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A PROPOSAL FOR STRUCTURING MONITORING AND CONTROL SYSTEMS OF NAVIGATION IN THE TRAFFIC LANE NEXT TO THE PORT OF SPLIT

ABSTRACT

The paper introduces a feasible frame for the reorganization and control of sea navigation (VTS system) in the access waterway to the port of Split. In the paper a proposal for the introduction of a routing system on the traffic lane next to the port of Split is presented. A high-grade monitoring of seagoing navigation means increased safety and a higher protection of the marine environment. In this sense the validity of structuring a VTS system in the controlled area results from the ever-increasing number of transiting vessels, some of which carrying dangerous cargoes with the majority being leisure craft and passenger ships. The need for installing the system arises as well from the unfavorable hydrographic conditions which affect navigation and reduce the level of safety in the traffic lane next to the port of Split. The described proposal of the VTS system foresees the opening of new navigable routes with radar and AIS equipments to be included for vessel monitoring. Their location and mode of operation are worked out in detail in this paper.

KEY WORDS

Port of Split, VTS system, routing system, proposal for structuring

1. INTRODUCTION

Ships in navigation are exposed to a number of dangers which depend on numerous factors recognised as maritime, waterway characteristics factors, meteorological and oceanographic factors, navigational and hydrographical and factors of traffic flow. The level of safety at sea nowadays includes all the necessary measures and procedures which can lower the risk of accident of navigation. One of the most important such measures includes surveillance and management of sea traffic in waterway areas which allows interaction with the above mentioned factors. Such systems which are set in many maritime countries,

make an integral part of models for risk management in sea navigation.

The fairway navigation, particularly in a limited waterway area is somewhat of a move in the area of uncertainty and it presents danger. For this reason in such areas it is necessary to limit the freedom of choice of waterway by defining the exactly stated waterway routes, thus acting preventively on safety at sea as well as protecting the sea and maritime environment.

The aim of this paper is to define a sole waterway access to the port of Split as well as the proposal of setting the system of Vessel Traffic Services (hereafter: VTS) on the access waterways to the port itself.

2. JUSTIFICATION OF SETTING THE RECOMMENDED ROUTE AND VTS SYSTEM TO THE PORT OF SPLIT

The access waterways to the port of Split include the access through Drvenik, Šolta, and Brač channel and Split gate. The access waterway through Drvenik channel is the northernmost access waterway and it is mainly used by ships sailing from the northern part of the Adriatic. The Drvenik channel is located between the mainland coast and islands Drvenik Mali and Drvenik Veli and at the same time represents the busiest waterway between Šibenik and Split areas. When sailing from the northern areas ships use this fairway because there is no other recommended route.

This applies in particular to tankers and ships with dangerous cargo due to the fact that when approaching the area of the Drvenik channel from the open seas they are located at position (43° 28.2'N – 016° 01.0'E) for boarding of the pilot, where coastal piloting is compulsory.

Navigation through this channel takes place in an area between islands of an average waterway width of 0.9 M whilst the narrowest part of it is 0.6 M and it is between the islands Drvenik Mali and islet Murvica on the western part of the channel entrance. The 7.5 M long access waterway of the Drvenik channel is the longest coastal access waterway to the port of Split if the access navigating around island Brač is excluded. If one includes the access to the channel itself, ships have to navigate in total 12 M on a short distance from the mainland coast and island and islets.

The Split gates is the shortest coastal access waterway towards the port of Split, but its passage capacities are limited. The passage approximately 2 M long is located between islands of Šolta and Brač. The limiting factor of this passage is its width which in its most narrow part comes to only 0.4 M. When the area of shallow waters is taken from this width, the remaining belt of safe navigational depth for ships with a bigger draft is only 0.15 M wide. Because of such hydrographical properties, two bigger ships are denied the possibility of clear passing of overtaking, whereas due to the dense concentration of smaller vessels the need for manoeuvring is frequent, which additionally threatens the safety at sea in this limited waterway.

Approaching the port of Split via 55 M long Hvar and Brač channels is the longest fairway from the open seas. Although along this waterway there is no significant navigational danger (depth from 50 to 80 m, the narrowest part 1.8 M), because of its length this waterway is rarely used. Navigational danger can lie in numerous local passenger and Ro-Ro passenger services connecting Split with the islands of Brač, Hvar, Vis and Korčula, as well as the location of anchorage placed south-west of the town. However, this route involves the longest time of navigation in the area of islands and thus represents an increased possibility of accidents (running aground, collision...) which is contrary to the safety at sea policy which involves taking the shortest and safest navigation route to the port of destination.

Although at the moment the frequency of traffic in the port of Split does not completely justify the introduction of VTS on its access waterways, the very fact that the port handles more than 3 million passengers annually (6.7 million in the area of the Split Port Authority) is sufficient to do so. The hydrographical circumstances of access waterways to the port of Split increase the possibility of accidents due to the fact that the port is drawn deep into the island area, which again is another reason for setting up the VTS system.

Apart from the passengers some of whom come from big cruising ships, the port of Split constantly deals with the increased number of merchant ships,

whose number dropped significantly during the 1990s. It is particularly important to point out such merchant ships which come to the port of Split with liquid cargo and bulk chemicals and the accidents of which would cause catastrophic damages to this part of the Adriatic. In the surveyed waterway there exists a high number of passenger and Ro-Ro passenger services, as well as a great number of fishing boats and sport and leisure boats which all have an impact on the safety at sea. During the summer months these waterways have additional traffic which multiplies the possibilities of maritime accidents.

Because of easier surveillance and management of traffic from and to the port of Split it is necessary to determine a sole access fairway from the area of the open seas. By determining such an access waterway the navigation through the more dangerous inter-island area would be reduced to the minimum, thus also greatly reducing the possibility of collision at sea. Such an access waterway would be monitored from the VTS centre in Split, which would manage the navigation and provide the information on momentary situation of the entire waterway.

3. THE PROPOSAL FOR SETTING THE RECOMMENDED ROUTE AND THE VTS SYSTEM ON THE WATERWAY TO THE PORT OF SPLIT

According to the International Maritime Organisation, the VTS system is defined as:

- the service established by the authorities with the aim of improving the safety and efficacy of the maritime traffic and the protection of maritime environment. The service has to provide the possibility of interaction with the traffic and the possibility of responding to the traffic situation developing in the area of surveillance.

This work is based on calculations made for radar surveillance systems where the range of the radar device is defined by the height of the radar antenna and by the height of the object detected. The approximately defined range of such radar systems in miles is given in the formula:

$$d = 2.21 \cdot (\sqrt{Hant}) + 2.21 \cdot (\sqrt{Ht}) [M],$$

where d - is approximate range of radar horizon in miles, $Hant$ - is the height of radar antenna position in meters and Ht - is the height of radar target in meters.

The VTS system in the area of port of Split would include the area immediately in front of the port itself (Split and Brač channel), but also the area of accessing the inner islands Brač, Šolta, Drvenik, as well as the navigation between the above islands.

Because of the above mentioned hydrographical circumstances at the access of waterways towards the

port of Split, the compulsory waterway can be defined in the area of Šolta and in part of the Split channel. In this area it is necessary to determine the recommended two-way route to and from the port of Split, as recommended by IMO in the areas where the navigation is difficult and dangerous. Such navigation routing would allow the safest ship waterways in the area between the open sea and the port of Split.

The area of Šolta channel and the recommended route should use all the ships above 500BT and all the ships transporting dangerous cargo. The exception to this rule would be ships navigating on exactly determined local routes which link the port of Split with the surrounding islands and which would be allowed the passage through Split gate with adequate surveillance and management of navigation. The existing place for pilot boarding the ship is necessary to move to position 43° 23.8'N – 016° 09.1'E at the entrance of the recommended route.

In the entire length of the access waterway the depths are satisfactory and nowhere smaller than 50 meters, except in the part of the recommended route south-west of islet Stipanska where there are areas with depth of 26 m.

With the recommended navigation route in the area of Šolta and Split channel, the sole coastal access route to the port of Split would be defined. The area of Šolta channel was chosen because of its suitable hydrographical properties (the width and the depth of waterway) as well as for the fact that on this access waterway the navigation takes the least part along the inter island area, except for the access through the Split gate previously defined as risky for navigation of bigger ships. The limits of recommended route would be defined by points:

Name	Latitude	Longitude
1.	43° 23.8'	016° 07.8'
2.	43° 24.2'	016° 09.0'
3.	43° 25.2'	016° 09.7'
4.	43° 26.4'	016° 14.7'
5.	43° 25.6'	016° 15.0'
6.	43° 24.7'	016° 10.0'
7.	43° 24.0'	016° 09.6'
8.	43° 23.2'	016° 09.8'
9.	43° 23.8'	016° 07.9'
10.	43° 23.8'	016° 07.9'

The establishing of ship position by radar surveillance during arrival is provided by multiple radar images of islands, first of all Vis, Hvar, Brač and approaching Šibenik channel also the islands of Šolta, Drvenik Veli and Drvenik Mali and the islets of Orud,

Mačaknar, Stipanska and Radiula. The present unsatisfactory marking of channel with lighthouses (Stipanska lighthouse Z Bl (2) 5s 8m 6M; Vid 355-255(260)) renders impossible safe orientation in this area, thus rendering impossible also the navigation at night and under low visibility. For this reason there is a need for marking this area supposed to be a recommended route in the Šolta channel, with additional lighthouses, isolated danger mark and Racon device.

It is necessary to erect a lighthouse on the south-west shore of the islet Mačaknar which would allow easier approach of ships during night navigation or navigation under poor visibility. By positioning of the lighthouse at the height of 10 m the nominal range (calculated for the height of object of 5 m) would be 11 M which is from the navigational point of view sufficient for a safe approach from the area of open seas. By establishing the additional sector of light in the range from 251 to 260 degrees would make easier the approach to the recommended route of ships from the Split channel during night navigation. Racon device with the range of 20 M should also be installed on the lighthouses which would additionally render easier the approach of ships to the recommended route with the help of radar.

It is also necessary to erect a lighthouse on the south-east coast of the islet Krnjaš Veli because of the easier establishing of the position inside the recommended route. By defining the sector of light from 22 to 34 degrees, this lighthouse would render easier homing of ships to the recommended route when approaching from the open seas. The lighthouse should have the light sector from 251 to 254 degrees and this should point out the dangers of shallow waters in the area Mlin to the ships sailing from the area of port of Split. The area of Mlin shoal is located 0.5 M north-west from the approach to the recommended route.

Since the access waterway towards the port of Split through the Šolta channel is compulsory for all the ships bigger than 500 BT which arrive to or depart from the port, it is necessary to erect an additional isolated danger mark. This is to mark the shallow waters (6.5 m) 0.6 M south-east from the islet Mačaknar. The shoal is located immediately next to the western borderline of the recommended route at a distance of 0.15 M.

Whilst arriving from the open seas ships will enter into the recommended route area crossing the south-west borders of this area which is located 1M from the shackle of islet Mačaknar with the island Stipanska. In this way the entrance of the above mentioned zone is removed from the above islands and islets Radula and Balkun as well as the crag Kamičić which represent a potential danger for the inbound vessels.

It is intended that whilst navigating through the recommended route ships keep to the right side of the

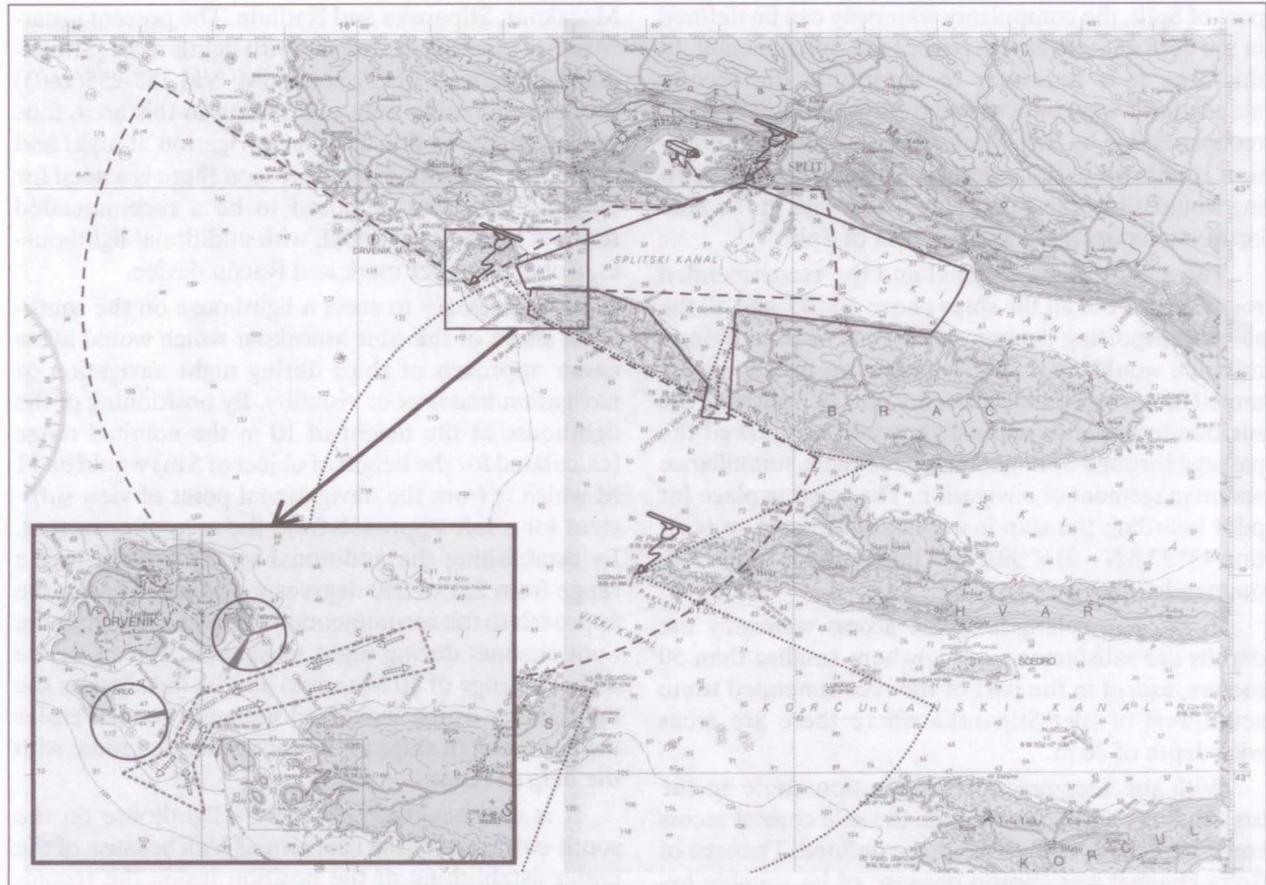


Figure 1 - Recommended route and layout of radar surveillance stations within the VTS System in the Port of Split area

Source: developed by the authors

fairway. This is to avoid the possibility of crossing situation within the fairway. During arrival the only manoeuvre within the recommended route is exercised in the area between the islands of Stipanska and Drvenik Veli when the course is changed from 40 to 50 degrees depending on the course approaching the recommended route. Determining of the position of turning is provided by the lighthouses on the island Stipan and the newly erected one on the islet of Krnjaš Veli as well as the lighthouse on the south-west cape of Maslenica. Whilst leaving the Split channel ships will change their course within the recommended route upon passing abeam of the lighthouse on the island of Stipanska.

The surveillance of approach of ships sailing in from the open seas into the recommended route would be exercised with one AIS station placed within the port area and with three radar stations. Approach to the port from the open seas would be monitored by radar installed on the islet of Veli Vodnjak which is located within the Pakleni otoci archipelago. By erecting the radar antenna at a height of 54 m (island altitude is 44 m) it would be possible to detect surface objects within the range of 16.3 M. Such range capacities pro-

vide the surveillance of the entire Vis channel, the western side of Korčula channel and the area of approach from the open seas between the islands of Vis and Korčula. It also provides for the surveillance of the area south-west of the island Vis which will be used for navigation of ships after diverging from the main Adriatic route. The range of this radar station is sufficient for surveillance of navigation in the outer area of the recommended route, as well as navigation within the Split gates and part of the Hvar channel.

The entire recommended route as well as the ships approaching from the northern Adriatic would be monitored by the radar station on the island Orud which is located 1.3 M north-west of the recommended route. By erecting the radar station at the height of 75m (island altitude 65m) the range of detection of surface objects at a distance of 19.1 M would be achieved. Such placement of the radar station would allow good quality monitoring of ships approaching from the area of northern Adriatic, approach to Drvenik channel, approach of ships from the main Adriatic route and the western part of Vis and Hvar channels. Apart from the surveillance of the recommended route it would also be possible to monitor the Split

channel and the western part of the Brač channel as well as the anchorage area of the port of Split.

The third radar station located in the area of Stara Luka with a 30 m high antenna would allow detection of surface objects within the range of 12 M. This radar station would provide the monitoring of the middle and western part of the Brač channel, the area of Split channel as well as internal part of the recommended route. With this radar station it would be possible to monitor the navigation of ships of the entire Split gates area as well as navigation to and from the Kaštele bay.

Such layout of radar stations provides for the most complete picture of the port of Split area as well as the approach waterways to the port. It is of importance that with such a layout of the radar stations it is possible to achieve satisfactory surveillance of the area monitored also in the event of failure of a single radar station. Since the areas of surveillance cross over, the important parts of fairway are monitored simultaneously from two radar stations. Thus, in case of failure of the radar station on the island of Orud the outer part of the recommended route would be monitored by the radar station on the island of Veli Vodnjak, whilst the inner part could be monitored by the station in Split, reducing in this way the area of shadows in case of radar failure to the minimum.

In case of failure of the radar station in Split, the monitoring of the area in front of the port would be done from the station on the island of Orud (the Split channel and the area of anchorage), whilst the monitoring of the passage through the Split gates would be done from the station on the island of Veli Vodnjak.

The area of Kaštele bay which is not covered by the mentioned radar surveillance would be additionally monitored by means of video surveillance. Such surveillance would allow monitoring of ships from entering the bay to the place of berth in the part of Kaštele bay. Monitoring of ships would be aided by the continuous following of ships via the AIS device.

4. CONCLUSION

This paper describes and establishes the conditions for setting the recommended route and analyses the basic properties and structure of the possible VTS system. The proposed set-up of the recommended route and the VTS system on the approach area to the port of Split systematically takes into consideration the possibilities of surveillance and managing of navigation as well as the impact on increase of the safety at sea and reducing the possibility of collision at sea.

Such a set-up allows for much higher safety at sea and reduces the possibility of collision at sea due to gross navigational errors or non-observance of regulations for preventing collisions at sea. With the timely

informing of ships on waterways by the operator well informed on the state of affairs for the entire monitored area, there is a possibility of avoiding the possibly dangerous situations in advance.

The data available to an officer aboard a ship is limited by the properties of his devices and his personal knowledge of the local circumstances. Such data in the areas of inter-island navigation are incomplete, i. e. they do not show the entire waterway which provides for making the decisions based on information of insufficient quality. Adding the ever bigger dimensions and the speed of modern ships and due to the hydrographical properties, the possibilities for collision at sea on the approach waterways towards the port of Split have increased substantially, thus justifying the introduction of the above-mentioned safety measures.

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SAŽETAK

PRIJEDLOG USTROJA SUSTAVA NADZORA I UPRAVLJANJA PLOVIDBOM NA PLOVNOM PUTU DO LUKE SPLIT

U radu je predstavljen mogući ustroj organizacije i upravljanja pomorskom plovidbom (VTS sustav) na prilaznim plovnim putovima do luke Split. Prijedlog preporučenog područja plovidbe na prilaznom plovnom putu prema luci Split također je definiran u samome radu. Kvalitetan nadzor pomorske plovidbe omogućuje povećanje sigurnosti plovidbe i zaštite morskog okoliša. U tom smislu opravdanost ustroja VTS sustava u promatranom području proizlazi iz činjenice kontinuiranog povećanja broja brodova od kojih se dio odnosi na brodove koji prevoze opasne terete, a veliki dio na plovila za razonodu i putničke brodove. Nadalje, potreba uspostave sustava proizlazi iz nepovoljnih hidrografskih uvjeta na plovnim putovima koji utječu na smanjenu razinu sigurnosti plovidbe na prilazu luci Split. Prikazani prijedlog VTS sustava obuhvaća uspostavljanje novih plovidbenih ruta te upotrebu radarskih i AIS uređaja u postupku nadzora brodova, a čiji se smještaj i način rada u radu detaljno opisuje.

KLJUČNE RIJEČI

Luka Split, VTS sustav, preporučeno područje plovidbe, prijedlog ustroja

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The paper describes and establishes the conditions for setting the recommended route and structure of the possible VTS system. The proposed set-up of the recommended route and the VTS system on the approach area to the port of Split is presented. The paper also discusses the possibility of surveillance and monitoring of the area as well as the impact of the proposed system on the safety of navigation and the possibility of collision avoidance.

Such a set-up allows for much higher safety at sea and reduces the possibility of collision by sea due to gross navigational errors or non-observance of regulations for preventing collisions at sea. With the timely monitoring of the port of Split area as well as the approach waters to the port, it is of importance that with such a system of the radar station it is possible to achieve satisfactory surveillance of the area monitored also in the case of failure of a single radar station. Thus the area of surveillance can cover the important parts of the area monitored simultaneously from two radar stations. That in case of failure of the radar station on the island of Čvrtak the other part of the recommended route would be monitored by the radar station on the island of Veli Vrh, which the inner part could be monitored by the station in Split, reducing in this way the area of shadow in case of radar failure to the minimum.

In case of failure of the radar station in Split, the monitoring of the area in front of the port would be done from the station on the island of Čvrtak (the Split channel and the area of anchorage) while the monitoring of the passage through the Split gate would be done from the station on the island of Veli Vrh.

The area of radar surveillance which is not covered by the mentioned radar surveillance would be additionally monitored by means of video surveillance. Such an arrangement would allow monitoring of ships from the pier to the place of berth in the part of harbor for the monitoring of ships would be aided by the continuous following of ships via the AIS device.

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