s and in particular, the rotating flow at the outer channel of North Passage has greater angle; on the other hand, in the geological aspect, the project has silty sand + mucky silty clay. The increased rotating flow and the smaller friction between the buoy sinkers and the soils, cause insufficient buoy anchorage and drifting of light buoys.

Under certain conditions, the key to reduce buoy drifting is to increase the anchorage, which is mainly formed by vertical and horizontal stretching resistance. The horizontal resistance comes from the friction of the soils (sandy soils) at the sea bottom and the difference between the passive soil pressure and the active soil pressure; while the vertical resistance is the combination of the weight of the sinker under water and the force of the covering soil. It is obvious that the anchorage of buoys, including the structure, shape, material, and installation mode of anchor chains and sinkers are factors to effect the anchorage.

We conducted much research and improvement to

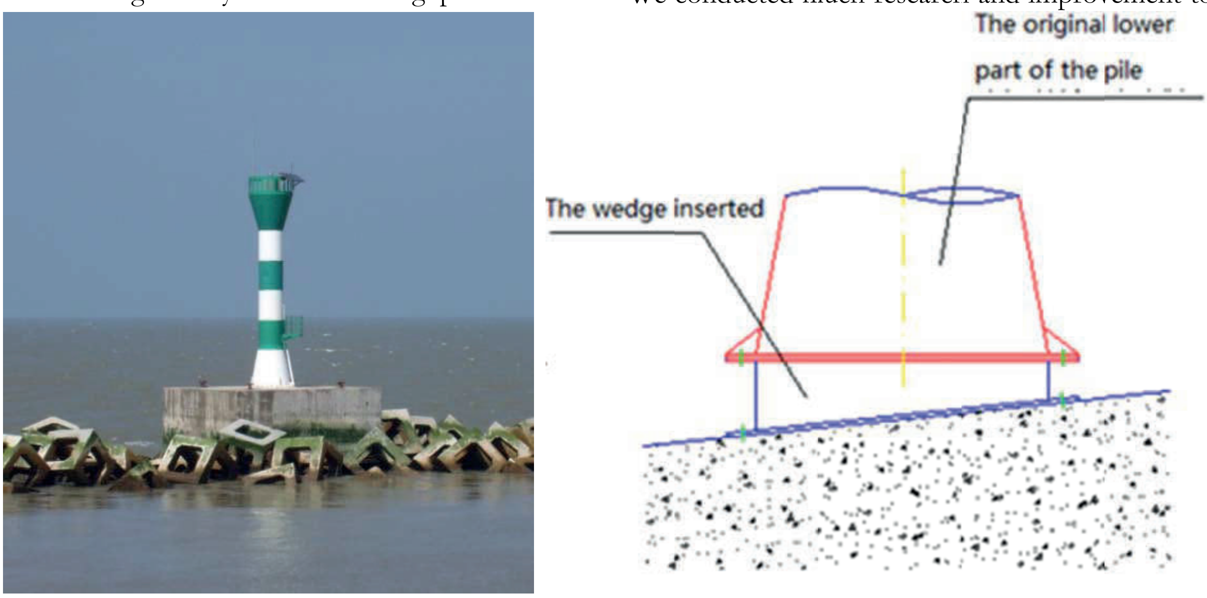

Figure 6: Solution for sedimentation of light beacon base along the guiding dikes

the anchoring of light-buoys along the Yangtze River Estuary. Although lengthening the anchor chain was considered as one means, it should not be used as this would increase the turning radius of the light-buoys and hence occupy more channel resources. It was once suggested that two sinkers are bound together with one of them in the shape of anchor fluke to improve the anchor holding capacity. However, the experiment showed that the improved capacity is limited and the difficulty in maintenance is increased. Therefore the only practical way is to use the single-point anchorage to increase the anchorage of the sinker by changing its structure, shape and material.

Geometrically, the sinkers contains rhombus, rectangle, bow-shaped, sphere, etc. The last two are of low gravity and good in stability. The sinkers can also be classed according to the installation position, i.e., placement or embedment. When the sinker is placed on the bottom, there will be no difference between the active soil pressure and the passive soil pressure, nor will there be the weight of the covering soil. There is only the friction, which is the difference between its weight and the upward pulling force. Hence the anchorage is poor. If the sinker is buried under the silt, the anchorage will be improved greatly. But the operation is not practicable where there are quite a lot of light-buoys, such as the Yangtze River Estuary as the operation and maintenance are complicated and expensive. As a result, we adopted the 5-ton cast iron sinker design recommended by IALA in its Suggestions on Design of General Anchoring Tools. By this way the light-buoys anchorage will meet the requirements under the conditions at the Yangtze River Estuary. Besides, the cast iron sinkers with small volume are easy to be pulled out, convenient for engineering maintenance, dredging and future widening and relocation. See ***Figure 7***.

6. Readjustment of light-buoys during long navigation channel dredging

The project at the Yangtze River Estuary was implemented in phases. For example, Phase 2 is to widen the channel from 300m dredged in Phase 1 to 350m (the outer channel to be widened from 350m to 400m); the bottom width should be dredged from 8.5m deep to 10m; and the light-buoys on both sides should be adjusted according to the progress of the project. Take the upstream channel as an example. The channel at Phase 2 should be widened in the northern direction, so the light-buoys should be moved accordingly to further north. See Fig. 8. First, the channel was to be widened then dredged deeper. It was important that the light-buoys be moved scientifically and reasonably for the numerous A-to-Ns.

As it was specified that the dredging boats used in the project, whose daily dredging capacity is about 100,000m3 each, should be operating 250m upstream or downstream away from a light-buoy, there would be a volume of 6250m3 after every light-buoy is removed. In order to reduce the impact on the navigation as much as possible, it was required that the movement of the light-buoys should meet the demand of the dredging project as well as the safe navigation of the 8.5m channel during Phase 1. To meet all the conditions above, the north channel would be retained on the premise that the project was implemented in segments. Firstly remove the light-buoys on the northern side and adjust some of the light-buoys to their temporary positions after the dredging was done so as to ensure the navigation in the original

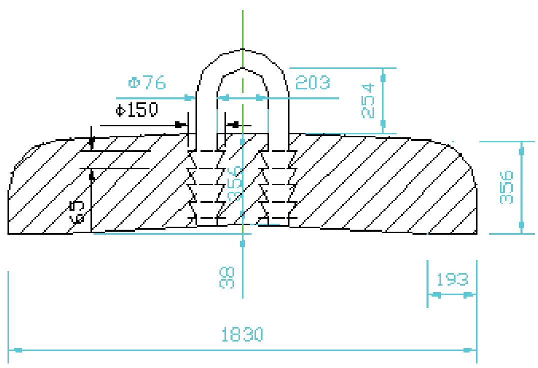

Figure 7 : Installation of light buoy

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Phase 1 channel. The light-buoys would be moved to the required positions after the channel was widened and deepened to meet the demand in Phase 2. Only that can the light-buoys on the southern side be adjusted. This was indeed efficient and safe.

AIS and ECDIS, without which the AIS virtual A-to-N would not be correctly displayed. Besides, the lack of international rules and regulations for the application reduced somewhat the creditability and reliability. Nevertheless, more than 3 years of the operation of the AIS virtual A-to-N won a

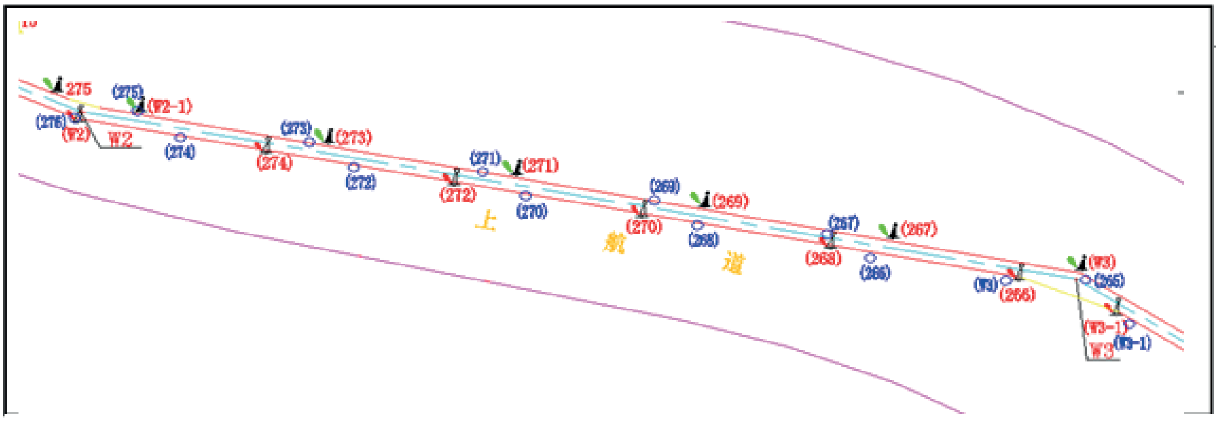

Figure 8: Contrast of light buoy deployment in the main channel (upstream channel) at Yangtze River Estuary before and after Phase 2

unanimous praise from piloting, port authorities and maritime institutions. The practice in using traffic warning signs, iron sinkers, the sedimentation of light-buoy bases and the readjustment of such during the channel dredging proved to be effective and have been introduced to similar projects in China.

7. Conclusion

From the time when Phase 1 deep water channel dredging project at the Yangtze River Estuary was completed in 2000 to 2012 when Phase 3 of the project was completed and up till now, the first A-to-N have been in operation for over 13 year, during which we accumulated some experience, giving us a lot of opportunities in summarizing and perfecting our work in design, maintenance and management. The topics discussed above were applied for the first time in China, of which the application of AIS virtual A-to-N in the compound navigation channels offered security to the safe and swift passage of large ships. However, the application is technically limited, since it required that all the passing ships should be equipped with

Moreover, the shipping industry in the Yangtze River is continuously developing, and the channel conditions are well under observation. Any change in the channel and navigation environment will have an impact on the deployment of the light-buoys. We must strive to perfect our work and get ourselves fully adapted to the changes so as to better our service to the ships and their safe navigation.

86 E-200 EXPLAINED

Malcolm Nicholson. General Lighthouse Authorities, United Kingdom & Ireland

In 2008 IALA published the E-200 suite of Recommendations. It was a culmination of the work carried out by the IALA Ad-hoc Specialist Working Group over a number of years. Their remit was to simplify, update and gather together all the recommended methods for the calculation, determination, measurement and estimation of the performance of light signals. Not a simple task! Since the release of E-200 many members have commented on the ease of use and the effectiveness of grouping these documents together.

This paper will give a history of events, including the decisions made while developing E-200, an overview of the technical content, explained in simple terms, how to use E-200 and will attempt to address some of the areas that require improvement.

En 2008 la IALA publicó la serie E-200 de Recomendaciones. Fue la culminación del trabajo realizado durante varios años por el Grupo de Trabajo Especializado «ad hoc» de la IALA. Su cometido era simplificar, actualizar y compartir todos los métodos recomendados para el cálculo, la determinación, la medición y la estimación del rendimiento de las señales luminosas. ¡Una tarea nada fácil! Desde la publicación de la serie E-200 muchos miembros han comentado la facilidad de uso y efectividad de agrupar estos documentos.

Esta ponencia expondrá los hechos, incluyendo las decisiones tomadas durante el desarrollo de la serie E-200 de Recomendaciones, una perspectiva del contenido técnico explicado en términos sencillos y cómo utilizar la serie E-200. Además, intentará abordar algunos de los ámbitos que requieren mejoras.

En 2008, l'AISM a publié la série de Recommandations E-200. Ce fut le couronnement de travaux menés pendant plusieurs années par Groupe de travail de l'AISM. Sa tâche était simplement de simplifier, mettre à jour et rassembler toutes les méthodes recommandées pour le calcul, la détermination, la mesure et l'estimation des performances des signaux lumineux. Pas si simple ! Depuis la sortie de E-200, de nombreux membres ont reconnu la facilité d'utilisation et l'efficacité du rassemblement de ces documents.

Ce rapport va rappeler l'histoire de ces travaux, avec les décisions prises pendant le développement de E-200, présenter en termes simples le contenu technique, expliquer comment utiliser E-200, et essaiera de trouver les quelques parties qui demandent à être améliorées.

E–200 explained

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E-200 explained

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Introduction/Background

In 1999 a European consortium submitted a paper to the IALA Conference in Hamburg with the aim of presenting a standard measurement procedure for the photometric characterisation of beacons used as luminous signals in maritime navigation. Some Members had reservations about the methods and when it was presented to the Commission Internationale de l'Eclairage (CIE) (Warsaw) the following year those reservations were voiced. The response to this was that IALA should develop its own standard. A draft standard was prepared and presented at IALALITES (Koblenz 2001) where a decision was made to make it into a Recommendation, not a Standard, as it covered a number of measurement techniques. A Standard, would normally be reserved for very specific applications and a single, approved procedure. What followed was the publication of IALA Recommendation E-122 on the Photometry of Marine Aids to Navigation Signal Lights (June 2001).

The rapid development of LED Buoy lanterns after the publication of E-122 meant that further amendments were required. During the IALABATTLITE workshop in Dublin (2004) a number of amendments were made, but it became apparent that, a) the document was becoming very large and b) the other Recommendations and Guidelines that were referenced needed updating as well. Thus, the Ad-hoc Specialist Working Group was formed. Their remit was to simplify, update and gather together all the recommended methods for the calculation, determination, measurement and estimation of the performance of light signals. Not a simple task!

Method

The first task was to collate information on the photometry, colours (including blue light) and colour measurement, incorporating relevant text / amended text from:

IALA Recommendation for the colours of light signals on aids to navigation, Dec. 1977;

IALA Recommendation on the determination of the luminous intensity of a marine aid to navigation light, Dec. 1977;

IALA Recommendation on the calculation of the effective intensity of a rhythmic light, Nov. 1980;

IALA Recommendation E-122 on the photometry of marine aids to navigation signal lights, June 2001 (as revised during IALABATT/IALALITE5, Oct. 2004)

Once this had been completed, the following tasks were required:-

1. Assess the most suitable presentation format for the information to provide a comprehensive, intuitive documentation structure for members.
2. Prepare draft documentation / recommendation(s) on Photometry, Colours and Colour measurement for Marine Aids to Navigation Signal Lights;
3. Identify an action plan to work proactively with other international organizations to promote research and development on aspects of light and power sources for aids to navigation.

The Working Group considered how best to achieve the most suitable presentation format. Initial discussions veered towards a beginner's guide and an advanced guide, along the lines of 'Photometry for Dummies' and 'Advanced Photometry'. On further discussion it was felt that the NavGuide was the beginner's guide and that the more advanced sections should be referenced in the NavGuide.

The next step was how to structure the document so it was intuitive for members to access. The Working Group tried to put themselves in the position of IALA's members and how they would use the document/documents. Since the majority of IALA members provide a mix of aids to navigation i.e. buoys, beacons and lighthouses the choice was to start with colour. The 1977 publication on the colours of light signals required several updates as well as the introduction of a blue region.

Once colour information is established the next logical step is to consider the range at which the signal is to be viewed, although this may come first in some situations. This being the case the group considered whether to have one, all-encompassing document, or a number of separate documents. The idea of having a suite of documents, all related to each other, came out of these considerations. Hence, each part could be referred to either individually or as a whole.

Incidentally, the title, E-200 only came about as the group didn't know how long it would take to write and by the time they had finished they felt IALA might have come close to that number during the course of developing its other recommendations.

Now that the colour and range 'Parts' had been decided, measurement, effective intensity (which was treated separately) and calculation of performance fell into place as natural 'Parts' to the suite. And so, the suite consisted of:-

Part 1 – Colour

Part 2 - Calculation, Definition and Notation of Luminous Range

Part 3 – Measurement

Part 4 – Determination and Calculation of Effective Intensity

Part 5 – Estimation of the Performance of Optical Apparatus

The Group wanted some way of linking the documents so members would know which 'Part' to reference when looking for specific information. 'Part – 0 Overview' was written to guide members to the appropriate Parts.

Overview of E–200

There are two main ways of using the E-200 series of recommendations, Top Down and Bottom Up.

Top-Down

From the navigational requirements, the required effective luminous intensity under given service conditions can be derived. If the design of the optical apparatus is known the photometric intensity can thereafter be determined.

Bottom-Up

For a given beacon the photometric intensity can be measured or calculated by the tools made available in part 3 or part 5. The results may then be used to obtain the value of the effective intensity under given service conditions and thus the luminous range.

Figure 1 shows how the different parts of E-200 are linked.

Required Updates

Consider revised flow diagram with some worked examples.

Part 1 – Colour

This part describes the recommended colour chromaticity regions of marine signal lights. It also provides information on how and why the regions have been adjusted taking into account the risks of colour confusion.

The key changes were to move away from general regions and give temporary regions for a defined time period (10 years after publication -2018).

Most of the preferred regions were retained, but renamed to IALA Optimum regions. ***Figure 2*** shows the revised regions on the CIE 1931 Chromaticity diagram. To avoid colour confusion the colour of AtoN lights should be inside the colour boundary.

The introduction of blue light via the Emergency Wreck Marker Buoy meant that a blue chromaticity region had to be defined. This region is a truncated version of that recommended by the CIE with a slight extension towards the green to include 470nm LEDs.

Required Updates

None at present, but temporary regions will be removed in 2018.

Part 2 – Calculation, definition and notation of luminous range

This recommendation provides a link between the physical and photometric features of marine AtoN lights and the luminous range information given to the mariner. Five previous IALA documents have been amalgamated into this recommendation. It permits providers and manufacturers of marine AtoN lights, as well as mariners, to determine the luminous range of lights as a function of their intensity and of the meteorological visibility.

It also provides the minimum values of illuminance at the eye of the observer or threshold of detection values for:-

Night time

0.2 µlux – No background lighting

2 µlux – Minor background lighting

20 µlux – Major background lighting

1 µlux – Leading Lights

Daytime

1 mlux - corresponds to a sky luminance of 10,000 cd/m^2

Conversion to metric units and nomograms are also provided, as well as examples of how to use them.

Required Updates

Minor amendments to structure and further examples. A methodology for evaluating background lighting and required illuminance levels. Alternative description of threshold of detection.

Part 3 – Measurement

This recommendation provides an approved methodology to promote uniformity in determining and reporting the photometric and colorimetric performance of a diverse group of marine AtoN lights. The competent technical authority should determine the appropriate measurements to be made for each type of AtoN

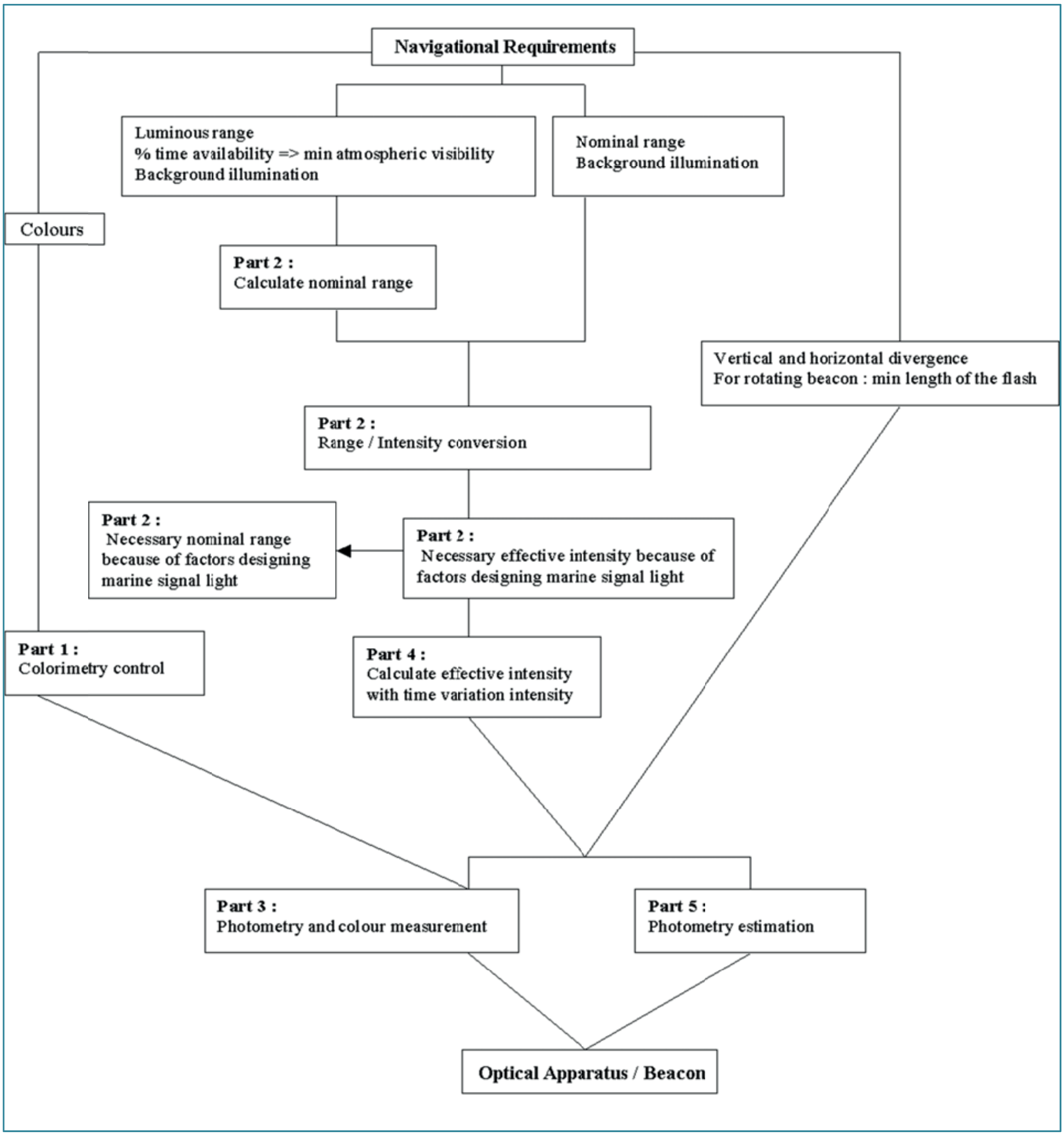

Figure 1: Links between the parts of E-200

light. Before bringing into service a new type of AtoN light at least one (of each type) should be subject to appropriate photometric and colorimetric measurement.

The measurement of light is a complex subject with many facets. To the uninformed practitioner there is a danger that measurements could contain large errors of which they are unaware. The best way to overcome this is by the use of an uncertainty budget. This, not only, captures the errors but also identifies the dominant uncertainties that can be used to refine the measurement method.

It should be noted that no measurement result is complete without a statement of uncertainty and confidence.

The recommendation gives instructions on the basic photometric principles through to integrated systems. It also provides detailed measurement methods for each type of photometric/colorimetric measurement.

Required Updates

Review relevance of the Talbot-Plateau Law. Update section on Array-based Spectroradiometer. Review overall structure for ease of use for the reader. A new section on Goniospectroradiometry is required.

Part 4 – Determination and Calculation of Effective Intensity

In the foreword to this recommendation it describes why the models used for 'effective intensity' don't really work. In simplistic terms, the models are based on threshold of detection (approximately 0.05 μlux), whereas a 'practical threshold' of 0.2 μlux is used to determine luminous range. Essentially, this all comes down to the infamous 'a'. 'a' is the term used for visual inertia or how long it takes your eye to respond to a flash of light. For threshold of detection (0.05 μlux) 'a' is 0.2s as determined by numerous experiments. However, for 0.2 μlux, 'a' is more likely to be 0.1s. This concept is known as Apparent Intensity. For further information and explanation please refer to paper number 84 on "Effective Intensity – Is it Effective?" by the same author.

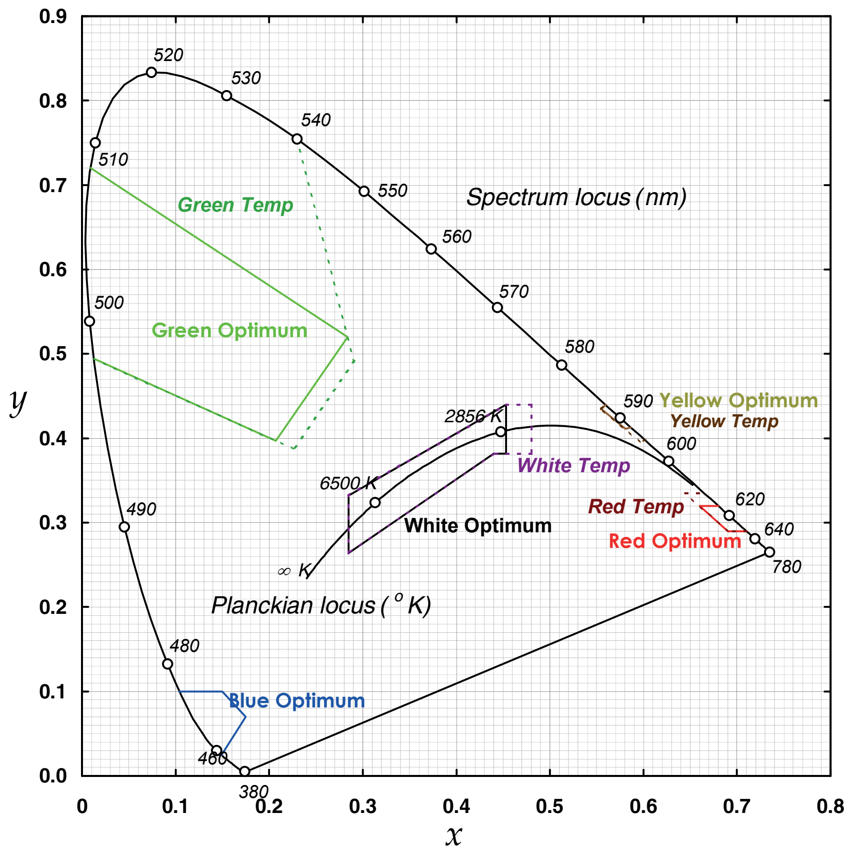

Figure 2: IALA recommended colours for lights

Once the above concept has been taken into consideration the recommendation then goes on to describe the various models for the evaluation of effective intensity and concludes that the modified Allard method should be recommended for the determination of effective intensity. Although Modified Allard can be realised in hardware, the application of the model requires measured data, as does the method of Schmidt-Clausen. In the absence of measured data an estimation of effective intensity can be determined from the Blondel-Rey formula Ie = (Io*t)/('a' + t) using the values of Io and t calculated by methods outlined in E-200 Part 5.

Required Updates

Further investigation and verification of 'Apparent Intensity' concept. Include examples of calculation and determination.

Part 5 – Estimation of the Performance of Optical Apparatus

This recommendation gives two further methods of determining the performance of AtoN lights, when direct measurement is not possible. Section A gives details of a method for the approximate calculation of the peak luminous intensity of a beam from an AtoN light (Io). It also gives details on the calculation of flash duration (t). From these two values the effective intensity can be evaluated as mentioned above.

Section B gives methods to obtain better estimates of performance provided there is measured data for either an optic or light source. This is known as the ratio technique.

Required Updates

All factors require verifying and updating to take account of new light sources (e.g. LEDs) and lens material (polycarbonate, acrylic). More examples are required.

Conclusions

What took the Ad-Hoc Working Group four years to develop and has been in publication for six years has served IALA Members very well.

Although all the technical content is valid a more user friendly structure should be adopted for some parts.

Recommendation

The IALA EEP Committee working group that deals with the topics mentioned should consider the suggested updates as part of their next work programme.■

99 A NEW RADIO SYSTEM FOR THE GERMAN COAST - INNOVATIVE APPLICATIONS FOR CONVENTIONAL VHF

Ralf Oppermann. Schnoor-INS GmbH & KG, Germany

In 2012, the German waterway administration decided to introduce a completely new infrastructure for the German coastal waters VHF communication. Radio Specialist Schnoor Industrieelektronik GmbH & Co.KG designed and built an innovative IP-based system including simulcast elements which is introduced in this paper in more detail.

En 2012, la administración alemana de vías navegables decidió introducir una infraestructura completamente nueva para la comunicación VHF en aguas costeras alemanas. El especialista en radiocomunicaciones Schnoor Industrieelektronik GmbH & Co.KG diseñó y construyó un innovador sistema basado en IP equipado con elementos de transmisión simultánea que se presenta más detalladamente en esta ponencia.

En 2012, l'Administration allemande a décidé d'introduire dans ses eaux côtières une infrastructure complètement nouvelle pour la communication en VHF. Le spécialiste en radio Schnoor Industrieelektronik GmbH & Co.KG a conçu et exécuté un système IP innovant comprenant des éléments agissant simultanément, qui est présenté et décrit en détail dans le rapport

A new radio system for the German coast

Innovative applications for conventional VHF

Ralf Oppermann

Schnoor Industrieelektronik GmbH & Co.KG, Germany

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

Introduction and results

The German Federal Waterways and Shipping Administration decided to introduce a completely new VHF coast radio system all along the German coast line.

The winner of the tender, Schnoor Industrieelektronik GmbH & Co.KG, designed and built an innovative system for VHF voice and DSC. While the air interface is still good old VHF FM radio, the new system is internally fundamentally different to the previous one, particularly in two areas: IP connectivity and availability.

Analog leased lines, E1 or other connections are increasingly replaced by IP-based connections as the sole connection available to customers in public networks.

The advantages of choosing IP as transport protocol are clear and can be highlighted as follows:

- Standard transmission lines can be obtained at lower cost (or may even be the only solution available in the future)
- Ethernet based industry standard components such as switches offer lower cost, are efficient to maintain and can be replaced by other industry standard components in future. Besides short term benefits with the system acquisition cost, this provides a good perspective for long term system life compared to bespoke components used in proprietary solutions
- The packet switched IP based architecture can be put into a fully redundant system
- Ethernet based cabling in VTS Centers makes a cost efficient setup based on standard architecture
- Supplementary functions such as voice recording and processing can be simply put in between the standard IP data streams

IP-based systems are much more flexible to install, maintain and reconfigure. Availability is another area where the new system is a leap forward: Rather than using good design practice and adding some redundant hardware, the solution is more radical. The architecture can not only handle failures of any device within the system but even demolition of any complete subsystem location or building will not lead to a loss of control.

For a system overview, please refer to ***Figure 2***. The three Data Centers are located in different towns and are linked via TCP/IP connections. These form the core of the system from a technical standpoint. 9 VTS Centers (VTS-C) are connected to one of these three Data Centers. A number of other system users include staff at locks and movable bridges, pilot's stations and the maritime disaster center. These are also connected to one of the Data Centers each.

VHF radio stations are shown on top of the diagram, however, these are in total over 150 VHF base stations. The backhaul network connecting

Figure 1: Radio sites in German coastal waters

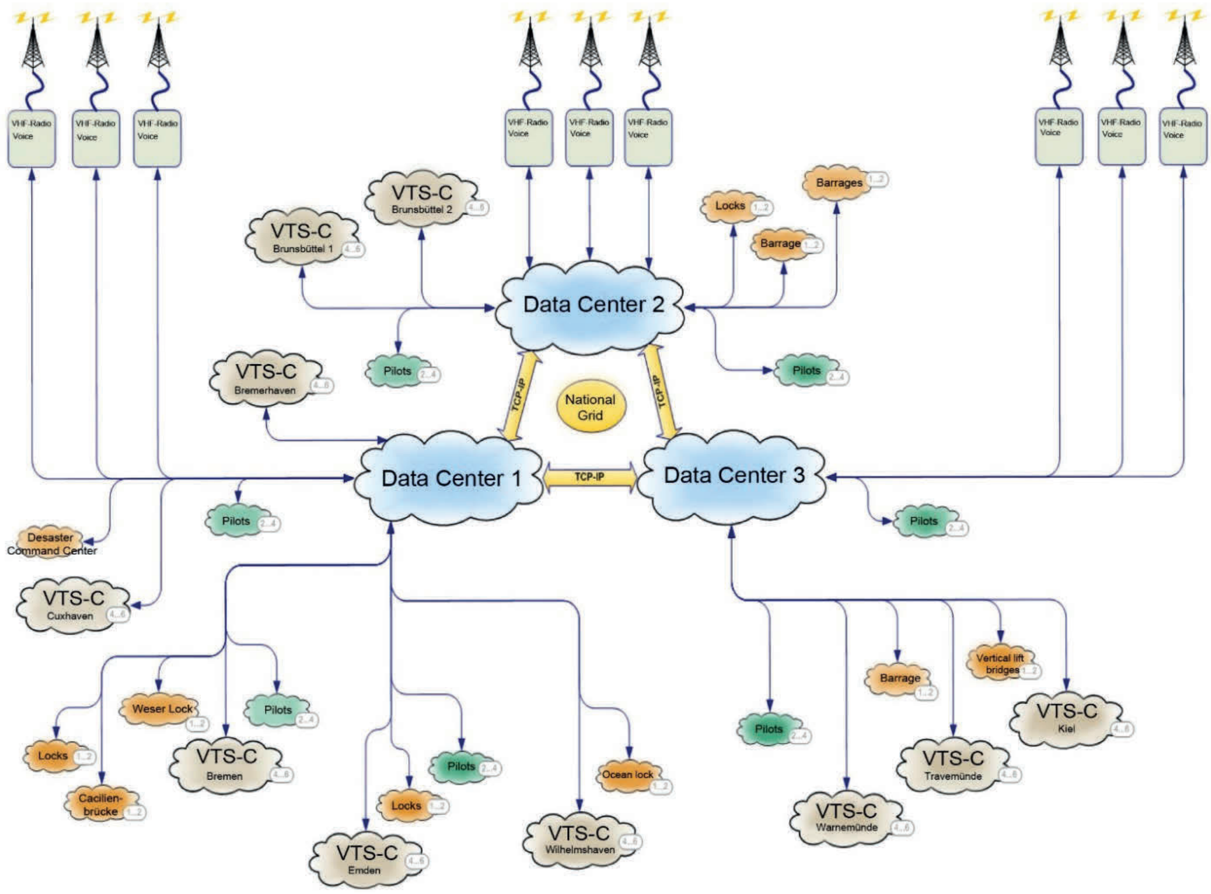

Figure 2 : System overview

these VHF base stations located on the North Sea and Baltic Sea is completely based on IP based infrastructure utilizing own line trunks of the administration, microwave radio links and leased lines.

Coming from the 9 VTS Centers, voice and data are directly coded into digital format using the well-known G711 codec, and processed with call header information based on the VoIP protocols Session Initiation Protocol (SIP) and Real Time Protocol (RTP), both then embedded into the standard Internet Protocol (IP) layer structure, physically based on Ethernet. During the routing of the call information through the network and the fully IP based radio exchange system, the call is not earlier decoded back to analog voice information than directly at the radio base station. The same is true in opposite direction for analog voice information received by a radio base station. As to DSC information, it is also modulated and demodulated for radio channel transmission and reception directly at the radio base station.

Within each of the three Data Centers, there are two separate server systems, which provide services and user data management. Each of these are redundant Linux-based “high availability servers”. A Linux-based solution has been preferred to a Microsoft one since task switching and routing are faster. Configuration is different from a Microsoft cluster, a RAID system distributed over the servers within a system site is sufficient. In addition, replication is used between the different Data Centers. As an exception, long term data storage is only provided in two of the three Data Centers. In case of a loss of status and configuration data stored in long term storage, they may need to be manually synchronized with another server.

To support the required overall system redundancy, priority listing is used in the system, described here as an example for an incoming call through one of the radio base stations: The base station radio will normally set up the connection to the Data Center with the highest priority in its list. Should that connection fail, the base station will select the next lower level Data Center for connection setup. Should that also fail, the base station will therefore connect to the lowest priority level Data Center. From time to time, base station radios will search if higher priority level Data Centers are back again.

The connections in the opposite direction from control center work positions to radios follow the same principle.

On the radio side, parts of the system are based on Simulcast base stations. This has been decided to provide optimized radio coverage while requiring as little frequency resources as absolutely necessary. Simulcast systems (also referred to as Single Frequency Networks) are not new as such, but this should be the first such implementation of simulcast technology in the maritime environment.

Simulcast systems pose two additional technical requirements over a non-simulcast installation: highest frequency stability of the base station transmitters on one hand. Transmitter carrier frequencies must be highly stable but also adjustable with a minimal variation. This is because unlike frequently misunderstood, simulcast transmitters are not working on exactly the same carrier frequency but there is intentionally an offset of a few Hertz introduced to provide best performance.

On the other hand, modulation at base station radios must also be synchronized. A typical conventional simulcast system covers areas from a single campus to a metropolitan area. Synchronization of modulation is achieved by an equalizer located at the central system location which makes sure that even with different transmission paths of different length to the various base station locations, modulation is synchronous on all of these locations. For the German coast system, the synchronization requirement cannot be achieved with a simple equalizer: Voice is transmitted in coded format over an IP network which does not offer constant transport time for data. Therefore the simulcast IP-connected base stations buffer received coded information and process them synchronized by a GPS signal received at each transmitter location and the central simulcast controller so that after decoding digitized voice in the radio base stations, modulation on the air interface is synchronous again.

Combining well-known solutions such as analog FM simulcast with IP networks placed new challenges for system design which required the development of new technology.

While the IP network in this system allows smart routing in case any element fails in the network, this has its limits at the end points. In particular on the individual radio base station end, these are extremely reliable Schnoor SEACOM radios, but they might fail as well. In order to provide a solution for such unlikely failures, a detail level analysis has been done based on traffic load, severance of failures and radio coverage. As a result, a backup concept has been built which meets operational needs and uses different solutions as needed while keeping investment at a reasonable level: Some areas can be covered by adjacent base stations, a few channels are considered less

Figure 3 : Radio base station rack with 4 transmitters/receivers, redundant power supplies and control Equipment. Antenna filter visible on side view (required if channel 16 and 70 are used with single antenna installation)

critical in case of failure and for others backup base station radios have been installed which can be switched to the channel which has failed on a given site. IP remote control of these radios covers all functions including channel selection. Each radio cabinet has a local RS 485 bus which is used to interconnect devices with a controller managing switchover in case of failures and providing reports to be transmitted back over the IP network for system management. Furthermore, tunable combiners had to be used since a single base station in n+1 configuration is used rather than full doubling of all radios in costly 1+1 configurations. Operationally, backup is clearly critical and required to provide full coverage on channel 16 even in case of a radio failure. ***Figure 3*** shows a typical radio cabinet used in the system.

The system described is not a fully duplicate installation to existing facilities in use today. That would have required to double all radio sites and equipment, as well. In order to allow for a reasonable migration and avoid excessive costs, in particular base station radios and the backhaul network go through a migration period. Complete new radio base station sites are installed but for the migration period connected to existing control room facilities, sometimes via existing analog backhaul network connections. This was easy to accomplish since SEACOM base stations can be fitted with remote control modules to fit the analog connections network in addition to IP interfaces, both working in parallel (see ***figure 4).***

What has to be considered for the backhaul network, for which the structure had to be seen as a given by the customer in this case, is that in case of failure of a Data Center the amount of data traffic on some links in the network will heavily increase. Network connections between Data Centers may require capacities which can by far exceed 32Mbit/s.

Finally, VTS Centers have simulation facilities which allow training center staff up to the highest professional levels which normal day to day traffic does not provide. Simulation for VHF radio was also included in the scope of delivery with the simulation equipment being connected to the real IP based system rather than being set up a separate training system of its own.

The fully redundant setup of VTS Centers, transmission lines as well as radio exchange systems provides optimum availability of the entire system. Being based on industry standard IP connections and equipment the solution represents a state of the art system combining optimum availability with low operating cost.

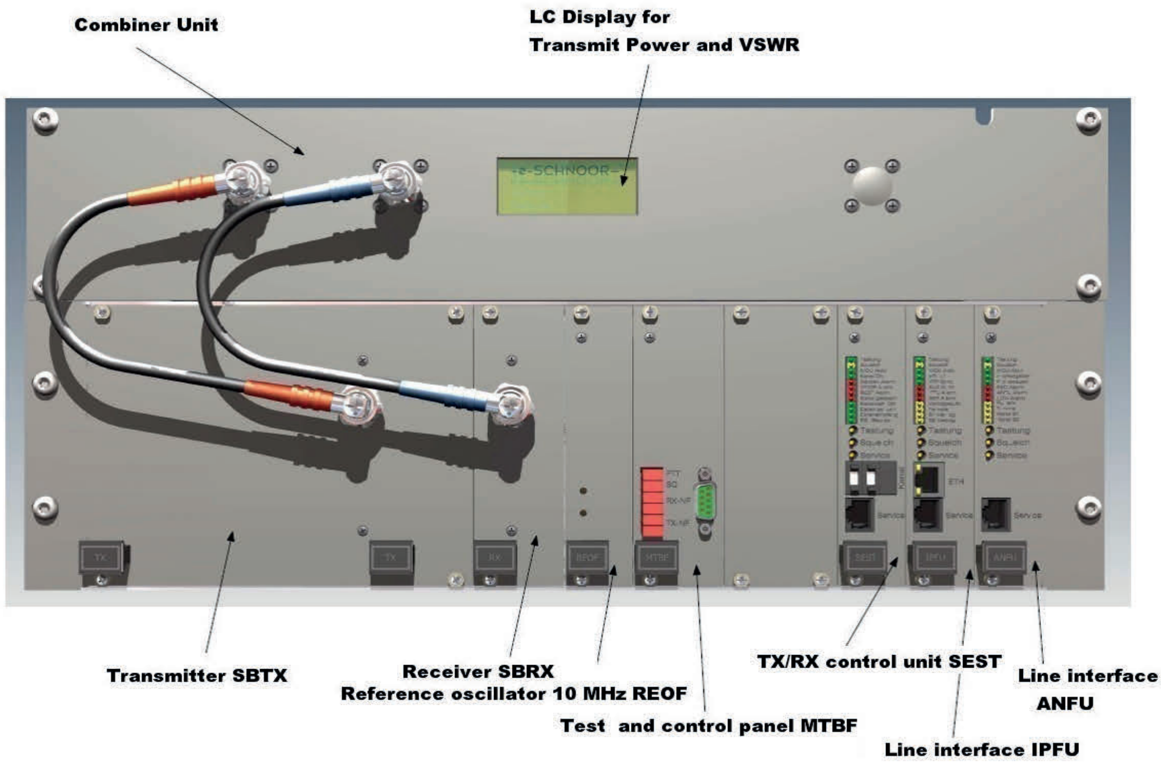

Figure 4: SEACOM radio with dual interfaces (bottom right of radio): IPFU to support IP connection and ANFU to support 4-wire analog connection

15 IMPLEMENTATION OF THE VOICE/DSC VHF RADIO COMMUNICATION SERVICE WITH SIMULCAST BROADCASTING AT THE GERMAN COAST

Heinz Park. Federal Waterways and Shipping Administration, Germany

This paper will introduce the new highly reliable coastal wide VHF radio communication service at the German coast with open technical interfaces and standards. The voice data transfer is done by Voice-over-IP (VoIP). Most of the maintenance tasks are done remotely.

For special locations long distance radio coverage on one VHF channel is requested. We decided to use simulcast transmission with common frequency. The challenge here is to broadcast a message at exactly the same time while the voice transfer over the IP-network is routed via different ways and therefore will be delayed. The paper will discuss in detail the challenges and the resulting layout of the simulcast transmission in combination with VoIP technology.

Esta ponencia presentará el nuevo y altamente fiable servicio de radiocomunicaciones VHF para todo el litoral de la costa alemana con normas e interfaces técnicas abiertas. La transferencia de datos por voz se realiza a través del sistema VoIP (voz sobre protocolo de Internet). La mayoría de las tareas de mantenimiento se efectúan de forma remota.

En ubicaciones especiales se requiere cobertura de radio de larga distancia en un canal VHF. Nosotros decidimos utilizar transmisión simultánea con frecuencia común. El desafío consiste en emitir un mensaje perfectamente sincronizado porque la transferencia por voz a través de la red IP se enruta de distintas formas y, por lo tanto, se desfasa. La ponencia analizará en detalle los desafíos y el esquema resultante de la transmisión simultánea combinada con la tecnología VoIP.

Ce rapport présente le nouveau service de radiocommunication VHF, très fiable, de la côte allemande avec ses normes et ses interfaces techniques ouvertes. Les données vocales sont transmises par Voice-over-IP (VoIP). La plupart des tâches de maintenance est réalisée à distance.

Pour certains sites il faut une couverture radio longue distance sur un canal VHF. Nous avons décidé d'utiliser une transmission simultanée avec une fréquence commune. Le défi ici est d'émettre un message exactement au même instant tandis que l'envoi de la voix sur IP-network est réalisé de différentes façons et peut donc être retardé.

Le rapport discute en détails les défis et les résultats de la transmission simultanée combinée à la technologie VoIP.

Implementation of the Voice/DSC VHF Radio Communication Service with Simulcast Broadcasting at the German Coast

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Implementation of the Voice/DSC VHF Radio Communication Service with Simulcast Broadcasting at the German Coast

Heinz Park, Central Engineering and Maintenance Office for Maritime Traffic Technology, Wilhelmshaven, Germany

To ensure the voice and DSC (Digital Selective Calling) communication between ships and VTS-centers around 200 VHF radio base stations at 50 locations along the German coast are in operation. The current technical implementations are already in operation for quite some time and were provided by several suppliers creating a big variety of technology. The voice transmission from the VTS-centers to the remote VHF radio stations is performed via either analogue connections or microwave links. Using the same VHF base station from different VTS-centers nearby is not possible.

The goal was to get a new highly reliable coastal wide VHF radio communication service with open technical interfaces and standards. Access to the radio sites should be possible from every VTS-center at the German coast. The voice data transfer should be uniformly handled by the coastal wide network to interconnect all users using Voice-over-IP (VoIP) technology. This design allows us to maximize the connectivity without any geographical limitations. Most of the maintenance tasks should be done remotely. An expansion of the new system should be done without being dependent on one ore a few companies.

As shown in the overview in ***figure 1*** there is a new VHF communication service architecture with the basic functions of each part. In our system design the application service for the user isn't part of the communication service. Communication from operator site to radio site and vice versa can only be done using the data center. To increase the system availability the components in the data center are designed site-redundant. Three data centers are located along the German coast in different site locations. In case of a system failure in one of the data centers the remaining ones are able to handle the coastal wide communication traffic automatically.

The challenge here is to minimize the downtime for the existing VHF communication service during installation new devices. Existing radio units must be replaced while VTS-centers are in operation. This is mainly because the radio sites do not provide enough space to ensure the coexistence of the old and new technology. For

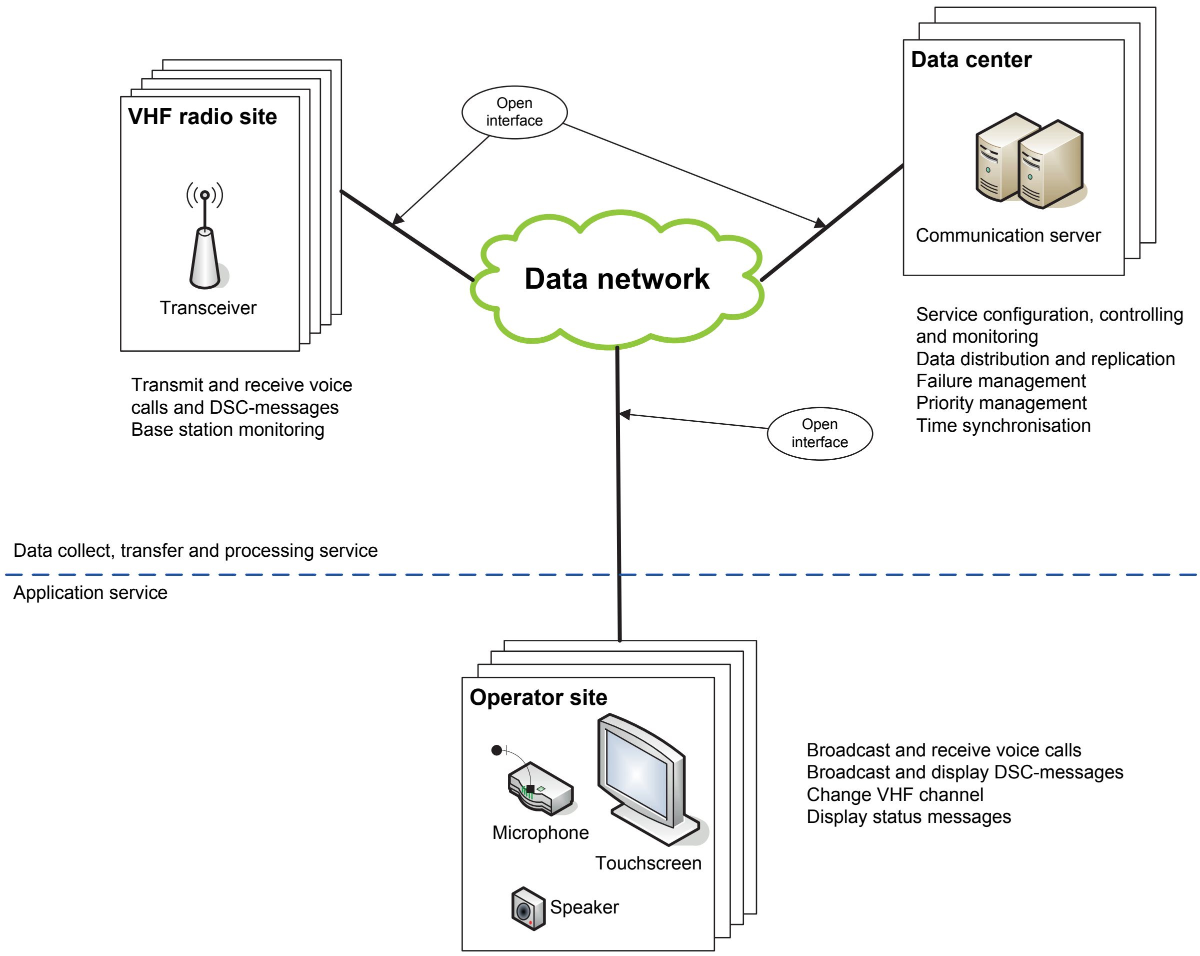

Figure 1: VHF communication service system architecture

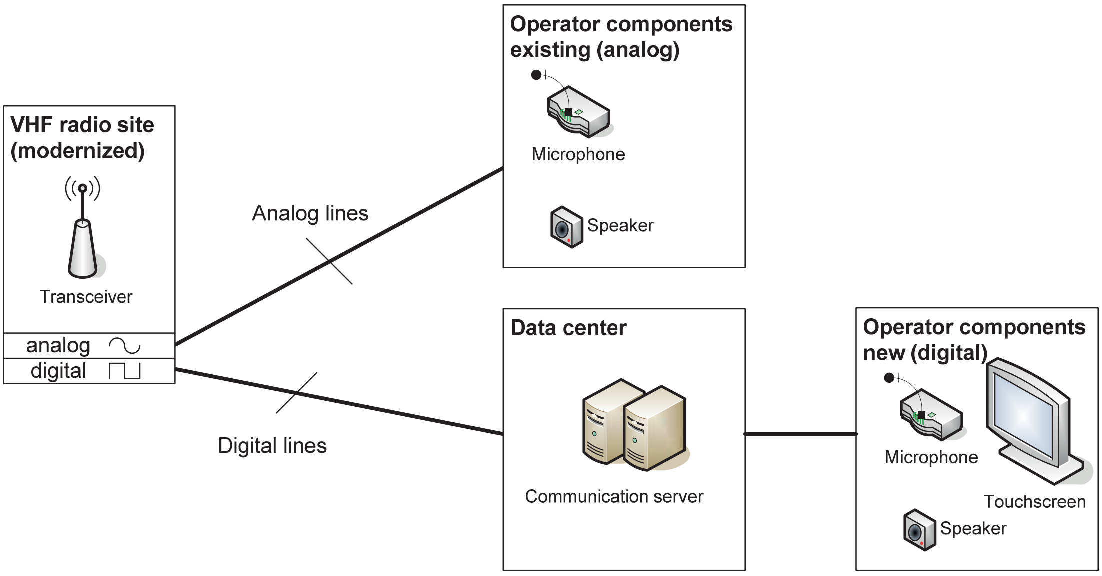

Figure 2: Migration to the new communication service

this issue our vendor developed the possibility to use two interface cards for each radio. One interface is used for the communication to the existing analog operating equipment and the second interface provides the connection to the new digital components in the operation sites (see *figure 2*).

Simulcast transmission with common frequency

The frequency spectrum for maritime VHF communication is very restricted and the radio coverage is limited. We decided to use simulcast transmission with common frequency for special locations. An implementation by using only IP-technology isn't in operation at the German coast yet. In the past simulcast transmission was implemented by using analog links (e.g. on Ultra High Frequency, UHF) feeding the distributed radio sites. Now our network is digital and routed, the voice is transferred with data packets. The way of transmission and therefore the time of transmission can change at every time. To transmit on both or more radio sites at exactly the same time, the radio sites and the data center use a GPS-receiver on site and simulcast transmission components in the data center. The delay time for the routed data packets to the radio site is measured continuously. To transmit at the same time, the fastest packets are buffered. The frequency drift in the transmitter unit is very small. For the VHF-user it seems that there is only one transmitter on air.

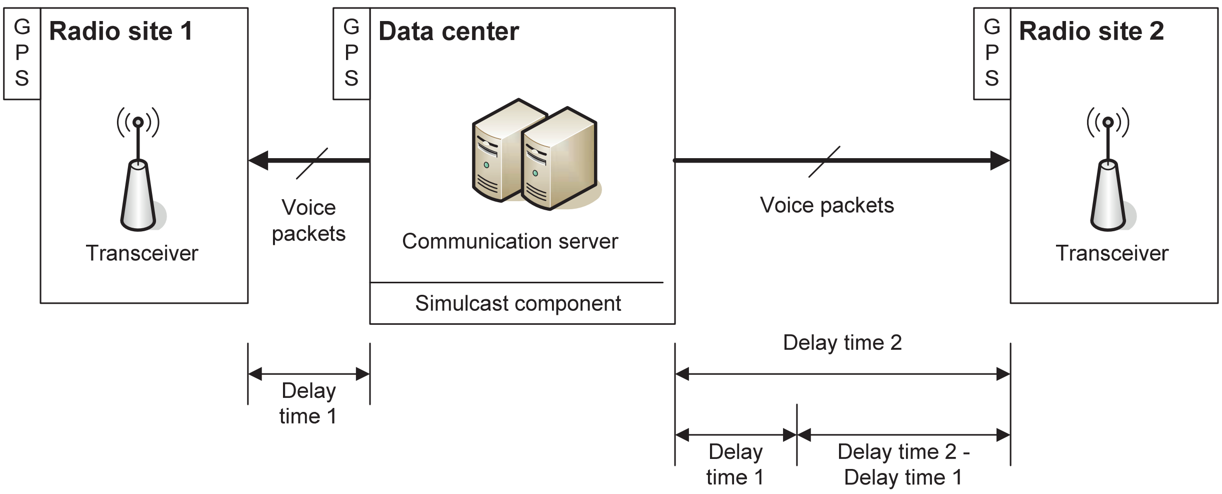

Figure 3: Principle of simulcast transmission

When a ship receives both radio sites with the same signal strength (e.g. in the center of two common frequency radio stations) receiving isn't possible. In this case a third radio station on the same channel will solve this problem. The operation of simulcast transmission in Germany will start in 2014.

In ***figure 3*** the principle of this technique is shown.

Technical operation and remote administration

Our technical operation center is on duty 24 hours 7 days a week. It has network access to the radio sites and the data centers. Configuration of the radio communication service can be done remotely by telnet, secure shell or web interface. The radio sites can be configured remotely or on site with telnet sessions (e.g. change output power or frequency). Monitoring and data replication is done by the service management in the data center automatically. If a failure in the radio sites is detected (e.g. output power less than 70%) the service management switches to the redundant radio transceiver if available and sends a warning message to our technical operation that one radio is down. At sites on islands or countryside locations the radio including power supply and network switch are redundant. Our coast wide IP-network is also redundant and has two different routes to each of our radio sites.

Spare parts are stored near the data center or at a central place for the radio sites. The server and radio hardware is identical and can be used for all sites. The relevant repository software is located on a central server at each data center and can be installed remotely. If a server has a hardware crash, it will be replaced by the local technical operation staff and installed over network.

27 AIDS TO NAVIGATION AND AUTOMATIC IDENTIFICATION SYSTEM: A WINNING COMBINATION FOR SAFETY SUPPORT. THE ITALIAN EXPERIENCE

Piero Pellizzari. Italian Coast Guard - Headquarters, VII Department "ITC and Maritime Traffic Monitoring", Italy

"AtoN" is the term officially used to identify the wide range of buoys and markers positioned in navigable waters to assist seafarers in order to avoid dangers and keep a safe navigation. In 2013 the Italian Coast Guard will be conducting some tests for the deployment of a new service aiming at providing broadcast information, binary messages and electronic AtoN information through the existing National AIS network, enhancing control to navigation and safety support in territorial and contiguous waters. As stated in IALA guidelines, AtoN can be equipped with dedicated AIS base stations (e.g. a lighthouse can be fitted with an AIS transmitter), but sometimes this might result not practicable. In such cases, AIS shore stations can be adapted to transmit AIS messages that simulate, as a matter of fact, the presence of the AtoN on electronic charts and navigation systems. This is known as a synthetic AtoN. In other circumstances, such as on provisionally marking a wreck until a physical buoy can be deployed, the so-called virtual AtoN can be created configuring AIS base stations so as to transmit AIS messages signalling the existence and location of the point to be marked. The Italian lighthouses are generally very old, so that it is only rarely possible to equip them with an AIS transmitter; therefore, a solution based on the synthetic AtoN concept is being devised and it will be possible to transmit the position of the all lighthouses with a range wider than 15 NM and to have these represented on an electronic chart with an update rate of 3 minutes. Information will be managed by a central AIS server (installed in Rome), based on a Service-Oriented Architecture and capable to configure the working parameters of the 56 Italian AIS base stations. Real-time information will be the key added value of this service, as the data pertaining to one or more AIS physical stations can be easily configured through a web interface. For instance, the AIS base station located in Naples may be set so as to broadcast information containing an alert message and/or AtoN (virtual and synthetic) information, and/or the operational health status of any of the lighthouses present in the area. Vessels within range could then be always informed on the existence, position and health status of all available lighthouses. Such new service for the provision of AtoN related information using AIS technology may be regarded as an "e-Aton" service, a first step towards the implementation of the e-Navigation concept in Italy.

«AtoN» es el término utilizado oficialmente para identificar la amplia gama de boyas y señales posicionadas en aguas navegables para ayudar a los navegantes a evitar peligros y navegar de forma segura. En 2013, la Guardia Costera Italiana realizó algunas pruebas para la implementación de un nuevo servicio destinado a transmitir información, mensajes binarios e información electrónica AtoN a través de la red nacional AIS existente, mejorando el control de la navegación y el apoyo en materia de seguridad en aguas territoriales y contiguas. Tal y como se establece en la directrices de la IALA, las AtoN pueden equiparse con estaciones base AIS específicas (por ejemplo, un faro puede equiparse con un transmisor AIS), pero a veces esto no es practicable. En estos casos, las estaciones costeras AIS pueden adaptarse para transmitir mensajes AIS que simulen la presencia de AtoN en cartas náuticas y sistemas de navegación electrónicos. Esto se conoce como AtoN sintética. En otras circunstancias, como en el balizamiento provisional de un naufragio hasta que pueda hacerse uso de una boya física, puede crearse la llamada AtoN virtual configurando estaciones base AIS para transmitir mensajes AIS que indiquen la existencia y ubicación del punto que desee señalizarse. Los faros italianos son, por lo general, muy antiguos y raramente es posible equiparlos con un transmisor AIS, por lo que se está ideando una solución basada en el concepto de AtoN sintética y será posible transmitir la posición de todos los faros en un radio superior a 15 millas y representarla en una carta náutica electrónica con una frecuencia de actualización de 3 minutos. La información será gestionada por un servidor AIS central (instalado en Roma), basado en una Arquitectura Orientada a Servicios y capaz de configurar los parámetros de funcionamiento de las 56 estaciones base AIS italianas. La información en tiempo real será el valor añadido clave de este servicio, ya que los datos pertenecientes a una o más estaciones físicas AIS pueden configurarse fácilmente a través de una interfaz web. Por ejemplo, la estación base AIS ubicada en Nápoles puede disponerse para emitir información que contenga un mensaje de alerta y/o información AtoN (virtual y sintética), y/o el estado de funcionamiento de cualquiera de los faros presentes en esa área. Los buques dentro del alcance podrían estar siempre informados de la existencia, posición y estado de todos los faros disponibles. Este nuevo servicio para proporcionar información relacionada con AtoN utilizando tecnología AIS puede considerarse un servicio «e-Aton», un primer paso hacia la implementación del concepto de e-Navegación en Italia.

« AtoN » est l'abréviation officielle utilisée en anglais pour désigner l'ensemble des bouées et marques positionnées dans les eaux navigables pour aider les marins à éviter les dangers et naviguer en sécurité. En 2013, la Garde côtière italienne a mené quelques essais de déploiement d'un nouveau service visant à émettre des informations, messages binaires et informations électroniques sur les aides à la navigation par le réseau AIS national existant, améliorant le contrôle de la navigation et la sécurité dans les eaux territoriales et adjacentes. Comme indiqué dans les Guides de l'AISM, les aides à la navigation peuvent être équipées de stations de base AIS (un phare peut par exemple être équipé d'un émetteur AIS) mais quelquefois cela s'avère impossible. Dans ce cas, les stations AIS à terre peuvent être adaptées pour émettre des messages AIS qui, en fait, simulent la présence d'une aide à la navigation sur les cartes et systèmes électroniques. Ceci est appelé aide à la navigation synthétique. Dans d'autres circonstances, comme le balisage temporaire d'une épave, jusqu'à ce qu'on y mouille une vraie bouée, une aide, dite « virtuelle » peut être créée représentant une station AIS capable d'émettre des messages AIS signalant l'existence et la position du point à baliser. Les phares italiens sont en général très anciens et il est assez rare qu'on puisse y installer un émetteur AIS : on a donc imaginé une solution basée sur le concept de l'aide à la navigation synthétique. Il sera possible de transmettre la position de tous les phares d'une portée supérieure à 15 milles nautiques et de les voir apparaître sur une carte électronique mise à jour toutes les 3 minutes. L'information sera gérée par un serveur AIS central (à Rome) basé sur une architecture orientée « service » et capable de configurer les paramètres des 56 stations de base AIS italiennes. La principale valeur ajoutée de ce service sera d'avoir l'information en temps réel, car les données concernant une ou plusieurs stations physiques AIS peuvent être facilement configurées au moyen d'une interface internet. Par exemple les stations de base AIS de Naples pourront être réglées pour émettre des messages d'alerte et/ou des informations sur l'aide à la navigation (virtuelle ou synthétique), et/ou l'état opérationnel de n'importe quel phare de sa zone. Les navires à portée pourront être toujours informés de l'existence, la localisation et l'état opérationnel de tous les phares disponibles. Ce nouveau service d'informations relatives aux aides à la navigation utilisant la technologie AIS peut être vu comme un service « e-AtoN », un premier pas vers la mise en œuvre de l'e-Navigation en Italie.

Aids to Navigation and Automatic Identification System: a winning combination for safety support.

The Italian experience

Piero Pellizzari, RDML

Italian Coast Guard

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Implementation of the Voice/DSC VHF Radio Communication Service with Simulcast Broadcasting at the German Coast

Piero Pellizzari, RDML, Italian Coast Guard

Introduction

As the National Competent Authority for Traffic Monitoring, Safety of navigation, SAR coordination, fishery control, sea pollution monitoring and maritime security, the Italian Coast Guard is a clear example of centralisation of coast guard functions, with the advantage of optimising the overall preparedness and response capabilities at sea thanks to a synergic, fast and unambiguous decisional process able to give concrete answers inside the Italian assigned maritime search and rescue Region.

The role of National Competent Authority for traffic monitoring, complying with the Directive 2002/59/EC [1], allows the ICG to manage a platform to provide VTMIS data/services and an interface sharing transport-related information with the EU SafeSeaNet [2] and CleanSeaNet [3] systems. The Italian VTMIS provides an integrated and vertical net-centric platform for Coast Guard functions implementation at the central and peripheral level. It integrates, in line with the relevant international and national regulations, the VTS service with the information supplied by AIS[4], LRIT[5], VMS[6] and other satellite monitoring assets at the central level, producing an integrated maritime traffic picture to support both traffic monitoring and operations at sea.

The regulatory framework in Italy requires the ICG to provide information and services based on its VTMIS data to other national Administrations in charge of military and civilian defense, maritime surveillance, public security and assistance.

The Italian AIS Network Architecture

Implemented in 2005 in order to fulfil the requirements of the Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002, the Italian AIS network has been completely upgraded in 2012-2103, with the aim to comply with the most recent relevant guidelines and recommendations, such as IALA Recommendation A 124 on "The AIS Service" (December 2012) and ITU Recommendation ITU-R M.1371-4 issued on April 2010[7].

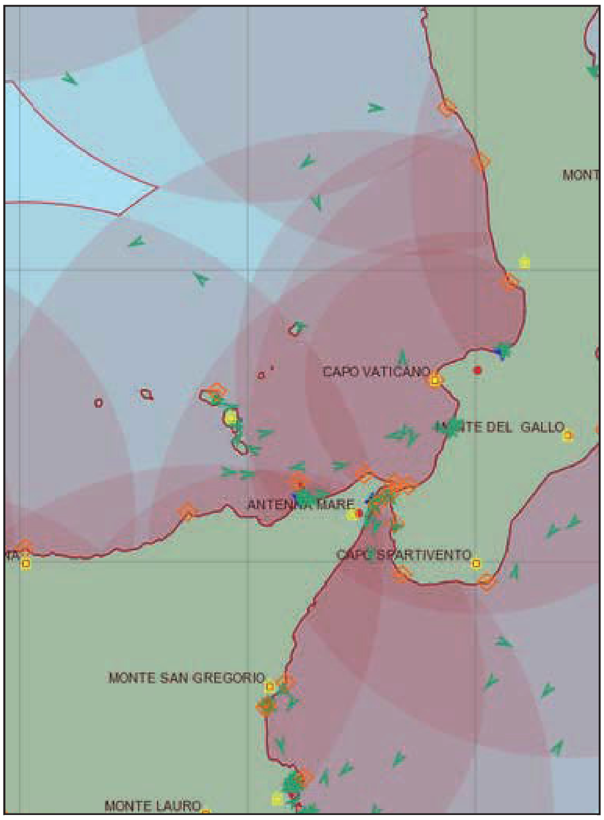

Figure 1 – AIS base stations coverage overlapping

The network currently consists of 60 base stations, mainly so located a s to get the best VHF coverage through the necessary overlap (up to 100 nautical miles, also in the absence of the duct effect).

[1] The Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 establishes a Community vessel traffic monitoring and information system and repealing Council Directive93/75/EEC.

[2] SafeSeaNet is the Community maritime vessel traffic monitoring and information system, developed by the Commission in cooperation with the Member States and managed by the European Maritime Safety Agency, to ensure the implementation of Community legislation (artt. 3, letter s) and 22a of the Directive 2002/59/EC).

[3] CleanSeaNet is an European satellite-based oil spill and vessel detection service, managed by the European Maritime Safety Agency, based on radar satellite images, covering all European sea areas.

[4] Automatic Information System as defined by the Res. MSC 74(69) adopted on 12 My 1998- Annex 3 "Recommendation on performance standards for an universal shipborne automatic identification system (AIS)".

[5] LRIT means a system for the long-range identification and tracking of ships (art. 3, letter w) of the Directive 2002/59/EC) in accordance with SOLAS regulation V/19-1.

[6] Vessel Monitoring System is a satellite-based vessel monitoring system for effective monitoring of fishing activities of the fishing vessels flying the flags of EU Member States wherever those vessels may be and of fishing activities in the Member States' waters according article 9 of the Council Regulation (EC) n.1224/2009 of 20 November 2009.

[7] Technical characteristics for an automatic identification system using time-division multiple access in the VHF maritime mobile band.

The base stations have been placed in such a way as to overlap the radio coverage (***Figure 1***), in order to:

- increase overall national AIS network services availability, including the ATON_DAT "Send or receive AtoN AIS stations data" service, referred to in the A124 Recommendation;
- enable the future adoption of anti-spoofing techniques to improve quality of AIS information received.

Each single base station is duplicated and capable of handling AIS encrypted information, according to STANAG 4468 e 4669[8], whenever operating with the Coast Guard air and naval craft.

The overall Italian AIS network architecture is shown in ***Figure 3*** One of the network key elements is the so-called *AIS Embedded Server*, a fully solid-state device featuring two separate servers, thus either supporting redundancy or the simultaneous interface to two TCP networks (***Figure 2***).

Figure 2 – The AIS Embedded Server (BCD-1135)

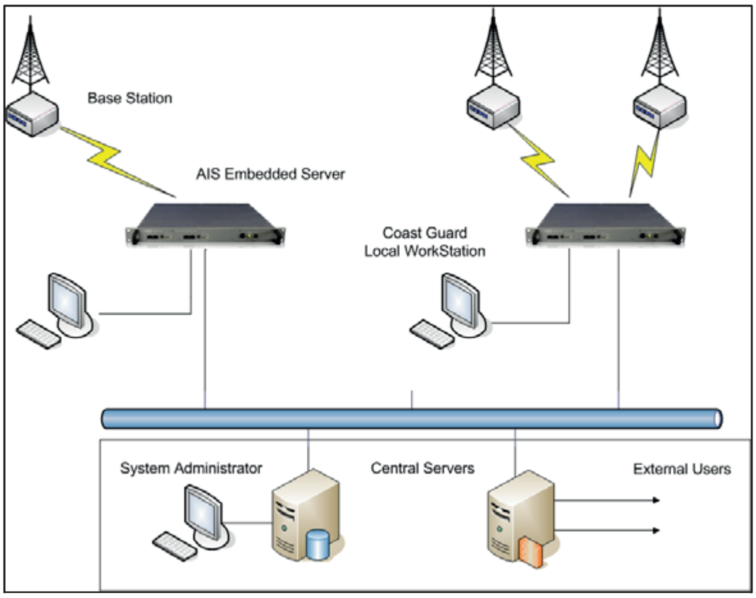

Figure 3 – The Italian AIS Network architecture

The *AIS Embedded Server*, acting as a PSS Controlling Unit (PCU) according to the IALA Recommendation A-124, allows integration of one or more base stations and their management from shore systems. The *Embedded Server* can acquire AIS data through the available serial ports and TCP connections, according to the specified configuration. In the same way, the collected AIS data are made available to serial ports and TCP connections. It also features an embedded interface for each web server which allows configuring and monitoring of both the servers and the connected AIS Base Station, eliminating the need of any additional software. Authorised operators can log-in on the web interface to configure and monitor every setting of the server, such as its ports and connections and the linked devices and users.

The *AIS Embedded Servers* can be equipped with an internal GPS receiver, which can be used as a position and time source both for the server and for the connected AIS base stations, thus simplifying the installation where more than one base station is required. Time synchronisation can also be achieved through the embedded SNTP client.

The AIS Embedded Server can also be used as a switching unit for base stations in redundant installations in active/passive configuration; the optional VHF antenna switch can be set to feed the active base station only, thus reducing the number of required antennas.

The AIS information received by the 60 base stations is delivered to a centralised system named PELAGUS, where a complex suite of constantly updated application software is operating.

At the current release, PELAGUS is able to:

- handle the whole AIS network, providing the external basic service identified by the IALA A-124 recommendation;
- collect, process, store, display and distribute the AIS information originating from the national network together with the AIS information acquired by the Mediterranean AIS Regional Exchange System (called MAREΣ), realised and hosted by the Italian Coast Guard[9];

[8] Warship – Automatic Identification System (W-AIS).

[9] MAREΣ supplies the SafeSeaNet with information gathered by the Member States' AIS national networks

- by means of a link with the European Union LRIT Data Centre, receive, collect, process and store information about the Italian vessels, and manage the information requests coming from the authorised Coast Guard users;
- provide an interface to handle a Mandatory Report System to acquire information from Italian vessels greater than 1,600 G.T.;
- handle information coming from the Vessel Monitoring System to control fishing vessels according to European Union legislation;
- provide a graphic interface to assist operators in monitoring and management of maritime traffic, thus facilitating identifying actual events.

Currently, PELAGUS manages more than 20 million pieces of information per day, which grow to as many as 40 million per day in those seasons when there is a heavy duct effect in the Mediterranean Sea.

PELAGUS' AtoN Core Module

PELAGUS application includes a dedicated module for handling of Virtual and Synthetic Aids to Navigation. Through dedicated tools, the system administrator (or the authorised users) may activate transmission of ITU messages 21 "Aids-to-Navigation report" by one or more base stations (***Figure 4***). This tool allows configuring of the parameters provided for by the ITU message 21 (i.e. type of aids-to-navigation, position, name, etc..), as well as the reporting interval (ordinarily set on 3 minutes).

The user is also advised by PELAGUS on which of the base stations is the fittest for broadcasting of the AtoN configured.

Taking into account the large amount of the external services (basic or not) provided by the AIS national network, and recognising the compelling need to ensure integrity of the AIS VHF data link, PELAGUS features a technique to gradually reduce the frequency of broadcasts for each of the services available, even cancelling them according to the priorities set by the system administrator. This automatically allows saving of more than 50% of the slots available in the VHF data link area for transmission to/from vessels.

Currently, the Italian AIS network is broadcasting ITU message n. 21 which is related to 131 Synthetic AtoN corresponding to the same lighthouses having a range greater than 15 nautical miles. Information on the AtoN broadcasts are provided to mariners also on the appropriate nautical documents (List of Radionavigation Services) issued by the Italian Hydrographic Institute.

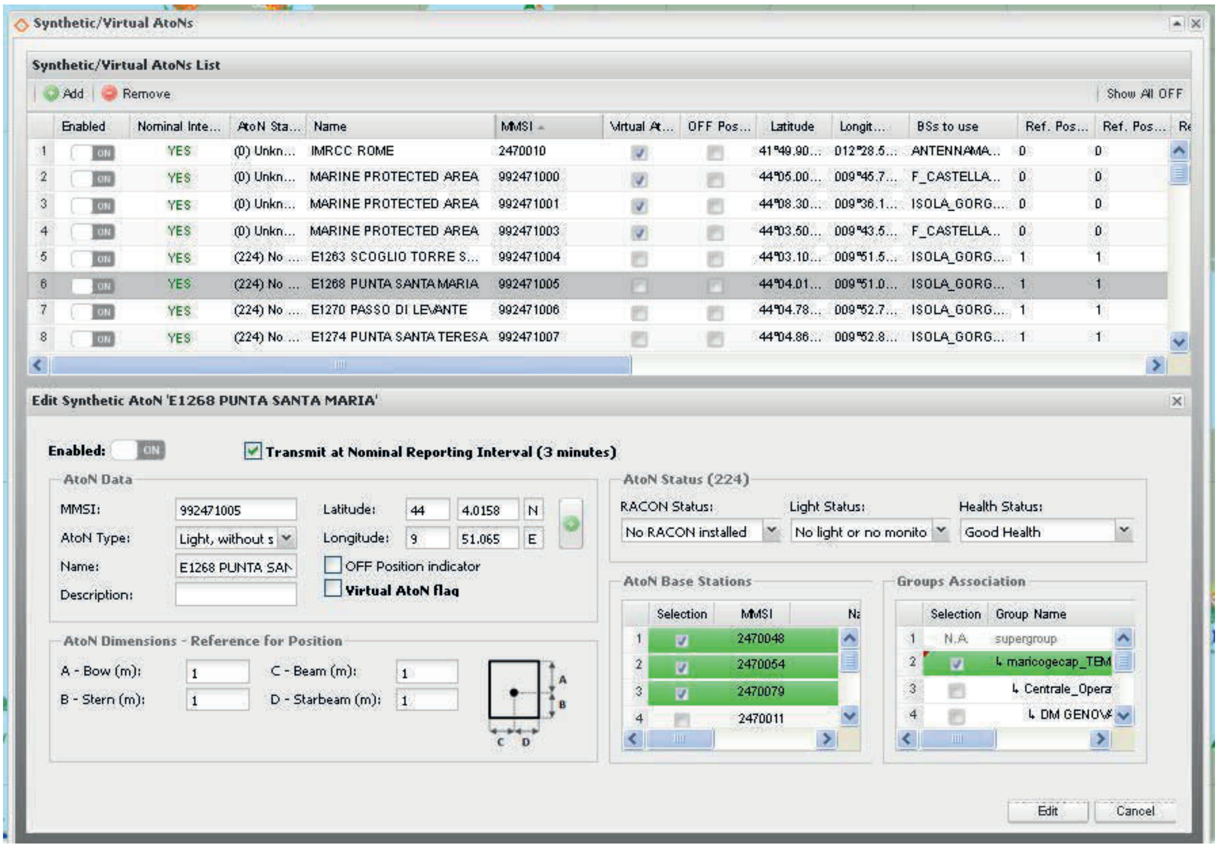

Figure 4 – The AtoN edit page

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PELAGUS allows the local Coast Guards Offices existing along the Italian coastline to only change the Light Status of the Synthetic AtoN, according to the use of the corresponding ITU Message 21 parameter suggested by IALA Recommendation A-126[10]. This capability is provided within a wider Marine Safety Information Single Window concept, where a Navigational Warning will be issued through one or more of the following systems: NAVTEX, voice via VHF/MF channels, AIS safety messages and AtoN AIS messages.

AtoN as a VTS tool

All the Italian VTS Centres and Coast Guard offices are provided with a minimum set of MMSI to be associated to Virtual Aids to Navigation, used to pinpoint location of any incidents occurring within their own respective jurisdiction areas.
In fact, virtual AtoNs broadcast by relevant base stations may be used to show:

- a location at sea, such as a rendez-vous position between a ship needing assistance and the search and rescue craft;
- the position of a wreck or of any obstacles/hazards to navigation, as provided for in IALA Recommendation A-126;
- a route, traced by a VTS Centre, to be followed by an endangered vessel (***figure 5***);
- an area to be avoided, for instance due to on-going diving operations.

In addition, PELAGUS has a tool to edit the Synthetic/Virtual AtoN schedule, which is very useful for transmission schedule planning (***figure 6***)

Signalling of protected marine areas

Over the last 25 years, the Italian Government has issued several tens of protected marine areas, where a huge number of bans and restrictions on the use of the sea are in force. In accordance with a law issued in 2002, the geographical boundaries of such areas have to be physically marked using buoys complying with the relevant regulations issued by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA-AISM).

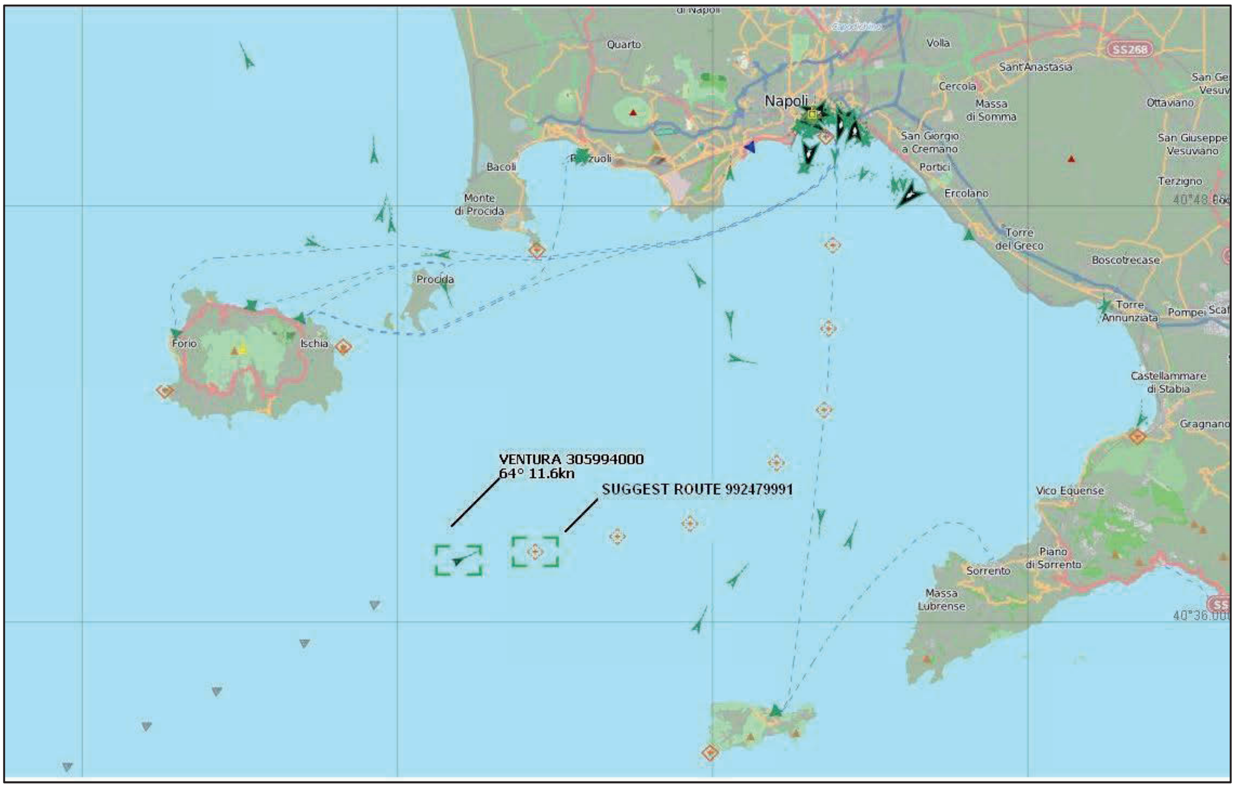

Figure 5 – Vessel sailing on a route traced by the VTS Centre

[10] On "The use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services.

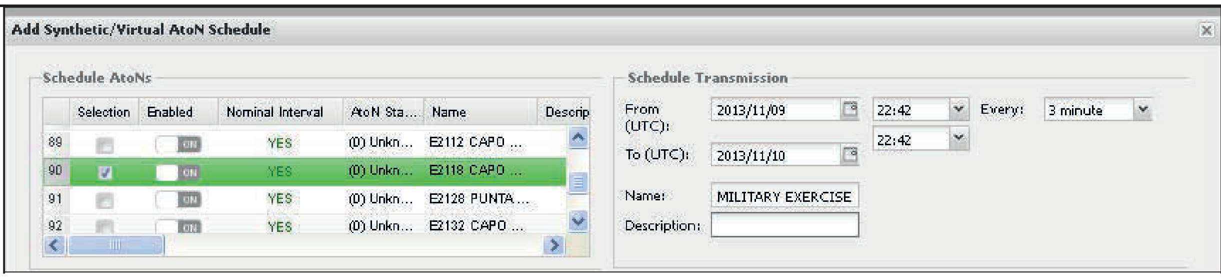

Figure 6 – The AtoN Schedule

In case of an infringement of these bans and restrictions, penalties are higher if the protected marine area is marked by buoys.

Figure 7 – Special mark

Currently, protected marine areas are signalled by means of **special mark** buoys, having the following minimum requirements, as outlined by the Hydrographic Institute of the Italian Navy:

- 2 meters above sea-level minimum focal height;
- 2 nautical miles minimum focal light range;
- yellow colour;
- fitted with a radar reflector.

Buoys can be positioned as far as several miles off the coast in the open sea, thus requiring a lot of maintenance and repositioning every time they are unanchored by rough sea.

The Italian Coast Guard has recently experimented the system feature allowing **AtoN** markers which are broadcast by the National AIS network to be shown on the chart.

In the European Union waters, AIS is not only compulsory on board SOLAS vessels but, in accordance with the 2002/59/EC directive, on pleasure craft greater than 45 meters and on fishing vessels greater than 15 meters as well.

Both the synthetic and virtual Aton are used, depending on the actual presence of the buoys.

The Figure 8 shows the perimeter made through Virtual AtoN of the "Cinque Terre" protected marine area, located in the Ligurian Sea between Genoa and La Spezia.

Personnel training

The Italian Coast Guard has implemented an IALA-standard set of training courses for VTS operators and supervisors. These are carried out at the VTMIS Training Centre in Messina and are intended to provide ICG personnel with the appropriate skill in the use of the available traffic monitoring systems, in order to consent the operators to perform their duties at their best. In July 2012, the Italian Coast Guard positively verified the Training Management System of the

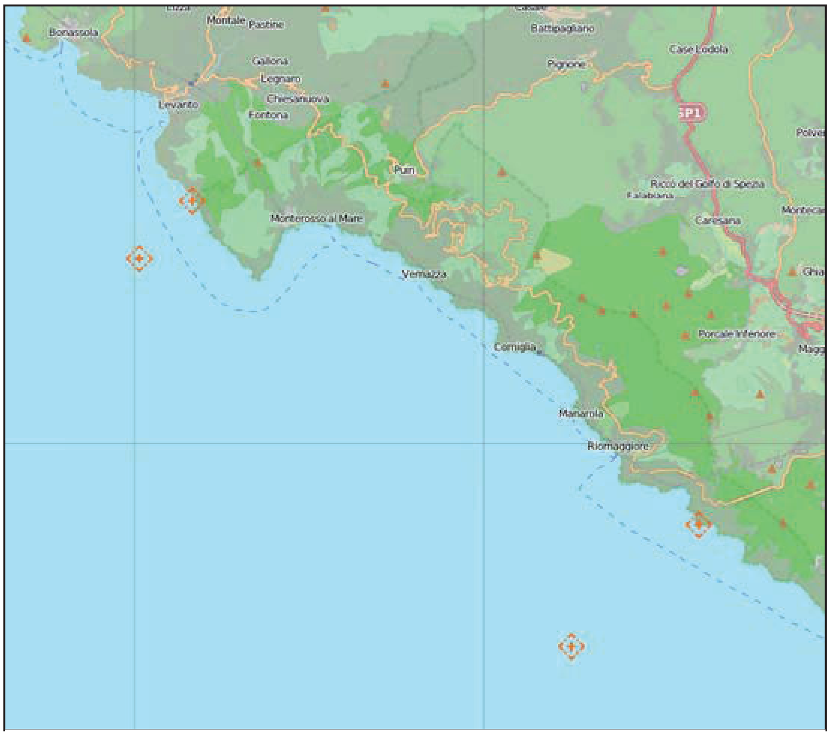

Figure 8 – Four virtual AtoN outlining the "Cinque Terre" marine protected area

VTMIS Italian Training Centre, and the related accreditation process was completed in accordance with both the relevant national legislation and IALA Guidelines 1014, 2011 edition. Moreover, compliance of the operators training with the IALA V-103/1 Model Course standards was positively verified and an *ad interim* approval Certificate of the VTS Operator Course was issued.

In order to ensure that the Italian Coast Guard stations have sufficient and properly qualified staff available, a specific training course for operators in charge of monitoring compliance with vessel traffic services and ships' routing systems, complying with 2002/59/EC Directive (article 9), has been implemented, with the aim of enabling PELAGUS application to be appropriately used. ■

3547 VHF DATA EXCHANGE SYSTEM (VDES) – A NEW MEANS FOR DATA COMMUNICATION TO SUPPORT E-NAVIGATION

Hideki Noguchi. Navigational Safety System Development Office, Aids to Navigation Engineering Division, Maritime Traffic Department, Japan Coast Guard, Japan
Stefan Bober. Federal Waterways and Shipping Administration, Germany

The Automatic Identification System (AIS) has been successfully introduced by IMO in 2002 for collision avoidance. Since then, more than 100,000 commercial ships and recreational vessels have been equipped with AIS. AIS is used in VTS, as aid to navigation, in search and rescue and for satellite detection of ships.

Further, AIS has some capability for the exchange of safety (navigation) related data between ships and between ship and shore. This functionality is known as Application Specific Messages (ASM) and can be used to send – for example – meteorological and hydrographic data, area notice or route information.

However, recognising the potential of ASM and considering the development of e-Navigation, additional possibilities for data exchange between ships and between ship and shore are required beyond the capability provided by AIS. The VDES must take into consideration the requirements of e-Navigation while protecting the AIS VDL from overload as AIS populations increase.

The concept, technical features, possible applications and a roadmap of the VHF Data Exchange System (VDES) as being currently developed by IALA are introduced. Furthermore, its place in the IALA Maritime Radio Communication Plan (MRCP) is described. VDES will provide a world-wide toll free, reliable and robust means for the exchange of navigation related information without compromising AIS capability. It is a further step into the field of maritime digital communication.

El Sistema de Identificación Automática (AIS) fue introducido con éxito por la IMO en 2002 para evitar colisiones. Desde entonces, más de 100 000 buques comerciales y barcos recreativos han sido equipados con AIS. El sistema AIS se utiliza en el Servicio de Tráfico de Buques (VTS) como ayuda a la navegación, en búsqueda y rescate y para la detección de embarcaciones por satélite.

Además, el AIS tiene capacidad para el intercambio de datos relacionados con la seguridad (navegación) entre barcos y entre barco y costa. Esta funcionalidad se conoce como Mensajes Específicos de Aplicación (ASM) y puede utilizarse para enviar, por ejemplo, datos meteorológicos e hidrográficos, avisos de zona o información de ruta.

Sin embargo, reconociendo el potencial de los ASM y considerando el desarrollo de la e-Navegación, se necesitan posibilidades adicionales para el intercambio de datos entre barcos y entre barco y costa más allá de la capacidad proporcionada por el AIS. El Sistema de Intercambio de Datos VHF (VDES) debe tener en cuenta los requerimientos de la e-Navegación al tiempo que protege al AIS VDL de la sobrecarga a medida que crecen las poblaciones AIS.

Se presenta el concepto, las características técnicas, las posibles aplicaciones y una hoja de ruta del VDES tal como la IALA lo está desarrollando actualmente. Además, se describe su lugar en el Plan para las Radiocomunicaciones Marítimas (MRCP) de la IALA. El VDES proporcionará en todo el mundo un medio gratuito, fiable y estable para el intercambio de información relacionada con la navegación sin comprometer la capacidad del AIS. Es un paso más en el campo de la comunicación marítima digital.

Le Système d'Identification Automatique (AIS) a été introduit avec succès par l'OMI en 2002 pour éviter les collisions. Depuis, plus de 100 000 navires marchands et de plaisance ont été équipés d'AIS. L'AIS est utilisé par les VTS, comme aide à la navigation, pour la recherche et le sauvetage et pour détecter les navires par satellites.

En outre, l'AIS a quelques capacités d'échange de données relatives à la sécurité de la navigation, entre navires et entre navires et terre. Cette fonction est appelée « message d'application spécifique » (ou « ASM », pour Application Specific Messages) et peut être par exemple utilisée pour envoyer des données hydrographiques, des avis sur la zone ou des informations la route. Cependant, vu le potentiel de l'ASM et considérant le développement de la e.Navigation, d'autres possibilités d'échange entre navires et entre navires et la terre sont nécessaires, qui sont au-delà des possibilités de l'AIS. Le VDES doit prendre en compte les besoins de la e.Navigation tout en protégeant l'AIS VDL de la surcharge que provoque la multiplication des AIS.

Le concept, les structures techniques, les applications et la feuille de route du VDES tel qu'en cours de développement par l'AISM, sont présentés ici. On décrit en outre sa place dans le Plan de Radio-communication Maritime de l'AISM (MRCP).

VDES sera un système mondial gratuit, fiable et robuste, d'échange d'informations relatives à la navigation sans impact négatif sur les possibilités de l'AIS. C'est une étape de plus dans le domaine de la communication maritime numérique.

VHF Data Exchange System (VDES) – a new means for data communication to support e-Navigation

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Japan Coast Guard

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German Federal Waterways and Shipping Administration

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

AIS — a successful introduction

The Automatic Identification System (AIS) has been successfully introduced by IMO for safety of navigation in 2002. More than 100,000 vessels are equipped with AIS worldwide and the use of AIS is still increasing. AIS is mandatory for vessels subject to SOLAS Chapter 5. However, there are many other users not falling under SOLAS carriage requirements like fishing fleet, inland ships or recreational vessels (AIS Class B). AIS is used as Aid to Navigation (AIS AtoN), in search and rescue (AIS SART, AIS MOB and EPIRB AIS) and for satellite tracking of ships, providing global coverage. AIS shore infrastructure (AIS Base Station) enables the usage of AIS in VTS, ship reporting schemes and other shore based services.

AIS has some capability for the exchange of navigation related data between ships and between ship and shore. This functionality is known as Application Specific Messages (ASM) and can be used to send for example meteorological and hydrographical data, area notice or route information.

The expanding use of the AIS technology has caused a significant load on the capacity of the VHF Data Link (VDL). First indications show an emerging high VDL loading in areas like Gulf of Mexico (64% channel load), Korea and Japan (almost 40% channel load)[1]. However, the introduction of e-Navigation with the expected additional need for digital data exchange has yet to come. The existing AIS will not be able to cope with this expanding need for navigation and safety related digital communication, therefore there is a need to allocate additional channels in order to allow for future developments, i.e. new applications.

The concept of VDES

IALA has developed the technical concept of the VHF Data Exchange System (VDES) which addresses the need for additional capacity for digital data exchange in maritime communication. VDES is now further developed in collaboration with ITU and discussed at IMO and other international organizations.

VDES aims for protecting the original functions of AIS by providing additional capacity for a wide range of applications in maritime safety communication utilizing digital data exchange. VDES is intended to be a globally available data exchange system dedicated to maritime safety, security, efficiency and the protection of the environment.

VDES has the potential to support e-Navigation, maritime data communication and possibly the modernization of GMDSS.

VDES is a technological concept utilizing terrestrial and satellite radio communication links in the VHF maritime mobile band to facilitate globally interoperable digital data exchange between ships, between ships and shore/shore and ships and between ship and satellite.

The concept of VDES comprises the functions of the existing AIS, an additional communication link for the exchange of Application Specific Messages (ASM) and an additional communication link enabling higher capacity VHF digital data exchange (VDE). The concept includes terrestrial radio communication links as well as the satellite radio communication links in the VHF maritime mobile band.

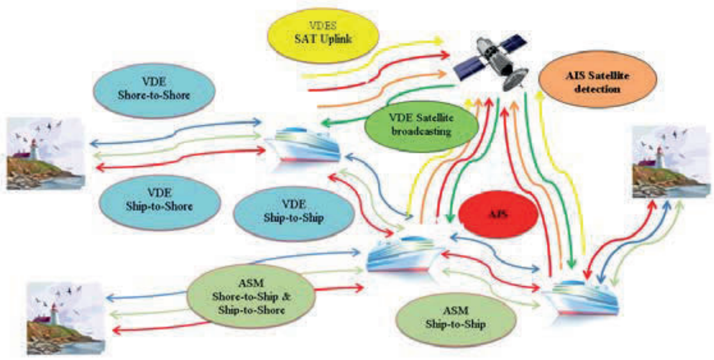

Figure 1: VDES functions for data exchange between ships, shore and satellite

Figure 1 explains the various functions of the VDES providing a robust data exchange between ships, shore and satellite.

The functions of the VDES can be summarized as follows

AIS

The existing Automatic Identification System (AIS) as defined by IMO[2] and ITU[3] will be kept unchanged in its original purpose to provide identification and navigation data to support ship to ship collision avoidance, VTS, tracking of ship and locating in search and rescue. AIS position reports and ship data reports, AIS AtoN message and AIS SART messages will stay on channels AIS 1 and 2. For long range tracking of AIS channels 75 and 76 are used.

The existing ASM on the AIS channels will be gradually moved towards the new ASM channels to ease the channel load for the original AIS functions.

ASM

The function of Application Specific Messages (ASM) is known from the existing AIS. ASM provides a kind of container for data which are supplied by external applications. The data structure and its interpretation must be known by the recipient to be able to decode and understand the content of the ASM.

IMO has defined several international Application Specific Messages like meteorological and hydrographical data, area notice or route information. In addition to those, regional defined ASM are used, e.g. in St. Lorenz Sea Way or in inland navigation. The use of ASM is slowly growing, but with the introduction of e-Navigation the use of ASM it is expected to rapidly increase due to the expanding need for digital data exchange for e-Navigation.

VDES will provide ASM channels that might have higher capacity than AIS, however the data structure of the messages shall remain as defined in AIS. This will allow for gradual transfer of existing ASM from the AIS channels to the new VDES ASM channels.

VDES functions	VHF Data Communications		AIS	
	ASM	VDE	AIS for safety of navigation	AIS long range
Functionality	• Marine safety information • Marine security information • Short safety related messages • General purpose information	• General purpose data exchange • Robust high speed data exchange • VDE satellite communications	• Safety of navigation • Maritime locating devices	• Satellite detection of AIS • Locating during SAR
Applications	• Area warnings and advice • Meteorological and hydrographic data • Traffic management • Ship-shore data exchange • Channel management	• High message payload • Satellite communications	• Ship to ship collision avoidance • VTS • Tracking of ships • Locating in SAR • VDL control (by Base Station)	• Detection of vessels by coastal states beyond range of coastal AIS base stations
Message types	• IMO SN.1/ Circ.289 international application specific messages • Regional application specific messages • Base Station		• Vessel identification • Vessel dynamic data • Vessel static data • Voyage related data • Aids to Navigation • Base Station	• Long range detection of AIS
Radio channels (proposed)	• Proposed channels 27 and 28 (simplex)	• Proposed channels 24, 84, 25, 85, 26, 86	• AIS-1 and AIS-2 (simplex)	• Channels 75 and 76 (simplex)

Table 1: Functions of VDES and their envisaged functionalities

Utilizing the higher capacity of the ASM channel may allow for acknowledged reception of ASM and thus enable an automatic delivery assurance of the ASM.

All new ASM and gradually all existing ASM should be transmitted on the VDES ASM channels.

VDE terrestrial

VDE will facilitate a wide seamless data exchange to enhance digital radio communication beyond the capabilities of ASM.

VDE will enable a two way terrestrial data exchange between ships and between ships and shore in coastal coverage areas. The VDE may provide up to 32 times higher capacity than AIS. This will allow for data exchange which is not bound to the message structure of ASM. It will enable a whole range of new applications which may require data exchange of higher volume.

VDES data exchange by satellite

VDES will provide data exchange between ships and shore via satellite. This will enable a global coverage of the VHF data exchange. VDES satellite data exchange should complement the VDES terrestrial outside the coast station coverage area. This will extend the VDES coverage to high sea, to polar regions and to remote areas, where no shore infrastructure is available.

VDES satellite reception (satellite uplink)

Like the satellite reception of AIS today, satellites which are equipped with the appropriate VDES receivers can receive data exchange transmissions from the ships.

For AIS and ASM this will be most likely the reception of the regular terrestrial transition. For satellite reception of VDE transmissions an optimised protocol for satellite reception might be used to ensure a robust data exchange from ship to satellite. VDES transmission received by satellite (satellite uplink) will be forwarded from the satellite to a ground station on earth and from there further to the shore based user.

VDES satellite transmission (satellite downlink)

VDES will provide the capability for data transmission from satellite to one or more ships. VDES satellite transmission will allow sending data to ships at high sea, in remote areas or in the polar region.

The capability of satellite reception and satellite transmission of VDES has the potential to provide a mechanism to ensure high confidence of data delivery through the acknowledgement of message reception by ships or by satellite depending on the direction of the data exchange.

Table 1 provides a summary of the different functions of VDES and their envisaged functionality.

Technical characteristics of VDES

At the World Radio Conference 2012 (WRC 12) the International Telecommunication Union ITU has allocated a set of radio channels in the VHF maritime mobile band to permit their use by digital systems. Furthermore ITU encourages studies for enhanced AIS technology applications and enhanced radio communication. This matter will be further discussed at WRC 15 under agenda item 1.16.

The VDES concept intends to use the channels permitted for digital data communication. Some of the channels are already assigned for testing future AIS applications; those are planned as ASM channels. Other channels that shall be used for VDE in the future still need assignment by ITU.

An example for a channel plan of globally available VHF radio channels for VDES is shown in Figure 2. Future studies and tests may require amendments for the final arrangement of channels.

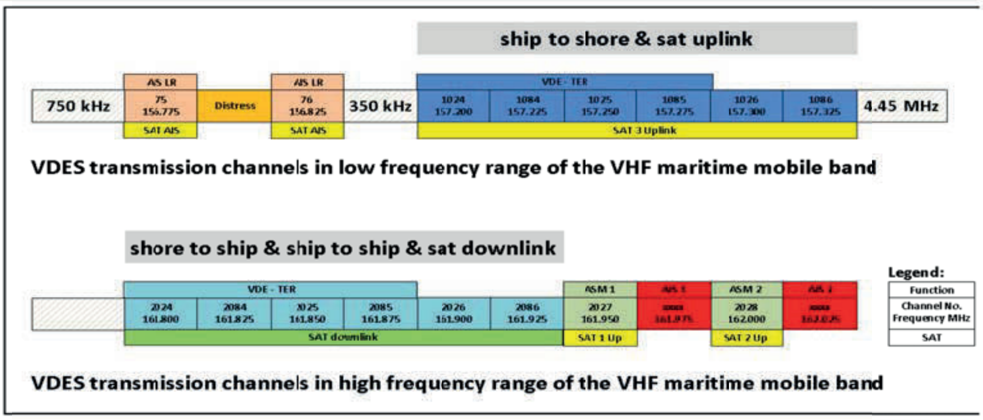

Figure 2: Example of channel designation for VDES in the VHF maritime mobile band

Figure 2 shows the usage of VHF channels by VDES. AIS 1, AIS2, ASM1 and ASM2 are simplex channels used by ship station and shore station transmission and reception of messages. Channel 75 and 76 are used for AIS long range transmissions.

The VDE channels are duplex channels (blue). Four of the six 25 kHz bandwidth channels may be bundled to a 100 kHz wide band channel for higher data rate. Channels in the low frequency range of the maritime mobile band (dark blue) are used for ship station transmission. Channels in high frequency range (light blue) are used for shore station transmission as well as for ship station transmission operating in simplex mode (ship to ship data exchange). VDE channels in the high frequency range are also used for satellite to ship transmissions (satellite downlink). VDE channels in the low frequency range and the ASM channels are used for ship to satellite transmissions (satellite uplink).

The VDES concept utilises technical characteristics specified in Recommendation ITU-R M.1842[4]. This recommendation describes general transceiver characteristics for digital data exchange systems ranging from 25 kHz bandwidth providing 43 kbps data rate through to 100 kHz bandwidth providing 307 kbps.

Further considerations need to address standardised com-munication protocols, coverage range, robustness, channel spacing data rate and modulation schemes.

Sharing the same radio channels by all VDES participants worldwide is the most efficient use of the maritime radio spectrum as requested by ITU. However, the VDES shall always give priority to AIS position reporting and safety related information and shall not impair the functions of DSC, voice distress and safety communication on Channel 16.

ITU-R Working Party 5B is developing a new Recommendation on Technical Characteristics for VHF Data Exchange Systems (VDES) in the VHF maritime mobile band. This recommendation will define the functions of VDES and its performance on the radio channels.

Further steps towards the implementation of VDES are needed. VHF channels need to be assigned for VDES, technical standards need to be drafted, VDES equipment needs to be developed and prototype stations need to be tested.

VDES is envisioned to play an important role for digital data exchange in maritime safety radiocommunication. It will supplement existing systems like VHF voice radiotelephony, DSC, LRIT and GMDSS and pave the way for e-Navigation and possibly the modernization of GMDSS.

VDES is not intended to be a free public correspondence service, but it can be easily complemented and expanded by commercially available data services, thus serving the needs for commercial and public communication.

VDES applications

Since VDES is designed to be a higher, robust and global data exchange system in VHF band, the most possible application is e-Navigation that is aimed to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment. However, VDES is not limited to be for e-Navigation only. The capability of VDES will also enhance GMDSS that is currently discussed at IMO with respect to its modernization and improve other maritime activities such as efficiency of shipping and logistics and marine scientific activity.

In 2010, IMO defined the following 17 messages for the international AIS Application Specific Messages[5].

- Number of persons on board
- VTS-generated/synthetic targets
- Clearance time to enter port
- Marine traffic signals
- Berthing data
- Weather observation report from ships
- Area notice – broadcast
- Area notice – addressed
- Extended ship static and voyage-related data
- Dangerous cargo indication
- Environment
- Route information – broadcast
- Route information – addressed
- Text description – broadcast
- Text description – addressed
- Meteorological and Hydrographic data
- Tidal window

Under the current VDES plan, the AIS Application Specific Message (AIS-ASM) will be migrated from the AIS 1 and 2 channels to ASM 1 and 2 channels that will enable a higher speed of data exchange (up to eight times) than the present AIS. Therefore the first possible VDES applications will be applied for these AIS-ASMs or for its enhanced version. In addition to the AIS-ASM, other new VDES applications will be developed.

VDES applications in e-Navigation

The 59th session of IMO Sub-Committee on Safety of Navigation (NAV) agreed five prioritized potential e-Navigation solutions as follows[6]:

- S1: improved, harmonized and user-friendly bridge design;
- S2: means for standardized and automated reporting;
- S3: improved reliability, resilience and integrity of bridge equipment and navigation information;
- S4: integration and present-ation of available information in graphical displays received via communication equip-ment;
- S9: improved Communi-cation of VTS Service Portfolio.

VDES will be able to contribute to the three of those five e-Navigation solutions, namely S2, S3 and S9.

For the solution S2, means for standardized and automated reporting, two AIS-ASMs, "Extended ship static and voyage-related data" and "Dangerous cargo indication", will be usable. The present AIS-ASM "Extended ship static and voyage-related data" contains various information such as air draught, last port of call, SOLAS equipment status, VHF working channel, Type of bunker oil, etc. The AIS-ASM "Dangerous cargo indicator" contains amount and type of dangerous cargo using IMDG code, IGC code, BC code or MARPOL list. Therefore these two AIS-ASMs will be directly converted to VDES applications and, if necessary, additional information, for example ISPS code, will be incorporated into the application.

However, in order to exchange such information by VDES some security consideration should be required. AIS was designed as an open system and thus it is difficult or even impossible to secure its data. Since VDES is capable of handling a larger volume of data than AIS, a protection of data will become possible by encryption or authentification.

Regarding S3, improved reliability, resilience and integrity of bridge equipment and navigation information, many AIS-ASMs will be usable. For instance, some Aids to Navigation (AtoN) authorities have already started an AIS-ASM service that provides weather data observed at an AtoN. The AIS-ASM "Meteorological and Hydrographic data" contains such data in an internationally standardized form. Other AIS-ASM such as "Clearance time to enter port", "Marine traffic signals", "Berthing data", "Area notice", "Environment", "Tidal window", are also useful for navigation information and these AIS-ASMs will also be directly converted to VDES applications.

Regarding S9, two AIS-ASMs, "VTS-generated/synthetic targets" and "Route information" will be usable. The present AIS-ASM "VTS-generated/synthetic targets" can transmit four targets in one message using two slots. VDES will be able to increase the number of the targets in one message. The present AIS-ASM "Route information" can transmit maximum 16 way points in one message using five slots. VDES will also be able to increase the number of the way points.

In addition to the AIS-ASM, VDES application will be useful for the exchange of navigational intention. At 54th session of NAV Sub-Committee, Japan proposed the Navigational Intention Exchange Support System (NIESS) using AIS binary message[7]. Although this proposal was not included in AIS-ASM since one of AIS-ASMs comprises the exchange of route information, the concept of this proposal will be considered to be included in VDES application.

These are the possible applications of VDES for e-Navigation. These applications will soon be available once core VDES techniques, such as modulation and channel allocation, are established.

However, in order to utilize VDES in e-Navigation, improvement of the data structure will be needed. For instance, the present AIS data structure uses the Maritime Mobile Service Identifier (MMSI) for identification of the AIS station or service. In e-Navigation more detailed identification information will be required such as service origin identifier and service destination identifier. VDES will be capable to accommodate such identifier in its data structure. Further, since IMO decided to use the IHO S-100 data model as the Common Maritime Data Structure of e-Navigation, the development of the VDES data structure should be carried out in accordance with IHO S-100.■

Notes:

[1] According to the IALA Recommendation A-124 "VDL Loading Management"; if the VDL load exceeds 50% it may have an impact on the smooth transmission of AIS messages. This may affect the reliability of ship to shore and shore to ship communication but will not impair the basic AIS functionality for collision avoidance since ship to ship communication is more robust.

[2] Resolution IMO MSC 74(69) "Adoption of new and amended Performance Standards Annex 3 Recommendation on performance standards for an universal shipborne automatic identification system (AIS)"

[3] Recommendation ITU-R M.1371 "Technical Characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile band"

[4] Recommendation ITU-R M.1842 "Characteristics of VHF radio systems and equipment for the exchange of data and electronic mail in the maritime mobile service RR Appendix 18 channels"

[5] SN.1/Circ.289 "Guidance on the use of AIS Application Specific Messages"

[6] NAV 59/WP.8 "E-NAVIGATION, Report of the Working Group"

[7] NAV 54/18/2 "Ship-to-Ship Binary Message for Collision Avoidance"

125 ADVANCES IN RADAR AIDS TO NAVIGATION

Paul F Mueller. Tideland Signal Corporation, USA

Radar aids to navigation are increasingly important to marine safety as ship navigation moves toward greater electronic contribution.

A tremendous boom in the use of radio services in general such as Global Positioning System, other Global Navigation Satellite Systems (GNSS) and Automatic Identification System (AIS), coupled with advances in technology have resulted in availability of devices that would have been cost prohibitive or effectively impossible just a few years ago.

Miniaturization leads to better integration of devices, such as AIS for Aid to Navigation (AtoN) and a racon in the same package, which is discussed here. Recent regulatory changes are allowing superior radars (at least for the S-band) to be installed. Some new radar technologies are inherently incompatible with existing racons and ways to mitigate are discussed. New ideas such as the eRadar/eRacon positioning service (a positioning service independent of GNSS) as demonstrated in the EfficienSeas and ACCSEAS trials are discussed.

Las ayudas de radar a la navegación son cada vez más importantes para la seguridad marítima, ya que la navegación de barcos se dirige hacia una mayor contribución electrónica.

Un tremendo auge del uso de servicios de radio en general como el Sistema de Posicionamiento Global, otros Sistemas Globales de Navegación por Satélite (GNSS) y el Sistema de Identificación Automática (AIS), junto con los avances tecnológicos, han dado lugar a la disponibilidad de dispositivos que hace solo unos pocos años tenían un coste prohibitivo o eran efectivamente imposibles.

La miniaturización lleva a una mejor integración de dispositivos, como AIS para Ayudas a la Navegación (AtoN) y un racon en el mismo paquete, lo que aquí se analiza. Los recientes cambios normativos están permitiendo instalar radares superiores (al menos para la banda S). Algunas nuevas tecnologías de radar son inherentemente incompatibles con racones existentes y se debaten las formas de mitigación. Se examinan nuevas ideas como el servicio de posicionamiento eRadar/eRacon (un servicio de posicionamiento independiente de GNSS) demostrado en las pruebas EfficienSeas y ACCSEAS.

Les aides à la navigation radar sont de plus en plus importantes pour la sécurité maritime car la navigation maritime met l'électronique de plus en plus à contribution.

Un « boom » terrible dans l'utilisation des services radio en général comme le GPS (Système mondial de positionnement), les GNSS (Systèmes de Navigation par satellites) et l'AIS (Système d'identification automatique), ajoutés aux progrès de la technologie, ont conduit à l'existence de produits qui, quelques années plus tôt, auraient eu un coût prohibitif ou auraient été simplement impossibles à acquérir.

La miniaturisation a mené à une meilleure intégration des équipements, comme un et un racon dans un seul élément d'aide à la navigation, qui est présenté ici. Des changements récents dans la réglementation permettent d'installer de super radars (au moins dans la bande S). Quelques technologies radar nouvelles sont par nature incompatibles avec les racons existants ; les moyens d'y pallier sont présentés. De nouvelles idées, telles que le service eRadar/eRacon (service de positionnement indépendant de GNSS), démontré par les essais EfficienSeas et ACCSEAS, sont discutées.

Advances in radar Aids to Navigation

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Advances in radar Aids to Navigation

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Introduction

There has been a tremendous boom in the use of radio services in general, such as Global Positioning System, other Global Navigation Satellite Systems (GNSS) and Automatic Identification System (AIS). Upcoming radio services such as VHF Data Exchange System (VDES) are considered enablers for the data and information exchanges needed for International Maritime Organization's (IMO) e-Navigation concept. As many readers know, the e-Navigation concept is an effort to guide the implementation and integration of services new and old.

Rapid advancement in radio technology has yielded devices that cost less and have much higher performance than ever before. Digital techniques for transmitters and receivers, especially the astounding decrease in cost for digital signal processing in receivers, has fueled development at a rapid pace. We now have devices that would have been cost prohibitive or effectively impossible just a few years ago. Radar and radar aids to navigation, which are increasingly important to marine safety as ship navigation moves toward greater electronic contribution, have been taking advantage of these benefits.

Today we are seeing new features and capabilities reach the main stream of installations. Coupled with recent changes in IMO ship equipment carriage requirements, some of these new capabilities that have been difficult to take advantage of are more easily adopted.

This paper discusses some of the recent activity in the area of radar aids to navigation. Low cost digital processing is a common theme in all advances discussed in this paper. The authors hope the discussion is useful to providers and operators of radar aids to navigation.

Figure 1

Racon with AIS

Miniaturization of components and high levels of function integration have led directly to smaller, less costly devices with higher performance that use less power. Many devices have become small enough that they can be used as conveniently embeddable components within other products. One example of this is a complete AIS for AtoN system embedded into a racon.

In one product, the AIS radio, VHF antenna[1] and GPS antenna are fitted into an X-Band-only racon. ***Figure 1*** is a cut-away view showing how the AIS components are arranged. All of the AIS components fit into the volume remaining after taking out the S-band antenna from a normal, dual-band racon. This AIS/ racon arrangement has many advantages: mounting is simplified; the AIS antennas are protected against the elements; there are no exposed RF cables or connectors; etc.

Please note, that with the S-Band section removed, this Racon with AIS is more suitable for a port and harbor installation, rather than a landfall installation.

IMO Carriage Requirements for Radars

IMO requires that certain classes of ships carry X- and S-Band radars. A ship is allowed to carry more radars, but cost and limited bridge and antenna space effectively reduces the number of ships that would carry more than two radars. The previous IMO performance standards for radars required X- and S-Band radars be able to trigger, detect and display racons. X-Band radars are also required to trigger, detect and display Search and Rescue Transponders (SARTs).

All presently installed and commercially available racons respond only to high-power pulse radars, a very old, but still effective technique. This essentially means that the IMO required racons must be high-power pulse radars. The use of digital signal processing in radar receivers has improved performance of target detection in pulse radars. However, other techniques of radar transmission can give even greater performance but have been difficult for the mariner to take advantage of. Superior radars have been available for general use for decades, but many of the transmission techniques used by these radars either do not trigger racons, or can cause racons to transmit unusable responses to the radar. These radars might not display racons in a usable way. Coupled with the cost and physical limitations described in the previous paragraph, very few modern, superior radars have been installed on ships.

S-Band radar, while having coarser angular resolution compared to X-Band radar, because of its frequency, has much better performance in bad weather (precipitation and sea "clutter"). IMO recognized that the higher performance of S-Band in bad weather and the performance improvements that could be obtained by using superior radars would be particularly beneficial. The requirement for S-Band radars to trigger racons was therefore dropped in order to allow ships to carry superior radars. In 2004, IMO MSC79 approved new radar performance standards in Resolution 192(79), which from 1 July 2008 removed the requirement for S-Band radars to trigger racons[2].

IMO continues to recognize the importance of racons as an aid to navigation, since they provide a means of identifying and locating navigation marks in poor visibility without reliance on GNSS or other electronic position fixing systems. For this reason the requirement for X-Band radar and racon compatibility has not changed.

NT Radars

It is likely that several S-Band radar solutions will emerge over the next few years and that these will be rapidly adopted by users and manufacturers. Radars using these techniques are, as a class, called New Technology (NT) radars[3]. Various receiver digital processing techniques (e.g., Doppler information) may be used to enhance target visibility. The use of solid-state transmitters allows easy and inexpensive digitally determined frequency diversity techniques, which can also improve target detection. The low peak power resulting from pulse compression techniques enables the use of low-power low-cost solid-state transmitters. The required technology for all of this has become increasingly affordable because of the development done for microwave digital communication systems. The net result is that affordable and extremely high performance radars will be offered.

Unfortunately, many of the techniques used to increase radar performance do not work well with existing racons. Many racons will simply ignore signals they do not understand. Some racons may respond, but unintelligibly to the radar. However, recalling that these new radars use inexpensive digital techniques, there is a way.

At least one manufacturer of an NT S-Band radar has chosen to retain compatibility with existing racons by interleaving "normal" pulses with the special NT signals. These pulses trigger the racons, and the radar can digitally process the response. This may become an ad-hoc standard for NT radar operation. This radar, however, transmits at a very low power compared to traditional high-power radars. Low power limits the range at which racons can detect the radar signal.

A series of trials was conducted the General Lighthouse Authorities of the UK and Ireland[4] to test the NT S-Band radar against installed and currently available racons. Loss of range was noted, as well as some "unspecified" behavior by many of the older racons. Newer racons, with high gain antennas and high sensitivity receivers can mitigate against loss of range. In the GLA field trials, it was shown that a racon as described has significantly longer detection range than older racons.

Enhanced Radar Positioning – eRadar and eRacon

There is some concern about providing position services that are not dependent on GPS or GPS-like GNSS services. Current GNSS services can be easily jammed rendering the services unavailable. The services can also be spoofed, which can cause receivers to indicate incorrect positions. Interruption of service for bridge systems that use GNSS directly (e.g., chart plotters and ECDIS) can cause problems with determining the ship's own position. Systems that use GNSS indirectly (e.g., AIS displays) can cause problems with situational awareness.

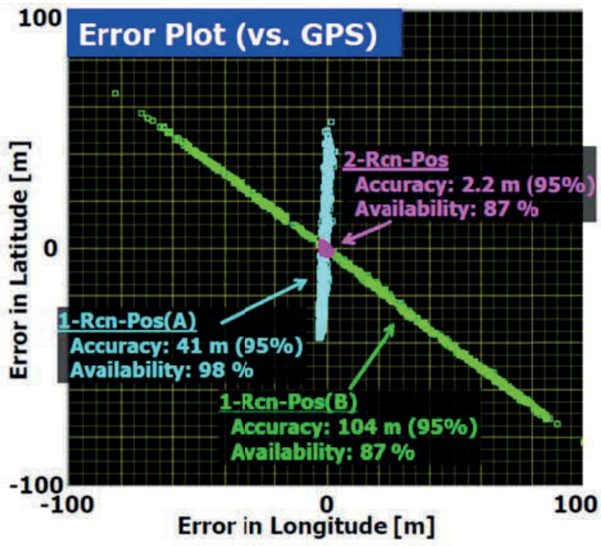

Figure 2

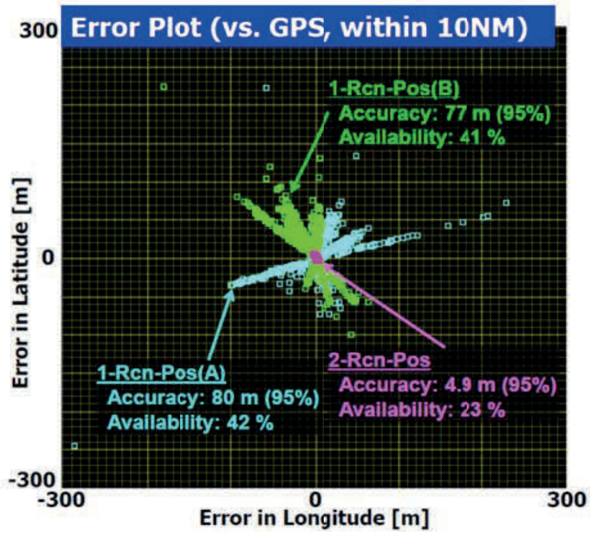

Figure 3

Many radio-based alternatives to GNSS already exist (e.g., LORAN, eLORAN, private services, etc.) and they all have their own benefits. While it is expected that future GNSS systems will be increasingly robust against disruption and/ or interruption, in the end, all of these services are provided as utilities to the maritime user – the user is dependent on a large, external infrastructure for position determination.

There are a number of ways for the ship's position to be determined without a large external infrastructure. Certainly, looking out the window is the oldest method. Celestial navigation and inertial navigation are also used.

Radar is simply a form of looking out the window, using different electromagnetic frequencies. The navigation radar of a ship is currently considered a primary position verification device by navigators, as the radar can be used to identify conspicuous objects or coast lines, giving range and bearing to objects of a known charted position. However, object or feature identification is a manual operation, though some manufacturers have been working on automatic coastline detection. There have been a number of solutions using radar and special digital pattern recognition processing (remember, digital processing is now quite inexpensive) for coast line identification and finding radar reflectors in known, charted positions.

Another technique is proposed that uses racons that communicate their identification and surveyed position to specially equipped radars. Since each racon has a unique identification and position, ambiguities inherent in other techniques can be eliminated. This technique has been named Enhanced Radar Positioning by the Danish Maritime Safety administration. Participating devices are known as eRadars and eRacons. It is interesting to note that this positioning system is independent of the chart – the ship needs no other information other than that provided by the eRacons in order to determine its position.

Two recent trials of this technique were conducted. The first, as part of the EU EffencienSeas project, was hosted by the Danish Maritime Safety Administration and took place on the Baltic side of Denmark in October 2011. The second, as part of the Resilient PNT stream of the EU ACCSEAS project, was hosted by Trinity House Lighthouse Service and took place on the North Sea side of England in July 2013. In both trials, modified racons and a prototype radar were used to successfully predict the ship's own position triangulating from the racon return transmissions.

The first trial was conservatively managed. Due to the type of racon transmitter modulation used for this trial, it was thought that the racons' unusual response might confuse radar operators. The operating parameters for the radar and racons were set to prevent other radars from triggering the racons, thus radars not involved in the trial did not display the racons. For the second trial, however, a different type of modulation was chosen and the operating parameters for the radar and racons allowed the racons to respond to normal radars as well as to the trial radar. This allowed some subjective observation of the effect of the modulation when the racons' response was displayed by a normal radar.

Figure 2 illustrates typical position determination results from the trials[5]. This diagram is for data taken when the trial vessel was stationary and with a large number of measurements. Racon A was nearer to the vessel. Please note that the returns from the racons are comparatively precise in range (narrow) and comparatively imprecise in angle (wide). This is actually the case for any radar target – single target references are always imprecise in angle compared to range, which is the major cause of uncertainty in location determination when using radar[6]. Triangulation is used to locate the vessel, which mitigates the large angular imprecision. But none of this is new. What is new is that the radar will only use targets that identify themselves for automatic position determination. Thus there is no ambiguity in target identification.

Figure 3 illustrates positioning results for the trail vessel while it was moving. The low availability indicated was attributed to normal multipath effects. Position determination is easily as good as or better than un-augmented GNSS.

Implementing a network of eRacons, and fitting ships with eRadars seems expensive. But it is not (remember, digital signal processing techniques are quite inexpensive). The added cost to a new racon for transmitting its position is inconsequential. The added cost for an NT radar to detect the encoded signal and calculate ship's position is also inconsequential. This is because digital devices already have the hardware they need to perform the functions. There may be some devices now installed that could perform as eRadars and eRacons with software upgrades. In the course of normal recapitalization, it is conceivable that all radars and racons could be fitted standard as eRadars and eRacons.

Conclusions

The work at IMO and the NT radar/ racon issue have been discussed in many venues over the past ten years or so and is likely familiar to the reader. The Racon with AIS and the Enhanced Radar Positioning eRadar and eRacon work may be new to most readers. In particular, the Enhanced Radar Positioning trials have demonstrated positive results. It is expected that work will continue.

It can be safely stated that improvements in radars and radar aids to navigation, fueled by low cost digital and signal processing hardware and software are already on the market and many more improved products are sure to come. The result is safer navigation. ■

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[1] The VHF antenna used here is interesting; it is a form of an H-field (loop) antenna – essentially a tuned coil. It works by use of the magnetic field of a radio signal, which can be compared to a normal, E-Field (whip or dipole) antenna that uses the electric field. This particular antenna has an equivalent gain of 6 dB, about the same as a two-meter tall whip antenna. This antenna is actually an old technology, but recently reworked by its manufacturer into an omnidirectional, high performance, low cost, small sized product. Directional H-Field loop antennas may be familiar to the reader as they are often used with radio direction receivers.

[2] Another driver for this is to make way for more stringent limits on spurious and out of band emissions of marine radars to be considered by International Telecommunications Union (ITU) in order to improve the utilization efficiency of the radar spectrum and nearby bands.

[3] There may be some actual new technology used, especially in terms of components and subsystems, but many of the techniques have been known and used for decades on other radars. New Technology is used here in the sense of new to the IMO regulated community.

[4] RPT-07-NW-10 Second Racon Trials, GLA R&RNAV 2010

[5] Radar Positioning Report 26th Sep 2013; Furuno Corp.

[6] There is another effect visible. Racons do not know exactly when the radars' rotating antennas are pointing towards themselves. Racons are configured to identify the radars in-view and to only respond to the strongest signals from those radars. This process is called side lobe suppression. Uncertainty in this process makes racons appear to be "wider" than normal targets of the same physical size.

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