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Target Tracking in RIS

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ABSTRACT: The article treats of problems bound with the tracking of surface water targets in RIS systems. A concept of RIS has been briefly presented, indicating the need for locating in them the tracking and tracing of ships. The most popular sensors used for the purpose have been characterised, the most important relevant documents have been presented and the requirements set for tracking systems have been described.

1 INTRODUCTION

The River Information System (RIS) is a package of solutions for the needs of inland shipping, which has been worked upon for a dozen years by representatives of most European countries. The underlying foundation of this concept is harmonising the activities of all kinds of enterprises, institutions and other users of inland waterway networks in Europe. It is high time Poland too should join the group of countries involved in this undertaking. Directive 2005/44/WE of the European Parliament and Council of Europe, along with respective regulations of the Commission of European Communities (414/2007 and 415/2007) oblige the member countries to introduce this type of system. At the same time they specify requirements pertaining to its implementation, pointing out among other things, which services should be covered by it. Among them are Traffic Information service and Traffic Management. According to assumptions, both should be based on tracking and tracing of vessels conducting navigation in inland waters.

Within the framework of European projects there was called a Tracking and Tracing Expert Working Group, whose work effected in guidelines providing the basis for designing tracking systems in RIS (Tracking and Tracing Expert Group, 2005). They were subsequently accepted by practically all organisations regulating RIS services in Europe.

The present article sets forth the subject matter related to target tracking in RIS and the demands made on it.

2 VESSEL TRACKING AND TRACING

Defining vessel tracking in RIS requires the taking into consideration of a kind of semantic dualism, ushered in by the European Law in force and its translation into English, as the European documents use the English words *tracking* and *tracing*, which in both cases may be translated into Polish as *śledzenie*. Therefore, in official translations two separate concepts were introduced. And so, according to Regulation of Commission of European Communities Nr 414/ 2007 13 March 2007 the following definitions were introduced:

- *Vessel tracking* (Polish *śledzenie*) means the function of maintaining status information of the vessel, such as the current position and characteristics, and — if needed — combined with information on cargo and consignments.
- *Vessel tracing* (Polish *namierzanie*) means the retrieving of information concerning the whereabouts of the vessel and — if needed — information on cargo, consignments and equipment.

Both definitions partly overlap each other, and their differentiation becomes more complete, when the various applications are known for information obtained in effect of tracking and tracing vessels. The issue here is first of all division into static information, pertaining to characteristics of the vessel or the voyage, and into dynamic information, pertaining to the vessel's current navigational situation. Nevertheless, in almost all RIS-related studies, both concepts are linked to each other, being two parts of a conceptual whole.

3 TARGET TRACKING REGULATING DOCUMENTS IN RIS

The problem of tracking targets in inland waters appeared automatically at the moment of introducing supervision of barges and other river vessels. The traditional technique applied for this purpose was radar tracking backed up by various communication technologies, starting from VHF up to cellular telephony. The next step forward is including tracking in the RIS system.

Since the emergence of the concept of harmonised services for inland shipping in the scope of RIS a number of documents have been prepared, which are mainly the result of international programmes under the aegis of European Communities. The main participants of those programmes were countries and firms bound with shipping in west Europe's largest rivers. At the same time, the preparation of RIS standards was the activity of Central Commission for Navigation on the Rhine (CCNR), and Permanent International Association of Navigation Congresses (PIANC). The subject matter of target tracking has always been an essential part of RIS services.

In 2000 the programme ***Inland Navigation Demonstrator for River Information Services*** (INDRIS) was completed, organised within the framework of 4. PR of the Directorate-General for Transport and Energy of the European Commission, which is the first pan-European attempt at implementing the idea of harmonised RIS services. Within its scope there were conducted a few demonstrations of RIS concept on the main inland routes of West Europe. The possibility was indicated of making use of techniques applied in marine VTS centres (Vessel Traffic System), also for tracking inland traffic. It was to be based on data obtained from shore radar, but AIS was taken account of as a source of additional information about targets. (INDRIS, 2000)

Within the scope of 5PR two large RIS-related programmes were started. The first of them was ALSO DANUBE, which lasted from 2002 to 2003, and the other was COMPRIS, a sort of continuation of INDRIS, which lasted from 2000 to 2005. The first was oriented to implementing new technologies of improving shipping on the Danube, the other developed the concept of pan-European RIS within an international consortium (more than 11 member states). In both projects the significance of AIS was stressed both for tracking and tracing targets. At the same time, in COMPRIS programme the attention was directed to the inaccuracies of radar tracking, resulting both from its characteristic and from the specificity of traffic in inland water areas, with frequent manoeuvres, especially by course (COMPRIS, 2004). The importance of data fusion and information was also stressed, acknowledging that radar will be only one of the sensors within the tracking system (COMPRIS, 2005).

Apart from programmes described, within the scope of RIS European platform and with the support of Central Commission for Navigation on the Rhine as also the Danube Commission, expert groups were called with the objective of working out standards and requirements related to RIS. One of the groups handled problems of target tracking and tracing. Its work was based on guidelines for RIS systems worked out by PIANC and approved by CCNR in 2004 (CCNR, 2004). It was pointed out in the study that AIS-based tracking systems supplement radar tracking, which remains the basic source of information about vessel tracking. The experts, without negating this fact, concentrated almost exclusively on AIS development in two variants - Inland AIS and AIS-IP. Their activity effected in standards, worked out in 2005, concerning tracking and tracing of vessels in inland shipping (Tracking and Tracing Expert Group, 2005), which were further adopted by CCNR (CCNR, 2006), and also included in a resolution by European Economic Commission at the UN (UNECE, 2007). They state that a complex tracking system should be made up of various types of sensors. The AIS system, however, is indicated as the unquestionable leader. It may in a way seem amusing that in the document it is said in one place that radar should be the basis for the tracking system, followed by over 100 pages of considerations pertaining to the AIS system. In this way, a clear pro-AIS trend looms out among RIS designers, on a scale surprisingly large in places. For example the DoRIS system, which regulates navigation in the Austrian part of the Danube is based exclusively on AIS and does not avail itself of a radar station. The question arises here about the safety and reliability of Inland AIS.

In the writer's opinion, two things determine the popularity of AIS. In the first place, the high accuracy of dynamic information obtained concerning the vessel's movement (assuming the correct functioning of the system and the ship's sensors; in the second place, the possibility of widening these data by static information about the vessel's dimensions, cargo, port of destination etc. In neither respect does radar stand comparison with AIS.

From 2003 parallel work went on on introducing the DoRIS system of river services, covering the Austrian part of the Danube. In this system, too, AIS was indicated as the main source of information concerning vessel tracking and tracing.

As can be observed, in only a few years there emerged a lot of institutions and consortiums in connection with RIS introduction in Europe, which brought fruit in many documents related to RIS

standards and requirements as a whole and vessel tracking in particular. For the time being, the key documents in this area are the RIS Directive, accepted by the European Parliament and Council in 2005 (EP and UE Council, 2005), two Regulations 414 and 415 of 2007 by the Commission of the European Communities, 2007 a & b, as also the previously mentioned Resolution No.63 of the European Economic Commission at the UN (UNECE, 2007). The RIS Directive is at the moment the basic legal act in Europe related to RIS. It establishes the framework for distribution and using harmonised river information services (RIS) in the Community. At the same time, in matters concerning technical details the Directive refers to the works of European Commission, which issued two regulations on the subject of tracking in RIS. Regulation 414/ 2007 contains technical guidelines concerning planning, implementing and operational use of river information services (RIS), whereas Regulation 415/ 2007 pertains to technical specifications related to systems of vessel traffic control within the scope of RIS.

4 PLACE OF TRACKING IN THE RIS CONCEPT SYSTEM

According to the EU Directive, but also to some earlier works, river information services are a few kinds of services related to inland shipping, whose harmonisation and standardisation are to serve objectives resulting from general European needs in the scope of surface transport. Three basic objectives of introducing RIS were defined in Regulation KE 414/2007 describing goals to be attained:

- transport should be safe;
- transport should be efficient;
- transport should be friendly to the environment.

The realisation of the above general goals, and also partial objectives resulting from them, should be possible by supporting particular tasks bound with inland fleet management. They can be divided into three groups with respect to "arenas" in which they are realised (EC, 2007a):

- arena of transport logistics, in which parties initiating transport cooperate with parties organising transport (e.g. senders, consignees, loaders, forwarders, freight brokers, shipowners);
- arena of transport, where the parties organising the transport cooperate with parties realising transport (e.g. shipowner, terminal operators);
- arena of traffic, in which parties realising transport (e.g. vessel masters and navigators) cooperate with parties managing the resulting vessel traffic (e.g. respective authorities managing the traffic).

Looking for a place for vessel tracking in this flowchart, it will certainly be found among tasks realised in the last arena. In order to present the location even more accurately, in Fig.1 there have been presented particular RIS services, dividing them according to Regulation 414/2007 into services related mainly to traffic and to services related mainly to transport. It should be noticed that a few services may be used for performing RIS tasks.

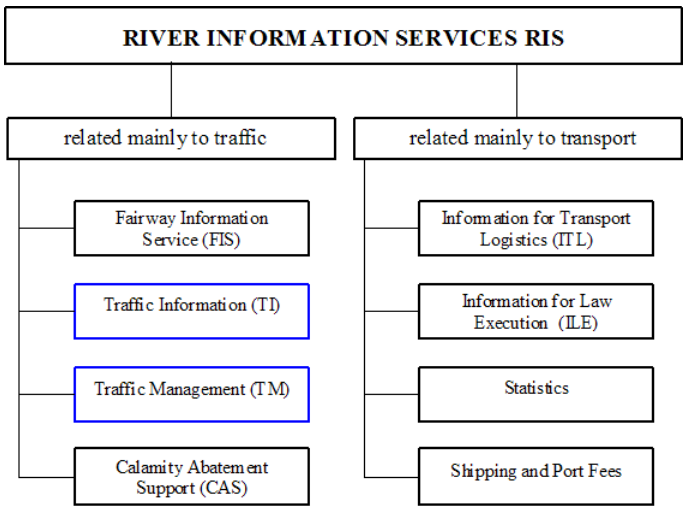

Figure 1 River information services in RIS

In Fig. 1 the services where target tracking can be used have been marked in blue. Regulation 414/ 2007 divides particular RIS services into RIS subservices, which are in turn realised by means of respective RIS functions. Table 1 presents a division of tracking-related services. Specifying the remaining services is not necessary in the aspect of the study's subject matter. It should be noted, however, that information on vessel traffic can be used in services other than those marked, although they are not directly bound with them. For example, for calamity abatement support information on vessel traffic seems to be essential.

In the RIS philosophy three information levels have been introduced (EC, 2007a):

- information on fairways (FI);
- tactical traffic information (TTI);
- strategic traffic information (STI).

From the tracking point of view it is particularly essential to distinguish between the last two. Traffic-related services cover mainly these two information levels.

Tactical traffic information is information affecting the vessel master's or VTS operator's immediate decisions made in relation to navigation in real navigational traffic and concerning local traffic. Strategic traffic information (STI) signifies information af-

fecting medium- and long-term decisions made by RIS users. (EC, 2007a)

As sources of the tactical image, the radar, electronic chart and AIS are mentioned. This information can be gathered directly on the ship or provided by the VTS centre. The strategic traffic image is worked out at the RIS centre and is delivered to the users on request. Strategic traffic area includes all vessels of essential significance present in the RIS area with their characteristics, determination of cargo and position, presented as a table or plotted on an electronic chart. So it seems that in a certain generalisation the tactical traffic image corresponds to the concept of tracking, and the strategic traffic image is based on the concept of tracing. It should be remembered, however, that both tracking and tracing provide different kinds of information, and joining them gives the fullest tactical and strategic traffic image.

It is surprising that in the functional decomposition of RIS services contained in regulations of the Commission for European Communities, in the part related to traffic, there is no function realising the presentation of vessel movement parameters, which are of key significance both for solving current collision situations and determining, say, the time of vessels passing each other, or time of reaching the lock. In the writer's opinion, lack of such information seems to be a gross oversight on the part of the authors of the task-service RIS concept, as it is difficult to imagine constructing TTI or STI without such information. Only in the service Traffic Management there appear functions VTS.2 and VTS.3, in which use is made of information pertaining to vessel traffic.

The essence of vessel traffic control within the scope of RIS was presented in more detail in Regulation 415/2007 (EC, 2007b). It was acknowledged in it that one task of the VTS system was to support active navigation of vessels in the area. Three stages of navigation were introduced there:

- navigation, prediction in medium time;
- navigation, prediction in short time;
- navigation, prediction in very short time.

Prediction in medium time denotes observation and analysis of water traffic in advance of a few minutes to an hour. The Master considers in that time possibilities of approaching, passing and overtaking other vessels. The required image exceeds the range of deck radar, hence VTS information support may prove necessary. This is certainly one of the main areas of making use of tracking.

Prediction in short time is the decision-making stage in the navigational process. Information concerning traffic affects the navigational process, including undertaking actions aimed at avoiding possible collision. In this stage, other vessels are observed present at a short distance. In particular, it is essential to track using the ship's sensors, but shore centre support may prove equally essential.

Prediction in very short time is the operational stage of the navigational process that consists in realising decisions made earlier and monitoring the results of such activities. Information required in this case from other vessels are bound with the conditions of a given vessels, such as relative position and relative speed. In this stage it is necessary to give very accurate data obtained by means of tracking.

As far as making use of tracking goes, the service *Traffic Organisation* is equally essential. It concerns traffic operational control and the planning of the vessel's movement in order to avoid traffic jams and dangerous situations. This service is particularly important with high traffic intensity or in situations, where special transports may affect normal traffic in waterways.

To sum up it can be stated that tracking vessels finds application within RIS for building a mainly tactical, but also strategic traffic image. This in turn is used by vessel control service and directly by navigators on inland shipping vessels.

5 REQUIREMENTS SET FOR TRACKING IN RIS

The basic documents presenting the standards and requirements pertaining to tracking in RIS are the previously mentioned Resolution of European Commission 414/2007 (EC, 2007a), and also resolution 63 of the European Economic Commission at the UN (UNECE, 2007), being the approval of CCNR Standards, which in turn are the result of work of an expert group called by the European RIS platform (CCNR, 2006; Tracking and Tracing Expert Group, 2005). It should be noticed, however, that in all these documents references can be found to IALA work related to requirements in VTS vessel management systems.

Standards for tracking devices in inland waters can be considered in two ways. Firstly, from the ship's side, that is as requirements for devices mounted on the vessel, and secondly from the VTS side, as requirements for shore devices.

In the first case two documents seem to be crucial. The first of them contains requirements prepared by CCNR concerning radar devices mounted on vessels navigating on the Rhine (CCNR, 2004). These requirements in turn became the basis for working out guidelines by the European Telecommunication Standardisation Institute related to navigational radar devices in inland waters (ETSI, 2006). The standards presented both requirements and test-

ing methods. The fact deserves attention that they do not give guidelines for tracking targets, which is why it can be concluded that it is not required at all in river radar. On the other hand, there are relatively high demands related to measurement accuracy of targets' position and discrimination. The document mentioned does not exclude, however, the possibility of enriching radar by additional software, which is why manufacturers frequently apply „tracking overlays" on the radar, where the tracking accuracy approximates marine tracking systems.

There are definitely more requirements for tracking devices within the scope of VTS systems. International tracking and tracing standards recommend that dynamic data in the VTS should be delivered with various accuracies for particular services in accordance with Table 1.

At the same time these documents indicate that the radar remains the basic source of navigational information, stressing the considerably rising role of AIS, which is able to improve significantly the quality of data acquired about the targets. As the work of the expert group was concentrated above all on preparing new AIS standards for inland waters, however, it seems justified in the Regulation of the European Commission to refer to IALA documents, which is the institution to set down VTS standards. In 2001 there appeared IALA guidelines pertaining to VTS systems in inland, which subsequently became the resolution of the European Economic Committee at the UN (UNECE, 2005), and were also adapted by the CCNR (CCNR, 2006). There was included general information on creating vessel management systems in inland waters, for more detailed guidelines it being referred to, *inter alia,* IALA requirements for devices used in VTS systems, V-128. This document has lived to a few editions, the latest of which (3rd version) appeared in 2007 (IALA, 2007).

Table 5 Accuracy requirements for dynamic data in VTS

service	position	SOG	COG	true course
	m	km/h	º	º
Navigation in short time	10	1	5	5
VTS assistance	10	1	5	5
VTS traffic manag.	10	1	5	5
Lock operation	1	0,5	3	
Bridge operation	1	0,5	3	

IALA guidelines related to devices in systems of VTS traffic control were divided into a few sections, in which various appliances are described. Three various accuracy levels were introduced for all of them (basic, standard and extended) bearing in mind economic and technological indexes.

According to IALA guidelines, radar devices are the basic source of navigational information. Because of the specificity of each VTS system (surface shape, traffic density, economic factors, number of radar stations etc.) IALA recommends that the competent authority for a given VTS should lay down individually the requirements for tracking in each system, at the same time giving approximate reference values for a single coastal radar station (IALA, 2007). They were divided into three accuracy levels: basic, standard and advanced. In the last two, the permissible errors of course and speed determination are 2º and 1 knot, laid down on the level of one standard deviation (assuming Gaussian distribution), for a target moving at uniform motion.

What seems interesting is the status of television cameras in the RIS concept, and also VTS. Analysing Regulation 414/2007 it can be noticed that the CCTV camera is mentioned as one of the sensors providing information on traffic on an inland waterway; on the other hand, as it does not appear in any other place in the regulation, its role remains actually unknown. The Tracking and Tracing Expert Group does not mention the camera at all, concentrating on AIS. Only IALA devotes in their recommendations a little more room to CCTV television, but still moving about on a very general level. The camera is indicated there as a potential cheaper than radar source of information about targets in the VTS system. It can fulfil the role of a separate sensor, or supplement information acquired from radar with additional data, like the ship's name or kind. The camera is presented as a good method of supplementing radar coverage in a VTS area. The possibility is admitted that the camera may track targets on its own, but first of all its identification role is highlighted. The camera may show what the radar does not see, e.g. the kind of vessel or danger. Exact requirements are given with regard to the identification function, but there are none such concerning tracking. The only hint is the statement that in the scope of reliability, accuracy, range and resolution a system of industrial television has to meet the requirements of VTS system and expert organisations in the realm of graphics. In this case, the concept of tracking seems to take on a meaning from computer graphics, strictly speaking from computer vision, where tracking means following something and continuous monitoring something rather than determining its movement parameters. Nevertheless, the camera remains one of the sensors that can be used in the VTS system as a source of information about movement and target.

6 RECAPITULATION

The article characterises the subject matter of tracking surface water vessels in RIS systems. This is a problem many international organisations have been preoccupied with in recent years and the European Commission has in some way "dotted the i's and crossed the t's" by issuing directives in the RIS matter. Fortunately, the organisations mentioned cooperated with one another by mostly accepting solutions worked out in common. In their light, as the basic sources of information about vessels in the RIS system there appear Inland AIS, tracking radar and the vision camera within the framework of CCTV industrial television network.

An unquestioned leader in this area is the AIS system, whose introduction, also into inland waters, has opened a completely new chapter in the history of water traffic control. Its indications, assuming the correct functioning of the system, are clearly the most accurate. The radar system, though theoretically still the basis for tracking targets, ceases to be attractive, not only because it gives a less accurate position than GPS, but also because it provides significantly less useful information than AIS. The camera in turn is a short-range sensor, and its application for vessel movement vector estimation is practically unusual. Therefore, only the linking of both sensors into one complementary system gives hope that it will be up-to-date and face the challenges of modern times. What is more, such a system will have basic advantage over the AIS system, namely it will be independent from ship sensors and therefore, the RIS operator will have full control over it. AIS is based, after all, on information delivered by other vessels, and so, in case of their improper functioning, it gives erroneous values. The method of combined tracking based on radar and the camera seems to be a natural attempt at "unification" of these two sensors in order to meet the requirements set for modern tracking systems.

What seems most reasonable is making use of all mentioned sensors for tracking targets in RIS, which leads towards multi-sensor fusion of navigational data.

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