CESNI

EDINNA
Education in Inland Navigation

Track Guidance Assistant for Inland Navigation

Aspects of Safe Use

Contents

Photo credits

© Adobe Stock
© Alphatron (p.4, right)
© Tresco (p.4, left)
© Port of Switzerland (p.7 and 8)
© SWISSRADAR (p.9)

Why this brochure?

Automated means of navigation are developing at a rapid pace in inland navigation. The Track Guidance Assistant for Inland Navigation (TGAIN) is one such modern navigation tool.

The first journeys with a TGAIN were carried out in 2013. At the beginning of July 2024, about 10% of the vessels navigating the Rhine were equipped with a TGAIN. At the same time, standards containing minimum requirements and regulations for the TGAIN are being developed on an ongoing basis.

This brochure was initiated by the European Committee for Drawing up Standards in the Field of Inland Navigation (CESNI) and was drawn up in co-operation with the educational network of inland waterway navigation schools and training institutes "EDINNA". It is relevant to inland navigation for the following purposes:

- as basic lesson material for training institutes
- for training of crew members, both at operational and management level
- as a catalyst for discussion on the subject of TGAIN among nautical experts
- as a basis for the development of procedures and working instructions for TGAIN

In 2024, there are as yet no standards or regulations regarding the use of TGAINs. However, as work within the Central Commission for the Navigation of the Rhine (CCNR) and CESNI is progressing rapidly, it is recommended that the future regulatory framework be taken into account.

Track Guidance Assistant for Inland Navigation (TGAIN)

What is a TGAIN?

The Track Guidance Assistant for Inland Navigation is a system for automatically steering the vessel along a track to follow; its purpose is to support the boatmaster[1] and reduce his steering tasks. The TGAIN can operate the rudder and possibly the propulsion system.

Collision avoidance is not one of the functions of the TGAIN. Some TGAINs have a collision warning function. Therefore, the TGAIN is a system that has been given the level of automation 1 (steering) or 2 (steering and propulsion) of the International definition of levels of automatione[2] published by the CCNR.

TGAIN: Examples from various companies

[1] For reasons of better readability, the masculine gender is used (his).
[2] See https://www.ccr-zkr.org/files/documents/AutomatisationNav/DefinitionAutomatisation_en.pdf

The aim and purpose of a TGAIN

The deployment of a TGAIN is intended to increase general safety standards on inland waterways by allowing the boatmaster to concentrate better on the essential navigational duties.

In addition, TGAINs should help to save fuel by optimising the use of the rudder system in order to reduce costs and protect the environment.

- The TGAIN is **not** intended for boatmasters/helmsmen leaving the wheelhouse briefly to go to the toilet, make coffee or watch their favourite series on the "on-board TV" in peace.
- It must be possible to monitor and immediately operate a TGAIN at any time during its use.

By "automatically" steering a craft along a predefined track to follow, the TGAIN supports and relieves boatmaster of his tasks. The latter can and should therefore concentrate mainly on observing and monitoring the vessel's surroundings.

- With an active TGAIN, the boatmaster can monitor the surroundings more closely within its field of vision or by means of technical aids and also obtain information at an early stage about the conditions on the waterway and the shipping traffic via the so-called operational safety zone!

Aspects of navigation: Background

The development of interoperability

Until the introduction of the Automatic Identification System (Inland AIS), the boatmaster only used the rudder and engine to steer his craft. If necessary, he was assisted by navigation equipment such as rate-of-turn regulators and/or radar.

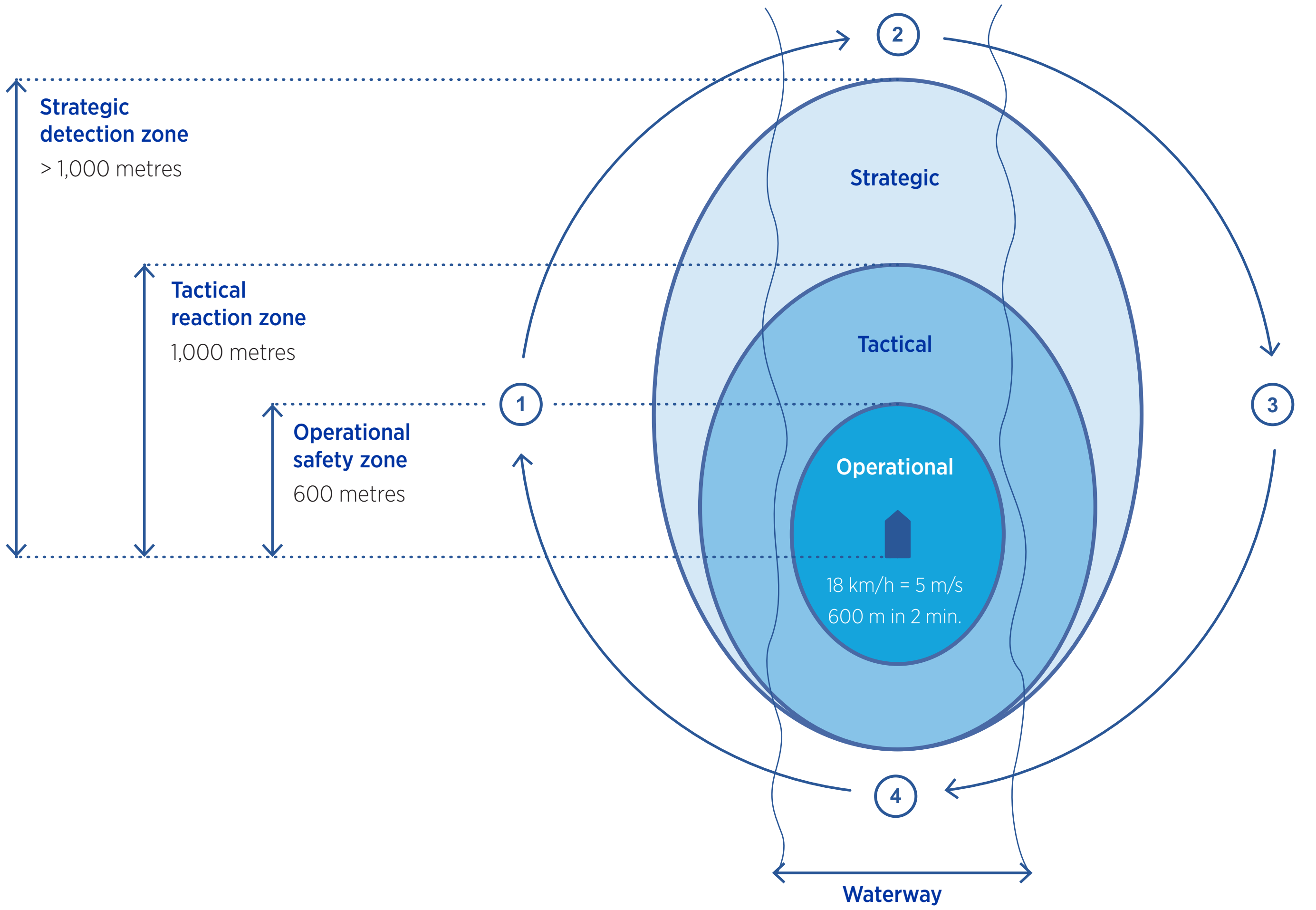
With the obligation to use Inland AIS equipment and electronic chart display equipment (Inland ECDIS), the basic technical requirements were laid down enabling different systems in the wheelhouse and aboard the vessel to communicate with each other, thus opening the way to the interoperability of means of navigation. Interoperability is the technological framework that enables systems to communicate with each other.

The development and use of a TGAIN is therefore the first step in this direction. It requires information from other technical components such as sensors (for heading, position, rate-of-turn) and gives a direct or indirect command to the steering system of the craft (steering apparatus and/or propulsion system) via actuators. However, the sensors, actuators and Inland ECDIS equipment themselves are not part of the TGAIN.

- Interoperability is the basis for the introduction of automated means of navigation in inland navigation.

Visual navigation

Navigation in inland navigation is complex and strongly dependent on the surrounding area and its influences. Unlike in maritime navigation (terrestrial navigation, electronic navigation and celestial navigation), visual navigation is used in inland navigation. Visual navigation is limited to the view from the wheelhouse and is divided into three safety zones.



The cycle of visual navigation in inland navigation

Visual navigation can be summarised by the following four steps that are repeated over and over as part of a never-ending cycle:

1. Monitor the operational, tactical and strategic zones
2. Check the course in accordance with the rules and regulations (e.g. wake and wave action)
3. Decide on the type of navigation and its implementation (e.g. adjusting course)
4. Act to implement the navigation decision (by operating the rudder and propulsion)

Visual navigation can be divided into three safety zones:

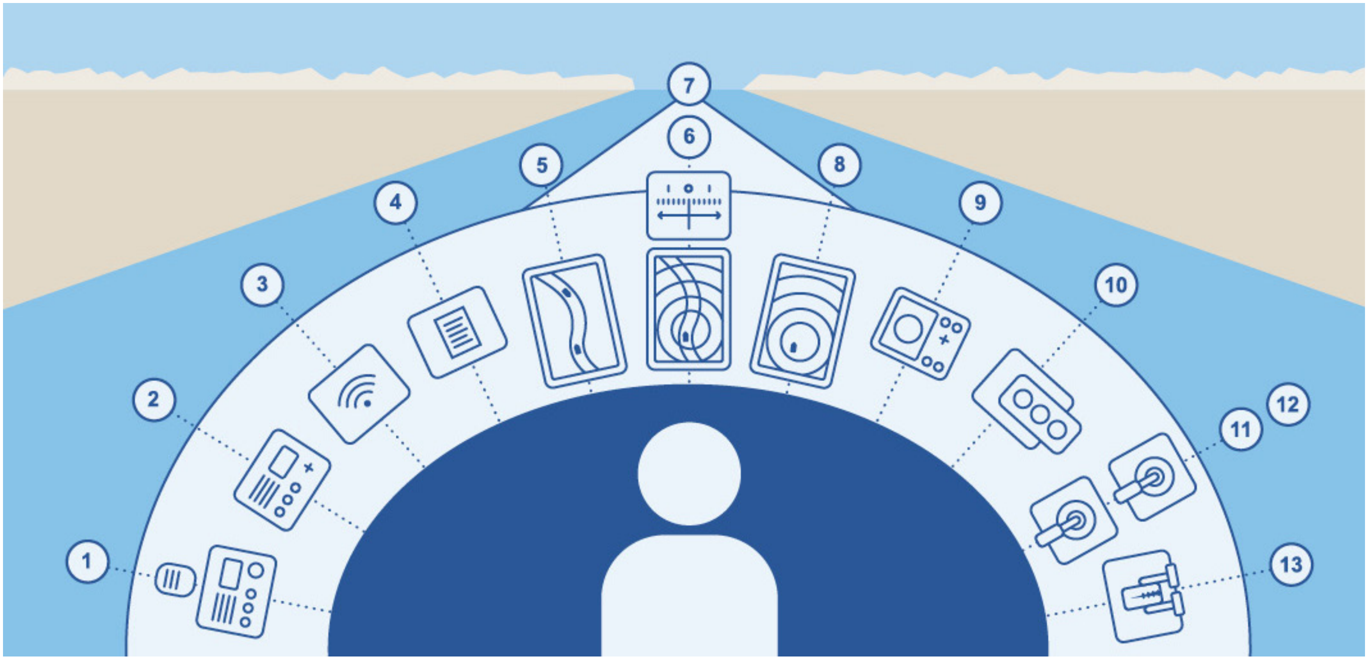
1. **Operational safety zone:** range of up to 600 metres
   The immediate, visible area is limited to the operational safety zone. This safety zone must be free of obstacles. If there are obstacles in this area, the boatmaster should initiate measures (such as acoustic signals, radio communication).
2. **Tactical safety zone:** ranging from 600 metres to 1,000 metres
   Within the tactical safety zone, the boatmaster monitors the wider area and assesses the effects on the operational safety zone.
3. **Strategic safety zone:** of 1,000 metres and more
   The boatmaster obtains information from the strategic safety zone on any encounter that may affect the decision in the operational safety zone.

Equipment for visual navigation in the wheelhouse on a modern inland navigation vessel

With the introduction of radar, the boatmaster has been relieved of visual navigation, especially at night and in case of restricted visibility. Radar navigation is mandatory in poor weather conditions such as fog (Article 6.30 of the Police Regulations for the Navigation of the Rhine). Radar navigation requires a high degree of concentration on the part of the boatmaster.

As a result, radar navigation was initially carried out at steering positions designed for radar navigation by two persons, with the radar operator instructing the helmsman on how to navigate and the helmsman executing these decisions using the rudder and propulsion.

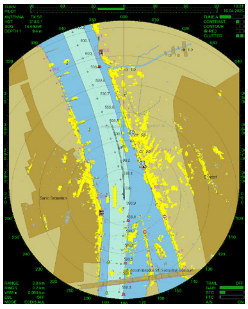
Besides, radar navigation has been simplified by the use of a rate-of-turn regulator (autopilot). Today, the boatmaster can operate the radar, rudder and propulsion alone if the steering position is designed for navigation by one person!



1. VHF radio
2. AIS
3. Electronic reporting screen (example: BICS)
4. Notices to Skippers (NtS)
5. Inland ECDIS information mode
6. Radar
7. Rate-of-turn
8. Inland ECDIS navigation mode
9. GPS compass
10. TGAIN
11. Rate-of-turn regulator
12. Drive unit
13. Propulsion

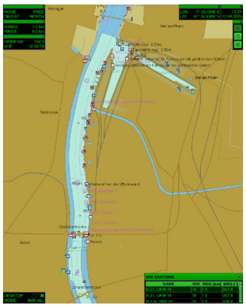
The figure above provides a structured view of the technical equipment for navigation and providing information that is already available at the steering position of a modern inland navigation vessel.

Inland ECDIS: Information mode versus navigation mode



The **navigation mode** refers to the normal operating mode of Inland ECDIS. It provides important information in real time for navigation in the operational and tactical safety zones.

In the navigation mode, the chart showing the vessel's current position is displayed, as well as the Inland AIS data of other vessels within range of the VHF radio. The current radar image is also overlaid. This operating mode can therefore also be used for navigation in poor weather conditions. The radar overlay should therefore not be hidden, especially since it can also show any inaccuracies in the chart display.



The **information mode** of Inland ECDIS displays all kinds of chart sections for information purposes before the start of a journey. However, not all functions of the navigation mode are available.

For example, the radar display is suppressed and initially only the chart showing the current position is displayed. However, charts of other river stretches can also be accessed. The information mode is therefore more useful for journey planning than for journey execution, at best in the strategic safety zone.

- A clear distinction should always be made between the functions of the navigation mode and those of the information mode.
- Note: Only the navigation mode offers the possibility to display the current traffic situation!
- The radar overlay in navigation mode also shows vessels and objects without Inland AIS that cannot be displayed in the information mode.

TGAIN: Designation of the levels of automation

The CCNR has defined the levels of automation in inland navigation at international level. It provides a structured framework for automated navigation and standardised designations for the assessment of TGAINs.

	Level of auto-mation*	Designation	Craft command (steering, propulsion, wheelhouse, etc.)	Monitoring of and responding to navigational environment	Fallback performance of dynamic navigation tasks
BOATMASTER PERFORMS PART OR ALL OF THE DYNAMIC NAVIGATION TASKS	0	**NO AUTOMATION** the full-time performance by the boatmaster of all aspects of the dynamic navigation tasks, even when supported by warning or intervention systems	Boatmaster	Boatmaster	Boatmaster
	1	**STEERING ASSISTANCE** the context-specific performance by a <u>steering automation system</u> using certain information about the navigational environment and with the expectation that the boatmaster performs all remaining aspects of the dynamic navigation tasks	Boatmaster + System	Boatmaster	Boatmaster
	2	**PARTIAL AUTOMATION** the context-specific performance by a navigation automation system of <u>both steering and propulsion</u> using certain information about the navigational environment and with the expectation that the boatmaster performs all remaining aspects of the dynamic navigation tasks	Boatmaster + System	Boatmaster + System	Boatmaster
SYSTEM PERFORMS THE ENTIRE DYNAMIC NAVIGATION TASKS (WHEN ENGAGED)	3	**CONDITIONAL AUTOMATION** the <u>sustained</u> context-specific performance by a navigation automation system of <u>all</u> dynamic navigation tasks, <u>including collision avoidance</u>, with the expectation that the boatmaster will be receptive to requests to intervene and to system failures and will respond appropriately	System	Boatmaster + System	Boatmaster + System
	4	**HIGH AUTOMATION** the sustained context-specific performance and <u>fallback performance</u> by a navigation automation system of all dynamic navigation tasks, <u>without expecting a boatmaster responding to a request to intervene</u>**	System	System	System
	5	**AUTONOMOUS = FULL AUTOMATION** the sustained and <u>unconditional</u> performance and fallback performance by a navigation automation system of all dynamic navigation tasks, without expecting a boatmaster responding to a request to intervene	System	System	System

* Different levels of automation may make use of remote control but different conditions to be defined by competent authorities might apply in order to ensure an equivalent level of safety.

** This level introduces two different functionalities: the ability of “normal” operation without expecting human intervention and the exhaustive fallback performance. Two sub-levels could be envisaged.

Accordingly, TGAINs only meet automation level 1 or 2, which means that the boatmaster remains solely responsible at all times for the control of the craft - including track adjustment to avoid collision, if necessary. Fully automatic collision avoidance without intervention by the operator is only possible from automation level 3 upwards. This is therefore not supported by a TGAIN. The table below shows the characteristics of a TGAIN (and its application) depending on the level of automation:

1	For **automation level 1**, the following applies: The TGAIN is a **steering assistance** = automated rudder system	Example: The TGAIN automatically steers the craft along a track to follow. The TGAIN corrects deviations from the track with the aid of the **rudder**. The boatmaster anticipates (foresees) and corrects deviations from the track during dangerous encountering situations or overtaking manoeuvres with the aid of the TGAIN.
2	For **automation level 2**, the following applies: The TGAIN is a **partially automated control system** = automated rudder and propulsion system.[3]	Example: The TGAIN automatically steers the craft along a track to follow. The TGAIN automatically corrects deviations from the track with the aid of **the rudder and the propulsion**. The boatmaster anticipates and corrects deviations from the track during dangerous encountering situations or overtaking manoeuvres with the aid of the TGAIN.

Possible reasons for deviations from the track:
Strong winds, currents or momentary loss of GPS coverage.

The boatmaster remains responsible for the course and speed up to and including automation level 2.
For that purpose, the boatmaster should continuously monitor the current traffic situation in the surrounding area in order to be able to intervene immediately.

[3] See https://www.ccr-zkr.org/files/documents/AutomatisationNav/Note_explicative_en.pdf

Regulation makes sense

Minimum technical requirements

The provisions of the European Standard laying down Technical Requirements for Inland Navigation Vessels (ES-TRIN) must always be complied with. However, a legally binding technical standard for TGAINs has not been published yet at the end of 2024. The aim is to publish requirements in the 2027 version of ES-TRIN.

Future regulations for the installation of a TGAIN could be based on the requirements for radar or Inland AIS. In principle, however, the boatmaster always remains responsible for the vessel's course and speed – with or without a TGAIN!

Competence standards for the use of the TGAIN

Knowledge of the possible applications, characteristics and limitations of a TGAIN will be required in the future Standard of competence for the management level in the European Standard for Qualifications in Inland Navigation (ES-QIN). The competences required must be acquired for obtaining the certificate of qualification as a boatmaster. Accordingly, training institutes for initial and further training can tailor their training programmes to the "TGAIN competences" which are specified later in this brochure.

Those who already have a certificate of qualification as a boatmaster shall acquire the knowledge and skills needed to use a TGAIN, including its characteristics and limitations, in terms of installing or maintaining a TGAIN on board. This can be done by attending specific courses organised by the manufacturer or by training institutes.

Legal implications with regard to sailing with a TGAIN

The TGAIN should be operated and monitored by the holder of a certificate of qualification as a boatmaster. For training purposes, the TGAIN can also be operated by other crew members, but only under the direct supervision of the boatmaster.

Before using the TGAIN, the operator should be adequately instructed in the use of the TGAIN installed on board. As the boatmaster has the ongoing responsibility, it would be negligent to operate a TGAIN without proper instructions. It is therefore recommended that when a boatmaster is transferred to another vessel with a different type of TGAIN, the boatmaster should be reinstructed in the use of the TGAIN.

For more information on operational aspects, please refer to the applicable police regulations. Not all European countries allow the use of a TGAIN.

Risks and human factors

Risks of using a TGAIN

A TGAIN should not jeopardise the health and safety of the vessel crew, not impair the vessel's integrity and safety, nor interfere with any other information and navigation systems.

The following major risks must always be kept in mind when using a TGAIN:

- Improper installation, maintenance and/or replacement
- Insufficient track accuracy due to traffic and water conditions
- Incorrect input of vessel data
- Gaps in GPS coverage, for example under bridges
- Human factors, such as distraction caused by administrative tasks or "on-board TV"

Focus on human factors

The manual-to-digital transformation in vessel's command, i.e. the fundamental transition from manual to automated vessel control through the digitalisation of individual processes, will keep the shipping industry busy in the coming years. In particular, the psychological, cognitive and social factors influencing the interplay between humans and technology should not only be considered but should also be taken very seriously.

Human fallibility is statistically the major source of errors in complex human-machine systems. On the positive side, however, it is mainly humans who are able to correct the errors of technology and handle the resulting consequences. Therefore, for the future of navigation, in addition to adequate qualification through training, a strong awareness of human-machine interaction is crucial. Education and training institutes will have to pay more attention to these problem areas in the future.

Consequences of relieving the boatmaster of his tasks

The "automatic" TGAIN steering system reduces the workload of the boatmaster, enabling the boatmaster to concentrate better on observing and monitoring the relevant navigation situations on the track. However, as with many other monitoring tasks, there is a risk that the boatmaster may become inattentive or distracted by other (professional or private) activities. The challenge for any boatmaster is therefore to remain focussed on its core tasks and the vessel's surroundings for prolonged periods of time.

- The main risk in using a TGAIN is that the boatmaster relies too heavily on the steering assistance and no longer monitors the navigational surroundings and the vessel's behaviour as required.

TGAIN in education and training

Years of training experience show that the installation of new technical navigation equipment is usually not accompanied by adequate training. This leads to incorrect operation or inadequate reactions in critical situations. On the other hand, the possibilities provided by the equipment to facilitate navigation tasks are often not even utilised.

Potential operators have several options to acquire knowledge and skills regarding the characteristics and limitations as well as safe use of a TGAIN.

- **Vocational training** for vessel-handling – in accordance with the ES-QIN Standard of competence for the management level.
- **Further training** to reach the management level as a boatmaster – in accordance with the ES-QIN Standard of competence for the management level.
- **Instructions** given by the manufacturer or the specialised firm installing the equipment – operators should receive confirmation of participation after having been instructed.

To ensure that the TGAIN can also be successfully used in critical situations, the following competences for the TGAIN should be respected by education and training institutes as well as by manufacturers.

TGAIN competences

TGAIN operators should have the following competences based on a six-point programme:

Installation and function

- ▢ Describe the structure and characteristics of a TGAIN and the TGAIN installed on board.
- ▢ Basic knowledge of cooperative devices such as Inland ECDIS, radar, Inland AIS, heading sensor, rate-of-turn regulator.

Operation

- ▢ Anticipate encounters with other craft based on the proposed track.
- ▢ Anticipate external influences such as crosscurrents, strong wake, and effects in narrow canals and their banks, etc.
- ▢ Interpret and be able to determine position and heading, as well as e.g. move the intended track, change direction of travel and speed.
- ▢ Interpret and take into account speed in relation to water and over the ground as well as environmental factors such as weather, wind and floating material.

Possibilities and limitations

- ▢ Set and display an appropriate, practicable track (minimum radius, etc.).
- ▢ Prevent hazards, e.g. due to low engine revolutions at high speed and resulting slowness of the craft.
- ▢ Recognise and interpret the Global Navigation Satellite System (GNSS) shadows caused by structures.
- ▢ Optimise and avoid the use of TGAIN in connection with various manoeuvring situations (e.g. lock manoeuvres).

Malfunctions

- ▢ Respond appropriately to warnings, alarms and other malfunctions and take appropriate measures, e.g. switching from the TGAIN to manual rudder control.
- ▢ Take appropriate measures as soon as a significant deviation from the intended track of the vessel is detected.

Responsibility

- ▢ Take responsibility for visual navigation, even after a TGAIN has been activated. It should always be the boatmaster's responsibility to ensure supervision of the TGAIN.
- ▢ Be able to check whether the type of vessel or convoy specified still corresponds to the actual formation.

Security

- ▢ Ensure recording and temporary storage of data.
- ▢ Identify the hazards of a cyberattack and its potential impact on the TGAIN and the vessel's behaviour. Take measures to mitigate or avoid the risk of an attack and its impact.
- ▢ Ensure that the TGAIN is using the latest version/update of the software.

European committee for drawing up standards in the field of inland navigation (CESNI)
Secretariat of the Central Commission for the Navigation of the Rhine (CCNR)
2 place de la République – CS10023
67082 Strasbourg cedex
France
comite_cesni@cesni.eu
https://www.cesni.eu/

In partnership with Education in Inland Navigation (EDINNA)
Mailbox 58
8860 AB Harlingen
The Netherlands
edinna@maritiemeacademieharlingen.nl
https://edinna.eu/