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ASPECTS OF SHIP OCEAN VOYAGE PLANNING WITH THE APPLICATION OF COMPUTER PROGRAMS

Computation algorithmization and the application of computer programs in ship ocean voyage planning is a continuous subject of research done by land-based ship routing centers as well as non-commercial institutes dealing with transport problems. Computer programs which support captains with optimum-route selection are quite common on ocean-going ships. Among others, commercial programs in use are BRIDGE (Weathernews) and SPOS (Meteo Consult). This article analyses the above mentioned tools and compares them with the GRAFY program, developed at the Institute of Navigation, Maritime University of Szczecin [1, 7, 8].

ASPEKTY PLANOWANIA PODRÓŻY OCEANICZNEJ STATKU Z WYKORZYSTANIEM PROGRAMÓW KOMPUTEROWYCH

Algorytmizacja obliczeń i zastosowanie programów komputerowych w procesie planowania podróży oceanicznych statków stanowi ciągły przedmiot badań zarówno ośrodków pogodowego prowadzenia statków jak i niekomercyjnych instytutów badawczych związanych z transportem. Na statkach morskich coraz częściej instalowane jest oprogramowanie wspomagające decyzje kapitana w wyborze trasy optymalnej. Przykładami takich komercyjnych narzędzi są między innymi programy BRIDGE firmy Weathernews i SPOS firmy Meteo Consult – w artykule zamieszczono analizę tych narzędzi, porównując wyniki obliczeń z programem GRAFY, opracowanym w Instytucie Nawigacji Morskiej, Akademii Morskiej w Szczecinie[1, 7, 8].

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1. INTRODUCTION

The problem of choosing a particular ocean route is of continuous interest to ship's captains, owners and operators. The properly determined route, taking into consideration changeable weather conditions as well as the characteristics of a ship as a control object, translates into enhanced navigational safety and economical profits resulting from ship's shorter voyage duration or lower fuel consumption. In the age of sailing ships and later on till first regular ocean weather charts were introduced, ship captains could use seasonal climatic data only. Numerical models of weather forecasts marked another stage of development in the field, accompanied by ocean route recommendations worked out by land-based weather navigation centers. Route recommendations from land are worked out by a land-based center to indicate an optimum route on the basis of previously obtained information from the ship concerned, such as: port of departure, port of destination, basic characteristics of the ship, type of cargo carried. The recommended way points are send back onboard a ship in a verbal form. As an alternative, ship's programs, ONBOARD ROUTING SYSTEMS (ORS), for calculating the most optimal routes can be used. The new type of service was introduced when satellite communications cost had been reduced. The operation of such programs is based on onboard computer software fed with weather data in the form of analyses and forecasts. The program makes it possible to calculate routes and assists the captain in selecting the optimal route for his ship.

This article aims at analyzing ORS type tools and at evaluating them from user's point of view. At present the market offers several types of such programs. The analysis herein will cover two programs used for training purposes at the Laboratory of Weather Navigation, Maritime University of Szczecin – the program BRIDGE by Weathernews and SPOS (Ship Performance Optimisation System) developed by Meteo Consult [5]. The results were verified by means of GRAFY, a program developed at the Institute of Marine Navigation, Maritime University of Szczecin. [8].

2. THE PRINCIPLE OF OPERATION OF THE ONBOARD ROUTING SYSTEM

2.1 CHARACTERISTICS OF A SHIP AS A CONTROL OBJECT

If ORS programs are to select optimum ocean routes, they should offer the user an option of modelling ship speed characteristics, that is they should take into consideration speed losses depending on pre-set weather conditions. The examined programs present two different approaches to this problem (see Fig. 1). The BRIDGE software (Fig. 1, left) models speed characteristics on the basis of ship's particulars, and later enables the calibration of these characteristics [3]. SPOS leaves the construction of speed characteristics to the system user (Fig.1, right). In this case speed characteristics are based on data from observations (records in the log book) [2].

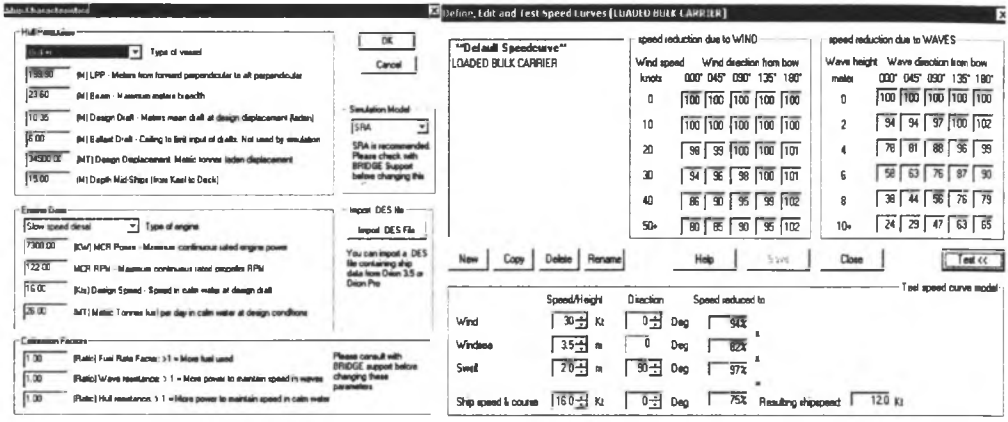

Fig.1. Modules for modelling ship's speed characteristics of two programs: BRIDGE (left) and SPOS (right)

2.2 WEATHER DATA FEEDING

The principal advantage of ORS is the availability of weather data in a digital form. This form of data allows to visualize them as well as use them effectively for calculating routes to recommend to a given ship. The particular programs differ from each other in such elements as the scope of available information and the length of available forecasts. Table 1 presents a comparison of the available scope of weather data for the two programs.

Table 1

The scope of weather data available in the BRIDGE and SPOS programs

Weather / Ocean Parameters	Length of Forecast (Time Series Step)	
	BRIDGE	SPOS
Surface Pressure Contours	240h (12h)	120h (12h)
500mb Height Contours	240h (12h)	N/A
Atmospheric Fronts	096h (12h)	N/A
Surface Winds	240h (12h)	120h (12h)
Primary Waves Heights and Directions	240h (12h)	120h (12h)
Secondary Waves Heights and Directions	240h (12h)	120h (12h)
Sea and Swell Periods	N/A	120h (12h)
Monthly Currents	Seasonal	Seasonal
Observed Currents (Gulf Stream & Kuroshio)	Analysis	N/A
Tropical Cyclones Data (Track & Radius)	72h / 12h	72h / 12h
Pack Ice Limit	Analysis	Analysis
Iceberg Limit	Analysis	N/A
Sea Surface Temperature	Analysis	N/A

While assessing this kind of programs one should bear in mind that a wider scope of information is connected with additional fees for data transmission to the ship (in most cases it is satellite transmission, usually Inmarsat B). The right choice of data is therefore a compromise between the scope of data and their usability in a specific situation of a traveling ship. In this respect the BRIDGE can be highly valued – it allows the user to freely specify the scope of data in terms of the required information range, forecast time interval, and the flexibility in determining the geographical area of interest to the navigator. While evaluating the usefulness of data one should also consider the fact that long-term forecasts (6-10 days) prove to be far from perfect. The reduction of forecast length to 120 hours by the manufacturer of the SPOS program has been a purposeful move – in voyages longer than five days climatic data are used in the first days of the voyage.

Due to the fact that various sources of information are used, forecasts specifying how particular elements of the weather will develop may vary for different onboard routing systems. Figure 2 presents forecasts of sea waves, the most important weather component affecting the sea-going ship. The left-hand side of Figure 2 illustrates fields of wave action as displayed by BRIDGE, the right-hand side shows the outcome of SPOS. Both sides of Figure 2 show wave heights of three metres and above (the first closed isoline represents three metre waves). The isolines are marked at one metre increments of height. The compared data cover a period of four days – from 13 to 16 June 2005 (data recorded at 1200 UTC). The wave height marked in the diagrams is a resultant wave from the added height of seawave and swell as presented by SPOS. The other program, BRIDGE, displays waves of the primary and secondary swell systems. Such wave overlapping aims at an overall presentation of waves affecting ships in a given point. The marked wave height is calculated from this formula:

$$H = \sqrt{H_1^2 + H_2^2}$$

where:
H – resultant wave height;
H_1 – first component height;
H_2 – second component height;

The wave height forecast used in BRIDGE comes from a numerical model of waves developed by the software producer Weathernews [3]. The results from model calculations are also compared with the results obtained from other numerical models, from such centers as ECMWF (European Centre for Medium-Range Weather Forecasts), NCEP (National Centers for Environmental Prediction), JMA (Japan Meteorological Agency) or FNMOC (Fleet Numerical Meteorology and Oceanography Center) [6]. The SPOS program makes use of the numerical waves model designed by Bracknell UKMO (United Kingdom Met Office) [4]. The illustration shows that forecasts for the development of wave fields were similar for both programs. Both BRIDGE and SPOS for the longest forecasts presented (for 16 June 2005) forecast a development of wave fields with 3 to 5 metre height in the eastern region of the ocean; notably, the forecast from SPOS featured higher waves (5 metres) as compared with BRIDGE (4 metres).

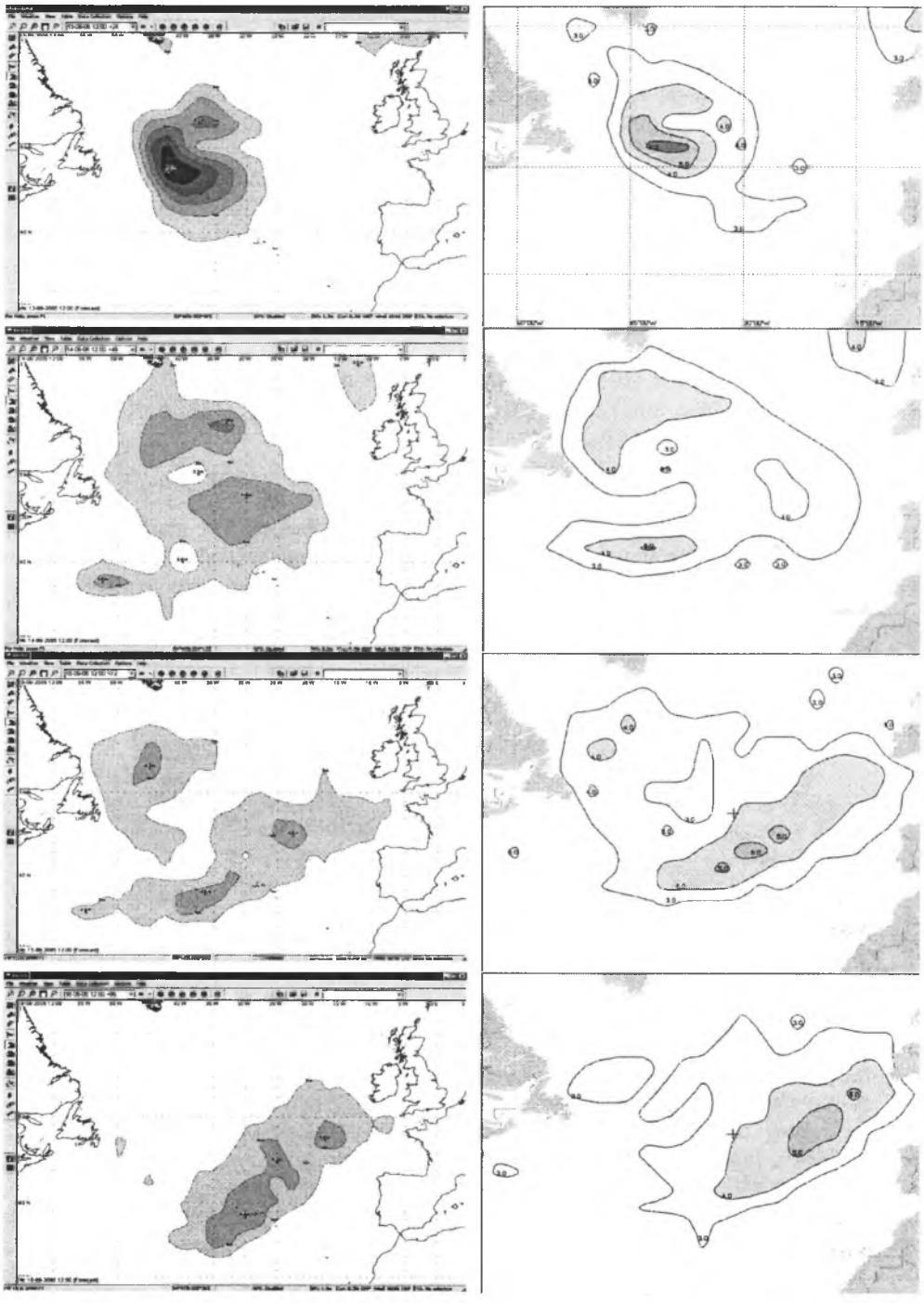

Fig.2. Wave fields in the North Atlantic area obtained from BRIDGE (left) and SPOS (right) for, respectively from top: 13,14,15 and 16 June 2005. Explanations in the text

2.3 ROUTE CALCULATIONS

The basic function of ORS software is route calculation. The records of weather conditions in a numerical form as well as information on vessel performance as a control object provide a basis for quick calculations of parameters for particular routes. Both BRIDE and SPOS are capable of considering any number of variants. SPOS has a built-in optimization algorithm, based on the isochrone method, well described in the literature [1]. BRIDGE, in turn, enables the recommendation of an optimum route through the effective graphic user interface. Figure 3 presents three basic route variants: rhumb line, great circle and optimum, all generated by the software herein examined. The following starting data have been adopted:

- departure: 13 June 2005, time 1200 UTC;
- departure point: port of BREST (φ = 48°24.0' N λ = 004°46.0 W);
- voyage final position: PROVIDENCE CHANNEL (φ = 25°45.0' N λ = 077°00.0 W);
- speed in calm sea: V_0 = 16 knots;
- speed characteristics of a bulk carrier (see Fig. 1);

The minimum time criterion was assumed in the calculations. The graphic illustrations of the analyzed routes are shown in Figures 3 and 4, while the calculated route parameters are given in Table 2.

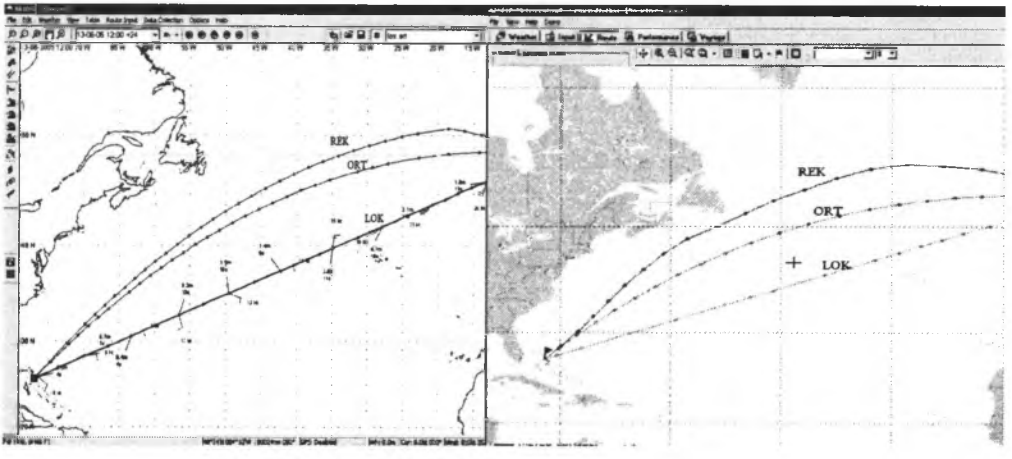

Fig.3. The graphic image of calculated routes – rhumb line (LOK), great circle (ORT) and time-optimum (REK), generated by BRIDGE (left) and SPOS (right)

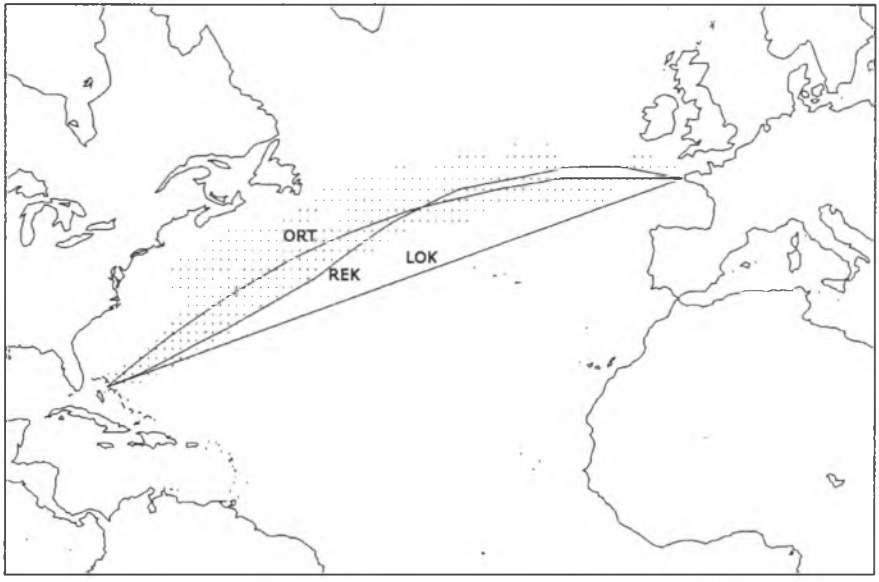

Fig.4. Graphic presentation of calculated routes – rhumb line (LOK), great circle (ORT) and time-optimum (REK), generated by GRAFY software

Table 2

Basic parameters of calculated routes, generated by BRIDE, SPOS and GRAFY

ROUTE	DISTANCE [NM]			TIME [H]			AVERAGE SPEED [KN]		
	BRIDGE	SPOS	GRAFY	BRIDGE	SPOS	GRAFY	BRIDGE	SPOS	GRAFY
RHUMB LINE	3676	3679	3680	242	258	247	15.2	14.3	14.9
GREAT CIRCLE	3577	3581	3573	239	249	241	15.0	14.4	14.8
TIME-OPTIMUM	3594	3649	3617	238	239	234	15.1	15.3	15.5

Apart from commercial software offered by foreign firms, these authors have made calculations for the same voyage and the same testing conditions (vessel performance, voyage departure time, weather conditions) using their software GRAFY (Fig.4.)

The results of routes tested by three programs differ in voyage time, particularly the sailing along the great circle and rhumb line, which results from differences in the interpretation of weather conditions (Fig.2.), the adopted method of points resolution and speed characteristics chosen for calculations. In general, the testing program GRAFY confirmed that the commercial programs SPOS and BRIDGE take into account dynamically changing weather conditions for the tested route. It can be said that these programs have determined the most convenient, optimum route which runs above the great circle and the rhumb line.

3. SUMMARY

SPOS and BRIDGE have proved to be good application tools whose work is based on present weather conditions, offering possibilities of adopting various ship characteristics. BRIDGE is the latest version of the program developed by the Weathernews center (former Oceanroutes) and it has replaced the software called ORION, which has been tested by these authors since 1997 [7].

Neither of the two programs qualifies as an expert system, therefore each operator has to have sufficient knowledge to use them. This knowledge should include the scope and selection of weather data, interpretation of weather conditions – their influence on ship's safety (conditions for weathering during hull slamming and shipping water), modelling of ship's speed characteristics, considering other criteria for route optimization, evaluation and choice of routes. Such requirements indicate there is a need for proper training of the users (deck officers) of these optimization programs.

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