ZVONIMIR LUŠIĆ, Ph.D.
E-mail: zlusic@pfst.hr
University of Split, Faculty of Maritime Studies
Zrinsko-Frankopanska 38, HR-21000 Split, Croatia
SERĐO KOS, Ph.D.
E-mail: skos@pfri.hr
University of Rijeka, Faculty of Maritime Studies
Studentska 2, HR-51000 Rijeka, Croatia
STIPE GALIĆ, mag.ing.
E-mail: sgalic@pfst.hr
University of Split, Faculty of Maritime Studies
Zrinsko-Frankopanska 38, HR-21000 Split, Croatia

Safety and Security in Traffic
Preliminary Communication
Submitted: Jan. 12, 2014
Accepted: July 8, 2014

STANDARDISATION OF PLOTTING COURSES AND SELECTING TURNING POINTS IN MARITIME NAVIGATION

ABSTRACT

Today's methods of plotting courses and selecting sailing routes and turning points in maritime navigation are still largely based on subjective assessment of the master or the officer in charge. This results in a great variety of course distributions and, accordingly, in various ship movements. Modern electronic aids, in particular ECDIS (Electronic Chart Display and Information System) can significantly facilitate maritime voyage planning, course plotting, selection of turning points, etc. In addition to displaying electronic charts, the specific feature of these systems is that they facilitate route planning, supervision of ship movements, data recording, database search, alarm setting, etc. However, these systems do not yet provide automatic selection of courses on the user's request in a standardised form. Therefore, in most cases, the routes and turning points are selected empirically or because they have been previously defined and used. This paper shows the drawbacks of the existing methods of selecting routes, i.e. plotting courses in maritime navigation, and gives recommendations how to improve them. The defined recommendations and models can also be used for manual entering of waypoints in the electronic chart display systems, but they can also serve for upgrading these systems with automatic selection of the initial route.

KEY WORDS

maritime navigation; route selection; course plotting; turning points

1. INTRODUCTION

Passage planning is mandatory for all types of SOLAS [12] vessels and the master takes overall responsibility for the passage. Typically, the process of planning is performed by the master, who assesses the optimum route, and an appointed officer who analyses the generally designed route and plots a detailed course on the paper or electronic chart. The master of the vessel always has to approve the final version of the passage plan. Given the fact that the voyage planning is based on subjective assessment of the master, or appointed officer, the selection of courses in maritime navigation may be very diverse (assessment for appropriate ship in the corresponding state of the environment, taking into account navigation rules, recommendations and good practice). This assessment is further hampered by the fact that navigation rules and recommendations cannot cover all possible situations, and their interpretations may also vary.

The consequence is that, as a rule, one part of the traffic flow gets too close to the shore or other dangers; in addition, unnecessary course crossings occur with the vessels in the opposite traffic flows or with the vessels sharing the same traffic flow. This problem can be largely resolved by using navigation routing systems (traffic separation systems, recommended routes, roundabouts, etc.), but these systems cannot be applied to the whole world. Besides, an adequate freedom of movement must always remain to a certain extent. So, if navigation routing measures are to be implemented in heavy traffic areas (approaches to major ports or passages and in canals and channels of limited dimensions) then it would be necessary to apply some other measures and define standardised procedures in other areas. Standardisation of the procedures for selecting routes and plotting courses requires resolution of three issues:

– how to select a general route,

- what are the minimum / maximum distances from the coast when plotting the courses, and
- how to select turning points.

2. PROBLEMS RELATING TO ROUTE SELECTION IN COASTAL NAVIGATION

Modern monitoring of vessels is significantly easier with AIS system (Automatic Identification System) and on-line monitoring of ship movement in real time. It takes just one look at this system to realise that in the areas without specific traffic regulation there are intense encounters of ships on various courses (*Figure 1*).

By establishing navigation routing systems, particularly traffic separation schemes, it is possible to significantly avoid many unnecessary meetings of vessels on head-on reciprocal or nearly reciprocal courses as well as dangerous approaching to the coast. The example of the Dover Strait clearly shows to what extent traffic separation arrangements, such as Traffic Separation Scheme (TSS), can reduce the risk of collision [13]. However, these systems cannot provide solutions for crossing over the navigation traffic-lanes nor for the crossing situations near the entrances and exits from the system. If there is no routing system, the navigation flows tend to cross in various courses and result in a large number of head-on situations. On the one hand, the main reasons for such movements of ships include the natural location and distribution of ports and the considerable freedom in selecting the desired route. On the other hand, the reasons include subjective estimation of the master and navigational watch officers when selecting courses and carrying out the voyage.

The results produced by researching the methods of passage planning used by the master and officers have confirmed that the distribution of opposite courses is very similar to the distribution which can be determined by monitoring the real movement of ships [8]. Most of the masters and officers tend to plot courses towards central parts of a limited waterway, or to plot courses closer to the coastline points where the course is altered, with large differences in the selection of turning points. All this causes a strong overlap of reciprocal traffic flows (*Figure 2*) [8].

The existing recommendations for planning and plotting courses, which can be found in nautical manuals and textbooks, and the resulting routes in *Figure 2* [1, 11]:

- plot courses along the shortest and safest route,
- plot courses at reasonable distance to the coast so that the arrangement of shore objects and structures allow accurate position fix,
- plot courses at a safe distance to any hazard to navigation,
- plot courses over safe sea depth given the ship draft and additional squat in shallow water arising from the ship speed,
- if possible, plot courses so that they lead to prominent objects, transits or leading marks, and alter the course athwart to prominent objects (lighthouses at night),
- at night, plot courses at greater distance to navigational dangers,

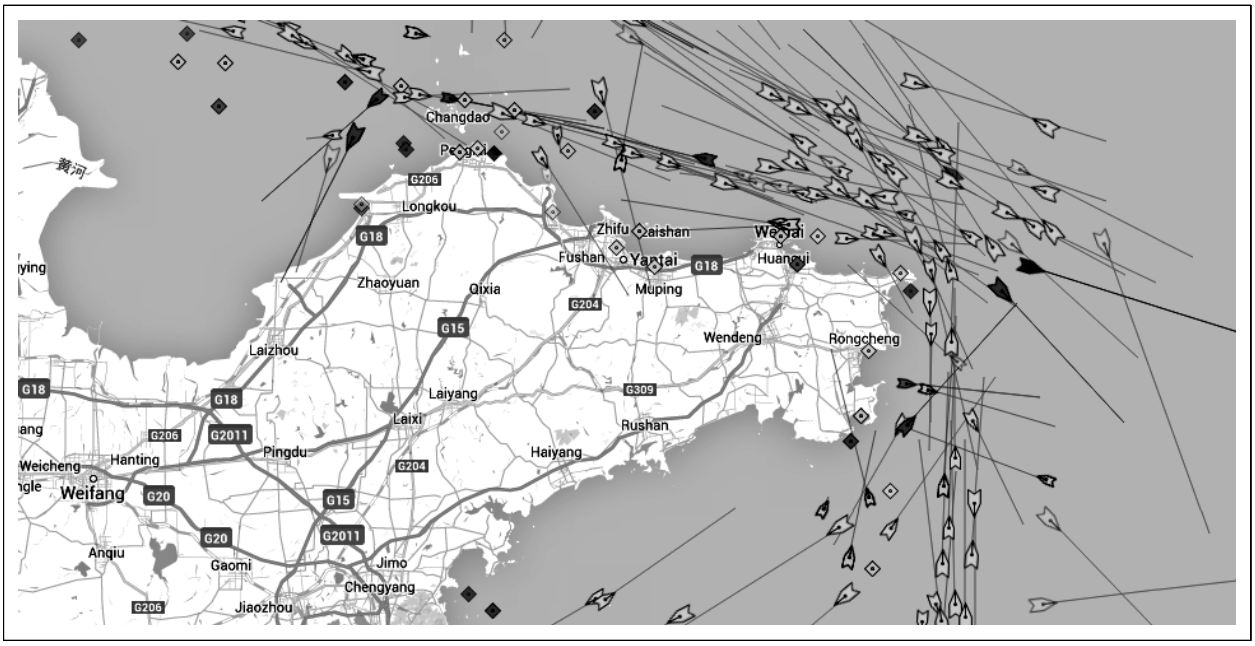

Figure 1 - Example of navigation flows in areas without navigation routing systems (Yellow Sea, 25 April 2014 at 2005 UT, fishing and small boats not included)

Source: [20]

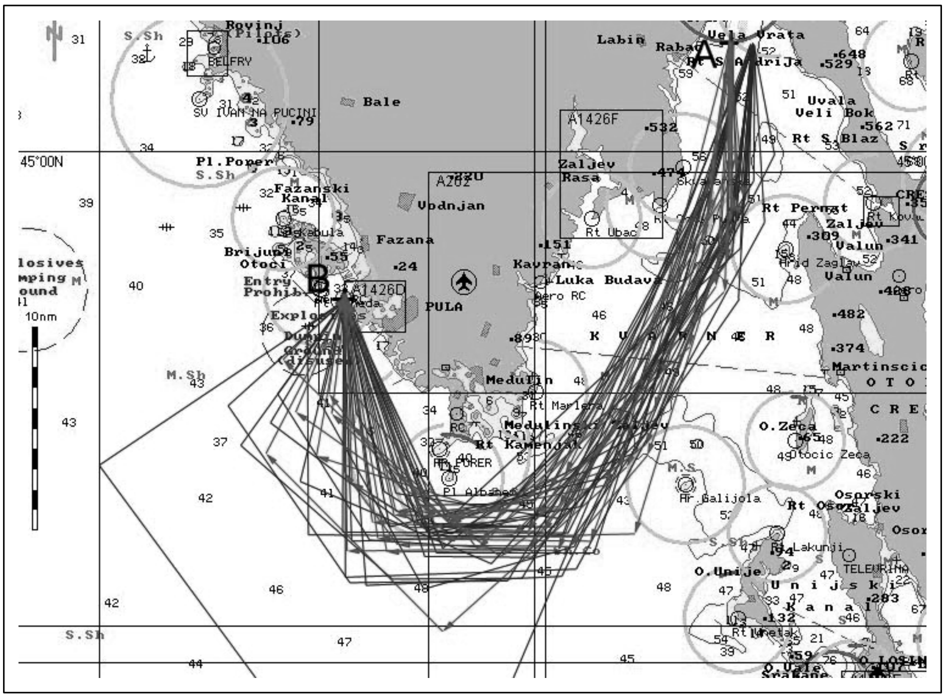

Figure 2 - Example of variations in course plotting in coastal navigation – for the same type/size of ship and under normal sailing conditions

(Ordinary line – east-bound traffic, Line with arrows – west-bound traffic)

– do not rely on incomplete and unchecked information,
– take into consideration the traffic density and avoid head-on meeting (keep to starboard), considering the available area for safe manoeuvring,
– follow recommended courses according to publications and guidelines, particularly when they feature prominent objects, light and sound signalling, leading marks, etc. along sailing routes, etc.

Besides the navigation safety, these recommendations affect the economic aspect of the voyage. According to the above-mentioned recommendations, the course planning should be aimed at obtaining the shortest route, i.e. the route ensuring the shortest time of navigation and sufficient level of safety. Depending on the subjective evaluation of the vessel's master, some routes will get closer to the coast and other dangers because of time saving during sailing, while other routes will unnecessarily get further away and thus extend the duration of the voyage. The following analysis (which also involved experienced masters and officers of the navigational watch) compares the distances obtained on the basis of voyage planning with the aid of ECDIS system (Navi-Sailor 3000 from Transas) (*Table 1*).

It should be noted that all the respondents planned a voyage for the ship having the same characteristics and under the same conditions of navigation. Also, each planned route is tested and meets the minimum safety requirements. The purpose of this analysis is to confirm that masters and officers of navigational watch for the same ship and for the same environment conditions are choosing very different routes. This also confirms very large differences in interpretation of the existing recommendations and good practice.

3. CHOICE OF DISTANCE OF THE COASTLINE

One of the key elements in the standardisation of course selection is the definition of the course

Table 1 - Results of obtaining the distance between ports with ECDIS system

Route	Number of Respondents	Maximum Distance (M)	Minimum Distance (M)	Middle Distance (M)	Standard Deviation (M)
Ras Iaffan-Yokohama PS-PS	112	6,811	6,492	6,612.5	60.9
Yokohama-Los Angeles PS-PS	20	4,911	4,824	4,858.1	26.8
Los Angeles-Ras Iaffan PS-PS	44	11,840	11,300	11,435.2	96.6

PS - Pilot Station, M - nautical mile. Candidates have had the same ship and the same external conditions, all rhumb line courses.

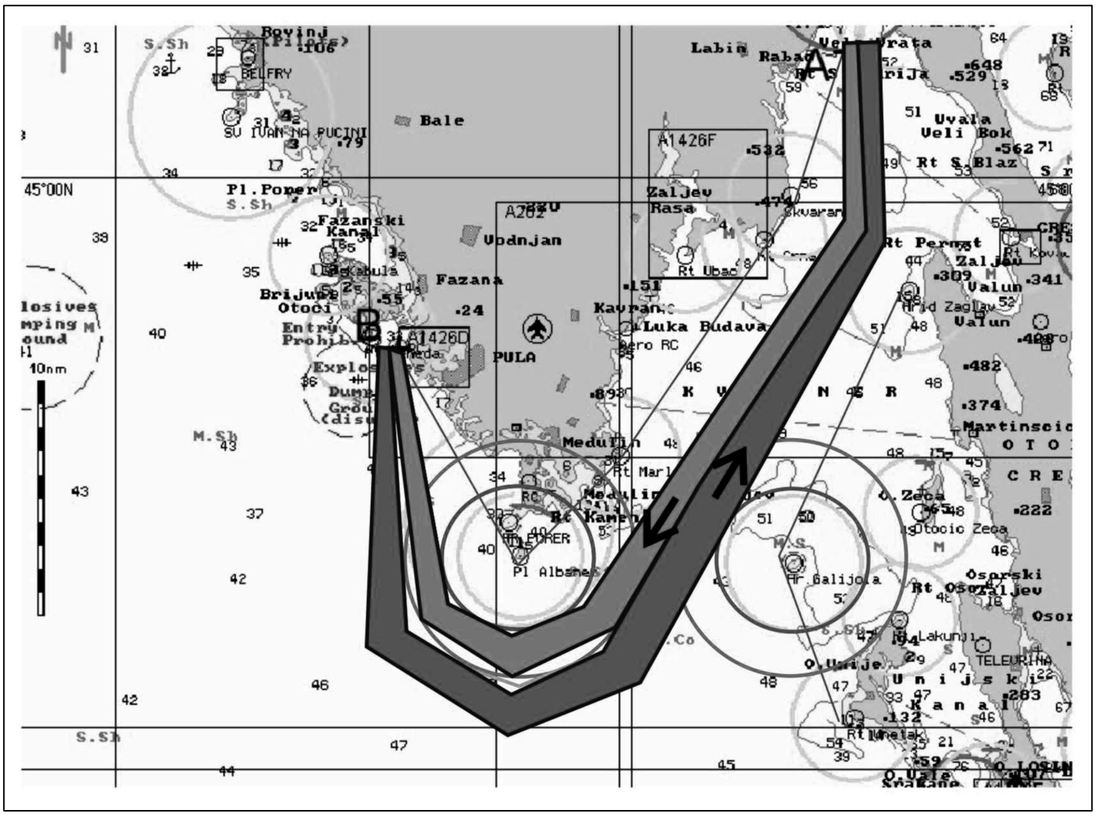

Figure 3 - Example of using additional recommendations when plotting courses in order to avoid head-on situations

distance from the coastline (generally based on subjective assessment; however, it can be formally prescribed by the coastal states or within the recommendations of the companies). If the use of navigation routing systems is excluded, one of the possible solutions is to redefine the recommendations in terms of using appropriate zones in line with the size and manoeuvring characteristics of the ships. The zones would be selected arbitrarily according to the master's evaluation. For example: for courses along starboard coastline to use the zone within 3 to 5M or 10 to 13M or 20 to 25M from the coastline; for courses along port coastline to use the zone within 5 to 10M or 13 to 20M from the coastline or sail outside of 25M from the coastline; use safe distance circles for avoiding dangers and to control position within appropriate zone [9].

Figure 3 shows how the additional recommendations can serve as simple and effective tools for reducing unnecessary meetings in the reciprocal courses. In case of bad weather conditions, or other difficulties, or special requirements of navigation, the master will decide whether this is acceptable or not.

4. SELECTION OF TURNING POINTS

In addition to choosing a safe (minimum) distance from danger these are the key recommendations when selecting the turning points in coastal navigation:

- choose turning points abeam to prominent objects, and if possible, use leading marks and prominent objects in the direction of the course [11],
- when considerably altering the course, the turning points should be chosen so that they have the same bow or stern bearing to the prominent object [1],
- when considerably altering the course, the turning points have to be selected in such a way that the vessel is moving around the circle of safe distance, or moving away from the object by following a logarithmic spiral [7],
- use *advance* and *transfer* to find the turning point [2] (*advance* – the distance the vessel moves along its original course from the time the rudder is put over until the new course is reached; *transfer* – the distance the vessel moves perpendicular to the original course during the turn),
- consider the opposite traffic (lay the track out to the starboard side of the channel to allow for any vessel traffic proceeding in the opposite direction [2].

One of the most important recommendations in selecting the turning points during voyage planning is undoubtedly the athwart turn about the prominent objects. Depending on the change of the heading angle, this recommendation can generate significant approaching to the coast (danger), if the safe distance circle from the danger is not defined and plotted. This can result as additional negative impact (final approach to the danger will depend on manoeuvring characteristics of the vessel, a possible negative impact of currents, waves and wind, traffic density and human errors). Also, in reciprocal flows of navigation, turning abeam on the objects tends to result in greater number of meetings in the reciprocal or near reciprocal courses. *Figure 4* shows two reciprocal routes with the ideal turning point at point C. If the vessels attempt to turn at the athwart point (point B, B'), their next heading will tend to take them closer to the coast. In reciprocal sailing flows, this eventually implies a larger area of overlapping (z).

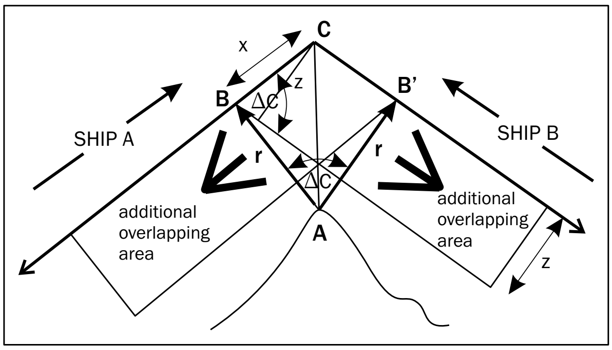

Figure 4 - Turning point athwart the object (B, B')

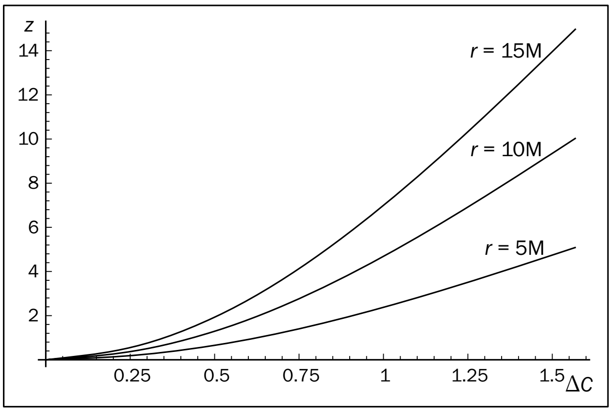

Figure 5 - Distance z for r = 5, 10 and 15M (ΔC from 0 to $\pi/2$)

The expected approaching to the coast *z* in *Figure 4* is in the function of the radius circle of turning the vessel and altering the course (ΔC).

Figure 5 shows the change in value z (distance in naut. miles), assuming that the *advance* and *transfer* of the vessel are not taken into account and that the minimal safe distance (safe distance circle) from the coast (danger) is not defined.

$$X = r \cdot \tan\frac{\Delta C}{2} \tag{1}$$

$$z = x \cdot \sin\Delta C \tag{2}$$

$$z = r \cdot \sin\Delta C \cdot \tan\frac{\Delta C}{2} \tag{3}$$

Choosing the turning points athwart to prominent objects is a very useful recommendation and should be therefore maintained. It implies a very simple and effective monitoring of the approach to a desired turning point and visual recognition of the moment when the turning manoeuvre should start. However, in case of a larger alteration of the course, the athwart turning around the objects should be always combined with a defined minimum safe distance. Only when the course alteration is small (up to 10-15°), depending on the distance from the coast and acceptable deviation, the athwart point alone is sufficient. *Figure 6* shows a method of safe passing around eminent dangers when a smaller (a) or greater (b and c) alteration of the course is required.

Figure 6 does not show the advance and transfer, i.e. the calculation of the real turning point (wheel over point), which should certainly be taken into account. If, in *Figure 4*, point C was the ideal turning point and point B was the real point (where the manoeuvre should begin in order to bring the ship onto the desired course), then the value x would be [10]:

$$x = r \cdot \tan\frac{\Delta C}{2} \tag{4}$$

r – turning radius of the ship for the corresponding deflection of the rudder from the table of manoeuvring characteristics,

ΔC – change of course.

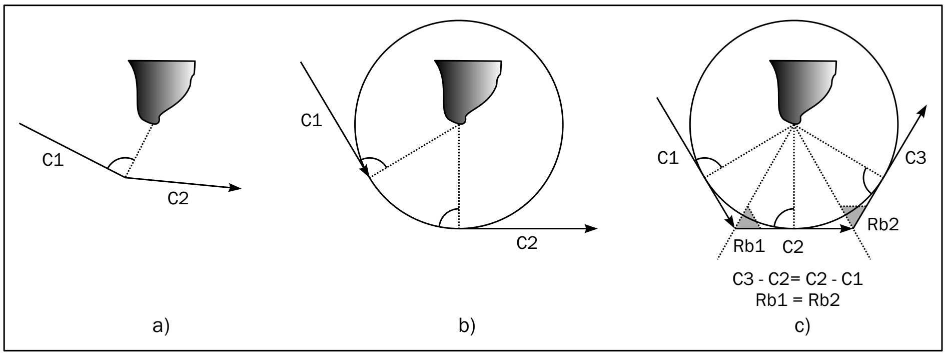

Figure 6 - Safe way of rounding the capes
(a – turning the course on athwart, b – by circle, c – by tangents of circle, same fore/aft angles) C1, C2, C3 – Courses, Rb-relative bearing

The value of *x* in the above expression is calculated under ideal conditions for deep water, but in reality it is necessary to take into consideration additional errors, i.e. the correction of the turning circle, especially in shallow waters [6] and in areas with strong currents.

5. ROUTE SELECTION

Standardisation of the route selection is a much more complex issue in relation to the problem of standardisation of plotting individual courses and selecting the turning points. The reason lies in the number of factors affecting the possible selection of optimum routes and in correlative evaluation of each factor. After defining the objective, the process of maritime voyage planning starts with studying the navigational charts, publications, navigation instructions and warnings, as well as studying other available sources of information in order to gather enough data about the possible safe navigational route (or routes) with respect to the dimensions and characteristics of the ship. Then the optimal route is selected with reference to the objective of the voyage, taking into account variable factors, particularly the impact of current, wind, and waves, i.e. long-term weather forecast for longer voyages. The selected navigation route must be safe enough with regard to navigational and other dangers for the entire duration of the voyage. In the areas where the navigation routing systems are established, or other restrictive measures by coastal states are enforced, the possibility of route selection will be reduced or will be non-existent. If there are recommended navigation routes, they will be followed, except under special circumstances threatening the safety of the ship or significantly increasing the costs (longer voyage, pilotage, ...). Furthermore, passage planning does not stop with making final voyage plans or ship's departure. Passage planning generally lasts throughout the entire voyage, mainly due to the inability to predict various situations and states of the environment for the intended voyage. Each new contingency, change in navigation conditions and forecast, as well as possible changes in the desired objectives according to the shipper's decisions, require a thorough modification and update of the existing passage plan, or the creation of a new one. Generally, there are four stages of passage planning: Appraisal, Planning, Execution, Monitoring [4, 5]. Also, there are Draft Guidelines for Voyage Planning introduced by IMO (IMO Resolution A.893) [17].

During the appraisal stage the master, in consultation with deck officers, considers all the relevant information and makes a general decision on the track (route) to be followed. The key element here is the subjective assessment of the master. In merchant shipping, this assessment typically tends to select the shortest route, i.e. the route requiring minimum time for completing the voyage and meeting the minimum safety requirements. *Figure 7* shows a simplified scheme of making decision on the optimal navigation route, in this case the one with the shortest navigation time. The objectivisation of the route selection can be approached in several ways. One of them is to define the minimum safety conditions within which the optimal achievement of goals is sought. If all factors that affect or may affect the choice of the navigation route are marked as acceptable or unacceptable (1 or 0), the final choice should be a navigation route without any unacceptable elements [14].

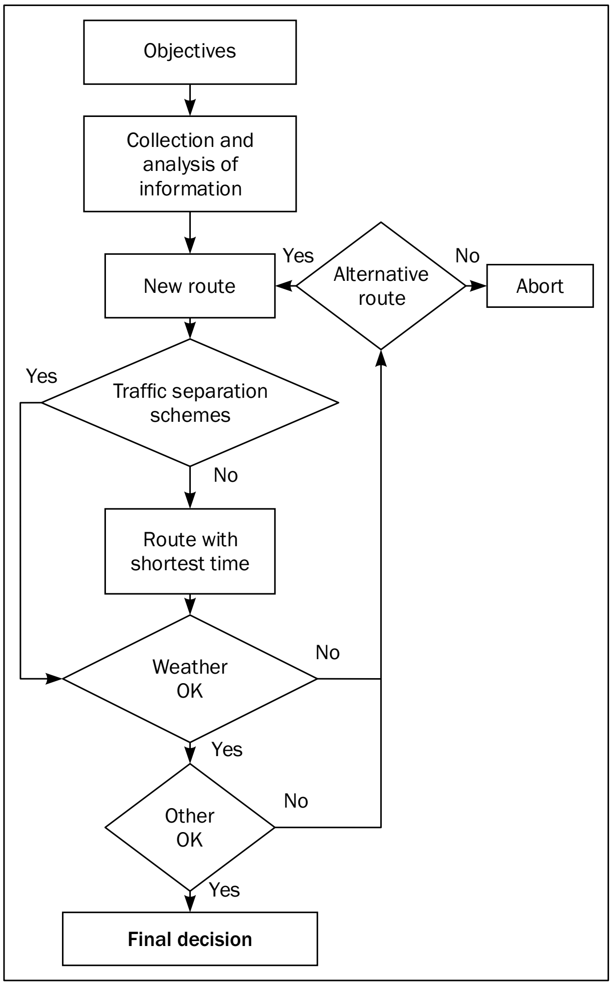

Figure 7 - Standard selection of the navigation route

When selecting the route in ocean navigation, the assessment of weather conditions is one of the most important factors affecting the final route selection. It is therefore obvious why the Ship Weather Routing (SWR) is one of the common methods of developing the optimum route today. The Ship weather routing is a procedure to find an optimum track for ocean voyages based on weather forecasts, sea conditions, and ship's individual characteristics for a particular transit [2]. The term optimum implies minimum fuel consumption, minimum time underway, maximum safety and crew comfort, or any desired combination of these factors. In the context of finding a model that can simplify the selection of the general route, SWR is important because this service evaluates various interrelated factors, e.g. meteorological and oceanographic conditions with regard to fuel costs or minimum travel time. The application of SWR in coastal navigation is possible but significantly limited by configuration of the coastline and the availability of alternative sea routes. Also, SWR uses various complex methods, and algorithms [15].

To optimize the route selection one of the solutions is the use of risk assessment methodology (*Figure 8*). The optimal solution is where the total sum of costs and risks is minimal, or where there is maximum profit at minimum risk. Naturally, the safety minimum must always be satisfied.

In favour of this method are amendments to the SOLAS Convention (Chapter XI/1) which, among other things, requires that the risk assessment must be

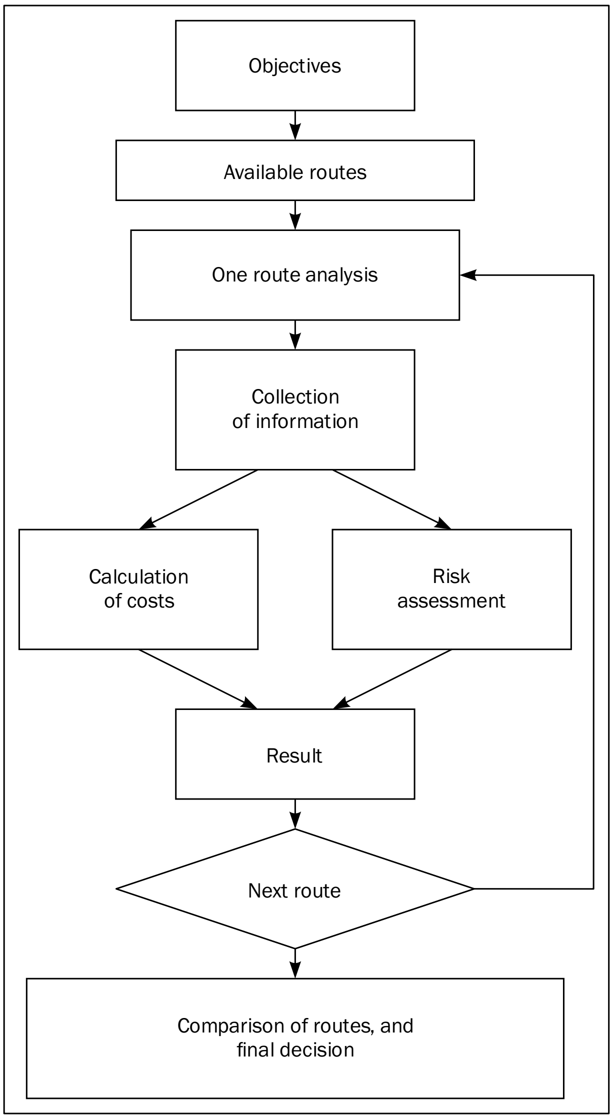

Figure 8 - Selection of the navigation route by comparing the factors of safety and cost

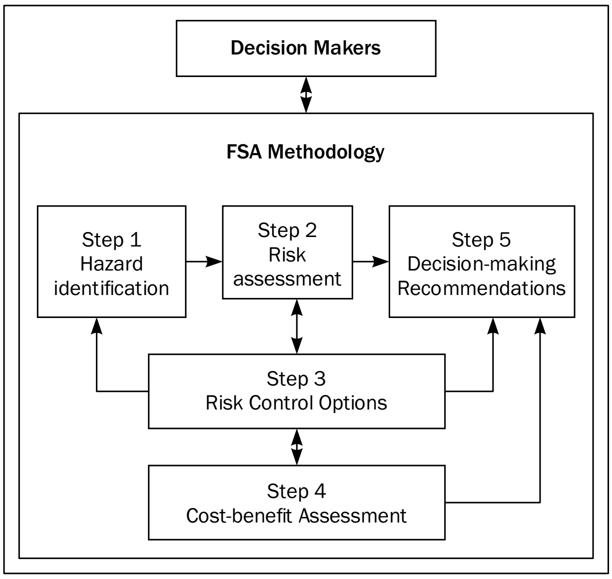

Figure 9 - FSA Methodology

Source: [19]

made in each particular case [12]. Also, the Maritime Safety Committee, at its seventy-fourth session (2001), and the Marine Environment Protection Committee, at its forty-seventh session (2002), approved the Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process (*Figure 9*) [19].

The method of selecting the navigation route based on comparing the factors of safety and cost-effectiveness should be far more effective; however, the major problems still include the required input data and the complex risk assessment methods [18]. If there are no modern electronic navigation systems on board, nor the possibility of using some of the complex models of optimization, then it is rather difficult to improve the system of master's decision-making regarding the selection of the navigation route. A common way to standardise the system of decision-making and avoid possible system failures is to use the bridge checklist systems that companies deliver within the Safety Management System (SMS). An SMS includes a set of documents about how a vessel is operated safely and how risks are controlled. It details the policies, practices and procedures for operating a commercial vessel. It states what to do onboard a vessel and how to do it safely. It has become a common tool [21]. There are also general recommendations on how to plan a maritime voyage, e.g. Bridge Procedure Guide [3]. Although there are additional checklists relating to the navigation in coastal zones, ocean navigation, sailing in heavy weather etc., i.e. recommendations regarding risk assessment, the subjective assessment of the master (or officer in charge) remains crucial. A relatively simple way of risk evaluation is the risk matrix. Here is an example provided by IMO:

Table 2 - Severity and frequency index table

Severity Index			Frequency Index		
SI	Severity	Fatalities	FI	Frequency	Per ship year
1	Minor	0.01	7	Frequent	10
2	Significant	0.1	5	Reasonably probable	0.1
3	Severe	1	3	Remote	10^{-3}
4	Catastrophic	10	1	Extremely remote	10^{-5}

Source: [18, 19]

Table 3 - Risk matrix table based on Table 2

Risk Index (RI)					
FI	Frequency	Severity (SI)			
		1	2	3	4
		Minor	Significant	Severe	Catastrophic
7	Frequent	8	9	10	11
6		7	8	9	10
5	Reasonably probable	6	7	8	9
4		5	6	7	8
3	Remote	4	5	6	7
2		3	4	5	6
1	Extremely remote	2	3	4	5

Source: [18, 19]

Initial ranking of accident scenarios can be relatively easily resolved by defining the risk matrix (*Table 3*). This principle allows for risk ranking, i.e. it enables the assessment of safety factors on one or more navigational routes. It is necessary to make a supplementary estimation of the economic factors with which the security factors (risk) can be compared. The economic factors may include daily vessel operating expenses and their comparison on a number of navigational routes having different distances. Instead of expenses, the expected profits can be taken into account. Both types of economical factors represent an ''Economical Index''.

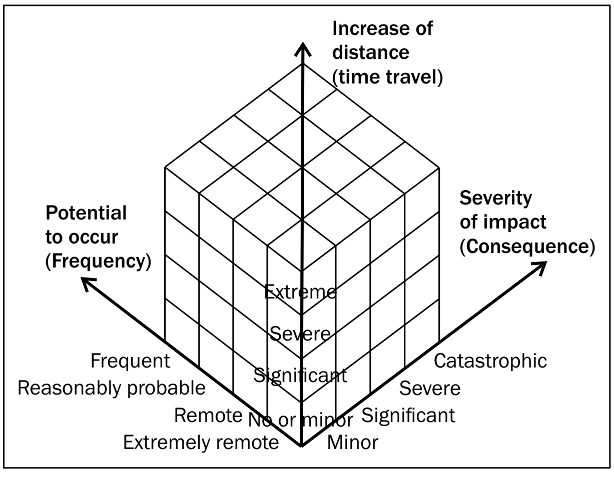

Figure 10 - Route selection 3D Matrix

Taking into consideration the Severity Index, Frequency Index and Economical Index results in defining three major factors by which the navigation route can be evaluated. They can be displayed graphically on 3D Matrix [16]. The matrix in *Figure 10* can be used in such a way that the Risk Index is defined for the basic navigational route (default, previously used, or generally the shortest). The Risk Index is then compared to other available navigation routes. The best choice is the route where the probability of expected accidents is the lowest, where there are the least consequences in case of adverse events, and where distance tends to be minimal.

6. CONCLUSION

The master of the vessel is responsible for the selection of the navigation route, the route of the ship, and the related courses. The subjective assessment of the master and his experience play an important role in the process. Continuous economic development and the demands for maritime transportation result in the constant increase in the number of ships worldwide and, accordingly, the increased traffic density. In the areas without specific measures regulating the navigation, the existing recommendations on course selection allow a considerable freedom in choosing the courses and turning points, which eventually leads to a large number of potential collision situations, i.e. situations where an accident is inevitable if the crew does not take appropriate avoiding manoeuvre. This problem can be simply solved by defining the appropriate navigational route zones along the coast (as an additional recommendation) for different classes of vessels, and by proper implementation of the existing recommendations for selecting courses and turning points. In the end, the final selection and acceptance of routes and these additional recommendations will remain on the master's decision. When selecting general routes, the subjective assessment of the master remains a crucial element, but this assessment can be significantly easier (and more objective) if the risk assessment is made properly using an appropriate methodology. The FSA methodology recommended by the IMO can be used not only for assessing the risk of accident, but it also provides the principles for evaluating the correlation between the safety factors (risk of accident) and the economical factors (travel time, cost, profit, etc.) in order to determine the optimum route. Moreover, this estimation may be approximate, for example, with the aid of the 3D matrix, or may be based on the quantitative determination of the risk and the comparison with the expected costs (profits). Recommendations presented in this paper could assist the masters in selecting courses and routes, but they can also improve the automated selection of courses in the electronic chart systems.

ZVONIMIR LUŠIĆ, Ph.D.
E-mail: zlusic@pfst.hr
Sveučilište u Splitu, Pomorski fakultet
Zrinsko-Frankopanska 38, 21000 Split, Hrvatska
SERĐO KOS, Ph.D.
E-mail: skos@pfri.hr
Sveučilište u Rijeci, Pomorski fakultet
Studentska 2, 51000 Rijeka, Hrvatska
STIPE GALIĆ, mag.ing.
E-mail: sgalic@pfst.hr
Sveučilište u Splitu, Pomorski fakultet
Zrinsko-Frankopanska 38, 21000 Split, Hrvatska

SAŽETAK

UJEDNAČAVANJE NAČINA CRTANJA KURSOVA I IZBORA TOČAKA OKRETA U POMORSKOJ NAVIGACIJI

Današnji izbor ruta, crtanja kursova i izbora točaka okreta u pomorskoj navigaciji još uvijek se većim dijelom temelji na subjektivnoj procjeni zapovjednika broda, odnosno odgovornog časnika na brodu. Rezultat toga je vrlo velika raznolikost u distribuciji kursova, odnosno u konačnici raznolikost kretanja brodova. Suvremena elektronička pomagala, posebno ECDIS (Electronic chart display and information system) danas znatno mogu olakšati planiranje pomorskog putovanja, crtanje kursova, izbor točaka okreta, itd. Specifičnost ovih sustava je što osim prikaza elektroničkih karata omogućuju planiranje rute, nadzor kretanja, pretraživanje baze podataka, postavljanje alarma, snimanje podataka, itd. Ono što ovi sustavi još uvijek ne nude je automatski izbor kursova na zahtjev korisnika, po standardiziranom obrascu. Dakle, u većini slučajeva rute se iskustveno odabiru, uključujući i točke okreta, ili se koriste prije definirane i već korištene. U ovom radu pokazat će se nedostatak postojećeg načina odabira ruta, tj. crtanja kursova u pomorskoj navigaciji, te će se dati preporuke kako ga poboljšati. Definirane preporuke i modeli mogu se također primijeniti i kod ručnog ubacivanja točaka okreta u sustave za prikaz elektroničkih karata, ali i mogu poslužiti kao podloga za nadogradnju takvih sustava automatskim izborom početne rute.

KLJUČNE RIJEČI

pomorska navigacija; izbor rute; crtanje kursa; točke okreta

REFERENCES

[1] **Benković F**, **Piškorec M**, **Lako Lj**, **Čepelak K**, **Stajić D**. *Terrestrial and electronic navigation* [in Croatian]. Split: Hidrografski Institut Ratne mornarice; 1986.
[2] **Bowditch N**. *The American Practical Navigator*. Bethesda, Maryland: DMAHTC; 2002.
[3] *Bridge Procedure Guide*. International Chamber of Shipping; 1998.
[4] **Coolen E**. *Nicholls's Concise Guide to Navigation - Volume 1*. 10th ed. Glasgow: Brown, Son & Ferguson Ltd; 1987.
[5] **Coolen E**. *Nicholls's Concise Guide to the Navigation Examinations - Volume 2*. 12th ed. Glasgow: Brown, Son & Ferguson Ltd; 1995.
[6] **Drachev VN**. *Calculating wheel over point*, Asia-Pacific Journal of Marine Science & Education. 2012;2(1):27-46.
[7] **Kos S**, **Zorović D**, **Vranić D**. *Terrestrial and electronic navigation* [in Croatian]. Rijeka: Pomorski fakultet u Rijeci; 2010.
[8] **Lušić Z**. *A contribution to the analysis of the safety and economical factors influence on marine voyage optimization* [dissertation, in Croatian]. Rijeka: Pomorski fakultet u Rijeci; 2010. 158 p.
[9] **Lušić Z**, **Kos S**. *Plotting courses in coastal navigation*. Pomorstvo – Scientific Journal of Maritime Research. 2010;24(3):115-128.
[10] *Nautical tables* [in Croatian]. Split: Hrvatski hidrografski institut; 1999.
[11] **Simović A**. *Terrestrial navigation* [in Croatian]. Zagreb: Školska knjiga; 2001.
[12] *International Convention for the Safety of Life at Sea (SOLAS)*, 1974; IMO, 2009.
[13] **Squire D**. *The Hazards of Navigating the Dover Strait (Pas-de-Calais) Traffic Separation Schemes*. The Journal of Navigation. 2003;56(2):195-210.
[14] **Vidan P**, **Kasum J**, **Zujić M**. *Meteorological navigation and ECDIS*. Promet – Traffic & Transportation. 2010;22(5):373-378.
[15] **Zec D**. *Planning of maritime voyage* [in Croatian]. Rijeka: Pomorski fakultet; 1997.
[16] **Antoniadis D**, **Thorpe A**. *Evaluation of risks using 3D Risk Matrix* [Internet, cited 2013 August]. Available from: http://www.academia.edu/1131772/Evaluation_of_risks_using_3D_Risk_Matrix
[17] International Maritime Organization (IMO). *Guidelines For Voyage Planning*, Resolution A.893(21) [Internet]. London: International Maritime Organiza-

tion; 2000 [cited 2013 July]. Available from: http://www.imo.org/blast/blastDataHelper.asp?data_id=24282&filename=893%2821%29.PDF

[18] Health and Safety Executive (HSE). *Marine Risk Assessment, Offshore Technology Report 2001/063* [Internet]. London: Health and Safety Executive; 2002 [cited 2013 August]. Available from: http://www.hse.gov.uk/research/otopdf/2001/oto01063.pdf

[19] International Maritime Organization (IMO). *Guidelines for Formal Safety Assesment (FSA)* [Internet]. London: International Maritime Organization; 2002 [cited 2013 August]. Available from: http://www.imo.org/OurWork/HumanElement/VisionPrinciplesGoals/Documents/1023-MEPC392.pdf

[20] Marine Traffic. *Live Ship Maps – AIS* [Internet, cited 2013 May]. Available from: http://www.marinetraffic.com/ais/

[21] Safety Management Systems. *Roads and Maritime Services* [Internet, cited 2013 August]. Available from: http://www.maritime.nsw.gov.au/cv/sms.html