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The usefulness of River Information Services data to assess the probability of a collision by inland vessels navigating under bridges on the Odra River

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Abstract

The article presents an analysis of the possibilities of using RIS to assess the probability of collision during the transition of inland vessels under the bridges on the Odra River. Operational and technical analysis of the bridge structures and their restrictions affecting shipping in the area are also presented. The analysis of the traffic streams of the vessels under the bridge in Radziszewo and the bridge in Gryfino was made on the basis of the AIS data. The number of vessels in the selected area was divided into type and length. The probability of an accident, like collision during an overtaking and passing manoeuver, was defined.

Introduction

RIS (*River Information Services*) is the data collection system for the Odra River. It has been in service since 2014, and covers the supervision of inland waterways of international importance. Szczeciński Węzeł Wodny includes sections of the Odra River from Ognica to Szczecin, East Odra, West Odra and Lake Dąbie. The system is equipped with tools to continuously monitor and track moving objects in the area, so it gives reliable information about the movement of the vessels on the lower stretches of the Odra River. The European Agreement on Main Inland Waterways of International Importance (AGN) classifies the Odra (from Widuchowa to Szczecin) as a strategic bottleneck. This means that the parameters of this stretch of the river require modernization in order to improve its navigability. The current operating parameters do not meet the requirements of the relevant shipping classes or have substantial limitations, which prevents the development of inland waterway transport.

Two of the limitations on the inland waterways of the lower Odra River are clearances under the bridges from highest level of navigable water (WWŻ) and the width of navigable route. These dimensions limit the carriage of cargo, as well as that of container and oversized cargo. On the stretch of the Odra River near Widuchowa, transit depth is not less than the following at the noted locations: 250 cm on Przekop Klucz to Ustowo and Lake Dąbie; 350 cm on East Odra; 400 cm on West Odra, Regalica, Parnica and Parnicki Ditch.

According to the Regulation of the Council of Ministers on the classifications of inland waterways (Journal of laws of 2002, No. 77, item. 695), the minimum vertical clearance under a bridge over WWŻ should be:

- 525 cm – for ships carrying cargo containers in two layers;
- 700 cm – for ships carrying cargo containers in three layers;

(50% containers may be empty otherwise the ballasting of projected unit) (Rozporządzenie, 2002).

The article presents an analysis of the possibilities of using RIS to assess the probability of collision during the transition of inland vessels under select bridges of the Odra River.

Operational and technical analysis of selected bridges of the Odra River

The port of Szczecin is a potential facility for developing the port of Świnoujście. The port of Szczecin taking increasingly larger ships gives the possibility of reloading of cargoes to smaller vessels. The port, which would function as an efficient transshipment facilities, should be capable of handling both large vessels and inland barges. In addition, it is important to have a good railway and road facilities. Barges navigation from the southern regions of Poland in the direction of Szczecin is limited due to the parameters of the waterways. A unit moving on the East Odra and Regalica from Gryfino to Lake Dąbie has to pass under four bridge structures, which are a bridge in Gryfino, a bridge on the Highway A6 (Radziszewo), a road and railway bridge on the Poznań Highway / gen. Karola Świerczewskiego, and the Pioneers of the City of Szczecin bridge.

The bridge in Gryfino is a steel – mesh construction. The middle span between two massive pillars is the span of 100.5 m. Table 1 shows the basic technical operating parameters for the road bridge in Gryfino.

Table 1. Operational and technical parameters – the bridge in Gryfino (General Directorate, 2015a)

The Road bridge in Gryfino		
Width [m]	Vertical clearance [m]	Width of navigable route [m]
100.50	5.17	50.00

The bridge on Highway A6 (Figure 1) (km 8+239) is in the Board of General Directorate for national roads and highways (GDDKiA). The bridge consists of two independent lanes, a northern lane in the direction of Kołbaskowo, and a southern lane in the direction of Gdańsk. These were constructed between 1934 and 1938. Table 2 shows the basic technical operating parameters for the bridge on the Highway A6.

The next bridge is a bridge on the Poznań Highway, which is located on Regalica. This bridge consists of two distinct structures, the road bridge and the railway bridge. The maximum size of the navigable

a) b)

Figure 1. The road bridge in Gryfino (a) and the bridge on the Highway A6 (b) (Praca zespołowa, 2011; General Directorate, 2015a)

Table 2. Operational and technical parameters – the bridge on the Highway A6 (General Directorate, 2015a)

The bridge on the Highway A6							
km	Year of construction	Year of construction spans	Deadweight [t]	Length [m]	Width [m]	Vertical clearance [m]	Width of navigable route [m]
5.976	1937	1937	30.000	205.600	13.050	6.00	50.00
5.976	1998	1998	50.000	205.600	13.200	6.00	50.00
8.239	1937	1937	30.000	226.600	13.000	6.00	50.00
8.239	1998	1998	50.000	226.600	13.200	6.00	50.00

route in this area is determined by the width of the spans under the road bridge, which are less than railway bridge spans. Table 3 shows the basic technical operating parameters for the bridge on the Poznań Highway.

Table 3. Operational and technical parameters - the bridge on the Poznań Highway (Informator, 2015)

The bridge on the Poznań Highway			
Width of road span [m]	Width of railway span [m]	Width of navigable route [m]	Vertical clearance [m]
44.50	45.10	35.00	5.96

The last bridge on the East Odra from Gryfino to Lake Dąbie is the Pioneers of the City of Szczecin Bridge, which is located at the 737.1 km of the river. Currently, the only navigable span length is the right span. Table 4 shows the parameters of The Pioneers of the City of Szczecin Bridge.

Table 4. Operational and technical parameters – The Pioneers of the City of Szczecin bridge (Informator, 2015)

The Pioneers of the City of Szczecin bridge				
Width of right span [m]	Width of left span (closed) [m]	Width of navigable route [m]	Vertical clearance (right span) [m]	Vertical clearance (left span) [m]
83.10	83.17	50.00	9.10	8.44

From comparative analysis of the parameters of the bridges on the Odra River and Regalica from Gryfino to Lake Dąbie, it appears that only the width of the navigable route under railway bridge span on the Poznań Highway (35 m) does not comply with the requirements of international rivers (Vb), which limits the size of the navigable route in the area (Journal of laws of 2002, No. 77, item. 695; Orymowska, Sobkowicz & Ślączka, 2015).

A bigger problem is the vertical clearance on the bridge in Gryfino. Its vertical clearance is only 5.17 m, which is the smallest value in the area and is a significant limit on the air draft of the ships proceeding in the direction of Szczecin. This clearance restricts the carriage unit while the other bridges have vertical clearances that exceed 5.25 m allowing two layers of containers to pass safely.

It should be noted that the vertical clearances are given from the highest level of navigable water (WWŻ), which for the selected area is 6.10 m. WWŻ is monitored by water level sensors. For the bridge in Gryfino, it is the water level sensor at Gryfino. For the remaining bridges, the water level sensor at Szczecin–Podjuchy provides measurements. According to data from 2014, the monthly average water level recorded by the Szczecin–Podjuchy sensor did not exceed 6.00 m. The number of days for which the transit depth was suitable for the East Odra was 334 days, while for the Regalica River, it was 345 days. This means that most days in a year the waterway from Gryfino to Lake Dąbie is navigable. Smaller united water means more clearance under the bridge. However, lower united water leads to lower ships draught.

This article gives an analysis of the traffic under two bridges located on the East Odra River; the bridge in Gryfino, which limits the section of the river, and the bridge near Radziszewo.

The analysis of the vessel traffic streams under the road bridges on the lower Odra River with the use of IALA IWRAP Mk2

The movement of vessels on inland waters is monitored by the Odra RIS system. It is based on an Automatic Identification System (AIS), along with radars, DGPS, and CCTV cameras. Two radar systems are located on the lower Odra River, one at a grain elevator in Szczecin and the second at Widuchowa – Jaz in the southern part.

An example of the use of the data collected by the RIS system, is the analysis of the ship's traffic patterns. The selected data for the analysis is in the National Marine Electronics Association (NMEA) format, which makes it possible to read the information contained in the code. This data includes type and parameters of the vessels, as well as time and coordinates of position for those vessels. Access to this type of information allows one to determine how many vessels of a particular type are navigating in the indicated area. Ship's classification is made on the basis of their type and length. The program IALA IWRAP Mk2 was introduced to analyse the traffic flows of inland ships under two bridges on the East Odra River.

For this article, a sample period from 01.05.2015 to 31.05.2015 was selected. The data was narrowed to focus on ships passing under the Highway A6 Bridge and Gryfino Bridge. Both of these bridges have restrictions preventing the use of the full capacity of the lower Odra River, especially considering the transport of containers. The research was conducted separately for each structure and for each direction of movement. There is two-way traffic in a northerly and southerly directions under each of the bridges. The number of ships has been segregated based on the type and length.

Table 5 shows the number of ships passing under the bridge in Gryfino traveling in a northerly direction. The data provided in the table shows that 2159 vessels travelled north in the period from 01.05.2015 to 31.05.2015. They are mostly ships defined as type "other", which is due to the fact that NMEA codes contained only the basic data of position, time, and the parameters of the vessel. Most inland vessels are not equipped with AIS receivers. Thus the system does not record information about the type of the ship. General cargo ships, support ships, passenger ships (cruises on the Odra River), and small tankers have been moving as well. Ships carrying cargo containers were not registered.

Table 6 shows the number of ships passing under the bridge in Gryfino traveling in a southerly direction. Registered traffic of vessels in the southern direction is much smaller than in the northern direction. The vessels with a length of less than 25 m dominate here. These small vessels include those carrying cargo, support vessels, and vessels whose type was not identified. In this area there are no passenger ships or tankers. Due to the adverse conditions prevailing in shipping, especially in the central part of the Odra River, traffic is directed to vessels on the lower Odra, which, despite restrictions, have appropriate shipping parameters.

Table 7 shows the number of ships passing under the Radziszewo Bridge traveling in a southerly direction. The data in Table 7 shows that 64.8% of registered vessels have a length of less than 25 m. Both the Radziszewo Bridge and Gryfino Bridge registered a larger number of vessels moving north than south. This is reinforced by the fact that the state of the navigation infrastructure on the lower Odra River is better compared to the middle and upper sections of the Odra River.

Table 5. The number of ships passing under the bridge in Gryfino towards a northern direction in the period from 01.05.2015 to 31.05.2015 (General Directorate, 2015b)

GRYFINO – the movement of the vessel towards a northern direction						
Ship's length	Tanker ships	General cargo ships	Passenger ships	Support ships	Other	Sum
0–25	0	485	0	23	923	1431 (66.3%)
25–50	0	0	11	47	11	69 (3.2%)
50–75	0	177	0	0	130	307 (14.2%)
75–100	11	130	0	0	11	152 (7.1%)
100–125	0	82	0	0	59	141 (6.5%)
> 125	0	0	0	0	59	59 (2.7%)
Sum	11	874	11	70	1193	2159 (100%)

Table 6. The number of ships passing under the bridge in Gryfino towards a southern direction in the period from 01.05.2015 to 31.05.2015 (General Directorate, 2015b)

GRYFINO – the movement of the vessel towards a southern direction						
Ship's length	Tanker ships	General cargo ships	Passenger ships	Support ships	Other	Sum
0–25	0	11	0	23	82	116 (55.5%)
25–50	0	0	0	59	23	82 (39.2%)
50–75	0	0	0	0	11	11 (5.3%)
75–100	0	0	0	0	0	0 (0%)
100–125	0	0	0	0	0	0 (0%)
> 125	0	0	0	0	0	0 (0%)
Sum	0	11	0	82	116	209 (100%)

Table 7. The number of ships passing under the bridge Radziszewo towards a northern direction in the period from 01.05.2015 to 31.05.2015 (General Directorate, 2015b)

RADZISZEWO – the movement of the vessel towards a southern direction						
Ship's length	Tanker ships	General cargo ships	Passenger ships	Support ships	Other	Sum
0–25	0	533	0	0	983	1468 (64.8%)
25–50	0	0	11	35	11	57 (2.5%)
50–75	0	213	0	0	142	331 (14.6%)
75–100	11	165	23	0	11	222 (9.8%)
100–125	0	71	0	0	59	118 (5.2%)
> 125	0	0	0	0	71	71 (3.1%)
Sum	11	982	34	35	1277	2267 (100%)

Table 8. The number of ships passing under the bridge in Radziszewo towards a southern direction in the period from 01.05.2015 to 31.05.2015 (General Directorate, 2015b)

RADZISZEWO – the movement of the vessel towards a southern direction						
Ship's length	Ships tanker	General cargo ships	Passenger ships	Support ships	Other	Sum
0–25	0	11	0	0	71	82 (50.6%)
25–50	0	0	0	35	11	58 (35.8%)
50–75	0	0	0	0	11	11 (6.8%)
75–100	0	0	0	0	0	0 (0%)
100–125	0	11	0	0	0	11 (6.8%)
> 125	0	0	0	0	0	0 (0%)
Sum	0	22	0	35	93	162 (100%)

Table 8 shows the number of ships passing under the Radziszewo Bridge traveling in a southerly direction. It should be noted that the greater number of units moving towards a northern direction affects not only navigable routes infrastructure. The exchange of goods by inland waterway between the northern and southern part of Poland is virtually non-existent. An alternative to the carriage of goods by water is rail and road. Investments aimed at improving the development of these modes of transport have made the use of inland waterways no longer attractive, despite the fact that it is still the lowest cost alternative. Improving the infrastructure along inland waterways and ships, would increase the interest in inland waterway transport, especially when it comes to transportation of container cargo and oversized cargo. Their carriage by other modes of transport is associated with high costs and greater risks.

a) b)

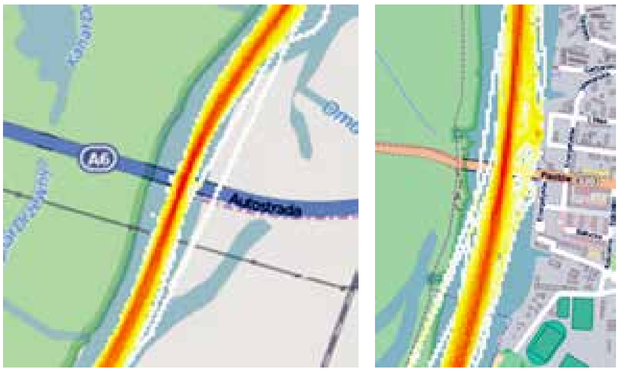

Figure 2. The traffic stream of the vessels passing under the bridge on the Highway A6 (a) and the traffic stream of the vessels passing under the bridge in Gryfino (b)

The usefulness of the RIS data to assess the probability of a collision by inland vessels navigating under the bridges of the Odra River

For this article, to describe the traffic under the bridge on Highway A6 (Radziszewo) and the Gryfino bridge, a mixture of normal distribution with the Uniform distribution was used for traffic to the North and only Uniform distribution for traffic to the South. Generated traffic stream images give clear information on the areas with increased traffic. The degree of congestion is read using a colour scale, with the darker colour representing more traffic in a selected area. During the transition of the vessel under the bridge, the manoeuvrability area is limited. Ships are ordered to proceed in designated lanes. The article analyses a stream of maritime traffic between 01.05.2015–31.05.2015. Figure 2 shows the generated traffic streams and distribution.

Risk analysis of inland vessel passage under a bridge requires knowledge of the likelihood of the occurrence of an accident and its consequences. During the manoeuvres the vessel under the bridge for the accident is considered a collision/impact of the construction of the bridge, or the other moving in this area. A collision with a pillar of the bridge may result from a sudden loss of manoeuvrability of the ships or as a result of human error. The effects of the collision can be described using relative permissible kinetic energy levels in the event of a collision of a ship with total energy (Gucma, Ślączka & Zalewski, 2013).

$$R = P_a \cdot S \tag{1}$$

$$S = E_p / E_t \tag{2}$$

where:

R – collision risk of inland ships with the structure of the bridge;

P_a – the likelihood of a ship's collision with the structure of the bridge;

S – the effects of a ship's collision with the structure of the bridge;

E_p – kinetic energy (permissible) of an inland vessel collision with the bridge;

E_t – kinetic energy (total) of an inland vessel collision with the bridge.

In the case of a ship passing under the bridge, collision can occur both with the pillar of the bridge and its upper part. Therefore, the right vertical clearance under the bridge is important. A solution that allows you to reduce freeboard of the vessel during the transition under the bridge, by increasing immersion tanks, ballasting of the vessel, and the possibility of folding construction of ships. The danger of collision with the upper structure of the bridge exists during the carriage of oversized cargo and containers cargo.

The pillars of the selected bridges presented in this article are not equipped with any fender system, which absorbs the energies of an impact thereby reducing its effects. The energy of impact of inland vessels on structures of the bridge depends on, among other things, the size of the vessel, the speed at which it moves, and the angle of impact. In the event of a collision with the upper structure of the bridge, the impact is determined by the speed of the vessel and the surface of the part which collides with the structure.

Number of episodes of the distance of the Odra River under the bridge in Gryfino and in Radziszewo is significant. This means that there is also the possibility of a collision between passings under the bridges. The risk of collision between entities in selected area, can be specified using the IALA IWRAP Mk2.

Defining risk in IALA IWRAP Mk2 is done through the introduction of so-called "Causation Factors". They define the probability of inadequate officer response to a threat (e.g. collision, grounding). They are of great importance when calculating the risk factor, which is assumed for the calculation based on values that were specified by the experts of IALA. They can be changed, but this is not recommended.

After defining the area of research, the analysis of the probability of an accident was done, for each of the events: grounding, collisions, other incidents, or accidents. The necessary data for the analysis comes from the AIS and includes: the number of units, their average speed, and course. The average speed of the moving vessels in the selected areas are different depending on the type and size of the unit.

Table 9 shows the average speed of units passing under the bridge in Gryfino. The lowest average speed (4.01 kn) was recorded for vessels with an unspecified type and a length of less than 25 m. proceeding in a southerly direction. The average speed varies within a range of 4 to 9 kn. The average draft of a ship proceeding towards a southern direction is between 1.58 m and 2.69 m, while towards a northern direction is between 1.58 and 4.79 m.

Table 9. The average speed of units passing under the bridge in Gryfino (General Directorate, 2015b)

The average speed of ships by their type
South bound
• General cargo ships (Length: 0–25 m) – 5.0 kn • Support ships (Length: 0–25 m) – 6.50 kn • Support ships (Length: 25–50 m) – 7.12 kn • Other ships (Length: 0–25 m) – 4.01 kn • Other ships (Length: 25–50 m) – 8.55 kn • Other ships (Length: 50–75 m) – 5.90 kn
North bound
• General cargo ships (Length: 0–25 m) – 5.76 kn • General cargo ships (Length: 50–75 m) – 6.52 kn • General cargo ships (Length: 75–100 m) – 7.95 kn • General cargo ships (Length: 100–12 5m) – 6.89 kn • Support ships (Length: 0–25 m) – 6.60 kn • Support ships (Length: 25–50 m) – 7.60 kn • Other ships (Length: 0–25 m) – 5.56 kn • Other ships (Length: 25–50 m) – 6.40 kn • Other ships (Length: 50–75 m) – 5.64 kn • Other ships (Length: 75–100 m) – 7.90 kn • Other ships (Length: 100–125 m) – 5.70 kn • Other ships (Length: > 125 m) – 5.24 kn

Table 10 shows the average speed of ships passing under the bridge in Radziszewo.

Table 10. The average speed of units passing under the bridge in Radziszewo (General Directorate, 2015b)

The average speed of ships by their type
South bound
• General cargo ships (Length: 0–25 m) – 5.10 kn • General cargo ships (Length: 100–125 m) – 4.70 kn • Support ships (Length: 25–50 m) – 8.67 kn • Other ships (Length: 0–25 m) – 3.92 kn • Other ships (Length: 25–50 m) – 10.80 kn • Other ships (Length: 50–75 m) – 6.10 kn
North bound
• General cargo ships (Length: 0–25 m) – 5.66 kn • General cargo ships (Length: 50–75 m) – 6.94 kn • General cargo ships (Length: 75–100 m) – 7.81 kn • General cargo ships (Length: 100–125 m) – 6.75 kn • Support ships (Length: 25–50 m) – 8.93 kn • Other ships (Length: 0–25 m) – 5.41 kn • Other ships (Length: 25–50 m) – 6.20 kn • Other ships (Length: 50–75 m) – 6.46 kn • Other ships (Length: 75–100 m) – 7.70 kn • Other ships (Length: 100–125 m) – 5.72 kn • Other ships (Length: > 125 m) – 5.33 kn

Information on the average speeds of vessels is essential to identify areas of high risk. For this, coefficients, which have been estimated by the experts of IALA, depending on the type of situation between ships, have been adopted. The Causation Reduction Factor for each variant is 1, and the following values for the Resulting Causation Factors are used:

- Head-on – 0.5000E–4;
- Overtaking – 1.1000E–4;
- Grounding – 1.6000E–4.

Determination of the grounding is possible after specifying the bathymetry. On the basis of knowledge of the depth of the area, where the ship is proceeding, and its draft, it is possible to determine the probability of the grounding. For the other two incidents, only analysis of the events could take place. The probability of occurrence of the head-on incident is 0.0001668 (incidents/year), while the probability an overtaking incident is 0.0001865. The probability that any accident is 0.0003534.

Table 11 shows the probability of a collision during an overtaking manoeuver in the area of bridge in Radziszewo. The data in Table 11 shows the greatest probability of collision is between general cargo ships and other ships. Within this category, the likelihood of collision is highest with a general cargo ship overtaking another general cargo ships or other ships. It can be concluded that the safest type of vessels in this area are support vessels. In the area of the bridge, including these type of units, 82 were registered (35 units proceeding North bound and 47 units South bound). Fewer are oil products tanker and passenger ships, however the probability of collisions with these types of vessel is greater.

Table 12 shows the probability of a collision during a head-on manoeuver in the area of bridge in Radziszewo. The probability of a collision while vessels are passing is greater that in an overtaking manoeuvre. The greatest likelihood of a collision is between general cargo ships and other ships, general cargo ships, and support ships. Ships of unknown type are a significant number of the registered vessels, which causes conflicts including them to be the most likely to occur. The analysis shows that, in this case, the safest types are passenger ships and oil products tankers.

Table 13 shows the probability of a collision during the overtaking manoeuver in the area of bridge in Gryfino. As in the case of the overtaking manoeuver in the area of the Radziszewo Bridge, the greatest probability of collision is between general cargo ships and other ships. The analysis shows that the number of vessels of a given type proceeding in the area has a big impact on the probability of collision.

Table 11. The probability of vessel's collision of inland waterways during the overtaking in the area of the bridge in Radziszewo (General Directorate, 2015b)

	Oil products tanker	General cargo ships	Passenger ships	Support ships	Other ships	Sum
Oil products tanker	–	1.69E–08	6.39E–09	2.96E–08	4.13E–09	1.17E–07
General cargo ships	5.46E–07	2.30E–05	8.03E–07	3.48E–06	4.65E–06	3.25E–05
Passenger ships	2.89E–10	1.99E–08	1.36E–09	5.96E–09	1.07E–09	2.86E–08
Support ships	–	–	3.11E–09	–	2.18E–08	2.50E–08
Other ships	1.308523–6	6.00E–05	1.43E–06	6.51E–06	1.38E–05	8.31E–05
Sum	1.86E–06	8.32E–05	2.24E–06	1.00E–05	1.85E–05	1.16E–04

Table 12. The probability of a collision during the head-on manoeuver in the area of bridge in Radziszewo (General Directorate, 2015b)

	Oil products tanker	General cargo ships	Passenger ships	Support ships	Other ships	Sum
Oil products tanker	–	4.43E–08	–	6.56E–08	1.67E–07	2.77E–07
General cargo ships	4.43E–08	6.53E–06	2.76E–08	5.09E–06	1.61E–05	2.78E+05
Passenger ships	–	2.76E–08	–	3.96E–08	1.03E–07	1.70E–07
Support ships	6.56E–08	5.09E–06	3.96E–08	2.30E–07	6.53E–06	1.19E–05
Other ships	1.67E–07	1.61E–05	1.03E–07	6.53E–06	2.72E–05	5.01E–05
Sum	2.77E–07	2.78E–05	1.70E–07	1.19E–05	5.01E–05	9.03E–05

Table 13. The probability of a collision during the overtaking manoeuver in the area of bridge in Gryfino (General Directorate, 2015b)

	Oil products tanker	General cargo ships	Passenger ships	Support ships	Other ships	Sum
Oil products tanker	–	6.87E–08	2.37E–10	1.51E–08	5.62E–09	8.96E–08
General cargo ships	3.43E–07	1.36E–05	7.17E–08	2.44E–06	8.58E–07	1.73E–05
Passenger ships	–	1.02E–08	–	1.87E–09	8.30E–10	1.29E–08
Support ships	3.41E–09	2.92E–07	9.56E–10	7.85E–08	1.42E–07	4.83E–07
Other ships	9.29E–07	3.92E–05	1.80E–07	7.10E–06	5.45E–06	5.29E–05
Sum	1.28E–06	5.32E–05	2.53E–07	9.64E–06	6.45E–06	7.08E–05

Table 14. The probability of a collision during the head-on manoeuver in the area of bridge in Gryfino (General Directorate, 2015b)

	Oil products tanker	General cargo ships	Passenger ships	Support ships	Other ships	Sum
Oil products tanker	–	1.37E–08	–	9.44E–08	1.51E–07	2.59E–07
General cargo ships	1.37E–08	1.53E–06	2.17E–09	6.13E–06	1.05E–05	1.81E–05
Passenger ships	–	2.17E–09	–	1.54E–08	2.39E–08	4.14E–08
Support ships	9.44E–08	6.13E–06	1.54E–08	6.91E–07	8.64E–06	1.56E–05
Other ships	1.51E–07	1.05E–05	2.39E–08	8.64E–06	2.33E–05	4.25E–05
Sum	2.59E–07	1.81E–05	4.14E–08	1.56E–05	4.25E–05	7.65E–05

Table 14 shows the probability of a collision during the head-on manoeuver in the area of bridge in Gryfino.

It can be concluded that the probability of a collision during any manoeuvre is very small. However, it should be noted that in the case of the area of the Radziszewo Bridge an accident is most likely to occur during an overtaking manoeuver, especially during the overtaking of vessels by unknown type and general cargo ships.

There is a high probability of an accident when units are passing. Caution should be taken when general cargo ships are passed by other vessels, for example support ships. The greatest risk exists when unspecified type vessels are passing, which is due to the fact that the number of these ships is the largest.

As in the earlier case, during the manoeuvre of the vessel under the bridge in Gryfino, the greatest risk of collision exists when manoeuvring general cargo ships and support ships. The lowest risk is with passenger ships and oil products tankers. This is because the number of vessels of a given type has the most impact on the possibility of a collision.

Determination of risk requires knowledge of the likelihood of the occurrence of the accident and its consequences.

Conclusions

It is clear from the analysis that the RIS data is useful for risk assessment in the area. With the data, IALA IWRAP Mk2 can evaluate the risk of collision between different types of ships in different situations.

This article describes the use of the program with sample data recorded by radar AIS within one month. It should be noted that most vessels do not have types identified, which has an impact on the determination of areas of increased risk. This prevents thorough analysis of the situation. Having complete data would better describe the actual situation of the traffic in the selected area.

To fully utilize the features of the IALA IWRAP Mk2 program depends on availability of data. More accurate identification of the small inland vessels could be performed if they were fitted with receivers. The IALA IWRAP Mk2 program gives the ability to depict traffic patterns, analysis of the trajectory, and location of units in relation to the bridge structures.

Manoeuvring vessels in restricted areas by hydro-technical structures, such as bridges, requires special caution. In this article, it is shown that in the parts of the bridges are situation that cause risk of collision.

The RIS system not only enables the ability to monitor and manage the movement of ships, thanks to the relevant study data, it also allows the creation of strategic information on maritime traffic on the inland routes.

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