SHALLOW DRAUGHT SHIPS FOR THE DANUBE

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ENVIRONMENTALLY FRIENDLY INLAND WATERWAY SHIP DESIGN FOR THE DANUBE RIVER

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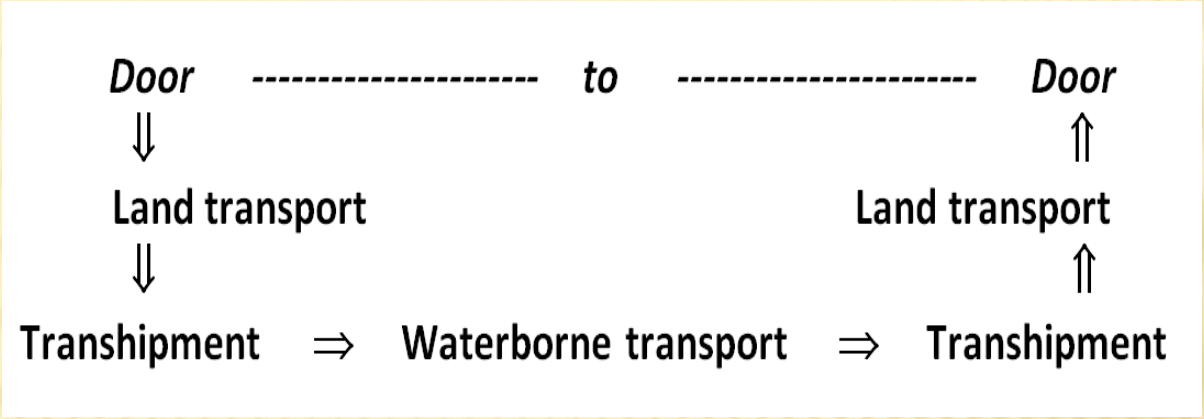
SHORT DESCRIPTION OF ASSIGNMENT:
DEVELOPING CONCEPT FOR SHIP DESIGN FOR THE DANUBE RIVER CONDITIONS

Presentation's structure

- *INTRODUCTION* (4 slides)
- *WATERBORNE TRANSPORT* (1 slide)
- *TECHNICAL MEASURES THAT MAKE INLAND SHIPS CLEANER AND MORE EFFICIENT* (4 slides)
- *PROPOSED SOLUTIONS FOR THE DANUBE* (8 slides)
- *CONCLUSIONS* (2 slides)

Contemporary trends - Intermodal transport



- The waterborne transport is only part of intermodal transport chain
- Transhipment costs are often substantial and are accounted to waterborne costs

- The land transport modes “dictate” prices.
  EU market share Rd/Rl/**IWT**/Pp = 75/13/**7**/5; varies from one country to another
- IWT should adapt itself to other modes and hence standards that are broadly used in Europe (to pallet-wise containers - EILUs)

General requirements

Operational costs are dramatically reduced with increase of water depth, i.e. increase of vessel draught

- During the low water levels, the ship should be able to operate with restricted economical effects
- The same ship should be able to operate in deeper water too, but will then be less efficient than the ship initially designed for deep-water operation only

Conclusions

- Transport costs, however calculated, are very much influenced by water depth
- Inland vessels should be designed (matched, adapted) according to the particular waterway

THE DANUBE WATERWAY

Water depth

Upper Danube – stretch Straubing-Vilshofen with $h_{W\text{-}LNRL}$< 2 m (1.7 m)
several sectors have $h_{W\text{-}LNRL}$= 2.0 – 2.3 m
Lower Danube – several sectors have $h_{W\text{-}LNRL}$= 2.3 – 2.4 m (1.5 m)
Elsewhere – $h_{W\text{-}LNRL}$> 2.5 m. Middle Danube - often above 5 m

Bridge height or air clearance

Critical bridges – Deggendorf $h_{A\text{-}HWL}$= 4.73 m and Passau $h_{A\text{-}HWL}$= 6.36 m
RMD canal bridges – ~ 6 m
Other bridges – upstream from Budapest ~6.7 m, downstream $h_{A\text{-}HWL}$> 7.5 m

Size of locks

Critical – Straubing at 12x190 m (as all locks of RDM canal)
Other on the Upper Danube are 2x24x190 m
The rest are 2x34x275 (310) m

IMPLICATIONS ON SHIP DESIGN

*All-around clearance between the vessel (or her cargo) and bridge/river-bottom/lock-side should be at least **0.3 m**!*

Maximal allowed vessel dimensions are:
For the whole Danube and DM Canal: $T < 1.7$ m (probably 2 m), $B \leq 11.45$ m
Downstream of Vilshofen: $T < 2.0$ m (probably 2.5 m), $B \leq 23.4$ m
The length of self-propelled vessels is practically unrestricted
Length of coupling train formation should be checked

In the shallow water, three characteristic regimes exist:
Sub-critical (according to ITTC, bellow $F_{nh} = 0.7$)
Critical, where P_B increases dramatically
Super-critical, where P_B may be smaller than in deep water

High speed vessels generate large wake (wash) which may cause serious bank erosion. So, the critical and near-critical speeds should be avoided due to environmental reasons as well.

PREVIOUS RESEARCH

Barge trains (for transport of large quantities of relatively cheap cargo)

•Partly loaded barges can be the simplest and cheapest answer to restricted draught problems (taking into account that power needed to push an additional barge (or few of them) rises slightly, while cargo volume can increase rapidly

• The problem usually poses the draught of a pushboat which cannot be reduced. So, a shallow draught pushboat would be advantageous in these situations

Selfpropelled vessels (for general, bulk and liquid cargo)

Selfpropelled vessels are faster and therefore more suitable for container transport (which has to compete with land transport modes, i.e. railway and truck)

Statistics: Rhine 84% & 34% and Danube 4% & 44% of European selfpropelled and pushed barges fleet, respectively

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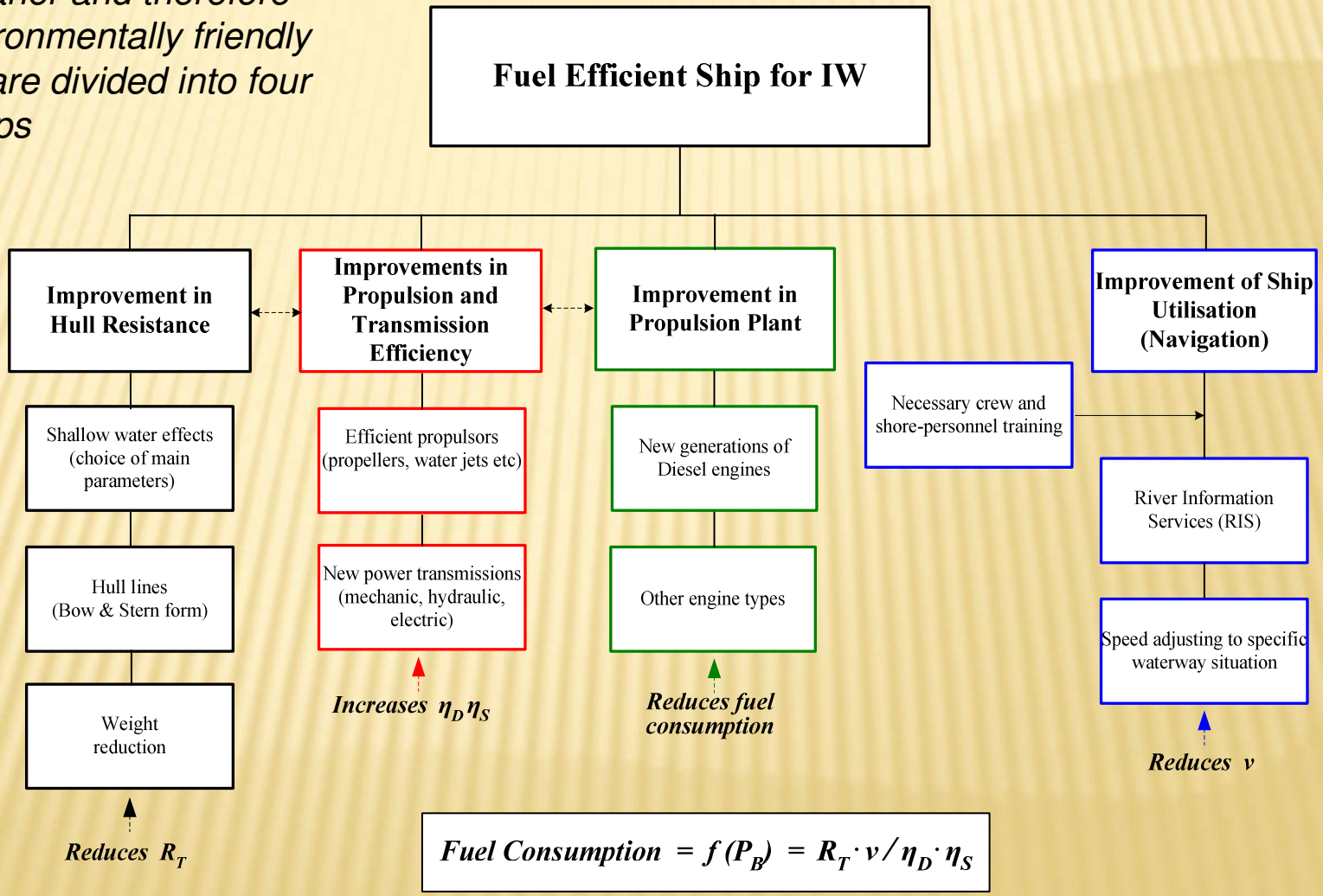
Previous projects of particular interest - *INBISHIP, VEBIS* and *INBAT*
The main reason why the innovative ship types are not applied in broader scale is economics (the state subsidies should be considered)

TECHNICAL MEASURES THAT MAKE INLAND SHIPS CLEANER AND MORE EFFICIENT

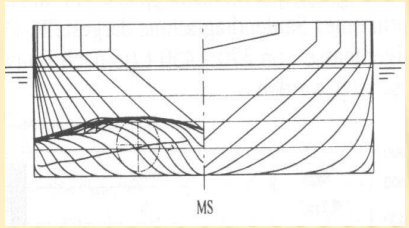
The main technical measures that enable fuel efficiency, hence cleaner and therefore more environmentally friendly shipping, are divided into four main groups

"It's not easy being green"
Kermit the Frog

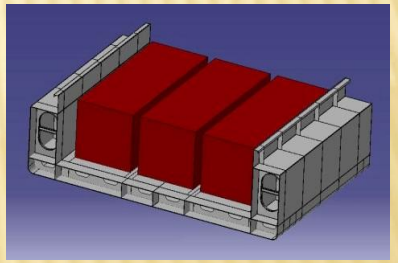


$$\text{Fuel Consumption} = f(P_B) = R_T \cdot v / \eta_D \cdot \eta_S$$

Conclusions



•Involve the hydrodynamic expertise an early design stage



- Reduce hull weight where possible (during ship production)

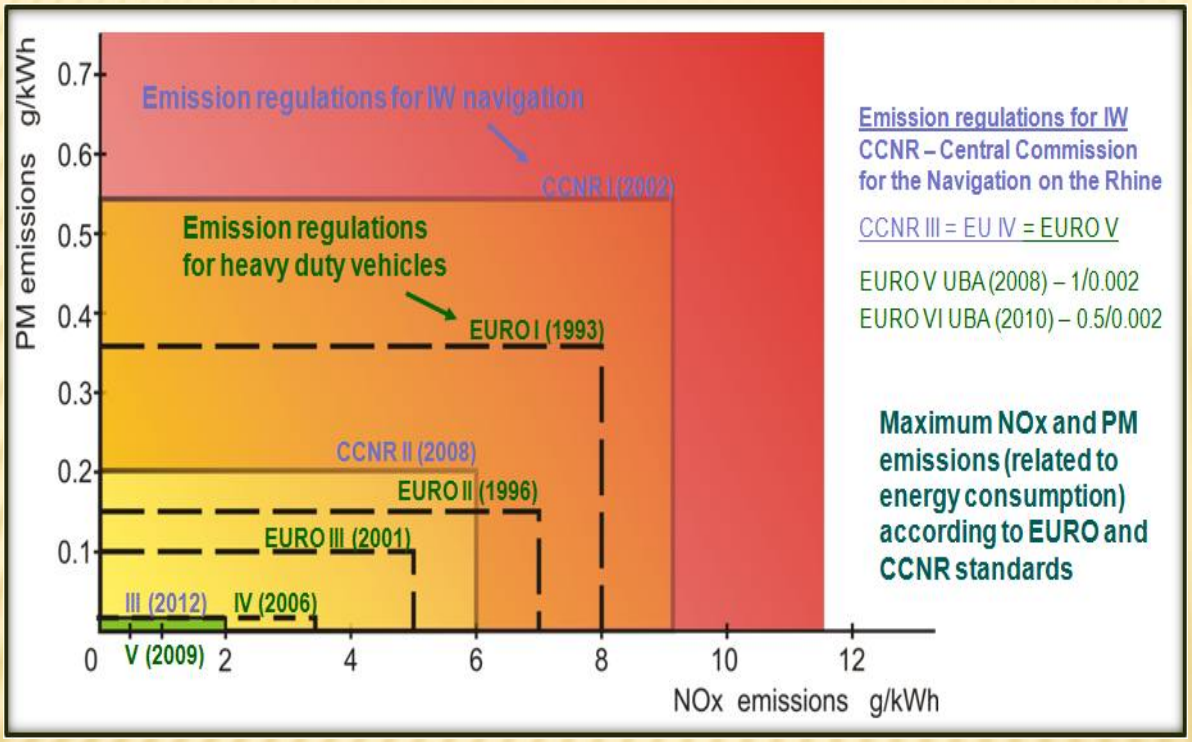
- New propulsor types should be considered

- New engine types should be considered for ship applications

- Command-bridge computerisation (RIS and other achievements)

- Crew training

AN INTERESTING TOPPIC - EMISSION LEGISLATIONS



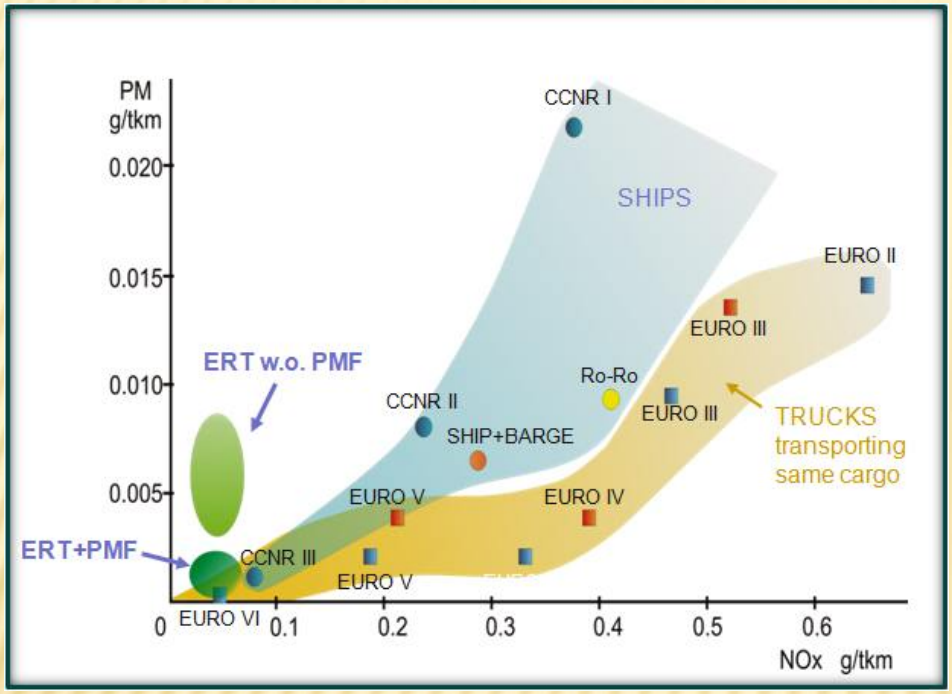
CCNR norms are assumed to be relevant for IWT

Ship Diesel engines have **CO_2** emissions lower than the truck engines, while **NO_X**, **PM** and **SO_X** emissions are higher

- Time lag in implementation of EURO & CCNR emission regulations
- Ship have a lifetime of at least 20 years vs. 5 years for trucks
- Precondition for low emissions is a low sulphur fuel

TECHNICAL MEASURES THAT MAKE INLANDSHIPS CLEANER AND MORE EFFICIENT

Comparison of emissions emitted by considered IWW ships and a truck on the basis of tkm



Ships are NOT so clean in terms of NOx and PM, unless Emission Reduction Technologies (ERT) are applied

Standards according to CCNR III (corresponding to EURO V) may be met only by application of ERT

Emission Reduction Technologies - ERT consist of several compatible and complementary measures:

- First step – Reduction of allowed sulphur for marine oil diesel
- Second step – Application of new diesel engine technologies and exhaust gas cleaning (older engines should be retrofitted with after-treatment devices)

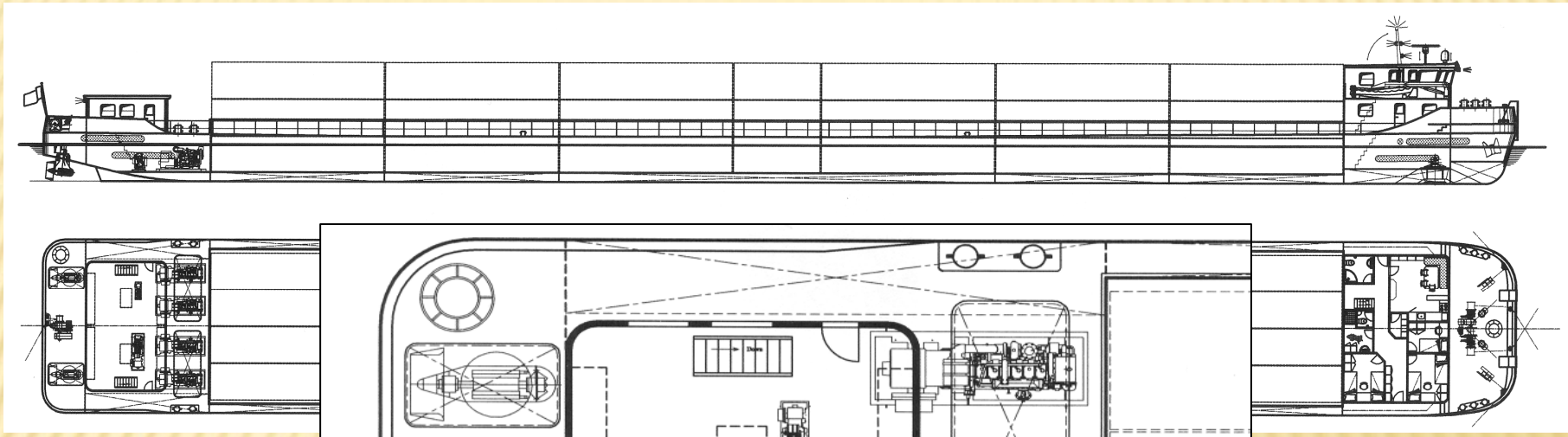
PROPOSED SOLUTIONS FOR THE DANUBE

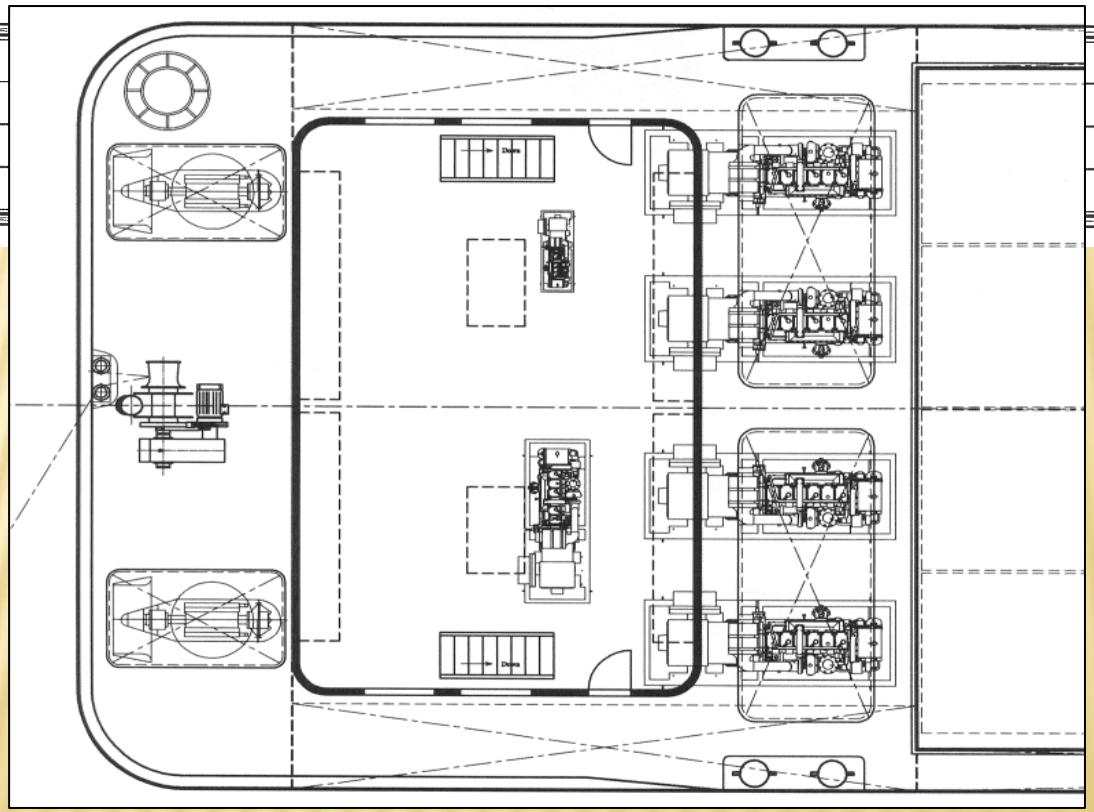
With the aim to demonstrate how a contemporary, safe, cost-effective, shallow draught vessel intended particularly for the Danube waterway should look like, some of the conclusions and technical achievements aimed at increasing efficiency of inland navigation are incorporated into design of two specific ship types:

- **Selfpropelled container vessel**
- **Barge train (actually a pushboat) for bulk cargo**

These two distinct ship type concepts are chosen because they are good representatives of typical ships used on the Danube

Danube container ship concept - Diesel-electric propulsion

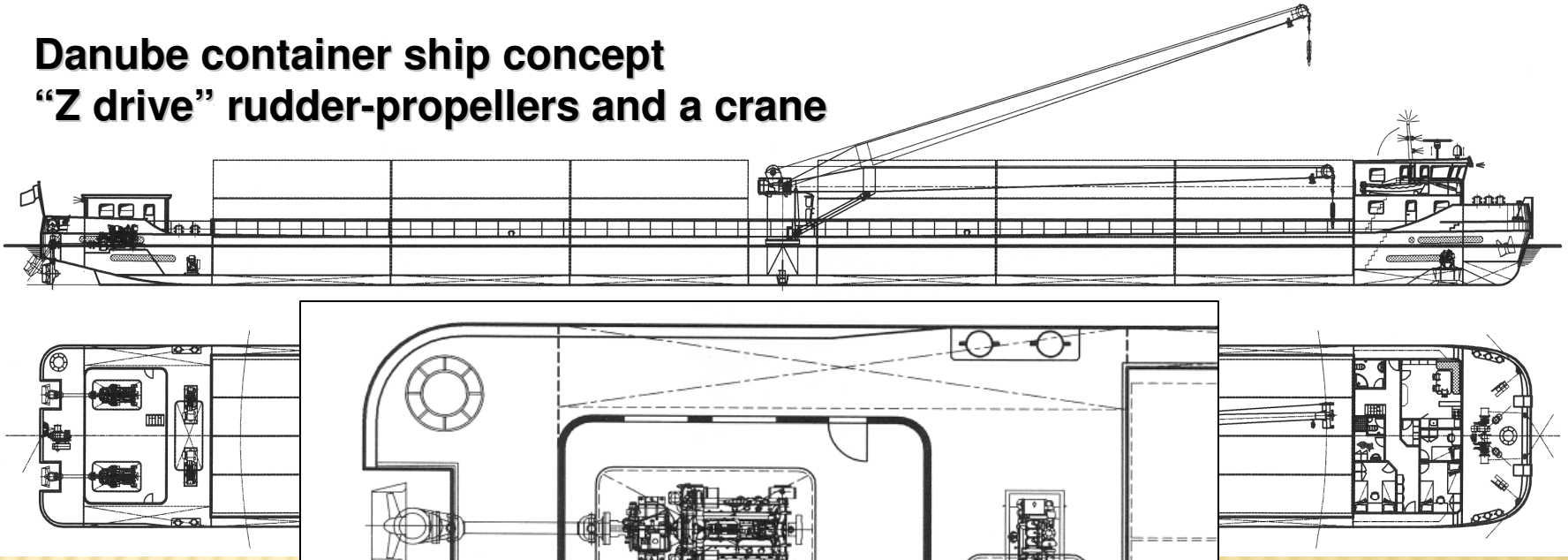


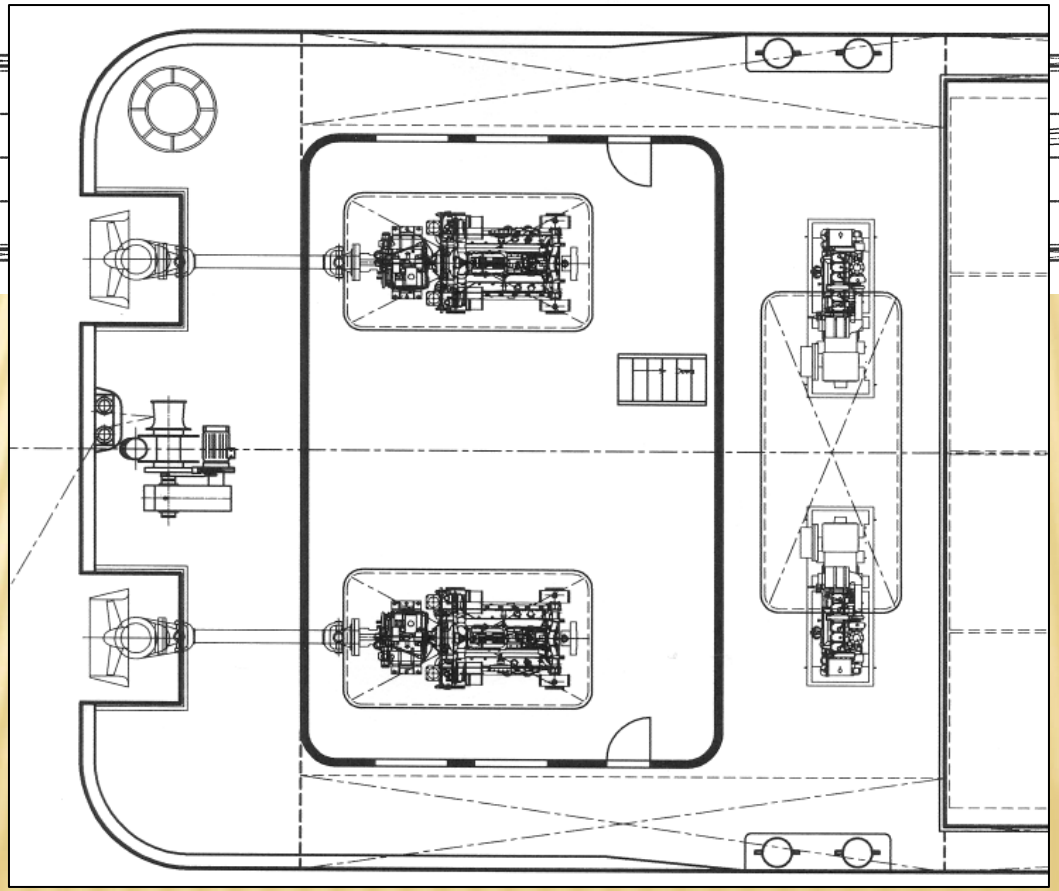


Enlarged engine room

PROPOSED SOLUTIONS FOR THE DANUBE

Danube container ship concept
“Z drive” rudder-propellers and a crane





Enlarged engine room

Main particulars of container ship concepts

		Configuration	
		Basic	With a Crane
Length	m	104.0	102.5
Beam	m	11.65	11.65
Height (Depth)	m	3.1	3.1
Draught (max)	m	2.5	2.5
Hold length	m	80.0	78.5
Hold width	m	10.34	10.34
Height above basis line	m	8.3	8.3
Installed power	kW	4 x 400	2 x 700
TEU (3 layers / 4 layers)		156/208	134/172
Payload capacity	t	1950	1800

Some of the concept's features

Special attention was paid to low-draught performance. Proposed concept should be able to operate successfully and therefore be cost-effective at both low draught of up to 1.7–1.8 m (with two container layers) and full draught of up to 2.5 m (with 3 layers of full containers or even 4 layers of mixed full and empty containers)

The chosen hold length (80 m) and breadth (10.25 m) allow stowing of a variety of 2.50-2.55 m wide domestic containers

An on-board crane would allow transhipment at any port

Rudder propulsors enable exceptional manoeuvring characteristics

Position of the engine room at the stern and the crew premises at the bow offers additional crew comfort

Barge train for transport of bulk cargo

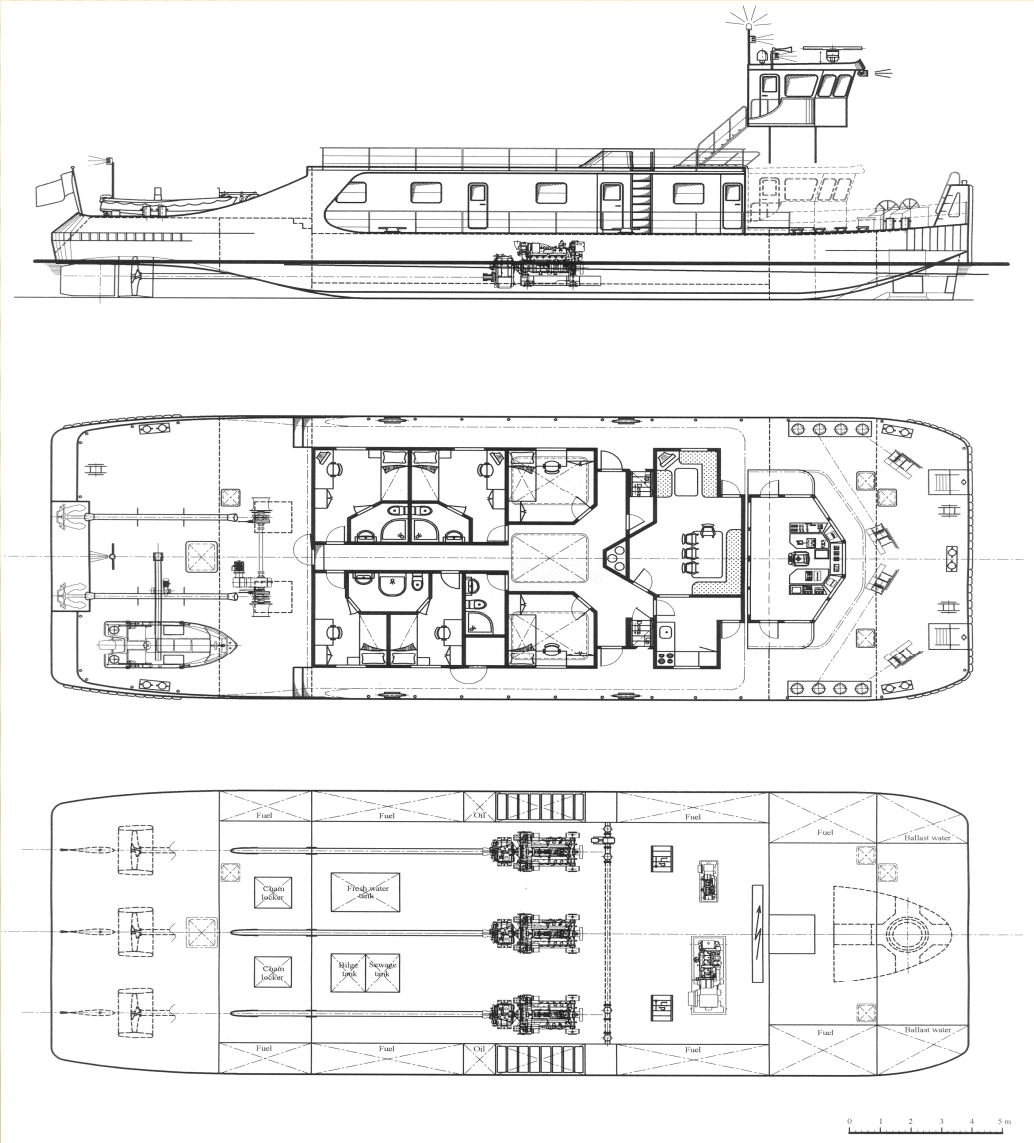
- The main advantage of barge transport is that cost-effective sailing with reduced draught, with partly loaded barges, may be utilized
- To substitute reduced carrying capacity, the number of barges in a convoy might be increased (power needed for pushing this convoy would not increase proportionally).

Tonnage capacity at reduced draught of a typical Danube barge (77x11x2.8 m) are given below:

Draught [m]	~0.5	1.0	**1.5**	2.0	2.5
Tonnage [t]	-	300-400	**700-800**	1100-1200	1500-1600

A low draught pushboat with a power of around 2000kW would be advantageous on the Danube

General Arrangement plan of a pusboat concept



Main particulars of pushboat concept

Length	m	30.0
Beam	m	11.0
Height	m	2.5
Draught	**m**	**1.4**
Height above basis line	m	6.0
Installed power	kW	3 x 700
Bow thruster	kW	250-300
Crew		8

The main advantages of the proposed pushboat concept

Its extremely low draught of only 1.4 m
(compared to draught of above 1.7 m of similar conventional pushboats)
This enables navigation with partly loaded barges on the whole Danube even at LNRL
Chosen length of 30 m and breadth of 11 m enables good packing possibilities of various push train formations

Enhanced manoeuvring (thanks to gondola-type bow thruster of 250 to 300 kW)

Application of the latest technological achievements that increase efficiency, safety, cleanliness and comfort

These benefits, however, are not a result of the proposed pushboat concept, but rather of a modern era. Namely, almost all Danube pushboats were built 30 or so years ago and therefore were equipped according to the standards belonging to the previous technological generation, so a newly built pushboat of any design or concept will be advantageous compared to the old (conventional) ones

CONCLUSIONS

- Contemporary (modern) shallow draught vessels, particularly suited for the Danube waterway are feasible (and desirable)

- They are inherently less efficient and less cost-effective (if water is deep enough) than the vessels with deeper draught

•When there is not enough water (when LNRL) low draught vessels will have a logistical advantage compared to deeper draught vessels as will be able to navigate all the year round

•Under which conditions IWT will work (i.e. what would be minimal/guaranteed water depth along the river and throughout the season, cost of fuel, taxes, eventual state subsidies etc.) is a political question which should be influenced, amongst other, by the technical and ecological requirements of IWT

COMMENT

Ships were navigating in the past although navigational conditions were worse (with a lot of shallows and free-flowing sectors), but the business environment was then different than it is today (with pipelines, railway and road infrastructure passing through the Danube corridor).

Under the present circumstances, there may be a limit (concerning low draught navigation) under which IWT will not be cost-effective anymore, as other modes, already much stronger and better positioned, will prevail.

Towing with the assistance of rail locomotives in Sipski kanal, Danube km 944+2200 m, right bank (current speed up to 18 km/h), from 1918 till the beginning of 1970

THE END - Thank you for your attention