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TSL and TSL-System State of Development and Progress

The TSL-System is a short-sea transport chain based on the Trans Sea Lifter (TSL), a fast barge carrier. Different from preceding barge carriers that carry cargo in proprietary special barges, the TSL-System is an open system, which carries across the open sea, all types of inland barges for independent operators. The TSL has been developed progressively by NAVTEC CONSULT GmbH, Emden, since 1992. Patents were applied for in Germany and in the US. Current work now addresses economy and application concepts of the TSL-System. The present state of development of the TSL and the TSL-System is outlined below.

The TSL - a Sea-Going Ship for an Open Transport System

The TSL is conceived as a barge carrier for the short-sea trade. The key design requirement was that the vessel should not be constrained to carrying special barges but must be able to transport standard push barges - and if economically feasible also motorized barges - of the types used on inland waterways throughout Europe and in the US. Because of their size, such barges must be floated rather than lifted onto and off the carrier vessel. In the short-sea trade with its frequent lay-times between short voyages, this process must be fast. This latter requirement can only be met if the carrier vessel does not discharge and load barges consecutively but, rather, simultaneously. Thus, the TSL must be wide enough for carrying barges side-by-side athwart ship and immerse deep enough for floating them onto its deck. (The breadth of the TSL pre-empts the need for another discussion of transverse stowage, of the carrier vessel's roll angle and of cargo safety.)

For rapidly changing from voyage draft to loading draft - and vice versa - the TSL is conceived as a semi-submersible catamaran (SWATH). In a hull of this configuration, a small change of burden causes a big change of draft. This characteristic is reinforced by a powerful ballast system, which turns the TSL into a rapidly immersing and emerging "floating forklift" for barges of up to 6,600 t displacement. Furthermore, the subdivision of the cargo deck into separately submersible cargo platforms accelerates the TSL's transition between voyage draft and loading draft. This also permits submerging only those cargo platforms from whose deck barges are to be exchanged. These measures result in a TSL (Fig. 1), which requires only 90 minutes for the exchange of inbound against outbound barges on all platforms, i.e. ≈ 18,000 t of cargo, or ≈ 1,800 TEU.

Handling 18,000 t of break-bulk cargo in 90 minutes!

The TSL in Fig. 1 is ≈ 185 m long, ≈ 80 m wide and displaces ≈ 42,000 m³. The width of the cargo platforms of ≈ 32.3 m may grow by ≈ 0.5 m due to optimization for future barge sizes. When the TSL is at voyage draft, a platform's deck is ≈ 8 m above water, when submerged it accommodates barges with up to 3.7 m draft. With 38,000 kW propulsive power the TSL makes 20 knots. This speed is at the hump of the resistance

curve that is characteristic of a SWATH; thus the TSL is noticeably faster after a burst of higher power.

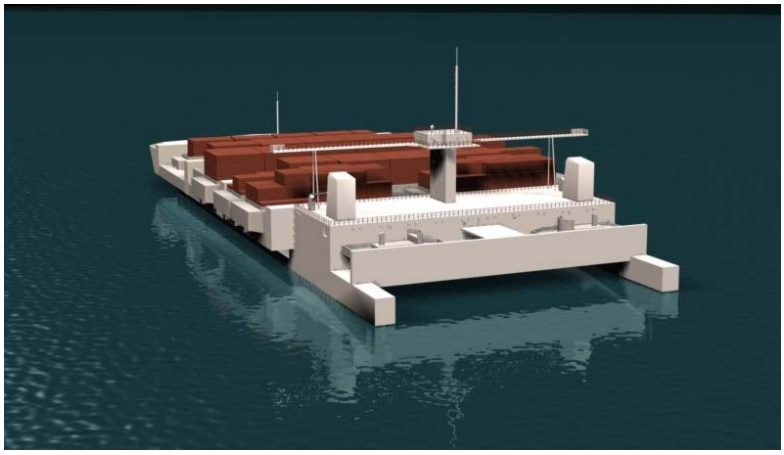

Fig. 1: The TSL carries barges athwart ship on 3 cargo platforms. Two ship-borne tugs in dry berth at the stern facilitate barge handling.

The TSL in Fig. 1 carries only barges laden with containers, for example as a container feeder. However, Fig. 2 shows the potential synergy effects of the TSL-System: a TSL is not confined to carrying a single commodity, rather, as a universal carrier it transports all kinds of goods that can be aggregated on its route. Thus, the TSL as a RoRo-ferry (pontoon with trailers on the aft platform) achieves high capacity utilization by carrying barges in other trades via the same short-sea route.

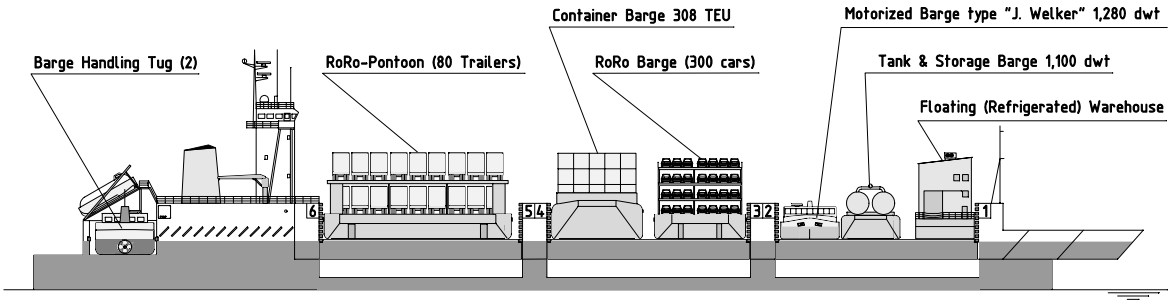

Fig. 2: A TSL RoRo-ferry's capacity is fully utilized by push barges of all kinds and a self-propelled inland waterway barge.

The TSL-System - More Than Short-Sea + River-Sea Traffic

Fig. 3 illustrates the principle of the TSL-System. The TSL sails on a *fixed schedule* between roadsteads off coastal ports or rivers where it drops off its full load of inbound barges and picks up another load of outbound ones within 90 minutes. Between roadsteads and related coastal and/or inland ports, barge traffic is synchronized with the TSL's sailings. Thus the TSL-System offers scheduled sailings from both coastal and inland ports and is a truly plannable marine link for multi-modal transport chains.

Fig. 3 indicates that in the TSL-System barges from several ports are aggregated in a related roadstead onto a single TSL short-sea line. As barges are transported across the open sea by the TSL, barges need not be seaworthy, i.e. in the TSL-System they are inland waterway vessels, which serve as "floating supercontainers". In other words,

a variety of barges is loaded with goods of all kinds at several terminals and then taken aboard by the TSL during a short stop at a single site. This mode of operation allows the TSL, a huge vessel in the short-sea trade, to acquire sufficient cargo.

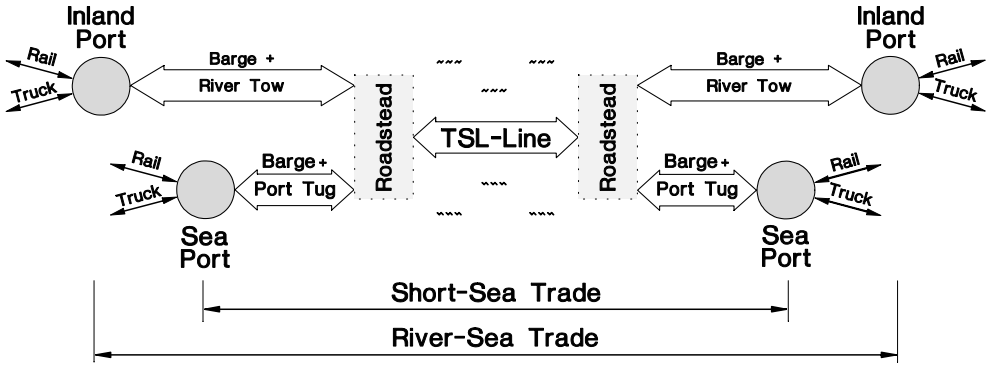

Fig. 3: The TSL-System comprises both short-sea- and river-sea traffic

Referring to the barges in the TSL-System as floating supercontainers, also illustrates that they are optimally simple load carriers without deductions from carrying capacity for providing for seaworthiness, propulsion or accommodations. This still holds true when expansion of the TSL-System will lead to barges that are optimized for the requirements of cargo and/or route, a development sure to come about due to the low cost of barges relative to sea-going vessels - analogous to the evolution of containers.

This system cooperates with all existing systems - after its introduction nobody must change, but we believe that most will

With regard to size, barges in the TSL-System can also be adapted more flexibly to the requirements of a route than a sea-going vessel, which because of economic viability on a given route, must be bigger than a simple barge. Furthermore, suitable barges can reach ports deep in the hinterland that are far beyond a river-sea vessel's operating range. In short-sea trade, too, barges in the TSL-System offer many basic advantages over sea-going ships. Barges can utilize shallower port basins, or due to their lower air draft, can load and/or discharge their cargo under roofed-over cargo handling facilities. Ultimately these features mean that (secondary) container terminals can be established at low cost outside deep seaports.

The use of barges as supercontainers turns the TSL-System into an integrated system that combines the capabilities of vessels in the short-sea and the river-sea trades and, in fact, is superior to both. In short-sea traffic, the TSL simultaneously transports all kinds of different goods, e.g. in parallel with containers in the feeder trade it can serve as a RoRo ferry as well. While in river-sea traffic mode it can service ports deep in the hinterland, which no river-sea vessel can reach because of its size. Thus, the TSL-System can be economically viable on routes on which the cargo offering is too low for an individual feeder, ferry or river-sea line. For a valid assessment of the qualification of the TSL-System in any given region it is, therefore, necessary to use an unbiased approach, which considers all of the TSL-System's innovative aspects. Most likely the TSL-System will start an evolution in short-sea shipping that may be as sweeping as that in deep-sea shipping resulting from the emergence of containers.

The TSL-System - Competitive and Profitable

Competitiveness of the TSL-System and profitability of the TSL carrier vessel in terms of its return on investment (ROI) were analyzed for a specific route in the North Sea (Fig. 4). Cost calculations for the TSL-System are based on a 17.9 knot TSL carrying barges of 4 exemplary sizes on 3 cargo platforms, which makes one round trip per day on the short-sea route between roadsteads off Rotterdam and off Spurn Head in the Humber river.

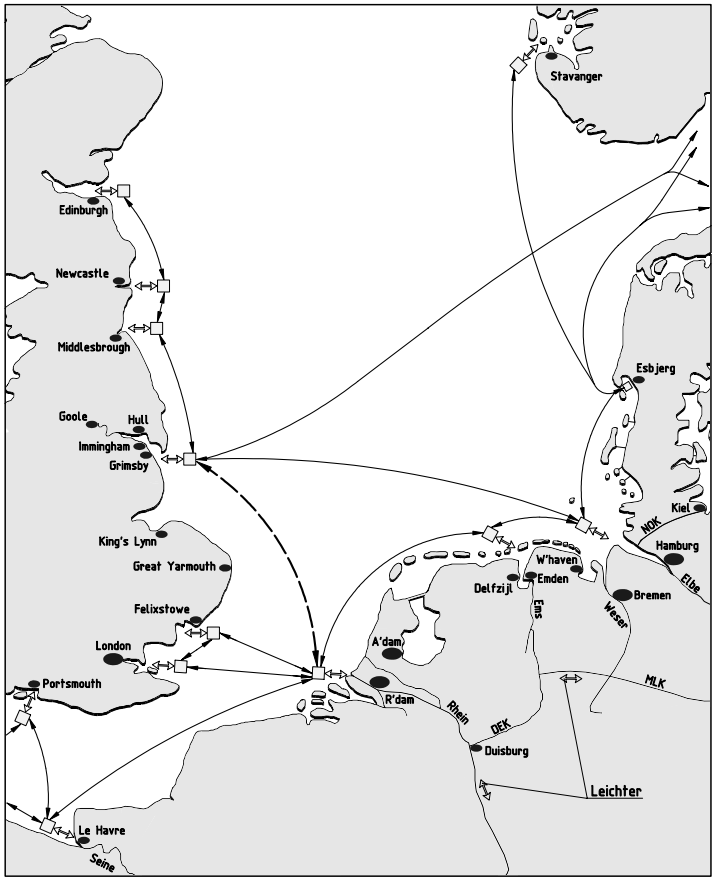

Fig. 4: Short-sea routes in the North Sea - a network of TSL lines for transporting barges could look like this.

The TSL-System's competitiveness was assessed by comparing the freight rates of these 4 exemplary barge sizes with the corresponding freight rates of competing carriers on a quay to quay basis, i.e. without the cost of handling between barge and quay. In the short-sea trade with short TSL barge routes before and after the sea leg, the competitors are container feeders. In the river-sea trade with long TSL barge routes before and after the sea leg, the strongest competitors are medium-size river-sea vessels that are optimal at all river conditions.

The four barges in the TSL-System are inland waterway barges of the canal-going standard types "Europa I" of 1,250 dwt / 84 TEU, "Europa IIa" of 2,565 dwt / 132 TEU (4 rows of containers in the hold) originally designed for bulk cargo, and 2 future barge types conceived for the container feeder trade. Optimized for being carried by the TSL, the latter are the "Container Barge" of ≈ 3,000 dwt / 308 TEU and the "½ Container

Barge" of ≈ 1,500 dwt / 133 TEU; the latter is exactly as wide but half as long as the Container Barge so that 2 fit onto its foot print area.

The economic analysis includes each barge's share of the TSL's operating costs and the barges' own operating costs. The TSL's operating costs for transporting the barges on the short-sea route are allocated to each barge proportionally to its foot print area on the TSL's cargo platform. The barges' operating costs are the costs of chartering, insurance, towing, mooring and unmooring, clearing, port charges and fairway dues.

Acquisition of realistic data, which was extremely arduous and took much time, was rendered possible only with the help of experts residing in the specific regions. When inquiring with authorities and port service companies at the ends of TSL traffic about fees and/or charges, they not only conveyed understanding of the novel characteristics of the TSL-System but also knew the discounts customary in the region for a trade of the expected volume.

At that time, costs and fees were still based on the DM. Other currencies were converted to DM at the exchange rates of April 1999, or GBP 1.00 = DM 2.92 and HFL 1.00 = DM 0.89, before conversion to EURO at DM 1.00 = € 0.51129.

The relation of freight rates of barges in the TSL-System vs. those of competing vessels calculated on this basis for the 2nd quarter 1999 is still valid today. Of course, fuel prices have risen since then, but the TSL-System is less affected by rising fuel costs than the competing container feeders, because the TSL-System requires ≈ 1.5 % less fuel on this route for the same transported container volume; besides, freight rates, too, have increased noticeably since then.

The economic analysis is based on the route Rhine - Humber (the dashed line in Fig. 4). The yardstick for the comparative analysis is the freight rate from quay to quay. For voluminous, light cargo such as containers, semi-trailers, trucks etc. this yardstick is the freight rate/TEU. For heavy cargo such as steel, machinery, heavy bulk etc. the freight rate/tdw serves as yardstick.

The TSL is so cost-effective that carrying the barges' dead weight is insignificant relative to conventional transportation costs

The most accurate yardstick for comparing the competitiveness of carriers is their Required Freight Rate ("RFR"), i.e. the freight rate at which they break even. For barges in the TSL-System this is easily calculated, but for competing carriers it could be obtained only for a medium-size river-sea vessel of 2,400 tdw / 220 TEU slots on the river-sea route Duisburg - Goole (this vessel discontinued operations on this route shortly afterwards).

- RFR/TEU slot = € 49.97
- RFR/tdw = € 4.58

For the short-sea route Rotterdam - Killingholme, the yardstick is the lowest offered actual freight rate ("AFR"). After subtracting the customary discount the

- AFR/TEU = € 74.65

The AFR of the 4 exemplary barges in the TSL-System that is required for the comparison is assumed as the barges' RFR/TEU slot, plus a margin of 113 % for partial capacity utilization and the operators' internal costs and profit. Calculation of the barges'

revenue is based on an average utilization of the TSL's capacity of 83 % (= 2 cargo platforms 100 % and 1 only 50 % loaded) and an average utilization of the barges' capacity of 75 %. The resultant total capacity utilization of 62 % appears to be realistic for an established, strictly scheduled service.

Table 5 summarizes the results of spread-sheet calculations that prove the competitiveness of barges in the TSL-System on the short-sea route Rotterdam - Killingholme and the river-sea route Duisburg - Goole.

No.	Route	"Europa I"	"Europa IIa"	Container Barge	½ Container Barge
	Short-Sea Route Rotterdam - Killingholme				
1	AFR/TEU of each barge*	€ 92.32	€ 78.05	€ 45.06	€ 55.31
2	AFR/TEU : competing AFR/TEU = € 74.65	+ 24 %	+ 5 %	- 40 %	- 26 %
3	RFR/TEU slot* of each barge	€ 43.27	€ 36.58	€ 21.12	€ 25.99
4	RFR/tdw* of each barge	€ 2.93	€ 1.88	€ 2.17	€ 2.30
	River-Sea Route Duisburg - Goole				
5	RFR/TEU slot of each barge*	€ 68.69	€ 60.96	€ 32.78	€ 41.81
6	RFR/TEU slot : competing RFR/TEU slot = € 49.97	+ 37 %	+ 22 %	- 34 %	- 16 %
7	RFR/tdw of each barge*	€ 4.65	€ 3.14	€ 3.37	€ 3.71
8	RFR/tdw : competing RFR/tdw = € 4.58	+ 2 %	- 31 %	- 26 %	- 19 %

*) Freight rates of II/99 for a one-way voyage of the barge on the respective route.

Table 5: Freight rates of 4 exemplary barges relative to the freight rates of competing carriers

Assessment of the relation between the freight rates of the 4 exemplary barges in the TSL-System relative to the freight rates of competing carriers in the short-sea trade (line 2) yields the following conclusions:

- The TSL-System's Container Barge and the ½ Container Barge transport containers at freight rates that are 40 % and 26 % respectively lower than those of competing short-sea feeder vessels.
- In spite of its 5 % higher AFR/TEU, the "Europa IIa" may well be competitive, for example, if its size is right for a regular service between industrial plants, particularly if the barge is tailor-made for a special cargo, or if it operates between port basins that are too shallow for short-sea vessels.
- Due to their 24 % higher freight rate, barges of the size of the "Europa I" are too small for transporting containers on this route and, thus, would not be utilized in the TSL-System.

The TSL's operator need not invest in a new fleet of barges - this already exists!

The relation of the RFR/TEU slot of the four barges in the TSL-System relative to the RFR/TEU slot (line 6) of the competing river-sea vessel shows corresponding results. However, the competitive advantage of the barges seems to be slightly smaller. The reason for this is most likely that the AFR of the river-sea vessel on this route is insufficient. This assumption is substantiated by the facts that this service was since discontinued, and that this vessel's RFR (€ 49.97/TEU slot, line 6) on the river-sea route appears to be too low relative to the AFR on the much shorter short-sea distance (€

74.65/TEU, line 2). This means that the competitive advantage of barges in the river-sea trade is most likely higher than that shown in line 6 and corresponds more with the values given in line 2 for the short-sea trade.

Comparison of the freight rate of each of the 4 exemplary barges with the freight rate of a competing vessel, will prove to a shipper and/or charterer that utilization of barges of optimal size operating in the TSL transport *system* is more economical than utilizing an independently operating vessel. The potential operator of the TSL will recognize the added synergy effect of being able to run on his route; a short-sea; a river-sea; and a ferry service, all with a single TSL and that, furthermore, the TSL-System with its regularly scheduled service is exceptionally well suited for establishing ship-based inter-modal transport chains with land-bound carriers. In many short-sea regions, such operation of the TSL-System may yield more synergies yet. These will be apparent to ship operators active in and familiar with a region. Based on their own data they will be able to determine how to gain such advantages; a comprehensive method for this evaluation is available today.

This is a concept as if made for major terminal operators who want to put to sea, though naval architect Hermann Janssen had classical ship owners in mind

For assessing profitability, the ROI of a TSL on the same short-sea route was calculated by means of the methodology customary in venture capital financing. The following results of the above cost calculation were utilized for this purpose:

- For fixing the average cost advantage of all barges in the TSL-System it is assumed that the uneconomical "Europa I" will not be used at all. Furthermore, the "Europa IIa" is utilized in 10 % of all cases for which it is assumed to have a cost advantage of 15 % - otherwise a more suitable barge would be selected. The remainder is split evenly between the Container Barge and the ½ Container Barge.
- The construction cost of € 53.949 million of a TSL built in the Far East - or correspondingly subsidized in the EU - is depreciated over 12 years to a residual value of 45 %. The interest rate is assumed at 6 % p.a. For 350 operating days p.a. the fixed costs of the TSL and its ship-borne barge handling tugs amount to € 17,807 per operating day.
- For the comparative profitability calculation, it is assumed that an equal investment will buy 8.17 container feeder vessels of 200 TEU capacity, which operate on the same route.
- At the referenced capacity utilization of barges in the TSL-System of 62.5 % and of the container feeder vessels of 70 %, the TSL's annual operating income is € 11.378 million and that of the feeder vessels is € 4.639 million.

Hence, the ROI of the TSL is 21.0 % and that of the 8.17 container feeder vessels 8.6 %. This means that the TSL at 2.4 times the latter’s ROI is by far the better investment.

The TSL-System - Applicable in Many Short-Sea Regions

The TSL-System will work in short-sea regions world-wide due to its competitive freight rates, its potential of establishing new kinds of marine traffic, and above all, because it is a transport system that integrates the capabilities of ferry; short-sea; and

river-sea trades and thereby is economically and technically superior to each of these trades taken separately. The examples below may illustrate the TSL-System's potential:

- Road-to-Sea: goods traffic *along* the coast by TSL-System rather than *on* the coast by truck on overloaded highways or by rail in transit through several countries at cumulative tariffs and on schedules secondary to national ones.
- New multi-modal transport chains: scheduled sailings and competitive freight rates enable the TSL-System to cooperate exceptionally well with land-bound carriers in long-distance goods traffic.
- New logistic services: due to their low cost of lay time, barges in the TSL-System can serve as buffer storage for just-in-time deliveries.
- Fast feeder service: the TSL-System is optimal for distributing large shipments of containers. In the round-the-world trade, the cargo of a huge container vessel is distributed to several barges that, after having been carried by the TSL to their destination(s), are discharged at several terminals simultaneously, while a conventional feeder vessel must make consecutive calls - and at much higher cost of lay time.
- Connectivity: the TSL-System would link inland shipping regions presently isolated by the open sea, e.g. Russian inland waterways via the Black Sea to the Danube as well as via the Baltic to the Elbe and Rhine rivers. Furthermore, the TSL-System can extent inland navigation to regions, which in isolation are too small to sustain economically viable barge shipping, e.g. Scandinavian fjords.
- Cargo handling without ports: a TSL line carrying barges fitted with a bow ramp for RoRo cargo handling over a paved section of beach would be a reliable, modern transport chain for industrializing countries, which does not require high investments in port infrastructure.

In most cases the TSL is more economical than conventional systems,
but even more attractive is its potential for developing new markets

- New traffic structures: vessels in the deep-sea trade need to call only at major ports, between these and secondary ports, their cargo would be distributed by the TSL-System, analogous to the structure of today's round-the-world container + feeder trades. This would be particularly attractive in regions with long coasts with many small ports or shallow ports or ports with slow customs procedures.
- Networks: TSL carrier vessels on neighboring routes exchange barges in a common roadstead. Relayed in stages through the resulting network, barges can carry cargo in unbroken mode, for example between central European ports and Scandinavian fjords or African sea port.

These examples show that the potential of the TSL-System cannot be judged by merely looking for existing trades that it can replace due to being more economical, because in many short-sea regions the TSL-System will evolve new types of trades that do not even exist today. Regional operators will recognize this potential when they consider all features of the TSL-System and assess, for their operating region, which synergy effects they can realize and what cargo volume they will be able to acquire.