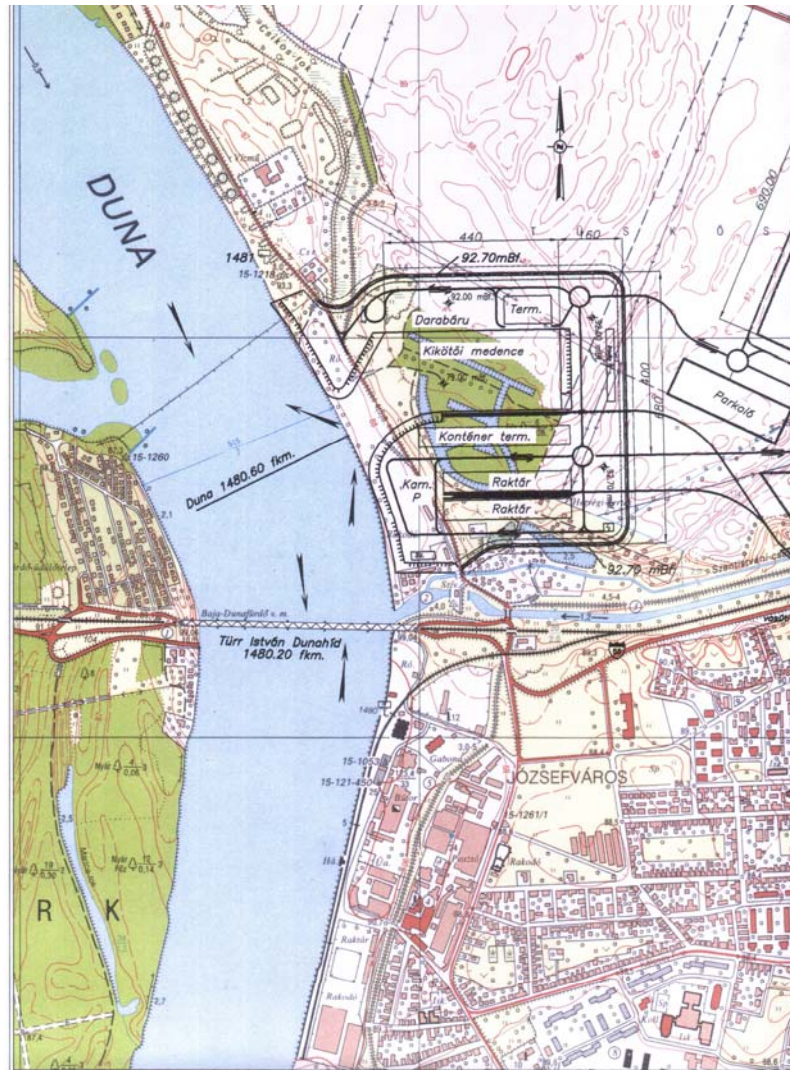


2D Simulation of inland vessel manoeuvrings

MAIF 5. Conference, Budapest



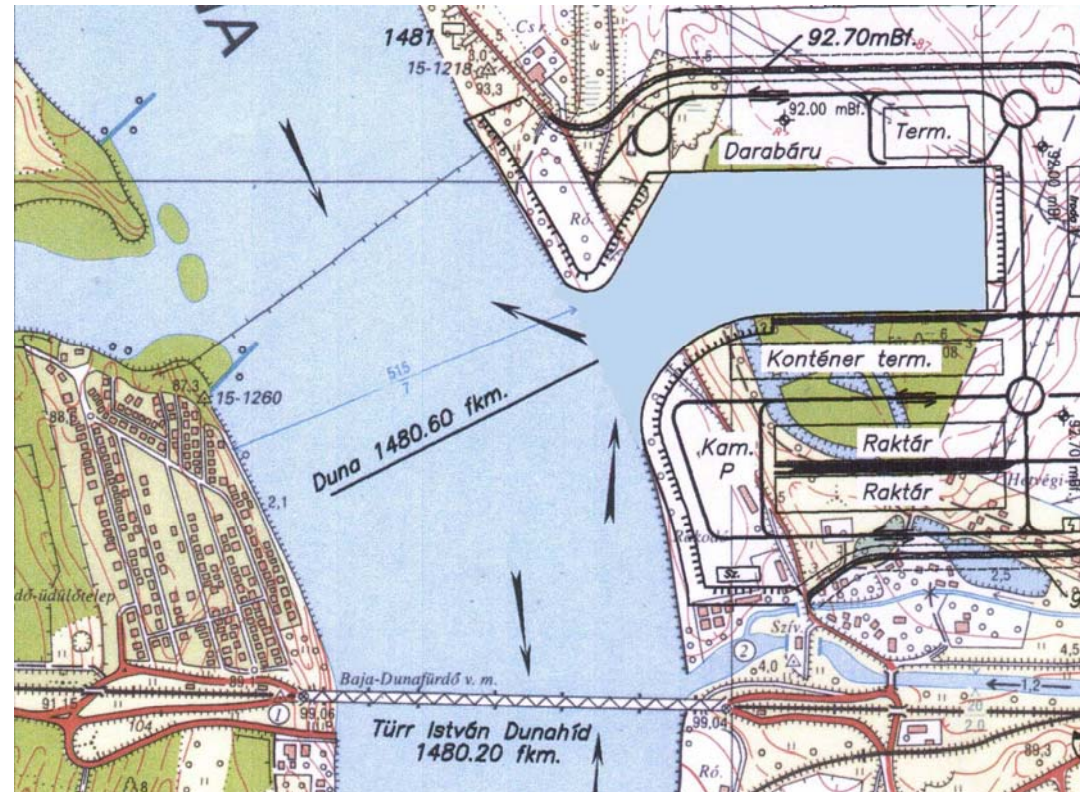
By:

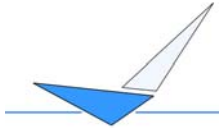
**Budapest University of Technology
and Economics**
Department of Aircraft and Ships



Contents

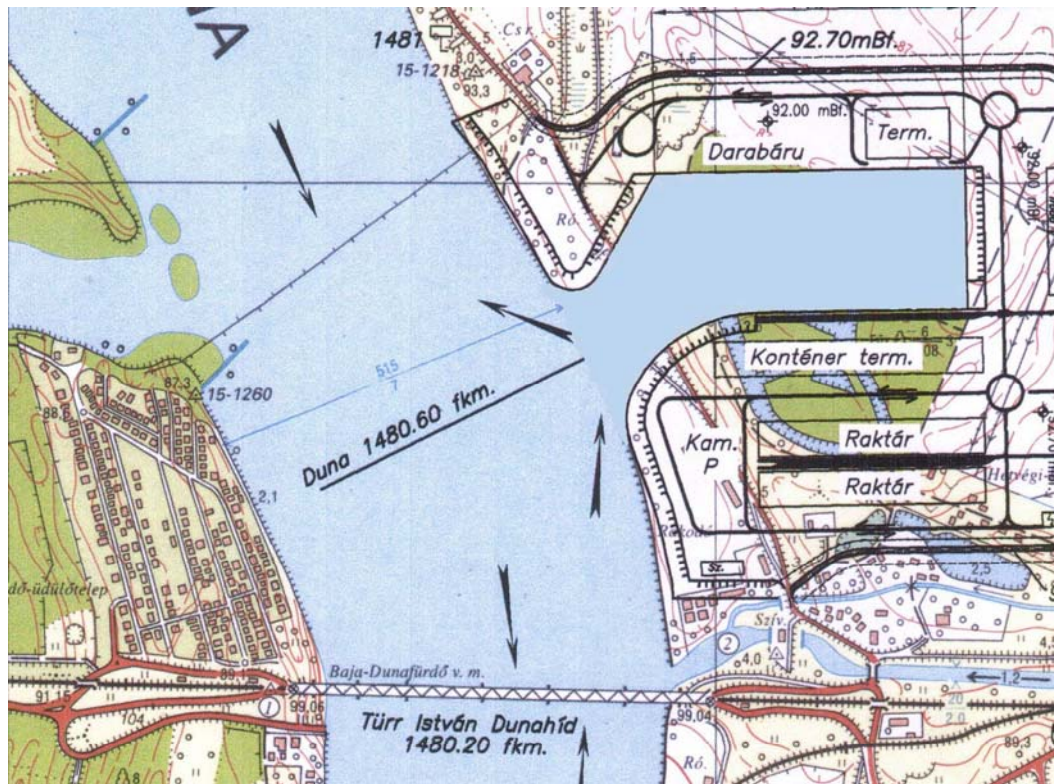
1. Objective
2. Methodology
3. Selection of test ship
4. Motion equations
5. Environmental conditions
6. Program structure
7. Validation
8. The simulation program
9. Summary





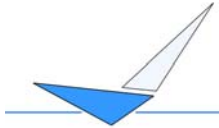
1. Objective

Research on the navigability of newly-designed basin of Baja International Port



The problem:

Main stream seems to be too close to the basin opening



2. Methodology

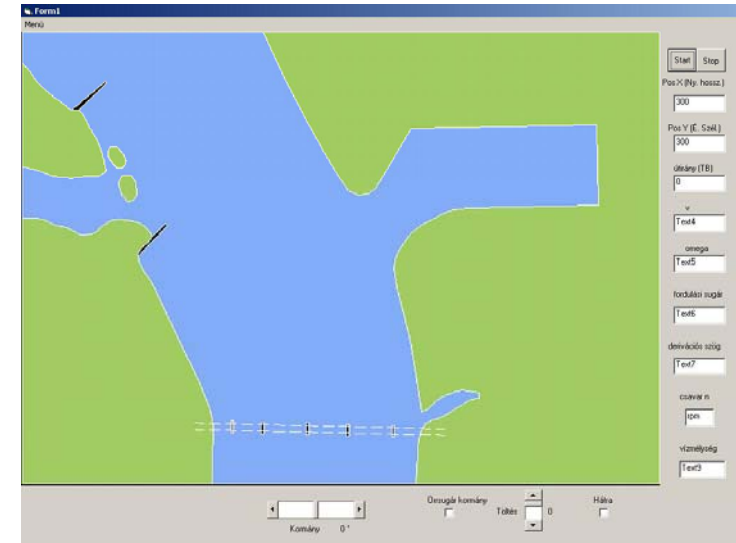
Research possibilities:

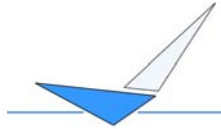
Model testing

- Ship and river test together
- Ship and river test separately



2D Computer simulation





General Inspectorate of Transport:
representative ship with a minimum
dimensions of

Length:	110m
Breadth:	11.4m
Draft:	2.5m

3. Selection of test ship



No available detailed design
documentation for such a vessel

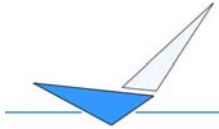
Theoretical test vessel design



3. Selection of test ship

Main dimensions of the accredited, fictive self propelled single screw vessel:

Length between perpendiculars:	110,00 m
Breadth:	11,4 m
Depth:	2,90 m
Max. draft:	2,50 m
Min. draft:	0,80 m
Displacement by 2,50 m draft:	2853 t
Displacement by 0,80 m draft:	847 t
Dead weight capacity:	1800 t
Main engine:	MTU 12 V 4000 M60
power:	1320 kW
nominal speed:	1800 1/min
Rudder:	three blade Jenckel rudder + bow thruster



4. Motion equations

Simplification by inland vessels:

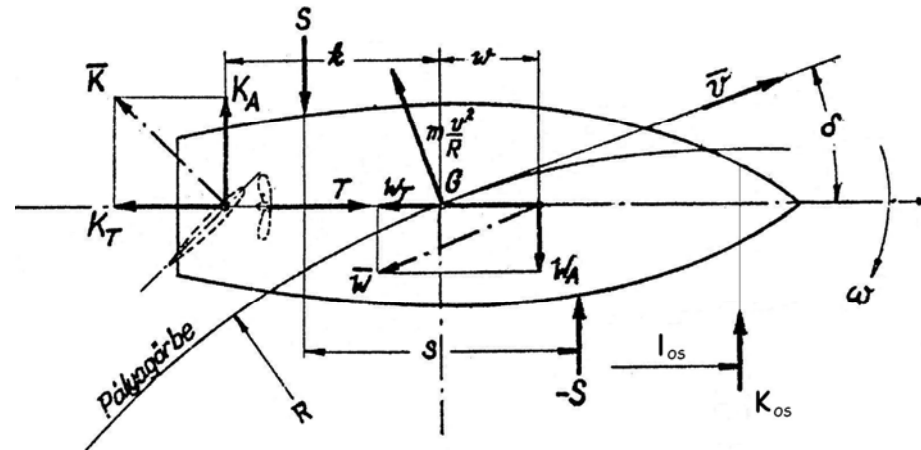
- No pitch
- No dipping
- No heeling

Motion equations:

$$m \frac{dv_x}{dt} + m \varpi_z v_y = \Sigma F_x$$

$$m \frac{dv_y}{dt} - m \varpi_z v_x = \Sigma F_y$$

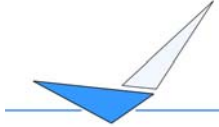
$$\theta_z \frac{d\varpi_z}{dt} = \Sigma M_z$$



$$m \frac{av_x}{dt} = -m \frac{a\delta}{dt} v_y + T - K_x - R_x + W_x$$

$$m \frac{dv_y}{dt} = m \frac{d\delta}{dt} v_x + K_y - R_y + W_y + K_{OS}$$

$$\theta_z \frac{d^2\delta}{dt^2} = -K_y \cdot k + R_y \cdot r - W_y \cdot w - K_{OS} \cdot l_{OS}$$



4. Motion equations

Forces acting on the ship:

$$T = c_T^* \frac{\rho_{v\acute{z}}}{2} \left[((1-w)v)^2 + (0,7D\pi \cdot n)^2 \right] \frac{\pi}{4} D^2$$

$$K_x = c_{Kx}(\alpha) \frac{\rho_{v\acute{z}}}{2} \left((1-w)v \cdot \sqrt{1 + \frac{T}{\frac{\rho_{v\acute{z}}}{2} \frac{D^2 \pi}{4} (1-w)v}} \right)^2 A_{korm}$$

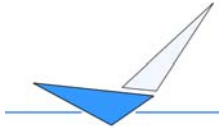
$$K_y = c_{Ky}(\alpha) \frac{\rho_{v\acute{z}}}{2} \left((1-w)v \cdot \sqrt{1 + \frac{T}{\frac{\rho_{v\acute{z}}}{2} \frac{D^2 \pi}{4} (1-w)v}} \right)^2 A_{korm}$$

$$W_x = c_{Szx} \frac{\rho_{leveg\ddot{o}}}{2} v_{sz\acute{e}l}^2 \cdot A_{sz\acute{e}lx}$$

$$W_y = c_{Szy} \frac{\rho_{leveg\ddot{o}}}{2} v_{sz\acute{e}l}^2 \cdot A_{sz\acute{e}ly}$$

$$R_x = \frac{R_t}{1-t}$$

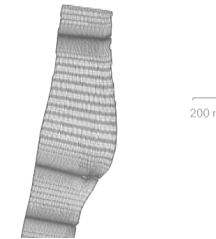
$$R_y = \frac{\rho_{v\acute{z}}}{2} c_{lat} \int_0^{L_{wl}} \left[v_y + (x - x_g) \frac{d\delta}{dt} \right]^2 A_{lat}(x) \cdot dx$$



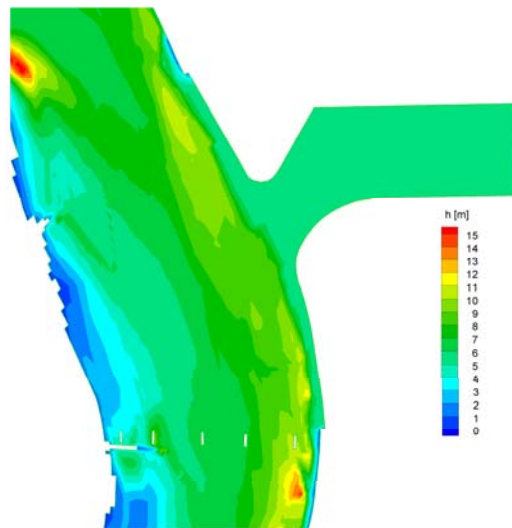
5. Environmental conditions

Wind → as wind force on ship, see before

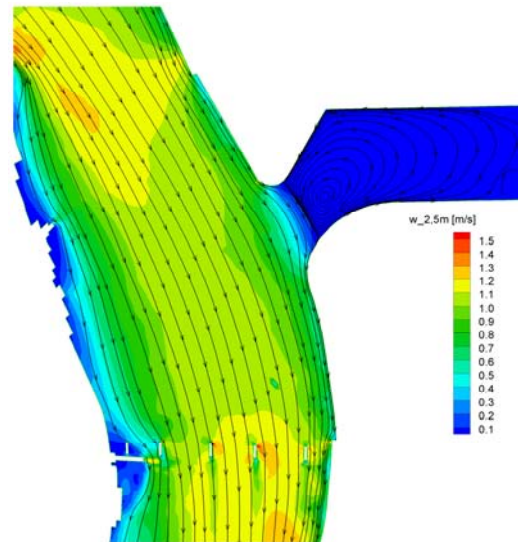
Stream of Danube → as stream data net
(v_x , v_y , depth)



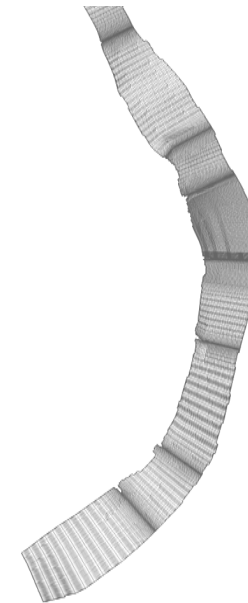
Department of Hydraulic
and Water Resources
Engineering

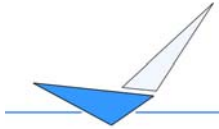


Water depth



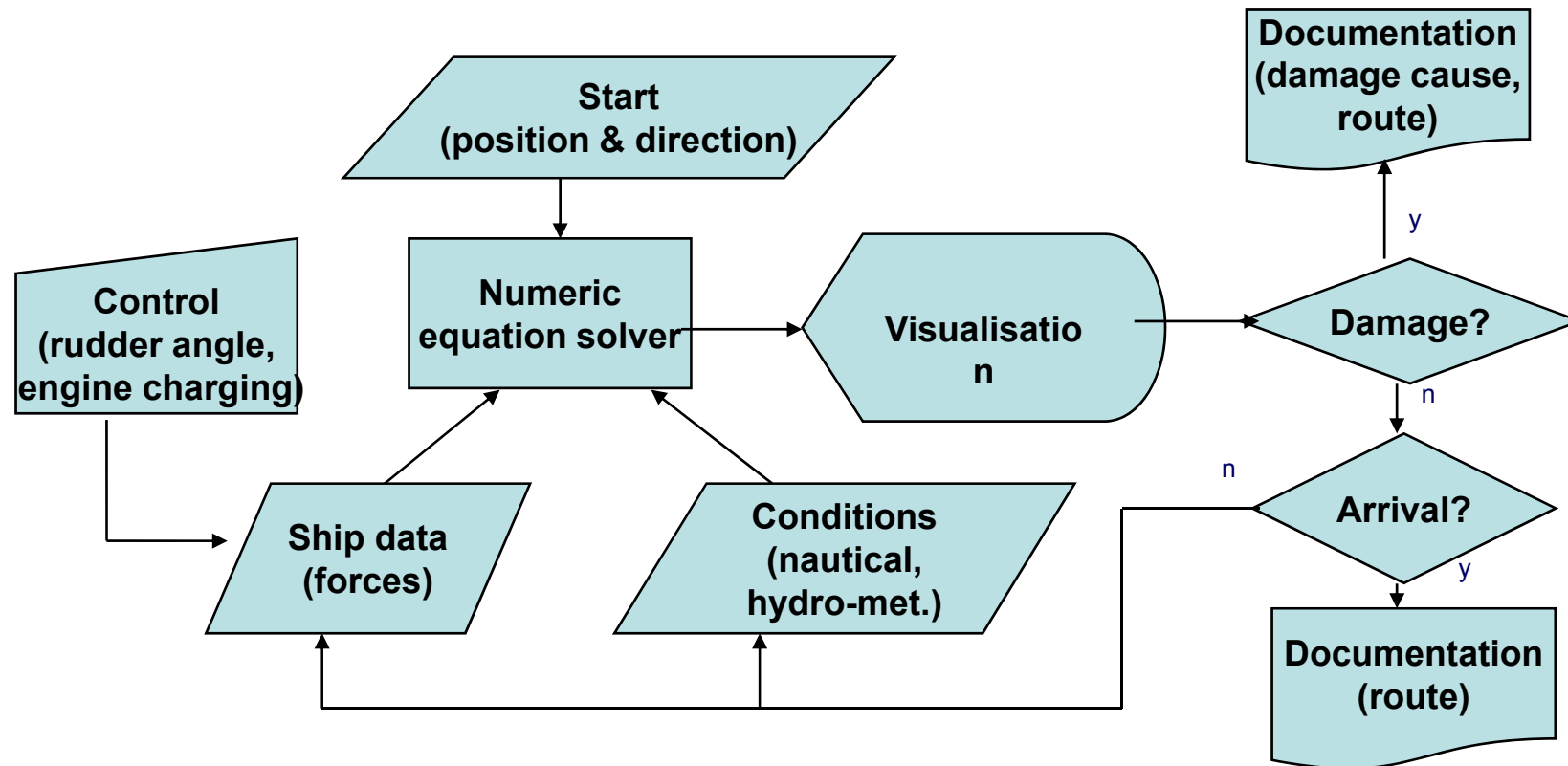
Flow speed

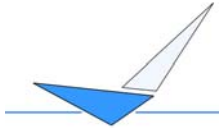




6. Program structure

Flow chart of the program:

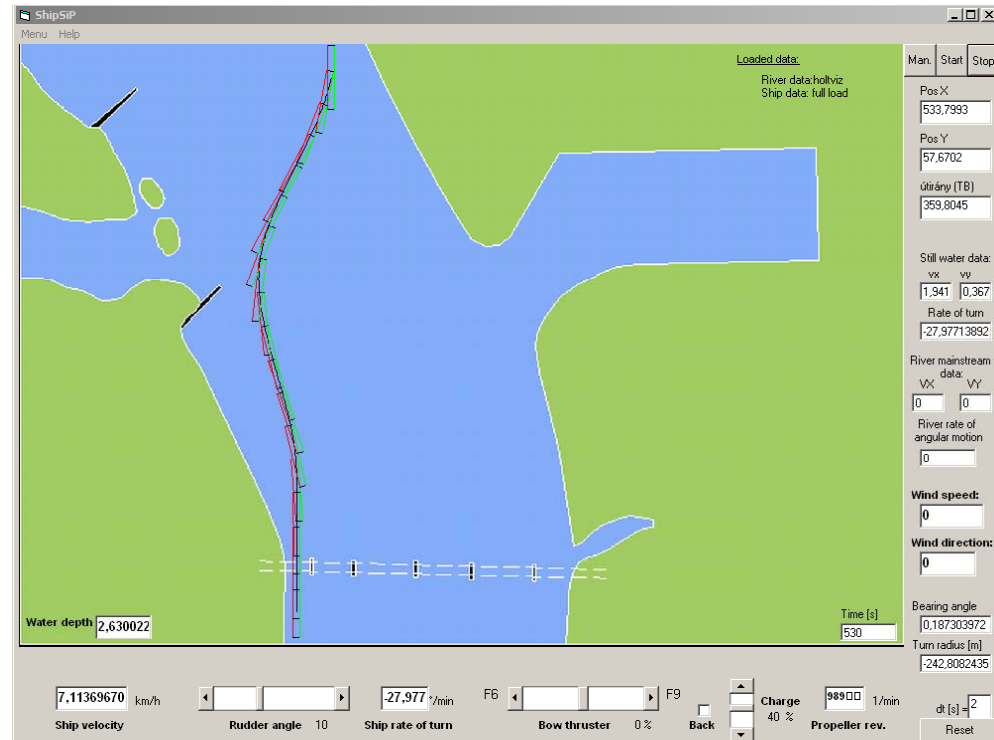




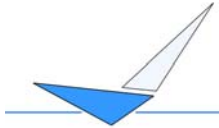
7. Validation

by zig-zag test results

by nautical experts and captains



	Ship speed [km/h]	Rudder angle [°]	Course angle [°]	Max.turning speed [°/min]	Overshoot angle [°]	Course max. side distance [m]
Same length caravan test results	7.2	20	10	30	6	50
2D ship model	7.19	20	10	34	9	78



8. The simulation program

Loading of data for wind, water level, and ship's load cases

The image displays two screenshots of a simulation software interface. The left screenshot shows the main window 'Form1' with a menu bar containing 'Betöltés', 'Folyóadatok', 'Paraméterek', and 'Hajóadatok'. The right screenshot shows the same window with a 'User controls' dialog box open, displaying various input fields for ship and environmental parameters. A 'Mehet!' dialog box is also visible in the right screenshot.

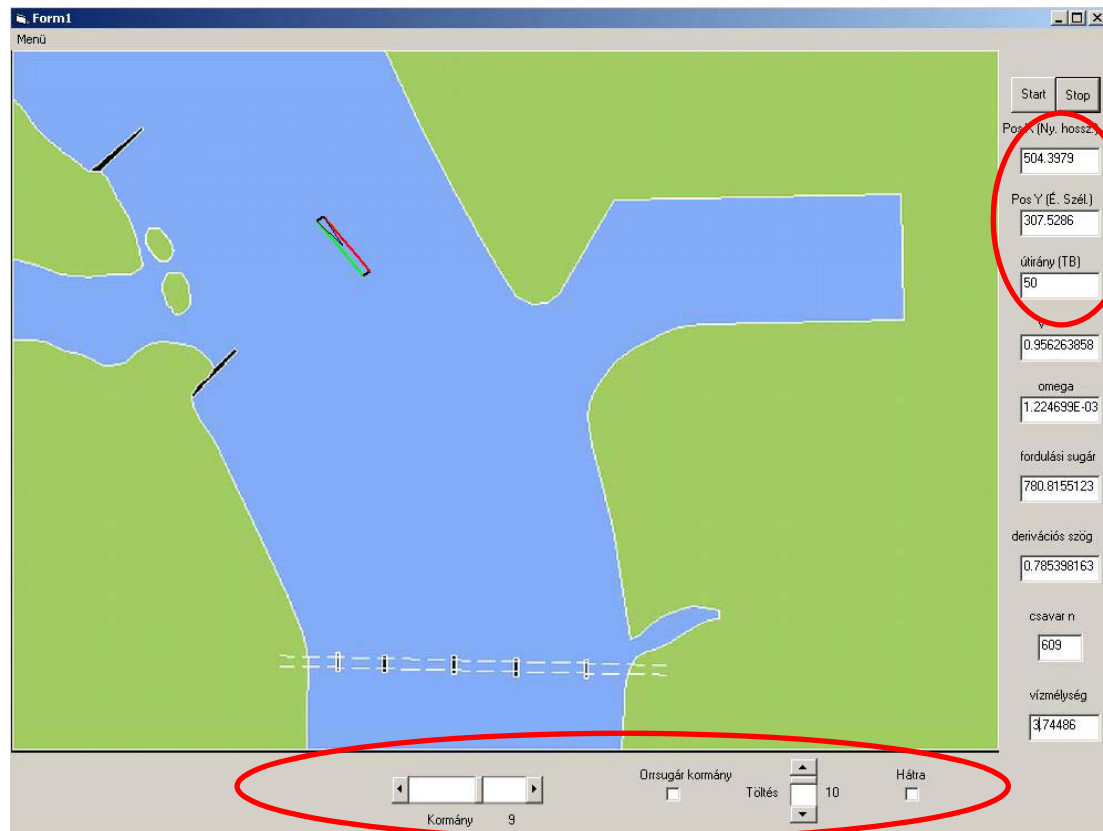
Bemenő adatok		Kimenő adatok	
Hossz ellentállás	16000	Hajóhossz	110
Kereszt ellentállás	20	Hajószélesség	11.4
Hossz szélerő	0	Merülés	2.5
Kereszt szélerő	0	Súlypont tartól	55.14
Tolórő	1864	Laterál kar	0.07
Hossz kormányerő	1568	Kormány kar	53.36
Kereszt kormányerő	883	Szél kar	5.2
Órrugárkom. erő	10000	Órrugárkom. kar	52.14
Tehetlenségi ny.	2305014	Hajótömeg	2853023
		Motortöltés	15



8. The simulation program

Starting position

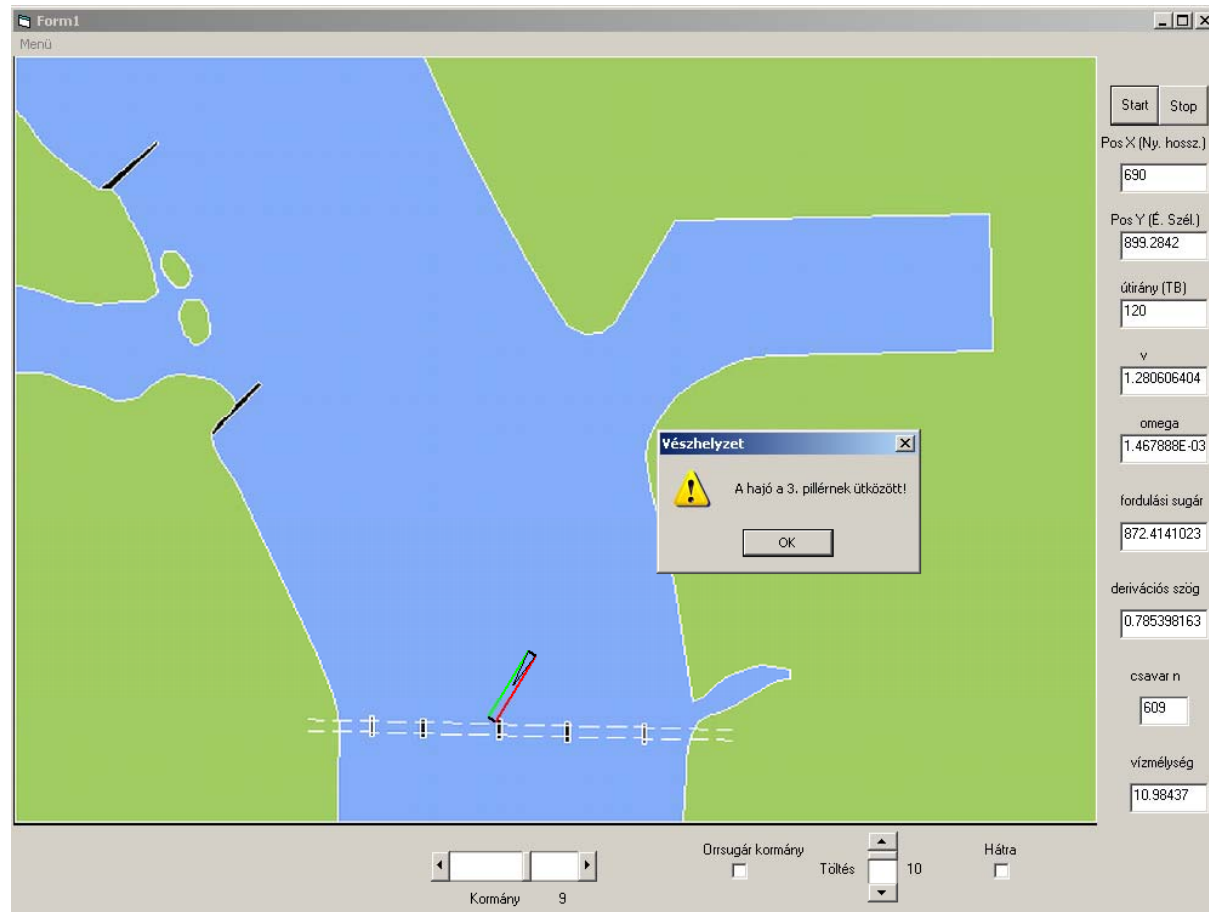
Control of the ship





8. The simulation program

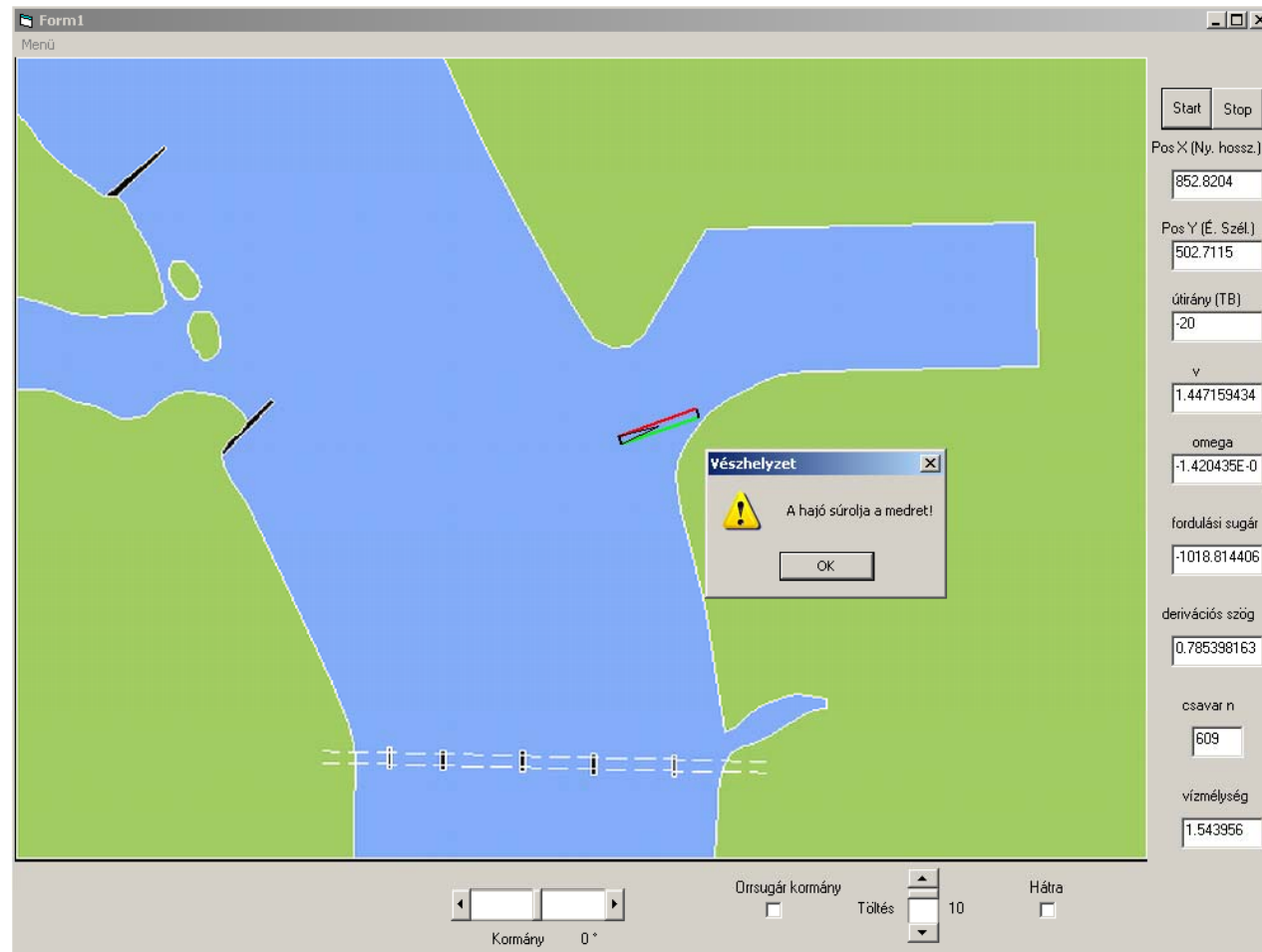
Collision with the bridge

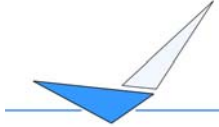




8. The simulation program

Grounding





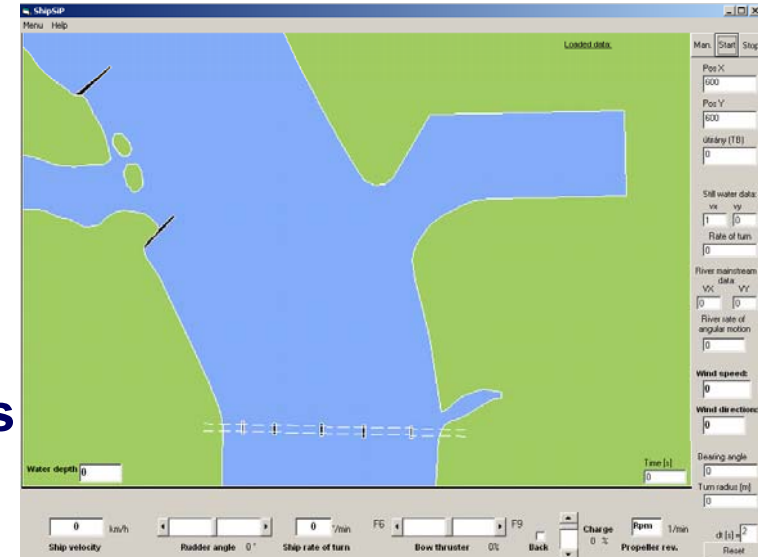
9. Summary

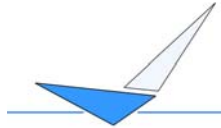
Application of the simulation program:

➤ The new Baja port navigability can be examined by different port arrangements

➤ The program can be applied for different ships and nautical environments

- Accident simulation up to the collision
- Crew training
- Different navigation situation study





Department of Aircraft and Ships

2D Simulation of inland vessel manoeuvrings

MAIF 5. Conference, Budapest



Thank You for Your Attention

Dániel HADHÁZI, Csaba L. HARGITAI, Győző SIMONGÁTI

**Budapest University of Technology and Economics,
Department of Aircraft and Ships,**

H-1111, Budapest, Stoczek u. 6.

Phone: (36-1) 463-1922

Fax: (36-1) 463-3080

E-mail:

hadhazi@rht.bme.hu

hargitai@rht.bme.hu

gyozo@rht.bme.hu