CO$_2$ reduction due to "topography orientated" voyage-planning and navigation

-Prerequisites of ship handling simulators as training tool-

DST – Development Centre for Ship Technology and Transport Systems
CO$_2$ reduction IWT - TopoNav – Training with ship handling simulators
What matters?

CO₂ emitted per cargo-ton / km transported
Areas of concern

- **technical**
  waterways & ships

- **business – company level**
  selection of ships, fleet-management, service design

- **nautical – onboard level**
  navigation, handling of ships
CO$_2$ reduction IWT - nautical aspects

- Water depth: h = 2.5 m, 5.0 m
- Draft: T = 2.0 m, 2.5 m
Speed is a well known predominant driving factor for consumption (all kind of vehicles)

Design speed can be achieved only with sufficient keel – clearance

Consumption of ships is largely driven not only by speed but rather by the overriding factor keel - clearance
Variability of water depth (soundings) during a voyage generally occurs due to:

- topographical variance – along a river or along a route (river and/or canal)
- positions in the cross section according to individual navigation
- water-level variance
Objective:

Reduction of CO$_2$-emission & fuel consumption

How to deal with expected water depths?
Example 2*

length of route: 120 km, duration target: 10 hours

*Ship: L=110mxB=11,4, draft 2,5m
List of examples*

<table>
<thead>
<tr>
<th>Case</th>
<th>distance</th>
<th>duration</th>
<th>segment 1</th>
<th>segment 2</th>
<th>segment 3</th>
<th>basic / optimum</th>
<th>savings</th>
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<td>[hour]</td>
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</table>

*Ship: L=110mxB=11.4, draft 2.5m
Basic approach to the simulated optimization process

- 3 segments differ in length and water depth
- per segment only one speed
- discretisation – speed interval 1 km/h
- specific & complex mathematical model for optimization

Findings

- **optimum speed** per segment largely depends on
  - water depth and
  - its length relative to the total distance
- **high saving potential**
  - especially if high average speed is needed and
  - segments differ in water depth and length
How to deal with these findings in practice (real life)?
Mathematical Solution

• A solution can be found using numerical methods for tabulated functions
  \[ P_D = f(\text{Fr}_h; T) \]

• By assuming simplified approximation functions such as
  \[ P_{Di} = P_{D0i} + k_i \cdot (\text{Fr}_h - \text{Fr}_{hi}) \]

or

\[ P_D = k(T) \cdot \text{Fr}_h^3 \]

an analytical solution can be found, but the approximation error has to be evaluated ?!
**Common practical situation:** *fixed voyage order:*

- route (port of departure >>> port of destination)
- sailing duration-time (time of departure >>> target ETA)
- ship’s draft

**Target-setting:** fuel consumption / CO₂ reduction ?

Basic awareness probably ok ? but how to deal with it ?
CO₂ reduction IWT - training aspects

Enhancing awareness and experience by
Simulator based training for concerned persons

Types of simulation scenarios (examples)

1. Simple scenarios >>> to show effects and to develop general approach to “topography oriented navigation”

2. Close to “real” routing scenarios >>> to show specific “CO₂ – saving potential” along selected routes

3. Close to “real” driving scenarios >>> to develop specific navigation tactics for “topography oriented navigation”
CO$_2$ reduction IWT - training aspects
Prerequisites of ship handling simulators for close to “real” routing scenarios

- a minimum of different types of inland-ships
- correctly implemented shallow water effects and other ship-related effects
- correctly implemented topography (ECDIS is not enough)
- correctly implemented river current, wind and other external effects
Prerequisites of ship handling simulators for close to “real” routing scenarios

- possibility to record continuously & sum up speed, positions, keel clearance, rpm or energy or consumption
- possibility to replay
- possibility to generate “stand alone / automatic simulations”
CO₂ reduction IWT - simulation aspects

Learning targets for specific training with simulators

- basic understanding concerning shallow water effects related to CO₂ emission
- use of a simplified mathematical model for speed optimization
- rough cascading of ship's energy profile according to speed and keel clearance
- rough segmentation of route into stretches with averaged water depths
- translation of simplified calculation into voyage planning
  - envisaged speed per segment -
Topography orientated voyage planning and navigation appears to be

**a possible approach to CO₂-reduction**

- Suitable simulators are useful tools to develop and train appropriate methods
- Suitable training is – amongst others - a solution to enhance awareness, i.e.

  **to make CO₂-reduction happen!**

*Thanks for your attention!"
CO₂ reduction IWT - simulation aspects