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Shapes' Optimisation using Numerical Naval Hydrodynamics of a Ro-Ro Double Ferry with Electric Propulsion to cross the Danube

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ABSTRACT

One of the crucial problems of the 21st century is pollution. Regarding a low carbon footprint, efforts are being made through research, to minimise fuel gas emissons. Through the powers established for propulsion and the fossil fuels used, ships are some of the most toxic human inventions .Scientists, in many European countries and beyond, are developing studies either to reduce emissions from propulsion engines or to design body shapes of ships with low forward resistance and to find electric propulsion solutions. This paper carries out studies of naval hydrodynamics to find body shapes that generate the lowest resistance to advance. Thus, using hydrodynamic observations and with the help of the NUMECA calculation program, two different hulls are studied in order to establish the optimal shape with the lowest forward resistance. Furthermore, acknowledging the limited aquarium of the inland waters, an important aspect to be approach is the size of the waves, as well as their length. In order not to cause damage to existing shores and facilities, the waves produced by the floating body must have minimum heights and wavelengths.

Keywords: computational fluid dynamics, hydrodinamic problems, innovative ship design.

1. INTRODUCTION

Accomplished with special ships, inland navigation accounts for approximately 18% of the total amount of goods transported worldwide. The crossing of Romanian waters, in the absence of the bridges over the Danube River, is realised with the help of some Ferry type ships of various sizes, but all propelled by over 20 years old engines that consume fossil fuels. In order to reduce pollutant emissions, according to the latest European norms, these ships will be abandoned in time, and the clean ones will come out in their place.

Adopting two body shapes, numerical hydrodynamics studies will be performed in this paper to determine the optimal hull examining the resistance to advance and the specific wave sizes.

Another important feature of these two concepts is that they are designed to be double ended. This has been adopted so that the mooring maneuvers be simple and can be carried out in a minimum amount of time. This also leads to minimal port delays, which involves low operating costs.

2. CHOOSING THE HULL SHAPE

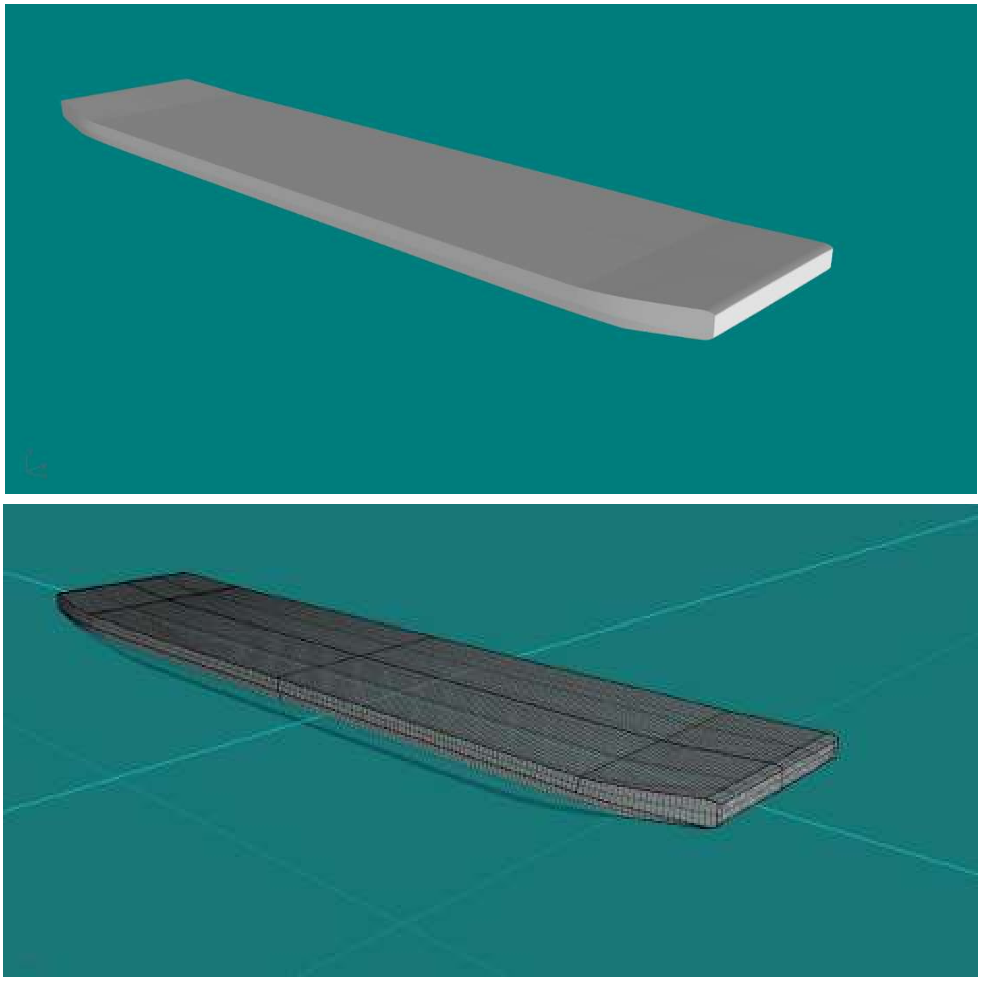
The figures show both the quotient for a single-hulled and double-hulled ship (catamaran) and their isometries.

The chosen forms for the hydrodynamic studies are conceived iteratively by consecutive modifications of existing inland ships.

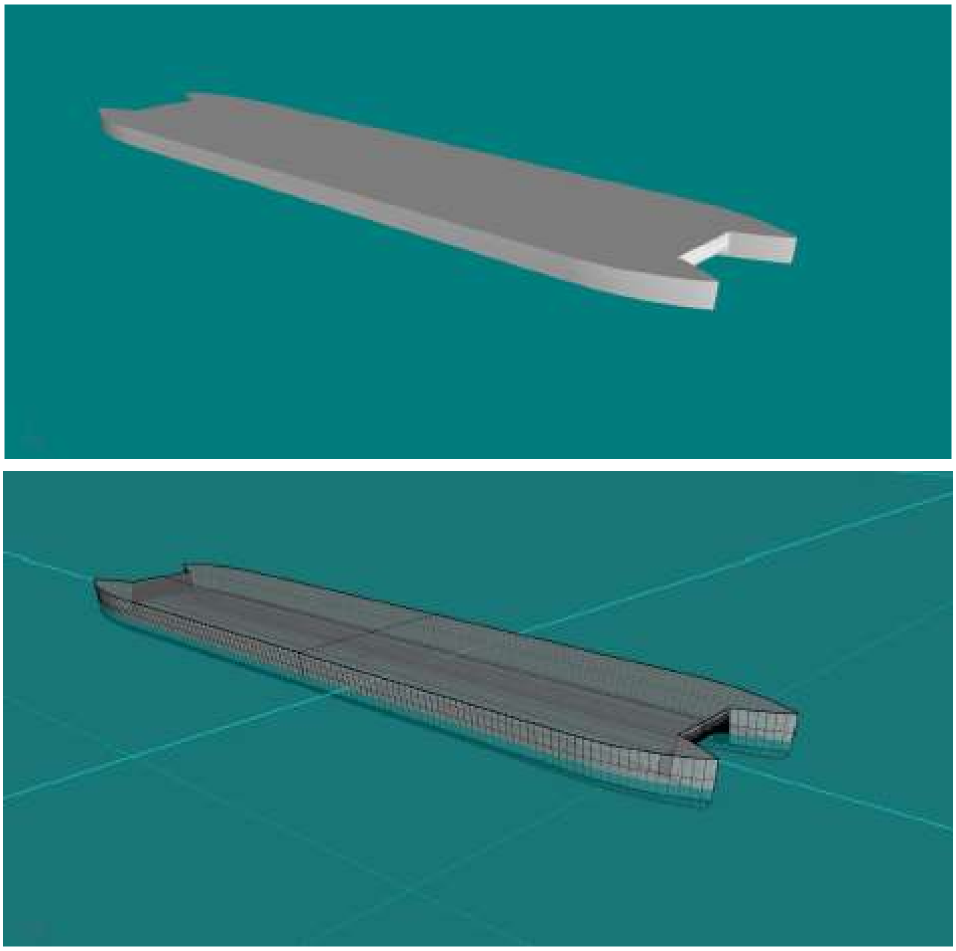
The changes were made using the Rhinoceros program.

The two forms resulted from the modifications are presented in Figure 1.

The main dimensions of the two body shapes were chosen to be identical and are presented in Table 1.



a) Monohull



b) Double hull (catamaran)

Fig. 1 Hull concept

Table 1. Main dimension and characteristics

Length over all	55 m
Length car deck	55 m
Maximum breadth	12 m
Depth	3 m
Draught	1,5 m
Speed	10 kn
Passengers	100
Car equivalent (4,30x1,65m)	44

3. USE OF NUMERICAL METHODS, OF NAVAL HYDRODYNAMICS, FOR CHOOSING THE OPTIMAL SHAPE OF THE FERRY SHIP

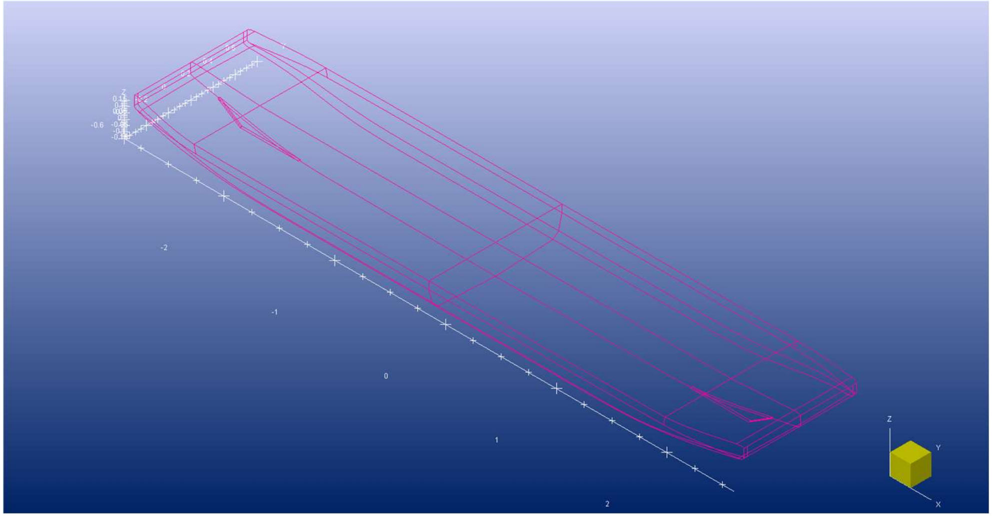
For the calculation of the forward resistance and of the wave fronts produced by the considered body shapes, the NUMECA calculation program was used.

In order to estimate the forward resistance for the two hulls, they were discretised. In Figure 2, there are the two discretised bodies ready to be calculated.

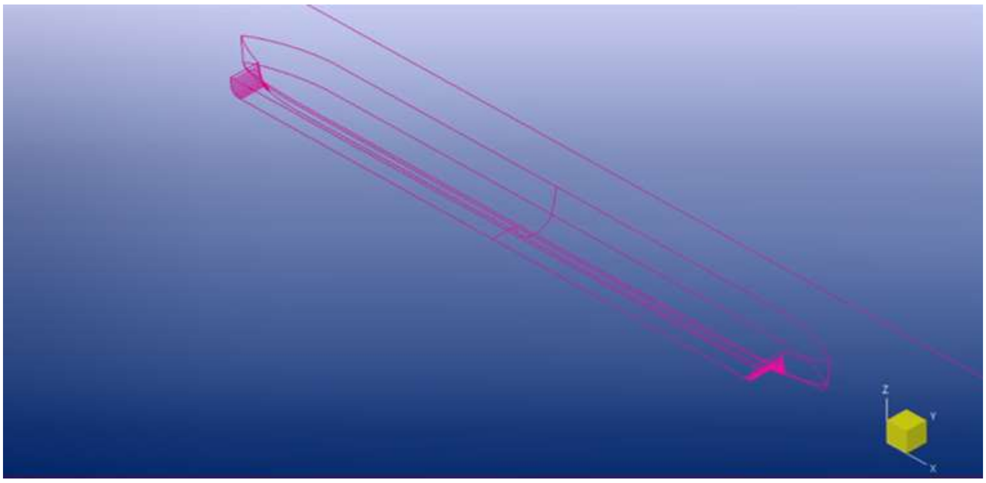
Along these lines, using the Fine^{TM}/ Marine, the fluid flow around the two hulls was captured. The C-Wizard module was run to configure the calculation matrices for various velocities and angles of flow of the fluid stream.

After entering all the data necessary for the calculations, the two body types for the Ferry were carried, obtaining the results for the forward resistance presented in the graphs in Figure 3.

The wave fronts produced by the two body shapes are shown in figure 4.

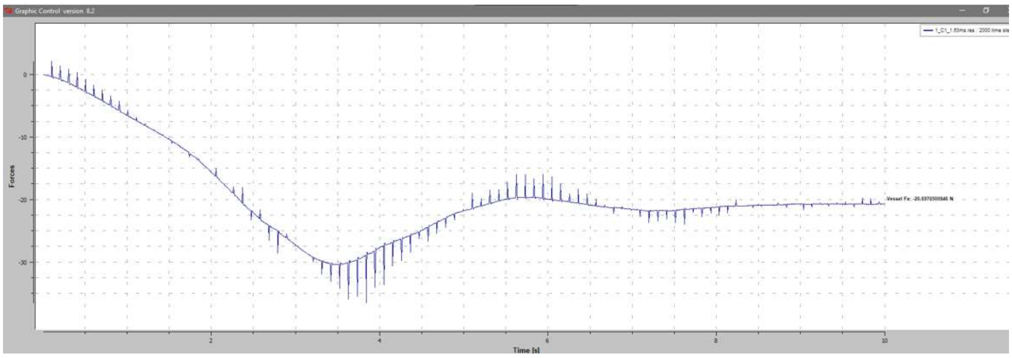


a) Monohull

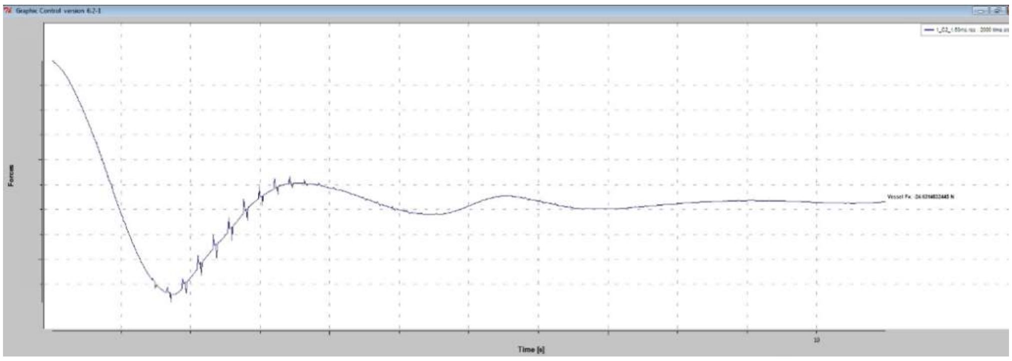


a) Double hull

Fig. 2 Hull discretisation

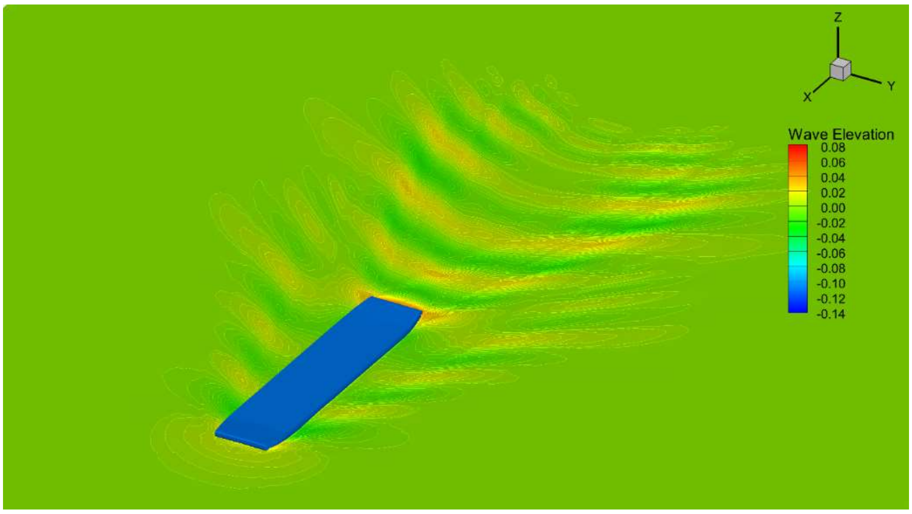


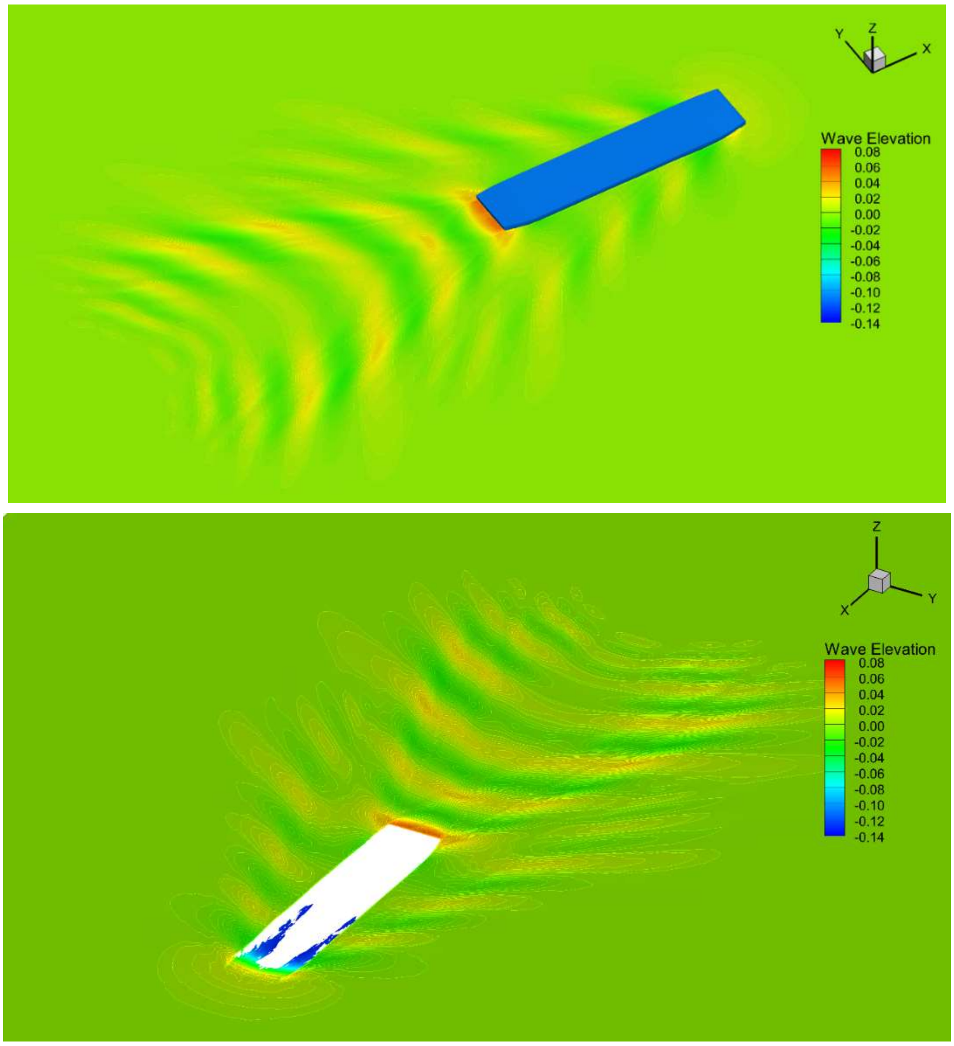
a) Monohull



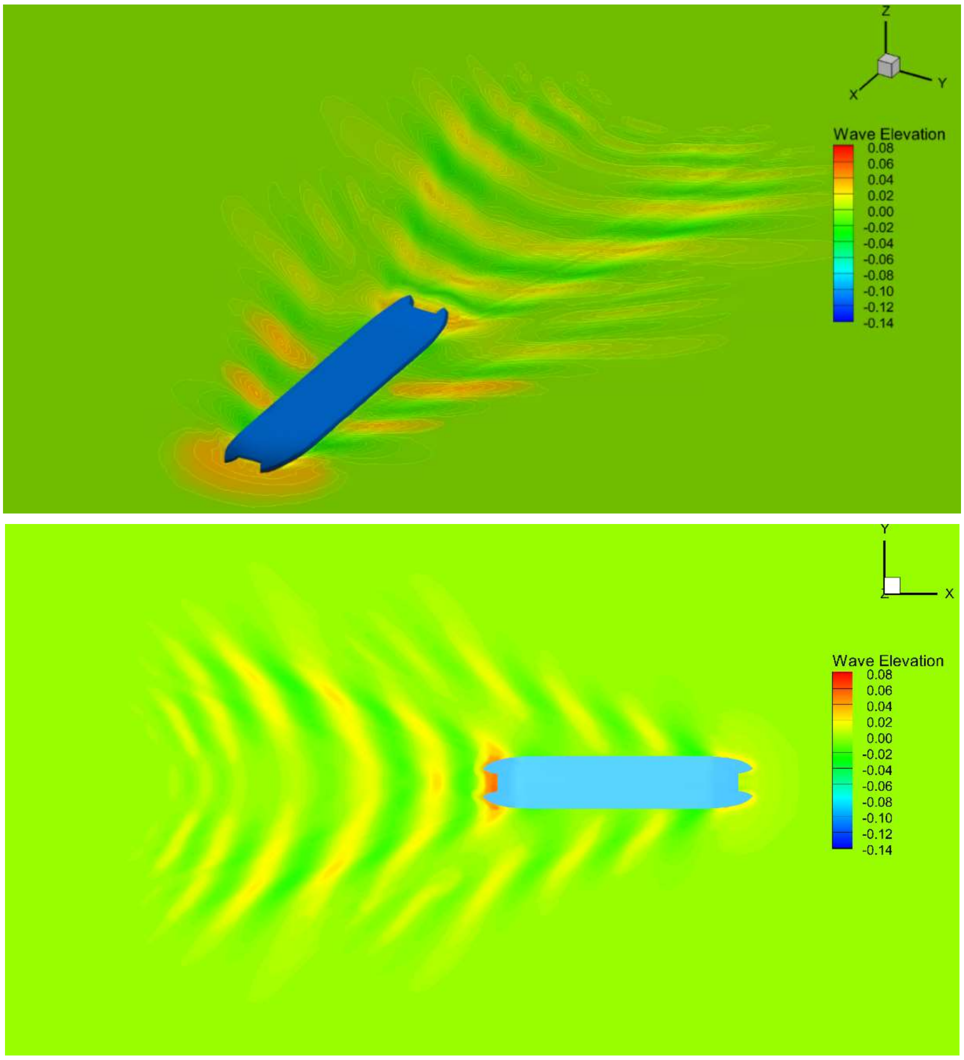
a) Double hull

Fig. 3 Forward resistance




Y
Z
X
Wave Elevation
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
Z
X
Y
Wave Elevation
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14

a) Monohull



a) Double hull

Fig. 4 Wave fronts

4. CHOOSING THE OPTIMAL SHAPE FOR THE BODY OF THE FERRY

From the analysis of the results obtained in Table 2, the forward resistances for the both hulls are presented.

Table 2.

Hull shape	Forward resistance [N]	Maximum wave height [m]
Monohull	20.691	0.050
Double hull	24.631	0.062

Consequently, it can be remarcked that the ship with a single-body hull has the best characteristics both in terms of forward resistance and maximum wave height.
Following these analyses, it will also be possible to identify the wave front produced in the form chosen for the Ferry.

5. CONCLUSIONS

Numerical analyses using CFD methods showed that the optimal solution for the Danube waterways is a monohull double ended ferry. Besides, this design has also a great technological advantage. The body is much easier to build, generally consisting of rigged surface.
Regarding both the load capacity and the electric propulsive system, this concept encapsulates the future itself of this kind of floating bodies.

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