POLISH MARITIME RESEARCH 4(58) 2008 Vol 15; pp. 3-11
10.2478/v10012-007-0090-1

Functional model of river-sea ships operating in European system of transport corridors

Part II
Methods of determination of design assumptions for river-sea ships operating in European system of transport corridors, according to their functional model

Magdalena Kaup, Ph. D.
Szczecin University of Technology

ABSTRACT

This paper presents continuation of the research on the functional model of river-sea ships operating in European system of transport corridors. It deals with a set of methods of determination of design assumptions for river-sea ships. Relevant calculations were performed on the basis of a future network of European routes for operating the river-sea ships within EU system of water transport corridors, in which rates of cargo flows and lengths of particular routes as well as their mathematical model were taken into account. In consequence, technical assumptions for designing the fleet of river-sea ships to be operated in European system of water transport corridors, were obtained.

Keywords: European system of transport, river-sea ships, river-sea transport system, water transport

INTRODUCTION

Every floating unit is designed and used to fulfill a shipping task attributed to it. Depending on a given shipping task such shipping strategy, out of various transport possibilities, can be selected which will ensure best features and profits. In Part I (3/2008 PMR) of the paper the graphical and mathematical model for analyzing the functioning of fleet of river-sea ships (shortly marked SRM) was presented. From the investigations a determination model of design assumptions for river-sea ships has been obtained. In this part of the paper are presented results of investigations of the functional model of river-sea ships, performed for the proposed system of European transport corridors.

AREA OF INVESTIGATIONS OF THE FUNCTIONAL MODEL OF RIVER-SEA SHIPS

The first step of proceeding with the functional model is to form databases of:
- ⇨ geography of cargo flows in Europe
- ⇨ geography of waterways and transport corridors intended for river-sea navigation in Europe.

By making use of information on export and import of particular European countries it is possible to elaborate rates and directions of cargo flows realized in the frame of the EU.

In Fig. 1 graphical illustration is presented of cargo flows structure in Europe, which will be used for analysis of the functional model.

To the next database for the functional model, collected information on European inland waterways network and sea routes was introduced. On their basis the future network of European water transport corridors to be used by river-sea ships was elaborated (Fig. 2). On the network today existing connections of inland waterways widened by sea route sections, are shown. Also, are there indicated the lacking connections and those necessary to be extended, which could supplement the existing network after introduction of certain changes to internal and external factors. Moreover, distances between ports in [km] as well as rates of cargo flows running within the network are given in [mln t/year]. The performed analysis showed that rates of the cargo flows possible to be shipped by the SRM fleet constitute 7-10 % of the total rate of cargo flow running along a given route. The SRM fleet effectiveness will be respectively higher at greater cargo flow rates. Some cargo flows have been attributed to river-sea routes by shifting them from other transport branches in compliance with EU policy guidelines for the transport services sector.

Only one, the most representative port of each country was indicated on the map because the rates of cargo flows were elaborated by using the data distinguished only by the names of the countries, with the exception of Poland, Slovakia and Germany for which also the lacking connections very important for further development of the countries, were shown.

Fig. 1. Directions and rates of cargo flows in 25 EU countries, candidate countries, EFTA countries and Russia – current state (2007).

The elaborated databases made it possible:

➲ to elaborate the system of European river-sea transport corridors for which different variants of the SRM fleet functioning were calculated

➲ to adjust parameters of the river-sea ships both to rates of cargo flows and dimensions of waterways.

DETERMINATION OF DESIGN ASSUMPTIONS FOR RIVER-SEA SHIPS OPERATING IN THE SYSTEM OF EUROPEAN TRANSPORT CORRIDORS

The crucial aim of the functional model is to determine design assumptions for structure of the RSM fleet intended for operating in the system of European transport corridors. The determination process consists of the following phases:

Phase I. The determination of effective operation limits for the SRM fleet.

Phase II. The analysis of the obtained results and determination of design assumptions for the RSM fleet structure.

Phase III. The correction of the design assumptions.

The procedure of determination of design assumptions for structure of the RSM fleet operating in the system of European transport corridors, based on the functional model, was carried out in accordance with the algorithm presented in Fig. 3.

Within the functional model of the SRM fleet, the assumptions were made as to:

- decision variables
- limitations
- choice criteria.

on the basis of the parameters of:

- possible shipping routes
- present rates and directions of cargo flows as well as probability of their changes
- groups of shipping tasks, strategies and schemes of functioning the river-sea ships.

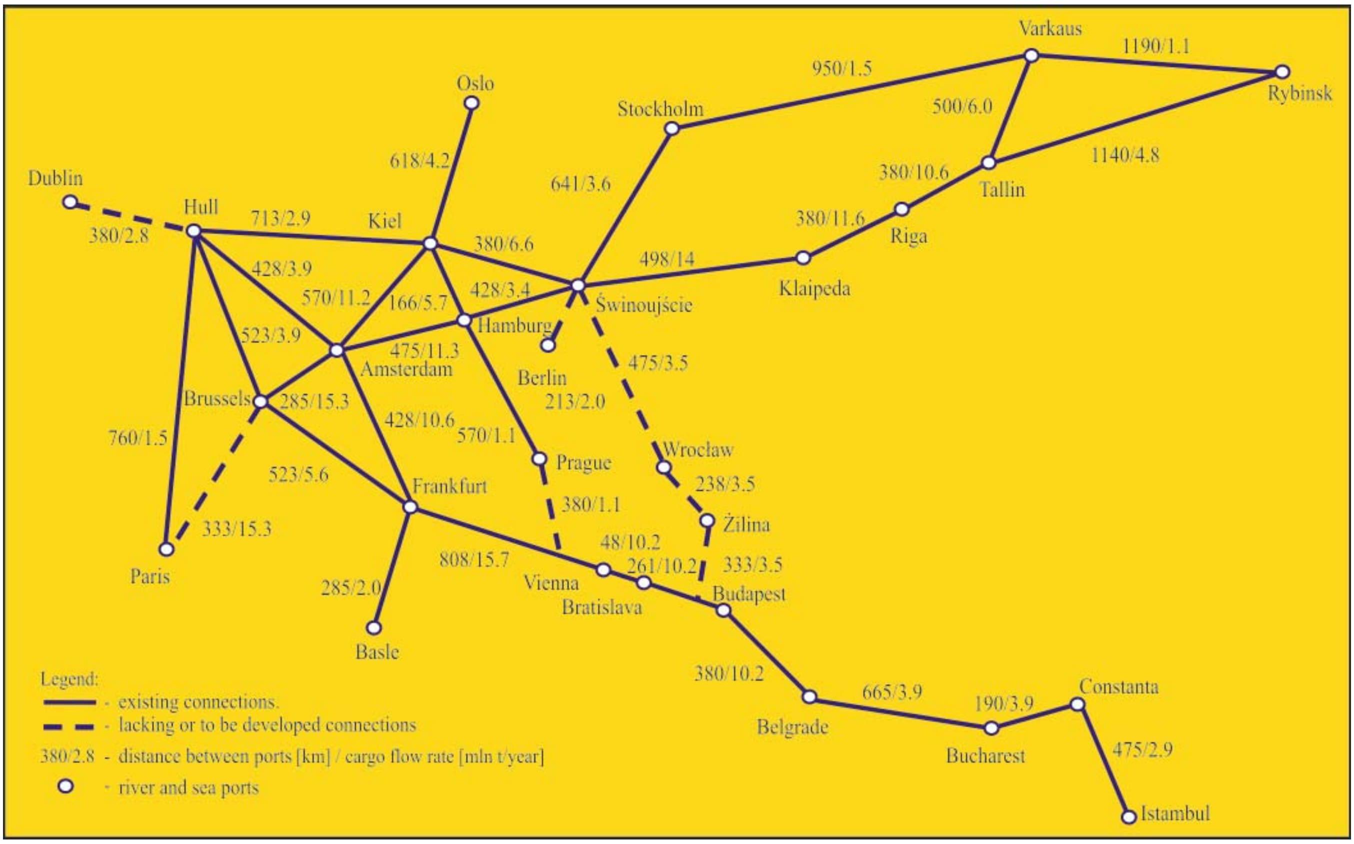

Fig. 2. Future system of European water transport corridors intended for operation of fleet of river-sea ships.

Results obtained from the investigation of the functional model should satisfy all demands of cargo senders. The algorithm of effectiveness of functioning the river-sea ships in the system of European transport corridors is presented in Fig. 4.

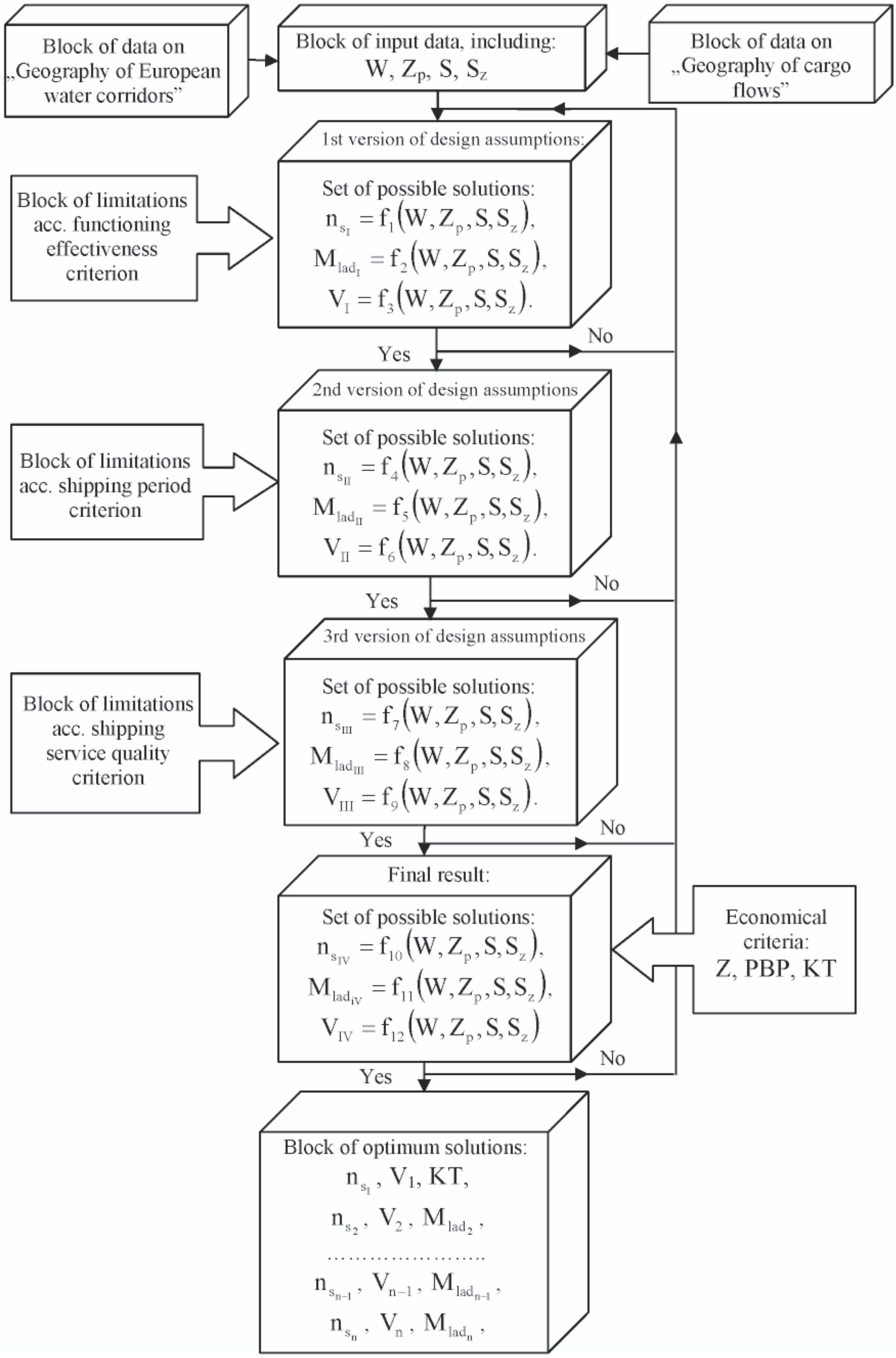

Fig. 3. *Algorithm for determining the design assumptions of the SRM fleet intended for operating in the system of European water transport corridors.*

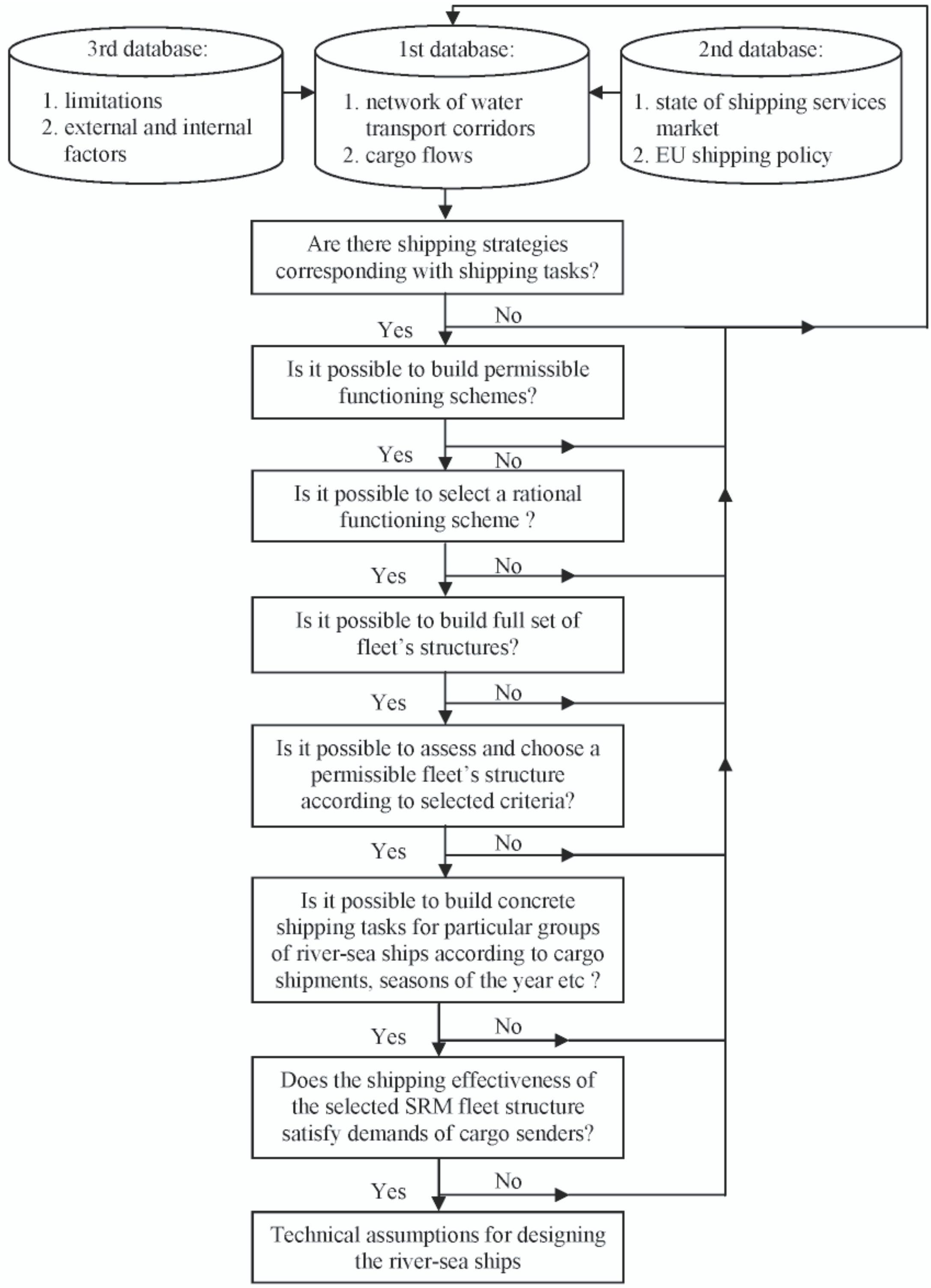

Fig. 4. *Algorithm for assessing the shipping effectiveness of river-sea ships operating in the system of European water transport corridors*

DETERMINATION OF BOUNDARIES OF AREAS OF EFFECTIVE FUNCTIONING THE SRM FLEET

The first phase of the determination of design assumptions for structure of the SRM fleet intended for operating in the system of European transport corridors is to determine number of the ships depending on their speed and cargo carrying capacity. To this end, after performed analysis 10 corridors (Tab. 1) were selected out of the future European network of water transport corridors shown in Fig. 4, for which calculations according to the functional model were performed and their results analysed.

Tab. 1. *European river-sea transport corridors*

Route	Corridor parameters
From west to east	
Corridor 1. Dublin – Hull – Amsterdam – Frankfurt – Vienna – Bratislava – – Budapest – Belgrade – Bucharest – Constanta – Istambul	S = 4063 [km] W = 7.43 [mln t/year]
Corridor 2. Dublin – Hull – Brussels – Frankfurt – Vienna – Bratislava – – Budapest – Belgrade – Bucharest – Constanta – Istambul	S = 4253 [km] W = 7.90 [mln t/year]
Corridor 3. Dublin - Hull – Kiel – Świnoujście – Klaipeda – Riga –Tallin – Rybinsk	S = 3871 [km] W = 7.61 [mln t/year]
Corridor 4. Dublin – Hull – Kiel – Świnoujście – Stockholm – Varkaus – Rybinsk	S = 4254 [km] W = 3.083 [mln t/year]
Corridor 5. Paris – Brussels – Amsterdam – Hamburg – Świnoujście – Stockholm – Varkaus – Rybinsk	S = 4302 [km] W = 7.36 [mln t/year]
Corridor 6. Paris – Brussels – Amsterdam – Hamburg – Świnoujście – Klaipeda – Riga –Tallin – Rybinsk	S = 3919 [km] W = 10.79 [mln t/year]
From north to south	
Corridor 7. Stockholm – Świnoujście – Wrocław – Zilina – Budapest	S = 1687 [km] W = 3.53 [mln t/year]
Corridor 8. Oslo – Kiel – Hamburg – Prague – Vienna	S = 1734 [km] W = 3.03 [mln t/year]
Corridor 9. Oslo – Kiel – Amsterdam – Frankfurt – Basle	S = 1901 [km] W = 7.00 [mln t/year]
Corridor 10. Hull – Paris	S = 760 [km] W = 1.50 [mln t/year]

where:
S – assumed length of shipping route [km]
W – assumed cargo flow rate [mln t/year].

The following assumptions were made to determine limits of the effective functioning of the SRM fleet:

Assumption 1

As the river-sea ships belong to those of relatively small deadweight and speed (resulting from various limitations from the side of waterways and amount of available cargo shipments) the following values of particular parameters were taken for the calculations:

$$8 \leq V \leq 20 \text{ [km/h]} \tag{1}$$

$$1000 \leq M_{lad} \leq 3500 \text{ [t]} \tag{2}$$

Assumption 2

Inland sections of the river-sea corridors are led along 4th class waterways.

Assumption 3

Cargo flow rate in a given corridor is equal to the mean value of its components.

Assumption 4

In the end terminals 100 % of cargo is unloaded, and in intermediate ports – 30% of it.

The second phase of the determination of design assumption for the SRM fleet intended for operating in the system of European water transport corridors was to determine such values of ship speed and cargo carrying capacity for which the capital return period PBP would be as short as possible. To this end, on the basis of Eq. (3) the required cargo shipping capability of the SRM fleet for particular variants of the corridors was determined under assumption that the designed structure of the fleet satisfies demands of the cargo flows (Eq. 4).

$$PBP = KI / Z \tag{3}$$

$$\sum_i E_i \geq W \tag{4}$$

where:
KI – investment cost of river-sea ship [mln €/year]
Z – profitability of river-sea ship [mln €/year]
W – assumed cargo flow rate [mln t/year]
$\sum_i E_i$ – functional effectiveness (shipping capability) of the SRM fleet [mln t/year].

The last phase of the determination of tasks for the SRM fleet was to select their optimum variants and to determine influence of selected market factors (fuel price, freight rate) on the return period of the capital invested in the SRM fleet.

RESULTS OF THE INVESTIGATIONS

On the basis of the functional model of river-sea ships, presented in Part I (PMR 3/2008) of this paper, relevant calculations were performed to obtain design assumptions for the river-sea ships depending on length of a given corridor and its parameters as well as values of cargo flow rates. Below are given the example calculation results which made achieving rational solutions possible.

To determine searched decision variables the following values were assumed:

- in order to check conditions of the mathematical functional model of river-sea ship:
  - assumed period of repairs, inspections etc of river-sea ship: $t_{rm} = 30$ [days]
  - assumed cargo handling capacity of port: $Z_p = 2400$ [t/day].

- in order to determine the economic criteria:
  - for determination of the invested capital return period:
    - yearly interest rate of credit: i = 0.04 [%]
    - credit payback period: e = 7 [years]
  - for determination of current expenditures:
    - unit shipping rate: $f_{r,j}$ = 0.013 [€/t*km]
    - number of months of labour of one member of crew of river-sea ship: k_1 = 10 [month]
    - coefficient of repair and maintenance cost of river-sea ship: k_2 = 0.025 [-]
    - assumed fuel price: C_{pal} = 492 [€/t]
    - assumed specific fuel oil consumption during voyage: h^j_{pal} = 220 [g/kWh]
    - assumed calculation factor: q = 1.10 [-]
    - assumed port charge: β = 0.1 [€/t]
    - assumed cargo handling charge: χ = 0.02 [€/t]
    - mean monthly wage of one crew member of river-sea ship: w = 4000 [€]
    - required number of crew members: n_{zal} = 10 [persons].

On the basis of the performed analysis, assumed values and simplifying assumptions, results of the calculations for particular European water transport corridors were obtained. Three of the calculated variants are presented below.

Variant 1. Corridor: Dublin – Hull – Amsterdam – Frankfurt – Vienna – Bratislava – Budapest – Belgrade – Bucharest – Constanta – Istambul

Tab. 2. *Minimum number of ships necessary to cope with rate of cargo flow along the proposed river-sea corridor no. 1 [units]*

W = 7.43 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	513	419	357	312	279	253	232	215	200	188	178
10	419	344	294	258	232	211	194	180	169	159	151
12	357	294	253	223	200	183	169	158	148	140	133
14	312	258	223	197	178	163	151	141	133	126	121
16	279	232	200	178	161	148	138	129	122	116	111
18	253	211	183	163	148	137	127	120	113	108	104
20	232	194	169	151	138	127	119	112	107	102	98

Tab. 3. *Yearly profit per one ship operating in the proposed river-sea corridor no. 1 [mln €/year]*

W = 7.43 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-0.08	0.17	0.40	0.61	0.81	0.99	1.15	1.30	1.43	1.55	1.65
10	0.20	0.56	0.84	1.10	1.33	1.54	1.73	1.90	2.05	2.18	2.30
12	0.47	0.93	1.26	1.55	1.82	2.05	2.26	2.45	2.61	2.76	2.88
14	0.73	1.28	1.65	1.97	2.27	2.52	2.75	2.95	3.12	3.27	3.40
16	0.98	1.61	2.02	2.37	2.68	2.96	3.20	3.40	3.58	3.73	3.86
18	1.21	1.93	2.36	2.74	3.07	3.36	3.61	3.82	4.00	4.16	4.28
20	1.44	2.24	2.69	3.09	3.44	3.73	3.99	4.21	4.39	4.54	4.67

Tab. 4. *Capital return period for the proposed river-sea corridor no. 1 [years]*

W = 7.43 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-	35.97	15.58	10.54	8.28	7.02	6.22	5.68	5.31	5.04	4.85
10	23.32	10.73	7.41	5.89	5.04	4.50	4.13	3.88	3.70	3.57	3.47
12	10.14	6.44	4.96	4.17	3.69	3.38	3.16	3.01	2.90	2.83	2.78
14	6.57	4.67	3.78	3.28	2.96	2.75	2.60	2.50	2.43	2.38	2.35
16	4.92	3.70	3.09	2.73	2.50	2.35	2.24	2.17	2.12	2.09	2.07
18	3.96	3.09	2.63	2.36	2.18	2.07	1.98	1.93	1.89	1.87	1.87
20	3.33	2.67	2.31	2.09	1.95	1.86	1.79	1.75	1.73	1.72	1.71

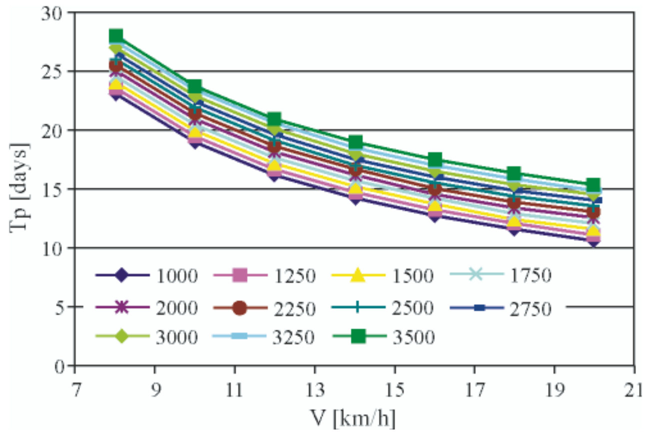

Fig. 5. *Shipping period in function of ship speed in the proposed river-sea corridor no. 1*

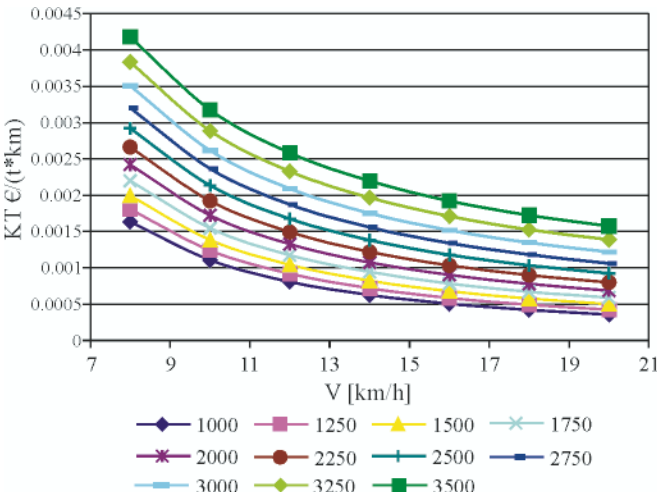

Fig. 6. *Unit shipping cost in function of ship speed in the proposed river-sea corridor no. 1*

Variant 4. Corridor: Dublin – Hull – Kiel – Świnoujście – Stockholm – Varkaus – Rybinsk

Tab. 5. *Minimum number of ships necessary to cope with rate of cargo flow along the proposed river-sea corridor no.4 [units]*

W = 3.08 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	218	177	150	130	116	105	95	88	82	77	72
10	177	144	123	107	95	86	79	73	68	64	61

W = 3.08 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
12	150	123	105	92	82	74	68	63	59	56	53
14	130	107	92	81	72	66	61	56	53	50	47
16	116	95	82	72	65	59	55	51	48	45	43
18	105	86	74	66	59	54	50	47	44	42	40
20	95	79	68	61	55	50	47	44	41	39	37

Tab. 6. *Yearly profit per one ship in the proposed river-sea corridor no.4 [mln €/year]*

W = 3.08 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-0.02	0.22	0.45	0.66	0.87	1.05	1.24	1.41	1.56	1.71	1.84
10	0.28	0.57	0.86	1.12	1.36	1.60	1.81	2.01	2.20	2.37	2.53
12	0.56	0.92	1.25	1.56	1.84	2.11	2.35	2.58	2.79	2.98	3.16
14	0.85	1.25	1.63	1.97	2.29	2.58	2.85	3.11	3.33	3.54	3.74
16	1.12	1.57	1.99	2.37	2.72	3.04	3.33	3.60	3.84	4.06	4.26
18	1.39	1.88	2.33	2.74	3.12	3.46	3.77	4.06	4.31	4.54	4.75
20	1.64	2.18	2.66	3.11	3.50	3.86	4.19	4.48	4.75	4.98	5.20

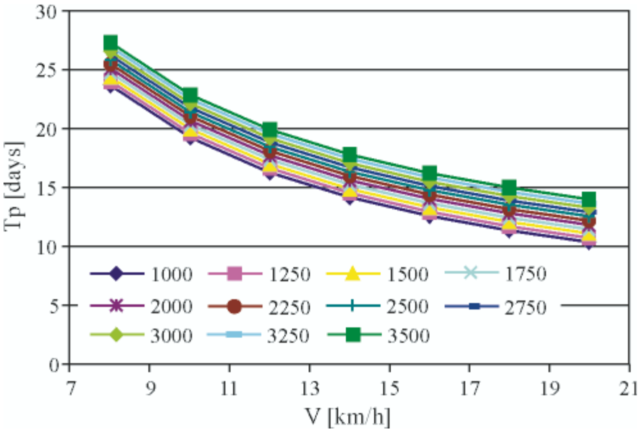

Fig. 7. *Shipping period in function of ship speed in the proposed river-sea corridor no.4.* **Source**: the author's elaboration

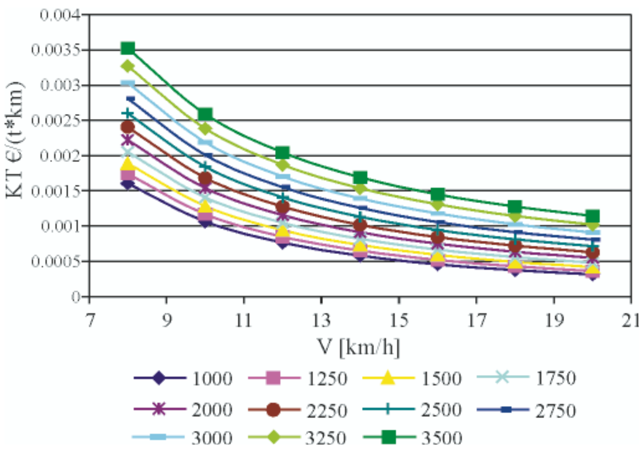

Fig. 8. *Unit shipping cost in function of ship speed in the proposed river-sea corridor no.4.* **Source**: the author's elaboration

Tab. 7. *Capital return period for the proposed river-sea corridor no. 4 [years]*

W = 3.08 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-	23.09	11.78	8.26	6.54	5.54	4.88	4.42	4.09	3.84	3.64
10	17.28	8.72	6.12	4.86	4.13	3.66	3.32	3.08	2.90	2.76	2.65
12	8.45	5.46	4.19	3.50	3.07	2.77	2.56	2.41	2.29	2.20	2.13
14	5.65	4.01	3.22	2.76	2.47	2.26	2.11	2.00	1.92	1.85	1.80
16	4.28	3.20	2.64	2.30	2.08	1.92	1.81	1.73	1.66	1.61	1.58
18	3.46	2.67	2.25	1.99	1.81	1.69	1.60	1.53	1.48	1.44	1.42
20	2.92	2.31	1.97	1.76	1.61	1.51	1.44	1.39	1.34	1.32	1.29

Variant 10. Corridor: Hull - Paris

Tab. 8. *Minimum number of ships necessary to cope with rate of cargo flow along the proposed river-sea corridor no. 10 [units]*

W = 1.50 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	22	18	16	14	13	12	11	11	10	10	9
10	18	16	14	12	11	11	10	9	9	9	8
12	16	14	12	11	10	9	9	9	8	8	8
14	14	12	11	10	9	9	8	8	8	7	7
16	13	11	10	9	9	8	8	7	7	7	7
18	12	11	9	9	8	8	7	7	7	7	6
20	11	10	9	8	8	7	7	7	7	6	6

Tab. 9. *Yearly profit per one ship in the proposed river-sea corridor no. 10 [mln /year]*

W = 1.50 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-0.28	-0.15	-0.07	0.00	0.04	0.07	0.08	0.07	0.04	0.00	-0.05
10	-0.07	0.08	0.18	0.25	0.29	0.32	0.32	0.30	0.27	0.23	0.17
12	0.13	0.28	0.39	0.47	0.51	0.53	0.53	0.51	0.46	0.41	0.34
14	0.29	0.46	0.58	0.66	0.71	0.72	0.71	0.68	0.63	0.56	0.49
16	0.46	0.63	0.76	0.83	0.88	0.88	0.87	0.83	0.77	0.70	0.61
18	0.61	0.79	0.91	0.99	1.02	1.03	1.00	0.96	0.89	0.82	0.72
20	0.75	0.93	1.05	1.13	1.15	1.15	1.13	1.07	1.00	0.91	0.81

Tab. 10. *Capital return period for the proposed river-sea corridor no. 10 [years]*

W = 1.50 [mln t /year]											
V [km/h]	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
8	-	-	-	-	-	-	-	-	-	-	-
10	-	-	29.72	21.83	19.08	18.31	18.76	20.35	23.42	29.08	-

V [km/h]	W = 1.50 [mln t /year]										
	M_{lad_i} [t], i = 1÷11										
	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
12	-	18.07	13.43	11.66	11.00	10.95	11.37	12.24	13.68	15.97	19.75
14	16.05	10.82	9.00	8.26	8.02	8.12	8.49	9.13	10.12	11.58	13.81
16	10.41	7.92	6.94	6.55	6.47	6.62	6.96	7.49	8.27	9.38	11.00
18	7.85	6.36	5.75	5.53	5.53	5.69	6.01	6.48	7.14	8.06	9.37
20	6.40	5.38	4.97	4.84	4.89	5.06	5.36	5.79	6.38	7.18	8.30

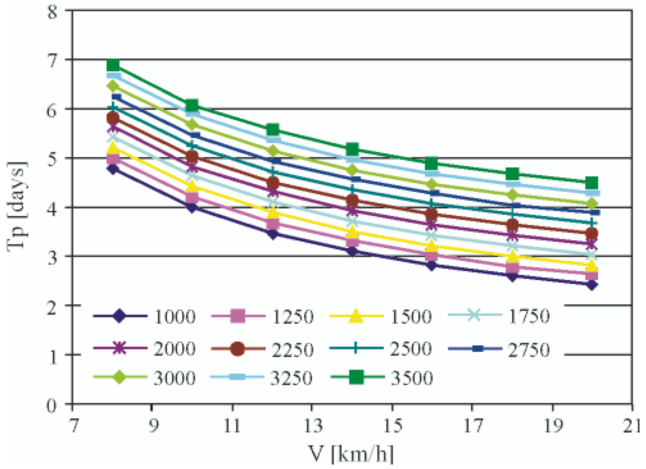

Fig. 9. Shipping period in function of ship speed in the proposed river-sea corridor no. 10

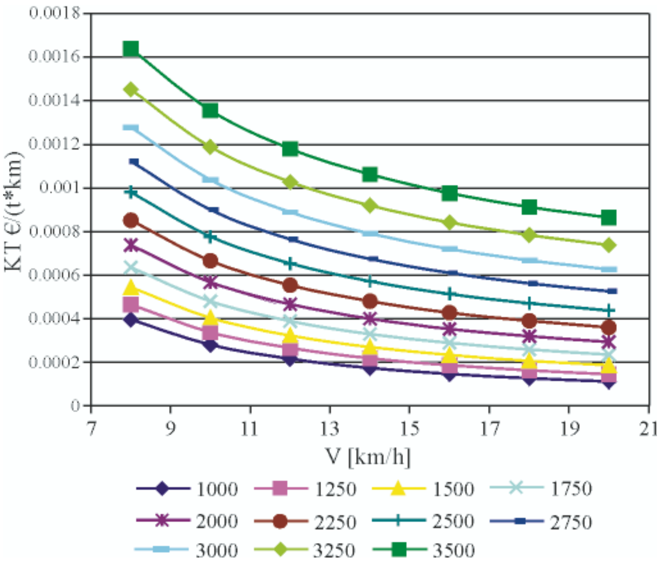

Fig. 10. Unit cost in function of ship speed in the proposed river-sea corridor no. 10

CONCLUSIONS

In the above presented tables is shown the influence of the SRM fleet's speed and deadweight on limits of areas of permissible solutions for the fleet of such ships necessary for servicing the analyzed cargo flows. The following parameters have significant impact on number of the ships:

- length of shipping route
- cargo handling capacity of ports.

On the basis of the investigations performed for 10 proposed river-sea corridors the rational variants of the SRM fleet with a view of economic criteria were achieved (Fig. 11).

The performed simulation investigations made it possible to draw the following conclusions:

- In the case of the shortest routes a weak dependence of necessary number of ships on their cargo carrying capacity can be observed.
- For the longest routes a significant decrease of number of necessary ships along with increasing their cargo carrying capacity can be observed.

The main aim of shipowner is to find ways for reaching possibly large profits at possibly low investment outlays. However to predict either short- or long- term costs and profits for river-sea ships is difficult. This is caused by changeability of main cost-generating factors which mainly depend on situation on the market and are very hard to be predicted for whole ship service period.

In this work the influence of fuel oil cost and freight rate on capital return period for 10 optimum solutions of the functional model of the SRM fleet was analyzed. It was assumed that changes in fuel oil price and freight rate amount to 15%. The performed investigations made it possible to draw the following conclusions:

- the fuel oil price change within 15% range does not influence the capital return period significantly
- further increase of the fuel oil price results in an insignificant increase of the capital return period
- the freight rate change very much influences the capital return period, resulting either in its lengthening or shortening, that was shown in Fig. 12.

The analysis performed by means of the elaborated functional model of river-sea ships intended for operating in the system of European water transport corridors can be concluded by the following statements:

- The direct cargo shipping on sea-river or river-sea routes makes it possible to achieve some profits which lead to:
  - decreased investment outlays by about 8÷14 % (due to a lower number of ships by a better usage of their cargo shipping capability resulting from elimination of ship lying periods in intermediate ports)
  - decreased cargo handling costs even by 30% (due to elimination of intermediate ports).
- The analysis of the functional model of river-sea ships with taking into account relevant limitations and criteria makes it possible to obtain a set of the best solutions which can increase profits of ship operators on the water transport market by 3 ÷ 7 %, or avoid choice of an unprofitable variant.
- Regardless of physical and geographical limitations associated with a navigation region the task assigned to a given ship and its parameters are important.
- The neglecting of the functional model can result in an incorrect adjustment of number of ships, their speed and deadweight values to traffic capacity of river-sea routes and - in consequence - capital return periods longer even several times.
- Investigations with the use of the functional model make it possible to increase the probability of compatibility of ship design assumptions with real state of transport market, at least by 21 ÷ 28 %, as it results from the performed transport development prediction up to 2015 and 2030. It can be stated that the neglecting of the predictions would result in a proportional incompatibility of ship design assumptions with real state of transport market.

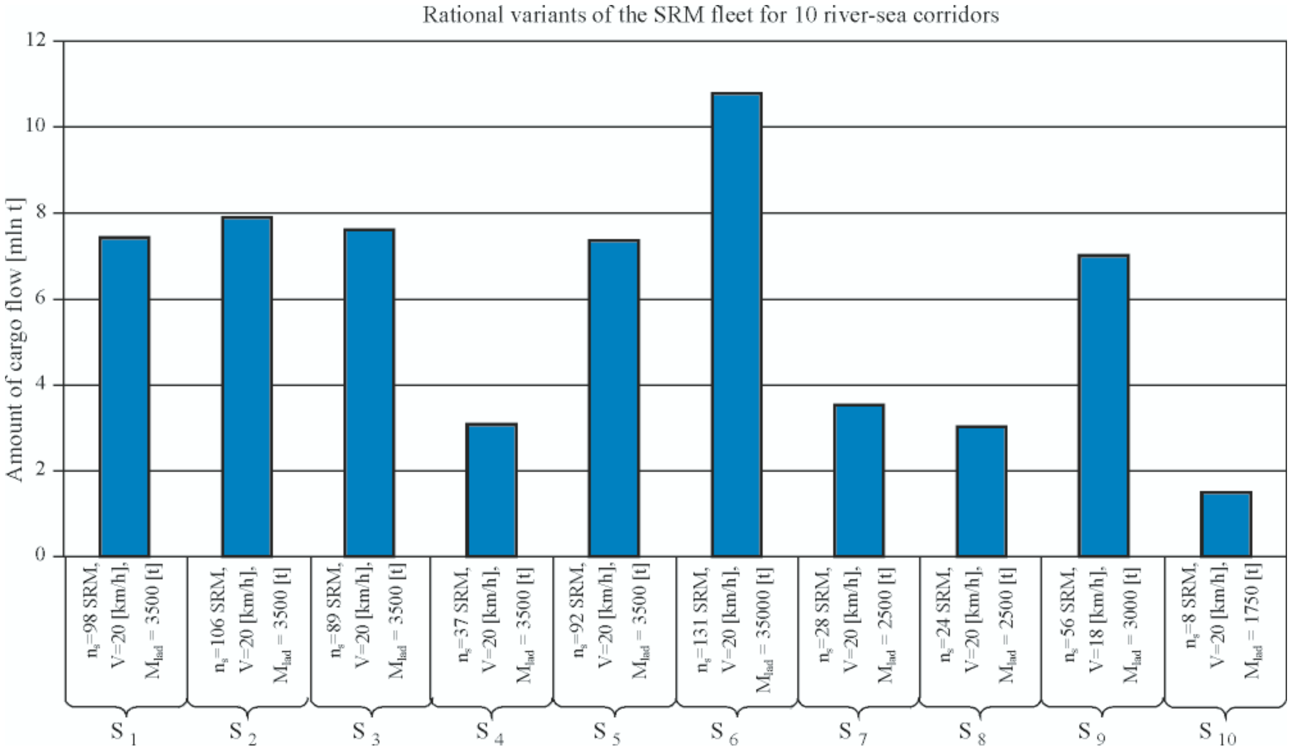

Fig. 11. *Rational variants of SRM fleet for particular shipping corridors with a view of economic criteria*

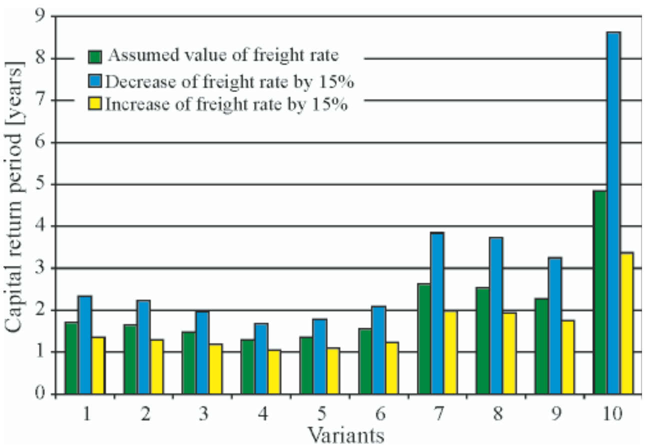

Fig. 12. *Influence of freight rate change on capital return period*

BIBLIOGRAPHY

1. Charlier J. & Ridolfi G.: *Intermodal transportation in Europe: of modes, corridors and nodes*. Maritime Policy and Management, 21 (3), 1994
2. Kaup M.: *Importance of river-sea fleet for development of the Baltic Sea region* (in Polish). Materials of 2nd International Scientific Conference on „ Operation of the Polish Liner and Ferry Fleet in 2004", Szczecin 2004
3. Kaup M., Kaup J.: *Design model of river-sea ships operating on European waterways*. Marine Technology Transactions, Vol.16, Polish Academy of Sciences – Branch in Gdańsk, Gdańsk 2005
4. Kaup M.: *Functional model of river-sea ships operating in European system of transport corridors. Part I. Methods used to elaborate functional models of river-sea ships operating in European system of transport corridors.* Polish Maritime Research, 3/2008 (57), Vol. 15, Gdańsk, 2008, p. 3-11
5. Kreutzberger I.E.: *Innovative networks and new-generation terminals for intermodal transport*, 1999
6. Tarnowski W.: *CAD CAM computer aiding. Essentials of technical design* (in Polish). Scientific Technical Publishers (Wydawnictwo Naukowo-Techniczne), Warszawa 1997.

CONTACT WITH THE AUTHOR

Magdalena Kaup, Ph. D.
Faculty of Marine Technology
Szczecin University of Technology
AL. Piastów 41,
71-065 Szczecin, POLAND
e-mail: mkaup@ps.pl
phone: (091) 449 - 47 - 50