Implementing Digital Aids to Navigation in European Inland Navigation

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ABSTRACT

The European RIS COMEX project offers the opportunity to evaluate new possibilities for digital aids to navigation on inland waterways. AIS and ECDIS have proven that they can improve safety of navigation. Improved traffic awareness on board is a well-known benefit. However, the existing digital infrastructure of AIS and ECDIS has even more to offer: The digital data exchange between ships and shore allows for the provision of dynamic digital aids to navigation and other safety related information.

The project investigates how the constantly changing navigation-relevant information on inland waterways can be provided in the context of Aids to Navigation applications with ASM and ECDIS.

For example, information such as recommended lane in shallow navigational channels, the crossing of a ferry, the vertical clearance of a bridge and the signal status of a traffic lights, can be provided via ASMs and displayed on an inland vessel's on-board ECDIS. Smart buoys can measure precisely and transmit information about the current water level in front of a bridge in addition to its position, type and operating status.

KEYWORDS: AIS, physical AtoN, virtual AtoN, ASM, ECDIS, inland waterways, RIS COMEX,

ABSTRACT (FRENCH)

ABSTRACT (SPANISH)

1 EU RIS COMEX PROJECT - ENHANCEMENT OF SAFETY IN INLAND NAVIGATION

Within the framework of the EU project RIS COMEX, inland waterway information services (RIS) are provided in a sustainable and uniform manner. In principle, these RIS services are harmonized across countries, in relation to the corridor in which they apply.

The "Sub Activity 5.1" is a subtask in the RIS COMEX project, which focuses on "Safety on inland waterways". New digital messages of the European Standard for River Information Services (ES-RIS) are to be tested in various conditions in inland navigation.

The Automatic Identification System (AIS) is a digital radio data exchange system, used worldwide to identify ships in both, maritime and inland navigation.

Navigation on inland waters differs considerably from navigation on the open sea. It is usually made more difficult by the narrowness of the navigation channel, bridges, crossing pipelines, cross currents, changing water levels and frequently changes in the waterway bed. In addition, there are temporary construction sites to remove traffic restrictions or to improve operating conditions. Navigation conditions on inland waterways change frequently and inland navigation needs up-to-date information about them in order to navigate safely.

Despite the differences between maritime and inland navigation, efforts are made to apply the standards established in maritime navigation to inland navigation as well. Parts of the maritime standards do not fit in inland navigation and are therefore not used. Other rules have to be supplemented to meet the conditions on rivers and canals. Thus, the standards "Inland AIS" and "Inland ECDIS" were developed, which take into account the specific requirements of inland navigation. These two standards interact as well and this area of overlap must therefore be further developed in close coordination during standardisation.

The information provided by the Inland AIS standard is mostly received by the Inland ECDIS on board the inland vessels, interpreted and displayed on the inland navigation chart, with symbols and concise texts that are as easy to recognise as possible. The inland navigation chart is the so-called Inland Electronic Navigational Chart (IENC), a part of the Inland ECDIS standard. It contains all information relevant for navigation on inland waterways, e.g. the fairway, navigation signs, bridges, locks, ports, and shows your target state. This is the state that the German Waterways and Shipping Administration (WSV) constantly maintains to ensure operation.

Inland navigation in Germany is obliged to be equipped with a certified AIS device according to the Inland AIS Standard as well as an Inland Electronic Navigational Chart (IENC) according to the Inland ECDIS Standard and to use it during the voyage. In this way, the skipper can already detect all vessels in his vicinity on the ECDIS, even if they are still out of sight.

The Inland AIS Standard has now been extended with a number of functions that provide inland vessels with information about the nautical environment they are in. These are for example recommended routes in shallow water, hazard warnings of ferries just crossing, warnings of restricted bridge clearance heights at high water levels, and the actual signal status of a traffic light system. These functions were implemented and tested in the Elbe-Weser corridor as part of the European project "RIS COMEX". As both standards are concerned, it was important to further develop the Inland ECDIS standard in parallel with the Inland AIS standard. These standardisation processes is not yet completed. The results of the RIS COMEX project still have to be incorporated in those standards.

In order to be able to carry out the tests in RIS COMEX, it was necessary to upgrade the Inland ECDIS systems on board in such a way that the new Inland AIS messages are also displayed on the navigation chart. This was realised through a research and development contract awarded to the Inland ECDIS manufacturers within the RIS COMEX project.

The temporary restrictions, that are passed on to the inland vessels via AIS AtoN messages or ASMs are now also visible on board on the Inland ECDIS with the new software versions of the Inland ECDIS manufacturers. This is done on a local basis, i.e. the restrictions appear where they exist.

This means that in addition to the static information of the navigation environment, temporary information on traffic restrictions are now also displayed on the navigational chart where it applies.

If the display of this additional temporary additional information obscures important important static information on the navigation chart, for example in the case of a difficult bridge passage, the skipper can also temporarily hide the additional information in the IENC.

2 RESULTS OF THE TEST APPLICATIONS IN THE ELBE-WESER CORRIDOR

In general, the objective of the European project RIS COMEX was to provide River Information Services (RIS) in a sustainable and uniform way within the inland waterway corridors. New Inland AIS messages, so-called Inland AIS AtoN messages and Inland Application Specific Messages (Inland ASM), were tested in the Elbe-Weser corridor with view to improving safety and ease of navigation.

Inland AIS AtoN messages and Inland ASMs have been specifically developed to take into account the special requirements of inland navigation. These messages are based on the maritime equivalent but adapted for inland navigational use. These developments are based on IALA Recommendation R0126 “The use of AIS in marine aids to navigation services” and IALA Guideline G1095 “Harmonised implementation of Application Specific Messages (ASM)”.

Inland AIS AtoN messages are special AIS messages for:

- fixed and floating navigation marks on inland waterways, equipped with an AIS AtoN station, so-called "Physical Inland AIS AtoN".
- virtual inland navigation marks, which are not physically present and for which the information is transmitted by an AIS land infrastructure. The so-called "Virtual AIS AtoNs".

Inland ASMs are application specific developments on inland waterways and are also transmitted via the AIS land infrastructure.

All these Inland AIS messages are received by the on-board Inland AIS device and displayed on an Inland ECDIS device, extended for these purposes.

3 PHYSICAL AIS ATON: BOUYS

"Physical Inland AIS AtoN" are physical navigation marks which are additionally equipped with an Inland AIS AtoN station. This Inland AIS AtoN station regularly sends an Inland AIS AtoN Report message with information about the type of AtoN and its position. The Inland AIS AtoN message also contains a so-called "off-position indicator". This indicates on the Inland ECDIS chart whether the buoy is at its nominal position or whether it is “off position”. The skippers and the waterway administration are thus made aware of buoys that have drifted.

The Inland AIS AtoN station is based on the maritime AIS AtoN station according IEC 62320-1, but by using AtoN status bits in the AIS Message 21, the information provided is extended by the Inland AIS AtoN type. The AtoN status page ID 1 is used and a set of up to 32 Inland AtoN types are defined. Details can be found in CESNI ES-RIS 2023/1.

Within the project, physical Inland AIS AtoNs are used to highlight the junction of navigable canals or lock canals at the river Elbe (Figure 1).

For the test operation in the Elbe-Weser corridor, physical Inland AIS AtoNs were laid out at the following points:

- Branch Elbe-Seitenkanal
- Lock entrance UW Geesthacht
- Branch Rothenseer Verbindungskanal

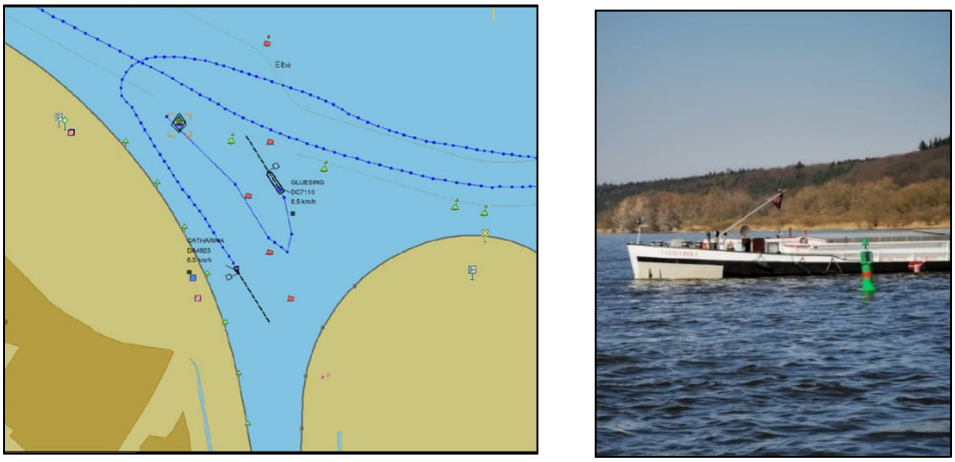

Figure 1: Visualization of a physical AIS AtoN at junction of the Elbe-Seitenkanal in Inland ECDIS

4 VIRTUAL INLAND AIS ATON: BUOYS AND BEACONS

Virtual Inland AIS AtoNs are navigation marks, e.g. buoys, which do not exist in nature. The information of a virtual AtoN is only send via the Inland AIS AtoN Report message and displayed on board of inland vessels in the Inland ECDIS system.

They can be used to highlight an isolated danger point, e.g. by displaying a buoy, or to mark an area where restrictions apply or special attention is required, e.g. during construction works.

During the project it was discussed whether a sequence of buoys, or a line connecting waypoints, or an area would be better suited to visualize certain aspects. For that purpose an ASM providing a line shape or an area shape on an Inland ECDIS could also be seen as a virtual AtoN.

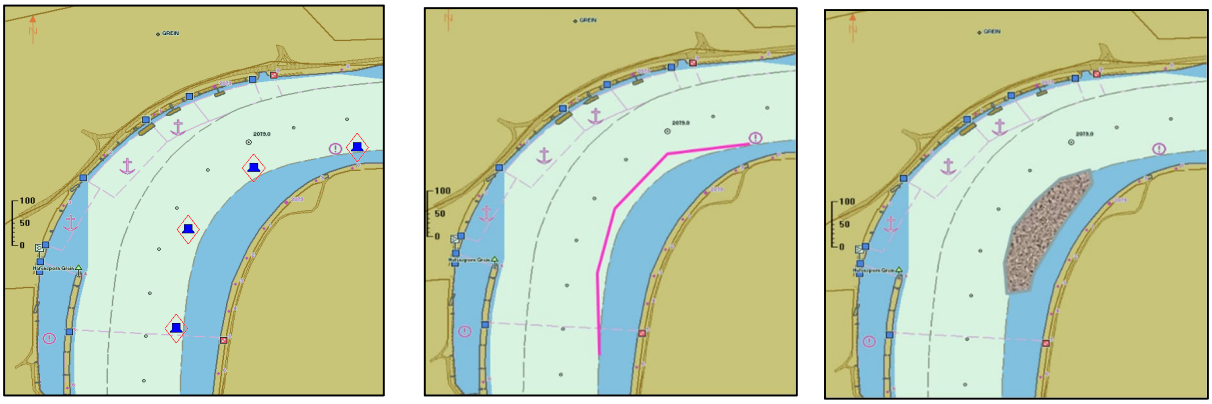

Figure 2: AIS AtoN and ASM depicting a restricted area at the right hand side of the river

5 VIRTUAL AIS ATON: RECOMMENDED ROUTE

In the area of the Lower Elbe near Lauenburg, the so-called residual water stretch, there are constant changes in the river bed. The riverbed is so unstable that even a small flood leads to considerable material shifts in the riverbed. The meandering fairway in the river is marked by buoys and additional beacons on the bank. And this marking often has to be adjusted on site.

With the help of a virtual polygon sent via an ASM, the "recommended route" can now also be displayed in Inland ECDIS (Figure 2).

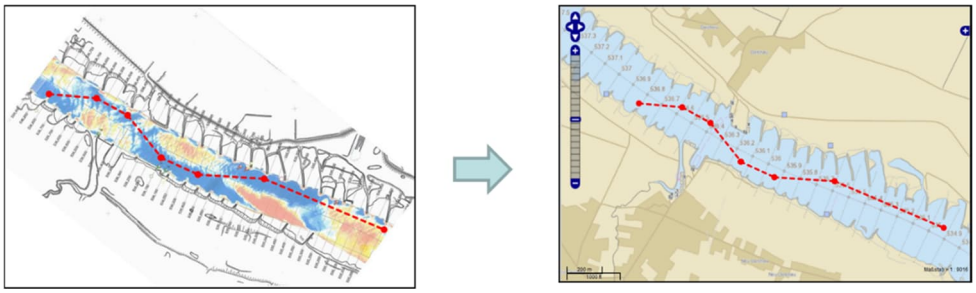

Figure 3: Construction of a “recommended route” from sounding results and visualization on an Inland ECDIS

6 VIRTUAL AIS ATON: WARNING OF CROSSING YAW ROPE FERRIES

On the Elbe, there are a number of yaw rope ferries whose yaw rope is anchored in the river. The yaw ropes are marked by buoys and runs close under the water surface. When the ferry moves from bank to bank, the yaw rope is a source of danger for continuous navigation.

For the test application, four yaw rope ferries were equipped with Inland AIS stations and the functionality to transmit the ASM "Yaw rope ferry crosses fairway":

- Ferry Rathen, Elbe-km 22.67, DE

- Ferry Sandau, Elbe-km 416.10, DE

- Dolní Žleb, Elbe-km 731.9, CZ, in the area of responsibility of the Czech waterway authority

- Velké Březno, Elbe-km 757.05, CZ, in the area of responsibility of the Czech waterway authority.

When crossing the waterway, the ferries send an ASM "geographical message" with an area shape representing a warning area at regular intervals (Figure 3). The ASM is manually triggered and stopped by the captain of the ferry.

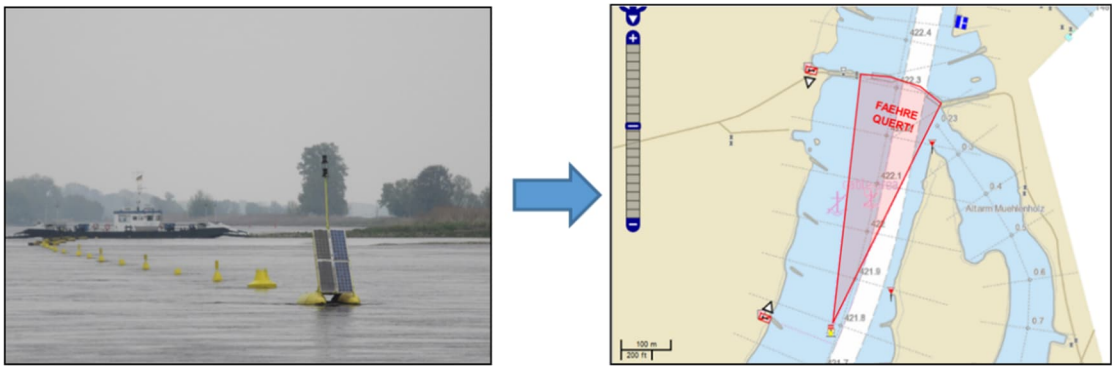

Figure 5: Yaw rope ferry at the river Elbe Virtual caution area while the ferry is crossing

7 - VIRTUAL AIS ATON: WATER LEVEL MESSAGE

The German Waterways and Shipping Administration (WSV) publishes water level at specific stream gauges and related information on its website “Pegelonline.wsv.de”. Those information can be retrieved via the internet at the appropriate webpages or via web services for machine to machine communication.

In the project, the current water levels from https://www.pegelonline.wsv.de/ were transferred via AIS ASM "Water level" to the vessels in the vicinity of the gauge and displayed as a text field at the corresponding position of the gauge in the Inland ECDIS. In addition the current vertical bridge clearance for nearby bridges were calculated according the current water level, transferred via AIS ASM "Bridge Clearance" and displayed as a text field at the corresponding position of the bridge in the Inland ECDIS.

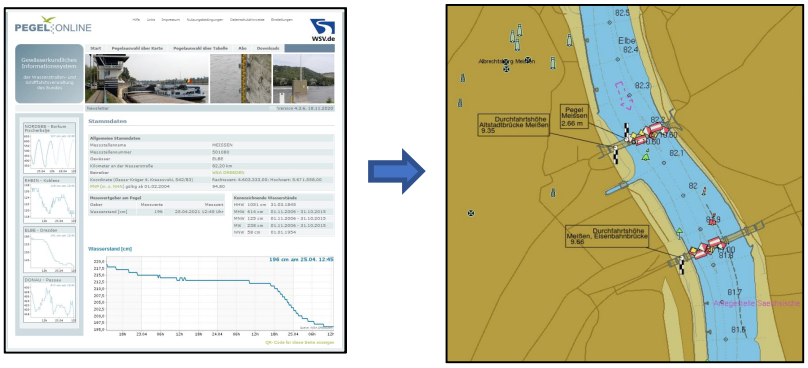

Figure 6: Website Pegelonline and display of the water level and vertical bridge clearance in Inland ECDIS

8 VIRTUAL AIS ATON: WATER LEVEL DEPENDENT WARNINGS

For the particularly low bridges on the Elbe, a warning area is automatically displayed in the Inland ECDIS, depending on the water level when the clearance falls below 7.00 m. The warning area is part of an "ASM area notice message". In addition to the warning area, the value of the currently available bridge clearance is displayed. The warning message disappears automatically again when a clearance height of 7.00 m and more is given (Figure 6).

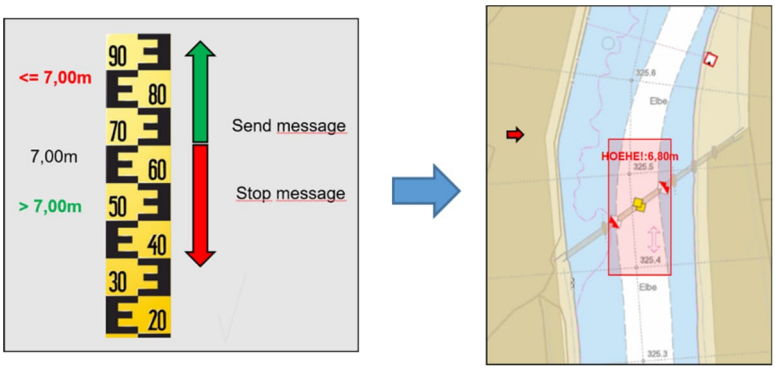

Figure 7: Warning area in Inland ECDIS at low bridge clearance height

9 ASM TEXT MESSAGE: POSITION RELATED WARNING MESSAGE

In order to alert navigation to temporary traffic restrictions and hazards at the waterway, there are Notices to Skippers (NtS). Via NtS service information such as the status of the inland waterway infrastructure (i.e. bridges and locks), failures of aids to navigation, temporary blockages of waterway sections, works, water level and water depth information, ice information and weather messages is provided.

For example, Notices to Skippers in Germany are provided via the web service ELWIS.de. Those information have to be retrieved from the corresponding server via internet access. Incidents and accidents at the waterway are usually reported via VHF voice communication from the appropriate Inland VTS center responsible for the area.

Within the project a functionality was implemented to automatically provide these messages via AIS ASM. The Inland ASM "Text message with position reference" offers the possibility to display particularly important traffic information directly in a text field at the referenced position on the electronic inland navigation chart on board the inland vessels (Figure 7).

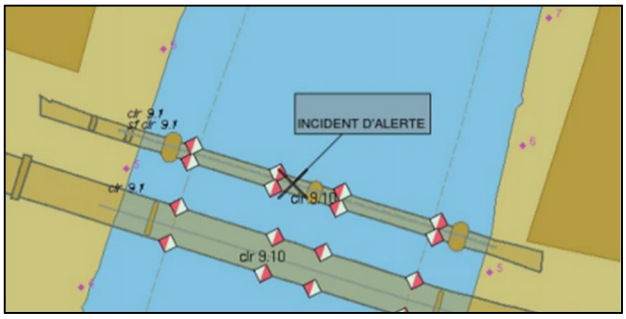

Figure 7: Position related text message

10 - ASM: TRAFFIC LIGHTS

In the area of the "Magdeburger Domfelsen (Wahrschaustrecke)", Elbe-km 325.10 to km 327.10, inland vessels cannot run accross at certain water levels. It's due to the lack of depth, caused by a rock formation partly in the river, the "Domfelsen". A so-called "Wahrschaustrecke" has been set up there. This is a section for which special dynamic regulations apply. Traffic lights at the end points of this section regulate temporary one-way traffic, depending on the traffic situation upstream and downstream. The traffic lights are manually switched on demand via VHF radio from the nearby VTS centre.

The project created an AIS based traffic image of the area, which is displayed on an inland ECDIS. The current status of the traffic lights is transmitted to the vessels via the Inland ASM "Signal Status" and displayed on the Inland ECDIS on board (Figure 8).

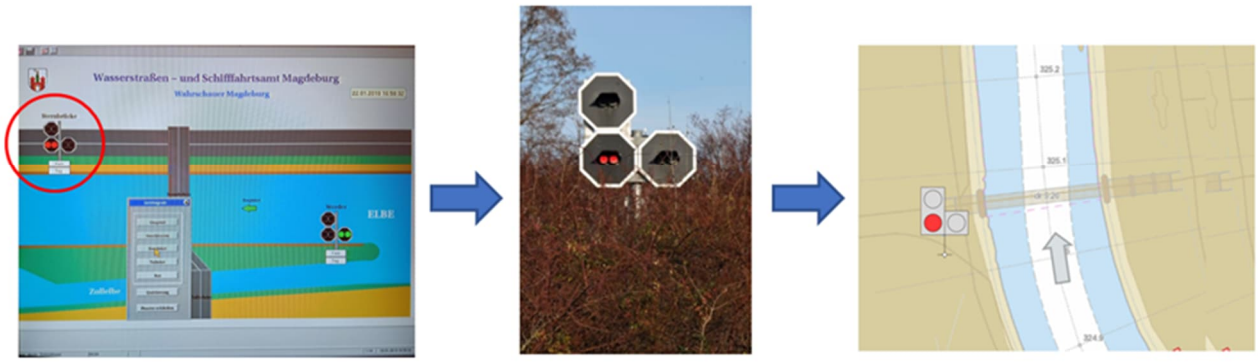

Figure 8: Status of the traffic light system in Magdeburg, shown on the right in Inland ECDIS.

11 SMART BOUY

The WSV operates bridge clearance indicators at some bridges crossing the federal waterways. They are usually connected to a stream gauge in the immediate vicinity of the bridge.
As part of the project an intelligent buoy was developed to measure the current water level which can be used as a basis for determining the current bridge clearance height.
An inland buoy was equipped with a solar power generator, an AIS AtoN station and a high-precision GNSS receiver using RTK information. The buoy thus became a "smart buoy" that records the water level at its location with high accuracy. This is the first buoy of its kind in the inland navigation. It turned out that the measurement results of the smart buoy fulfilled the accuracy requirements. A height accuracy of + -5cm could

be achieved. In the future, such a smart buoy could be used as a flexible precise measuring tool for determining water level heights at any point on the river, independent of any infrastructure or relative costly stream gauges.
The high measuring accuracy is achieved by a high measuring frequency. During a measurement period of 10 minutes, measurements are taken every second. This usually results in 400 to a maximum of 600 validated measurements. The average of these results compensates for the sway and roll of the buoy during the measurement period (Figure 9). This was validated by independent terrestrial laser scanning of the water surface during different measurement periods of the buoy.

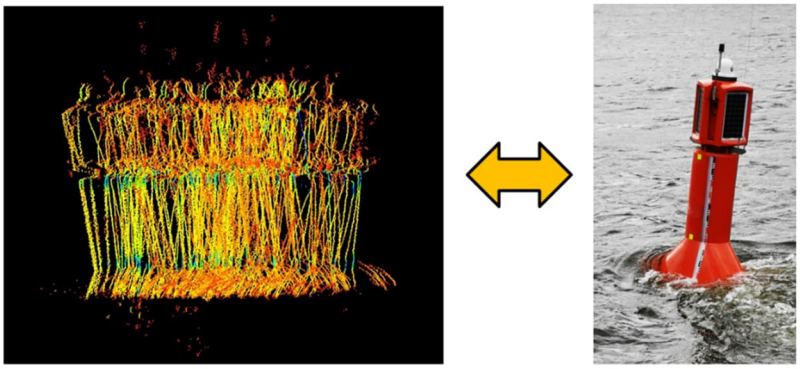

Figure 9: Waving and swaying of the measuring buoy in Dresden.

12 IMPLEMENTATION OF THE RESULTS IN EUROPEAN REGULATION FOR INLAND NAVIGATION

The results of the RIS COMEX project where input to the European standardisation group for river information services (RIS), the European committee for drawing up standards in the field of inland navigation (CESNI).
This standardisation group publishes and maintains the European Standard for River Information Services (ES-RIS). This standard is updated every two years and contains standards for an inland vessel reporting system, notices for skippers, Inland ECDIS and Inland AIS. With the latest update of this standard, ES-RIS 2023 now also includes a standard for Inland AIS AtoN and Inland ASMs used on European inland waterways. It is expected that ES-RIS 2025, the next edition of ES-RIS, will include requirements for the visualisation of Inland AIS AtoN and Inland ASM in Inland ECDIS as well as test standards for these features.

13 SUMMARY

The potential of the new Inland AIS messages (AIS AtoN and ASM) lies in the versatility of the application possibilities and is far from being exhausted. The basic functionality could be created within RIS COMEX and the applications can thus also take place in other waterways.

The various test applications in the Elbe Weser Corridor have shown that the safety and ease of navigation is improved by these applications. Within the framework of RIS COMEX, a sustainable starting point for future applications could be created. However, the existing solution approaches should be refined and made more practicable. On the basis achieved, further useful technical applications can be found to take us forward in the direction of "digitalization of shipping". The components on board that are necessary to use these messages for navigation must be uniform across national borders. Therefore, a coordinated further development of the standards affected by the Inland AIS and Inland ECDIS applications, seems particularly promising to us in this respect.

14 REFERENCES

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