European Danube Transport Research

EUDET is a project under the Fourth Framework Programme for RTD-Inland Navigation of the European Commission

EUDET

Final Report

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Evaluation of the Danube Waterway as a Key European Transport Resource

Final Report

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CONTENT

1. Introduction

1.1 The Subject Matter of the Study

For centuries the Danube waterway has formed an important transport infrastructure for Central and Eastern Europe contributing significantly to the economic development of the regions alongside the river. But inland waterway transport on the Danube could not keep pace with the dynamic development of rail and road transport for technological and political reasons. Even in the best years of Danube navigation the actual use of the waterway lagged far behind the (theoretical) capacity.

Things have been changing a lot, though, for inland navigation on the Danube in the last decade:

- The opening of the Rhine-Main-Danube-canal in 1992 offered a link between the waterway network in Western Europe and the Danube. This new transcontinental link connects Western Europe to the Black Sea and the Danube region to the ARA ports.
- The socio-economic changes in the CEE countries after the break down of the COMECON system has had tremendous effects on the transport sector. Transport flows and transport volumes have abruptly changed in connection with the transformation process in these countries with more dynamics expected in the wake of the accession to EU.
- Transport infrastructure is showing very severe short-comings in all the CEE countries, which makes it necessary to assess carefully the investment priorities not only on national but also at EU level. This necessity gives new impetus to consideration about the possible contribution of inland navigation.

Unfortunately some developments had extremely negative impacts on Danube navigation too. First of all the military and political action in relation to Yugoslavia, 1995-1997 the UN-embargo and 1999 the Kosovo war, interrupted the traffic on the Danube almost completely. Today the most pressing problem for Danube navigation is to remove (and rebuild) the destroyed bridges from the navigation channel and to reinstall free navigation on the Danube. The Danube Commission has already taken a lead in this process. It may be hoped that these efforts are successful soon and that the interruption of the waterway will again be only temporary, as had been assumed (in respect to the UN-embargo) in the study. The damage to Danube navigation by the Yugoslavia crises has already been tremendous but not yet irreversible.

Since the launching of this project (early 1996) the Danube waterway has gained the status of one of 10 Pan-European Corridors (Helsinki Corridors) and thus gained political acknowledgement of its extraordinary importance. This acknowledgement though does not solve the manifold technical and/or economic problems related to inland navigation on the Danube but puts more pressure on their solution. The study therefore is not only a piece of research but intended from the very beginning a clear policy orientation.

1.2 Objectives of the Project

This study sets out to evaluate and, before that, to explore the actual and the potential role of the Danube waterway as a transport resource. On the basis of such an evaluation it is possible to define preconditions and measures to install an attractive and efficient system of inland waterway transport for East-West-European transport flows.

The main objectives of EUDET therefore are:

- to examine existing conditions of inland navigation on the Danube
- to identify main physical, commercial, organisational and infrastructural bottlenecks
- to outline intermodality requirements in order to integrate inland navigation into combined transport chains
- to evaluate existing and future market potentials for inland navigation in the corridor through detailed freight analyses and forecasts

1.3 Approaches and Proceedings

1.3.1 The Work Programme

In order to achieve these objectives it seems necessary to pursue a comprehensive approach taking into account not only the waterway itself but the entire system which determines the performance of the Danube as a transportation resource.
This is reflected by the work programme (workpackages), the kind of activities (research and dissemination) and the basic approach (as illustrated in figure 1.2)
The workpackages (WP) comprised the following:

WP 1 Navigability and Technical Transport Capacity
The navigability of the Danube waterway was analysed and the corresponding capacity levels quantified. A comprehensive inventory of navigable conditions and constraints to navigation due to physical and infrastructural causes are provided.

WP 2 Fleets and Ports
The present state of the Danube fleet, the port infrastructure and the travel time are described, existing infrastructural and organisational restraints, as well as the impact of future technical trends on inland navigation are identified and discussed.

WP 3 Interoperability
This work package provides a comprehensive inventory of restraints upon interoperability of Danube to Rhine navigation including the Main-Danube canal and the west-European canal system. Furthermore, operating conditions on important east-European waterways are reviewed and compared with inland navigation on the Danube.

WP 4 Transport Markets in the Danube Corridor
This work package describes the structure and the organisation of national transport markets in the Danube corridor in general and the markets of inland navigation in particular.

WP 5 Analysis of Transport Demand

Trade flows between the countries of the Danube corridor will are reviewed. Relevant transport flows in the Danube corridor has to be identified and quantified through origin-destination matrices (O-D) regarding transport modes and major commodity groups.

WP 6 Forecast of Transport Demand

Scenarios for the future socio-economic development of the corridor countries, for the expected transport infrastructure and policy, leads to a forecast of transport volumes by commodity groups and transport modes through transport models for the year 2010.

WP 7 Identification of Infrastructure Bottlenecks

Future bottlenecks in land transport infrastructure are identified and assessed. Exceeding or missing capacity levels in sections of the Danube are quantified regarding different levels of shifted cargo.

WP 8 Identification of Measures for Optimisation of IWT

Measures and different sets of measures resulting from the findings of previous work packages and, their relevance for Danube navigation are identified, discussed and sorted regarding their relevancy .

WP 9 Evaluation and Assessment

Costs, benefits and environmental consequences for the implementation of the identified measures which are inclined to increase inland navigation on the Danube are estimated and assessed. In addition to the assessment of individual measures, a comprehensive evaluation of the general effects resulting from increased utilisation of the waterway is elaborated.

WP 10 Recommendations

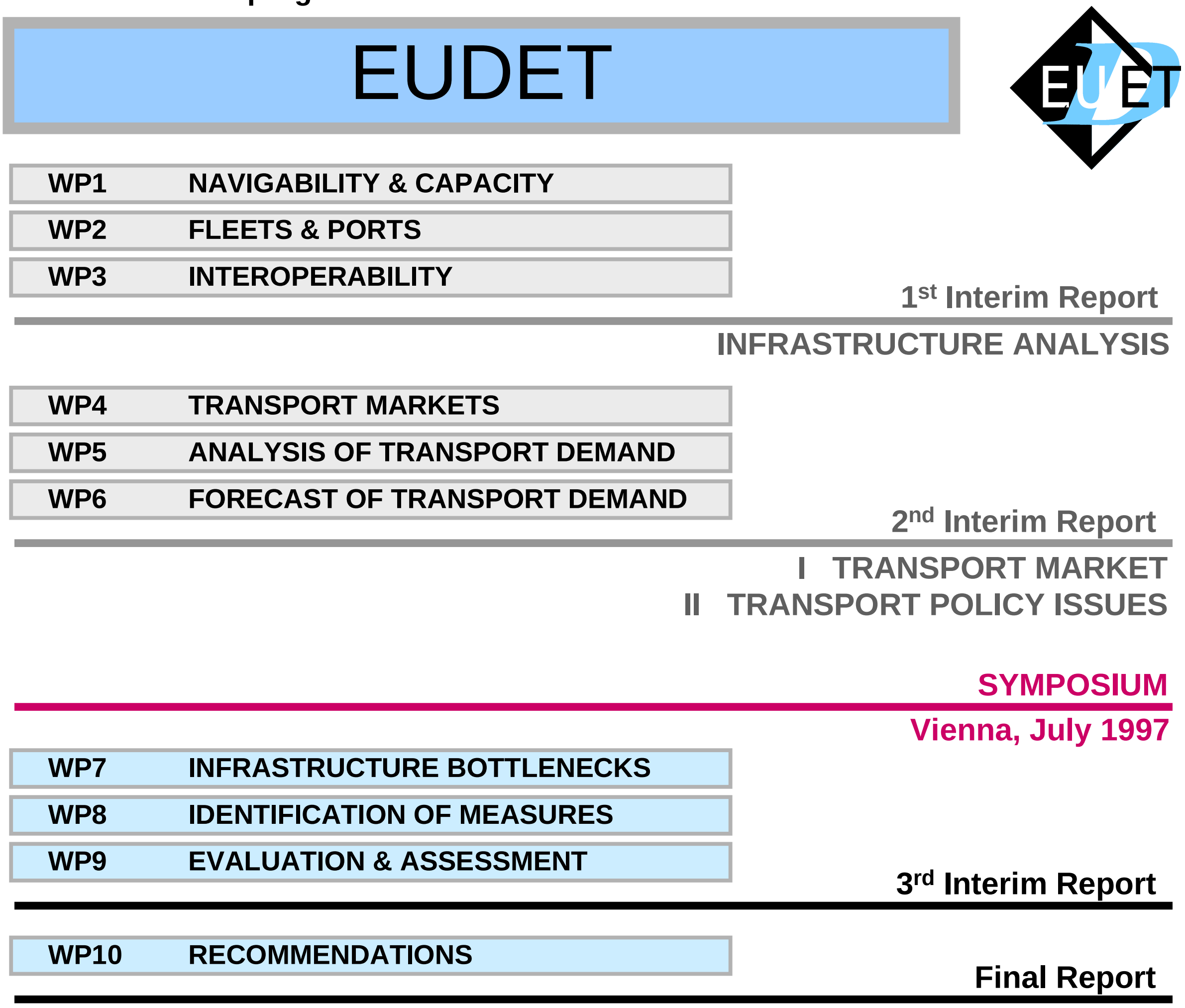
EUDET provides recommendations for infrastructure improvements, production modes and for a transport policy favourable to shift freight from other modes to inland navigation. The overall advantages that could be obtained will be emphasised.

The project started with the elaboration of the proposed workpackages in January 1996. The envisaged lifetime of the project was 24 month, but due to some delays, mostly caused by the lack of complete information and the unexpected complexity of the transport demand forecast, the project was extended to July 31st 1998. Within this time the major part of the work could be finished. This Final Report and the Summary have been drafted in March 1999 and only slightly adapted before delivery in October 1999.
The results and the methods of this workprogramme are documented in 3 interim reports (with restricted publicity).
This Final Report is the only publicly available document of the research work and contains all foreground results in a condensed form.

Beside the research study there were intensive dissemination and awareness raising activities carried out by the consortium, where interim or details of the research results were presented. The most important of these activities was a conference held in Vienna in 1997 on the subject of the "Perspectives of Inland Navigation in a Wider Europe". This conference was attended by representatives of the research community and policy makers from all countries interested in the development of Danube navigation. Its results are documented in a brochure published by ÖIR in German language[1].

1 PS (Hg), Europäische Binnenschiffahrt - Perspektiven im erweiterten Europa, Wien 1998

Figure 1.1:
The EUDET work programme



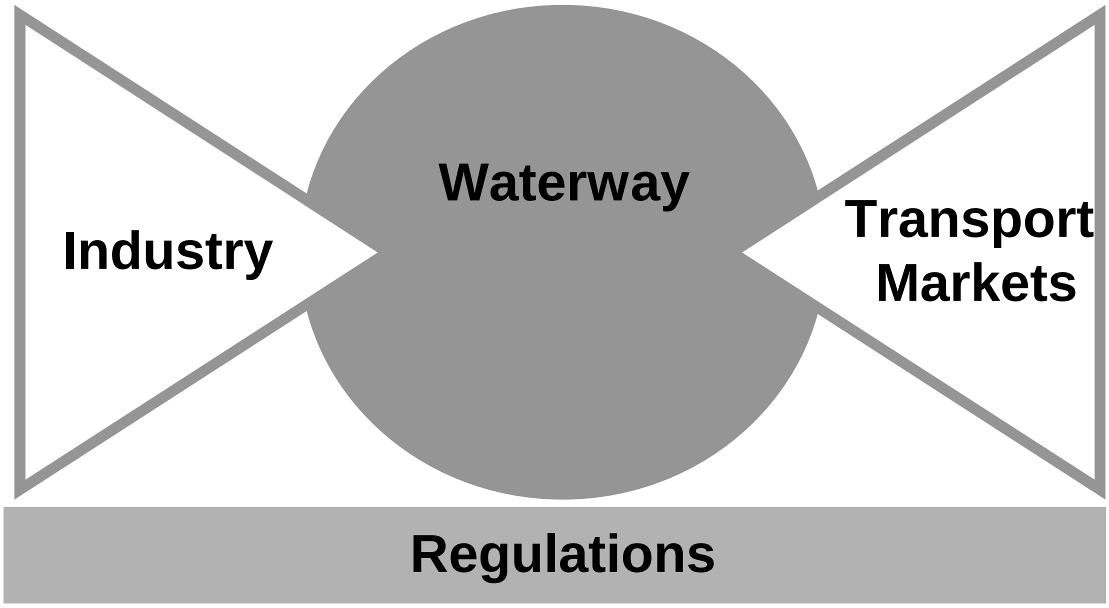
Throughout the project an approach was pursued that understands inland navigation not merely as a field of transport technology but rather as a complex and very dynamic system integrating technological and socio-economic elements.
In a very rough picture these elements are grouped into four sets (or subsystems):

- the waterway itself, as the actual subject of the infrastructure analysis, standing in the centre,
- the inland navigation industry, comprising the economic actors with direct relations to (Danube) navigation, the most important being the ship operators and service providers but also the (relevant) ship builders and other suppliers of inland navigation technology; the ports (authorities) constituting an intermediate group belonging partly also to the infrastructure.
- the transport markets of relevant regions which can be regarded in principle as consisting of the whole globe or as those primarily affecting inland navigation. In any

case this set of elements comprises the modal competition and hence the market behaviour (and its determinants) of all shippers

- finally the regulations for all three elements constitute an element of the system themselves. From international law (e.g. the Belgrade Convention) to national or even regional regulations, they constitute the actual basis for the others but, viewed in a time perspective they are not independent of the market(s) or the industry or even the state of the waterway. Especially in the last decade this interaction has been very obvious in many cases.

Figure 1.2:
The Danube Navigation System



1.3.2 Report Structure

This systems-approach is as far as possible reflected in the structure and content of this report. All three major parts (chapters 2, 3 and 4) refer to this view as a system.
In chapter 2 the present status of the system is described in some detail, drawing heavily on the results of workpackages 1, 2, 4 and 7. The potential performance of the Danube Waterway as a transport infrastructure is assessed and quantified in chapter 3 using a simulation model which again combines market developments, industry behaviour and the state of infrastructure in the future, taking into account the (changing) regulations only implicitely. Chapter 3 tries to focus on the possibilities of (re-)designing the system so that it performs better at least in the long run, adding also a few new aspects, that will play a more prominent role in the future, like e.g. telecommunication.

Finally chapter 4 gives very short overview of the results achieved and the actions proposed, again trying to cover all elements of the systems as only such an integrated approach is deemed to be eventually successful.

2. The Danube Navigation System

2.1 The Waterway

2.1.1 Navigable Conditions

From the source of the Danube in Southern Germany to its mouth into the Black Sea near Sulina, the Danube has a total head of 678 m over the length of 2857 km. The Danube Delta comprises three main branches:

- Chilia (northern) channel with 59%
- Sulina (middle) channel with 19% and
- St. George (southern) channel with 22%

of the total Danube discharge

The Danube becomes navigable for small vessels at Ulm, 2588 km from the mouth into the Black Sea at Sulina. The section between Ulm and Kelheim is navigable for ships having a deadweight less than 250 tons. The length of 2414 km between Kelheim and the mouth is important for international traffic.

”Canalised“ sections of the river are sections where the influence of extremely low or high water flow is compensated by dams and other hydrotechnical structures and thus considerably stable and convenient navigational parameters (waterway depth and width, low stream flow rate) are ensured through most of the year.

In the free-flowing river sections the parameters for navigation vary in wide range.

Regarding different navigable conditions on the Danube, three water levels have to be distinguished:

LNRL: **L**ow **N**avigation and **R**egulation **L**evel is the water level that corresponds to the flow available for 94% of the duration of the navigable season, i.e. excluding the winter periods of break of navigation affected by ice.

MWL: **M**iddle **W**ater **L**evel is the water level that corresponds to the arithmetical mean value of the water flow (registered during the period between 1924 and 1963).

HWL: **H**igh **W**ater **L**evel occurs during just 1% of the duration of the navigable season.

Table 2.1:
Subdivision of the Danube

Section	Danube km		Length	Number of dams	Remark
	from	to	(km)	(-)	
Kelheim - Straubing	2414	2324	90	4	canalised
Straubing - Vilshofen	2324	2249	75	-	free-flowing (shallow)
Vilshofen - Melk	2249	2038	211	8	canalised
Melk - Dürnstein	2038	2008	30	-	free-flowing (shallow)
Dürnstein - Vienna	2008	1921	87	3	canalised
Vienna - Cunovo	1921	1853	68	-	free-flowing (shallow)
Cunovo - Palkovicovo 1)	1853	1811	42	1	canalised
Palkovicovo - Budapest	1811	1646	165	-	free-flowing (shallow)
Budapest - Slankamen	1646	1215	413	-	free-flowing (good)
Slankamen - Iron Gates II	1215	863	352	2	canalised
Iron Gates II - Bala Arm	863	346	517	-	free-flowing
Bala/Borcea Arm - Giurgeni 2)	346	240	126	-	free-flowing (good)
Giurgeni - Braila	240	170	70	-	free-flowing
Braila - Sulina	170	0	170	-	maritime section 6)
Bala Arm - Cernavoda 3)	346	299	47	-	free-flowing (shallow)
Cernavoda - Giurgeni 4)	299	240	59	-	free-flowing (good)
Cernavoda - Constanta	64	0	64	2	navigable canal
Chilia Arm - Black Sea 5)	116	0	116	-	free-flowing (good)

1) 38 km long navigable canal of the hydro-electric power plant Gabcikovo by-passing 42 km of the Danube main course
2) Bala Arm is a natural canal that at Danube km 346 links Danube main course with its left branch called "Lower Borcea Branch". Lower Borcea Branch which joins the Danube main course again at river km 240. The length of Bala Arm is 10 km and of Lower Borcea Branch 68 km up to the mouth in so-called "Old Danube" (river km 249). The remaining 9 km of this navigable by-pass of the Danube main course lead through the Old Danube up to Giurgeni. At low water levels ships use this 87 km long by-pass with special regime of navigation instead of 106 km long section of the river main course.
3) The section over the Danube main course, not convenient for navigation at lower water flows
4) The section of the main Danube course between the Port of Cernavoda (end point of the Danube - Black Sea Canal) and the confluence of the Arm - Lower Borcea Branch. This section is also very important for river vessels with extended draughts (fully loaded) on the routes between the Port of Constanta and the Danube ports located upstream km 346. In low water periods such ships or barge convoys use round-about way over Giurgeni. River-sea vessels use usually Sulina Canal instead of Constanca-Cernavoda and thus avoid the whole section of the main river course between Giurgeni and branching of the Bala Arm.
5) The section between branching of the Chilia Arm at Danube km 80 to the mouth into the Black Sea near the Ukrainian Danube and sea port Ust-Dunajsk.
6) This section over the main river course is allowed for sea-going vessels having a draught of maximal 24 feet (7.32 m). The guaranteed water depth is maintained all the year round by intensive dredging

Table 2.2:
Slope and fall of the Danube

Section	from	to	length (km)	min. slope (cm/km)	max. slope (cm/km)	fall (m)
I-1	Kelheim	Passau	188.02	2.75	13.75	40.08
I-2	Passau	Linz	91.53	0.00	7.90	39.98
I-3	Linz	Vienna	206.08	2.00	7.50	95.29
I-4	Vienna	Gönyü	137.79	5.04	16.30	47.23
II-1	Gönyü	Budapest	144.80	2.50	22.00	10.86
II-2	Budapest	Moldova Veche	598.50	0.25	45.00	34.13
II-3	Moldova Veche	Drobeta	117.00	0.00	21.00	29.46
III-1	Drobeta	Braila	761.00	1.50	17.10	33.31
III-2	Braila	Sulina	170.00	0.20	1.30	1.38

Source: Annuaire Statistique de la Commission du Danube, issues 1988, 1991, 1992, 1996

Table 2.3:
Water flow on the Danube

Location	Water flow (m^3/s)				
	extreme low water	LNRL	MWL	HWL	extreme high water
Linz	370	680	1490	3690	8530
Vienna *	504	830	1700	5070	9600
Bratislava	582	948	2010	5470	10400
Nagymaros	529				8836
Budapest	685		2360		8224
Zemun			3995		
Drobeta	1955		5620		12140
Rousse	1590		5900		15140
Oltenita	1530				15100
Braila		1750	5980	16100	16400
Tulcea		1850	6430	14800	15540
Sulina		500		3100	

*) Discharge through Donaukanal (about 10% of the main flow) not included
Source: KWD 1985, Pomorska enciklopedija 1975, PIANC Bulletin N°75 1991, Navigabilty of the Danube river 1993

The average water confluence of the tributaries along the upper Danube is about twice as big than along the middle course and five times bigger than that on lower Danube. These discrepancies result from the different amount of precipitation. The average value for the Alps region is about 1600 mm per year (with local peaks of 3000 mm) and in the Danube Delta it comes down to only about 350 mm.

Table 2.4:
Average water flow contribution of the biggest Danube tributaries

Tributary	Danube sector	Danube km	Water flow (m^3/s)
Isar	upper	2281.71	110
Inn	upper	2225.20	760
Enns	upper	2111.82	200
March	upper	1880.26	105
Drau	middle	1382.50	622
Theiss	middle	1214.50	995
Sava	middle	1170.00	1722
Velika Morava	middle	1104.50	244
Olt	lower	604.00	163
Siret	lower	155.05	225
Prut	lower	134.14	76

Source: Various German, Austrian and ex-Yugoslav publications

The narrowest waterway sector lies at the beginning of the international part of the Danube waterway between Kelheim and the junction point of the Main-Danube Canal. But regarding the importance for navigation, the most critical sector is between Straubing and Vilshofen where the waterway width is only 40 m (from km 2281.78 to km 2281.03). Here only one way navigation of barge trains (consisting of two barges abreast or self-propelled ship and one barge also coupled abreast due to the vessels or convoy length restrictions on 110 m) is allowed.

Table 2.5:
Average river and waterway width on the Danube

Section	from - to (km)		Length (km)	River width (m) LNRL	River width (m) HWL	Waterway width (m) LNRL	Waterway width (m) HWL
I-1	2414.72	2226.70	188.02	150	350	40	70
*	2414.72	2411.54	3.18			30	
*	2411.54	2377.70	33.84			50	
*	2377.70	2354.30	23.40			75 - 100	
*	2354.30	2247.00	107.30			40 - 70	
*	2247.00	2226.70	20.30			75 - 100	
I-2	2226.70	2135.17	91.53	200	450	70	120
*	2226.70	2201.77	24.93			75 - 100	
I-3	2135.17	1929.09	206.08	250	400	70	120
I-4	1929.09	1731.30	137.79	300	500	70	150
II-1	1731.30	1646.50	144.80	350	600	80	160
II-2	1646.50	1048.00	598.50	300	600	100	130
**	1072.00	1048.00	24.00			180	180
II-3	1048.00	931.00	117.00	600	1300	180	180
III-1	931.00	170.00	761.00	600	800	60	210
**	931.00	863.00	68.00			180	180
***	863.00	743.00	120.00			180	
***	743.00	493.00	250.00			150	
***	493.00	346.00	147.00			120	
***	346.00	170.00	176.00			150	
III-2	170.00	0.00	170.00	150	800	80	210
***	170.00	80.00	90.00			180	
***	80.00	0.00	80.00			80	

Source: Danube Commission Yearbooks (non-shaded fields) , WESKA, Romanian and ex-Yugoslav publications

*) Minimum waterway width exceeded at 89% of the year (325 days)
**) Guaranteed waterway width all over the year
***) Minimum waterway width exceeded at 95% of the year (347 days)

The widths of other sectors correspond to the usual dimensions of barge convoys in two way traffic of respective sections and ECE waterway classification.

Table 2.6
Stream flow rates on the Danube

Section	from - to (km)		Length (km)	Stream flow rate (km/h) LNRL	HWL
I-1	2414.72	2226.70	188.02	0.84 - 5.40	3.60 - 6.10
I-2	2226.70	2135.17	91.53	0.40 - 7.30	2.90 - 10.10
I-3	2135.17	1929.09	206.08	0.70 - 9.00	5.40 - 11.20
I-4	1929.09	1791.30	137.79	3.21 - 7.63	4.58 - 13.70
II-1	1791.30	1646.50	144.80	2.32 - 4.93	4.02 - 10.20
II-2	1646.50	1048.00	598.50	1.51 - 6.93	4.20 - 8.67
II-3	1048.00	931.00	117.00	0.50 - 5.00	1.00 - 8.00
III-1	931.00	170.00	761.00	1.10 - 5.70	3.82 - 7.92
III-2	170.00	0.00	170.00	1.92 - 2.40	5.64 - 6.29

Source: Danube Commission Yearbooks, issues 1988 - 1996

Under certain circumstances the flow rates can be influenced by power plants. In low water periods these variations cannot be very high, but during the extremely high waters, a certain amount of water must sometimes be released through the overflow fields of the dam. On the upper Danube sudden changes of water level (rising) of about 1 metre, which corresponds to about 1000 m^3/s within 24 hours, are not exceptional.

The influence of instantaneous water level on some bigger tributaries may also affect the large variation of the stream flow rates on the respective Danube sections. For example, when the Danube is low and river Theiss has high waters, the flow rate dowstream the mouth can rise from regular 2 km/h up to 5 km/h.

But despite these uncertainties regarding its flow rates the river Danube is nowadays very convenient for navigation.

The water depth is the most influencing factor on the navigation in confined waterways. The depth of the Danube waterway shows discrepancy to a great extent.

On the Upper and middle Danube four sections with frequent unfavourable water depths can be identified:

- Straubing - Vilshofen 69 km (km 2318[2]- 2249)
- Melk - Dürnstein ("Wachau") 30 km (km 2038 - 2008)
- "Vienna - Bratislava" 45 km (km 1920 - 1875)
- Palkovicovo - Budapest ("Gabcikovo - Nagymaros") 165 km (km 1811 - 1646)

2 km 2318 = km 2324 due to shortcut of the waterway

The sector between Straubing and Vilshofen is the most critical one. On certain spots of this section upstream Deggendorf (km 2285) only a water depth of 1.70 m is guaranteed with 89% of probability, and between Deggendorf and Danube km 2247 a depth of 2.00 m is ensured with the same probability (on 326 days per year). The water depth at LNRL originally recommended by the Danube Commission with 2.70 m and 2.80 m for bedrock soil cannot be reached at 265 days a year. Therefore the Danube Commission reduced its recommendation to 1.85 m and 1.95 m respectively.

Becaues of bends with extremely sharp curvature in the sector between Straubing and Vilshofen the length of barge convoys is limited to 110 m (while anywhere else on the Danube main course at least a length of 185 m and overall width of 22.8 are allowed).

These conditions pose a severe drag on reliability (need to lighter, break of navigation) and efficiency (significantly lower draughts mean reduced profitability, market attractivity and flexibility in operation) of westbound Danube navigation. Unsatisfactory water depths also reduce interoperability of Danube and Western Europe waterways through the Main-Danube canal.

The most recent project proposal to improve this critical section foresees dams at Osterhofen and Waltendorf in order to achieve - together with river bed engineering measures - a guaranteed water depths of 2.80 m at LNRL (allowing a draught of 2.50 m) and a minimum waterway width allowing to fall in with other vessels or convoys of 23 m width under certain restrictions.[3]

In the Wachau river bed engineering measures carried out 1986/87 have improved water depths by restoring 2.50 m at LNRL.Plans to construct a hydro-power plant at Rührsdorf (km 2012) have been abandoned.

Downstream Vienna there was just 2.25 m water depth available on the average of the last decade. Therefore, this section of the Danube could not be navigated in the last two decades at 20 dm draught on an average of 84 days and at 25 dm draught on an average of 155 days.

The Austrian Government has renewed its obligation[4] to assure fairway conditions east of Vienna which will allow a draught of 2.70 m. But similar to the situation in Bavaria a final solution how to improve this particular section has not yet been found.

On the section between Palkovicovo and Gönyú 6 to 7 bottlenecks are present where the navigation channel is shallow and narrow, due to (sand) bars. Near Nyergesújfalu and Helemba island the navigation channel also is restricted in width.[5]

The Nagymaros threshold (km 1697) may be considered as a critical shallow presenting water depths of 1.4 m to 1.5 m for some periods of the year. A draught of 2.5 m cannot

3 Bewertung des Donauausbaues zwischen Straubing und Vilshofen, 1.Teilbericht, Planco, Essen 1995.
4 Binnenschiffahrtsmemorandum 1992
5 Feasibility Study Rajka - Budapest, Final Report Stretch B1: Szap - Ipoly Mouth, Delft Hydraulics, Frederic R. Harris and VITUKI, 1994 for the Goverrnement of Hungary.

be assured for 160 days/year. This conditions have worsened gradually within the last years in the zone of the circular dam.[6]

In 1992 the Hungarian Government has proposed a three step programme to improve navigation between Estergom and Vác, the third phase being scheduled for the years past 2005.

In summary, it has to be noted that the Danube upstream of Budapest doesn't satisfy the requirements and standards of European inland navigation.

The conditions **downstream Budapest** are substantially better. Unfavourable water level conditions (less than 180 cm allowed draught) appear during 8 to 10 days per year near Dunajvàros (km 1580), downstream from Dunaföldvàr (km 1547) and near Vukovar (km 1307). Their removal could be achieved by small-scale local interventions.

Downstream from Iron Gates II the average annual number of days with water depths less than 2.50 m is 24 or less than 7% of the year. Some 10 - 12 critical points regarding shallow waters in low water periods exist between Somovit (km 608) and Silistra (km 375). The most critical one is between km 566 and 562 with only 1.50 - 1.60 m water depth in the period of extremely low waters. Some further critical spots are between river km 345 and km 292.

In such circumstances the navigation is directed through Bala Arm (9 km long natural canal linking Danube main course with its left side branch called Borcea) and Lower Borcea Branch, joining the river main course again near Giurgeni (km 240). This waterway by-pass is relatively deep with just one spot with the depth of 2.70 m at extremely low waters at the junction point of Bala Arm (km 10) and the Danube main course (km 346). Navigation conditions at low water levels are better on this route than over the main Danube course.

The day and night two way navigation on Lower Borcea Branch is allowed for towed or pushed convoys with a length of up to 190 m and a width of up to 33 m. There are six spots on this 68 km long section where due to narrow and sharp waterway bends the overtaking or by-passing of maximal size convoys is not possible. The 10 km long Bala Arm is allowed just for one way navigation and only between sunrise and sunset.

6 Programme of Development for the Infrastructure of Inland Navigation, Bureau for Research Organiszation and Development at the Institute for Transport Sciences, Ltd., Budapest 1994, for the Ministry of Transport, Communication and Water Management.

Table 2.7:
Average waterway depths on the Danube (1989-1990)

Section	from (km)	to (km)	Length (km)	Depth by LNRL (m)	Min. depth (m)
I-1	2414.72	2226.70	188.02	1.20 - 2.90	1.20 - 1.60
*	2414.72	2411.54	3.18	1.20 1)	
*	2411.54	2354.30	57.24	2.90	
*	2354.30	2285.00	69.30	1.70	1.55
*	2285.00	2247.00	38.30	2.00	1.55
*	2247.00	2226.70	20.30	2.80	
I-2	2226.70	2135.17	91.53	1.85 - 2.80	1.85
*	2226.70	2201.77	24.93	2.80	
I-3	2135.17	1929.09	206.08	1.85 - 2.80	1.60 - 1.90
I-4	1929.09	1731.30	137.79	2.50 - 3.50	1.40 - 1.50
II-1	1731.30	1646.50	144.80	2.50 - 3.50	1.20 - 1.60
II-2	1646.50	1048.00	598.50	2.50 - 3.50	1.40 - 1.60
**	1072.00	1048.00	24.00	3.50	3.50
II-3	1048.00	931.00	117.00	3.50	3.50
III-1	931.00	170.00	761.00	2.30 - 3.50	1.40
**	931.00	863.00	68.00	3.50	3.50
***	863.00	743.00	120.00	3.70	3.40
***	743.00	493.00	250.00	2.30	1.80
***	493.00	346.00	147.00	2.70	2.00
***	346.00	170.00	176.00	2.40	1.80
III-2	170.00	0.00	170.00	7.32	7.32

Source: Danube Commission Yearbook 1996, WESKA 1994, PIANC Bulletin N°75 1991

*) Minimum waterway depth exceeded at 89% of the year (325 days)
**) Guaranteed waterway depth all over the year
***) Minimum waterway depth exceeded at 85% of the year (310 days)
1) international traffic does not use this section but follows the course of Main-Danube canal

Table 2.8:
Annual number of days with small water depths on most critical Danube sections (statistics from 1980 to 1994)

1	2	3	4						5	6
Sector (country code)	Danube km (from - to)	Water depth less than (m)	Number of days per year (season) with water depths less than in column 3 (-)						DC recom-mendation (m)	Depth less than 1.70 m (days/year)
			80/81	85/86	90/91	91/92	92/93	93/94		
D	2338-2319	1.90	11	82	40	154	67	11		47
		1.80	3	73	40	141	67	11	1.85	
		1.70	0	57	32	125	61	8		
A	2022-2013	2.00	0	3	58	116	49	0	2.00	14
		1.90	0	3	43	98	49	0		
		1.80	0	0	26	60	33	0		
A	1897-1884	2.50	97	100	7	29	6	31	2.50	10
		2.40	93	100	7	29	6	31		
		2.30	87	93	4	29	4	23		
SK-H	1810-1735	2.50	109	135	201	186	172	99	2.50	44
		2.40	88	124	190	186	172	99		
		2.30	75	114	175	177	160	78		
H	1699-1558	2.50	112	100	139	149	135	62	2.50	14
		2.40	10	88	139	149	135	41		
		2.30	6	80	130	141	115	28		
HR-YU	1310-1206	2.50	0	0	166	122	123	31	2.50	8
		2.40	0	0	156	122	123	24		
		2.30	0	0	143	105	91	9		
YU-RO	861-858	2.50	0	41	87	20	61	34	2.50	9
		2.40	0	41	81	20	61	25		
		2.30	0	39	74	14	51	21		
RO-BG	760-561	2.50	36	52	89	67	110	72	2.50	15
		2.40	36	51	73	67	110	72		
		2.30	30	44	63	58	103	64		
RO	345-322 *	2.50	39	59	223	86	128	103	2.50	55
		2.40	37	59	214	86	128	97		
		2.30	33	56	208	66	124	94		

Source: Danube Commission

*) Danube main course; this why Bala arm and Lower Borcea Branch are used quite often

The section between Braila and Sulina is the maritime part of the Danube where the minimal water depth is maintained at 24 feet (7.32 m) over its whole length through intensive dredging.

Regarding the morphological characteristics of the Danube, the following sectors can be identified:

- From Kelheim to Vienna the river bed is covered with gravel of different grades and frequently crossed with rocky sills.
- From Vienna to Budapest the river bed is sandy. Due to the terrain configuration and type of soil, the course of the river is characterised by sharp meanders, frequent and numerous fan branching, plenty of shallows and frequent changing of river bed.
- From Budapest to Moldova Veche (Hungarian lowlands) the river bed is much more stable than upstream Budapest despite of the similar soil composition. Only the river Theiss brings sediments into the Danube thus forming sandbars.
- From Moldova Veche to approximately river km 800 the river bed is rocky. The Danube flows through the gorges of the South Carpathian mountaines.
- From the exit out of the Carpathian mountains to the mouth the river bed is prevailing of sand crossed on some spots with rocky sills. On certain sectors the Danube branches into two or more arms like between Silistra and Braila (Upper and Lower Borcea Branch, Bala Arm, Old Danube, Macin Arm) and on the last 80 km before the mouth where the river builds a Delta with three navigable branches.

Especially in its lower course, the Danube must be regularly dredged. This intensive dredging is very important in the last maritime sector in order to keep the guranteed 24 feet water depth. On certain sections dredging is not possible due to the erosion of the river bed and there other measures must be done in order to maintain the waterway (erection of warfings, dykes etc.)

Table 2.9:
Number of sandbars on the Danube for period 1985-1994

Section	Section length (km)	No. of sandbars						
		1985	1986	1988	1989	1990	1993	1994
I-1	188.02	6	5	-	-	5	5	2
I-2	91.53	-	-	-	-	-	-	-
I-3	206.08	1	1	-	1	1	1	1
I-4	137.79	17	18	12	10	11	14	10
II-1	144.80	5	5	4	8	7	8	8
II-2	598.50	8	8	10	11	12	12	8
II-3	117.00	-	-	-	-	-	-	-
III-1	761.00	24	25	8	12	13	41	37
III-2	170.00	-	-	-	-	-	9	4

Source: Danube Commission Yearbooks 1988-1996

The Danube has more than thirty navigable tributaries and navigable linking canals. But if the term ”navigability” is applied only to commercial vessels or convoys having at least 1000 tdw, then the number of tributaries having the class ”III” or ”IV” according to the official ECE classification of European inland waterways has to be considerably reduced.

Table 2.10:
Main navigable tributaries and canals of the Danube

	Name of navigable tributary or linking canal	Danube km	River bank	Country code	Navigable length (km)	ECE class	Remark referring to the allowance of foreign ships to use the waterway **
1	Main-Danube Canal	2411.54	left	D	171.0	Vb	allowed
2	River Traun	2124.73	right	A	2.0	VIa	allowed
3	River Drau (Drava)	1382.50	right	HR, H	155.0	III, IV	status unknown
4	Bogojevo-Becej Canal	1363.40	left	YU	90.2	IV	with special permission
5	Novi Sad-S.Selo Canal	1253.50	left	YU	39.1	IV	with special permission
6	River Theiss (Tisa)	1214.50	left	YU, H	543.0	III, IV	allowed for riparian states
7	River Sava	1170.00	right	YU, HR	587.0	III, IV, Va	status unknown
8	B.Palan.-N.Becej Canal	1076.50	left	YU	147.3	IV	with special permission
9	Bala Arm/Borcea Branch	346.00	left	RO	87.0	VIb	allowed
10	Cernavoda-Constantza	299.50	right	RO	64.4	VIb	allowed
11	White Gate-Midia Canal	*	left	RO	26.6	Va	status unknown
12	Chilia Arm of the Danube	79.17	left	UKR, RO	116.0	VII	allowed up to Ismail

*) White Gate-Midia Canal is a side navigable canal that links Cernavoda-Constantza Canal (Danube-Black Sea) with the Black Sea Port of Midia. The canal branches from the Cernavoda-Constanta Canal near Poarta Alba (White Gate), 34.5 km from Cernavoda

**) Main-Danube Canal, navigable section of river Traun (up to the heavy cargo transhipment zone of the Port of Linz), Bala Arm/Lower Borcea Branch and Cernavoda-Constanta Canal are allowed for all ships on the Danube even though these waterways are under the jurisdiction of the respective country.

River Drau was international waterway up to City of Osijek (Croatia), about 20 km upstream from the mouth. This section can be classified as ECE class IV. Upstream from Osijek both river banks are on Croatian territory up to km 68. From km 68 to km 155 (end of navigable section), the river belongs to both Hungary and Croatia (border line along the waterway). It is expected that after the final resolution of confrontations in ex-Yugoslavia, the Drau will get the status of an international waterway.

Navigable canals of the so-called Danube - Theiss - Danube (DTD) system (N° 4, 5 and 8 in the Table) are national waterways (Serbia) and foreign ships are requested to have a special permission to use them.

River Theiss is allowed for Yugoslav (Serbian) and Hungarian ships on the section between the mouth into the Danube (km 0) and Yugoslav-Hungarian border (km 164). Other ships are requested to ask for permission.

Navigable section of river Sava flows through Croatia, Bosnia (border with Croatia) and on the last 207 km before the mouth through Serbia. Before the war in ex-Yugoslavia, special permission for foreign ships was requested (except for the last several hundred metres before the mouth - entrance in passenger zone of the Port of Belgrade). Its status is therefore similar to that of Drau.

Chilia Arm is allowed for all Danube flags between the branching of the Danube main course and the Port of Ismail on a length of 23 km. The section between Ismail and the mouth into the Black Sea is nowadays free for Ukrainian and Romanian ships.

The navigable length and the traffic importance of these tributaries and canals vary in wide range. The Main-Danube Canal, The Danube-Black Sea Canal and the Chilia Arm of the Danube Delta are of crucial significance for the Transeuropean inland waterway network.

Climatic conditions

The geographical location, surrounding mountain chains as Alps, Carpathian and Balkan mountains, the large Panonic plain and the relative vicinity of the Mediterranean commonly contribute to the climatic conditions along the course of the river. The most influencing climatic components for inland navigation are undoubtedly ice, winds and fog.

The periods of winter navigation breaks due to the forming of an ice cover on the Danube are relatively seldom and short lasting.

Table 2.11:
Number of days with ice on the Danube for period 1986-1994

Section	Section length (km)	No. of days with ice appearance						No. of days with total break of navigation					
		1986	1988	1989	1990	1993	1994	1986	1988	1989	1990	1993	1994
I-1	188.02	32	-	9	9	11	-	28	-	-	-	-	-
I-2	91.53	34	-	11	9	8	-	30	-	-	-	6	-
I-3	206.08	33	-	10	10	7	-	30	-	-	-	-	-
I-4	137.79	30	-	-	-	3	-	11	12	-	-	-	3
II-1	144.80	32	-	-	-	3	-	12	4	-	-	-	-
II-2	598.50	31	-	-	3	-	-	12	10	-	-	-	-
II-3	117.00	36	-	-	-	18	-	35	-	-	-	5	-
III-1	761.00	34	-	-	7	9	-	26	8	7	-	2	-
III-2	170.00	28	-	-	-	19	-	17	-	-	-	-	-

Source: Danube Commission Yearbooks 1988-1996

In the Danube area low rate winds prevail. Most frequently it is calm or there is a breeze with a rate of up to 1 m/s. On the upper Danube such situation occurs at 40-50% of the whole year, and on the lower and middle Danube even up to 75%.

In exceptional cases stormy winds with rates of up to 31 m/s appear downstream from Novi Sad (km 1255). These winds cause relatively high waves, especially along the wide and deep sector of Iron Gates I water reservoir between Belgrade and Moldova Veche (Danube km 1170 - 1048) with peaks near Ram (km 1077). On these extreme occasions the wave heights are more than 1.2 metres and the navigation of barge trains is almost impossible.

Table 2.12:
Average annual wind rates distribution on the Danube

Wind rate	(m/s)	1 - 5	6 - 10	11 - 15	16 - 20
share regarding all winds	(%)	33	61	5	1

Sourse: Proceedings from "Waterways-Shipbuilding-River Shipping" conference 1976

In the case of dense fog, radar equipment may not be sufficient for enabling the safe navigation. The decision of the skipper to proceed or to stay at anchor will depend on the waterway width and depth, the density of floating buoys with radar reflectors, current traffic density, kind of cargo being transported onboard, size and speed of the ship or barge train and its manoeuvring abilities etc. Moreover, it is not the same if the ship navigates downstream or upstream because the manoeuvre in upstream navigation is far more effective than in downstream. Concerning relatively dense traffic in confined spaces of inland waterways, fog represents one of the biggest handicaps for safe navigation.

The highest probability and the highest number of foggy days on the Danube occur in November and December.

Table 2.13:
Average annual number of foggy days on the Danube

Location	Section	Danube km	No. of foggy days
Linz	I-2	2135	43
Vienna	I-3	1929	36
Budapest	II-1	1647	44
Belgrade	II-2	1170	46
V. Gradiste	II-2	1059	21
Lom	III-1	743	55
Rouse	III-1	496	49

Source: Proceedings from "Waterways-Shipbuilding-River Shipping" conference 1976

Bridges

In periods of high water, to little air clearance under bridges and other overpassing structures (pipelines, power cables) can hinder, and in extreme cases even interrupt navigation. On the upper course of the Danube there are much more bridges than on the middle and especially lower Danube.

Table 2.14:
Bridges over the Danube (1992)

		Number and purpose of the bridges *			
Section	Length (km)	Rail	Road	Others	Total
I-1	188.02	8	27	4	39
I-2	91.53	-	3	4	7
I-3	206.08	7	12	7	23
I-4	137.79	2	9	2	13
II-1	144.80	2	4	-	6
II-2	598.50	6	17	1	19
II-3	117.00	-	2	2	3
III-1	761.00	3	3	2	6
III-2	170.00	-	-	-	0

Source: WESKA 1994, Set of Danube navigational maps

*) Some bridges have dual purpose, e.g. they are executed as combined rail and road bridges and therefore the sum of all bridge types is greater than the total number of bridges on some sections.

There are 21 bridges with an air clearance less than 7.50 m above HWL.

The minimal air clearance under the bridges on the sector between Kelheim and the river lock near Regensburg (Danube km 2414.72 - 2379.68) is 6.40 m at the HWL.

Table 2.15:
The most critical bridges (1994)

Location	Bridge purpose	Danube km	Air clearance over the HWL (m)
Kelheim	Road	2414.25	5.25[1)]
Kelheim	Road	2412.72	6.35
Bad Abbach	Road	2400.24	6.31
Bad Abbach	Pedestrian	2398.78	6.32
Regensburg	Road	2380.17	6.31
Regensburg	Road	2378.39	6.73
Regensburg	Rail	2376.82	6.08
Pfatter	Road	2353.32	5.75 (8.42) [2)]
Bogen	Rail	2311.27	5.02
Deggendorf	Rail	2285.87	4.73
Deggendorf	Road	2284.59	7.30
Kachlet	Crane	2230.63	6.67
Passau	Rail	2230.28	6.36
Passau	Road	2380.17	4.61 (6.03) [2)]
Linz	Road & Rail	2133.83	7.42
Linz (Vöest Port)	Rail	2127.16	6.65
Vienna[3)]	Rail	1924.96	7.10
Bratislava	Road	1868.14	6.70
Budapest	Road	1648.75	6.70
Budapest	Road	1647.00	7.30
Novi Sad	Road	1255.00	6.07

Source: WESKA 1994, Set of Danube navigational maps

1 These bridges are located on the navigable stretch of the Danube but upstream the Port of Kelheim and the junction of the Main-Danube Canal. Therefore they practically do not affect the navigation. Only the access to the cellulose production plant on km 2414.40.
2) in middle of the span
3 The bridge has been recently elevated to match the higher water level arisen after the erection of the new Freudenau dam.

The navigation under bridges is affected by the width of free passage between two adjacant bridge columns, angle between the bridge and water flow direction (optimal 90°), local water flow rate, intensity and direction of wind etc. "Free span of the bridge" (table 2.15) means the width of the waterway under the bridge. Usually that is the distance between bridge columns reduced for necessary side clearances during passage, but sometimes, due to the profile of water bed or highly bended arcs, this width can be smaller.

Between Kelheim and Vienna there are 6 bridges with a free span of less than 40 metres, downstream of Vienna 11 bridges with less than 70 m. All other bridges dowstream Budapest have a span of at least 100 metres. (The road and railway bridge at Bogojevo (km 1366.30) has 97.00 m).

Table 2.16:
The narrowest bridge spans on the Danube

Location	Bridge purpose	Danube km	Free span under the bridge (m)
Kelheim	Road	2414.25	22.00
Kelheim	Road	2412.72	30.00
Poikam	Rail	2401.96	31.00
Mariaort	Rail	2385.67	36.70
Regensburg	Highway	2381.13	39.00
Regensburg	Rail	2376.82	37.00
Vienna	Road	1931.71	61.00
Vienna	Rail	1931.20	65.00
Vienna	Road	1930.45	65.00
Vienna	Rail	1924.96	67.00
Bratislava	Road	1868.14	67.00 + 86.00 *
Medvedov	Road	1806.35	67.00
Budapest	Road	1651.40	65.00 + 65.00 *
Budapest	Road	1648.75	60.00 + 60.00 *
Budapest	Road	1643.20	60.00 + 60.00 *
Dunaföldvar	Road & Rail	1560.55	74.00 + 74.00 *
Baja	Road & Rail	1480.22	60.00 + 60.00 *

Source: WESKA 1994, Set of Danube navigation maps

*) two navigable passages between different bridge columns

River and Canal locks

The first hydro-electric power plant (at Kachlet) with dam and river lock has been put into service in 1928. Up to nowadays, a total of 18 river lock groups have been built.
Two more single chamber locks are planned at Waltendorf (km 2301) and at Winzer-Osterhofen (km 2265).

The erection of the hydro-electric power plant and river lock near Nagymaros in Hungary (km 1695) has started 1977.

There are projects for power plants near Nikopol (km 581) and near Silistra (km 375).

Table 2.17:
Locks on the main course of the Danube Waterway

			Inner chamber dimensions				
Section	Name	Location (km)	Width (m)	Usable length (m)	Elevating height (m)	Sill depth (m)	Locking time * (min.)
I-1	Bad Abbach	2397.16	12	190	5.70		20
I-1	Regensburg	2379.68	12	190	5.20		20
I-1	Geisling	2354.30	24	230	7.30		20
I-1	Straubing	2324.25	24	230	-		20
I-1	Kachlet	2230.60	2 x 24	230	9.80	3.50	20
I-1	Jochenstein	2203.21	2 x 24	230	10.20	4.00	20
I-2	Aschach	2162.94	2 x 24	230	15.90	4.05	20
I-2	Ottensheim-Wilhering	2147.17	2 x 24	230	12.00	4.00	20
I-3	Abwinden-Asten	2119.63	2 x 24	230	10.70		20
I-3	Wallsee-Mitterkirchen	2095.62	2 x 24	230	13.20	4.00	20
I-3	Ybbs-Persenbeug	2060.42	2 x 24	230	12.00	3.75	20
I-3	Melk	2038.16	2 x 24	230	11.10	4.00	20
I-3	Altenwörth	1980.40	2 x 24	230	16.00	4.00	20
I-3	Greifenstein	1949.23	2 x 24	230	14.00	4.00	20
I-4	Vienna-Freudenau	1921.00	2 x 24	275			20
I-4	Gabcikovo	1819.30	2 x 34	275	10.00	-	30
II-3	Iron Gates I	942.90	2 x 34	2 x 310	34.40	5.35	90
III-1	Iron Gates II	863.70	2 x 34	310	12.50	4.50	30
III-1	Iron Gates II (small)	863.70	14	140	12.50	2.50	20

Source: WESKA 1994, Set of Danube navigation maps, DDSG Logbooks 1991

*) Locking time depends on duration of action of locking itself (opening respectively closing the chamber gates, changing the water level in chamber - usually 10-15 minutes depending on the elevation height) and time needed for aproaching manoeuvre of the ship respectively for leaving the chamber. Some values given above are extracted from available logbooks and can be used just as for the rough orientation

The **Main - Danube-Canal** enables the navigation of barge trains consisting of two "Europe II" barges in line and the pushboat, respectively one barge pushed by the self-propelled ship. Such convoy has an overall cargo capacity of about 3300 tons. According to the ECE-classification, the Main - Danube Canal belongs to the class "V b" of European inland waterways

All canal locks on the 170.71 km long Main-Danube Canal have a single chamber with a length of 190.00 m and a width of 12.00 m. The waterway depth is at least 2.70 m (usually about 4 m) and the width at least 36 m. The bridge with lowest air clearance (Canal km 4.82) enables an air draught of 5.49 m by HWL, respectively 6.50 m at standard water level.

Table 2.18:
Locks on the Main - Danube Canal

No.	Name	Location * (Canal km)	Elevating height (m)
1	Bamberg	7.41	10.94
2	Strullendorf	13.29	7.41
3	Forchheim	25.88	5.29
4	Hausen	32.86	12.00
5	Erlangen	41.04	18.30
6	Kriegenbrunn	48.66	18.30
7	Nürnberg	69.09	9.40
8	Eibach	72.83	19.49
9	Leerstetten	84.32	24.69
10	Eckersmühlen	94.94	24.67
11	Hilpoltstein	98.99	24.67
12	Bachhausen	115.46	17.00
13	Berching	122.51	17.00
14	Dietfurt	135.26	17.00
15	Riedenberg	150.83	8.40
16	Kelheim	166.06	8.40

Source: WESKA 1994

*) The distances are officially measured from the junction point of the Main - Danube Canal and the river Main

The entrance into the **Danube - Black Sea Canal** is located at km 299.50 and that point corresponds to the Canal km 64.4. The bend curvatures have a radius of not less than 3000 m. The water depth of 7.00 m is guaranteed. The Canal bottom width is 70-90 m and an air clearance along the waterway of at least 17.00 m is provided.

This, according to the ECE classification class "VI c" inland waterway, enables the navigation of pushed barge convoys with an overall length of up to 300 m and breadth of up to 22.8 m. That corresponds to an overall convoy capacity of 18000 tons when full loaded "Europa II a" barges with a draught of 3.8 m are used. Self-propelled maritime vessels of up to 5000 tdw, having a length of up to 140 m, a beam of 16.8 m and a draught of 5.5 m are also allowed.

The average passing time through the Canal is 6 hours for pushed convoys and about 5 hours for single self-propelled vessels.

Table 2.19:
Locks on the Danube - Black Sea Canal

Name	Location * (Canal km)	Chamber dimensions Width (m)	Length (m)	Elevating height (m)	Sill depth (m)	Locking time (min.)
Cernavoda	59.30	2 x 25	310	5.50	7.50	30
Agigea (Constanta)	1.90	2 x 25	310	7.50	7.50	45

*) The distances are measured from the canal entrance by Agigea (Constanta)

The 26.60 km long **White Gate - Midia Canal** links the Romanian Black Sea Port of Midia with the Cernavoda - Constanta Canal. The junction point of this side canal is at km 29.4 near Poarta Alba - ”White Gate”. The Canal has three sections - one between the lock groups and two outer sections. The outer sections have a trapezoidal cross-section with a bottom width of 36m and a waterway width of 50 m, while the inner section has rectangular cross-section with the bottom width of 50 m. The water depth along the whole Canal is 5.5 m, minimum radius of bends is 1000 m and the air clearance under the bridges is 13.5 m.

The locks on the White Gate - Midia Canal consist of two groups with two parallel chambers each. The chamber inner dimensions are:

- length .... 145.0 m
- width .... 12.5 m
- sill depth .... 5.5 m

The Canal and lock dimensions enable two-way navigation of convoys consisting of one ”Europa II a” barge and corresponding pushboat or equivalent self-propelled vessels including maritime types too. Referring to the allowable ships’ respectively convoy dimensions, the cargo capacity of such units is about 2000-3000 tons, and the canal itself can be classified as ”V a” class inland waterway.

This canal network links the Danube and Tisa rivers with some other minor navigable tributaries on the territory of northern Yugoslavia and some parts of western Romania with a total length of 598.70 km. The total length of canals that can be nominated as ECE class IV is 337.60 km.

Navigational aids

The system of navigational markings is unified along the whole river course. The navigational aids consist of floating buoys, water level gauges and various kinds of markings on the river banks, on the bridges, in front of the river locks etc. Floating buoys are equipped with radar reflectors.

2.1.2 Transport Capacity

The most influencing factors for the transport capacity of an inland waterway is the capacity of river locks. Other factors are the allowed draught of the vessels, waterway depths, high water periods, winters with ice appearance, fog and stormy winds, as well as some technical restrictions (prohibition of two way navigation on certain sectors or speed limits).

Furthermore, the disposition of capital harbours along the waterway must be taken in account.

Moreover, the fleet composition is also an influencing factor. On one side the Danube, especially the middle and lower Danube, is ideal for pushing long and broad barge convoys of moderate draught (2.0 - 2.5 metres), but on the other side the transport market often requires the use of considerably faster and more flexible single self-propelled units. The different specific weights of various commodity groups involve additional difficulties.

For free flowing stretches of the river also factors like safety distance between two ships heading in the same direction, allowance for overtaking and by-passing must be considered.

All above influences make the matrix of components for the calculation of the transport capacity over the Danube waterway pretty complicated. A lot of sometimes rough assumptions must be applied in order to get realistic values.

River locks

The estimate of the theoretical traffic capacity through the locks on the Danube, the Main-Danube Canal and the Danube-Black Sea Canal, is based on the the following assumptions:

- the navigational season lasts 330 days per year
- all the locks are in service 24 hours a day
- there are no waiting times in front of the locks
- for approaching manoeuvre 10 minutes have to be added to the pure locking time
- the overall locking efficiency is assumed as 40-60%. (This assumption has been made as a corrective factor having in mind that sometimes also single cargo ships or passenger vessels pass through the locks and thus the theoretical capacity is not utilised.)

- all the barges passing through the locks are loaded up to the most probable average draught achievable during the year on the corresponding river sector.

The capacity calcluation is based on the so-called ”Danube-Europe II-b” barge unit with

- length over all	....	76.5	m
- breadth max.	....	11.0	m
- depth	....	3.1	m
- draught max.	....	2.8	m
- loading capacity	(at 2.5 m draught)	1600	t
- immersion	(at 2.5 m draught)	abt. 8	t/cm

The annual lock capacity **ALC**y in million tons of cargo (per direction) has been calculated using the following formula:

$$ALC_y = \frac{n}{2} * \frac{60*24*330}{LT} * \frac{OLE}{100} * \frac{CC}{10^6} \quad \text{(million tons/year),} \qquad (1)$$

where:

n = 1 or 2	is the number of parallel lock chambers,
LT (min)	is the technical locking time in one direction,
OLE (%)	is the overall locking efficiency as defined above and
CC (tons)	is the barge train cargo capacity

The theoretical annual number of lockings in one direction - **ANL**y - is calculated by the formula:

$$ANL_y = \frac{n}{2} * \frac{60*24*330}{LT} * 0.9 \quad \text{(lockings/year of cargo vessels only)} \qquad (2)$$

Due to the diversity of lock particulars and possible draughts, each lock or group of locks with identical characteristics on the main Danube course, as well as on the important linking canals are considered separately.

River locks Bad Abbach (km 2397.16) and Regensburg (km 2379.68)

The corresponding Danube sector lies between the junction point of the Main-Danube Canal (Danube km 2411.54) and the Port of Regensburg with a length of about 37 km. These two locks have single chambers thus allowing an alternative locking only (with twice lower frequency in one direction).

- locking time...	30	minutes
- allowed draught over the sector with a probability of 90%	2.5	metres
- cargo capacity of barge train	3200	tons
- overall locking efficiency	60	%
- number of chambers	1	

- annual cargo capacity per direction ANLy = 15.2 million tons
- theoretical annual number of lockings per direction ANLy = 7128

All the locks on the German stretch of the Danube have regular operating hours between 06:00 and 22:00. The locks operate also between 22:00 and 06:00 if the skippers announce their arrival to the lock master in advance.

River locks Geisling (km 2354.30) and Straubing (km 2324.25)

This sector covers the distance between the Port of Regensburg and the river lock Straubing (km 2324.25) with a length of about 50 km. These two locks have also single chambers.

- locking time.. 30 minutes
- allowed draught over the sector with a probability of 90% .... 2.5 metres
- cargo capacity of barge train .... 6400 tons
- overall locking efficiency .... 50 %
- number of chambers 1

- annual cargo capacity per direction .... **ACL**y = 25.3 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 7128

River locks from Kachlet (km 2230.60) to Greifenstein (km 1949.23)

There are 10 twin chamber locks on this sector that covers the distance between the ports in Passau (Danube km 2229-2228) and Vienna (km 1936-1920). The overall sector length is about 310 km.

- locking time.. 30 minutes
- allowed draught over the sector with a probability of 90% .... 2.5 metres
- cargo capacity of barge train .... 6400 tons
- overall locking efficiency .... 50 %
- number of chambers 2

- annual cargo capacity per direction .... **ACL**y = 50.7 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 14256

River lock Freudenau (km 1920.75)

The usual convoy on the Danube stretch between Vienna and Bratislava consists of up to four barges. Despite of that restriction, the locking capacity of Freudenau lock is calculated assuming the 6 barge convoys. The assigned nominal draught is 2.0 m respecting the situation on the stretch between Vienna and Bratislava respectively the beginning of the Gabcikovo navigable canal.

- locking time	30	minutes
- allowed draught over the sector with a probability of 90%	2.0	metres
- cargo capacity of barge train	7200	tons
- overall locking efficiency	50	%
- number of chambers	2	

- annual cargo capacity per direction .... **ACL**y = 57.0 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 14256

River lock Gabcikovo (km 1819.30)

The uppermost Danube port which large pushed barge convoys consisting of 9 barges (3 x 3 + pushboat) can reach is the Slovakian Port of Bratislava (km 1865.40) - the most important port on the Slovakian section of the Danube. Downstream, the Port of Novi Sad (Danube km 1253.50) can be defined as the lower end point for 9 barge convoys. Having in mind the frequent draught restrictions upstream Budapest, an average draught of 1.7 m has been assigned.

- locking time	40	minutes
- allowed draught over the sector with a probability of 90%	1.7	metres
- cargo capacity of barge train	9000	tons
- overall locking efficiency	40	%
- number of chambers	2	

- annual cargo capacity per direction .... **ACL**y = 42.8 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 10692

River lock Iron Gates I (km 942.40)

The sector assigned to the river lock Iron Gates I lies between the Port of Novi Sad (km 1253.50) and the Rumanian Port of Drobeta on the left river bank (former Turnu Severin - km 931.00) respectively the Serbian Port of Kladovo (km 932.50) on the opposite Danube bank. It has a length of about 320 km.

The Iron Gate I river lock allows the locking of barge trains consisting of up to eleven ”Danube - Europe II b” barges together with an up to 11.40 wide pushboat (or 10 barges plus corresponding self-propelled cargo ship equipped for pushing the convoys).

- locking time	90	minutes
- allowed draught over the sector with a probability of 90%	2.5	metres *
- cargo capacity of barge train	17600	tons
- overall locking efficiency	40	%
- number of chambers	2	

- annual cargo capacity per direction .... **ACL**y = 37.2 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 4752

River lock Iron Gates II (km 863.70)

The single stage river lock group of Iron Gates II consists of two large chambers and an additional small lock, providing a more economical and quick locking of smaller units. Due to the considerable capacity of this smaller lock, it is calculated separately and added to the capacity of the bigger lock chambers.

The ports of Drobeta and Kladovo can be defined as the upper sector limit assigned to the lock group Iron Gates II. The navigable conditions do not change in considerable extent downstream Danube km 743, i.e. the Bulgarian Port of Lom can determine the lower end of the sector. Thus the overall length of this sector is about 190 km.

Large chambers (2 x 34 x 310 m):

- locking time.. 30 minutes
- allowed draught over the sector with a probability of 90% .... 2.5 metres
- cargo capacity of barge train .... 17600 tons
- overall locking efficiency .... 40 %
- number of chambers 2

- annual cargo capacity per direction .... **ACL**y = 111.5 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 14256

Small chamber (14 x 140 m):

- locking time.. 20 minutes
- allowed draught over the sector with a probability of 90% .... 2.5 metres
- cargo capacity of barge train .... 1850 tons
- overall locking efficiency .... 60 %
- number of chambers 1

- annual cargo capacity per direction .... **ACL**y = 13.2 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 10692

The total annual cargo capacity of the lock group Iron Gates II is estimated at 124.7 million tons per direction.

Locks on the Danube linking canals

For the navigation on the Danube international waterway the capacities of the Main - Danube Canal and the Danube - Black Sea Canal with its side branch White Gate - Midia are of special concern. The Danube - Tisa - Danube canal system is mostly of regional significance and is therefore not considered here.

Locks on the Main - Danube Canal

The capacity of each individual lock is the same as of the first two locks on the Danube main course (Bad Abbach and Regensburg) referring their identical chamber dimensions and locking times. Differences appear due to the small distances between certain locks, as well as the speed limits, overpassing prohibition, technical ability of vessels themselves to accelerate respectively decelerate on short sections between the locks etc.

Taking this into account, the capacity of the Main - Danube Canal can be estimated with:

- annual cargo capacity per direction .... **ACL**y = 10.0 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 4800

Locks on the Cernavoda - Constanta Canal

The Danube - Black Sea or Cernavoda - Constanta Canal can be used by vessels with a draught of more than 5 metres, but the navigation of larger sea going ships coming from the Black Sea is likely to be terminated in the Port of Cernavoda. Therefore only the usual Danube barge train with a draught of 2.5 metres is considered here. The sector covered by these locks corresponds to the end points of the Canal and has the total length of about 65 km.

- locking time...	45	minutes
- allowed draught over the sector with a probability of 100%	2.5	metres
- cargo capacity of barge train	11800	tons
- overall locking efficiency	50	%
- number of chambers	2	

The locking time of the Cernavoda lock is only 30 minutes but assuming the fact that most of the traffic is between the Port of Constanta and the Danube ports, the time of Agigea lock is used for the calculation.

- annual cargo capacity per direction .... **ACL**y = 62.3 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 9504

Locks on the White Gate - Midia Canal

This Canal has been taken into consideration due to the importance of the Black Sea Port of Midia. The sector covers the distance between the Port of Midia and the junction point with the Danube - Black Sea main canal branch near Poarta Alba, i.e. about 27 km.

- locking time...	20	minutes
- allowed draught over the sector with a probability of 100%	2.5	metres
- cargo capacity of barge train	1850	tons
- overall locking efficiency	60	%
- number of chambers	2	

- annual cargo capacity per direction .... **ACL**y = 26.4 million tons
- theoretical annual number of lockings per direction .... **ANL**y = 21384

Sectors without Locks

Sector between Straubing (km 2324) and Passau (km 2229)

The most inconvenient sector for navigation on the whole Danube course lies between Straubing and Vilshofen over the length of 69 km. That is the only sector where the dimensions of barge trains are limited to 22.8 x 110 metres only. There is also a short stretch of 750 metres in length (km 2281.78-2281.03) where the by-passing of such convoys is not allowed. Besides, between the river lock Straubing and the Port of Deggendorf (km 2285), the most important port on this sector, the waterway depth by LRNL is 1.70 m. That means that the vessels navigate during a considerable period of the year loaded up to 1.5 m draught. Regarding all these limits, the corresponding cargo capacity of a single unit can not be more than 2000 tons. Downstream the mouth of small river Vils (km 2248.63) and further up to Passau over the length of about 20 km, the navigable conditions are better. At first, the usual draught allowed by the LNRL is 30 cm higher and secondly, the overall barge train dimensions can be 22.8 x 185 metres making a theoretical cargo capacity of about 4500 tons per 2 x 2 barge train. Upstream Passau the only port of considerable importance on this short 20 km distance is the Ro-Ro harbour Schalding (km 2234), the usual west end station of Danube truck Ro-Ro lines coming from Budapest, Vidin and Rousse.

Thus, the annual cargo capacity just behind the Straubing lock is about 14.3 million tons in one direction (7128 lockings per year at Straubing) and nearby Schalding about 28.5 million tons (14256 lockings through Kachlet lock).

Wachau Section

On the about 30 km long non-canalised Wachau section, the loaded draught of 2.0 m and total annual number of convoys like those on the adjacent canalised sections can be expected. Using the proportional reduction of capacity from 6400 tons per convoy at 2.5 m draught to 4800 tons at 2.0 m, the calculation gives approximately 38 million tons per direction.

Free flowing stretches Vienna-Bratislava-Budapest-Novi Sad-Iron Gates I

It was assumed that the Freudenau lock determines the sectorial capacity on Vienna-Bratislava stretch, i.e. about 57 million tons. Equally Gabcikovo lock determines the capacity of the free flowing stretch Bratislava-Budapest resulting in 42.8 million tons per year and direction.

Downstream Budapest, to the Port of Novi Sad, maximal 9 barge convoys having a draught of 2.3 metres and a total deadweight of 13000 tons can be assumed. The annual capacity can be estimated with about 62 million tons.

From direction Novi Sad downstream, even bigger than 9 barges convoys can be used with a frequency like between Budapest and Novi Sad and a draught of 2.5 m, but Iron Gates I lock has a considerably lower frequency of lockings than Gabcikovo. The ports of Smederevo (km 1118), Pancevo (km 1153) and Belgrade (km 1167) can be end points for 11 barge convoys (17600 tdw) heading westbound, respectively for 9 barge convoys (14400 tdw) heading eastbound. Therefore, between Novi Sad and Smederevo the total annual capacity of about 69 million tons per direction can be estimated while between Smederevo and Iron Gates I, the low frequency of Iron Gates I determines the capacity of about 37.2 million tons.

Sector between Lom (km 743) and Cernavoda (km 299)

The capacity limits on this sector are mostly defined by shallow waters. The waterway width on the considered sector of the lower Danube permits the forming of large pushed or towed barge trains.

Table 2.20:
Permissible convoy size between Lom and Cernavoda

	Convoy length (m) *	Convoy width (m)
Upstream navigation		
Towing	650	45
Pushing	300	40
Downstream navigation		
Towing	370	60
Pushing	250	50

*) For towed convoys, the specified lengths also include the length of the towing cable (30 to 180 m, depending on direction of navigation), but do not take into account the length of the tugboat which can be up to 60 m.

The usual maximal pushed barge convoy consists of 3 x 3 or 2 x 4 standard "Danube - Europe II b" in upstream and downstream navigation respectively, including the corresponding push boat:

For upstream navigation:

- convoy length: 2 x 76.5 + 110.0 = 263.0 m
- convoy width: 2 x 11.0 + 11.4 = 33.4 m
- convoy cargo capacity at 2.5 m draught: 8 x 1650 + 1850 = 15050 t

For downstream navigation:

- convoy length: 76.5 + 110.0 = 186.5 m
- convoy width: 3 x 11.0 + 11.4 = 44.4 m
- convoy cargo capacity at 2.5 m draught: 7 x 1650 + 1850 = 13400 t

In order to estimate the annual cargo flow capacity of the waterway sector (in one direction), a mean convoy capacity of 14400 tons is assumed. The limits are defined by the water depth.

Table 2.21:
Draught and capacity limits between Lom and Constanta

	Minimum depth (m)				Draught *	Capacity **
Danube km	95%	90%	85%	80%	(m)	(tons)
743 - 493	1.8	**2.05**	2.3	2.4	1.75	8700
493 - 346	2.0	**2.35**	2.7	3.0	2.05	10800
346 - 299	1.8	**2.10**	2.4	3.1	1.80	9000

*) 30 cm clearance between ship's bottom and river bed has been deducted from the water depth exceeded by 90% probability
**) 14400 tons convoy capacity at 2.5 m draught has been taken as reference value

Table 2.22:
Annual cargo capacities on subsections of the lower Danube

Danube km	Subsection	Annual capacity (mill. tons)
743 - 493	Lom - Rousse	124.0
493 - 346	Rousse - Mouth of Bala Arm *	154.0
346 - 299	Mouth of Bala Arm - Cernavoda **	45.0

*) The Danube branch itself at km 346 on the Old Danube (the main course) and Bala Arm that flows into the river branch called Lower Borcea Branch. These two branches (the Danube and Bala Arm - Lower Borcea Branch) join themselves again at Danube km 240. Both branches are navigable, and the decision which one will be used depends on the level gauge reading at Calárasi (km 370.5) . When the gauge shows +25 cm level or less, the navigation through the Bala Arm-Lower Borcea Branch with its water depths of always more than 2.70 m and size limits of 6 barges is usual.
**) Due to the prohibition of navigation over night as well as allowance for only one-way traffic through the Bala Arm, the maximal annual number of convoys on this stretch is estimated at 5000 per direction.

Sector from Cernavoda to Sulina

Between Cernavoda (km 299) and Braila (km 170) the waterway conditions enable the navigation of 9 barge convoys having a draught of 2.5 m and more, i.e. with a capacity of 14400 tdw. The frequency of these convoys can be assumed to be the same as on the upstream Cernavoda stretches, i.e. some 5000 convoys per year and direction. That means an annual capacity of about 72 million tons per direction. But this section also accepts the convoys coming from the Cernavoda-Constanta Canal and that means additional 62 million tons that make all together about 134 million tons of cargo per year in each direction.

Downstream Braila the minimum water depth is maintained on 7.32 m along the whole sector between Braila and Sulina all over the year. The permissible convoy size between Braila and the embranchment of the Chilia Arm is the same as on the section between

Cernavoda and Braila. That means that besides 134 million tons, some additional capacity can be attached to the sea-going vessels coming through the Sulina and Chilia Branches. Referring to the potentials of the ports located along this stretch, at least 20 million tons can be added giving together the theoretical capacity of about 154 million tons. This value remains the same over the Chilia Arm. This 116 km long northern channel of the Danube Delta is navigable for sea-going ships too and the water depth is more than 5 metres along its whole length. International Danube navigation is allowed nowadays from the embranchment of the Chilia arm (Chilia Arm km 116) downstream to the Port of Ismail (channel km 93), i.e. along about 23 km.

Table 2.23:
Permissible convoy size between embranchment of the Chilia Arm and Sulina

Danube km	Subsection	Upstream		Downstream	
		Length (m)	Width (m)	Length (m)	Width (m)
80 - 63 *	Chilia Arm-St.George Arm	190	33	190	33
63 - 0	Sulina Arm	150	22	150	22

*) Between the embranchment of Chilia Arm and St. George Arm of the Danube main course

Assuming one full loaded convoy per direction and hour during 330 days annually, and relatively intensive traffic of river-sea and sea-going vessels (carrying capacity between 2000 and 12000 tdw per unit) of 3 such ships per hour, that makes all together 23760 sea and river-sea ships per year and direction.

Table 2.24:
Annual cargo capacity on Danube km 80 - 0

Danube km	Max. river convoy capacity (tons)	Frequency of river convoys (convoys per year)	Average size of sea-going ships (tons)	Frequency of sea-going ships (units per year	Annual waterway capacity (mill. tons per year and direction)
80 - 63	10100	7920	5000	23760	198.8
63 - 0	3500	7920	5000	23760	146.5

2.1.3 Ports and their Facilities

Of the large number of ports along the Danube the 25 most important ones are treated in the course of EUDET in detail. The following criteria have been applied for the selection:

(1) regional importance
(2) strategic importance as an intermodal traffic node
(3) overall capacity of the port (transhipment and storage capacity)
(4) existence of special cargo equipment
(5) diversity of supplied services
(6) state of the art of different supply services regarding navigation itself
(7) strategic importance as maritime - inland navigation interface
(8) distance to adjacent ports along the Danube main course
(9) development perspectives based on market potential forecasts
(10) vicinity of developed shipbuilding centres and ship maintenance facilities

Table 2.25:
Selected Danube ports

	Port*)	(Danube km)	Country	Prevailing criterion
1	Regensburg	2376	Germany	1, 2, 3, 4, 5, 9
2	Passau - Schalding	2228	Germany	2, 4, 9
3	**Linz**	2135	Austria	1, 2, 3, 4, 5, 10
4	**Enns-Ennsdorf**	2112	Austria	1, 2, 3, 4, 8
5	**Krems**	1998	Austria	1, 4, 7, 9
6	**Vienna**	1929	Austria	1, 2, 3, 4, 5, 7, 10
7	**Bratislava**	1868	Slovakia	1, 3, 4, 5, 10
8	Komarno	1768	Slovakia	1, 2, 3, 10
9	**Budapest**	1647	Hungary	1, 2, 3, 7, 10
10	Dunaujvàros	1579	Hungary	1, 3
11	Baja	1478	Hungary	1, 3
12	Vukovar	1333	Croatia	1, 3
13	Novi Sad	1255	Serbia	1, 3, 10
14	**Belgrade**	1168	Serbia	1, 2, 3, 7, 10
15	**Pancevo**	1153	Serbia	1, 3, 5, 7, 10
16	Smederevo	1116	Serbia	1, 2, 8, 9
17	Vidin	790	Bulgaria	2, 4, 8, 9
18	Lom	742	Bularia	2, 8, 9
19	**Rousse**	496	Bulgaria	1, 2, 3, 4, 5, 8, 10
20	Cernavoda	300	Romania	1, 3
21	Braila	170	Romania	1, 2, 3, 5, 7, 10
22	**Galati**	150	Romania	1, 2, 3, 5, 7, 10
23	Reni	123	Ukraine	3, 7
24	Ismail	Chilia Arm	Ukraine	1, 2, 3, 4, 5, 7
25	**Constanta**	D-Black Sea Canal	Romania	1, 2, 3, 4, 5, 7, 9, 10

*) The ports printed in bold letters have been visited.

The **Port of Regensburg** is located within river km 2379 - 2373. It consists of three zones respectively basins:

- West Harbour,
- Oil Harbour and
- East Harbour.

The water depth is 4.0 m. The storage capacities are:

210.000 sq.m. of open-air storage
120.000 sq.m. of warehouses
50.000 cb.m. of refrigerating warehouses
90.000 cb.m. of silos for grain and animal food
100.000 cb.m. of tank capacity for mineral oil

The total waterborne throughput of the Port of Regensburg is about 2 million tons (1995).

The **Port of Passau** consists of two zones. Passau-Racklau is located on the right bank of the Danube at km 2228.38. The average water depth is 3.10 m. There are no arranged storages. The Ro-Ro terminal is located in Passau-Schalding on the right side of the river on km 2233.45.

The total waterborne throughput of the Port of Passau is about 83.000 tons (1995).

The entrance to the **Port of Linz** (Cityport), is located on the right bank of Danube at km 2130.7. The main port area has three basins. The entrance to the tank zone of the port is at Danube km 2128.1. This zone has two water basins. The waterdepth in the port basins is about 7 metres.

The trade harbour (main zone) is mostly used for coal, coke, chemicals, paper, bags, sacks, grain as well as for containerised and palletised commodities.

Storage capacities in the trade zone:

- open-air storage: 20.000 sq.m.
- warehouses: 60.000 sq.m.
- grain silos 12.000 tons
- container depot 2500 TEU

The tank zone offers facilities for reloading of all kinds of mineral oil products. The basins in the tank zone are equipped with tank pontons for transhipment of liquids and offers a total liquid storage capacity of 340.000 cb.m.
The total waterborne throughput of the Port of Linz is 1.1 million tons, with 0.64 million tons in the oil port.

The **Port of VOEST-Alpine** is a private port of the steel concern, located on the right Danube bank at km 2127.5.

The average annual though put is more than 3 million tons of ore, coal, cake and crude oil. Its reloading capacity is 4-5 million tons/year.

The VOEST-Alpine has also a port zone for reloading havy single piece cargoes located in the nearly Danube tributary Traun.

The **Port of Enns-Ennsdorf** is located on the Danube right bank at km 2112 about 25 km downstream of Linz. It will be the core of a future industrial zone.
The port consists of three basins. Guaranteed water depth for navigation is 2.7 m all over the port. The storage capacities are:

- open-air storage: 20.000 sq.m.
- covered storage: of 20.000 cub. m.
- 11 silos for loose bulk goods, gain, animal fodder and cement

The waterborne throughput of the port is about 90.000 tons (1995).

The **Port of Krems** is located on the Danube left bank at km 1998. The typical cargoes are agricultural and forestry products and fertilisers. In recent times the Port of Krems developed quickly as multimodal terminal for combined transports.

The total waterborne throughput of the Port of Krems is about 460.000 tons (1995).

The **Port of Vienna** comprises the harbour zones Wien-Freudenau, Wien-Lobau and Wien-Albern. The entrances to the basins are located on the Danube left and right banks between river km 1916.4 and 1920.1.

Besides the conventional facilities, the harbor zone **Wien-Freudenau** comprises the container terminal, the customs free zone, Ro-Ro ramp and the passenger car terminal.

The customs free zone offers the following storage spaces:

– 55.000 sq.m. of covered storage area
– 10.000 sq.m. of warehouses equipped with storage shelves
– 20.000 sq.m. of central customs storehouse

and performs loading, unloading, packing, commissioning, separation of goods and however customs formalities.

The container terminal was handling 150.000 TEU in 1995. Less than 3.000 TEU have been waterborne.

The harbour is **Wien-Lobau** equipped for the transhipment of mineral oil and oil derivative products. The total capacity of the tanks is about 200.000 tons. A pipeline links the tanks with the ÖMV oil refinery in nearby Schwechat.

The total waterborne throughput of the Port of Vienna is about 1.4 million tons (Freudenau 160.000 tons, Lobau 1.1 million tons, Albern 170.000 tons,).

The **Port of Bratislava** is located on the left river bank between km 1867 and km 1864. It contains three basins and further downstream the repair yard and the new oil harbour (under construction).

The total throughput of the Port of Bratislava is about 1.2 million tons (1994).

The **Port of Komárno** is located on the left bank of the Danube within km 1764 and 1770.

The total throughput of the Port of Komárno is about 210.000 tons (1994).
The **Port of Budapest - Csepel** is located in two basins with common entrance from the Danube (left river bank, km 1639,74). The third basin with the separate entrance from the Danube has been dredged some 10 years ago, but never been put into operation. About 200 metres downstream, at river km 1639.50, lies the entrance to the oil harbour and winter quarters for tankers.

The total throughput of the Port of Budapest - Csepel is about 1.2 million tons (1994).

The **Port of Dunaujváros** is located at river km 1579, right bank, at Szalkisziget.
The total throughput of the Port of Dunaujváros is about 500.000 tons (1994), whereby more than 88 % was an iron ore.

The **Port of Baja** is located at river km 1479, left bank.

The overall throughput of the Port of Baja and nearby located Port of Mohàch (about 30 km downstream) is about 130.000 tons (1995).

In 1990 the **Port of Vukovar** located on the right river bank (territory of Croatia) at km 1333.1 had an annual throughput of 560.000 tons coal, coke and metal products.

The **Port of Novi Sad** is located in the navigable canal Novi Sad - Savino Selo belonging to the Danube - Theiss - Danube canal network. The canal entrance is on the left bank of the river at km 1253.4.

Port facilities:

– 50000 sq.m. of open-air storage area
– 25000 sq.m. of warehouses
– several grain silos

The total throughput of the Port of Novi Sad was about 1 million in 1990.

The entrance into the **Port of Belgrade** (main dry cargo zone) is located on the right Danube bank, km 1167.5. The technical capacity of the port is about 3 million tons per year. The oil terminal of the port is located at the right bank of Sava river, some 4 km from the mouth into the Danube.

The peak in container transhipment was achieved in the first half of the eighties with 5000-6000 twenty feet ISO boxes annually plus about 1.000 boxes of other sizes. The distribution among the different modes calling the port was roughly as follows:

– waterborne	50%
– railway	25%
– truck	25%

In the 90ies the share of waterborne transport dropped to about 10 %. This trend is expected to remain, as the port oriented itself rather to storage services than to ship-to-shore transhipment.

Port facilities:

- 300.000 sq.m. of covered storage area comprising:
- 650.000 sq.m. of arranged open-air storage area
- container storage area with a capacity of 2000 TEU

The total throughput of the Port of Belgrade was about 1.5 million tons in 1990.

The **Port of Pancevo** is located on the left bank of the Danube at km 1153. Pancevo is an industrial site with the biggest oil refinery in Serbia, a large chemical plant (fertilisers), and a number of light industry branches (small commercial and sport aircrafts, road trailers and chassis, process equipment, glass factory, plywood factory etc.).

The port has three zones:

- Public port of Pancevo
- Industrial port of oil refinery and
- Industrial port of chemical plant “HIP”

The public port has the following facilities:

- 32.000 sq. m of warehouses
- 210.000 sq. m. of open storage area
- 55.000 t silos

The annual capacity of the port nowadays is about 2 million tons of goods including about 800.000 tons of construction material (sand and gravel). Container reloading capacity is 10000 TEUs per year. It is planned to erect a Ro-Ro terminal.

The **Port of Vidin** is located on the right Danube bank. The Ro-Ro ramp is located at km 792.85. Transhipment zone for conventional cargoes is located at km 787.70. There exist plans to build a bridge over the Danube. The location at Vidin is preferred by the Bulgarian side, the Romanian side prefers a location further,east at Turnu Magurele (river km 597.00).

The total throughput ot the Port of Vidin is about 150.000 tons (1994).

The **Port of Rousse** is located on the Danube right bank between km 495 and km 485. The Port complex incorporates six harbours, all under the common administration of the Rousse Port complex.

The Port of Rousse has two zones. The western zone deals mostly with general cargo while the eastern zone deals with bulk, containers and Ro-Ro services.

Port facilities:
– 155.000 sq.m. of open-air storage area
– 12.000 sq.m. of covered storage area
– 12.000 sq.m. of covered storage area under construction
– Ro-Ro ramp with parking area

The throughputs of the port in Rousse: (both harbour zones) is about 960.000 tons (1994).

The harbour administration is well experienced in the handling of transit commodities from Western and Middle Europe along the Danube to the Black Sea, the Mediterranean, Near and Middle East through the maritime ports of Varna and Bourgas.

The other Danube ports belonging to the port complex of Rousse are:

Svistov:	600.000 tons
Somovit:	40.000 tons
Tutrakan:	17.000 tons
Silistra:	45.000 tons troughputs 1994.

The second biggest Bulgarian Danube port, the **Port of Lom**, has a total throughput of 780.000 tons (1994).

The most important Romanian ports on the Danube are Orsova, Turnu Magurele, Giurgiu, Calarasi, Cernavoda, Braila, Galati and Tulcea. The throughputs of these ports and the prevailing commodity groups in 1994 are shown beneath:

– Orsova	186.000 tons	solid fuels (coal and coke), ore of non-ferrous metals
– Turnu Magurele	192.000 tons	ore of non-ferrous metals, fertilisers, iron ore
– Giurgiu	298.000 tons	construction materials (gravel, stones)
– Calarasi	603.000 tons	construction materials, solid fuels
– Cernavoda	413.000 tons	construction materials
– Braila	799.000 tons	construction materials, metals, round timber
– Galati	6995.000 tons	iron ore, solid fuels, construction materials, metals, round timber
– Tulcea	603.000 tons	ore of non-ferrous metals, construction materials

The **Port of Cernavoda** is located on the right Danube bank. The entrance into the port is at river km 299.10, just 400 metres downstream the junction point of the Danube and the Cernavoda - Constanta Canal. The water basin has a minimal water depth of 6 metres.

The port has a capacity of 1 million tons per year and further extension possibilities to reach up to 7 million tons of annual throughput.

The **Port of Braila** is located on the left river bank at km 169.10. The following facilities are available:

- 200.000 sq.m. of open-air storage area
- 3.000 sq.m. of covered storage area
- 6.000 tons grain silos capacity

A container terminal with a capacity of about 70000 TEU per year is planned.

The **Port of Galati** has three harbour zones on the left bank of the Danube:

- the zone for transhipment of minerals, iron ore and steel (Portul Mineralier) between km 157.5 and 155.5
- the old harbor zone (Bazinul Docurilor) at km 148.62 and
- the new harbour zone (Portul Bazinul Nou) at km 146.49.

The Mineral port was built in 1974 in order to ensure an effective transport of iron ore, coal, coke, limestone and rolled steel for the nearby steel plant. The following storage facilities are available:

- 5.400 sq.m. platform for storing iron ore
- 1.200 sq.m. warehouse for storing limestone
- 18.500 sq.m. of storage area for rolled steel products
- 6.300 sq.m. of warehouses for rolled steel products

Port facilities of the Docuri Port:

- 36.000 sq.m. of open-air storage area
- 21.000 sq.m of covered storage area in 9 warehauses
- silos for grain with a capacity of 6000 tons

The Port Bazinul Nou is specialised in the transhipment of rolled steel products and timber. There is about 52.000 sq.m of open-air storage area.

The total port capacity of Galati is estimated at about 1.5 million tons per year.

The **Port of Reni** is the only Ukrainian port located on the Danube. The entrance is at km 123.71.

Port facilities:
- 190.000 sq.m. of open-air storage area
- 25.000 sq.m. of covered storage are (6 warehouses)

The total throughput of the Port of Reni is about 2,4 million tons (1994).

The **Port of Izmail** located on the left bank of the Chilia Arm of the Danube Delta at km 93 (from the mouth, respectively 23 km from the embranchment point from the main Danube course) opened for all Danube flags. (The other two ports along the Chilia Arm are opened just for Ukrainian vessels.)

Port facilities:

- 23.000 sq.m. of covered storage area (9 warehouses)
- 160.000sq.m. of open-air storage area
- 1 grain silo

The total throughput of the Port of Izmail is about 4 million tons (1994). The prevailing commodities were iron ore and steel scrap, metals (plates, coils, wire etc.), solid fuels (coal and coke) and different final products.

The **Port of Constanta** is placed on the western coast of the Black Sea about 85 nautical miles from the mouth of the Sulina Branch - the beginning of the Danube Waterway. The port consists of two zones: The annual capacity of the Northern Port is 63.5 million tons while the designed capacity of the Southern Port is about 170 million tons, making a total of 233.5 million tons. At the moment, the annual capacity is estimated at about 83.5 million tons.

Through the Canal, the waterway distance between Rotterdam and Constanta is about 3100 km over the Rhine - Main - Danube Waterway and the Danube - Black Sea Canal compared with about 6000 km over the sea route via Gibraltar and Bosphorus.

Port facilities Northern Port:

- 107 ha of open-air storage area
- 33 ha of covered storage area

Port facilities Southern Port:

- 14.0 ha of open-air storage area (accomplished in 1993)
- 3.3 ha of covered storage area (accomplished in 1993)
- Ro-Ro ramp for road vehicles (operational)
- Ro-Ro ramp for railway wagons (operational)

The planned oil terminal will have a bunkering capacity of about 40000 tons of diesel oil.

The total throughput of the Port of Constanta had its peak in 1988/89 with over 60 million tons. After an abrupt decrease between 1989 and 1991, the throughputs show a slowly rising trend achieving 34.9 million tons in 1995. The share of container transport is about 11 %.

Ports on the linking canals and most important tributaries

Due to their importance for the waterborne transport along the Danube transport corridor, some ports located on the linking canals, main Danube tributaries and Chilia Branch of the Danube Delta as well as the Black Sea Port of Constanta are briefly described beneath.

The largest port on the Main - Danube Canal is the **Port of Nürnberg** located between Canal km 70.41 and km 72.10 with

- 500.000 sq.m. of open storage area
- 360.000 sq.m. of covered storage area
- silos with a total capacity of 65.000 cu.m.
- tanks with a total capacity of 55.000 cu.m. and
- Ro-Ro and heavy cargo facilities

The total throughput of the Port of Nürnberg for all transport modes is about 6.5 million tons (1992).

The Croatian **Port of Osijek** is located at the river Drau km 18 from its mouth into the Danube. The port has:

- 10.000 sq.m. of covered storage area
- 18.000 sq.m. of open-air storage area

The average annual throughput is about 200.000 tons.

There are 28 ports and reloading sites along the Theiss within the Hungarian sector and another 7 on the Serbian sector of the river. The most important are: Szolnok, Csongrád, and Szeged in Hungary and Senta, Novi Becej and Elemir in Serbia.

The most important ports along the River Sava are: Sisak, Slavonski Brod and Zupanja (Croatia), Gradiska and Samac (Bosnia and Herzegovina) and Mitrovica and Sabac as well as the oil terminal and some other harbour zones of the Port of Belgrade in Serbia.

The most important ports on the Danube - Theiss - Danube canal network (with an average annual throughput between 250.000 and 50.000 tons per year) are besides the Port of Novi Sad: Sombor, Srbobran, Becej, Crvenka, Zrenjanin, Perlez and Novi Becej. The most transported commodities are gravel, crude oil and its derivates, round and cut timber, grain, sugar beet, fertilisers, coal and bricks and tiles.

The ports along the Cernavoda - Constanta Canal of certain significance for international shipping are Medgidia and Basarabi. The Port of Ovidiu located on the Poarta Alba - Midia Canal has only regional importance.

The location of the **Port of Chilia** is on the left bank of the Chilia Arm at km 47 from the mouth into the Black Sea. The total throughput is about 550.000 tons (1994). The prevailing commodities are metals (plates, coils, wire etc.).

The location of the **Port of Ust Dunajsk** is near the mouth of the Chilia Arm into the Black Sea. The total throughput is about 2.5 million tons (1994). The prevailing commodities are iron ore and steel scrap (39.4 %) metals (27.9 %), special products (22.3 %) and grain (6.7 %).

2.1.4 Summary

It is important to note that the calculated capacities are insofar only theoretical as the capacities of ports along the particular sections have not been considered. In most cases the ports, especially on the middle and lower Danube, are not able to absorb the difference in waterway capacities between two adjacent stretches with considerably different navigation conditions. The relatively low capacity between Smederevo and Drobeta despite the optimal waterway conditions is caused by the Iron Gates I lock. Otherwise, this wide and deep stretch has practically no limits.

Table 2.26:
Summary of Danube Waterway capacities

Danube km		Sector	Length	Annual capacity per direction	Annual number of convoys and ships per direction
			(km)	(mill. tons/year)	(-)
-	2412	Main - Danube Canal	171	10.0	4800
2412 -	2375	Kelheim - Regensburg	37	15.2	7128
2375 -	2324	Regensburg - Straubing	51	25.3	7128
2324 -	2229	Straubing - Passau	95	14.3 - 28.5	7128 - 14256
2229 -	2038	Passau - Melk	191	50.7	14256
2038 -	2008	Melk - Dürnstein	30	38.0	14256
2008 -	1920	Dürnstein - Vienna	88	50.7	14256
1920 -	1865	Vienna - Bratislava	55	57.0	14256
1865 -	1647	Bratislava - Budapest	218	42.8	10692
1647 -	1255	Budapest - Novi Sad	392	62.0	10692
1255 -	1116	Novi Sad - Smederevo	139	69.0	10692
1116 -	931	Smederevo - Drobeta	85	37.2	4752
931 -	861	Drobeta - Prahovo **	70	124.7	14256 + 10692 *
861 -	743	Prahovo - Lom **	118	112.1	14256
743 -	493	Lom - Rousse	250	124.0	14256
493 -	346	Rousse - Bala Arm	147	154.0	14256
346 -	299	Bala Arm - Cernavoda	47	45.0	5000
299 -		Cernavoda - Constanta	64	62.0	9504
299 -	+30	White Gate - Midia	27	26.4	21384
299 -	170	Cernavoda - Braila	129	134.0	5000 + 9504 ***
170 -	80	Braila - Chilia Arm	90	154.0	18000 ****
80 -		Chilia Arm - Ismail	23	154.0	18000
80 -	63	Chilia Arm - St.George Arm	17	198.8	31680
63 -	0	Sulina Arm - Sulina	63	146.5	31680

*) The sum of number of annual lockings through two big (14265) and one small chamber (10692)
**) The intermediate point at Prahovo is inserted due to the expected average water depth of 2.3 m on Prahovo-Lom section.
***) The sum of convoys coming from the Danube and from Cernavoda-Constanta Canal
****) Including river-sea and sea-going vessels

Figure 2.1a:
Schematic review of the Danube waterway capacity from km 2412 to km 1255

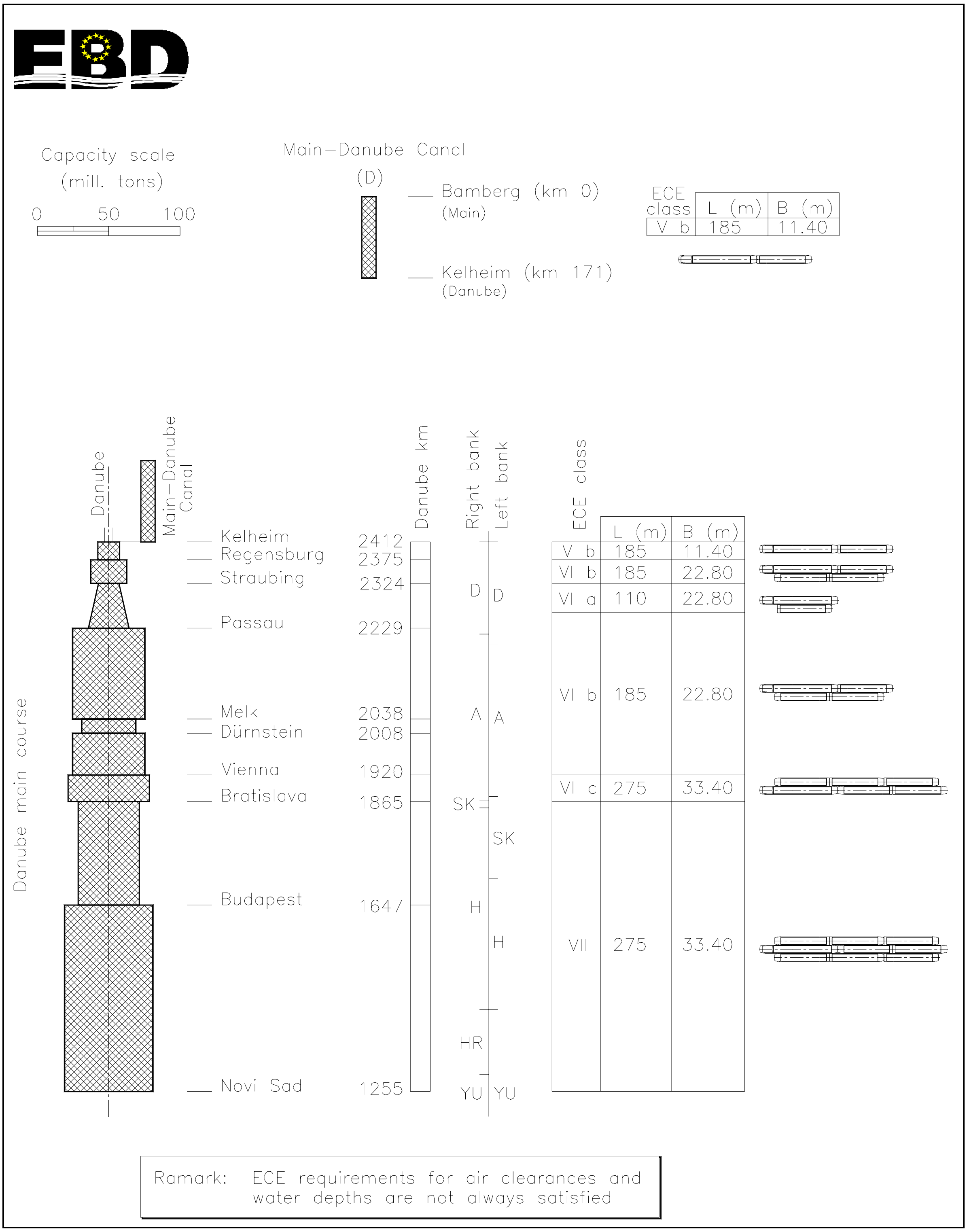
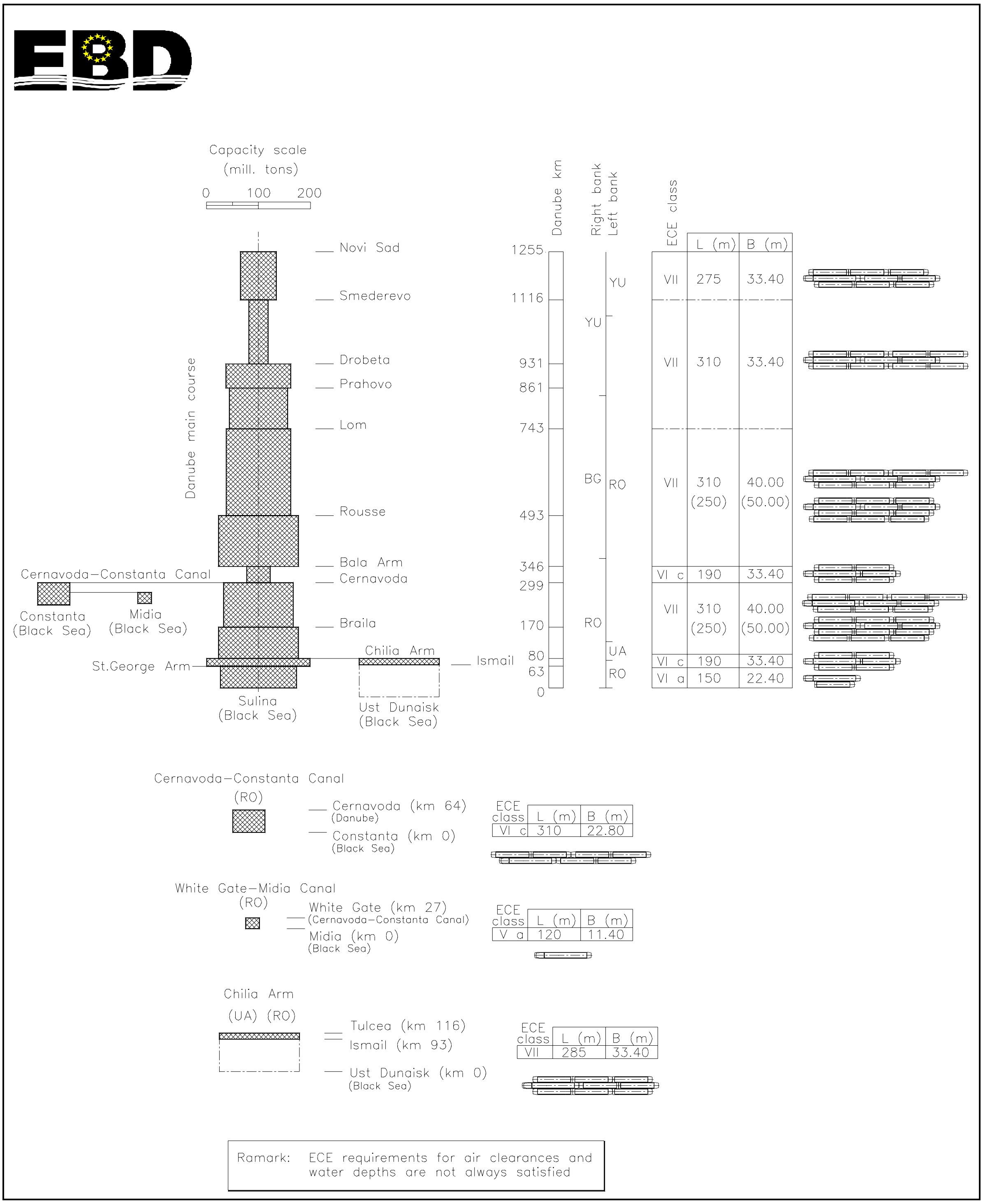


Figure 2.1b:
Schematic review of the Danube waterway capacity from km 1255 to km 0



2.1.5 Trip Duration

The duration trips of course depends on the distance between origin and destination, but also on two groups of other factors:

- technical or physical factors as e.g.:
  - maximal speed of the ship,
  - loading condition, i.e. draught and trim of the ship or number, loading condition and arrangement of barges in towed or pushed convoy
  - water depth
  - stream flow rate
  - wave height, length and bearing relative to the courses of ship and river flow
  - course of navigation (upstream or downstream)
  - number and duration of lockings under way
  - weather conditions (wind speed and direction, ice, fog).

- subjective factors as:
  - waiting time at river locks
  - operating hours of river locks
  - time for customs formalities
  - traffic rules on particular sections as speed limits, prohibition of passing by or overtaking, prohibition of navigation over night
  - time for coupling respectively uncoupling single barges of the convoy under way
  - sporadic, non-predictable events as dredging on the waterway, accidents
  - time for bunkering potable water and provision supply under way etc.

Table 2.27:
Distances between selected origins and destinations

	Nürnberg	Regensburg	Linz	Vienna	Bratislava	Komarno	Budapest	Dunaujvaros	Mohach	Belgrade	Svistov	Rousse	Cernavoda	Constanta	Galati	Reni	Izmail	Sulina
Nürnberg		136	377	583	644	744	865	933	1065	1342	1958	2016	2212	2277	2362	2385	2455	2512
Regensburg	136		241	447	508	608	729	797	929	1206	1822	1880	2076	2141	2226	2249	2319	2376
Linz	377	241		206	267	367	488	556	688	965	1581	1639	1835	1900	1985	2008	2078	2135
Vienna	583	447	206		61	161	282	350	482	759	1375	1433	1629	1694	1779	1802	1872	1929
Bratislava	644	508	267	61		100	221	289	421	698	1314	1372	1568	1633	1718	1741	1811	1868
Komarno	744	608	367	161	100		121	189	321	598	1214	1272	1468	1533	1618	1641	1711	1768
Budapest	865	729	488	282	221	121		68	200	477	1093	1151	1347	1412	1497	1520	1590	1647
Dunaujvaros	933	797	556	350	289	189	68		132	409	1025	1083	1279	1344	1429	1452	1522	1579
Mohach	1065	929	688	482	421	321	200	132		277	893	951	1147	1212	1297	1320	1390	1447
Belgrade	1342	1206	965	759	698	598	477	409	277		616	674	870	935	1020	1043	1113	1170
Svistov	1958	1822	1581	1375	1314	1214	1093	1025	893	616		58	254	319	404	427	497	554
Rousse	2016	1880	1639	1433	1372	1272	1151	1083	951	674	58		196	261	346	369	439	496
Cernavoda	2212	2076	1835	1629	1568	1468	1347	1279	1147	870	254	196		65	150	173	243	300
Constanta	2277	2141	1900	1694	1633	1533	1412	1344	1212	935	319	261	65		215	238	308	365
Galati	2362	2226	1985	1779	1718	1618	1497	1429	1297	1020	404	346	150	215		23	93	150
Reni	2385	2249	2008	1802	1741	1641	1520	1452	1320	1043	427	369	173	238	23		70	127
Izmail	2455	2319	2078	1872	1811	1711	1590	1522	1390	1113	497	439	243	308	93	70		103
Sulina	2512	2376	2135	1929	1868	1768	1647	1579	1447	1170	554	496	300	365	150	127	103	

Trip duration for a pushed barge convoy

The number of barges and their arrangement in a pushed-barge convoy on the Danube differs on different river sectors. In order to simplify calculation, the following convoy sizes are taken as typical (the term ”barge” means always the standard Danube-Europa II barge with a length overall of 76.50 m and beam of 11.00 m):

– for the section between Nürnberg and Linz and for the Sulina canal:
  – two barges in line + pushboat (”Schubverband”) or
  – self-propelled cargo ship equipped for pushing + one barge in line (”Koppelverband”)

– for the section between Linz and Komarno:

  – four barges + pushboat or equivalent convoy with pushing cargo vessel (instead of pushboat and one barge)

– for the section between Komarno and Izmail and for the Cernavoda - Constanta Canal:

  – six barges + pushboat or equivalent convoy with pushing cargo vessel

The calculation is based on a long line pushboat or river cargo vessel with an output of 1500 kW. (Although the output varies from 700 to 1800 kW for self-propelled cargo vessels and even up to 3550 kW for the most powerful Danubian pushboats). A six barge convoy with approximatelly 9000 tdw pushed by a 1500 kW pushboat can achieve about 12 km/h in streamless, calm and relatively deep water.

Table 2.28:
Estimated trip durations for pushed barge trains (in hours)

	Nürnberg	Regensburg	Linz	Vienna	Bratislava	Komarno	Budapest	Dunaujvaros	Mohach	Belgrade	Svistov	Rousse	Cernavoda	Constanta	Galati	Reni	Izmail	Sulina
Nürnberg		20	35	55	48	53	59	63	71	86	122	125	136	144	145	147	151	155
Regensburg	21		15	25	28	33	39	43	51	66	102	105	116	124	125	127	131	135
Linz	56	35		10	13	18	24	28	36	51	87	90	101	109	110	112	116	120
Vienna	86	65	30		3	8	14	18	26	41	77	80	91	99	100	102	106	110
Bratislava	96	75	40	10		5	11	15	23	38	74	77	88	96	97	99	103	107
Komarno	113	92	57	27	17		6	10	18	33	69	72	83	91	92	94	98	102
Budapest	133	112	77	47	37	20		4	12	27	63	66	77	85	86	88	92	96
Dunaujvaros	144	123	88	58	48	31	11		8	23	59	62	73	81	82	84	88	92
Mohach	166	145	110	80	70	53	33	22		15	51	54	65	73	74	76	80	84
Belgrade	211	190	155	125	115	98	78	67	45		36	39	50	58	59	61	65	69
Svistov	301	280	245	215	205	188	168	157	135	90		3	14	22	23	25	29	33
Rousse	308	287	252	222	212	195	175	164	142	97	7		11	19	20	22	26	30
Cernavoda	332	311	276	246	236	219	199	188	166	121	31	24		8	9	11	15	19
Constanta	340	319	284	254	244	227	207	196	174	129	39	32	8		17	19	23	27
Galati	351	330	295	265	255	238	218	207	185	140	50	43	19	27		2	6	10
Reni	354	333	298	268	258	241	221	210	188	143	53	46	22	30	3		4	8
Izmail	361	340	305	275	265	248	228	217	195	150	60	53	30	38	11	8		7
Sulina	370	349	314	284	274	257	237	226	204	159	69	62	38	46	19	16	12	

Downstream (above diagonal) / Upstream (below diagonal)

Trip Duration for a self-propelled River Vessel

A typical self propelled river vessel has:

- a cargo capacity of about 1350 tons (”Europa ship”) and
- a propulsion output between 600 and 800 kW

Such a ship when fully loaded is able to achieve the speed of about 16 km/h in streamless, calm and relatively deep water. Due to the specific conditions of the Danube as an inland waterway, this type of ship is not in wide use, especially on the long hauls on the middle and lower river course. But rising presence of these vessels can be expected in the future, as well as of the significantly bigger stand-alone units with similar speed performance.

Table 2.29:
Estimated trip durations for stand-alone river vessel (in hours)

	Nürnberg	Regensburg	Linz	Vienna	Bratislava	Komarno	Budapest	Dunaujvaros	Mohach	Belgrade	Svistov	Rousse	Cernavoda	Constanta	Galati	Reni	Izmail	Sulina	
Nürnberg		16	31	41	44	49	55	59	67	82	117	120	131	139	139	141	145	148	
Regensburg	18		15	25	28	33	39	43	51	66	101	104	115	123	123	125	129	132	
Linz	43	25		10	13	18	24	28	36	51	86	89	100	108	108	110	114	117	
Vienna	65	47	22		3	8	14	18	26	41	76	79	90	98	98	100	104	107	
Bratislava	72	54	29	7		5	11	15	23	38	73	76	87	95	95	97	101	104	
Komarno	82	64	39	17	10		6	10	18	33	68	71	82	90	90	92	96	99	
Budapest	93	75	50	28	21	11		4	12	27	62	65	76	84	84	86	90	93	
Dunaujvaros	99	81	56	34	27	17	6		8	23	58	61	72	80	80	82	86	89	Downstream
Mohach	112	94	69	47	40	30	19	13		15	50	53	64	72	72	74	78	81	
Belgrade	138	120	95	73	66	56	45	39	26		35	38	49	57	57	59	63	66	
Svistov	193	175	150	128	121	111	100	94	81	55		3	14	22	22	24	28	31	
Rousse	198	180	155	133	126	116	105	99	86	60	5		11	19	19	21	25	28	
Cernavoda	216	198	173	151	144	134	123	117	104	78	23	18		8	8	10	14	17	
Constanta	224	206	181	159	152	142	131	125	112	86	31	26	8		16	18	22	25	
Galati	230	212	187	165	158	148	137	131	118	92	37	32	14	22		2	6	9	
Reni	232	214	189	167	160	150	139	133	120	94	39	34	16	24	2		4	7	
Izmail	238	220	195	173	166	156	145	139	126	100	45	40	22	30	8	6		7	
Sulina	244	226	201	179	172	162	151	145	132	106	51	46	28	42	14	12	9		
								Upstream											

Downstream there is practically no difference in the trip duration between a pushed barge train and a single river motorship. But for upstream navigation, the differences are very significant, especially between the sites where no locks are under way. For example, on the section between Izmail and Linz, this difference is 110 hours or approximately 4.5 days.

Along the whole course of the Danube downstream from Regensburg also **”river-sea” vessels** can be seen, i.e. sea-going ships or coasters with such design modifications and equipment that enable them to navigate along rivers. They usually have the following particulars:

– full loading capacity of 1500 to 5300 tdw
– length overall between 75 and 140 m
– breadth max. between 9.5 and 16.4 m
– draught, fully loaded, between 2.5 and 4.0 m
– max. speed in relatively deep, calm and streamless water about 11 knots (20 km/h)

Due to the unfavourable water depth on long sections of the river, these ships are not able to achieve substantially better performances than nominally slower river vessels. There are just a few sections where significantly shorter travelling times can be reached:

- Sulina - Reni - Braila (170 km) and
- Iron Gates II - Belgrade (about 300 km) with a water depth of more than 10 metres

- Chilia Arm of the Danube Delta with a water depth of more than 6 metres

Therefore, the overall trip duration between Sulina and e.g.Vienna can be estimated to about 166 hours or only about 7% less than that of a self-propelled river vessel. The trip from Sulina up to Budapest takes about 138 hours (8.6% faster) and up to Belgrade about 93 hours or 12.3% faster than the river ship. Differences in trip duration downstream are negligible.

2.1.6 Sea Ports and Maritime Transport

According to the Danube Commission 170 km the following ports located along the Danube can be treated as “maritime”:

– Sulina (Danube main branch km 0.00)
– Tulcea (Danube main branch km 71.30)
– Reni (Danube main branch km 123.71)
– Galati (Danube main branch km 150.00)
– Braila (Danube main branch km 170.00)
– Izmail (Chilia branch km 93 from the mouth into the Black Sea)
– Chilia (Chilia branch km 47 from the mouth into the Black Sea)

Applying the criterion that maritime ports are all ports of call of river-sea ships, then the above list could also include the ports of Rousse, Belgrade, Budapest, Bratislava, Vienna and Krems.

The Black Sea Ports of the Danube Delta

Three important navigable rivers flow into the Black Sea - the Danube, Dnjepr and Don (linked over the Volga - Don Canal with the biggest European river - Volga and the Caspian Sea) - thus considerably extending the hinterland of the Black Sea itself.

The following Black Sea ports are concentrated in the area of the Danube Delta:

- Port of Constanta (Romania), near the junction point of the Danube - Black Sea Canal at Agigea, the biggest port in the Black Sea region.

- Port of Sulina (Romania), at the mouth of the main Danube Arm (Sulina Branch).

- Port “Ust Dunajsk” (Ukraine) at the mouth of northern, Chilia Arm of the Danube.

- Port of Midia (Romania) near the junction point of the White Gate - Midia Canal and the Black Sea.

- Port of Mangalia (Romania), some 45 km south of Constanta, the second biggest Romanian shipyard after Constanta.

The port of Constanta is the only one of this five ports with large international importance. Ust Dunajsk has a relatively high annual throughput (about 2.5 million tons), but due to the prohibition of river traffic through Chilia Branch for foreign ships (other than Ukrainian and Romanian), this port has a considerable importance only for the Ukraine. The ports of Sulina, Midia and Mangalia have relatively low throughput and thus only regional importance.

Important Shortsea and Deepsea Links

There are six littoral states along the coasts of the Black Sea: Romania, Ukraine, Russia, Georgia, Turkey and Bulgaria. These countries together with Greece and Albania created a zone of economic cooperation in the Black Sea (BSEC). All together, there are more than 35 ports along the coasts of the Black Sea and the Sea of Azov.

In summer 1996, the following regular short sea lines were in operation:

- Ro-Ro line between Varna (Bulgaria) and Poti (Georgia)
- Ro-Ro line between Burgas (Bulgaria) and Poti (Georgia)
- Ro-Ro line between Constanta (Romania) and Istanbul (Turkey)
- rail ferry line between Constanta (Romania) and Samsun (Turkey)

At the meeting of the BSEC Working Group for Transport held in Anape in 1995 it was recommened to study the extension possibilities of Ro-Ro and rail-ferry links among the ports in the Black Sea and the Sea of Azov. Furthermore the integration of the Volga-Don inland waterway into the European transport corridor N°9 (Helsinki - the Aegean Sea coast, crossing the TEN corridor N°7 - the Danube - at Rousse) was requested.

Ukrainian Danube Shipping Co from Izmail provides regular river - short sea service between Port of Reni (Danube km 127) and Egypt - Port Said and Alexandria.

Combined river-sea-river direct waterborne transport between the ports on Danube and Dnjepr and Danube and Volga - Don waterway already exists for years, but not regularly.

Sporadic direct waterborne service (river - short sea) between the ports along the Danube (including those on upper and middle stretches of the river) and the Black Sea and Aegean ports in Turkey and Greece exist since the beginning of the eighties.

Regular deep sea service exists between the Black Sea ports of Novorossiysk (Russia), Ust Dunajsk (Ukraine) and Constanta (Romania) and overseas ports of Karachi (Pakistan) and Bombay (India). The distance from the Black Sea ports to Karachi is about 3970 and to Bombay about 4150 nautic miles. Between 1978 and 1994, the service provider “Interlighter” made 130 round voyages on this line using the SEEBEE barge carriers and 15 round trips using conventional vessels. Some 850 thousand tons of cargo have been transported between the Black Sea ports and Karachi and about 2.5 million tons between them and Bombay.

Multimodal waterborne transport (river barge - deep sea barge carrier - river barge) with collecting cargo over the Danube 2414 km river stretch, sea leg of 6870 nautical miles (from the mouth of Danube to Bangkok) and further 495 km of river stretch along the Mekong river exists since 1978.

2.2 The Inland Navigation Industry

2.2.1 Fleet structure and capacity

Table 2.30:
General review of the fleet structure for some Danube countries

	Country	Barges	Tugs and pushers	Self-propelled cargo vessels	Total N° of units	Total deadweight	Total output
		(-)	(-)	(-)	(-)	(tdw)	(kW)
1	Austria	130	19	21	170	212879	30620
2	Slovakia	151	44	12	207	378693	65376
3	Hungary	170	35	21	226	233075	29829
4	Serbia	516	143	73	732	612835	99058
5	Bulgaria	183	22	none	205	280111	28515
6	Romania	1606	410	112	2128	1758772	253725
7	Ukraine	851	80	77	1008	1137909	255017
Total 1-7		**3607**	**753**	**316**	**4676**	**4614274**	**762140**

Source: Danube Commission Statistical Yearbook 1996

Table 2.31:
German Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	14	-	1567	-	112	43
Pusher-tugs	3	-	1468	-	489	28
Pushboats	1	-	109	-	109	5
Self-prop. dry cargo ships	23	11659	8824	507	384	26
Self-propelled tankers	2	2469	1988	1235	994	15
River/sea vessels	none					
Towed dry cargo barges	4	2345	-	586	-	78
Towed tank barges	1	852	-	852	-	45
Towed combined barges	3	1047	-	349	-	38
Pushed barges	18	29339	-	1630	-	11

*) in 1990
N.B.: In all available statistics only the data about the decade in which the ship was being built are given. Therefore, the average age given in the above table is approximate, assuming that the ship has been built in the middle of the respective decade, e.g. a ship being built between 1960-1970 was considered as built in 1965 having an age of 25 years in 1990.

Source: Danube Commission Statistical Yearbook 1992

Since the opening of the Main - Danube Canal in September 1992, the Danube Commission does not issue any information about the composition of the German Danube fleet.

The German inland waterway fleet consists (1996) of a total of 3124 self-propelled cargo vessels and barges (LASH barges not included) having a total cargo capacity of 3090671 tons. There also exists a fleet of 515 tugs and pushboats (harbour tugs not included) with total output of 154348 kW. Of the total number of German vessels, only 40 units with total carrying capacity of 41643 tdw have had their ports of registry located in the Danube region. The majority of the German Danube fleet belongs to Bayerischer Lloyd Schiffahrts-AG.

Table 2.32:
Austrian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Averag e age * (years)
Tugs	13	-	3756	-	289	32
Pusher-tugs	none					
Pushboats	6	-	8133	-	1356	24
Self-prop. dry cargo ships	17	22895	14944	1347	879	20
Self-propelled tankers	4	4461	3787	1115	947	24
River/sea vessels	none					
Towed dry cargo barges	35	24342	-	695	-	19
Towed tank barges	14	14036	-	1003	-	49
Towed combined barges	none					
Pushed barges	81	147144	-	1817	-	14

*) in year 1994 - it was taken into account the same assumption referring to the age as in Table 3
Source: Danube Commission Statistical Yearbook 1996

In 1991 the oldest Danube shipping company - DDSG (founded in 1829) has been split in two companies: “DDSG Cargo GmbH” for cargo shipping and “DDSG Donaureisen GmbH” for passenger service.

The core of the “DDSG Cargo” consists of seven pushing self-propelled single-screw cargo ships of “BURG” class, and six twin-screw cargo vessels of “STEIN” class. Smaller “Burg” type vessels have an output of 710 to 1000 kW, a cargo capacity of 1100 to 1315 tons, a length varying from 74.6 to 84.3 m and different breadth in range from 9.53 to 10.02 m. “Stein” ships have all an output of 1200 kW, 2000 tons cargo capacity, length of 95 m and breadth of 11.4 m.

The fleet of self-propelled tankers consists of two vessels originally built as motorships and two former towed barges reconstructed and equipped with propulsion units in 1969.

DDSG has also four powerful long-range pushboats and two smaller vessels. The pushed barge fleet consists of types “SL 17000” (dry cargo, 18 units), “SL 18000” (dry cargo, 36 units), “SL 24000” (dry cargo, 3 barges) and “SL 16800” (tank barges, 12 units).

Another significant Austrian ship operator is “AVANTI-Tankschiffahrt”, with the fleet of four pushing self-propelled tankers, three pushboats and 15 pushed barges.

Table 2.33:
Slovak Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	2	-	2242	-	1121	34
Pusher-tugs	4	-	5858	-	1465	29
Pushboats	38	-	41356	-	1088	9
Self-prop. dry cargo ships	8	13847	7622	1731	953	27
Self-propelled tankers	none					
River/sea vessels	4	14925	6536	3731	1634	17
Towed dry cargo barges	49	50933	-	1039	-	32
Towed tank barges	14	11817	-	844	-	50
Towed combined barges	none					
Pushed barges	188	293798	-	1563	-	11

*) in year 1994 - it was taken into account the same assumption referring the age as in Table 3
Source: Danube Commission Statistical Yearbook 1996

The Slovak Danube fleet has a total of 307 commercial cargo units, tugs and pushboats. The technical fleet consisting of dredgers and other vessels providing maintenance and survey on the Danube and its navigable tributary river Váh has 55 units that making a total of 362.

Table 2.34:
Hungarian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	15	-	8029	-	535	
Pusher-tugs	1	-	1470	-	1470	
Pushboats	19	-	16630	-	875	
Self-prop. dry cargo ships	21	11651	3700	555	176	
Self-propelled tankers	none					
River/sea vessels	none					
Towed dry cargo barges	137	178631	-	1304	-	
Towed tank barges	9	9450	-	1050	-	
Towed combined barges	24	33343	-	1389	-	
Pushed barges	none					

*) data not available
Source: Danube Commission Statistical Yearbook 1996

The dominating Hungarian Danube shipping company is the state-owned MAHART. The MAHART fleet comprises a total of 227 units including 18 self-propelled river cargo ships, 107 pushed and 45 towed barges. The overall capacity of MAHART's cargo fleet lies between 150000 and 225000 tons.

Table 2.35:
Croatian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	20	-	6900	-	345	
Pusher-tugs	none					
Pushboats	9	-	7190	-	799	
Self-prop. dry cargo ships	5	3539	4536	708	907	
Self-propelled tankers	none					
River/sea vessels	none					
Towed dry cargo barges	44	26300	-	598	-	
Towed tank barges	40	40000	-	1000	-	
Towed combined barges	3	3000	-	1000	-	
Pushed barges	40	43120	-	1078	-	

*) data not available
Source: Former Yugoslav Register of Shipping, Register of inland ships, Split 1991

By far the biggest national river shipping company is “Dunavski Lloyd”.

Among a plenty of small companies mostly engaged in dredging duties and dealing with construction material (sand and gravel) or in ore, coal and timber transports, “Drava Shipping Company” is the most significant one.

Two other companies worth to be mentioned, which mostly operate on the upper course of Sava river, are “Hidroput” and “Hidrotehna”

Table 2.36:
Serbian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	98	-	22404	-	229	34
Pusher-tugs	none					
Pushboats	45	-	51660	-	1148	25
Self-prop. dry cargo ships	68	66801	23285	982	342	19
Self-propelled tankers	5	3020	1709	604	342	32
River/sea vessels	none					
Towed dry cargo barges	182	105799	-	581	-	36
Towed tank barges	47	44113	-	939	-	35
Towed combined barges	none					
Pushed barges	287	393106	-	1370	-	24

*) accurate data extracted from Yugoslav Register of Ships 1994-1995
Source: Danube Commission Statistical Yearbook 1996

According to the Yugoslav Register of Ships, there exist 78 state owned and private shipping companies involved in inland navigation in the Federal Republic of Yugoslavia. The biggest of them are:

Table 2.37:
The main Serbian Danube shipping companies and their fleets

Owner's name	Head office	Number of units (-)	Total deadweight * (tdw)	Prevailing types of vessels **
BBP	Belgrade	128	74735	barges, towboats, motorships, dredgers
Brodarstvo DTD	Zrenjanin	12	7590	self-propelled vessels
Brodarstvo MDD	Pozarevac	11	6193	self-propelled cargo vessels, dredgers
Heroj Pinki	Novi Sad	77	75903	barges, towboats, motorships, dredgers
JRB	Belgrade	267	301840	barges, towboats, motorships
K. Gagrcin	Sombor	18	12752	self-propelled cargo vessels
Krajina ZDP-IHP	Prahovo	62	67589	pushed barges, pushboats
Luka Leget	S.Mitrovica	22	6040	towed barges
PIM	Belgrade	110	54606	barges, towboats, motorships, dredgers
RB Vojvodina	Apatin	26	11959	towed barges, tugs, motorships

*) including deadweight of tugs and pushers, i.e. their fuel and water supplies etc.
**) barges mean both towed and pushed barges, motorships mean self-propelled cargo vessels
Source: Yugoslav Register of Ships - Statistics for 1994-1995

Table 2.38:
Romanian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	272	-	72793	-	268	28
Pusher-tugs	none					
Pushboats	138	-	156110	-	1131	11
Self-prop. dry cargo ships	108	37990	22470	352	208	4
Self-propelled tankers	4	4600	2352	1150	588	42
River/sea vessels	none					
Towed dry cargo barges	756	462845	-	612	-	29
Towed tank barges	168	68385	-	407	-	35
Towed combined barges	none					
Pushed barges	682	1184952	-	1737	-	13

*) in year 1994 - it was taken into account the same assumption referring the age as in Table 3
Source: Danube Commission Statistical Yearbook 1996

Among all Danube riparian countries, the biggest fleet operates under Romanian flag. The ships are distributed among four large state-owned companies:

- CNFR NAVROM S.A. with head office in Galati,
- Braila NAV S.A. from Braila,
- CNF Giurgiu S.A. from Giurgiu and
- NFR Drobeta S.A. with head office in Turnu Severin

as well as two relatively small private companies having 2 respectively 3 pushboats and 18 respectively 32 pushed barges.

Table 2.39:
Bulgarian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	6	-	6642	-	1107	29
Pusher-tugs	none					
Pushboats	16	-	21873	-	1367	14
Self-prop. dry cargo ships	none					
Self-propelled tankers	none					
River/sea vessels	none					
Towed dry cargo barges	13	14736	-	1134	-	39
Towed tank barges	10	10441	-	1044	-	28
Towed combined barges	none					
Pushed barges	160	254934	-	1593	-	21

*) in year 1994 - it was taken into account the same assumption referring the age as in Table 3
Source: Danube Commission Statistical Yearbook 1996

With an exception of four river Ro-Ro catamarans the Bulgarian Danube fleet is characterised by the total absence of self-propelled river cargo ships.

The Bulgarian Danube fleet is concentrated mainly in BRP - Bulgarian River Shipping Company.

The Ro-Ro catamarans that operate under Bulgarian flag are in the ownership of the international German-Bulgarian truck operator SOMAT.

The ships operate regularly between the Ro-Ro terminals in Passau-Schalding in Germany and Vidin in Bulgaria on an approximately 1450 km long route.
The average annual turnover of the fleet is about 6000 trailers (total, in both directions).

Table 2.40:
Ukrainian Danube fleet sorted upon ship types

Type	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age * (years)
Tugs	11	-	9301	-	846	30
Pusher-tugs	47	-	69500	-	1479	29
Pushboats	22	-	44323	-	2015	13
Self-prop. dry cargo ships	67	173293	112393	2586	1678	16
Self-propelled tankers	none					
River/sea vessels	10	17000	19500	1700	1950	9
Towed dry cargo barges	70	114664	-	1638	-	28
Towed tank barges	25	35716	-	1429	-	31
Towed combined barges	167	188066	-	1126	-	29
Pushed barges	589	609170	-	1034	-	9

*) in year 1994 - it was taken into account the same assumption referring the age as in Table 3
Source: Danube Commission Statistical Yearbook 1996

The Ukrainian Danube fleet, second biggest in tonnage and the first regarding total installed output on the whole Danube, is concentrated mainly in state-owned UDP (Ukrainian Danube Shipping Company). It has to be mentioned that the Ukraine has, besides the access to the Danube, also a well developed inland waterway network comprising river Dnjepr and its tributaries.

Other countries

Moldova has a legal access to the Danube though the total length of Moldavian Danube does not exceed several hundred metres of the left river bank between the mouth of river Prut and Ukrainian border. Moldova has a fleet of small, up to 500 tdw barges and corresponding towboats being in operation mostly on river Prut. These barges appear also on Danube from time to time, being used mostly for grain import from Romania to Moldova.

The Russian Federation is a full member of the Danube Commission. Russian river-sea vessels come from Volga-Don inland waterway system to the Danube.

The Republic of Bosnia-Herzegovina operates 5 self-propelled twin-screw dry cargo ships, two non-self-propelled floating dredgers and one small auxiliary tug, mainly on the Sarariver.

Summary

Table 2.41:
Summary table of Danube fleet sorted upon ship types

Type *	N° of units (-)	Deadweight total (tdw)	Output total (kW)	Deadweight per unit (tdw)	Output per unit (kW)	Average age ** (years)
Tugs	452	-	133721	-	296	32
Pusher-tugs	55	-	78296	-	1424	32
Pushboats	294	-	347384	-	1182	15
Self-prop. dry cargo ships	322	344825	198364	1071	616	15
Self-propelled tankers	15	14550	9836	970	656	33
River/sea vessels	14	31924	26036	2280	1860	13
Towed dry cargo barges	1290	980595	-	760	-	32
Towed tank barges	328	234810	-	716	-	38
Towed combined barges	197	225456	-	1144	-	31
Pushed barges ***	2033	2948717	-	1450	-	16

*) data (if available) about other types not mentioned here are given beneath in additional comments about each ship's type
**) recalculated for 1996
***) dry cargo and tankers

Tugs

The towing barge technology is still present on the Danube and its tributaries. The operation of towed convoys is possible on river sections with problematic water depths even in low water periods, when due to technical and economical reasons (draught of propulsion unit, payload to empty weight ratio of barges) the navigation of pushed convoys is impossible or at least unprofitable. By far the biggest number of tugs are still in service in Romania, 272 units or more than 60% of all tugs operating on the Danube.

Pusher-tugs

The “Kiev” type has a length of 58.80 m, breadth of 8.80 m and output of 1570 kW, while very similar “Riga” class has a length of 57.60 m, breadth of 8.60 m and output of 1470 kW. All these ships are twin-screw vessels.

The majority of ships of this type are operational in the fleet of UDP (47 units or 85%). The remaining vessels are in Slovak SPD (4 units) and Hungarian MAHART (one ship). (The remaining three ships are registered in Germany.)

Pushboats

Romania has the most numerous pushboat fleet on the Danube with 138 units having a total output of 156110 kW.

There is a total of about 100 pushers with more than 1500 kW installed power per unit on the Danube as well as the similar number of vessels having an output between 1000 and 1500 kW. The remaining group consists of units suitable for short range operation, “packing” services and navigation on the navigable tributaries and canals.

Dry cargo motorships

The whole Danube fleet of dry cargo self-propelled ships has about 342 thousand tons of cargo capacity or just a little bit more than 7.4% of the total fleet capacity. The majority of this ship’s type is not suitable for longer international trips - they are either too small or under-powered or - what is mostly the case - both.

More than one half of self-propelled tonnage and almost 60% of installed power belongs to the Ukrainian Danube fleet. Other Danube countries usually use their motorships just as stand alone units.

Self-propelled tankers

The self-propelled tanker fleet consists of 15 vessels with a total of 14550 tdw. All this ships are suitable for transportation of liquid fuels only. Germany (2), Austria (4), Yugoslavia (5) and Romania (4) have self-propelled tankers on the Danube.

Dry cargo towed barges

Almost 60% of all units and almost 50% of the total tonnage are registered under Romanian flag. But due to their usually weak structural elements and therefore insufficient strength, lower block coefficient and reduced cargo space, these vessels cannot match the efficiency of modern pushed barges.

Despite of these disadvantages in periods of low waters the old tugboats with draughts very often less than 1.6 m and light loaded towed barges are still applicable.

Towed tank barges

All these vessels are as self-propelled tankers being used just for transportation of liquid fuels (crude oil and its products) not for other chemicals. Again the Romanian fleet is the most numerous one with 168 units or more than 50% of the total Danube fleet. The rest belongs to Yugoslavia (47), Croatia (40), Austrian (14) and Slovakia (14 units).

Towed combined barges

These vessels are built for transport of bulk cargo in their hatches and liquids in side (wing) tanks. Almost 85% of all units of this type can be found in the Ukrainian fleet and further 12% (24 vessels) in Hungary.

Pushed barges

The total cargo capacity of all pushed barges on the Danube is more than 3 million tons thus covering about 65% of the overall tonnage. There are also special Ro-Ro twin deck (Germany, Slovak Republic) and single deck barges (Bulgaria) equipped with stern ramps for horizontal transhipment of road vehicles.

Romania with 682 units and about 39% of the overall tonnage and Ukraine with 589 units and a share of more than 20% of the total cargo capacity have the largest Danube pushed barges fleets. Other countries have fleets counting between 96 (Austria) and 285 units (Yugoslavia).

The most usual size is: 76.5 m overall length, 11.0 m breadth and maximal draught between 2.3 and 2.8 metres - the so-called “Danube - Europe II” barge. However, in Germany, Austria and Slovak Republic there are also plenty of 11.4 barges which are more convenient for the upper Danube and Main-Danube Canal. Barges of other nominal sizes, varying in breadth from 7.6 to 15.5 metres can be found mostly in Croatian, Yugoslav and Ukrainian fleets.

River-sea cargo ships

According to the Danube Commission official statistics, just 4 ships of this type registered in the Slovak Republic and 10 vessels from Ukraine belong to the Danube shipping companies.

Russian and Ukrainian ships operate on lower and middle Danube providing the waterborne link between Budapest, Belgrade, Bulgarian and Romanian Danube ports and the ports on Dnjepr, Don, Volga and Caspian Sea.

Pure sea ships of up to 12000 tdw (with draught equal or less than 24 feet) are allowed to enter the Danube through Sulina Arm and to reach Reni, Galati and Braila.

A particular type of the waterborne sea-river service based on so-called SEABEE system was introduced on the Danube by establishing the international shipping company “Interlighter” in 1978. The “Interlighter” system consists of sea-going barge carriers and special river pushed barges. The barges are pushed in convoys along the whole international Danube and elevated over the stern of the carrier on its deck to be transported over the sea section. Between 1978 and 1994 these ships provided regular service between the mouth of the Danube (Ust Dunajsk, Constanta), the Black Sea port Novorossijsk and overseas ports of Karachi, Bombay, Kelang, Singapore and Bangkok. Sometimes the barges have been pushed along the Mekong river and reloaded also in Saigon (Vietnam) and Phnom Penh (Cambodia) some 500 km upstream the mouth. The organisation of such a kind of service between the Rhine-Main-Danube waterway and inland waterway system in the Russian Federation is now under consideration.

Special cargo ships

The most unconventional cargo vessels in service along the Danube are the Ro-Ro catamarans. Besides their main role to transport truck trailers between German and Bulgarian Danube ports, these vessels have also been used sporadically in on deck transport of passenger cars from Germany to Budapest. The capacity of each vessel is either 49 forty-feet trailers or 35 trailers with drawing vehicles or about 200 medium class passenger cars. German BL also introduced special double deck Ro-Ro barges in service between Kelheim, Regensburg or Passau and Vienna respectively Budapest. These barges are reconstructed standard “Europe II” size barges with a breadth of 11.4 m. Each barge of this “RL”-series is able to load 15 forty-feet trailers on lower and 17 on upper deck.

Austrian DDSG equipped two barges for Roll-on-Roll-off and Ukrainian UDP has several flat deck barges having a capacity of 15 forty-feet trailer. Slovak SPD has also 4 Ro-Ro barges with an average carrying capacity of 975 tons each.

A considerable number of ferry services exists across the lower Danube. To the most important lines belong those between Romanian Calafat (Danube km 795) and Bulgarian Vidin (km 793), then between Romanian Giurgiu (km 493) and Bulgarian Rousse (km 490) and across the river nearby Galati (km 154 - mouth of river Siret).

2.2.2 Design particulars in ships’ and transhipment technology

Resistance, propulsion and steering

Standardised pushed barges on the Danube, mostly of Europe II type are characterised by very high block coefficients (C_b up to 0.93) that leave not too much freedom for considerable alterations of body lines in order to reduce the resistance. A considerable decrease of resistance can be achieved by optimal arrangement of barges in convoys. More than two barge trains offer many different combinations of convoy layout.

The reason for different arrangements of convoys consisting of the same number of barges for upstream and downstream navigation lies in the fact that the relative speeds through the water in both directions are approximately the same but due to the considerably higher speed relative to the ground in navigation downstream, the centrifugal force acting on the convoy during the turning manoeuvre is pretty higher.

The convoy length has the prevailing influence on the requested width of the curved waterway. In upstream navigation, the speed of a pushed convoy relative to the ground is 2-3 times lower than that in downstream navigation, thus the centrifugal force at the same radius of curvature is 4 to 9 times smaller.

Due to the high requirements regarding steering efficiency on one side and hydrodynamically very unfavourable aspect ratios of rudder blades pushboats have usually two rudder blades with synchronous parallel motion behind each propeller and an additional pair of rudders in front of the propellers in order to ensure steering in navigation astern as well as so-called flanking

The majority of vessels have twin-screw propulsion although single screw ships are also not the rarity.

Winds and waves, freeboard, stability

The resolutions of the ECE sub-committee for inland waterways defines three wave heights:

– area of navigation 1: wave heights up to 2.0 m
– area of navigation 2: wave heights up to 1.2 m
– area of navigation 3: wave heights up to 0.6 m

The whole course of the Danube is assigned as area of navigation 2. The basic freeboard for the area of navigation 2 has to be 300 mm.

Danube ships have usually a very high beam to draught ratio and therefore their initial stability is high too. Standard size cargo ships are not too sensible on the waves. Strong lateral wind represents a problem for the course keeping of large pushed convoys with empty barges.

Structural aspects

Danube river barges and especially self-propelled cargo ships have high length to beam and beam to draught ratios. That makes them very inconvenient regarding longitudinal strength aspects. The majority of vessels has a single hatch opening over up to 80% of ship's length. Tankers and flat deck vessels, i.e. ships with continuous deck over the whole length are much more convenient regarding both longitudinal and torsional strength and therefore the scantlings of their structural elements are usually smaller. The consequence is that closed deck vessel have on average an about 10% lighter steel structure than those having an open deck. One typical Europe II barge has an own weight of between 380 and 430 tons.

The barges with structural elements according to the rules of the Russian Register are considerably lighter that those built according to the German Lloyd (GL) rules. The rules of the Jugoslav Register give a total barge weight somewhere in the middle of these two extremes.

Reloading technology

The vertical reloading technology from ship to shore and vice versa prevails. Real Ro-Ro facilities exist in several ports on the upper Danube (Germany, Austria, Slovak Republic) and in Budapest, Vidin and Rousse.

It is typical for the ports on the middle and lower Danube that dry bulk cargoes are mostly reloaded using cranes with grabs. For mass cargoes like coal, ore etc. cranes of only five tons and moderate size 16 tons lifting capacity prevail.

Other equipment

Some of the rules, especially regarding anchoring and mooring equipment on the pushed barges have been adopted by the Central Rhine Commission and the ECE for the navigation on the West-European inland waterways and some years later accepted and recommended as standards by the Danube Commission. This harmonisation has been done many years before the opening of the Main-Danube Canal, but on the Danube still exist numerous vessels built 20 or more years ago, not properly equipped for the navigation on Rhine, Main and M-D Canal.

2.2.3 Shipyards

Table 2.42:
The most important river shipyards on the Danube

	Name and site	Country	Danube km
1	Schiffswerft und Maschinenfabrik Theodor Hitzler GmbH & Co. KG - Regensburg	Germany	2377.00
2	Deggendorfer Werft und Eisenbau GmbH (DWE) - Deggendorf	Germany	2284.70
3	Österreichische Schiffswerften AG (ÖSWAG) - Linz	Austria	2131.50
4	Österreichische Schiffswerften AG (ÖSWAG) - Korneuburg	Austria	1942.95
5	Slovenské Lodenice a.s. - Komárno	Slovak Republic	1767.10
6	MAHART Újpesti Hajójavító Üzem - Budapest	Hungary	1652.95
7	GANZ Danubius Hajó- és Gépgyar Rt. - Budapest	Hungary	1651.25
8	MHD Balatonfuredi Gyaregyseg - Balatonfured	Hungary	1497 + 121*
9	Brodogradiliste “B. Kidric” - Apatin	Yugoslavia	1401.50
10	Brodogradiliste “Novi Sad” - Novi Sad	Yugoslavia	1258.00
11	Brodogradiliste “Sava” - Macvanska Mitrovica	Yugoslavia	1170 + 136**
12	Brodogradiliste “Beograd” - Beograd	Yugoslavia	1170 + 3***
13	Santierul Naval Orsova - Orsova	Romania	954.00
14	Brodogradiliste “Brodoremont” - Kladovo	Yugoslavia	934.70
15	Severnav S.A. - Drobeta	Romania	931.00
16	Rusenska Korabostroitelnica O.O.D. - Rousse	Bulgaria	495.60
17	Santierul Naval Giurgiu - Giurgiu	Romania	492.15
18	S. C. Naval - Oltenita	Romania	428.70
19	Santierul Naval Braila - Braila	Romania	174.00
20	Santierul Naval Galati S.A.- Galati	Romania	148.16
21	Santierul Naval Tulcea - Tulcea	Romania	71.30

*) On Balaton Lake linked with the Danube over 121 km long navigable Sió Canal
**) On Sava river, 136 km from the mouth in Danube
***) On Sava river, 3 km from the mouth in Danube

Germany

The Theodor Hitzler Yard in Regensburg was specialised in newbuildings of all types of river vessels but is closed since 1994.

The DWE shipyard in Deggendorf is equipped to build the biggest Danube ships, river Ro-Ro semi-catamarans as well as passenger semi-catamaran cruise ships. Since the mid of the fifties, the DWE has started with production activities other than shipbuilding. Numerous institutes specialised in shipbuilding technics and ship hydrodynamics (among others the VBD - Research Institute for Shallow Water Hydrodynamics - uniquely suited to this specific field in whole Europe) as well as seven faculties for shipbuilding science in Germany ensure the optimal scientific background for the domestic shipbuilding industry.

Austria

The ÖSWAG yard in Linz built numerous ships, often in large series for domestic orderers and for export, mostly for the ex-Soviet Union and the Ukraine, including large cruise passenger ships, self-propelled pushing vessels, pushboats, barges, excursion passenger ships, special vessels etc.

Since four years ago the yard has mostly performed repair works on the vessels being previously build in Linz or Korneuburg (Austrian, Bulgarian, Ukrainian ships). Some smaller passenger ships for Swiss customers (for day excursions on rivers and lakes) have been built in this period), as well as some small special objects (e.g. floating system for cutting the grass growing from the river bed).

The production programme also comprises e.g. special track vehicles (as railway cranes), final processing on large castings and the variety of production and repair works on special heavy equipment.

The ÖSWAG yard in Korneuburg has built barges, self-propelled river and river-sea cargo ships, tugs and pushboats but was recently closed.

Slovak Republic

The shipyard in Komarno is a joint stock company. Up to six ships of 136 m in length and 17 m in breadth can simultaneously be built in the assembly hall. Besides, the container production line has an annual capacity of 15000 boxes. At the moment the yard has 3700 employees.

There exist three yards in Bratislava which are almost exclusively involved in ship repairs for domestic customers.

Hungary

The oldest and most famous Hungarian shipyard, “GANZ Danubius built a large series of pusher-tugs and pushboats and had a long tradition and world-wide reputation in crane building. It was closed some years ago.

MAHART yard in Újpest is mostly involved in repair activities of the Hungarian state-owned MAHART fleet. The yard has about 300 employees representing more than 50% of all shipbuilding staff in Hungary.

There exist also some smaller yards in Budapest and Baja as well as in Balatonfured.

Yugoslavia

All eleven river shipyards in ex-Yugoslavia are located on the territory of Serbia, along the Danube, its tributaries (Sava and Theiss) and navigable canals. Very well developed shipbuilding industry in Croatia is exclusively oriented to the production of sea-going vessels. A relatively good developed industry of ship's equipment remains distributed now in all successor states but mostly in Croatia and Slovenia.

Almost all Serbian river shipyards deal with newbuildings, the most important are in Belgrade, in Macvanska Mitrovica, in Apatin and in Novi Sad.

The shipyard "Beograd" delivered about 1000 newbuildings since its foundation in 1990. All eleven yards deal also with ship repairs.

According to some rough estimates, Serbian river shipbuilding industry has nowadays a total of about 4000 manpower (the biggest one, shipyard "Beograd" alone about 800 employees, others between 500 and 150). The ships are usually built according to the rules and under survey of JR, LR, GL, Russian Register, DnV and occasionally under other classification societies.

Romania

The Romanian shipbuilding industry ranked on 7th place in the World with its annual production of 1.2 mill. gross tonnage of newbuildings at the end of 1995. The largest yards are those on the Black Sea coast in Constanta and Mangalia, but also the shipyards in Galati, Braila and Tulcea are able to build relatively large sea-going vessels. The yards located along the Danube in Oltenita, Giurgiu, Drobeta and Orsova are more oriented in production of river vessels and smaller sea ships of up (5000 tdw).

There is a diesel engines factory in Romania that makes propulsion long stroke, low speed diesel engines under the licence of B&W with an output of up to 22900 HP, as well as the propeller manufacturer (fixed blades) with max. 7 m in diameter located in Galati.

The prevailing activities in Romanian yards are newbuildings. The ships are built to match the classes of all world-wide recognised classificaton societies as LR, ABS, GL, BV, DnV as well as Russian Register of Shipping and RNR (Romanian classification society). All these societies have their permanent survey offices in Constanta, Tulcea or Galati.

According to very rough estimates, Romanian shipyards, have a total of about 20000-25000 employees (5800 in Galati, 4000 in Constanta, 2800 in Tulcea, 600 in Orsova).

All design activities, model testings and production of documentation (classification drawings) that covers all the needs of the robust Romanian shipbuilding industry are concentrated in ICEPRONAV - Research and Design Institute for Shipbuilding - located in Galati.

Bulgaria

The Bulgarian shipbuilding industry is concentrated mostly on the production of sea-going vessels in the Black Sea yards in Varna and Burgas. Danube shipyards are located in Lom (almost exclusively repairs) and Rousse.

At the moment the Rousse shipyard has manpower at about 2000 and the annual production of about 12.000 - 15.000 tons built in steel. The Ship Research and Design Institute (INFOKOR) in Varna established in the late seventies performe scientific research in the field of ship-building and ship hydrodynamics.

Perspectives

Shipbuilding has a long tradition on the whole Danube. The production potential of the yards located on the Danube banks excels demands of the local ship operators to a large extent. Therefore, a large amount of newbuildings is exported to customers outside the the Danube waterway system.

Since the opening of the former East-block countries, a considerable shifting of activities towards East has been identified. The production in Germany, Austria, Hungary and Serbia dropped down abruptly since 1990, while Slovak Republic, Bulgaria and especially Romania strongly increased their activities.

The Hungarian shipbuilding industry is in a bad situation after the recent bankruptcy of GANZ Danubius.

Serbian river shipyards lost their traditional customers in the ex-USSR after 1990, then the war in ex-Yugoslavia came and UN sanctions between 1992 and the end of 1995. It is very difficult to predict if the very good pre-war reputation, quality of work and accurate time-scheduled delivery can be maintained after years of almost total inactivity.

In general, it can be expected that in case of a quick recovery of the national economies in South-eastern Europe, and consequently an increase of transport demands through the Danube corridor, Danube river shipyards can expect a certain rise of new orders and repair jobs. Especially self-propelled ships for all categories of cargo will be needed in large number. Western experience and advanced know-how in building of such vessels combined with low eastern prices can be beneficial for both.

2.2.4 Infrastructure Bottlenecks: Ports and Fleets

Ports

In order to ensure the adequate transport of cargo and passengers, ports have to be linked to their hinterland and distant regions by suitable and efficient communications and traffic facilities, particularly by a network of railways and roads. Ports constitute important traffic junctions of integrated traffic systems and together with transhipment centres play a substantial role in ensuring combined transport. Each modern port profferes therefore, a container terminal and a platform for roll-on / roll-off transport.

The main functions of ports have shifted from distributed transport towards direct transport that does not require cargo re-loading.

The following ports meet classification requirements, as ‘European inland ports”:

Germany	Regensburg, Deggendorf, Passau
Austria	Linz, Enns, Krems and Vienna
Slovakia	Bratislava, Komárno
Hungary	Budapest, Baja, Mohach
Croatia	Vukovar (strategically important but pretty damaged during the war 1991-1992)
Serbia	Novi Sad, Beograd, Pancevo, Smederevo, Prahovo
Bulgaria	Lom, Svistov, Rousse
Romania	Turnu Severin, Giurgiu, Braila, Galati, Cernavoda, Constanta
Moldavia	none
Ukraine	Reni, Izmail

According to the European Agreement on Main Inland Waterways of International Importance (AGN) each port of international importance would have to meet the following conditions:

- it must be situated on an E-route;
- it must be linked to important railway and road routes (if possible, with those included into AGC or AGR agreement);
- its annual re-loading capacity should be at least 500 t;
- it should provide conditions for the development of port industrial zones;
- it should allow the handling of standard containers;
- it should provide conditions for trade and customs operations connected with the international exchange of goods;
- distances of ports having protective function should allow ships, in case of unfavourable climate conditions, to arrive to the port in time.

Port of Bratislava
The loading of goods in the long trains is limited by the short rail line in the western part of the port area. The growth of the harbour in the direction of the Danube is limited by urban developments.

The petroleum loading facility in the harbour area is judged to be very dangerous as the petroleum harbour extends to the outer bank in a curve and it is feared that a ship that loses control of its rudder could bump into the petroleum facility.

Port of Budapest
The major bottleneck at this port is the traffic situation and, in particular, the harbour’s connection to the road network.

Port of Dunaujvaros
The harbour's dependence on the Dunau-Ferr ironworks has led to a one-sided orientation towards bulk goods.

The town of Dunaujvaros is planning to build a new harbour downstream to the South in the course of building a new bridge. This harbour will connect the town's industrial area to the river. There is a paper factory and other operations. Rail connections will be better than at the existing harbour, especially as the topography of the right-hand bank of the Danube further to the South is much better.

Port of Lom
The port is a typical bulk port, but has no facilities for RoRo, nor containers. Most structures are in a desolate condition. For the present situation, the port is over-dimensioned and is one-sided being equipped only for bulk.

Port of Ruse
Bottlenecks are expected particularly due to the port's equipment, as well as the qualification of the workforce, which leaves considerable room for improvement. Particularly inconvenient is the continuously ongoing dredging operation in the harbour basin, especially during low water.

Fleets

The main problem of inland waterway transport is the dependence on bulk cargo which has decreased during the last years and therefore has led to spare capacities.

A special problem arose in recent years, as many fleet operating companies sold their vessels to and former employees became independent barge owners. This development had led to management deficits in the operation of vessels, as cost calculations and investments are only made on a very small scale.

Generally the fields of activity that would improve the situation are the offering of enhanced (logistic) services, customer-orientation, management improvement, combined transport and informatics and telematics.

Whereas the loading and unloading of vessels in German and Austrian ports do not pose any problems, it faces severe problems in the ports east of Austria due to inadequate infrastructure and equipment of the ports as well as of transhipment centres. The transhipment of agricultural products is especially time-consuming since the ports do not have any facilities for the storage in transit, the goods have to be loaded into trucks and loaded again on the vessels.

In Hungary and the Slovak Republic an unlimited liability is valid for ship damages, whereas in the West European inland waterways the liability is generally limited. Therefore a substantial liability risk is in effect for the use of Western tonnage on these Danube sections. This is not acceptable if the two-way-traffic is to be extended.

Germany
Ships from Eastern Europe are free to navigate as far as Kelheim without becoming subject to German technical requirements and corresponding surveys. However, when

entering the Main-Danube Canal north of Kelheim for the first time, foreign ships are mandatorily surveyed by the German “Staatliche Untersuchungskommission” for compliance with the technical and nautical rules that are valid in Eastern Europe and also on the German IWT system and Rhine. This creates high costs and delays on East European ships, before they are issued an admittance certificate.

Only ships that were built on the Slovenske Lodenice A.S. of Komarno and therefore have a class certificate of either Germanischer Lloyd or Slovakian Lloyd are issued an admittance certificate without further surveys.

Austria
The fleet of DDSG is in good technical condition. Some hindrances in recent years resulted from the frequent change of ownership and a decrease in traditional DDSG transports of iron ore, which concentrate from Izmail to Linz with large pushed convoys.

Slovak Republic
The Slovak Republic has a simple licensing system. Therefore, one typical bottleneck is the lack of nautical personnel with licenses for the Rhine and other West European IWT systems. The problem is aggravated by Slovakian license holders who, once they have managed to also obtain a West European license, often quit the Slovakian fleet and continue working on West European ships where they earn more money than with their original home fleet.

This problem is notorious for all East European fleets, not only for the Danube, but for all other systems as well, including deep-sea shipping.

Hungary
The Hungarian licensing system for ship personnel is far more complex than in the Slovak Republic and fully corresponds with the recommendations of the Danube Commission.

There are bureaucratic difficulties arising from the procedures involved in obtaining permission for transit transports through the Yugoslav section of the Danube, which have been introduced by the international community through the United Nations. Danubian shipping became one of the most adversely affected sectors in the economies of the riparian countries. The East European riparian countries were not able to compensate for the losses caused by the slow, unreliable and expensive (because of the transit dues imposed by the Serbs) transports through the Yugoslavian section of the Danube.

Yugoslavia / Croatia
In consequence of the breaking up of former Yugoslavia, the Croatian fleet was split up into three parts, of which the first on the upper Danube is only formally active, the second on the Sava river has no access to the lower part and to the Danube on Serbian territory. The third part of this fleet is located on the lower Danube (Reni and Izmail).

In the Serbian fleet, on the other hand, technical conditions are very bad. More than 50% of the units and a lot of vessels even lost the national operating license.

Romania
Typical commercial bottlenecks of the romanian fleet are:

- For each passage through Serbia, the NAVROM ships have (had) to pay an immediate tax in cash, (whether loaded or empty), which is a clear breach of the Belgrade Convention guaranteeing free passage for all ships of all Danube riparian countries.
- Entry inspections by the customs, harbour masters and sanitary authorities at Vidin (Bulgaria) and Mohacs (Hungary) are, time-consuming and also create frequent bureaucratic problems.
- Because of the war in ex-Yugoslavia, large amounts of former cargo from and to this country have been lost.

Bulgaria
In Bulgaria the major IWT organisations are the Bulgarian River Shipping Company and SOMAT. The problems and issues of these major fleets and their commercial perspectives in Danube are discussed below.

The Bulgarian River Shipping Company (BRP) has no navigation experience in Germany beyond Regensburg, and it has no ships that would be accepted by the SUK, nor could it navigate through the MD-Canal or the Rhine, because, the small pushers are not powerful enough for Rhine navigation.

With SOMAT units navigating regularly to Germany, the scope and range of commercial bottlenecks is completely different. But they complain about bureaucracy, e.g. that German customs officers have claimed that the bus carrying the truck drivers from Vidin to Passau needs to return exactly with the same number of drivers back to Vidin. This creates difficulties, if in the case of refrigerated cargo, some drivers needs to accompany the catamaran transfer in order to serve the reefer engines of the trucks. Or that Austrian customs officers claime easy access to all trucks loaded, enabling them to check all their seal numbers on each passage. The consequence would be that the member of trucks on a catamaran would be reduced from seven to six lanes only, i.e., by 14.3%.

Some of the gate locks on the Danube stretch, particularly the system at Gabcikovo are persistently under repair so that the catamarans are often delayed by several hours in each gate lock passage, particularly during the summer period, when passenger ships with tourists on board cruise on the Danube and are given priority on the gate lock passages.

The Bulgarian MoT has ambitious ideas to promote the use of the Danube Corridor also for transit to the countries beyond the Black Sea.

But this kind of transit through Bulgaria will have to compete with the same type of transit through Romania where there no need to use the railways system. The prospective competition with Romania and its more favourable geography is a major commercial bottleneck for any potential Bulgarian transit on the Danube Corridor.

Ukraine
The large fleet provides ample overcapacity. Despite of a large number of relatively modern river vessels the fleet structure is not appropriate to actual demand.

2.3 The Transport Markets

2.3.1 Recent Economic Development in the Danube States

Western countries in the Danube region showed a fairly homogenous development characterized by little dynamic from 1990 to 1995. In 1990 and1991 a strong growth was to be observed, a recession in 1993 and a moderate upturn in 1994 and 1995. The boom in 1990/91 was mainly the result of the sudden increase in demand after German reunification. High interest rates, fiscal rentrenchment and a revaluation of the German mark (and other hard currencies) against the dollar from 1992 on contributed to a strong recession in 1993 in most of the Western countries. The upturn in 1994 and 1995 was strongly stimulated by an increase in exports as a result of the economic prosperity in the USA as well as trade generating effects of the Common Market within the European Union.

The external trade competitiveness of the Western countries in terms of prices was strongly influenced by the exchange rate development. From 1990 to 1995, European hard currencies were revaluated against the dollar. Except Greece and Turkey, all Western countries of the Danube region are regarded as hard currency countries. The German mark (and to a similar extent the other currencies of Western countries except Greece and Turkey) experienced a real increase of 15 % against the dollar. As a consequence, export prices increased while imports cheapened.

Some of the likely effects of the economic development of the Western countries on their trade performance may be summarized as follows:

- the moderate growth in GDP may contribute to a moderate overall growth in trade
- the economic recession of 1993 restrained trade in that year
- the slow expansion of consumer spending may cause a restrained growth in demand for imported consumer goods
- the overall increase in labour productivity may positively affect export competitiveness and, thus, contribute to a growth in exports
- the increase in real exchange rates on the other hand may contribute to show-down in export growth

The **transition countries** of the Danube region experienced a totally different economic development from that of the Western countries. The time period from 1990 to 1995 was characterised by a dynamic transformation process from socialist economies to capitalist ones and first resulted in a profound recession. Large parts of the productive resources were devaluated, and employment fell dramatically. Major sources of this recession were the breakdown of the COMECON trade regime, the missing technological competitiveness of Eastern products on Western markets, and political difficulties in the process of economic and political transformation. The latter including uncertainty as to the speed and direction of reforms, uncertainty as to ownership restitution and privatisation, price destabilisation etc. In all countries, the economic recession lasted from 1990 to 1993.

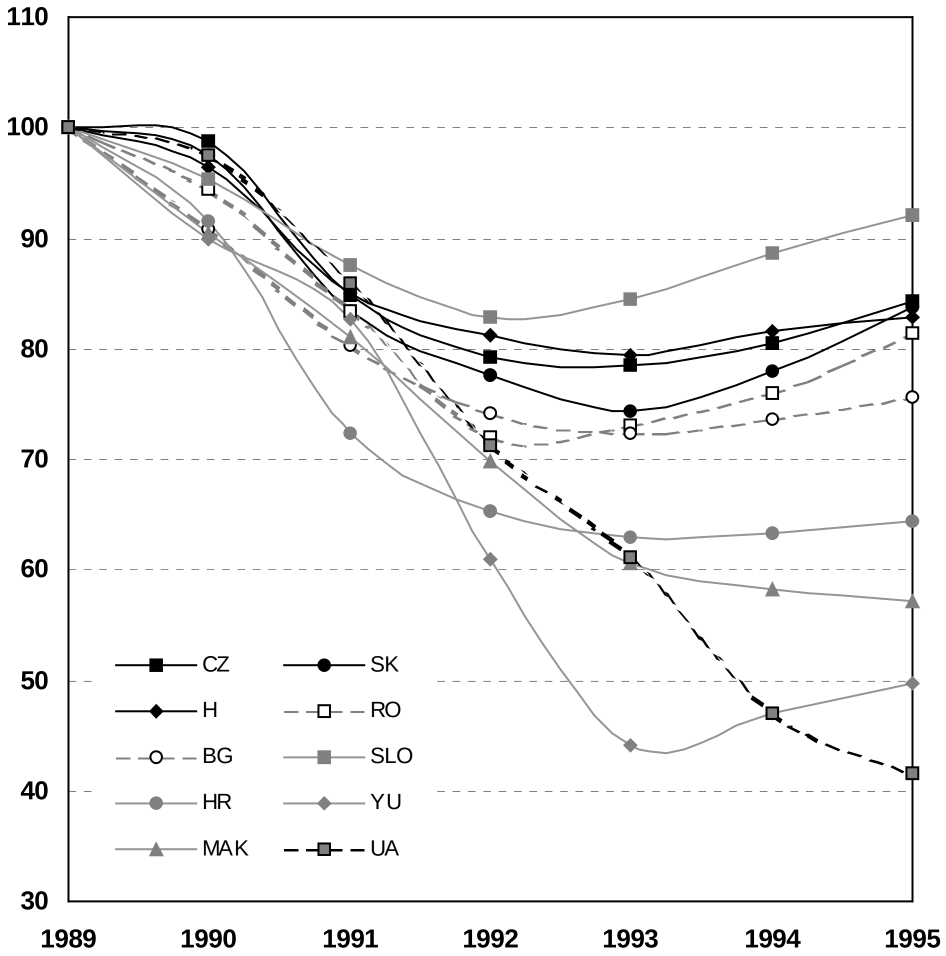
This general pattern of economic development applies to all transition countries covered in this report, though the individual countries show significant differences as to the actual path of transformation.

In figure 2.2, changes in real GDP for 10 transition countries (Bulgaria, Croatia, the Czech Republic, Hungary, Macedonia, Romania, the Slovak Republic, Slovenia, the Ukraine and the Federal Republic of Yugoslavia) are shown. With 1989 as a starting point, all these countries faced a sharp decline in GDP in the first years of transformation. Slovenia and Romania were the first countries to experience positive rates of growth in 1993, while in 1994 and 1995, GDP was growing in most transition countries. However, the economy of the Ukraine, which started the process of transformation in 1991/92 only, shrank also in 1994 and1995.

The extraordinary strong decline in economic activity in the first years of transformation is reflected by the fact that no country was able to reach the 1989 level of economic activity by the year 1995. The best performance in relative terms was that of Slovenia, followed by the Czech Republic, the Slovak Republic, Hungary and Romania. Extremely weak performances were exhibited by Macedonia and the Federal Republic of Yugoslavia. The worst economic development (in terms of real GDP growth) of the countries considered was experienced by the Ukraine, where GDP in 1995 was only 41 % of that in 1989.

The figures depicted in figure 2.2 should be interpreted with some caution. In the course of transformation, informal sectors of the economy evolved which are regarded as being of significant quantitative importance. Their value is not reflected by the official GDP figures. Therefore, the actual GDP should be taken to be higher than the figures shown and GDP growth less negative than shown.

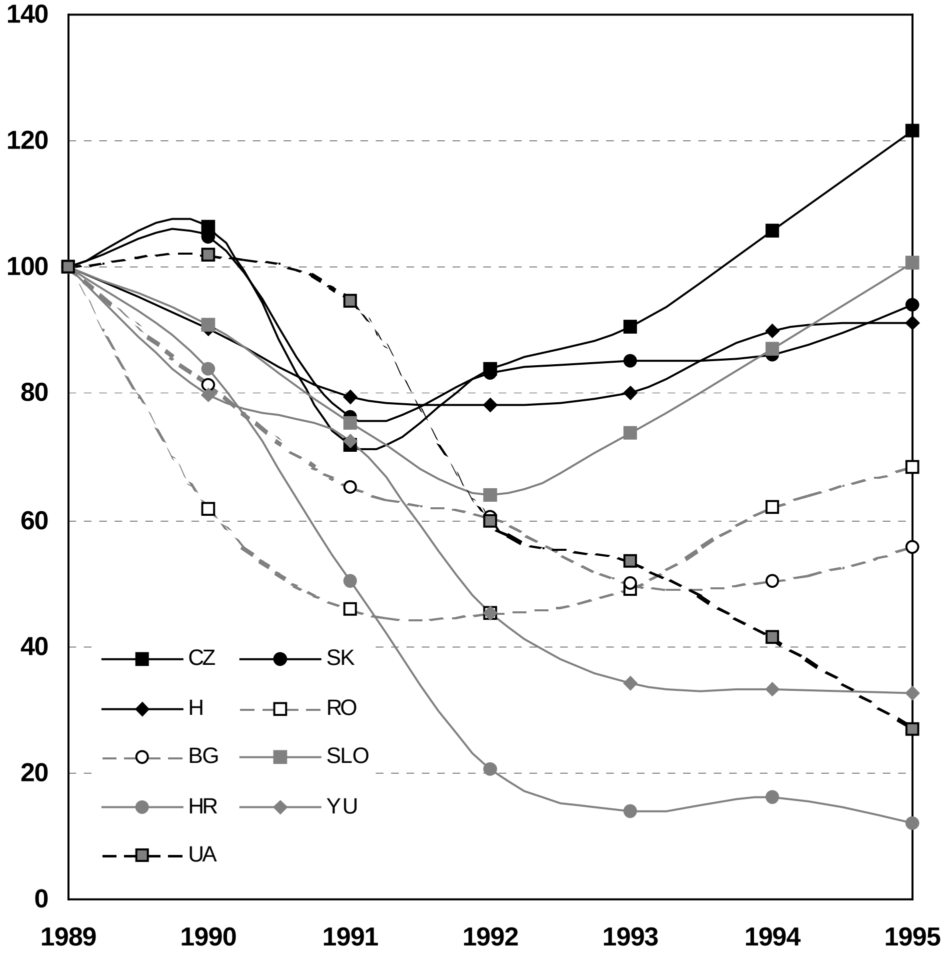
Figure 2.2:
Real GDP 1990-1995 of selected transition countries
(1989 = 100)



Source: WIIW (1995, 1996, 1997)

Real gross investment may be considered both as a major demand side factor regarding changes in GDP and trade, and an indicator of technological change in Eastern Europe, as it may be assumed that new investment incorporates new process technologies. It shows the highest diversity of all indicators considered. In the Czech Republic, the 1995 level of investment significantly exceeded that of 1989, while in the successor countries of the Soviet Union and Ex-Yugoslavia, investment in 1995 reached only 15 to 35% of the level at the beginning of the transformation (see Figure 2.3). The sequence of countries in terms of 1995 investment levels indicates the speed of renewal of productive sources. The Czech Republic was followed by Slovenia, the Slovak Republic and Hungary. Clearly behind were Romania and Bulgaria at the very end we find Yugoslavia, the Ukraine, and Croatia.

Figure 2.3:
Real gross investment 1989-1996 of selected transition countries
(1989 = 100)



Source: WIIW (1995, 1996, 1997)

The most important demand side factor of trade is personal consumption which accounts for 55 to 80% of all expenditures of GDP in the countries considered. The level of personal consumption is strongly influenced by the level of employment and the level of real wages. In all transition countries within the catchment area of the Danube the level of total employment fell, this process was not stopped until 1995 in most countries.

The simultaneous decrease in employment and real wages led to a reduction of personal consumption which negatively influenced the demand for consumer goods and, in principle, for imports of consumer goods. In the first years of transformation, this effect was counteracted by a decrease in the workers' saving ratios and using up of savings. It may be assumed that from 1993 on this effect became less important. Reduced consumption essentially dampens demand for the import of consumer goods, though this will not necessarily affect imports of consumer goods, if foreign products can raise their market shares at the cost of domestic production.

Table 2.43:
Average economic development in the transition countries 1990-1995

Transition countries except the Ukraine		*1990*	*1991*	*1992*	*1993*	*1994*	*1995*
Per capita income (in USD) at exchange rate		3 223	2 214	2 029	2 091	2 304	2 799
Change in:	Real GDP	-6.2	-12.6	-9.9	-3.7	+3.3	+4.2
	Manufacturing Output	-12.4	-20.9	-13.8	-5.0	+4.3	+5.7
	Real Gross Investment	-14.7	-22.6	-8.0	-2.8	+13.4	+5.8
	Total Employment[a]	-2.1	-5.4	-5.0	-3.1	-0.9	-1.4
	Real Wages[a.b]	-1.1	-18.9	-4.3	-6.0	+1.0	+2.5
	Manufacturing Employment[a.b]	-2.9	-8.2	-9.7	-7.8	-4.5	-4.0

a Except Macedonia (no data available)
b Except Macedonia and Yugoslavia (no data available)

Source: WIIW

In Table 2.43, selected indicators of the economic development from 1990 to 1995 are shown. The figures indicate weighted averages for the transition countries except the Ukraine. Per capita income (measured in USD at official exchange rates) decreased until 1992, then rose substantially. This rise however was not caused, by an increase in real GDP, but a revaluation of national currencies against the dollar. With the Ukraine not being taken into account, positive rates of growth can be observed for most variables (except employment) in 1994 and 1995 indicating an upward move on the path of transformation.

A major supply side factor is the level of labour productivity in the production sector of the economy and associated competitive advantages. In general, labour productivity fell until 1992/93, then steadily and afterwards continously increased.

Taking into account the significantly stronger reduction in real wages, the development of labour productivity in manufacturing suggests a decrease in efficiency wages (unit labour costs) in almost all transition countries between 1989 and 1995. In labour intensive production with little technological requirements, efficiency wages represent the most important factor of competitiveness. As transition countries are known as having substantial advantages in low-tech and medium-tech labour intensive production, decreasing unit labour costs should contribute to increasing competitiveness on export markets.

Monetary turbulences in the course of economic transformation seem to be even larger. All transition countries had to manage inflation of enormous dimensions as well as fluctuating exchange rates of national currencies. Compared to the dollar, all currencies of the transition countries were nominally devaluated between 1990 and 1995, although to very different extents.

In general, currency devaluations positively affect competitiveness in exports by diminishing international unit labour costs and hamper imports as foreign goods become relatively more expensive in national currencies. In the case of strong inflation this might be different. If inflation increases faster than the national currency is devaluated, a de facto revaluation is taking place with contrary effects on trade. In most of the countries considered this evaluation can be seen. Bulgaria, the Ukraine, and Yugoslavia where the only countries were rapid inflation and even hyperinflation were exceeded by currency devaluation. In countries with a de facto revaluation, per capita income in foreign currency (i.e. USD) at exchange rates will rise despite a decrease in real GDP (the population remaining the same). This per capita income increase may stimulate demand for imports while export competitiveness in general is beeing reduced.

Another factor potentially influencing the trade behaviour of the transition countries is foreign debt. Bulgaria, Hungary, and Yugoslavia show a considerable degree of indebtedness. But also the Czech Republic, the Slovak Republic, the Ukraine, and Croatia have high running external debts. In a fairly good position are Slovenia, Romania and Macedonia. There is no country with an extraordinary increase in external debt.

The most important of the likely effects of the economic transformation process on trade performance in the transition countries within the catchment area of the Danube can be summarized as follows:

- the strong decline in GDP in the early 1990s may result in a contraction of the overall volume of trade,
- the economic upturn in most countries since 1994 may stimulate trade again,
- the strong increase in gross investment since 1993 may increasing by stimulate import of investment goods,
- shrinking employment and falling real wages have negative effects on the level of consumer demand, but de facto revaluation of national currencies in most transition countries may raise demand for imports (at the cost of domestic production of consumer goods),
- the strong increase in labour productivity in the manufacturing sector since 1992/93 along with retarding real wages reduces efficiency wages which should affect export competitiveness in a positive way,
- however, positive effects on export activity by decreasing unit labour costs may be undermined by de facto revaluation of most natural currencies,
- monetary instability in most countries represents a threat to trade due to increased uncertainty and problems in long term-planning,
- external debts may contribute to financial difficulties with negative results on imports.

2.3.2 Structure of Transport Markets in the Danube Region

According to the systems approach to the Danube navigation, it is necessary to take into account not only the waterway and the actors directly connected but the relevant transport market(s) as a whole. The characteristics of the markets will be treated primarily on a modal basis. Thus the spatial and modal barriers within the freight transport system of the Danube area become more obvious.

The three modes (inland navigation, railways, road) are to be seen as competing and cooperating, a factor being relevant, for the demand side of transport, as well as for the use of public and privat financial funds, especially for infrastructure investment and foreign direct investment.

2.3.3 Inland Navigation Markets

For the market situation of inland navigation in the Danube area three factors are at least some effect prevalent in all countries. In short, these factors are:

- The socio-economic changes in the CEE countries are described in section 2. Central planning played a particularly important role for the transport sector of COMECON countries. With the exception of Germany inland navigation used to be an affair of public enterprise in all Danube states. Restructuring of this sector in entrepreneurial terms seems hard as the business attractivity and the public priorities are not much in favour of inland navigation.

- The war in Yugoslavia did not only cause the market of this region to achieve rock bottom figures, but it led to the UN embargo, which did not allow any transports in transit through Yugoslavia from 1993 to 1995.

The compliance of this proclamation together with the war actions hindered all transports along the Danube. Therefore the transports on the Danube but also from the other modes were shifted to other routes through Romania and Bulgaria or via Italy crossing the Mediterranean Sea.

In November 1995 the sanctions were suspended and in October 1996 they were finally removed.

- The opening of the Rhine-Main-Danube-canal in 1992 offered a link between the waterway network in western Europe and the Danube. Great expectations have been and are connected with this new transcontinental link. This new waterway connects western Europe to the Black Sea and the Danube region to the ARA ports.

Germany

Germany has a large network of inland waterways, which can be divided into different regions. The Danube region is relatively far apart from the other waterways - but connected by Main-Danube-canal to the Rhine region (since 1992). The transport performance on the Danube in 1995 was only 2.8% of the total performance in Germany.

In 1990 1 148 ship operators were registered in Germany, 95% of these companies were so called "Partikuliere“ with a maximum of three vessels, but in most cases owning only one, so owner and captain being the same person. Therefore only 19 ship operators owned ships with a total deadweight of more than 10 000 tons, of which only six companies had a carrying capacity of 50 000 tons or more at their disposal.

In 1994 there were 9 425 employees in inland navigation in Germany, of which 7 782 sailing personal and 1 643 land personal.

Five ports are located on the Danube in Germany. Before the opening of the RMD-canal, they were mainly used for the transhipment of gravel - in 1991 this goods had a share of 92% of the total throughput in the German Danube ports.

- **Deggendorf** has three ports, of which only two are handling waterborne transports. The main commodities transhipped in the other ports are mineral oil products, iron- and steel-products and fertilisers.

- **Kelheim-Saal** is the most western port on the Danube and was built in 1978 to improve the situation of the local chemical and paper industry. In the meantime these companies reduced or stopped their production, so other commodities increased their share. Besides gravel the most important commodities transshipped are agricultural products, feeding stuff, stones and fertilisers.

- **Passau** has two ports of which Schalding is the more important. It is equipped with a RoRo ramp built in 1982 as the end terminal of the RoRo connection on the Danube between Bulgaria and Germany. The most important goods are vehicles, iron and steel as well as feeding stuff.

- **Regensburg** is the part with the biggest transshipment volume on the Bavarian Danube. This port was highly involved in transports for the iron and steel industry in the 1970ies (total throughput of this port in 1970 was 3.7mt), but as production decreased, also the transhipment volume in this port was reduced; the bottom was reached in 1991 with 1.3 mt. Still today iron- and steel-products have the highest share of all commodities, followed by coal and ores.

- **Straubing** is the youngest harbour on the upper Danube, it was opened on June 28, 1996.

In general inland navigation in Germany is focusing on transports of bulk goods (wet and liquid), but it has also a significant share in other commodity groups (except for group 9: Machinery and other manufactures).

The maximum cargo volume transported on the Danube in Germany was nearly five million tons in 1968. The lowest value since these days was reached in 1992 because of a long period with low water conditions and the crisis in Yugoslavia. The development of the transport on the Danube was highly influenced in the past by the dispositions of the iron and steel plant in Linz (VOEST ALPINE STAHL).

After this decrease the transport volume began to increase in 1993 due to the opening of the RMD-canal. The additional volume is partly caused by ship-to ship transhipment for the following reasons:

- Many vessels on the Danube do not have a patent for the Rhine and are therefore not allowed to enter the RMD-canal.

- The locks downstream of Regensburg are 24 meters wide, while between Regensburg and Kelheim and at the RMD-canal their width is only 12 m, which is exceeded by some Danube vessels.

- Ships designed for the Rhine are smaller, but have a higher maximum draught than those for the Danube, so they have to be lightened on the upper Danube under insufficient nautical conditions.

The transport volume on the German Danube in 1996 amounted to 6.0 mt, which was 10.2% less than in 1995. The international traffic crossing the Austrian border at the lock near Jochenstein decreased by 5.8% (4.6 mt in 1996), the traffic between Danube and the waterways to the West by 16.0% (1.3 mt) and the domestic transportation by 58.1% (.1 mt). The same could be observed in the situation of the ports along the Danube in Germany, the total transhipment volume decreased by 16%.

The only commodities which increased were coal, ore, metal waste and high quality industry products, while all the other decreased (some of them considerably).

Austria

There are only a dozen, **ship operators** registered in Austria, of which the following five are offering freight transport services:

- **Avanti Schiffart und Lager GmbH.** operates for transportation of petroleum products and liquid fuels using a fleet of four self propelled vessels, five push-boats and 24 barges. As this company owns petrol stations in Austria, Germany, the Czech Republic, the Slovak Republic, Hungary and Spain as well as seven tank depots (of which five are along the Danube), it uses its tank vessels only on its own account. In addition to the above transports, this operator also offers dry bulk cargo capacity for other shippers.

- **DDSG-Cargo GmbH** is the major part of the former Austrian state-owned Danube fleet and was privatized by selling it to the Stinnes group in the early nineties. It was sold again from the Stinnes to Meier of Regensburg, a hauler company mainly using road transport mode.Consisting of 22 self-propelled vessels and 85 barges with a total deadweight of about 160:000 t this fleet is still the most important waterway provider under the Austrian flag.

- **SRN Alpina Schiffahrt** started its activities in Austria in 1996 with only two ships, one tank vessel and one called RoRo Simmental. This 1 475 tdw ship was built for heavy loads and is not only assigned to inland waterways, but has already been used for short sea trips in the North Sea and will also be used for transport to Istanbul.

- **Mencke** offers RoRo transportation on the Danube as a part of a multi-mode transportation chain focused upon. Toyota passenger cars from Japan with a destination in the East of Austria enter Europe at the port of Rotterdam. The railway mode is used for the transport to Regensburg, where they are transhipped to inland navigation and unloaded in Vienna.

- **DTSG - Donautankschiffahrt.** This was split off in 1996 main the DDSG fleet in 1996 creating an independent company belonging to the Jaegers group. The fleet consists of four self-propelled vessels and twelve tank barges, whereas 14 vessels are chartered in addition. About one million tons of liquid cargo (mainly petrol and diesel oil) are carried annualled between Linz and Vienna for nearly all of the big oil companies between Linz and Vienna as well as other relations to or from the ARA ports. Transport of heavy fuel oil are also carried through from Vienna to Linz.

Since the Danube passes through two main Austrian cities, the most relevant **ports** are located there. Vienna and Linz have got three ports each which gather collectively 78% of the total thoughput Austrian ports in 1996. The volume of loading and discharge in all fifteen Austrian ports amounted to 7.2 million t.

To show the status of inland navigation in Austria compared to other transport modes, Table 2.44 contains the modal split of the international transport in Austria in 1994 (since this is the last year on which data for all modes are available).

The total transport volume on the Danube in Austria was 9.3 million tons in 1996. Both internal and international transport increased from 1995 to 1996 (in total by 5.8%), but the transit (as a part of international traffic) decreased by 7.6%.

Table 2.44:
Modal split of international transport in Austria

	Import in %	Export in %	Transit in %	Total in 1000 tkm	Total in %
Road	22	35	25	7 695 845	**25**
Rail	35	63	18	9 421 584	**31**
IWT[1)]	9	2	5	1 741 476	**6**
Pipeline	35	0	52	11 407 116	**38**
Total	**100**	**100**	**100**	**30 266 021**	**100**

[1)] incl. Rhine-Main-Danube canal
Source: ÖSTAT, Schnellbericht Güterverkehr 1994

The demand side of the inland navigation market is dominated by one big industry, the steelworks of VOEST ALPINE STAHL in Linz, provided with an own port. This plant uses waterborne transport for receiving ores from Brasilia via Rotterdam and from Ukraine; coal is also handshipped by this mode. In 1995 2.5 mt were unloaded from ships, which is a share of 33% of the total cargo received by VOEST. On the output side 12% (300 000 t) of the cargo volume used inland navigation. The port of VOEST, Linz therefore had a share of 46% in the cargo loaded and discharged in Austria in 1996.

Reflecting on the total cargo volume, the values for 1996 (9.3 mt) surpassed the maximum volume before the Yugoslav crisis (9.1 mt) in 1989. The lowest values within this period were reported for 1992 and 1993 (6.5 mt), when the embargo in Yugoslavia disabled the access to the lower Danube. The opening of the RMD-canal in 1992 started to affect the transport market in 1994 and together with the end of the embargo in 1995 an increase by 42%from 1993 to 1996 was possible.
Considering import and export volumes only the maximum was reached in 1989 with 7.2 mt and the crisis in the following years (minimum: 4.6 mt in 1993) has not yet been overcome until 1996 (6.1 mt).

An interesting development of the last years are transports of passenger cars to Vienna using inland navigation. In 1996 about 60 000 cars (Renault, Ford, Toyota, Nissan, Mitsubishi, Volvo) were distributed from the port of Vienna - about one quarter of it (Toyota and Ford) via Danube. The port management wants to double this figure in the near future and to use the RoRo equipment of the port also for (un-) loading of trucks.

Since 1997 also Saab and Mitsubishi cars are brought to Vienna onboard RoRo ship with three decks and an own RoRo ramp. These transports (organised by a freight forwarding company specialised on car transports) start in Kehlheim. After discharging in Vienna, the ship sails on to Györ, where Suzuki cars produced in Hungary are loaded to be carried to Kehlheim. This round-trip is done once a week.

Another interesting service offered is a combined transport chain between ARA ports and Austrian ports. It is a combination of vessels on the Rhine up to Ludwigshafen, where the containers are transhipped to railway and carried overnight to Regensburg. From there they are delivered to Linz, Ybbs, Krems, Vienna and also Enns if required. These transports are offered once a week, from Vienna to Rotterdam six days are needed. These transport services offer considerate growth potential, both concerning the capacity (presently 80 TEU per train) and the frequency.

The Slovak Republic

The inland navigation transport market in the Slovak Republic is determined by four carriers with two of them providing water transportation services (SPaP and Slovcargo) and in two state owned companies that cover the rivers and their water basins (Povodie Dunaja and Povodie Váhu).

- At present, **SPaP - Slovenská plavba a prístavy a.s.** (Slovak Navigation and Ports j.s.c.), is the most important carrier of the Slovak Republic employing approximately 2 800 persons. SPaP is a 100% state-owned joint corporation and was established on January 1^{st,} 1997 by transformation ("privatising") of he former Slovenská plavba dunajská š.p.).

  The Company provide all kinds of transport services along the Danube. The majority of the fleet is composed of bulk-cargo barges DE II b and pushers. This fleet was built for services on the shallow sections of the Danube, because nearly 95% of the volume transported was formerly transported between Bratislava and the Danube estuary. Now, nearly 95% of the volume transported is between Bratislava and the upper part of the Danube (Austria, Germany). However, the fleet is not fully suitable for these services, especially because of the lack of vessels, with hatch covers, tank vessels and suitable pushers or motor boats. The fleet is completely unsuitable for services on the Rhine-Main-Danube Canal or on the Rhine. Only four or five pushers have valid certificates for the Canal and the Rhine. Only three barges are equipped with bow thrusters. The only motor ship for the Main-Rhine region (it is a former pusher boat joined together with a former pushed barge) has prooved ineffective (length of the ship 105 m, length of the cargo hold 63 m, crew - 6 people). Besides, the great volume of cargo which is transported only in one direction, and the over-manning of the ship crew and shore personnel are additional reasons for the relatively low efficiency and production deficit over the years.

- **Slovcargo s.s.r.o.** (Slovcargo Ltd.) is the second company providing water transport services, a small company owning only one dry cargo ship named "Sylvia", a former DDSG ship. The company was established approximately two years ago with Austrian financial involvement (DDSG Cargo).

- **Povodie Dunaja š.p.** and **Povodie Váhu š.p.** are two state-owned companies that dredge gravel and sand from the rivers Danube and Vah and provide national water transport services only for their own purposes, with the exception that Povodie Dunaja š.p. manages gravel pit near the riverbank.

There are three ports in the Slovak Republic:

- **The Port of Bratislava** provides all the usual sorts of port services including a RoRo facility, a heavy loads reloading facility (2 x 300 t), liquid cargo and cement reloading. The profits of the division have been decreasing from year to year. This is mainly caused by the low volume of the reloaded cargo, over-manning of the division, and competition from an increasing number of other port service providers.

- **The Port of Komárno: T**he great change of commodity flows has had a fatal influence on this division. The reloaded volume decreased approximately by the factor 10 in comparison to the year 1989. The division is now trying to find other commodities for reloading (mostly agricultural products). These new commodity flows have not yet been developed and the division is experiencing a big crisis.

- Twenty years ago the **Bratislava Shipyard** was designed to provide repair works. It has never worked efficiently and never achieved a positive balance. Its ship lift and ship hall, facilities special machinery and devices offer good prospects for the recovery of the shipyard though. Recently, the whole division has been incorporated in the newly established corporation Dunajská Lodenica a.s. (Danube shipyard s.c.). This will probably be its first step towards recovery. Apart from the Bratislava Shipyard this corporation includes Slovenské lodenice Komárno (the Slovak Shipyard Komárno), a very successful company producing mostly sea and river ships, the company Martimex, a well - established international trade firm.

River navigation is almost exclusively used for international transport in the Slovak Republic. The only exception is the paper manufacturing and recycling company Juhoslovenské celulózky a papierne in Štúrovo - JCP. This company is situated on the left Danube riverbank and has its own small port which is used for supplying the factory with liquid asphalt from the Refinery Slovnaft in Bratislava. This port is also used for shipping wood (timber and finished products such as paper, tissue, building insulation, etc.) and also offers its services to other customers.

Before the political and economic changes in 1989, over 90% of the ports of origin/destination were downstream of Slovakian ports (in the Danube delta, Belgrad or

Hungary). Now the situation has reversed. Over 90% of the ports of origin/destination are upstream (the upper Danube or even the Main and Rhine).

The most important commodities are: petroleum products, steel and composite steel products, fertilisers and other chemicals in solid or liquid form, agricultural products, ores, cement and cars.

The most important users of the water transportation mode are companies in the petroleum, metallurgy, chemicals and cement sectors. The new Volkswagen production plant Volkswagen in Bratislava has also become an important customer of water transportation services over the past few years.

One special group of customers are the agricultural producers. These companies export their products and import feedstuffs, having trade relations with the local agricultural trade companies (they also provide storage services and produce feedstuff mixes). These agricultural producers usually perform their international activities through special export import companies or forwarding companies (e.g. Protein Servis).

Freight forwarders have to overcome great obstacles such as legislation and custom procedures. Both are not in full compliance with the EU legislation. The custom procedures are very complicated and time consuming. In addition, foreign customers also have to pay value added tax, which makes all services much more expensive for this group.

The forwarders have to pay the full price of the merchandise as a customs deposit. This means that transactions of large sums are necessary for forwarding operations, and greatly hinders small forwarding companies. This also blocks the forwarding of transit goods which must be stored on Slovak territory (e.g., when transfered from rail to boat) and is consequently a hindrance in using water transportation.

The statistics of the locks at Gabcikovo provide a representative view of transportation on the Danube within the Slovak Republic. The numbers of vessels passing through the locks per year amount to about 8.400 vessels down stream and 8.300 upstream (1996). Usually one push/tug boat handles a convoy consisting of two or three barges. The dimensions of the locks are designed for passing convoys consisting of 9 barges DE II b (76,5 x 11m). These dimensions are the main reason for the long handling times and waiting times at the locks. It would therefore be very reasonable if at least one of the locks were divided into two sections.

Hungary

The supplier side of Hungary's inland waterway transportation can be evaluated by looking at most important Hungarian **shipping companies**.

- **MAHART Magyar Hajózási Rt.** (Hungarian Shipping Co. Ltd.). The biggest Hungarian shipping company is presently still 100% state-owned. For the lower Danube region, MAHART is the only carrier among the Hungarian shipping companies. For the upper Danube region it accounts for 2/3 of the Hungarian transport volume. The significant share in inland transportation mainly for construction material) it held in the 1980s has practically vanished today.

- **Pannon-Cargo** (PANCAR holding) and Lloyd Danube Co. Are German-Austrian owned shipping companies (with Hungarian representation) which appeared after the opening of Danube-Main canal and operate exclusively the upper Danube traffic (not considering marginal inland transport). Here, their total market share of Hungarian companies amounts to 1/3.

- **FOKA River Regulation and Gravel Dredging Co. Ltd.** is the biggest domestic waterway carrier. Dealing almost exclusively with the transportation of locally dredged gravel and stone. It occasionally takes part in export-import transportation, too, but this activity is not typical for the company. Its share in the domestic transport amounts to 2/3.

- **MAHAJOSZ Hungarian Shipping Carrier Cooperative** is similar to FOKA, the company transports domestic gravel and stone. It accounts for 1/4 of the total inland transportation volume.

MAHART's carrying capacity accounts for 60% of the entire Hungarian river fleet. At the same time, MAHART owns only 3 of the 12 self-propelled vessels that are also suitable for traffic on the Rhine. The remaining owned are by Pannon Cargo (PANCAR group) and Lloyd Danube. Nearly 90% of the Hungarian river tonnage (according to ist carrying capacity) relies on tug boat and pushing technology. Tug shipping is mainly used in shipping on upper Danube with its end point in Regensburg/Kelheim, while the push-barge transportation is used in the lower Danube section traffic.

Hungary's most important **industrial sectors** for shipping on the Danube are the building industry, the metal industry, agriculture and the oil industry. Half of total Hungary's inland traffic is connected to the building industry (gravel dredged from the river bed). Of the total export/import traffic, almost 1/2 of the goods are related to the metal industry (typical are imports of raw and basic materials, export of finished products) and 1/4 are agricultural products (export of grain, import of fodder) and products of the oil industry (export of petrol products).

Hungary's **cargo shipping market** on the Danube is basically determined by the metal industry. The largest volume originates from the iron and steel works Dunaújváros (DUNAFERR Dunai Vasmű), but Danube river transportation also carries the metal products from the region of Miskolc/Ózd. 20 - 30% of all raw and basic material imports from Dunai Vasmû are carried out on the Danube (the rest by railway) and 30% of the finished products export is transported by Danube cargo ships (the rest by trains). Import by waterway mainly originates from the lower Danube, a possible future use of the Rhine delta ports is justified by the need for having multiple options. The exports of finished products from Dunai Vasmû go to the upper and lower Danube regions a ratis of 3:2.

The product market catered for Dunai Vasmű is relatively stable and quite conservative. Since the plant is working at almost full capacity for the well-established markets, no expansion is planned. As a result changes in transport are mainly caused by changes in proportions and by modification of the waterway/railway ratios. The modernization of the Diósgyõr steelmill, and its the scrap iron process may result in significant changes in the steel production - and installation of scrap iron - markets. These changes however cannot be quantified for the moment. Services of waterway transportation to Hungary's aluminium industry may also lead to important market changes. The potential is there, but neither the intention the nor the necessary technical/infrastructural background seems to prevail.

RoRo transportation established by Hungarolloyd on the Danube was started between Passau and Budapest. Testing shipments were carried out in 1992 and regular traffic started in 1993. Services were basically used by Hungarocamion, but Romanian and Bulgarian trucks were transported too. (Volumes transported: 1 800 units, 24 000 tons in 1992; 5 000 units, 83 000 tons in 1993; 3 000 units, 55 100 tons in the first half of 1994). The cooperation between the partners was interrupted resulting in the temporary discontinuation of the RoRo lines. Presently, the service is working with one call per week.

Hungary played a pioneer role in the Danube container transportation when it opened a container terminal in the Port of Csepel in 1968. In the 1970s - mainly due to lighter carrier services in India-Pakistan and the South-East Asia connection of the international INTERLIGHTER shipping company - Hungarian container transportation on the Danube increased. Traffic to the terminal in Csepel and later in Baja nearly amounted to 10 000 TEU per year. This development ceased in the early 1990s and today Hungary’s Danube container transportation is not worth mentioning.

Forwarding agents have established links between carriers and senders and receivers of products.

- **DUNAFERR-Portolan Co.** was originally the in-house forwarding agent for DUNAFERR (iron and steel works of Dunaújváros) today it forwards agriculture al products as well. It makes up for more than 40% of the import of raw materials and finished products of the export market. Its presence on the agricultural export-import market, accounting for 15%.

- **Ferroport Co.:** The Preimesser-MAHART joint venture, operates its own terminal in the free port of Csepel. Originally established for the transportation of metal products its present market share in this sector amounts to 15%. Additionally it has a share of more than 10% in agriculture.

- **MASPED Co. Ltd.** a traditional Hungarian Company, is specialized in forwarding. It holds a strong, nearly 20% share in the shipping of agricultural products on the Danube. The shipping of metal products makes up relatively smaller part of not quite 5%.

- **RS PartnerShip AG.:** cooperates mainly German and Austrian shipping companies. It plays a relatively modest part in the forwarding of metal (round 5%). On the other hand, the company is a strong competition in the field of forwarding agricultural product with a share of nearly 20% share.

- **DMS Danube-Maritime Forwarding Co.** a Ukrainian interest company concentrates on forwarding activities between the Danube and the sea in cooperation with the Ukrainian shipping company (UDASCO). The company plays a very important role in Hungary’s Danube export-import transportation. Its share in the sectors of agriculture and the metal industry amounts to approx. 25%.

- **MAHART-Seatrade Co.** operates the ships of MAHART in the sector of the lower Danube and in the Danube to sea transportation. It holds a relatively modest market share, around 5% both in metal industry and in agriculture.

- **MOL Co. Ltd. Is the forwarding commissioner of the** Hungarian petroleum association and forwards mainly its own products, MOL products are dominant for more than half of the total volume - Hungary’ Danube waterway market of petroleum, the rest is foreign dominated.

The total turnover of Waterway transportation, on the Hungarian/Hungaro-Slovakian section of the Danube has been significantly reduced:The bottom line was reached in 1993 when total Danube transportation amounted to only 42% of 1988. By 1995, the total transport volume has increased again, but still amounts only to 52% of the volume of 1988.

From the end of the 1980’s on gravel dredged from the Danube bed is the main product of inland transportation. This is still characteristic for today. Significant stricter rules for of environmental and ecological protection resulted in the recession of in-bed gravel dredging, thus reducing domestic traffic. The disintegration of the former traditionally Soviet-oriented economic relations in the Danube basin, as well as the Yugoslavian crisis (UN embargo, introduction of transit taxes in Yugoslavia) played a determining role in the dramatic decrease of transit traffic.

In the given period Hungary’s Danube waterway export as a whole have remained relatively stable, while a tendency for growth can recently be noted. Imports have been reduced to half of the level of 1988, the main reason lies in the disintegration and restructuring of former Comecon relations.

In short: in the Hungarian/Hungaro-Slovakian sections of the Danube, Hungary’s domestic transport was reduced to 2/3, its import traffic to 1/2, transit traffic to 1/4 of the level of 1988, while at the same time exports increased by 1/3.

Ships under the Hungarian flag accounted for less than 1/3 of the total export-import volume. Intense restructuring of transport relations can be observed - while the traditional traffic in the lower Danube region decreased, the volume on the upper stream is increasing.

Hungary’s laws regulate only the property relations of the national public ports. The territory of the national public ports and the inseparable facilities (e.g. systems in the ground) are inalienable state property. The manager of a national public port can either be a concessionaire (this can be 100% private) or a port managing company established by the state or the local government - in the latter case the private capital may not be more than 49%. The names of the national public ports are given by law on the Danube they are: Györ-Gönyü, Budapest-Csepel, Nagytétény, Dunaújváros and Baja.

Apart from the port managing company under contract private tenants and settlers are permitted to work in national public ports, offering port services and related activities such as loading, storing, logistical services, production, etc. Today, Hungary’s ports and quays are either privately owned or (partly or totally) state-owned - e.g. The port of Csepel is owned by MAHART, the port of Dunaújváros is owned by DUNAFERR.

Several **projects for infrastructural development** concern the Danube waterway transportation and the development of national public port: The national public ports of Györ-Gönyü, Nagytétény and Baja are important elements of the national terminal and logistics centre system for combined modes of transportation. The construction of RoRo terminals at the Györ-Gönyü and Baja national public ports is carried out in accordance. The establishment of a RoRo terminal in the national public port of Nagytétény is also in planning (it will replace the presently operating terminal in Budapest).

The government's projected steps concerning the port infrastructure always include investment in association with enterpreneurial initiatives. This result in the fact - that the decision to start or continue the projects is not made by the state, but on the enterpreneurial level. The main goal of the state's development measures is the construction of the port as a traffic junction and the construction of the necessary waterway, railway and public road connections.

Croatia

As a result of the political situation after the war in ex-Yugoslavia (Eastern Slavonia is still under the control of the UN), Danube shipping in Croatia is still rather inactive.

This means that only a few units of the Croatian river fleet are presently operating on the upper Danube (not going downstream to the Hungarian border - km 1 433). Other active units (with negligible capacity) operate on the river Drau since the summer of 1996 but are still not permitted to enter the Danube. Part of the Dunavski Lloyd-fleet (the biggest Croatian river shipping company, which operated pracitcally exclusively on the Danube before the war) is cut-off from the domestic inland waterways since autumn 1991. It is completely inactive and mostly anchored in Izmail.

The situation of the Croatian sector of the Sava river is still after the end of the war in Croatia and Bosnia (Dayton peace treaty in November 1995).The wrecks of destroyed bridges and ships do not allow any kind of commercial shipping. Neither Croatian nor Bosnian ships located on the Sava (if any Bosnian vessels survived the war) are allowed to pass over to the Serbian sector of the Sava from Save-km 202, the Serbian border, to its mouth at Belgrade), as no bilateral traffic agreements between Serbia and Croatia respectively Bosnia-Herzegovina have been mode and the legal status of the Sava river (now flowing through three countries) is still unclear.

Federal Republic of Yugoslavia

The Yugoslavian fleet was scarcely used in the past years. As a result, only 70 - 80% of ist vessels can be considered in good condition and ready for transportation.

At present, there are a few private carriers that hire ships from the main carriers. The number of vessels and the amount of cargo transported are constantly changing.

Table 2.45:
Most important carriers in Yugoslavia

Company Name	Headquarters
Jugoslovensko Recno Brodarstvo (JRB)	Belgrade
Radna Organizacija za Vodne Puteve "Ivan Milutinovic" (PIM)	Belgrade
Bagersko Bordarska Povidba "Beograd" (BBP)	Belgrade
Radna Organizacija "Krajina-Transport" Ltd.	Prahovo
Radna Organizacija Pristanista, Hidrogradnje i Transporta "Heroj-Pinki"	Novi Sad
Radna Organizacija za Recni Saobracaj "Brodarstvo"	Zrenjanin
Radna Organizacija za Recnu Plovidbu "Panonija-Hidrotransport"	Sombor
Radna Organizacija za Recni Saobracaj "Vojvodina"	Apatin
Radna Organizacija za Recni i Jezerski Saobracaj "Brodarstvo"	Pozarevac

The following river ports offer possibilities of cooperation between different modes of transportation:

- on the Danube: Belgrade/Beograd, Novi Sad, Pancevo, Prahovo and Smederevo
- on the Sava: Sabac and Sremska Mitrovica.

The political situation in former Yugoslavia and its effects on the inland waterway transportation market has led to a heavy reduction in demand. The most important users of inland water transportation still come from the petrochemical, the food and the paper industry.

The total amount of demestic goods carried between the main river ports decreased considerably in the early 1990s. Due to the lack of data over the past three years it is very difficult to determine whether the light recovery between 1993 and 1994 has continued.

Commodity groups that are traditionally transported via inland waterways are:

- in national transport: crude minerals other than ore, petroleum and petroleum products, gas and crude materials for the chemical, mechanical and food industries

- in international transport: import priorities are on petroleum and petroleum products, gas iron ore and solid fuels (as import priorities) and cereals, other food products and metals (as export priorities).

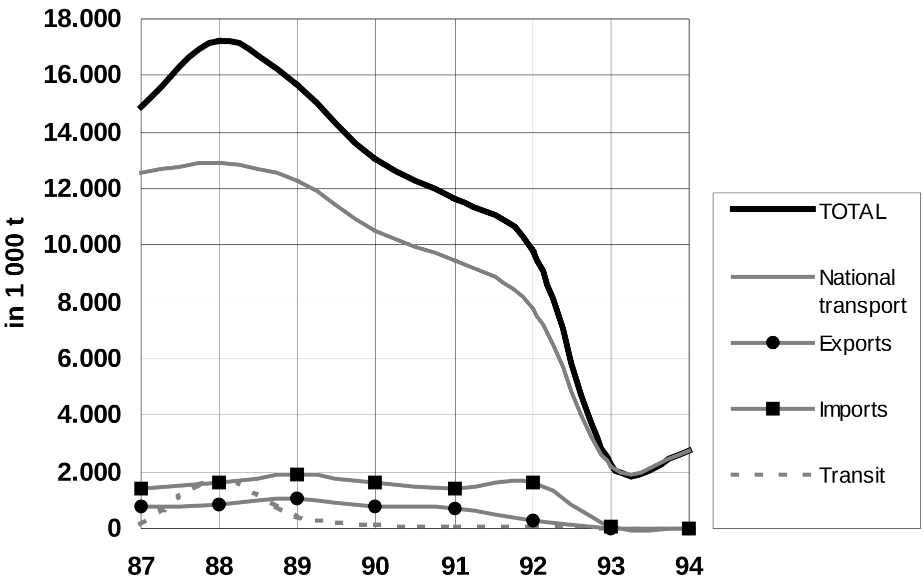
Inside former Yugoslavia, Serbia’s inland waterway transportation (Central Serbia and Vojvodina) played the most important role compared with the other parts of the country. Based on existing statistical data from 1989 and 1990, the inland waterway transportation in Yugoslavia within (in today’s borders) made up approx. 82% of the total amount of cargo transported in former Yugoslavia. This figure has remained stable during the past 50 years.

By 1991/92 the amount of cargo transported both nationally and international was drastically reduced due to the disintegration of the country. Nevertheless, the percentage of crude minerals other than ore is still very high (92% of national transport and 75% of both national and international transport during 1992).

From then onwards by a further reduction of the amount of cargo transported by inland waterways can be observed: transit does not exist; exports and imports are considerably reduced; only national transportation of cargo has slightly increased in 1994.

The enormous losses in the national and international (exports, imports and transit traffic) traffic are summed up in Figure 2.4. Although the data of the recent years (1995 and 1996) is not yet available to the public, the trend shows a decrease of slight increase in the amount of transported cargo.

Figure 2.4:
Development of national and international traffic in Yugoslavia 1987-1994



Bulgaria

At the end of 1995 the Bulgarian **river fleet** is accounted for:

- 4 self-propelled RoRo vessels
- 3 self-propelled general cargo vessels
- 35 tug-boats and push-barges
- 221 barges of various types with a total dead-weight of 330.000 tons.

The major Bulgarian river carrier is the BRP (Bulgarian River Shipping Corporation), a state-owned company, which possesses 88% of the fleet mentioned above, but has no self-propelled cargo vessels. Nearly 90% of the fleet of BRP is older than 15 years and only four of its barges can navigate the Rhine-Main-Danube canal. BRP owns four converted RoRo barges which maintain a RoRo service between Ruse and Reni.

An estimated 18 barges and three tug-boats are owned by the Bulgarian Dredging Corporation - another state-owned company, which has leased part of its fleet to private operators. The remaining fleet is used for the coastal transportation of gravel and sand dredged from the bottom of the Danube.

The 4 RoRo vessels are owned by SO-MAT - the "Number one" Bulgarian international road haulier. The RoRo vessels are used exclusively for the transportation of SO-MAT trucks/trailers up- and downstream ofthe Danube (from Vidin to Passau and from Ruse to Reni).

3 other private carriers own the remaining three self-propelled cargo vessels and five barges, all of them old.

The Bulgarian river ports are managed by four separate port authorities Vidin, Silistra, Lom (with Kozloduj, Oriahovo as subordinated ports) and Ruse (with Somovit, Nikopol, Belene, Svishtov, Tutrakan)

Up to 1990 the distribution of the international traffic volume transported via Bulgarian river ports (listed according to origin/destination and major commodities) has been as follows:

- 25% of the import/export transportation traffic originated from or was destined to the countries upstream of the Danube - mainly the Czech Republic, the Slovak Republic, Hungary and Germany with the following commodities making up the bulk of the traffic:
  - on the export side: metals, ore concentrates, basic chemicals, machinery, fertilizers, canned food, wine
  - on the import side: chemicals, cellulose, paper, machinery
- 65% of the import and export traffic originated from or was destined downstream of the Danube to the former USSR with the following commodities making up the bulk of the traffic:
  - for export: food, wine, machinery and equipment
  - for import: coal, ores, metals, machinery, equipment, cars, paper, timber.
- 10% of the traffic was in transit to the Near/Middle East, Turkey, Northern Greece, the Czech and the Slovak Republics and Hungary.

The embargo on former Yugoslavia closed Bulgaria’s access to upstream of the Danube. The directional change in Bulgaria’s foreign trade policy disrupted transportation patterns and drastically reduced the international traffic through Bulgarian river ports.

Apart from a few shipments approved by the UN Sanctions Committee for transit through former Yugoslavia, the Bulgarian river fleet was nearly isolated for four years from its markets upstream on the Danube.

After 1990, Bulgaria's trade with the former USSR decreased rapidly. As a result, the transportation business downstream of the Danube could not compensate the loss of the Central-European markets, and the Bulgarian river carriers suffered heavy losses from 1992 to 1995. In this period the major part of the Bulgarian river fleet was tied up. The remaining fleet operated on one-way transportation of coal, coke, ores and metals from Ukrainian riverports to Bulgaria and in transit to FYROM.

The 1996 "post-sanctions" statistics are not yet released, so only the figures from 1995 are available. 80.4% of the import/export volume carried by the Bulgarian river fleet in 1995 was to or from Ukrainian ports, 7.5% was to/from Romania and only 12% - to/from other destinations upstream (1% Hungary, 2% Slovakia, 4.5% Austria, 4% Germany).

In 1996 the inland waterway transportation market revived: Access to the upper Danube was reinstated; the BRP received a large government order for the import of grain to Bulgaria and also participated in the transportation of transit cargo to/from the Fed. Rep. of Yugoslavia via Constanza and on the route Varna-Ruse by rail - Ruse-Yugoslavia by river.

However, Bulgaria's inland waterway transportation market is still unable to overcome the shock of the Yugoslavian embargo. A few more years will pass before the traffic diverted to other routes and modes due to the sanctions against former Yugoslavia will return to the Danube.

Upstream on the Danube there is already a market demand to transfer the import/export goods between Bulgaria and Central/Western Europe from the road to the river using RoRo and container services. Shipowners expect major savings in transport cost compared with overland haulage, since the payload per trailer can be increased to 24 t (axle load limitations in Romania restrict the payload of 5-axle tilt trailers to a maximum of 20 t and of 4-axle trailers to 18 t).

Shipowners also show interest in scheduled liner break-bulk services on the Danube in order to accommodate the transportation of shipments ranging from 10 t to 200mt, for which the shipowner cannot afford to pay the costs of rail or road freight. Such services may become fairly popular if they perform scheduled calls to all the major riverports downstream from Regensburg and if the operator offers a TBL (Trailer Bulk Load) from inland locations in Germany, Austria, Czech Republic, the Slovak Republic and Hungary.

Downstream, the traffic volume with the former USSR will never again be what it was in the 1980s. However, the RoRo services Ruse-Reni have already become quite popular in the road haulage to the CIS-countries.

The Bulgarian inland water transportation market is very backwards in terms of transported goods - BRP carries only dry cargo and oil derivatives and offers capacity only in full barge-loads. It contracts only on a port-to-port basis and features a transit time of 4-6 weeks from Regensburg to Ruse. BRP does not offer multimodal services, groupage consolidation, refrigeration capacity and containers. Transmodal connections such as river-rail and river-truck are handled exclusively by forwarders. The only positive development regarding the transportation service in the last 5 years has been the inauguration of the RoRo service Ruse-Reni.

Corporate strategies are practically identical with the strategies of the BRP, since the private Bulgarian competitors still possess only a negligible transport capacity. The Bulgarian Governments still contemplating whether or not to privatize BRP. BRP itself has prepared a programme for:

- scrapping some of the old tonnage
- procurement of self-propelled river vessels and new EUROPA-II type barges
- more extensive involvement in RoRo services upstream on the Danube.

Given the desperate financial situation of BRP, however, this programme cannot be implemented unless BRP receives a major capital investment from foreign investors. Therefore any forecast on the future of the key player on the inland water transportation market can be made only after the government announces whether BRP will be privatized or not.

While waiting for the Government's decision, BRP runs down its fleet, lies up old vessels due for maintenance and overhauls (which BRP is unable to finance) and "cannibalizes" tonnage in order to keep at least part of the fleet in operation.

1997-1998 will perhaps witness the birth of one or two more private Bulgarian shipowners on the Danube. As has been done in the past, each of them will start their business by purchasing 1 self-propelled second-hand vessel and one or two second-hand barges for dry cargo.

Several private companies independent of one another plan to start RoRo services on the Danube to Austrian or German ports. BRP and SPD of Slovakia presently negotiate for a Ruse-Bratislava RoRo service, but the chances that the service will materialize and be successful are slim - hauliers prefer to embark/disembark in Germany, thereby avoiding the limited quotas of road permits and the road taxes in all countries en-route.

Romania

The **Romanian Danube fleet** is organized in a few companies that run the entire traffic the Danube and other Romanian inland waterways. All of them are capable of transporting the main kinds of dry goods (bulk, general cargo) and liquid goods (oil products). The entire fleet is subdivided in six big companies. All of these carriers hold their own tugs, push-boats and barges to operate dry and liquid cargo.

The free trade zones on the Danube and the Black See ports are an important branch of the transportation market. The are supervised by the Ministry of Transportation. The Agency of Free Zones was created in June, 1991. It works according to the law that regulates all free zones in Romania (law no. 84/1992). The following four free trade zones were established by Government resolution.

- Sulina (sea river port on the Danube)
- Constanza-South Port (Black Sea port)

- Galati and Brãila (sea river ports on the Danube)
- Giugiu (Danube river port)

Romanians and their foreign partners who wish to operate inside these zones have the advantage of certain fiscal and customs alleviations (based on law no. 35/1991, the regulation for foreign investment; and law no. 84/1992, regulations of free zones:

- partial or total reduction of customs fees and of profit tax
- exemption from payment of Value Added Tax and excise fax
- possibility to reinvest the profit and the capital in the country
- possibility to obtain a concession for the land for 10 to 50 years

The companies listed in the table 2.46 are the **key freight forwarders** best connected to inland water transportation.

Table 2.46:
Freight forwarders in Romania using inland water transportation

Company name	Location
Romtrans S.A.	Constanza-South Port
Romportmet S.A.	Galati-Port for Transfer of Metal Ore
Autotransnav S.A.	Tulcea Port
Riymar Ltd.	Tulcea Port

Romtrans S.A. is a fully private company and one of Romania's most important forwarders. It is divided into 10 subsidiaries which work out of 120 work sites in ports, on the border and in major cities. It is active in different areas in Romania and abroad esp.in storage for general cargo, in the development of selected operations, freight service and distribution and in the managment of container terminals in Bucharest, Oradea, Galati and Iasi.

- The Romtrans S. A. distribution centre offers combined modes of transportation is located inside Constanza Port and provides services like custom clearance and forwarding of goods, TIR trucks and railway waggons on the RoRo and ferry lines between Constanza and other Black Sea ports.

Romtrans S.A. operates a pier in Constanza-South Port (20 years lease). It is 1 000 m long and 200 m wide.

The Romanian river fleet provides transportation of raw materials and general cargo on the Danube destined for river ports that have access road and railway systems. The three **major industries** that use inland water transportation are: the steel works of Galati (SIDEX Galati) and Cãlãrasi (SIDERCA Cãlãrasi) and the chemical manufactures in Turnu Mãgurele (SC Turnu).

- The **steel works in Galati** use inland navigation for the water transportation of raw materials which arrive in Galati Port. Iron ore, coal and coke are transported by push-barge convoys (leaving from the port of Constanza and sailing on the Danube-Black See Canal and the lower

Danube) and by ships (max. 12 000 dwt) which enter the Sulina Canal in the Sulina section where the Danube flows into the Black Sea. Lime is transported by push-barge convoys from the port of Mahmudia (close to the lime quarry) in the Sfintu Gheorghe section of the Danube. Steel products are -at present - sent to sea directly on the Danube or from the port of Constanza (on the Danube-Black Sea Canal). The steel works in Galati are expected to yield a higher output and attain increased export rates of steel products within the next years.

- In the **steel works in Cãlãrasi** (SIDERCA) only the coke production is working. 65 % of the coal (60 000 tons/month) is transported via the Danube-Black Sea Canal and the Danube to the industrial port of Cãlãrasi, the rest by railway from Poland. Coke is the only major product (46 000 tons/month), which is presently sent by railway.

- Raw materials apatite and phosphate destined for the **chemical plant in Turnu-Mãgurele** (SC TURNU) arrive at the port of Turnu-Mãgurele by pushbarge convoy. They originate from the port of Constanza transported via the Danube-Black Sea Canal and the Danube. Fertilizers (bulk and bags) are sent directly to the Sea on the Danube or via the port of Constanza (on the Danube-Black Sea Canal).

Cost Comparison

Table 2.47 shows figures of Romania's operating costs of vessels, transportation costs and comparative costs (Danube - railway - road). The operating costs of vessels given as an example reflect the situation in the port of Galati where the allowance for all goods is 0.24 USD (approx. 0.21 ECU). The example for transportation costs refers to the Dunarom Company in Galati. It is to be noted, that the figures for the transportation costs depend on the conditions in the individual areas of trade. In addition, figures are classified information of the individual companies.

Table 2.47:
Operating costs of vessels (example: Port of Galati) and transportation costs (example: Dunarom Galati)

Commodity	Costs (USD/t)	Costs (ECU/t)	Remarks
Operating costs of vessels (example from the port of Galati)			
general cargo	2.52 - 7.80	2.22 - 6.89	depends on presentation of cargo
ballast and quarry stone	2.40 - 4.80	2.12 - 4.24	depends on granularity and shape
cereals	1.80	1.59	
iron ore	1.98	1.75	
steel products	2.82	2.49	
Specific transportion costs of different commodities (example taken from the company Dunarom in Galati)			
Transport on route Galati-Danube-Black Sea Canal-Constanza-South (214 km) by convoys of push-barges			
iron ore, coal	0.0125	0.0110	from port of Galati to Constanza-South
limestone	0.0081	0.0071	from port of Galati to Constanza-South

steel products	0.0118	0.0104	from Galati Metallurgical Port to Constanza-South

The Bratislava convention determines the maximum costs for transportation on the Danube. The real figures, however, are lower, in some cases down to 40%, depending on the client. Table 2.48 compares the transportation costs of selected commodities using different modes of transportation (ship (Danube), railway and road), using as examples the routes Constanza - Vienna and Galati - Regensburg.

Table 2.48:
Comparative Costs (USD/t and ECU/t) in Romania

Route	**Commodity**	**by Danube** ECU/t	**by Railway** ECU/t	**by Road** ECU/t
Constanza - Vienna	iron ore	14.1	27.4	37.1
	crude oil	29.1	27.4	37.1
	steel products	22.1	27.4	37.1
	cement	17.7	27.4	37.1
Galati - Regensburg	iron ore	21.2	45.9	65.4
	crude oil	44.2	45.9	65.4
	steel products	32.7	45.9	65.4
	cement	27.4	45.9	65.4

As for the past and present traffic situation, the basic facts are the following:

- The volume of goods transported on the Danube was substantially reduced for all Eastern countries, starting with the late 1980s. Bulk minerals, such as sand and ballast dredged from the Danube, account for the group of commodities wich was most seriously affected.

- In 1989 domestic traffic held a 68% share of the inland navigation market, in 1994 only 39%. Romania is the only country that maintains a substantial domestic traffic consisting mainly of sand and ballast from dredging in the lower Danube

- General cargo (not bulk) increased from 7% in 1989 to more than 14% in 1994. Demand for container transport, RoRo and break bulk increased considerably. Demand for transportation of solid and liquid cargo is less important than in the past.

- As a result of the fact that the cargo generally originates from locations inside the country (not along rivers), river traffic comprises combined modes of transportation. This emphasizes the demand to operate with RoRo and containers in Romanian ports.

The relevant facts for the future traffic, are following:

- If no major investments are made to the improve conditions for navigation on the rivers, to adapt the infrastructure of the ports to the new demands and to increase their operating efficiency, the traffic volume will increase at a slow rate of only 1.4% per year (0.6% in the pessimistic case). A significant part of the future demand for transportation in the corridor will be handled by the railway system, not by shipping on the Danube.

- The Danube is an important transportation route because of the relevance of the Danube corridor. The road system cannot handle more traffic as its capacity is saturated. The forecast shows an increase in the traffic on the Danube at a rate of 6% per year at short and medium range and at a rate of 3.5% a year later. Most of the additional traffic will be diverted from the railways and to a lesser degree from roads.

- There is still a demand for low value bulk commodities and growing demand for general cargo in containers or by the RoRo-system. In both cases, transportation could be diverted to the Danube, if the investment is made for adequate facilities.

- Therefore it is important for the transportation on the Danube to open new markets, to provide good quality and competitive services. River transportation must be reliable, safe and cost effective. Shipping services have to include the operation of regular liners.

- Only in Romania domestic transportation will increase future, because the distances make it worth to use inland waterway transportation.

The Romanian government has long identified the requirements. Their implementation, however, has been delayed due to lack of adequate financing and political obstacles. The requirements include:

- Building a large container and RoRo-terminal in Brãila. It will allow to transfer transit containers from sea going vessels to river vessels (and vice-versa) in one operation, avoiding delays due to railway or road transportation. The construction is in process.

- Building a new Romanian container and RoRo fleet.

The programme for the future development of the infrastructure of Romania’s waterway transportation includes several projects (see Table 2.49).

Table 2.49:
Romanian sea and river transportation programme

Priority Projects	Performance	Estimated costs		Notes
		mill. USD	mill. ECU	
Constanza South Port - The Container Terminal (stage I)	337 000 TEU/year	128.8	113.8	2001 year of completion target year: 2008
Improvement of waterway transportationbetween Cãlãrasi and Cernavodã	47	18.3	16.2	
Topohydrographic measurement sy-stem and signalling system on the Danube		9.5	8.4	
Container Terminal in Drobeta-Turnu of port Severin	24 000 TEU/Year	1.3	1.2	52,000 TEU/year at final stage
Container Terminal in the port of Brãila	40 000 TEU/Year	16.5	14.6	100,000 TEU/year at final stage

2.3.4 Rail Transport Market

The rail transport market is closely linked to inland navigation as rail services could form either feeding services to inland (Danube) shipping or competitive (parallel) services, as well.

Thus in this section an overview of the infrastructure network the market structure and the inland navigation links are given.

Another important feature of rail transport markets is characterised by the **"interoperability“:** railway rolling stock has been designed for a widely international use, but there are some technical limits, anyway in contrary to road haulage, as concerns in particular:

In view of the aim of this study, the **structure of the region’s railway network**, which competes with or, in some cases, sustains inland navigation on the Danube, may be described as follows:

The Alps and the highlands around Czech and in the Slovak Republic form a geographical barrier and hamper the development of the railway network. The valley of the river Danube constitutes the central east-west corridor between the plains in the north of Germanyand in Poland and northern Italy.

In Austria, several links from Germany, Switzerland and France meet to form a "bundle“ and run parallel to the river Danube, to Hungary and to the Slovak Republic, and via the core trunk line Bratislava - Kosice to Ukraine. In Budapest, this "bundle“ opens to outlets via Záhony to the Ukraine, and to Romania as well as Belgrade (Yugoslavia).

The trunk line Munich - Ljubljana - Zagreb (- B H) - Belgrade - Bulgaria, Turkey, Greece, which was heavily used before 1991, also runs parallel to the river Danube, as well as its additional link Nuremberg - Wels - Graz - Zagreb.

North of Austria, the most important axis runs from Hamburg - Berlin - Dresden - Prague via Brno to Budapest, and there it joins the links mentioned above. Concerning traffic from Germany to Ukraine and Russia, the following railway links have to be considered: Dresden - Katovice - Lvov - Kiev etc. (via Silesia), and the direct core line Berlin - Warsaw - Minsk - Moscow, with a branch fram Warsaw to Kiev.

The links mentioned above essentially compete with inland navigation on the Danube, whereas the following trunk lines may be regarded as feeder lines:

In Germany, the network from Frankfurt, Nuremberg, Regensburg, Deggendorf, e.g., acts as a feeder to various destinations.

Concerning Linz and Enns, particular attention should be paid to the north-south railway (Berlin -)Prague - C. Budéjovice - Linz - Salzburg - Villach - Italy.

In Vienna and Bratislava, there are very major north-south links crossing the river Danube: from Poland and Silesia via Vienna and the Semmering to Italy, Slovenia, Croatia and/or from Poland and Ukraine via Bratislava to Croatia and (as proposed) to Slovenia.

Similarly, there are interesting north-south facilities in Budapest as well: main lines from Ukraine via Záhony and from Poland via Kosice cross the river Danube in a southwestern direction running down to Croatia, Slovenia and Italy, and to the Adriatic ports.

Regarding Belgrade, railway connections to Bar and Skopje - Thessaloniki - Athens should be mentioned.

Running to and from Romania und Bulgaria ports on the river Danube, several northward lines to central Romania, Moldavia and Ukraine as well as the Bulgaria network could provide feeding services to extend the inland navigation catchment area.

A very, important issue in terms of line capacity and - as a consequence - of service quality is the fact that it was only in Western countries (and eastwards to Budapest) that the trunk network was originally built as a double-track, or was at least upgraded in early periods. In the Eastern countries in transition that are covered by this study, only the most important trunk lines have been equipped with a second track. Single-track lines provide merely approx. 30% of the capacity of modern double-track lines. Capacity and scheduling restraints cause a considerable reduction in commercial speed. This applies in particular to general freight services which traditionally give priority to passenger trains. Furthermore, these operational constraints have to be taken into account when scheduling train routes in order to minimise the risk of delays.

Railway network electrification is also an important issue, as electric locomotives are generally rated at power generally that which double diesel motors can provide. Consequently, electric locomotives cope better with steep grades and acceleration after stops so that transit times are considerably shorter than without electrification.

By now, most of the trunk lines in the countries concerned are electric. However, several gaps in electrification remain necessitating an exchange of locomotives. Therefore, operational practices sometimes avoid old links, thus putting a heavier burden on electric links and filling their capacity.

Finally, it should be mentioned that electrification of railways has not been unified, i.e. "comparability“ is not given at the time being. For historical reasons, different AC and DC systems have developed:

+ 15 kV, 16 2/3 Hz (older system):
  Germany, Schweiz, Austria, Sweden

+ 3 kV DC (simpler system):
  Belgium, Italy, Slovenia, Poland, Ukraine, Russia, France (in part), and

+ 25 kV, 50 Hz (the most effective system, established since the early 60s):
  Danmark, France (in part), Croatia, Bosnia-Herczegovina, Hungary, Romania, Bulgaria, Yugoslavia, Turkey, and the southern parts of Czech Republic and the Slovak Republic

As a matter of fact, electromotive power has to be changed at the borders of the supply system. To avoid this, dual-system locomotives have been in use for several years now. In principle, these problems can be solved, but the number of locomotives availabe is yet limited due to high investment costs.

The average commercial freight speed often is very low on single-track trunk lines and generally all the above mentioned criteria on not electrified network. Border stops usually add several hours time loss, especially at the borders of the Eastern countries in transition, whereas special agreements between EU countries reduce such stops in some cases to not more than a few minutes for certain trains.

Other important features of the interoperability in the rail transport market refer to technical restrictions, like track and loading gauge.

- Whereas all over the European continent the **British track gauge** of 1 435 mm was adopted as regular track gauge some 150 years ago, Spain, Portugal and in particular Russia (and, in consequence, USSR) implemented a wider track gauge. Now, this historical heritage causes severe problems for rail freight transport at the borders of the former Soviet Union.

- The **loading gauge** of rail vehicles (heigth, width) is unified in principle, but exceptions have been made in particular for Italy and for Slovenia due to early electrification, restricting height.

The present market position of the railways concerned is determined by the freight customer’s overall costs in comparison to other means of transport. As there are no detailed informations available concerning a comparison of tariffs and overall (logistic) costs, at least an overview on average figures should be given here. Obviously, average freight receipts are covering a great variety of destinations, goods and loading factors. Nevertheless, as more detailed informations could not be gained, at least a comparison of average receipts per ton-km is compiled in Table 2.50.

Table 2.50:
Average freight haulage receipts of railway (1994)

Country	Currency	Freight Receipts (million C.U.)	Net Freight ton-kms (million tkm)	Receipts per 1000 ton-kms C.U. national	ATS	ECU
Germany	DEM	8 053	69 775	115.4	812.0	59.8
Austria	ATS	9 761	13 049*	748.0	748.0	55.1
Slovak Rep.	SKK	12 036	12 334*	975.8	356.2	26.2
Hungary	HVF	32 354	7 293*	4 436.3	499.1	36.8
Romania	ROL	697 936	21 543	32 397.3	275.4	20.3
Bulgaria	BGL	6 485	7 740	837.9	184.3	13.6
Greece	GRD	5 365	321	16 558.6	778.3	57.4
Turkey	TRL	2 389 374	8 215	290 855.0	58.2	4.3

*) empty private waggons included

Sources: UIC, International Railway Statistics
C.U.: Currency Units; exchange rates as of mid-1994

Unsurprisingly, in EU-countries the receipts per ton-km are much higher than in countries in transition. Great differences within the group of countries in transition are obvious (compare: Bulgaria 13,6 - Hungary: 36,8) and partly due to the ratio internal/international traffic.

In future, the cost/revenue ratio will become much more important and suggestions about future development of rail freight market should be made with scrutiny.

Germany

Due to Germany's development as a federal republic, its topographic structure is rather polycentric. In the early construction period of its railway network, Germany was a federation consisting of a large number of many comparatively small and independent states, many of which developed their own railway companies and networks. Consequently, all central cities have been interconnected by railways resulting in a dense network. Rapid industrialisation led to a high demand for transport and passenger travel, which provided an adequate commercial background for developing an optimum trunk network with a view to the needs prevailing in the decades before and after World War I. This network connects all major cities as directly as possible and by double-track links. Moreover, due to early construction methods, in general favourable alignment principles have been applied, in particular moderate grades.

Contrary to the situation in most of the central and southeastern European countries - and even Austria for more than half a century - the trunk network has been double-track and well equipped with signalling systems, train control, telecommunications as well as station, yard and junction facilities, all of which, of cause have continuously been modernised since.

Market structure

The rather strong competition of trucking on the freight market in Germany leads to comparatively low figures for rail freight, as given in Table 2.51. The amount of freight-tons includes large proportions of ore, minerals and coal and should therefore be compared with industrial production on the one hand and with figures from (much smaller and less industrialised) countries in the other hand which now claim a "disastrous" turn of freight results by some 50 - 60% as compared to the COMECON situation.

Table 2.51:
Transport volume of Deutsche Bahn AG 1994

Net freight tons (revenue earning)	306.914	m.t.
Net freight ton-kms (revenue earning)	69 775	m. tkm
Passengers	1494.985	m. persons
Passenger kilometers	61 333	m.pkm
Traffic Units 1993 (sum of tkm and pkm)	131.108	millions
per employee:	405	

Note: Railway Sector only

Source: UIC; International Railway Statistics 1994

As a result of good performance on the long-distance passenger traffic market, the ratio of traffic units per employee is surprisingly good and has been further improved in the meantime. However, freight services are still contributing much more than 50% to this result. Accordingly, future price policies should be more moderate than in recent years, thus encouraging not only a shift from road to rail, but also (eventually) from inland navigation to rail. In view of these commercial factors, interesting opportunities may be created by future strategies of market-oriented combined rail-waterway service packages.

Austria

A large part of Austria is taken up by the region around the river Danube forming an east-west corridor which provides good rail and road facilities. The Alps set up a major barrier to north-south traffic, international (Germany-Italy) traffic as well as internal traffic. The railway network has been developed focussing on the capital of Vienna, and from there to the north (now Silesia, Poland, Ukraine) and to the south, to the empire's main harbour, Triest: (via Semmering - Graz - Maribor - Ljubljana). These lines have been built double track, also the presently most important line, Vienna - Salzburg. A more direct line from Vienna to Italy today is the southern main axis via Bruck a.d. Mur - Klagenfurt (almost all the way double-track). The section from Villach to Udine (Italy) has been a bottleneck for many decades due to poor infrastructure conditions: it was and still is partly single-track until the new high-speed line Udine - Tarvisio will be completed in 1998.

The Austrian rail network offers several opportunities to co-operate with inland navigation. However it also represents an important competitor to the river in terms of deep-sea and hinterland freight destinations.

A very large portion of **train movements** is taken up by passenger services. This is due to the integrated time-table services introduced in 1991. Remarkably, freight train-km account for merely 30% of all train-kms with 93% thereof being electrically powered. In terms of ton-km freight account for 57% - due to the large share of light local passenger services (rail busses) contributing a large part to the sum of train-km, but not of ton-km. Moreover, of the gross hauled ton-km of freight trains are 96% nearly by electric traction, thus reflecting the low importance of goods flows on non-electrified lines.

In total, the infrastructure offers an efficient basis for the economical operation of freight services. Unaccompanied freight trains of 1000 gross tons and with speeds up to 100 km/h are common.

Freight service quality is also influenced by operational factors due to the dense passenger traffic at higher average speeds. Several sections are presently operated at the limit of capacity. As the capacity of railway lines is not an absolute criterion, increasing freight traffic will primarily cause a reduction of service quality.

In order to avoid such a decrease in service quality, several infrastructural investments are under way or planned for the near future.

Market Structure

Even though Austria is a very small country in terms of goods flows, the total amount of more than 70 million tons (1996) of rail freight is exceptionally high and proves the political strategy right that good freight services are able to attract customers on the free market.

Rail transit still accounts for around 1/4 of the total rail freight. Surprisingly, internal goods traffic amounts to nearly 30% of the total rail freight. This demonstrates that even in a small country rail can attract freight over distances of merely 200 - 300 km, provided that services are good. Special services cover the market for high-value goods, especially overnight and several combined services.

Table 2.52:
Transportvolume of ÖBB 1993

Net freight tons (revenue earning)	66.148	m.t.*)
Net freight ton-km (revenue earning)	13 049	m. tkm
Passengers	190.412	m. persons
Passenger kilometers	9 292	m.pkms
Traffic Units 1993 (sum of tkm and pkm)	22.251	millions
per employee:	365,7	

*) 1995 and 1996: about 70 m tons
Source: UIC; International Railway Statistics 1994

In 1994, the greater part of traffic units of ÖBB were accounted for by freight transport. The number of passengers is largely influenced by regional and even urban services ("Schnellbahn") and is therefore not significant.

Inland Navigation linkings

Railway lines feeding Danube ports are in particular:

Vienna:	to the north	- via Hohenau (Czech Republic) - via Retz/Satov (Czech Republic)
	to the south	- via Villach (- Italy) - via Graz - Maribor (Slovenia, Croatia)
Krems:	local only, no attractive rail services to be considered	
Linz, Enns:	to the north - via Summerau (Czech Republic: Prague, Plzen, C. Budejovice)	
	to the south - via Selzthal to Italy and Slovenia, Croatia	

Depending on service quality, several feeding rail services could be taken into consideration to support inland navigation services on the Danube, in particular to regional catchment areas as well as to/from neighbouring countries, especially Czech Republic, the Slovak Republic in the north and Slovenia, Croatia in the south.

Moreover, the "Westbahn“ Vienna - Linz - Salzburg and on to Innsbruck, Schweiz etc. offers possibilities for additional freight connections, in particular to/from the Austrian Danube ports. All of them are situated along this rail axis, or at least not very far, so that good rail services could be provided.

The Slovak Republic

Situated in the north of the Pannonian plains, the territory of Slovakia is geomorphologically characterized by two parallel mountain ranges from Bratislava to the east: the Low and the High Tatra. The very first railway line was built from Bratislava northwards along the river Vah and the valley between these mountains.

The second line to be completed was Vienna - Marchegg - Bratislava - Nové Zamky - Sturovo - Vác - Budapest, double track and with a very straight alignment. In the following decades, railway infrastructure was developed along the broad valleys between the Tatra mountain ranges from Bratislava via Zilina to Kosice and on to the Ukrainean border at Cierna nad Tisou.

Due to COMECON traffic flows, great importance was accorded to the railway line from Prague - Brno - Breclav - Kuty - Bratislava and via Sturovo and Vác to Budapest. In the CSSR, the main internal link was Prague - Ostrava - Cadca - Zilina - Kosice.

All these lines are double-track and electrified, but need some repair now.

It should be mentioned that in the Czechoslovak period electrification had been promoted with great efforts since the mid-60s. The electrified main-line network, however, was into a northern DC section (3 kV DC) and a southern AC section (25 kV, 50 Hz), thus making even internal interoperability difficult. Electric supply systems changed south of the above mentioned main east-west axis, as in Prerov (CD) and in Slovakia (ZSR) in Puchov.

There are only two railway bridges over the river Danube which is the borderline to Hungary one in Bratislava (a double-track two-level rail/road bridge) and between Komarno and Komárom (single-track, electrified).

From the Bratislava region only few other railway lines were built leading to the hillside of central Slovakia.

However the network is able to provide good hinterland services from the Danube ports in Bratislava and Komárno.

In total the roughly 900 km of trunk network (double-track and electrified) plus additional electrified single-track lines in principle are sufficient for the main traffic flows, but now need major repair work to keep up standards. At present, the most severe problem is to cope with rapidly proceeding deterioration.

Market Structure

Data show that quantitative operational freight results are not so bad, either when compared to EU railways. It should be stressed that freight is predominating and operates with comparably reasonable efficiency. Problems seem to be a matter of passenger operations on the one hand, and of general tariff levels on the other.

Table 2.53:
Transport volume of the Slovakian Railways

Net freight tons (revenue earning)	58.953	m.t.
Net freight ton-km (revenue earning)	12 334	m. tkm
Passengers	99.101	m. persons
Passenger kilometers	4 548	m.pkm
Traffic units 1993 (sum of tkm and pkm)	16.882	millions
per employee:	301 464	

Note: Railway Sector only

Source: UIC; International Railway Statistics 1994

It may be assumed that future freight market conditions will be comparable to conditions in the EU after transformation of the state railway status. Severe financial problems are not to be expected for future "freight profit centres", but rather for passenger and permanent way structures.

Inland Navigation linkings

The Danube ports of Bratislava and Komárno are well equipped and provide good rail and road access. In particular, the port of Bratislava offers various link via road and rail to its northern hinterland and was the most important Czechoslovakian Danube port serving not only Slovakian industry, but in particular also Bohemian and Silesian industries.

As there is no Czech Danube port, Slovak and Austrian ports will compete in the future to serve these destinations. Slovak railways so far have provided attractive services via existing main railway lines, at least to/from Czech and Polish industries in Silesia. The project of upgrading the link Cadca-Zwardon (Poland) is deemed an important element of the strategical aims adopted by the Slovakian government.

Hungary

Hungary is a rather plane country, divided by the river Danube into a western and an eastern part with the capital city Budapest in the very centre of the country. But there are also hilly regions hampering the development of a railway network, as e.g. west of Budapest (Tatabánya), north of Lake Balaton, and also in the south - both stretching north-east to south-west -, and the mountain range forming the border to Slovakia from Szob to the Miskolc region in the north-east.

In the period of rail network development (more than 100 years ago) Hungary was part of the Habsburg Empire and much bigger than after the First World War (including in particular Croatia, Slovakia, a part of Ukraine and, of Romania, Transylvania). The network is therefore radiating out from Budapest to connect all these regions with the capital. Tangent links often have been neglected.

The first railway line from Budapest to Vienna was built via Vác and Poszony (Bratislava). The present day main line from Budapest to Vienna via Györ - Hegyeshalom was not completed before the late 1880s; the Hungarian section became the first electrified main line of all Hungary after World War I. A complete restoration of the Budapest - Hegyeshalom line will allow 160 km/h as of summer 1997. These two lines are presently the only international links in Hungary that are double-track throughout. All others are - at least partly and regarding cross-border links - only single-track:

The entire Hungarian railway network is quite long, but of the total of around 7 600 km - comprising some narrow-gauge lines and many rural branch lines - the core network is only around 3 000 km, of which merely 1 112 km are double-track and 2 191 km are electrified.

Market Structure

The railway freight market in Hungary is characterized by a rapidly growing inland sector - predominantly covering short distances - and a growing import/export market, with a shift to consumer goods, lighter commodities and smaller forwarding units.

Compared to other railways - including EU countries - the results of MAV Rt. with 127 million passengers and 43 million net freight tons are not so bad (despite the fact that the 1988 transport volumes have decreased by 50%).

The size of the country, the central position of the capital and, presently, rather small volumes of transit traffic (due to the economic situation in Croatia, Yugoslavia and Romania) may be a major influence in this area.

Table 2.54:
Transport volume of MAV

Net freight tons (revenue earning)	43.189	m.t.
Net freight ton-km (revenue earning)	7 293	m.tkm
Passengers	126.956	m. persons
Passenger kilometers	6 288	m.pkms
Traffic units 1993 (sum of tkm and pkm)	13.581	millions
per employee:	191	

Note: Railway sector only

Source: UIC; International Railway Statistics 1994

Inland Navigation linkings

There are only few inland ports on the river Danube, the most important ones are in Budapest and downstream at Baja.

A new port is planned in Györ with direct access to the motorway M1 and to the railway Vienna - Budapest. All ports are intermodal and provide rail access. From these ports, several destinations could be served by existing and well-kept railway lines feeding inland navigation. Some examples may illustrate this:

- from/to northern Hungary, eastern Slovakia, eastern Poland via Budapest:
  - Miskolc, Kosice
  - Hatvan, Eger
  - Sálgotarján, Zvolen, B. Bystrica
- from/to western Ukraine via
  Budapest - Debrecen - Záhony/Cop (- L'vov)
- from/to northern Romania via Budapest: upstream
- from/to western Hungary, Slovenia via Baja: downstream

Yugoslavia

The remaining Federal Republic of Yugoslavia comprises Serbia and Crna Gora (Montenegro). The latter is a very mountainous region from the Adriatic coast to an Alpine chain of high mountains. Serbia itself is characterized by plains north of the rivers Danube and Sava a hilly region in the south. The central axis Beograd - Nis runs anlong in the broad valley of Morava. The adjacent regions the east and the west become more and more mountainous.

Railways were therefore originally built either straight across the plains or along the valleys, as in particular:

All the main lines mentioned (except Beograd - Vrsac) are electrified and allow good service quality from the alignment point of view.

In total Serbia's rail network could be characterized as "Balkan rail turntable", but for obvious reasons has been neglected by international parties over the past years. Nevertheless, Beograd seems to be aware of this role and possible future advantages, as e.g. regulations on road transit are proving. The entire network is surprisingly long and comprises many branch lines. Many trunk lines are single-track, but electrified. Double-track sections amount to not more than 273 km.

As to the present market, no data are available. In view of the current economic situation, data would not be useful to consider future market development anyway.

Inland Navigation linkings

The main Danube port is Beograd. This port could serve several O/D-destinations, as e.g.:

from/to western Europe via Danube	to Macedonia and northern Greece, to Podgorica and Albania
from/to the Black Sea region	to eastern Hungary, to western Romania and to Croatia, to Bosnia and Herzegovina

Slovenia, Croatia, Bosnia - Hercegovina

For several reasons, the three ex-Yugoslavian countries will be analysed together:

- All three countries are currently in a transition phase and will develop at different speeds.

- The river Danube does not cross any of the three countries, but merely touches Croatia. In eastern Slavonia, the destroyed small town of Vukovar offers port facilites at the river Danube which may be of great interest after renewal and upgrading -not only for Croatia.

- The competition between rail and inland navigation in these countries is obvious as they offer a corridor from Central Europe (and the Danube region) to their respective Adriatic seaports.

- These rail links to the ports constitute alternative routes to Danube shipping when it comes to overseas destinations.

The Adriatic coast - from Crna Gora (Montenegro) in the south up to Istria and the Bay of Trieste - consists of high mountains which offer only few port sites (but these are deep-sea). There is only one large river - Neretva - with a delta, that provides natural access to the hinterland. Every transport corridor has to cross mountain passes, even the corridor via the Neretva valley up to Sarajevo. In addition to that, the railway links now have to cross the new borders.

Apart from that, former Yugoslavia with exception of Slovenia used the more modern 50 Hz-System. During World War II some trunk lines were electrified using the Italian 3 kV Dc-system (Trieste - Ljubljana and Postojan - Rijeka and over a steep ramp on to Zagreb). Since the 60s, Slovenia has proceeded with electrification by the DC-system.

All three networks of Slovenia, Croatia and Bosnia and Hercegovina are relatively small. Whereas the Slovenian network is in good working order, widely electrified and double-track, the Croatia network is still in 1997 partly interrupted and under reconstruction. Data concerning actual network of Bosnia and Hercegovina and its status are not available yet.

Bulgaria

Bulgarian geography is roughly characterised by three mountain chains stretching from west to east, between the Greece border and the river Danube, which is the northern border to Romania. As the capital city, Sofia is situated in the extreme west of the country, two main east-west railway lines link the capital between these mountain chains with the Black Sea ports of Varna and Burgas. These lines are mainly double-track and electric, providing links with Turkey and the eastern-most region of Greece; whereas the link to Yugoslavia via Dimitrovgrad is single-track and has not yet been electrified. However, the last stretches of the rail connections with FRY, Greece and Turkey are not electrified, which proves to create a bottleneck in times of frequent traffic.

Several north-south links cross the mountains or hilly regions. Most of them are single-track and some are not electrified, as in the Sofia-Thessaloniki (Greece) section in particular.

At the end of 1995, the total length of national railway tracks was 6 508 km, of which 4 291 km were running tracks and 2217 km were shunting and station tracks. 4 046 km (94%) of the running tracks have the standard 1.435 mm width, of which 65% are electric lines, 24% are double track lines, all electric and 9% are lines equipped with automatic breaking systems. 245 km (6%) of the running tracks are 760 mm narrow-gauge.

Market structure

During the first years of transition, the BDZ lost more than 50% of it's business, like many other OSShD-railways. The figures given in Table 2.55 clearly show the very low level of freight and passenger traffic, with the presently consequence of low productivity.

Table 2.55:
Transport volume of BDZ

Net freight tons (revenue earning)	29.620	m.t.
Net freight ton-km (revenue earning)	7 740	m. tkm
Passengers	65.740	m. persons
Passenger kilometers	5 059	m.pkm
Traffic Units 1993 (sum of tkm and pkm)	12.799	millions
per employee:	267	

Note: Railway Sector only

Source: UIC; International Railway Statistics 1994

Over the past seven years, the railway system of Bulgaria has performed well below its designated capacity and therefore has not experienced any throughput or capacity bottlenecks.

Relationship to Inland Navigation

There is no direct interrelationship between inland navigation and railway transportation. The BDZ does effect pre-/on-carriage to/from Bulgarian river ports, but the transmodal connection is organized by the exporters, importers and forwarders, themselves.

Romania

The geographical and the historical political situation determined the development of the railway system: the land is divided by the mountain chain of Carpathian mountains (around 2.500 m high), forming like a "lying U" a belt of some 50-100 km wide, scarcely populated forests. The inner land (former County of "Siebenbürgen" = Transsylvania) was Hungarian, when the trunk railway lines have been built. Consequently the main lines are leading to the former capital Budapest.

South and east of the Carpathian mountains, through the plain fields of Romania, straight railway lines were build radiating out from the capital Bucharest in several directions. Where all the lines crossing the Carpathian mountains have an Alpine pass character (from west to east). To improve transport facilities between industrial regions most of these mountain passes have been improved and electrified in the 70s and 80s.

Past investments provided for an essentially strong railway system. It is presently deteriorating in many parts, but improvement projects are under way. Technically the trunk network is viable, providing automatic train control, bi-directional signalling and operating, remote control of stations as well as an infrastructure that permits up to 140/160 km/h in many parts.

Nevertheless some bottlenecks need to be identified especially the single-track lines between Timisoara and Arad, Cluj - Oradea - Hungary, the old, not electrified line Timisoara - Stamora-Moravita (-Beograd), the steeply graded "Predeal pass" Ploiesti-Brasov.

The total Romanian network is shorter than the Hungarian, but compared to the Hungarian more than double is double-track and it has 76% more electrified lines. The trunk network makes up a much larger proportion of the total network, i.e. around 2/3 of the entire railway network. Compared to other countries, Romania has ha high proportion of 55% electrified lines and 33% double-track. This indicates a high planning standard and good pre-conditions for future development - if only from the point of view of infrastructure.

Market Structure

When analysing the figures shown for the national railways, the critical condition of Romania's economy over the past years should be taken into account. Moreover, during the last two decades within the COMECON Romania experienced a rigid policy of austerity. Therefore, foreign trade presently does not contribute much to goods flows on rail, as data for the Hungary/Romania borders indicate (around 1.2 million net tons only by rail in 1993, source: MAV).The rapidly growing sector of consumer goods generally prefers forwarding by truck.
In view of these facts and the low level of income of the country’s inhabitants, the figures shown in Table 2.56 are not that bad. The ratio of traffic units per employee is rather high with approximately around 245.

Table 2.56:
Transport volume of SNCFR

Net freight tons (revenue earning)*)	98.148	m.t
Net freight ton-km (revenue earning)*)	21 543	m. tkm
Passengers	206.920	m. persons
Passenger kilometers	18 313	m.pkm
Traffic units 1993 (sum of tkm and pkm)	39.856	millions
per employee:	244,6	

Note: Railway sector only
*) waggon-load only, no full information
Source: UIC; International Railway Statistics 1994

The approximately 100 million freight tons are primarily inland transport. The average distance is 219.5 km. The number of passengers - 207 million - is not much higher than that e.g. in Austria (190 million), a very low figure given the larger population, great distances and lack of inter-regional bus services. But, of course, low income and the long average distances (approx. 90 km, twice as much as in Austria and about the same as in Italy) need to be taken into consideration.

Inland Navigation linkings

The Romanian railway system offer feeder services from/to most Danube ports to various inland regions as well as to Moldova and to the central part of Ukraine. Service to central Ukraine, however, might not be an issue if sea shipping on the Black Sea and respective inland ports are prefered due to direct transshipment facilities for the industry.

To the certain extent, the rail network and future services could develop into strong competitors to inland navigation especially for some destinations to/from central and northeastern Romania, Moldova and parts of Ukraine to Hungary and western countries. The future competitiveness will clearly depend largely on infrastructure conditions, reliability of services, transport safety and, last, but not least, market prices for long-distance services.

2.3.5 River-Sea and Multimodal services

2.3.5.1 River-sea and multimodal services between the Danube and North Sea ports

- **Waterborne container services**

Since the opening of the Main - Danube Canal in September 1992, the possibilities for a direct waterborne transport between the Danube ports and the North Sea deep sea ports have been realised. The first regular container service using this waterway for direct waterborne transport was established between the Port of Rotterdam and Vienna by DCS in April 1993. Gradually, several other Danube ports have been included in this line. Theoretically, the trip duration between Rotterdam and Vienna along the distance of about 1600 km could be 10 days (with 6 intermediate stops under way) and in opposite direction about 9 days. The reasons for such relatively long trip duration will be discussed in Item 3.4 - ”Limiting factors”.

At the moment, two container shipping companies provide scheduled line service between the Port of Rotterdam and several ports along the Danube. That are:

– CCS - Combined Container Service GmbH & Co. KG - Rotterdam
– DCS - Danube Container Service - Rotterdam

DCS is the joint venture of ”Interrijn B.V.” - Rotterdam, ”Rhinecontainer B.V.” - Rotterdam and ”Penta Container Line AG” - Sliedrecht. The general Danube agent of the DCS is Austrian ”Centranaut Transportagentour GmbH” - Vienna.

The time tables of Rotterdam - Danube services of CCS duration (number of days under way starting from the end departure points in Rotterdam and Budapest) are shown beneath in Table 2.57.

Table 2.57:
Time table of the CCS

Departure from Rotterdam on Monday						
N° of days:	Arrival on:					
			Rotterdam		Monday	19
8	Tuesday		Nürnberg		Monday	12
9	Wednesday		Regensburg		Friday	9
10	Thursday		Deggendorf		Thursday	8
11	Friday	###	Linz	###	Wednesday	7
12	Saturday		Krems		Tuesday	6
14	Monday		Vienna		Monday	5
15	Tuesday		Bratislava		Sunday	4
18	Friday		Budapest			
					Arrival on	N° of days:
						Departure from Budapest on Thursday

Source: Port of Rotterdam - Inland Container Shipping, October 1994

Both companies operate their lines with modern container ships with a capacity of 100 TEU. The turnover in TEU rises for about 60% annually.

- **Passenger car transports**

A large number of passenger cars imported into Europe from the Far East and transhipped in the ports of Rotterdam or Antwerpen is further transported upstream the Rhine to the large distribution centres in Southern Germany on board specially built five or six-deck river ships. These vessels have each a capacity of between 380 and 650 cars. From these distribution centres located in Karlsruhe, Mannheim, Worms, Stuttgart etc. the cars are transported further, among other directions also to Kelheim, Regensburg and Passau by railway. A direct waterborne transport from Rotterdam to Danube ports is not possible aboard Rhine multi-deck car-carriers due to their high uppermost fixed point and limits in bridge heights on Main - Danube Canal and the upper Danube. Further eastwards the transports go again by river ships to Vienna and Budapest. The Danube ships involved in this multimodal transport chain are either pushed convoys consisting of two double deck Europe II Ro-Ro barges (BL) and a pushboat or Danube Ro-Ro catamarans (SOMAT). Respecting the models of passenger cars respectively their size, the capacity of each leg is between 200 and 250 automobiles. This economically approved and environment friendly mode of transport exist on the river Rhine already since 1983 while the additional links to Vienna and Budapest were realised in autumn 1993 the first time.

According to the recent information, the Romanian yard in Orsova delivered two reconstructed Europa II barges with four decks, equipped for passenger car transports in 1995. One barge is transferred through the Main-Danube Canal and is now added to the Rhine fleet, while the other one remains on the Danube and will be used for car transports between Regensburg and Vienna respectively Budapest.

- **Other commodities**

The opening of the Main - Danube Canal initiated also direct waterborne transports of other commodities between the West European centres and the Danube. According to the annual report N° 1-95/2-95 of the German WSD-Süd (Waterway and Shipping Management - South) from Würzburg issued on 5th of March 1996, the total amount of cargo transported by river vessels through the Main - Danube Canal in 1995 was more than 6.666 mill. tons. Thereby, the cargo flow through the Canal lock Kelheim was 4.076 mill. tons or even 22.3% more than in 1994. Of this amount, 2.071 mill. tons have been transported towards destinations on the Danube and 2.005 mill. tons towards Main and Rhine ports. The prevailing kinds of commodities transported in both directions were (sorted upon the quantities):

1. Food and animal feed: 1.105 mill. tons (27.11 %)
2. Ore and metal scrap: 0.698 mill. tons (17.13 %)
3. Iron, steel, non-ferrous metals: 0.589 mill. tons (14.46 %)
4. Agrarian and forestry products: 0.479 mill. tons (11.77 %)
5. Minerals (including construction materials): 0.463 mill. tons (11.36 %)
6. Fertilizers: 0.438 mill. tons (10.75 %)

Other kinds of commodities as solid mineral fuels (coal and coke), crude oil and its derivative products, chemical products and other finalised or semi-finalised goods have been transported in quantities less than 100 thousand tons.

The main commodities transported in direction of the Danube were ore and metal scrap as well as food and animal feed, while the prevailing transports from the Danube towards the West were iron, steel, non-ferrous metals, agrarian and forestry products and food and animal feed.

The huge majority of cargo has been carried through the Canal on board German and Dutch vessels - 46.6 and 35.8% of the total amount respectively. Belgian ships had the share of 7.7 %, Austrian 4.9 % and Hungarian 2.5 %. The ships under other flags (Slovak Republic, Luxembourg, France, Switzerland etc.) had own shares of between 1.2 and 0.1 % in 1995.

A frequent user of the Rhine - Main - Danube Waterway is the Austrian steel concern ”VOEST-Alpine” located in Linz. Namely, VOEST-Alpine imports considerable quantities of iron ore from Brasil over the Port of Rotterdam and uses both railways and inland ships (since the end of 1992) for further transport to the own industrial port in Linz. Final products of this steel plant (high quality steel plates and profiles) are delivered to the market in Southern Germany also by river ships and railways. Besides, Austrian ”Agrolinz-Chemie” use this route for exporting considerable quantities of synthetic fertilisers to the West-European market. Large shipments (in hundreds of thousand tons) of sunflower kernel from Hungary to the Benelux states have also been transported using river vessels in recent years. In 1993-94 a considerable amount of barley (about 100.000 tons) has been transported by river ships from the Netherlands to Austria.

But despite of the permanent and considerable grow year after year of the waterborne transports through the Main - Danube Canal, one question remains still open. Namely, according to some traffic experts (Prof. Dr. Eugen Wirth: ”Die Auswirkungen der Wasserstraße Rhein - Main - Donau auf den Donauverkehr” - The impacts of the Rhine - Main - Danube Waterway on the Danube traffic), the excelling of the most optimistic forecasts of the development of traffic through the Canal can be considered as the consequence of simultaneously arisen blockade of the Danube traffic through ex-Yugoslavia. From that point of view, the Main - Danube Canal had been put into operation in the best possible time. The countries on the upper Danube like Austria, Slovak Republic and Hungary got thereby the opportunity to use this alternative waterway access to the deep sea ports. But according to professor Wirth, it has to be kept in mind that typical river cargo ship starting from Vienna can reach the Black Sea within 4-5 days, while she needs 10-12 days to reach the Port of Rotterdam. This topic will be discussed in details in Item 3.4. The question is what will happen after the re-establishment of the free navigation on the middle Danube stretch.

2.3.5.2 River-sea and multimodal services between the Danube and Mediterranean Sea ports

Since 1981, German RMS (Rhein-Maas und Schiffahrts-Kontor GmbH Duisburg) and Hungarian MAHART organised a direct waterborne service between the Mediterranean and Black Sea ports and the Port of Budapest. Four RMS river-sea vessels have been engaged on this line: ”Käthe Wessels”, ”Ursula Wessels”, ”Lena Wessels” and ”Thekla Wessels”, all built between 1979 and 1982, with a deadweight of 2920 t and engine output of 1320 kW.

The first trial trip of one river-sea ship between Mediterranean Sea ports and the upper Danube was done in June 1984. The German river-sea vessel ”Osteteam” (built in 1976, 2550 tdw, 1065 kW) made a trip between the eastern Mediterranean and the Port of Vienna. On its second Danube trip, one month later, ”Osteteam” reached the Port of Krems (Danube km 1998). Many successful voyages between Vienna and the Turkish Black Sea Port of Trabzon, have been made but the service had to be cancelled in spring 1985 after a long period of low water.

One year after the first trip of ”Osteteam”, in June 1985, another German river-sea ship - ”Kirsten” (built in 1984, 1550 tdw, 441 kW) came from Greek Aegean island Milos to Krems with 770 tons of minerals. This uninterrupted trip lasted twelve days.

The German RMS had on average 10 river-sea vessels of its fleet in service between the Mediterranean area and the Danube in the eighties. The usual destinations/origins along the Danube were Krems, Vienna, Budapest and Belgrade and in the Black Sea and Mediterranean area Milos, Trabzon, Izmir and some other ports in Levant.

The DDSG in cooperation with the German ”Lenkering/Montan” from Duisburg established the line between Levant ports and Vienna respectively Krems with chartered Dutch river-sea ship ”Buizerd” since June 1988.

The Ukrainian UDP has some 60 sea-going ships with up to 5000 tdw in its fleet. These vessels are not included in the UDP Danube fleet because they are equipped for the navigation only along the maritime Danube section. These ships are used for river-sea respectively shortsea service between Ukrainian Danube ports of Reni and Izmail and the Black Sea and Mediterranean ports. The partner companies in this UDP service are German BL and Austrian DDSG.

International Shipping Company ”Interlighter” (established in 1978 by the shipping companies from USSR, Bulgaria, Hungary and CSSR) provides multimodal service (river barges - sea-going barge carriers) between Ust Dunajsk and Novorossiysk (the Black Sea) and the ports in Far East (Bombay, Karachi, Kelang, Penang, Singapore, Bangkok, Saigon, Haiphong and Phnom Penh). This service is provided with a fleet of about 600 river barges of so-called DM type, four barge carriers of ”Boris Polewoy” type and two of ”Yulius Fuchik” type. ”Interlighter” has ship-handling agents in Regensburg, Vienna, Bratislava, Budapest, Rousse, Galati and Izmail on the Danube and in the deep-sea ports in Koper, Constanta, Odessa, Ilyichevsk, Novorossiysk, Istanbul, Bombay, Karachi, Singapore and Bangkok.

At least, but not the last, the Romanian ”NAVROM” provides nowadays two regular line services:

– Ro-Ro line between Constanta and Istanbul
– rail ferry line between Constanta and Samsun (Turkey)

2.3.5.3 Other multimodal services with participation of the Danube Waterway

- **Ro-Ro service between Passau and Vidin**

The first river Ro-Ro multimodal service on the Danube has been established in summer 1982 when the SOMAT river semi-catamaran ”Han Asparuh” made its maiden voyage with the load of 49 forty feet road trailers on board from Passau-Schalding to Vidin. Optional stops were envisaged in Linz and Vienna. The Ro-Ro terminal for this line was also built in Rousse, but the ships mostly terminate their eastbound trips in Vidin. Since 1983 SOMAT provides this service with four ships of the same maximal capacity (49 trailers with an average weight of 28 tons each) with an interruption between 1992 and spring 1996 due to the Danube UN blockade on the ex-Yugoslav section.

The round trip Passau-Vidin-Passau is scheduled for 14 days. An average of 90 roundtrips per year have been recorded since the service beginning in 1983.

- **Ro-Ro service between Passau and Budapest**

The German - Hungarian joint venture ”Hungaro Lloyd” introduced regular line service between Passau-Schalding and Budapest, also with optional stops in Linz, Vienna and Bratislava in autumn 1992. Four twin deck Ro-Ro barges, each with capacity of 32 forty feet trailers, in ownership of German BL and two chartered Bulgarian BKR pushboats of ”Naidan Kirov” type with an output 2200 kW are engaged in this service. According to the time table, departures from Passau-Schalding are each Monday afternoon and from Budapest each Thursday morning.

2.3.5.4 Limiting factors

Before 1992 the Danube shipping had only an access to the Black Sea, i.e. river-sea ships had been able to link Danube ports with the Mediterranean region, the Black Sea, Sea of Azov and the big navigable rivers of their confluences (Dnjepr, Don and deeper into the ex-USSR hinterland over the Volga-Don Canal). Since 1992, direct waterborne link is realised with the North Sea too over the Main - Danube Canal and the rivers Main and Rhine as well as with the considerable part of the West European Inland Waterway System.

However, certain limiting factors for the utilisation of these waterway links for river-sea services still remain.

- **Technical obstacles**

Regarding the waterway conditions, river-sea ships heading from the Black Sea have no difficulties to reach the ports along the maritime section of the Danube, i.e. up to the Port of Braila. The Port of Cernavoda can also be reached through the Constanta - Cernavoda Canal without any difficulties, but it happens only if Cernavoda is the final destination of these ships. For any other port of call along the Danube, river-sea vessels use the Sulina Branch or (in case of Ukrainian ships only) Chilia Branch.

Further upstream, up to the Iron Gates II, the navigation of these vessels can be hindered by low water levels. Russian and Ukrainian river-sea ships have usually a maximum draught of 3.5 to 4.5 metres, i.e. the probability that they can reach deep waters upstream the Iron Gates II river lock is highly influenced by the seasonal water discharge on this stretch. The economic effects of these vessels (”Sormovsky”, ”Amur”, ”Volgo-Don”, ”Volgo-Balt” and other similar types) when just partially loaded, e.g. up to a draught of 2.5 metres or less are questionable. Considerably smaller RMS ships (1550 - 2920 tdw at full draught compared with Russian 3000 - 5400 tdw) are obviously more flexible regarding draught restrictions.

The next obstacle was the road bridge at Novi Sad (Danube km 1255) with its air clearance above the HWL of only 6.07 m. That means that in case of favourable water depth conditions (period of high water levels on the lower and middle Danube in late spring), the ships having high superstructures and deck erections were usually not able to pass under this bridge. The above mentioned Russian types have all two or three tiers of deckhouses and above all always fixed wheelhouses, i.e. the height of the uppermost fixed point is about 10 metres above the waterline, sometimes even more (when the ship is just partially loaded). For such ships it is sometimes difficult to reach even the port of Belgrade because of the air clearance of 9.15 m at HWL of the road and railway bridge on km 1154. German and new Slovak river-sea ships engaged in the Danube river-sea services have usually low superstructures with only one tier of deckhouses and hydraulically operated elevating wheelhouses that can be lowered down sometimes even to the height of superstructure deck. These ships are, despite of their extended freeboards compared to the pure river ships, much less sensitive to low bridges than the Russian vessels. Therefore, the probability to reach the Port of Budapest for the river-sea ships with considerable load on board, especially for mentioned Russian units, is not high.

Upstream Budapest, up to Vienna, all the bridges are higher than the one at Novi Sad but the waterway depth represents a very serious obstacle during the longer period of the year.

Sometimes, even the profitability of using pure inland vessels specially designed for shallow waters comes to its lower limit on this stretch. This problem appears again on the most critical stretch on the upper Danube between Vilshofen and Straubing. Moreover, It is combined with some very low bridges along the whole German section.

All the river locks starting from Regensburg (km 2379) and further upstream along the Danube and through the Main - Danube Canal have the chamber width of 12 m. Therefore, the Port of Regensburg represents the theoretical end point for all Russian and Ukrainian river-sea ships with their standard breadths between 13.2 and 16.4 metres.

Starting from the North Sea, the waterway conditions on the lower Rhine are usually favourable for all existing types of river-sea vessels including even most of the already mentioned Russian units. Further upstream in direction of the mouth of the river Main at Mainz, the most critical point regarding water depth is ”Bingen Loch”. Here the water depth can be less than 1.9 metres by extremely low water, i.e. even 0.6 m less than always guaranteed on the adjacent Rhine sections and the rest of the R-M-D waterway along river Main and the Main - Danube Canal.

Moreover, there exist numerous bridges with low clearances on the Main and Main - Danube Canal. These bridges as well as some of them on the upper Danube are one of the reasons why the existing multi-deck river car transporters are not able to reach the upper and middle Danube with their shipments from Rotterdam, Cologne or Stuttgart despite of the installed ballasting system on board.

- **Other restricting influences**

The relatively long trip duration between the North Sea or the lower Rhine ports and the Danube results from numerous lockings on Main, Main - Danube Canal and the upper Danube itself. There are a total of 64 river and canal locks on the route between Rotterdam and Vienna where the ships have to decelerate, standstill during the locking and then accelerate to their service speed again. Moreover, the maximal allowed speed through the Main-Danube Canal for ships having a draught of more than 1.30 m is only 11 km/h. And the third influence factor are operating hours of the locks on Main and Main - Danube Canal - only between 06:00 and 22:00.

Obviously, the long trip duration and resulting therefrom a very low forwarding speed influence the decision of shippers rather to select other routes or other transport modes.

Similar consideration but this time based on another cause can be applied to the river-sea route between Vienna and the Black Sea. Namely, the way of execution the revision checks on the Danube (the ship must stop and wait until the clerks finish their job) causes a loss of time between 12 and 24 hours (total on all check points). For slow convoys which need 250 to 300 hours upstream that is about 5 - 9 % of the total time under way, but in case of considerably faster stand alone river vessels and especially river-sea ships this stops represent up to 15 % of the unnecessary time losses.

To conclude, two of the most attractive attributes of direct waterborne transport against land-based modes as lower costs and higher reliability of delivery time cannot be applied in full scale to the river-sea links between the Middle-European Danube and the North Sea and the Black Sea respectively due to:

1. non-uniform waterway conditions along each of these routes and thereby very often resulting partially loaded ships that cause lower economical effects

2. often unpredictable delays in arrival or considerably higher scheduled duration of trip than technically feasible, thus causing a further drop of competitiveness of the in any case slow waterborne transport mode

These statements lead to the conclusion that probably the optimal solutions have to be looked for in more intensive application of multimodal transport chains utilising the best attributes of each particular mode in specific transport tasks. A very good example is the transportation of the passenger cars from the Far East over Rotterdam, Karlsruhe, and Regensburg to Vienna or Budapest.

3. Trade and Transport Prognosis within the Danube Region

3.1 Analysis of Trade Flows

The purpose of this section is to provide an empirical basis with a view to the overall development of transport demand within the Danube region. This basis will then be used for a reference when analysing transport on the Danube in section 3.2. The development of trade within the Danube region is analysed by trade relations and commodities (country-to country transport matrices) for the time period from 1990 to 1995.

To start with some general aspects of trade will be discussed including changes in trade regimes, trade agreements, free trade areas, and barriers to trade. The empirical analysis of trade flows will fall into three parts: first, changes in the trade volume of the individual countries considered will be analysed, second, changes in the product composition of trade flows will be examined, and third, changes in the spatial pattern of trade flows will be investigated. The data used in this section stem from OECD and WIIW (Wiener Institut für internationale Wirtschaftsvergleiche, overall volumes of trade in Western and transition countries, respectively), and from the UN world trade data bank (in the case of trade flows within the Danube Area).

3.1.1 General Aspects of Trade

During the period of investigation, radical changes in the institutional setting for international trade took place within the Danube area. In the West, the common market of the European Union (EU) was formally realized at the beginning of 1993. In 1994, member countries of the EU and member countries of the European Free Trade Agreement (EFTA) formed the European Economic Area (excluding Switzerland). In 1995, Austria joined the EU. All these measures of economic integration are expected to stimulate trade between individual member countries by eliminating tariff and non-tariff barriers to trade.

In the East, the former COMECON trading area collapsed during the year 1990 and was formally liquidated in 1991. The successor countries tried to establish new forms of trade agreements by, first, strenghtening cooperation with the European Union and, second, founding a new free trade area among former COMECON members. The EU effected so-called Europe Agreements with many transition countries within the Danube region (Bulgaria, the Czech Republic, Hungary, Romania, the Slovak Republic, Slovenia). Within the Europe Agreements, duties and import restrictions will successively be abolished (except for agricultural products). The agreements took effect in 1995 (Hungary: 1994). Russia, the Ukraine, and Moldavia signed so-called Partnership Agreements with the EU which also aim at facilitating trade among the member countries of the agreement. However, there are still considerable duties imposed on most products traded with these three countries.

The Central European Free Trade Agreement (CEFTA) was founded at the end of 1992, and shall fully come into effect by the year 2001. First measures (abolition of duties and quantitative restrictions on certain manufactured goods) were realized as early as 1993.

Member countries are the Czech Republic, the Slovak Republic, Hungary, Poland and Slovenia (since 1995). One important purpose of the CEFTA agreement is to avoid bilateral discrimination in the course of the Europe Agreements with the European Union.

Furthermore, the foundation of the World Trade Organisation including a new agreement on international trade at the Uruguay meeting of GATT which took effect in 1994 should also stimulate trade in the region of interest.

Another factor contributing to a dynamic development of trade of the Danube are the shifts occuring in the organisational links among the region's companies. Economic transformation in Eastern Europe was associated with strong direct investment activities by Western companies in Eastern Europe. New plants were established in Eastern Europe, existing firms in the East were taken over and joint ventures between Western and Eastern firms were formed. It is a well known fact that direct investment stimulates imports and exports between the countries concerned, both through intra-firm trade and through improved market access for both parties (see Pfaffermayer 1996, Bellak 1995). Companies from Western European countries within the area (Germany, France, the Netherlands, Belgium, Austria, Switzerland) invested mainly in Hungary, the Czech Republic, the Slovak Republic, Slovenia, and Bulgaria while Southern European countries within the Danube Area (Greece and Turkey) invested mainly in Bulgaria, Romania, and the Ukraine.

In 1995, Hungary was the country with the highest stock of foreign capital among all central and east European countries. Other transition countries with considerable foreign direct investment are the Czech Republic, Slovenia, Croatia, and Romania. Relatively small amounts of foreign capital exist in the Slovak Republic, Bulgaria, Macedonia, and the Ukraine. Yugoslavia, Moldavia and Bosnia-Hercegovina show almost no foreign direct investment from Western countries.

A major barrier to trade in the time period observed was the war in former Yugoslavia including the international embargo of Yugoslavia (Serbia and Montenegro) from 1993 to 1995. Trade with Yugoslavia was heavily restricted and sometimes not allowed at all. As a consequence of war, the traditional trade route between Western and South-Eastern Europe was closed and trade had to shift to other routes (Hungary-Romania-Bulgaria).

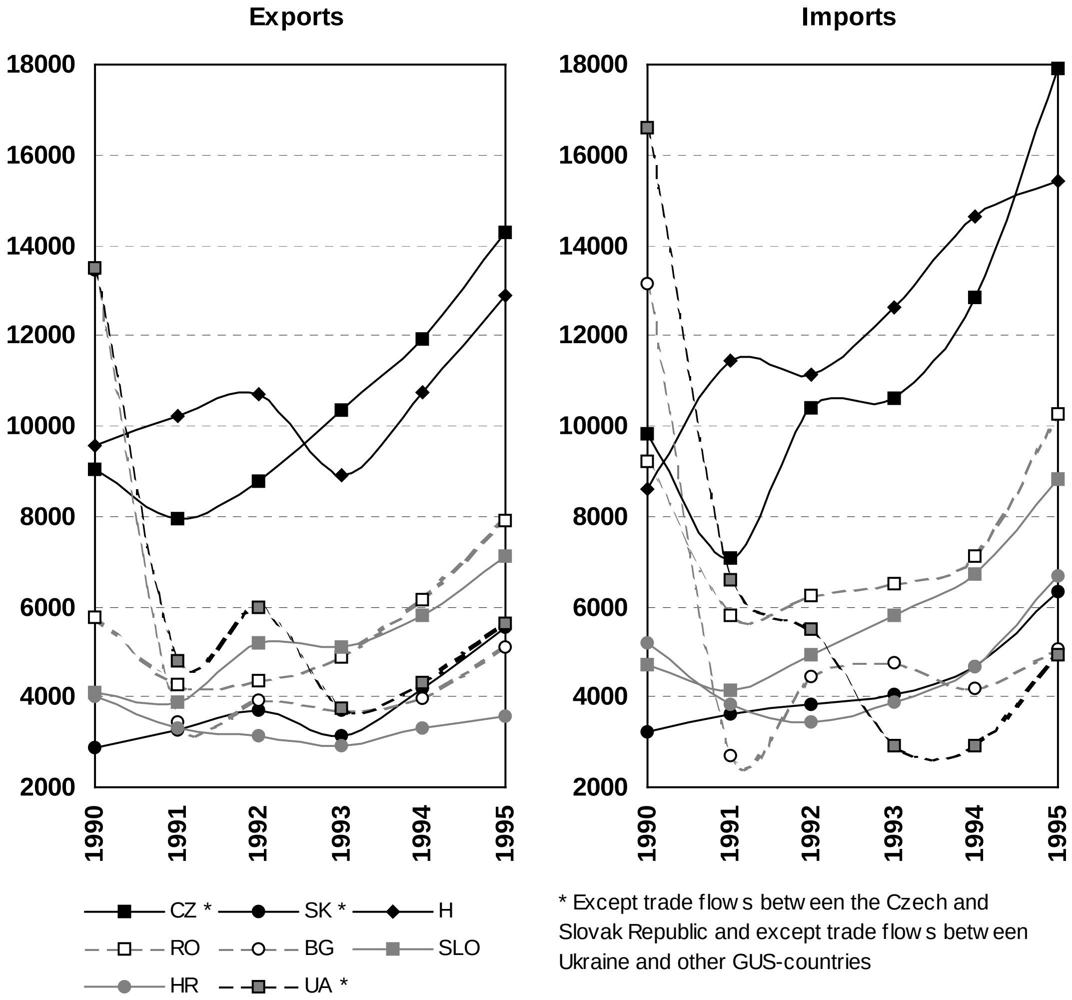
3.1.2 Development of Foreign Trade Flows in the Danube Region

Development of the total volume of exports and imports for the Western countries in the Danube region has shown a considerable increase since 1993. In 1995, the level of total trade exceeded that of 1989 by about 50%.

The development of trade in the Central and East European transition countries has been ambiguous (figure 3.1).

In the Czech Republic, the Slovak Republic, Hungary, Slovenia, and Romania, the volume of foreign trade today (both exports and imports) clearly exceeded the level of 1990. This was not the case with the Ukraine and Bulgaria, where the reduction in demand due to decreasing wages, employment and investment resulted in a tremendous decline in imports and, to a lesser extent, in exports.

Figure 3.1:
Development of Exports and Imports of Transition Countries
in million USD at current prices



Source: WIIW (1995, 1996, 1997)

The general pattern of foreign trade development in the countries of the Danube region is reproduced if **only the trade within that area** is analysed (Danube transport flows, table 3.1). This analysis is based on data of bilateral trade flows (in terms of prices and weight) among the individual countries within the Danube region for the years 1990 and 1995. Trade with successor countries of the Soviet Union is not considered as data for the year 1990 are not available. Countries which were founded later than 1990 (the Czech Republic, the Slovak Republic, successor countries of former Yugoslavia) had to be re-unified for this purpose as for 1990 no differentiation could be made).

Germany also had growth rates above the average. In terms of prices, trade with other countries of the Danube area expanded in all countries considered.

The matrix of growth shows development of experts and imports between three groups of countries: Western European, Central European and South-East-European countries.

In **terms of trade values** highest growth had exports and imports of Central European Countries. South-East European Countries generally had smaller growth ranging in the amount of the selected Western European countries.

Growth between Western European and Central/Eastern European country generally was higher than intra-regional growth. Trade between Central European and South-East European Countries even was reduced to the half of its 1990 volume.

In **terms of trade weight** the development in most relations was lower resulting in an overall growth of only 8 % but - yet in doubling East-West-Relations (table 3.1).

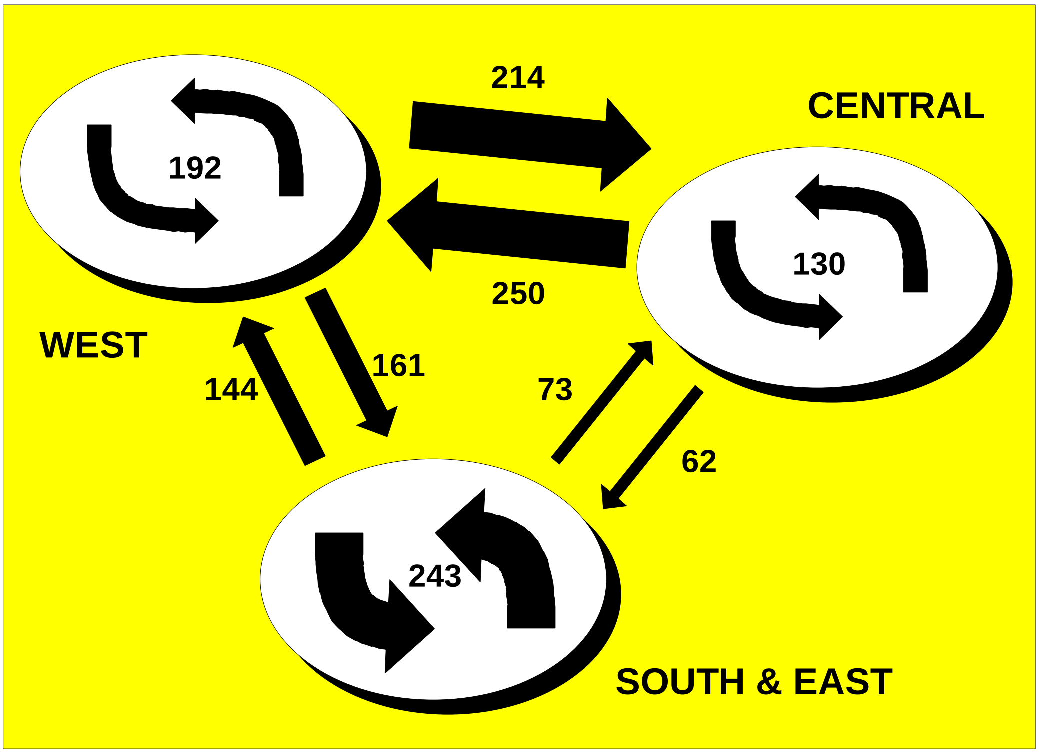
Table 3.1:
Change in the volume of trade within the Danube region 1990-1995 (Western, Central and South-Eastern European countries) (1990 = 100)

Country group of origin	*Country group of destination*			
	Western Eur. countries[a]	Central Eur. countries[b]	South-Eastern Eur. countries[c]	TOTAL
a. **Trade in terms of values**				
Western Eur. Countries	1.29	2.14	1.44	1.32
Central Eur. Countries	2.50	1.30	0.62	2.08
South-Eastern Eur. countries	1.61	0.73	2.43	1.57
TOTAL (export)	1.33	1.93	1.41	1.36
b. **Trade in terms of weight**				
Western Eur. Countries	1.00	2.05	1.34	1.03
Central Eur. Countries	2.10	1.84	0.43	1.85
South-Eastern Eur. countries	1.25	0.54	1.30	1.15
TOTAL (export)	1.06	1.68	1.14	1.08

[a] Austria, Belgium, Germany, the Netherlands, Switzerland
[b] Czech and Slovak Republics, Hungary, successor countries of former Yugoslavia
[c] Bulgaria, Greece, Romania, Turkey

Source: UN World Trade Data Bank, own calculations

Figure 3.2:
Change in the volume of trade by group of countries
Danube region 1990-1995 - Trade in terms of values (1990 = 100)



3.1.3 General Product Composition

This development is caused by the changes in the product composition of trade flows, which will be analysed by six groups of products. Special emphasis is put on the analysis of changes in the product composition of exports and imports of transition countries as it may be expected that the process of economic transformation have led to fundamental shifts in the structure of production, competitive advantages and, thus, the product structure of trade flows.

From 1990 to 1995, the share of raw materials in total exports of the transition countries fell slightly while the share in total imports decreased sharply. All transition countries show higher shares of raw materials in imports than in exports. Russia is the only net exporter of raw materials among the transition countries (in 1995 the Ukraine also shows an export surplus in trade with raw materials).

The share of labour or capital-intensive products both in total exports and total imports increased in almost all transition countries. The relative increase in exports may reflect the utilisation of comparative advantages in the production of goods which require cheap labour and/or high amounts of capital, energy or environmental inputs. The relative increase in imports may be interpreted in the light of a backlog demand for consumer goods and an emerging international division of labour between Western and Eastern Europe which resulted in an increased demand for the import of investment equipment and components from the West.

The share of technology-intensive products in total exports of transition countries on the average show a tendency to fall while the share in total imports stagnated or slightly increased. The relative (and also absolute) decrease in exports reflects missing competitiveness on world markets for this kind of products although in some countries from 1993 to 1995 an increase can be observed. The high and still increasing share in imports indicates the high demand for investment goods in the course of economic restructuring and foreign direct investment. Transition countries with relatively high shares of technology-intensive products both in total exports and total imports are Slovenia, Hungary, and the Czech Republic.

The figures show that a shift in the product composition of trade flows took place from 1990 to 1995. On the export side, labour or capital-intensive products increased its shares in almost all countries. On the import side, technology-intensive products dominated in most countries (except Bulgaria and Croatia) and increased its shares.

In a next step the product composition of trade flows was deepened from three into six. This product categorisation is similar to that used by Heitger et al. (1992) and Fischer and Rammer (1993, see figure 3.3).

In **terms of values**, the three most important product groups were labour-intensive, capital-intensive and high-end technology intensive products, each group accounting for approximately a quarter of the total trade. Of minor significance were low-end technology-intensive products with a share of about 14%. Agricultural products and raw materials only accounted for 9 and 6% of the total trade, respectively.

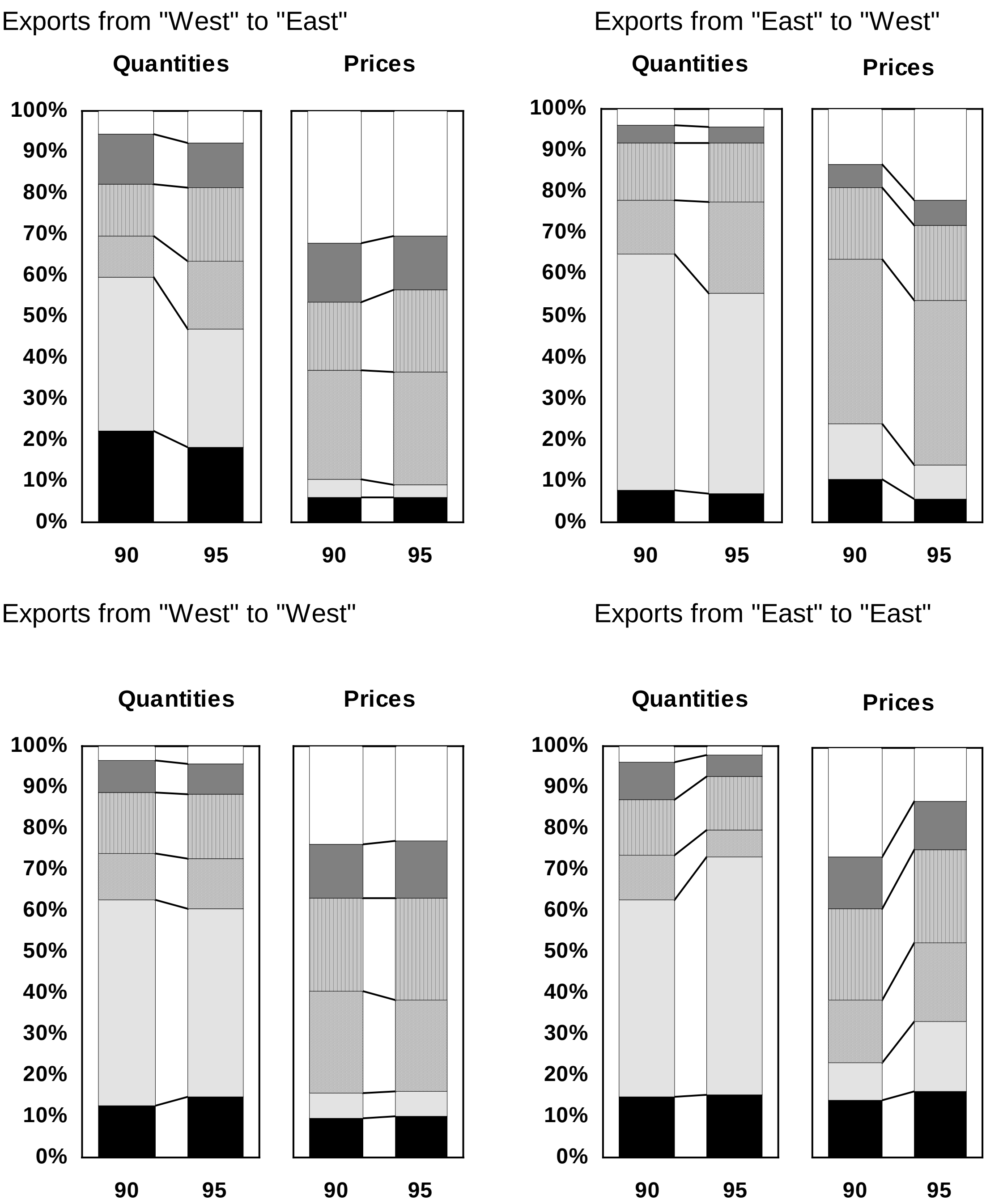
In **terms of weight**, shares changed significantly. In 1995, the most important product group by far were raw materials which amounted to nearly half of the total trade (in tons). Of minor significance were agricultural products, labour-intensive products and capital-intensive products, each group with a share of about 15% in total trade. Technology-intensive products showed a share of 7 and 4%, respectively.

The product composition of trade flows within the area did not change too much between 1990 and 1995 in terms of prices. Raw materials and labour-intensive products showed growth below the average of 36 %, while capital-intensive products and low-end technology-intensive products grew above this level.

In terms of quantities, the dominating position of raw materials was reduced to some extent. The volume of high-end technology-intensive products increased strongly. Low-end technology-intensive products showed an enormous reduction in terms of quantities.[7]

7 This reduction has to be interpreted with caution. It seems likely that there are some errors in the trade data for 1990 concerning trade quantities. The sources of errors cannot be analysed, however, as date for 1990 are taken from the study by Fischer and Rammer (1993) and go back to the UN World Trade Data Bank.

Figure 3.3:
Changes in the product group structure



Source: UN world trade data bank, Fischer et al. (1993)

Explanation of product groups: see figure 3.3

3.1.4 Product Composition of Trade Flows

Product structure of trade flows by country groups for exports of Western countries show high shares of technology-intensive products (which account for more than 40% of total exports to transition countries). Secondly, a shift towards labour-intensive and capital-intensive products occurred. In the case of trade flows from East to West, a shift away from agricultural products and raw materials to labour-intensive products and high-end technology-intensive products may be observed.

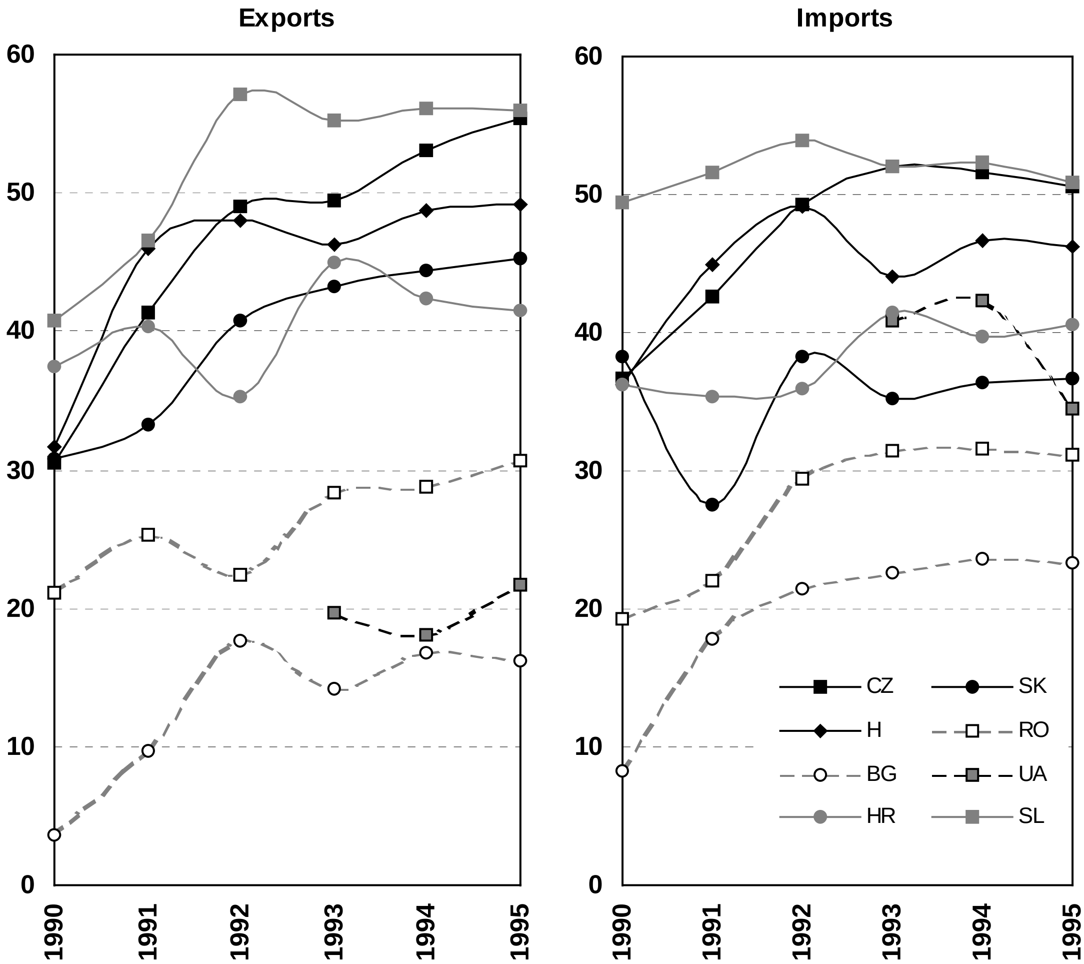
Trade flows among Western countries had a slight reduction in the share of raw materials and a minor increase in the share of technology intensive products. In contrast to the general development, trade flows among transition countries underwent significant changes in their product composition: Especially in terms of weight, raw materials considerably increased the share in total exports while technology intensive products lost shares. Moreover, labour intensive products and agricultural products relatively gained shares. The pattern of change in product composition of trade among countries may be interpreted as a bilateral specialisation on the same comparative advantages and a diminishing of intra-industrial trade relations from the time of COMECON.

3.1.5 Spatial Pattern of Trade Flows

The analysis shows shifts in the regional composition of exports by countries. Most of the transition countries succeeded in significantly increasing their shares in imports and exports with Western European countries. In 1995, this share exceeded 40% (in the case of exports) and 35% (in the case of imports) in Slovenia, the Czech Republic, Hungary, the Slovak Republic, and Croatia, i.e. the Central European countries, while the South-East-European countries showed considerable lower figures (figure 3.4).

The analysis show a clear domination of trade with Western European countries, which account for 90% of all imports and exports. Trade relations between Central and South-Eastern European countries as well as trade within these two groups is of small quantitative relevance for overall transport volumes in the Danube Region.

Figures 3.4:
Transition Countries: Development of Trade Shares with Western European countries (in %)



Source: WIIW (1995, 1996)

3.2 Forecast of Trade Flows

3.2.1 Methodology

3.2.1.1 The Specific Situation in the Danube Region

The section discusses the estimation procedure for the forecast of trade flows between the countries in the catchment area of the Danube. It includes a characterisation of the methodology employed, the scenario assumptions made and the data used.

The specific situation of the Danube catchment area comprising parts of Western, Central and Eastern Europe, which transgress the former East/West borderline, and also transgress a future borderline between an enlarged European Union and countries bound to stay outside the Union for some more years, will lead to different opportunities for economic development, different foreign investment patterns and a different state of infrastructure. Studies reveal a sturdy growth potential for international trade. Recent developments are more differentiated. Simplified up to a certain extent, but confirmed by recent trends, an enormous intensification of trade in Central Europe has been observed since 1994 compared to the slow progress in the integration of South-East European countries.

The geographical situation of the regions thus is specific and singular to the world:

- one large river connects countries of substantial different economic performance with enormous differences in GDP per capita,
- while there are historical links leading to cultural differences, which are rather small; the differences in living standards are far less dramatic than differences in GDP.

As the economic development of Central Europe clearly is on the way to a market economy, the change of this state of imbalance becomes obvious. Market economy tends to balance at least on regional scale, i.e., in short distances. Nevertheless, a number of open questions regarding international policies and economic issues leaves a wide range of possible developments open, which makes it extremely hard to forecast the development in the long term (and even in the medium term).

3.2.1.2 The Need for a Scenario Approach

It will thus become necessary to identify a range of future development for scenarios of economic development. Overall volumes of trade will be differentiated by two scenarios on the economic development of the area covered: A pessimistic scenario assuming slow economic growth and an optimistic scenario assuming moderate to high economic growth including the catching up process in Eastern European countries, at least to some extent.

- Scenario 'Pessimistic' takes into consideration the membership of the Central European countries in the European Union (1st EU enlargement), but no membership of further East European countries.

- Scenario 'Optimistic' bases on the membership of further East European countries to the European Union, economic recovery in Yugoslavia to the level of 1990.

The prognosis is further based on six product groups (see 3.1). Due to the importance of raw materials for River Danube transports there have been further divided.

3.2.1.3 The Trade Model

The Trade Model on which the sensitivity analysis is based is taken from the study by Fischer and Rammer (1993) on the development of trade within the catchment area of the Danube. The trade model may be characterised as a product-specific bilateral trade model of the gravity type (transaction type model). The model basically distinguishes four groups of explanatory variables: supply side factors of trade (characterising the level of economic activity in the country of origin), demand side factors (characterising the level of economic activity in the country of destination), product group-specific comparative advantages in trade (characterising competitive advantages in terms of price and/or quality in bilateral trade between countries considered), and link-specific variables (characterising transaction costs, information costs, similarities in economic structures, tariff and non-tariff barriers to trade, trade stimulating effects such as trade agreements etc.).

The Trade Model has been constructed from UN trade data on 1995 consisting of

- a matrix of 20 countries within the economic catchment area of the Danube:
- plus trade flows between non-sea countries (Austria, the Czech Republic, Hungary, Slovakia and Yugoslavia) and overseas countries
- but excluding trade flows among countries outside the Danube region (between Germany, The Netherlands, Belgium and Luxembourg, between Ukraine and Russia and other non-Danube relevant relations, see also matrices in Annex).
- This definition has been made rather generously to avoid exclusion of potential transport volumes (Bulgaria -Romania transports are included though of little practical importance for Danube transport.

The estimation of volume of trade in 2010 by scenario is based primarily on sensitivity analyses of trade volumes with respect to changes in major economic variables influencing trade flows in certain product groups and relations (such as supply and demand side factors, comparative advantages and barriers to trade). The estimation methodology employed consists of four main stages:

Figure 3.5:
Relations considered in the trade model

	F	B	NL	D	CH	A	CZ	SK	H	SLO	HR	YU	MK	GR	RO	BG	MD	UA	RUS *)	TR	OS
France																					
Belgium																					
Netherlands																					
Germany																					
Switzerland																					
Austria																					
Czech Rep.																					
Slovakia																					
Hungary																					
Slovenia																					
Croatia																					
Yugoslavia																					
Macedonia																					
Greece																					
Romania																					
Bulgaria																					
Moldavia																					
Ukraine																					
Russia *)																					
Turkey																					
Overseas																					

White: Relations considered in the trade model
Russia: only Black Sea Regions

1. Development of a trade model to identify the major economic variables influencing product group and relation-specific trade flows in the catchment area of the Danube, and their respective elasticity on the volume of trade.

2. Generation of two scenarios on the economic development in the individual countries within the catchment area of the Danube for the time period 1995 to 2010. A pessimistic scenario is used to represent the likely effects on trade if economic growth is slow, while an optimistic scenario is intended to show the likely trade effects of moderate to rapid economic growth.

3. Estimation of rates of growth by product group and relation-specific trade flows between 1995 and 2010 (in term of prices) based on the elasticity of independent variables of the trade model.

4. Calculation of product group and relation-specific volumes of trade in 2010 (in terms of weight, i.e. tons) for the two scenarios based on, first, actual (product group and relation specific) volumes of trade (in terms of prices) in 1995, second, (product group and relation specific) rates of growth of trade flows for 1995 to 2010 (for each scenario), and, third, estimates on changes in the (product group and relation specific) unit values of trade flows (for each scenario).

The trade model is estimated in a log-normal version by maximum-likelihood procedure (see for econometrical details Fischer and Rammer 1993, Fischer and Johannson 1994). Data refer to 1990 and stem from the UN world trade data bank (concerning trade volumes and unit values) and from World Bank statistics on main economic indicators in the countries considered. The values for the parameters estimated are taken for calculating product group and relation specific rates of growth of trade flows. The dummy variable for membership in Comecon was skipped as this trade arrangement regime do not exist anymore and the associated effect on trade volumes in 1995 and 2010 is zero, anyway.

3.2.2 Scenario Assumptions

The two scenarios comprise assumptions on changes in the independent variables of the trade model discussed above in the time period 1995 to 2010. An attempt was made to keep scenario assumptions as simple as possible to allow for a comparison of the effects of certain economic changes on changes in the volume of trade. Major emphasis is laid, therefore, on changes in GDP as this variable most strongly affects the rate of growth of trade flows.

3.2.2.1 Gross Domestic Product (GDP)

The following assumptions were made: for 1996 and 1997, actual and predicted change was taken. For the time period 1998 to 2010, economic development was modelled on uniform average annual rates of change (in real terms) for different groups of countries. In 'Western' countries within the catchment area of the Danube (Austria, Belgium, France, Germany, Greece, the Netherlands, Switzerland, Turkey) a uniform average rate of growth of 1.5% in the pessimistic and 2.5% in the optimistic scenario was assumed. A rate of 1.5% coincides with the economic development in the first half of the 1990s (1991-1995) while a rate of 2.5% corresponds with official long-term assessments by the OECD (which are somewhat optimistic in general).

In Central East European countries within the catchment area of the Danube (Croatia, the Czech Republic, Hungary, Slovakia, Slovenia) an average real rate of growth in GDP of 4.0% in the pessimistic and 5.0% in the optimistic scenario was assumed. These growth rates may look quite modest at first glance. But experiences of catch-up processes in various semi-periphery or periphery countries of the world economy so far have shown that an average real rate of growth in GDP of more than 5% within a 15-year-period is extremely unusual and can be achieved only under certain circumstances such as strong governmental regulations and protectionism (as in the case of South Korea and Taiwan). Of course, the situation in Eastern Europe is unique and cannot be compared to other historic events but general economic and political factors as well as the experience so far do not suggest itself a unprecedented positive development.

In Southeast European countries (Bulgaria, Macedonia, Romania, Yugoslavia) a slower rate of growth is expected of 2.5% in the pessimistic and 4.0% in the optimistic scenario. These lower rates shall represent the weaker economic position of the countries concerned such as a more unfavourable economic structure, a worse infrastructure, and an uncertain political situation. Economic disturbances in Bulgaria in 1996 and 1997 show that economic development in this region is in fact less stable than in Central East European countries.

In the successor countries of the Soviet Union even lower rates of growth are assumed. In Russia and Ukraine, average annual real rates of growth of 1.5% in the pessimistic and 3.0% in the optimistic scenario are expected. For Moldavia, a growth rate of 2.0% in the pessimistic and 3.0% in the optimistic is imputed. Given the tremendous economic and political problems in this area an average growth rate of 3% per year seems a best case scenario.

Table 3.2:

Main elements of Scenario assumptions

GDP growth p.a., in %

	'Pessimistic Scenario'	'Optimistic Scenario'
Central (CZ, SK, H, SLO)	4.0	5.0
East (CRO, RO, BG, TR)	2.5	4.0
GUS	1.5	3.0

3.2.2.2 Unit Values

In the pessimistic scenario it is assumed that unit values (in real terms) will change from 1995 to 2010 to the same total rate as they did in 1990 to 1995, i.e., that the speed of change will slow down to a third. This assumption is in accordance to the assumptions regarding economic development. If the economic catch-up process is not successful the pattern of production and the pattern of trade will not change very much as real unit values will not do so either. In the optimistic scenario, a value of 1.25 is assumed for the constant indicating a somewhat faster (positive) change in real unit values than in the pessimistic scenario reflecting the generally higher speed of change in economic variables under the optimistic scenario.

3.2.2.3 Other Variables

Concerning the dummy variable for "membership“ in the European Economic Area (EU and EFTA) changes in pessimistic scenario membership is assumed only for the Central European countries of the Danube region (Czech Republic, Slovak Republic, Hungary and Slovenia). In the optimistic scenario Croatia, Romania, Bulgaria and Turkey are assumed to be economically fully integrated also by 2010.

3.2.3 Commodity Group Estimation

3.2.3.1 General

The estimation procedure for calculating product group specific bilateral trade volumes in 2010 for the two scenarios differs in some respects from the general procedure described above.

- For five of the countries among the group of countries considered (Austria, the Czech Republic, Hungary, Slovakia, Yugoslavia) forecasts for trade flows from and to overseas countries were made.

- For relations underrepresented in the actual matrix, a dummy value was estimated due to corresponding trade intensity in Central Europe.

- In the case of Yugoslavia this method had to be enlarged to all relations, since the 1995 trade volumes were significantly below previous and ‘natural’ levels due to the war, the embargo and due to illegal trade not reflected in statistics. Thus, the 1990 trade matrix representing a ‘normal year ’was used as basis for the prognosis (‘dummy matrix).

- In the prognosis of the product group 2 followed a different approach as described in the next chapter.

3.2.3.2 Product Group 2 Estimation

Since first calculations of the product group 2 - raw materials and material-intensive products within the trade model have not led to satisfying results, the prognosis of product group 2 was spilt into the four sub-groups.

In the following the resulting 8 groups named commodity groups (figure 3.6).

The following assumptions were made (table 3.3).

- Crude oil (99% originating from Russia was excluded from product group 1) since it is transported by pipeline.
- Growth rates were estimated according to the overall economic performance by scenario.
- Since the change to capital-intensive mining, increasing significance of labour costs in central Eastern Europe (CZ, PL) and due to a foreseeable exhaustion of certain European mines a shift from traditional European suppliers to overseas suppliers was estimated in the case of solid mineral fuels (coal) and ores.
- Growth rates of PG2-rest were taken from the trade model, but also subjected to assumptions of a certain shift to future overseas suppliers.

Table 3.3:
Assumptions on Product Group 2 Development

	Pessimistic Scenario		Optimistic Scenario	
	Growth factor 1995/2010	Shift to overseas *	Growth factor 2010/1995	Shift to overseas *
PG 28	1.1	0.20	1.15	0.20
PG 32	0.7	0.50	1.0	0.50
PG 333	-	-	-	-
PG 2-Rest	1.21	0.20	1.36	0.20

* Shift 0,20: 20% of product originates from overseas, 80% from former origin (supplier country)

PG: see table 3.4.

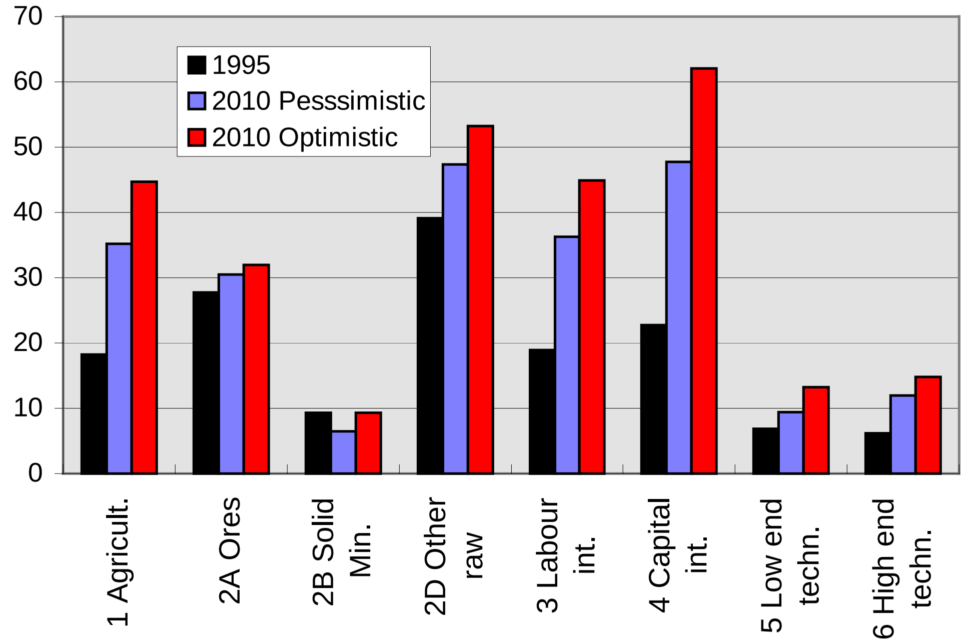
3.2.4 Results: Prognosis of Overall Transport Volume

Commodities by trade are shown in absolute figures (Mio net tons) and in relative figures. The results show:

- a generally positive development of transport volumes of most commodities taking place according to both economic scenarios.
- Commodity groups 1, 3, 4 and 6 undergoing strongest growth in both scenarios
- modest development of commodity group 2.
- modest development of Austria exports.
- considerable development in Central European countries exports.
- modest to high development in South-East European countries, depending on the Scenario of Economic development.

The development is illustrated by figures 3.6 and 3.7.

Figure 3.6:
Prognosis of transport volumes in Danube Region, by country (mn tons)



Note: Data contain transport flows parallel to Danube River region, by country of origin

Figure 3.7:
Prognosis of transport volume in Danube Region, by commodity group (mn tons)

Commodity Groups mn tons	**1995**	**2010 Pessimistic**	**2010 Optimistic**
1 Agricultural	18.3	35.2	44.7
2 Raw mat. & material intensive			
of which ores and solid minerals*	37.1	33.6	36.5
other	39.1	40.9	46.0
3 Labour intensive	18.9	36.2	44.9
4 Capital intensive	22.8	47.7	62.1
5 Low end technology	6.8	9.4	13.2
6 High end technology	6.2	12.0	14.8
1, 3-6 Medium and high valued comm.	72.9	140.5	179.7
2 Raw materials and mat. int. Products	74.5	74.1	82.5
All Commodities	147.4	214.6	262.2

Note: table only contains international relations parallel to the Danube River (see 4.1.2), and no country internal transports. * Crude oil not considered in transport matrix

3.3 Inland waterway Transport on the Danube between 1990 and 1995

This section aims to analyse goods transport on the Danube for the time period between 1990 and 1995 in terms of volume, product composition and the spatial pattern of transport flows.

The section consists of four sub-sections. First, some general characteristics of the organisational, infrastructure, navigational and political background of inland waterway transport on the Danube are summarised. Second, the development of the volume of transport on the Danube in the time period 1990 to 1995 is discussed but giving also attention to some long-term trends. Third, changes in the product composition of transport flows are analysed. Finally, changes in the spatial pattern of transport, i.e. shifts in the relative importance of transport relations are characterised.

3.3.1 General factors Influencing Transport on the Danube

There are different factors influencing the performance and competitiveness of inland waterway navigation. In the following, some major aspects of the organisational, infrastructure, navigational and political factors are summarised.

With respect to organisational factors, the following aspects seem worthy of mention:

- In the course of economic transformation in Eastern Europe, a reorganisation of state-owned national shipping companies took place which partially increased the market orientation and competitiveness of these companies.
- Following the opening of the Main-Danube canal, Western European "Partikuliere“ (small size enterprises) companies entered the transport market on the Danube introducing new concepts of logistics and transport management.
- In Germany, Austria and Hungary efforts were made to shift transport flows from other means of transport towards inland waterway navigation, especially by improving supply for containerised transport.

Concerning the infrastructure and navigational aspects of inland waterway navigation on the Danube, the most important improvement during the time period under review was without doubt the opening of the Main-Danube canal in September 1992 connecting the Danube waterway system with that of the Rhine. Furthermore, the hydroelectric power plant of Gabcikovo in Slovakia started operation in 1993 and improved the navigational quality of the Danube in this section. However, bottlenecks still exist in the infrastructure for inland waterway navigation such as bridges with low height and fairways of limited depth. On the other hand, some major investment in port facilities took place.

The war in former Yugoslavia and the embargo of Yugoslavia in this context from 1993 onward, heavily hampered transportation on Danube River. The embargo did not only reduce international transport volumes from and to Yugoslavian ports to nearly zero, it also considerably reduced Yugoslavian inland waterway transit, though it did not interrupt it completely.

Summing up, both positive and negative effects on goods transport on the Danube were observed in the time period reviewed. The opening of the Main-Danube Canal and new entries in the transport market have already improved the competitiveness of the Danube vis-à-vis other modes of transport and have led to slightly increased market shares of inland waterway transport in specific market segments.

3.3.2 Volume of Cargo on the Danube

Due to the decline in transported goods on the Lower Danube, the share of the Austrian section in overall Danube transport thus has become extremely high (see Figure below, domestic transport excluded).

Currently remaining transport relations of significant importance are iron ore shipments from Ukraine to Bulgaria and Hungary, and different products from Hungary and Bulgaria to Ukraine. Therefore, data on the Austrian section may be regarded as quite representative for overall international transport on the Danube. Fig. 2.1 shows a considerable reduction in transport volumes from 1989 (22 mn tons) to 1993 (9.7 mn tons) and a significant increase thereafter to 13 mn tons [8].

Following the opening of the Rhine-Main-Danube Canal in 1994, transport volumes on the Austrian section of the Danube increased considerably and only in 1996 the level of 1989 was reached again.

On the lowest section of the Danube, especially from and to the Galati port, additional goods are also transported by high-sea vessels. These volumes amounted to 17 mn tons in 1989 and 10 mn tons in 1995. Furthermore, in all Central and Eastern countries a considerable amount of stones and gravel (originating from river dredging and often used as construction materials) are transported. This transport volume comprising an estimated 20 mn tons is not included in further calculations because of its local importance.

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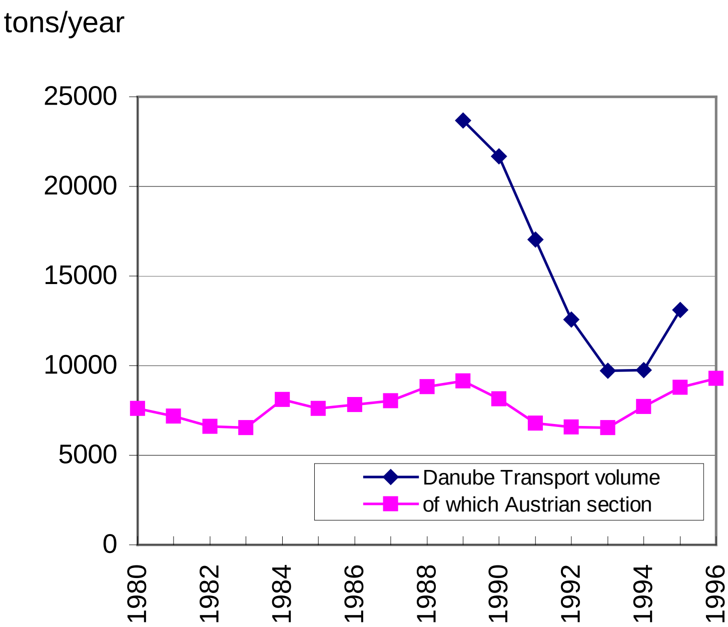
8 Data stem both from the Danube Commission and the ÖSTAT and are adapted in such a manner that high-sea navigation on the lowest section of the Danube (concerning ports in Romania and Ukraine) is not included.

Figure 3.8:
Transport volume on the Danube waterway



Source: Danube Commission/ÖSTAT

3.3.3 Market Share of the Danube

An estimation of actual Danube market potential can be obtained by two methods, firstly, by a comparison of trade statistics with Danube statistics, secondly by using national transport statistics. The advantage of the first method is the simple availability the advantage of the second is the option of analysing market shares by relations, which corresponds most to the category used by shippers to make decicions regarding the use of IWT or a competing mode of transport. A disadvantage is the restricted comparability of the two statistics. Trade statistics define country of origin and destination of goods thus representing the whole transport chain, whereas Danube statistics follows the concept of transport statistics showing origin/destination within inland waterway transport (port - port).

3.3.3.1 National Statistics

National statistics of the Danube Riparian Countries show the importance of inland navigation altogether.[9] Data in Western countries (except for Austria) are of little significance for Danube transport, but allow a comparison with the overall position of inland navigation within the transport system.

9 Source: Eurostat and DG VII, 1997. EU Transport in Figures, 2nd issue.

The figures show a rather small share of inland navigation on the Danube River within the overall transport performance of the countries: shares in Central and East European Danube riparian countries average from 4 - 6% compared to 21% for inland navigation in ‘Western’ countries. Whereas inland has been suffering from decreasing market shares in the long run, the figures show the increasing significance the of Danube as a transport corridor between Central European countries and West European countries as a consequence of the opening up of the Rhine-Main-Danube Canal (Austria, Slovakia).

Similar trends are also identified for the East European countries of Romania and Bulgaria.

Table 3.4:
Transport Performance in the Danube Catchment Area Countries

	1970	1980	1990	1994	1995
Mio ton-km					
West (NL, B, L, D)	86.5	91.1	97.0	103.6	104.4
Central (A, CS/CZ/SK, H)	3.7	6.0	6.1	3.0	3.4
East (RO, BG)	3.2	4.4	3.7	2.3	3.8
Inland navigation	93.4	101.4	106.8	108.9	111.7
Mio ton-km					
West (NL, B, L, D)	274.0	328.8	396.4	489.1	493.4
Central (A, CS/CZ/SK, H)	83.3	114.8	114.9	76.9	86.9
East (RO, BG)	77.4	128.1	109.4	60.0	67.1
3 Modes (Road, Rail, IWW)	434.7	571.6	620.7	626.0	647.5
in %					
West (NL, B, L, D)	31.6	27.7	24.5	21.2	21.2
Central (A, CS/CZ/SK, H)	4.5	5.2	5.3	3.9	3.9
East (RO, BG)	4.1	3.4	3.4	3.8	5.7
Share of IWW	21.5	17.7	17.2	17.4	17.2

Source: Eurostat and DG VII, 1997. EU Transport in Figures, 2nd issue.

In general, it may be said that the economic transformation of Central and East Europe has impacted inland navigation less than rail and even less than road (in terms of transport volume). Whereas inland navigation succeeded in becoming art of the economic recovery, road transport has proven to be more dynamic than inland navigation (Figure 3.9).

3.3.3.2 Comparison of Trade - Transport Statistics

In the following the development of the modal split of inland navigation on the Austrian section of the Danube River is shown to identify the dynamic aspects of development. The Austrian section is of particular importance for the whole Danube, since it contains most long-distance relations of the river and makes up 54% of total Danube region IWW transport. Data are given for important trade relations.

The figures in table 3.5 show a differentiated market situation, where modest gains and considerable losses of transport shares have resulted in a declining modal spilt of IWW from 20.5 to 15.4% within three years. Whereas overall transport (in tons) increased from 36.2 to 40.1 million tons, transport on the Danube River decreased from 7.4 to 6.2 million tons. In other words, the fact, that transport on the Danube River has increased considerably from 1992 to 1995, is entirely to gains in transport with the ARA ports (not included in table 3.5).

Gains were also pasted in Danube transport in bilateral German - Austrian transports, but as these started at a low level, they did not achieve more than 0.6 million tons in 1995. It should also be noted that the low percentage of inland navigation in Austrian - German transport is not only caused by a high share of short-distance border-crossing road transports, but also by the strong market position of rail (30% in Austrian exports to Germany, 24% in German exports to Austria, year 1992).

The losses in inland navigation occurred in both directions. The share of IWW in exports to the East has diminished to only 5 - 10%, whereas in the direction of the West, IWW still has a stronger share of 45% in Austrian imports and 19% in German imports from the Central and Eastern Europe. These differences reflect the heritage of well-established transport relations as well as the preponderance of low-value commodities in Austrian imports from the Eastern - of iron ore and coal.

Table 3.5:
Development of modal split by relation

Relation	1992 Total 000 tons	1992 IWW 000 tons	1992 IWW %	1995 Total 000 tons	1995 IWW 000 tons	1995 IWW %
Austria - Central/Eastern Europe						
Imports Austria	6 855	3 422	49.9	7 586	3 446	45.4
Exports Austria	2 380	679	28.5	2 003	112	5.6
Total	9 234	4 101	44.4	9 590	3 558	37.1
Germany - Central/Eastern Europe						
Imports Germany	6 057	1 593	26.3	8 741	1 650	18.9
Export Germany	2 197	540	24.6	3 470	349	10.1
Total	8 255	2 133	25.8	12 211	1 999	16.4
Relation Germany - Austria						
Austria - Germany	8 398	138	1.6	9 987	365	3.7
Germany - Austria	11 881	244	2.1	8 395	283	3.4
Total	20 279	382	1.9	18 381	648	3.5
All relations of Austria and Germany within Danube region						
Import (upstream)	21 309	5 153	24.2	26 314	5 461	20.8
Export (downstream)	16 458	1 463	8.9	13 868	744	5.4
Total	37 768	6 616	17.5	40 182	6 205	15.4

Note: only relations with Austria and Germany, transports, which represent 54% of international transports on the Danube.

* excluding Austria and Germany

If transport relations are broken down by country-to-country relations, an even more differentiated market situation is revealed. In some relations IWW still transports a considerably high share of transport volume, and, in others it has even managed to increase these high shares.

The sum of the fifteen relations with the highest IWW transport volume make up a share of 16.5%. If bilateral transports between Germany and Austria are excluded, the IWW share rises to 29.3%, which compares well to 28.6% three years before. In other words, IWW has succeeded in several relations not only in keeping pace with transport development, but it also has improved its position in many relations.

Country relations ranked by modal split give us the following picture:

Table 3.6:
Ranking of relations by modal split of IWW

Relation	1992 Total 000 tons	1992 IWW 000 tons	1992 IWW %	1995 Total 000 tons	1995 IWW 000 tons	1995 IWW %
1 Romania - Austria	349	224	64.1	423	300	70.9
2 Bulgaria - Austria	46	36	78.0	86	58	67.6
3 Ukraine - Austria	2 321	2 191	94.4	2 243	1 437	64.1
4 Hungary - Germany	1 751	481	27.5	2 288	953	41.7
5 Slovakia - Austria	1 600	697	43.6	2 165	893	41.3
13 highest IWW-relations (tons) excluding Germany-Austria	15 522	5 065	32.6	18 684	5 477	29.3
15 highest IWW-relations (tons) including Germany - Austria	35 800	5 447	15.2	37 065	6 125	16.5

Note: only relations with Austria and Germany. Source: Stabu, ÖSTAT.

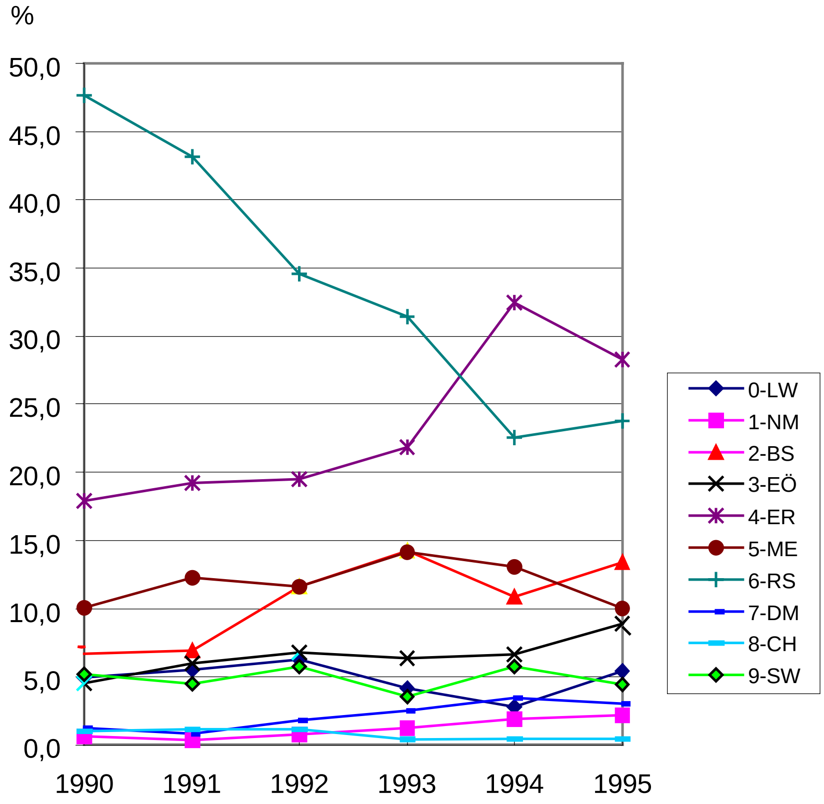
Relations between the ARA-ports and Austria have become increasingly important. Since 1995 transport statistics have not been completely available, the modal split of inland navigation can only be estimated as developing satisfactority. The Rhine-Main-Danube canal has, within three years, enabled the waterway to transport more than 1.1 million tons between the Netherlands, Belgium and Austria. It should be noted that during the same period, the railway has even managed to increase its transport volume to more than 1.3 million tons. The conclusion is that the opening of the waterway has intensified intermodal competition, reduced prices and/or provided better transport services in the relations in general. The presumed large overall growth of transport indicates, that among the consequences of this development might also be counted the creation of additional transport demand.

3.3.3.3 Product Composition of Goods Transport on the Danube

The product structure of transport flows on the Danube is analysed for the time period 1990 to 1995 by applying the NSTR classification on the digit-1 level.

Figure 3.9 shows the product composition of goods transport on the Danube both for overall transport volumes (according to data of the Danube Commission for which country specific information was summed up) and the transport flows on the Austrian section of the waterway for the time period from 1990 to 1995, and 1990 to 1996, respectively.

Figure 3.9:
Product composition of transport flows on the Danube by NSTR



0	Agricultural products and life animals
1	Foodstuff and animal fodder
2	Solid mineral fuels
3	Petroleum products
4	Ores and metal waste
5	Metal products
6	Crude and manufactured minerals, building materials
7	Fertilizers
8	Chemicals
9	Machinery, transport equipment, manufactured articles and miscellaneous articles

Source: Danube Commission

In overall inland waterway transport on the Danube, the most important product group is 'other raw materials and building material', which accounts for almost half of total transport flows in 1990, but whose share fell to approx. 25% in 1995. Other product groups with significant shares of inland waterway transport are ores, coal, oil products and metals. Food, agricultural products and fertilises as well as the two large groups of chemicals and fabricated goods, i.e., all consumer and investment goods (except building materials) - which show a share of 35 to 40% in overall trade in the economic catchment area of the Danube (in terms of weight) - only have a share in total transport on the Danube of below 10%. From 1990 to 1995, the category of other raw materials experienced a sharp decrease in their share, while ores, coal, oil products and metals were able to increase their shares.

Concerning the Austrian section of the Danube (with presumably more reliable data) the most important product groups are ores, oil products and metals. Chemicals and manufactured products only account for less than 3% of total transport volumes. From 1990 to 1995, the share of coal significantly decreased and the share of food and fodder strongly increased.

3.3.3.4 Danube Market Share by Products

The considerable differences in the pattern of product composition between the data for overall transport volumes and for transport on the Austrian section may be explained to some extent by different trade patterns in the Western part of the catchment area of the Danube compared with trade patterns among Eastern European countries. However, systematic differences might also exist in the collection of data by the Austrian Statistical Office, on the one, hand and the Danube Commission, on the other. The extremely high share of other raw materials and building materials in the statistics of the Danube Commission seems somewhat unrealistic, especially since the associated transport volumes in this product group do not appear in the data on bilateral transport volumes on the Danube provided by the same source of data. Therefore, the pattern of product composition as shown for the Austrian section of the waterway is likely to represent the more realistic picture.

For 1995, market shares have been calculated for a widened region including trade flows between riparian countries of the Rhine, on the one hand, (the Netherlands, Belgium, France, Switzerland) and the above mentioned riparian countries of the Danube (except Germany), on the other.[10].

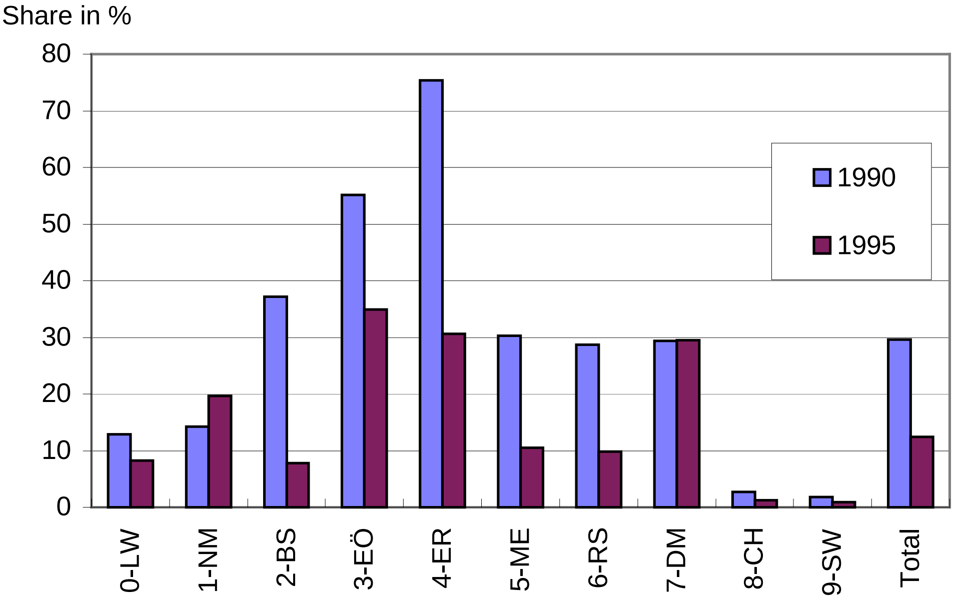
The results show that,

- the Danube lost considerable market shares in international transport (a more significant loss than in overall transport including domestic transport)
- there are significant differences in the market share of the Danube by different product groups and,
- the market share of the inland waterway navigation within the catchment area of the Danube declined between 1990 and 1995 in nearly all product groups.

The only product group of transport on the Danube, which was not able to increase its market share, is food and fodder, whereas the market share for fertiliser remained constant. The strongest decreases in market shares for the Danube between 1990 and 1995 were observed in coal (from 30% to 7%) and in iron ore (75% to 30%). The lowest market shares (with 3% and 2%, respectively, in 1990 and 1% and 0.5% in 1995) occurred in chemical products and manufactured products, i.e., classical products of intra-industrial trade.

10 Total volume of transport on the Danube is calculated using information both from ÖSTAT and from the Danube Commission. The level of high-seas shipment on the lowest part on the Danube which is included in the data published by the Danube Commission is not considered.

Figure 3.10:
Estimated market shares for the Danube waterway by NSTR



Source: Danube Commission

3.3.3.5 Transport Volume by Danube Sections

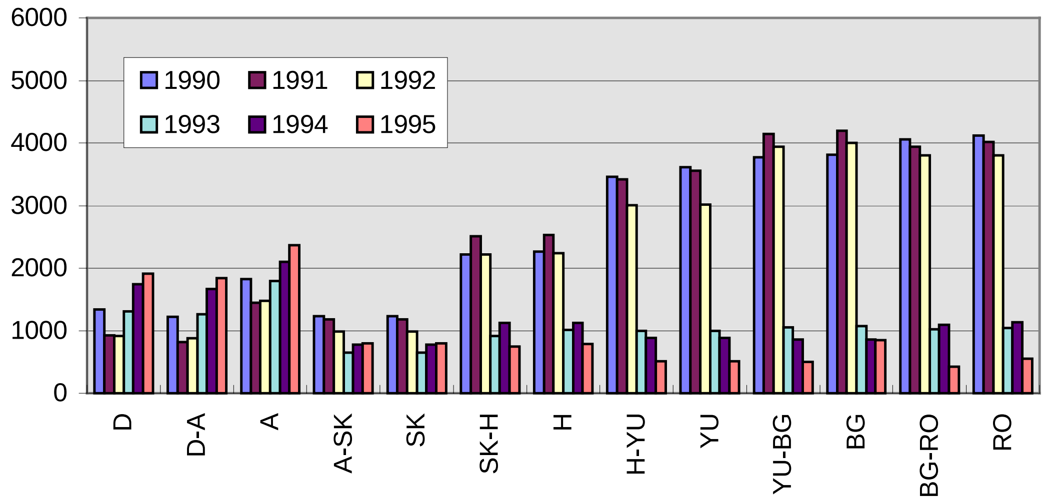
Sections are defined as such that the transport volume for a country comprises all incoming, domestic and transit traffic while the transport volume for the border between two countries consists of outgoing and transit traffic. Furthermore, transport flows are differentiated by the direction of transport, i.e. upward and downward traffic. Upward traffic corresponds to transport flows from East to West, downward traffic to those from West to East.

The main results of figures 3.11 and 3.12 may be summarised as follows:

- in all years of the time period 1990 to 1995, upward traffic significantly exceeded downward traffic, in general by the factor of 2;
- the transport volumes decreased in nearly all sections considered;
- the most dramatic reduction in transport volumes occurred in the Eastern part of the waterway, i.e., east of Hungary. This fact may be explained by the more serious transformation problems of these countries, by the specific reduction in demand for raw materials (iron ore and coal) and by the negative effects of the Yugoslavian war and the associated embargo;
- as a result there is a significant shift in the importance of individual sections for overall transport volumes.

Figure 3.11:
Development of Danube Transport Volume by sections - Downstream

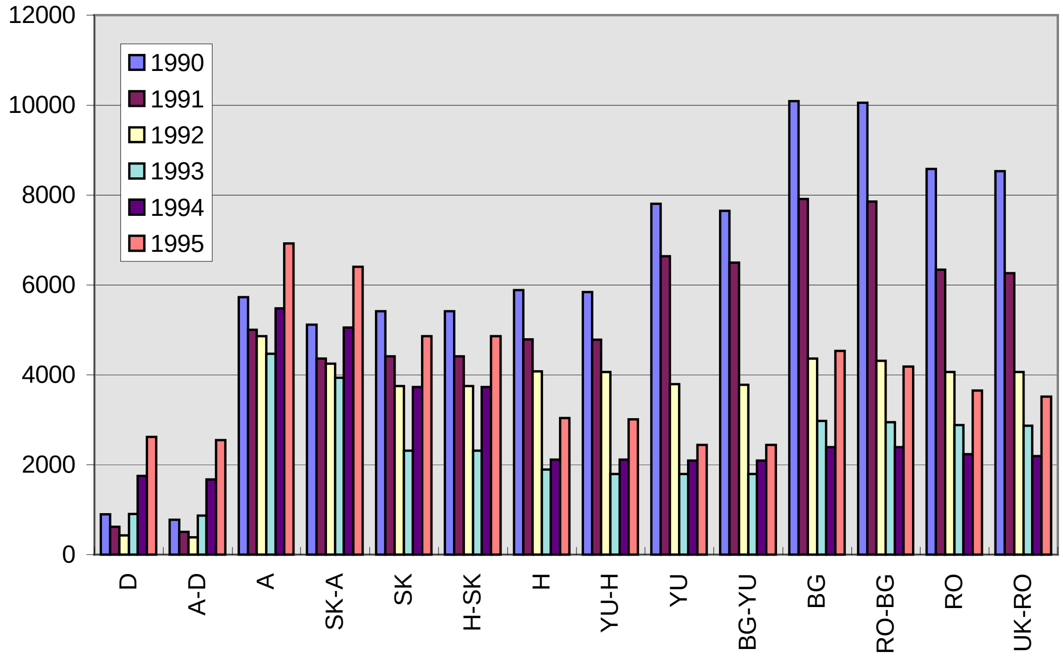
'000 tons



Source: Danube Commission

Figure 3.12:
Development of Danube Transport Volume by sections - Upstream

'000 tons



While in 1990, the Rumanian, Bulgarian and Yugoslavian sections were the most important in terms of transport volumes, in 1995 this role had changed to the Austrian section of the Danube. Downward traffic east of Hungary declined extremely until 1995, while the German section gained as a result of the opening up of the Main-Danube canal.

The ARA ports thus had gained additional customers formerly served via Black sea or by other modes. This especially true for agricultural products, food and fodder, and metals.

This development is reflected in the ranking of countries of origin and destination (table 3.7).

Table 3.7: **Ranking of Countries of Origin and Destination in Danube Transport in 1990 and 1995**

(in millions of tons)	1990		*1995*	
a) Countries of Origin:	Ukraine	9.9	Ukraine	3.6
	Hungary	2.1	Hungary	2.4
	Czechoslovakia	2.0	Slovakia	1.7
	Austria	1.8	Austria	1.3
b) Countries of Destination:	Austria	5.6	Austria	5.7
	Ukraine	5.1	Bulgaria	2.2
	Yugoslavia	3.4	Germany	2.2
	Bulgaria	3.0	Ukraine	1.0

Source: ÖSTAT, Danube Commission

3.4 Modelling Potential Transport Flows on the Danube

3.4.1 General

The objective of this section is the evaluation of present and future role of river Danube as a main European waterway by analysis transport demand and is likely reaction to improvement measures. A model has been designed to assess the potential of Danube River transport.

To assess the market for transport on river Danube transport matrices have been compiled on a *regional* base. To overcome the considerable shortcomings in data availability and quality, two approaches have been chosen and matched together:

- a ‘top-down’ approach using trade statistics data
- a ‘bottom-up’ approach based on transport statistics, supported by traffic count and regional data

The first approach has been widely demonstrated under section 3.2.

The second approach may be summarised under three central aspects:

- matching of trade with transport data (Trade statistics with Danube statistics)
- zoning and regionalisation (data disaggregation)
- transport modelling / potential calculation

3.4.2 Trade and Transport Data in Danube Region

Information on transport volume between countries can be found in two types of statistics: transport statistics and trade statistics.

- Trade statistics analyse trade flows between countries, but - when crossing the border - only one transport mode is given, even if transhipment takes place.

- Transport statistics are based on movements within a transport mode and provide information on goods carried from A to B, but there is no information, if B is the final destination or if transhipment to another transport mode takes place there.

The advantage of trade statistics thus is better information on import and export volumes providing information on the whole transport chain. Only trade statistics thus allow to simulate the shift of long-distance transport flows from one mode to another. This is essentially true in case of River Danube, where at present a considerable amount of transport does not take place within corridor, but uses other routes (as sea transport as short-sea-shipping via Greece).

As a consequence, trade statistics were used to regionalise transport flows. To split actual inland waterway transport on river Danube, transport statistics (port-to-port statistics) were additionally used and - in cases of data availability - where adopted to trade statistics. The most import case were exports from Ukraine to Austria which were correctly split into direct and transport and the rail/Danube transport chain.

3.4.3 Zoning and Regionalisation

Zoning is understood as regional disaggregation of country variables into regional subdivisions. It has been attempted to identify regions of similar size. Along the Danube River, the attempt has been made to use national statistical units up to a radius of 100 km from Danube ports. In more distant regions, also larger areas have been identified. The basis has been the statistical subdivisions of the countries. The exception is Croatia and Yugoslavia, where, due to the lack of data available, estimations on regional distribution were made on the basis of distance to Danube ports. The 67 regions identified are shown below (the task has been already documented in detail in IR 2-2, 5.3).

Contrary to the West European lowlands, in Danube region has no interconnecting network of tributaries or canals, which could be used as feeder transport routes improve the access to the Danube. Actual transport on river Danube is restricted more or less to transport between the ports. Transport within intermodal chains, which would integrate transport from the port's hinterlands, have hardly been established. With short distances from Danube port modal spilt of IWW at present tends to Zero. An analysis of IWW potential thus calls for the assignment of transport origins and transport destinations according to their position to Inland Waterway.

The matrix comprises of

- the Danube countries
- the main West European IWW-countries (Benelux, Germany)
- the Black Sea Countries: Ukraine, Turkey
- the main Overseas trade partners of land-locked Danube countries

To encompass trade volume exhaustingly - countries which may be more relevant for Danube transport in the future than at present, France and Russia were included. Transport volume of Russia was assigned to a reduced extent (estimation of Black Sea region transport).

Transport data thus had to be regionalised from country-to-country matrices to region-to - region matrices. The procedure of regionalization had to follow different paths:

- EU countries: transport matrices were available on NUTS-2 basis (1992). Origins and destinations were assigned by real 1992 shares

- East European Countries:

    - IWW data were assigned to main ports the hinterland region of the according to (Statistics of Danube Commission, 1995)
    - road and rail data had to be disaggregated by socio-economic regional indicators

Data have been compiled from two sources: trade and transport statistics. For two reasons the decision was made to use trade statistics to set up a country-to-country matrix:

- availability for all countries
- availability of more recent data (provided by UNCTAD data base for year 1995) data
- data covering the whole transport chain, with the possibility to simulate changes in transport routings

The data were available for all countries. This is especially important in the case of Eastern and Southeast Europe, where transport statistics data are available only up to a limited extent or are sometimes of low reliability.

The latter issue is of crucial importance for the prognosis of future Danube transport potential, since actual transport flows often use alternative routes. This mainly concerns sea transport in the Black Sea region and sea and shortdistance seatransport with Greece and Turkey, which at present are being used to a high degree[11] . The model was set up to consider possible alternate routings.

The situation is different for Upper Danube countries. Transport statistics from the EU member Danube countries of Austria and Germany have of well-documented regionally divided and modal transport statistics. This is at least true for the old concept of registration at the border, which included the total amount of transports crossing the border. With the new concept of samples at national shippers, the situation has worsened. Yet the study was able to avoid this disadvantage by using Austrian and German transport statistics data still relying on the old concept (year 1993 and 1994) to regionalise the transport flows. The transport statistics were used in a second step of regionalisation to adapt the regionalised trade statistics database.

Regionalisation was done in three steps:

Step 1: Aggregation of the port-to-port IWT transport matrix to the region-to-region matrix[12].

Step 2: Transformation of intermodal IWT relations to region of origin or destination of intermodal chain.

Step 3: Disaggreation of country-to-country matrix following two approaches, according to the availability of data. The result is the a 67 x 67 dimensioned matrix of disaggregation percentages for each country-to-country relation.

Step 4: Disaggregation of country-to-country prognosis matrices (documented above in previous chapter by the disaggregation percentage matrix).

These relations had been disaggregated by linear distribution according to the best available variable. Firstly, the variable industrial labour force was preferably used (based on the assumption, that regional transport volumes depend largely on industrial

11 See ASH, 1996.

12 Sources were Danube Commission ; ÖSTAT for Upper Danube and The KIENBAUM Study for Lower Danube, see also IR 2-2

production; and mining activities also are connected with the ancillary adjacent labour force). Secondly, if data on the labour force were not available, regional GDP was used; thirdly, population was used.

Table 3.8:
Regions and Nodes

	Region	Country	Node		Region	Country	Node
1	France	F	Paris	35	Vojvodina	YU	Novisad
2	Belgium	B	Antwerp	36	North Serbia	YU	Belgrade
3	Netherlands	NL	Rotterdam	37	Rest S., Kosovo, Monten.	YU	Nis
4	East Germany	D	Berlin	38	Makedonia	MK	Skopje
5	Hamburg, Schleswig-H.	D	Hamburg	39	Greece	GR	Athens
6	Niedersachsen, Bremen	D	Brunswik	40	Cluj	RO	Cluj
7	Nordrhein-Westfalen	D	Cologne	41	Timis	RO	Timisoara
8	Hessen, Rheinl-Pf., Saarl.	D	Francfort	42	Mehedinti	RO	Orsova
9	Baden-Württemberg	D	Stuttgart	43	Olt	RO	Craijova
10	North Bavaria	D	Nürnberg	44	Giurgiu	RO	Giurgiu
11	East Bavaria	D	Regensburg	45	Sibiu	RO	Sibiu
12	South Bavaria	D	Munich	46	Brasov	RO	Brasov
13	Switzerland	CH	Basel	47	Bucuresti	RO	Bucharest
14	West Austria	A	Innsbruck	48	Ialomita - Calarasi	RO	Cernavoda
15	South Austria	A	Villach	49	Constanta	RO	Constanta
16	Upper Austria	A	Linz	50	Galati	RO	Galati
17	East Austria	A	Vienna	51	Iasi	RO	Iasi
18	Czech Republic	CZ	Prague	52	Michailovgrad	BG	Vidin
19	Bratislava	SK	Bratislava	53	Sofija	BG	Sofia
20	Mid Slovak Rep.	SK	Zilina	54	Lovetch	BG	Pleven
21	East Slovak. Rep.	SK	Kosice	55	Plovdiv	BG	Plovdiv
22	North West Hungary	H	Györ	56	Ruse	BG	Russe
23	Budapest	H	Budapest	57	Haskovo	BG	Stara Zag.
24	Lower Danube	H	Dunaújvaros	58	Varna	BG	Varna
25	North East Hungary	H	Miskolc	59	Burgas	BG	Burgas
26	South East Hungary	H	Szeged	60	Moldova	MD	Chisinau
27	South West Hungary	H	Nagykaniza	61	Mid Ukrajina	UA	Lvov
28	Slovenia	SLK	Ljubljana	62	West Ukrajina	UA	Kyiv
29	Istria-Kvarner	HR	Rijeka	63	Odessa	UA	Odessa
30	Dalmatia	HR	Split	64	East Ukrajina	UA	Dnepropetr.
31	Zagreb	HR	Zagreb	65	Russia	RU	Novorossij.
32	Osijek-Baranja	HR	Osijek	66	Türkiye	TR	Istanbul
33	Bosna i Hercegovina	BIH	Sarajewo	67	Overseas	OS	-
34	Albania	AL	Tirana				

3.4.4 Network Assignment

3.4.4.1 The Networks

The task of modelling transport between a large number of regions requires the use of a detailed network graph. To simulate transport flows (inland navigation and transports of all modes) networks were generated covering the whole Danube region. The objective of this task was twofold:

- to set up matrices of distances, travel time and cost as input for the modal spilt model
- to show the volume of corridor transport, i.e., transport parallel to the Danube River and to give a rough idea of the share of Danube transport on certain Danube sections.

Two networks were constructed and attributed with main parameters:

The rail network was used to represent land transport as a whole[13]. The reasons were:

- due to its composition of low-valued commodities, rail transport is main competitor of inland navigation on the Danube River
- rail has a strong position in international transports on the Danube downwards to Budapest and still has a strong position in national land transport
- the rail network has a density comparable to high level road network

The inland navigation network was compiled from Danube, the Cernavoda - Constanza-Canal and the other West European waterways of at least ECE-class IV. Due to their minor importance the Danube tributary rivers were not included in the IWW network. An integrative part of IWW network are access links, which are represented by a whole rail network (as above) and by transhipment links.

The networks are demonstrated in the graph (figure 3.13).

The networks consist of nodes and links. Links were attributed by weights representing the quality of the transport network. The assignment of transport flows within network is based on shortest path algorithm. Weights correspond to actual generalised cost. Transport time and transport cost were combined into a general weight factor. Network elements were as follows:

---

13 Quality of infrastructure; a detailed analysis is given in IR2.

Network elements were as follows:

Table 3.9:
Elements of network graphs

Network	Elements	Distance	Time	Quality
IWW + land access	inland waterways	km	hours (see IR1)	cost function
	transhipment nodes	-	min.	type
	rail	km	min (km/h)	type
IWW + land access				
Land transport	rail	km	min (km/h)	type

3.4.4.2 Special Case: Overseas Relations

Goods given in trade statistics as 'Overseas origin' mutate to goods originating from sea ports in transport statistics. Whereas transport statistics reveal the route the good has taken, trade statistics in most countries withholds this information, but - knowing the network - it reveals information on the variety of possible alternative routings. The information trade statistics supply, might therefore be very valuable for the identification of transport potentials. The routing model thus has been designed to analyse alternating routings. This mainly, but not exclusively, refers to overseas transports.

An analysis of Oversea transport relations and nationality of carrier show a quite clear attribution of regions to the two Danube access routes:

- East and Southeast European regions use the Danube - Black Sea ports route (though on should not oversee that absolute figures are relatively low in comparison to land or short sea shipping transport),
- Middle Eastern countries use both routes and the
- rest of the world uses the route via the ARA ports.

The conclusion was drawn, that there is a certain potential for using the Danube and the Black Sea ports for transports with Greece, Turkey, the Near and Middle East for the whole course of the Danube. Thus the need was identified to simulate the choice of shippers between the two access routes to Danube River. As a consequence, the routing model was enlarged and sea transport routes introduced as access routes.

Table 3.10:
Austrian Overseas transports on the Danube River by sea routes

	Transport 1996 in '000 tons			in % of total	
Austrian Foreign Trade with	ARA	Black Sea	Total	ARA	Black Sea
Greece	0	10	10	0.0	100.0
Turkey	2	23	26	9.6	90.4
East	5	123	128	4.1	95.9
Middle East	49	40	89	55.2	44.8
Far East	68	10	78	86.7	13.3
Sub-Saharan Africa	431	3	435	99.2	0.8
America	242	1	242	99.7	0.3
Total	798	210	1008	79.2	20.8

Source: ÖSTAT

3.4.4.3 Transport Time in Network

The simulation of rail transport times was based on the LIM time tables of the European freight train conference. LIM time tables give travel frequency and travel time of complete load trains and of intermodal transports. The analysis covered transport relations parallel to Danube River. The fastest and the average rail connections were selected. The analysis of LIM tables shows considerable differences in travel speed by transport relations. Whereas the railways have a strong market position in freight transport in Austria, Hungary, Slovak Republic and the Ukraine, actually the railways' market position decreases towards from the Southeast. In former Yugoslavia, Romania, Bulgaria, Turkey and Greece a very weak position in international transport is observed. This statement is underlined by the extremely low average transport times between freight nodes.

Since transport speed varies from the train to train, generalised assumptions on transport speed had to be made. Links and nodes (centres with large marshalling yards, border stations) railway were classified by quality and average speed. Including stops at borders and at nodes, the average freight transport speed of rail is between 25 km/h and 40 km/h for Western Europe, 20-25 km/h for Central East and 15-20 km/h for Eastern Europe. These average transport speeds are comparable with an average speed of 7-10 km/h for inland navigation on the Danube River. This indicates, that inland navigation in Southeast relations can even compete with rail in terms of transport time.

Times within nodes were attributed case by case of which border waiting times were 2 - 8 hours.

Figure 3.14:

International transport volumes 2010 within Danube relations

All modes assigned to railway network (modest GDP growth assumptions)

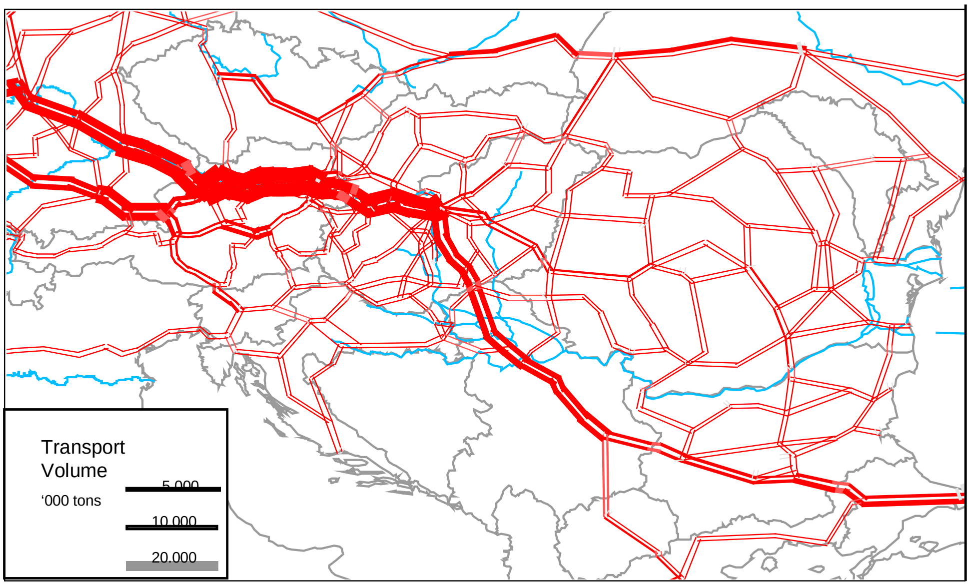
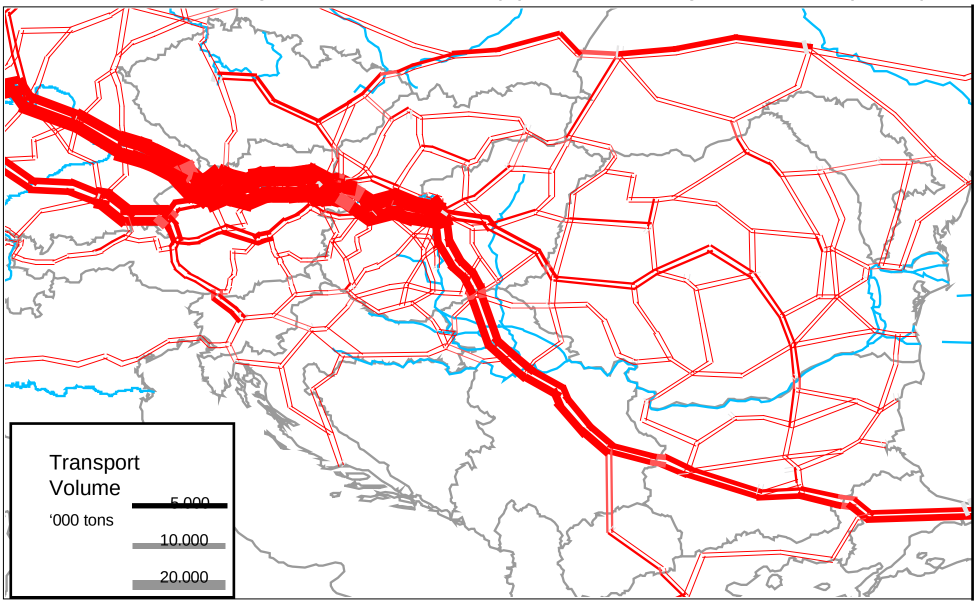


Figure 3.15:

Intenational transport volumes 2010 within Danube relations

All modes assigned to rail network (optimistic GDP growth assumptions)



3.4.5 General Elements of the Split Model

3.4.5.1 Methodology

The objective of this task was the identification of the future market potential for inland navigation on the Danube River out of the overall transport volume in the Danube Region. To identify the future inland navigation transport volume from overall transport volume, a modal split model has been applied.

Since main inputs for the model refer to costs and time, a general cost function had to be derived from the forwarding, the transport and the transhipment of cargo by kind of goods. And, in a further step, these cost elements had to be attributed to links and nodes of the inland navigation network. As a result, the future transport on the Danube River was modelled in a modal split model. The model considers both parameters of economic development and measures of inland navigation on the Danube River.

3.4.5.2 Intermodal Cost Comparison

Transport costs of modes have been analysed for a variety of relations. Most data stem from Upper Corridor companies, supplemented by data from Romania and Bulgaria. Since transport costs constitute quite sensitive data (in economic competition), precise data were sparse. Yet a restricted bundle of companies were willing to contribute to the study. The consultant also succeeded in obtaining access to tenders (which may not be cited).

An intermodal cost comparison on **medium distances** parallel to the waterway for Upper Austria - Germany shows, that

- the length of waterway is considerably longer than road or rail (depending on the relation by factor 1.30 to 1.52),
- transport cost of inland navigation including transhipment is 40 - 60% cheaper than road and 5 - 30% cheaper than rail,
- the cost ratio is usually better on longer relations, but even in the shortest relation (Kehlheim - Wels) inland navigation has been cheapest mode.

Data for **long distances on** the Rhine - Danube Relations (freight cost survey 2) support these findings, they reveal

- an even larger cost advantage of inland navigation in comparison to rail and road transport of cargo:

Transport costs in **Central and Eastern Europe** differ from transport costs in Western Europe. On the one hand, insufficient border facilities and inadequate customs procedures cause waiting times both on road and rail, which can range from a few hours up to several days. Another problem is the state of land transport infrastructure, which also increases transport time. This situation varies between border stations, routes and countries. In general, the quality of services is better in the central East European countries than in the countries further downstream in Danube region. This is also true for the railway system, where the railways have succeeded in maintaining or improving their organisational strength, often accompanied by targeted investment into infrastructure and often supplied by the European Community.

Distances and costs between Vienna and Central and East European relations were as follows:

- Low rail tariffs were matched by even lower IWT tariffs. Low tariffs offer can not offset low reliability, danger of cargo damage and lack of transport services.
- Road transport were more reliable than rail transport, but road transport is faced with considerably higher tariffs and border waiting times, too.
- Long-distance inland navigation on the Lower Danube transports between Greece and Turkey, on the one hand, and Germany / Western Europe, on the other had have to compete with the combination road - short-sea transport.
- Further on, a freight tariff overview published by the German inland navigation federation within short periods (fortnight to month), have been used to analyse the seasonal variations of tariffs and regional variations (tariffs in relation to distance).

3.4.5.3 Deriving a General Cost Function

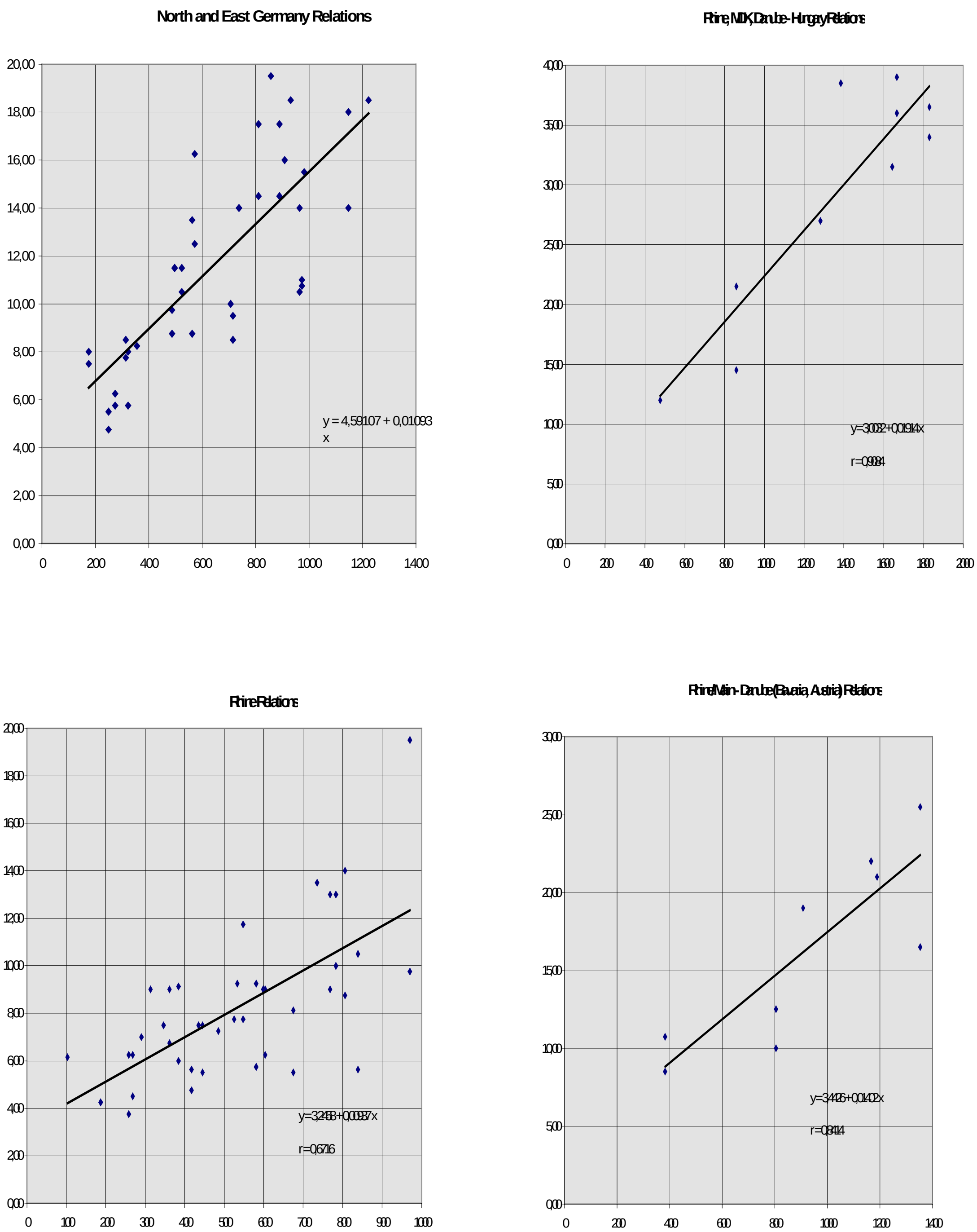
To derive a general cost function, which integrates all cost elements influencing modal choice, actual inland navigation tariffs have been analysed in a regression analysis. Tariffs were split into two elements - a fixed cost element - which has to be paid anyway for moving the cargo on the waterway, and a variable cost element. Variable costs depend mainly on distance and time. To integrate these variables into one cost element time was considered as another aspect of cost.

The regression was made for the main relations between

- ARA-ports, German ports, on the one hand, and
- Bavarian, Austrian and Hungarian ports, on the other hand

The analysis of relations showed a good the degree of correlation between cargo tariffs and distance, but there were significant differences among relations (figure 3.16).

Figure 3.16:
Correlation of Distance and Freight Tariffs.



Source: ÖIR calculations based on *Frachtenspiegel* 1996/97 data. DEM/ton and Distance in km

3.4.6 The Influence of Measures on River Danube

3.4.6.1 Cost of Danube Bottlenecks

It has been demonstrated that nautical conditions have considerable impact on Danube transport tariffs; a corresponding variation in cost for the shippers may also be assumed.

One element of adverse nautical conditions is the restricted navigability in the event of ice. As this situation is restricted to an average of a few days per year (usually on the Upper Danube) there is no restriction caused by ice at all and the situation can be foreseen some days in advance, it has been excluded for model calculations.

A problem, which is more severe, are the low water periods. Although the length of those periods is limited, days with low water have occurred at nearly all times of the year. Since this situation depends on the distribution of rainfall, notably in the eastern Alpine region, even the short term situation on the Danube River is difficulty to predict[14].

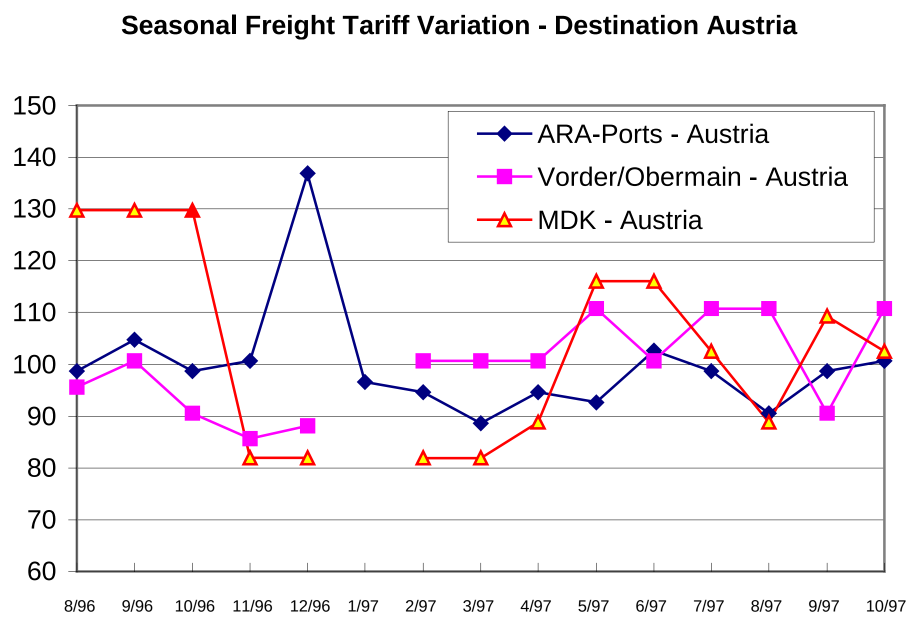
The question now arises to which extent the nautical situation causes additional costs for inland navigation.

Tariff variations did not only occur by season, the seasonal variation differed by relation. This was essentially true for such relations using the Upper Danube. This can be interpreted as a combination of seasonal variations, caused by low water periods, but influenced strongly by a certain delay in time as well as specific regional market situations (disturbances) caused by the interaction between supply and demand for inland navigation transports.

In particular, it is water depth as the hydrological most influential factor for navigation in confined waterways, which causes considerable drawbacks to navigation. Low water levels reduce the possible draught, which the vessels have left to dive. Low draughts result in reduced dead-weight capacity - the vessel has to lighten its load (which causes considerable additional transhipment costs) - and the lightered load has to be transported with another vessel.

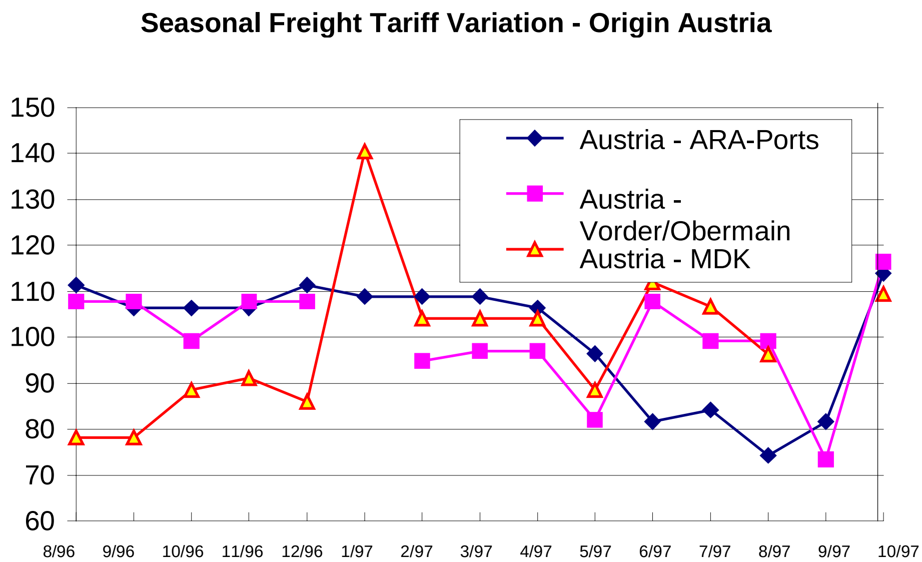
14 A DG XX project 'FLOAT' has developed a method of improving the prediction of Danube nautical situation

Figure 3.17:
Seasonal Tarif Variation of Selected Relations



Year = 100

Source: Frachtenspiegel / ÖIR.



Year = 100

Source: Frachtenspiegel, ÖIR.

Danube sections concerned

In comparison to other European river systems, the Danube neither has officially guaranteed minimum water depths, nor defined depths of immersion (sum of draught and sinking depths) exist. Up to now, the draught of a vessel is determined by the navigation company on the basis of the water level data supplied by hydrographic services. However, this does not mean that the draughts navigated are adjusted to the actual water depths according to hydrographic data, but that these correspond to a standard depth of immersion valid for the lowest daily water level of the relevant month.

The Danube Commission has defined minimum water depths at LNRL (Low Navigation and Regulation Level), which should be secured for navigation during 94% of the navigable season, i.e., excluding the few winter periods when navigation is affected by ice.

There are four sections with frequent unfavourable water depths:

- The 69 km long sector between **Straubing and Vilshofen** (Danube km 2318 - 2249) can be treated as the most critical section. On certain spots of Deggendorf (km 2285) a water depth of only 1.70 m is guaranteed with 89% of probability, and between Deggendorf and Danube km 2247 a depth of 2.00 m is ensured with the same probability (on 326 days per year).

- On the Austrian section of the Danube waterway the navigable bottlenecks regarding insufficient water depths are the sector "**Wachau**" (km 2038 and 2008) and downstream of Vienna with shallow spots down to Bratislava in the Slovak Republic (km 1920-1875).

- According to the recommendations of the Danube Commission, the navigable water depth downstream of Vienna (section **Vienna - Bratislava Cunovo**) should be 2.50 m (in the first phase without canalisation). As recently carried out investigations into the navigable conditions of this sector have proved [15], there was just 2.25 m water depth available on the average in the last decade. Therefore, according to the hydrographic data, the section of the Danube east of Vienna could not be navigated in the last two decades at 2.00 m draught on an average of 84 days and at 2.50 m draught on an average of 155 days, which reduces carrying capacity significantly.

- The fourth section concerns Bratislava - Budapest of which **Palkovicovo - Budapest** is faced with low water conditions.

- Within the Hungarian section from the Ipoly mouth (km 1708) to Budapest (km 1635), the most unfavourable conditions for navigation occur at Nagymaros (km 1697). The Nagymaros threshold may be considered as a critical shallow presenting water depths of 1.40 m to 1.50 m for some periods of the year. A draught of 2.50 m cannot be assured for 160 days/year. This condition has worsened gradually within the last years in the zone of the circular dam.[16]

15 ÖIR, 1995.
16 Ministry of Transport, Budapest, 1994.

3.4.6.2 Future Situation / Measures

The Austrian Government has renewed in the *Binnenschiffahrtsmemorandum 1992* its obligation to assure fair conditions east of Vienna which will allow a draught of 2.70 m. Intensive research on the methods suitable to achieve this goal have been carried out in the last years including conventional low water regulation methods plus a permanent adding of gravel as well as low water regulation methods combined with an artificial pavement of the sole.

Similar to the situation in Bavaria, a final solution on how to improve this particular section has not been found yet. Solutions discussed include conventional hydraulic engineering measures up to the construction of power schemes. The extent of measures which are necessary to guarantee minimum draughts are still being studied by the German 'Bundesanstalt für Wasserbau[17]. The Bavarian Government has postponed finding a solution to the year 2000.

The Hungarian government has proposed in 1992, a three-step programme to improve navigation between Esztergom and Vác, which will come close to the requirements of Danube Commission regarding draught and its availability, only in its third phase scheduled for the years after 2005. In the first phase, originally timed for 1993 to 1996, only 2.10 m to 2.30 m water depth for a width of the navigable channel of 80 m on an average of 240 days/year will be assured. Phase 2 should provide 2.50 m under the same restrictions by 2005.

To show the range of possible improvements, a feasible bundle of measures has been defined as target infrastructure scenario for model calculation. The scenario assumes the realisation of Danube upgrading up to the year 2010, securing a minimum water depth of 2.50 m between Kehlheim and Linz, and a minimum draught of 2.70 m between Linz and Budapest.

3.4.6.3 Integration of Nautical Conditions into the Model

The amount of draught necessary to secure full loading of the ship depends on the type of vessel, on the width of the waterway and on the draught. The crucial dimension is depth of the waterway, which enables maximum dead-weight capacity, which, in turn, determines transport capacity and cost of the transport.

The following procedure has been followed to model the correlation between draught and cost:

- In the first step the correlation between draught and dead-weight capacity defined. The correlations could be for the most common vessels types in on German inland waterways.
- In a second step the nautical situation on the Upper Danube was analysed. For each section and for each period falling in a class of draught, the average weight was calculated summed up to obtain the overall average weight per section.

17 Bundesanstalt für Wasserbau, Möglichkeiten und Grenzen flußbaulicher Alternativen in der Strecke von Straubing bis zur Isarmündung. In: KLEEMEIER, 1997.

- In the third step an *additional cost* factor was calculated by the quotient of average dead-weight/year and average maximum weight available on upgraded Danube sections (estimated at 1830 tons). The cost factor was applied to the whole section.
- To simulate the situation of increased cost by low reliability in a forth step this additional cost factor was multiplied by variable costs for cargo using the section.

3.4.6.4 Cost of Transhipment

Whereas upstream of Budapest it is the waterway itself that needs improvement, downstream it is rather the port infrastructure that is in urgent need of modernisation (also comprising the building of new ports). Inland navigation will have to be much more integrated in intermodal transport aims, if it is going to fulfil its function as an energy-effective long range transport mode not only for bulk cargo. This is not only true for port facilities in the narrower sense (hard ware), but applies especially to the communication sector, in which Danube navigation seems to lag behind the other European transportation sectors tremendously.

Time delays also are caused at ports, where the bad condition of infrastructure and insufficient services may lead to time delays, damages, losses of goods. Whereas a further reduction of tariffs is estimated to be modest due to the present low price levels of IWT, the introduction of general costs (considering also the low reliability of Danube transport) leaves open sufficient room to lower generalised costs of IWT by:

- a constant availability of services and better use of capacities
- reduction of waiting times
- reduction of damages/insurance fees
- the introduction of container services
- improvement of handling of containers[18]

Though an exact quantification of the possible reduction could not be made, a level of 10% - 50% was considered feasible by investments in logistics and port infrastructure. Since a reduction of transhipment costs at ports has to take into consideration the actual state of the ports and its transhipment facilities, three categories of ports were defined and the following assumptions made:

Table 3.11:
Cost reduction potential of Danube ports

Category of Danube port		Possible cost reduction*
A	Ports in EU member countries	10%
B	Well kept Danube ports in Central and Eastern Europe	25%
C	Ports with considerable potential for improvement	50%

*General cost reduction considered in Sc. 3 and 4

18 Container transport which is of very low quantity at present (0,4 % of total Danube transport in tons, Danube Commission, 1995).

3.4.7 Simulation of Future Danube Transport Potential

3.4.7.1 The Approach

To evaluate Danube transport potential the model centres on shifting goods from and modes to inland waterway navigation. The potential is defined as

- *the chances of Danube waterway transport to gain higher modal shares under present market conditions, but under changed parameters of Danube waterway performance.*

The approach can thus be described as a detailed cost model simulating the interrelations between generalised cost and modal split. It puts together the cost of transport chain by its various segments and differentiates transport volume data by commodity ‘macrogroups’. Its main characteristics can be summarised as:

- a predominately relational analysis based on regionalised matrices;
- based on overall and IWW transport volume (year 1995 and prognosis 2010);
- shifting parameters are cost, time and reliability, which have been integrated into the generalised cost function;
- and are calculated through network assignment of the matrices (rail, IWW, sea);
- contain costs of transport at link;
- and cost of transhipments.

3.4.7.2 Cost Functions

Generalised cost ratio of IWW transport in relation to land transport was calculated by a quotient Q. This quotient gives the relative cost position of IWT to competing land modes. Q is defined:

$$\text{(I)} \quad Q = \frac{(R_i + H_i + T_i *(1 - b_i) + W_{ij} + T_j*(1 - b_j) + H_i + R_i)}{(R_i + L_{ij} + R_i)}$$

Q	Relative cost position quotient		
W	Cost of inland waterway	T	cost of transhipments
R	Cost of transport within region	L	cost of land transport
H	Cost of region - IWW-Port		
S	Cost of sea transport		
a	Share of non-shiftable commodity	b	share of traffic within port

Cost of waterway transport itself has been split in a fixed Wf and variable cost element Wv (see 5.3). Cost of inland waterway W in condition (I) ... (IIII) is thus defined as follows:

(II) $W_{ij\,(I)} = \Sigma_{1,2...n} (Wf + Wv * C_w)$

whereas transport takes route via links 1,2...n. C_w is quality of link, which depends on scenario (degree of availability of a minimum water depth)

Cost of land transport L is defined as follows:

(III) $L_{ij} = \Sigma_{1..n} Lr_{ij} * C + B_{1..n}$

whereas
C Infrastructure condition, additional cost factor (1...2,5)
$B_{1..n}$ border waiting time

At present, origins and destinations of cargo using inland waterways concentrates in or within short distances from inland navigation ports. These transports can be handled with considerably lower transport cost. On the other hand, cargo at remote distances from ports have to cope with transhipment costs. To consider these cost differences, every transport relation having an origin or destination in wet regions (regions with inland navigation ports), have been split in two segments. Segment D (for dry share of cargo) and segment P (for wet or port share of cargo = b).

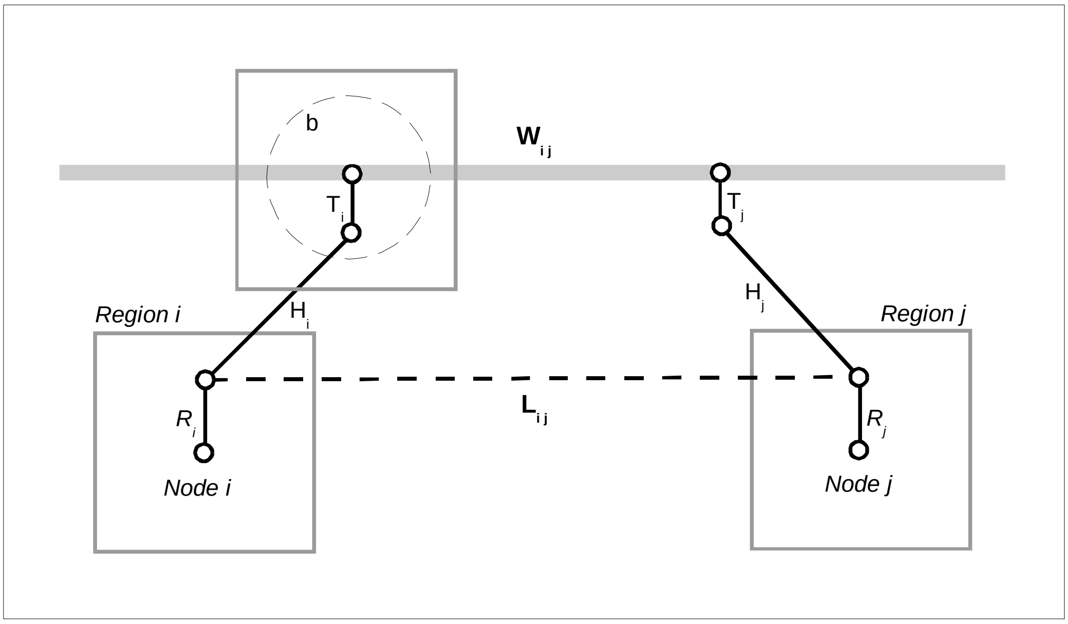
The share of D and P cargo have been estimated region by region. The estimation is backed by the German Statistisches Bundesamt data analysed by the consultant in DG VII Shifting Cargo project (IR1). Austrian shares were based on earlier studies of ÖIR, [19] In Central and Eastern Europe, estimates were made following the criteria documented in 4.3 (distribution of industrial activities / economy / on the basis of national statistical units and, additionally after an analysis of Danube port sites and their industrial activities (see IR-1)

Whereas, P cargo is calculated with no additional cost of D share (already considered in cost element Wv), D cargo cost are calculated by the average distance between region and its port, R (based on average distance region - port of D cargo).

The transport chain thus can be simulated from region of origin to region of destination (figure 3.18):

19 ÖIR, 1996. Binnenschiffaffine Güter.

Figure 3.18:
Transport Chain Elements of Generalised Cost Model



To derive the variables y, z and a for generalised cost model, the data were matched within a linear regression model with 1995 IWW data. Potential P of IWW - was defined:

$$\text{(IV)} \quad P = \frac{a * (1 + y - Q)}{z - Q}$$

whereas
y Minimum to be Shifted z Maximum Potential to be Shifted

Table 3.12:
Variables of the cost model

	Commodities A - Raw material and material intensive	Commodities B - medium and high valued
Minimum share y	0.755	0.965
Maximum share z	1.141	1.336
Constant a	*0.418*	*0.683*

The results were an improvement of the original basic cost elements. The regression, showed that the values did not have to be changed too much; they were fitting for the model. The model thus was used to simulate the impact of measures on inland navigation. The following cost elements were finally used:

Table 3.13:
Result of the regression analysis

	Land Transport	IWW
Fixed Cost (Origin + Destination, ECU/ton)	13	10
Variable Cost (ECU/ton-km)	0.025	0.006
Transport within Region R (ECU/ton-km)	0.070	0.050

To consider regional deviation in transhipment costs at ports with insufficient quality of transhipment infrastructure, additional factors were introduced, raising transhipment costs from 1.0 to 2.0.

In the same way the quality of land infrastructure was introduced by using additional factors: 1.0 motorway, 1.3 two-lane state highway, fair quality, 1.5 two-lane state highway, insufficient quality.

Concerning the quality of the Danube, a differentiation of sections was made only for the four sections with low navigation reliability. Average distances used in the model are shown in Annex 1.

3.4.7.3 Definition of Modal Split Scenarios

Two basic improvements of IWW were analysed:

- reduction of waterway costs
- reduction of transhipment costs at Danube ports

The following scenarios were assumed:

Table 3.14:
Definition of infrastructure Scenarios

in '000 t	Waterway	Transhipments
Scenario 1	Year 1995 Simulation	Year 1995 Simulation
Scenario 2	Upgrading of Danube	Year 1995 Simulation
Scenario 3	Year 1995 Simulation	Improved transhipment
Scenario 4	Upgrading of Danube	Improved transhipment

In a second stage, the infrastructure scenarios were combined with the scenarios of economic development (see 3.3.2). To secure a logic at connection, the pessimistic economic scenario was only combined with infrastructure scenario 1 (no measures). It was assumed, that investment in infrastructure would only coincide with a favourable economic development:

Table 3.15:
Scenarios calculated

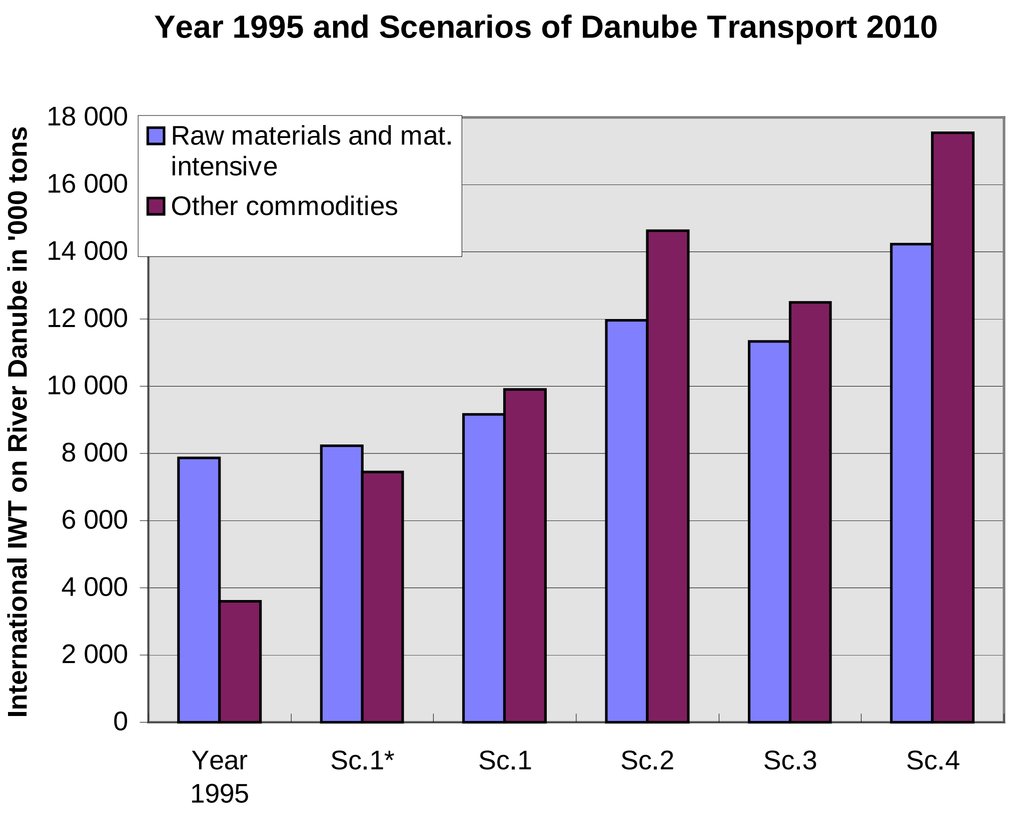
	Economic Scenario	Upgrading of Danube bottlenecks	Improvement of Transhipment
Scenario 1 - P	Pessimistic	no	no
Scenario 1 - O	Optimistic	no	no
Scenario 2 - O	Optimistic	yes	no
Scenario 3 - O	Optimistic	no	yes
Scenario 4 - O	Optimistic	yes	yes

3.5 Results - Danube River Transport Potential

3.5.1 Overall Results

The Calculations of the shifting models show that the Danube could acquire a considerable transport volume, thus strengthening its position as a key European waterway. First, overall results for the whole Danube region - including all transport relations within the region, from Bavaria to the Black Sea area - are given. Split into two basic commodities, the scenarios would lead to the following transport volumes of inland navigation:

Figure 3.19:
Potential of inland navigation in Danube Region



Given in numbers, the results are as follows:

This development would result in the following growth based on the situation of year 1995:

Table 3.16:
Growth of IWT Scenarios and Commodities

1995 = 100	CG 2 - Raw materials and mat. Intensive products	CG 1, 3-6 Other Commodities	All Commodities
Year 1995	100	100	100
Prognosis 2010			
Scenario 1 - Pessimistic	105	207	137
Scenario 1 - Optimistic	117	275	166
Scenario 2 - Optimistic	152	407	232
Scenario 3 - Optimistic	144	347	208
Scenario 4 - Optimistic	181	488	278

Modal Spilt calculated on the basis of the whole Danube region would develop as follows:

- Scenario 1 would lead to a slightly diminishing modal spilt in the Danube region;
- Scenario 2 would raise the modal spilt significantly (from 9 to 12%);
- Scenario 3 would result in a rather modest development (10.8%);
- Scenario 4 would take advantage of synergy effects and raise the modal split over 14%.

Though there are significant differences - a stronger *relative* growth of percentages of medium and high-value commodities in Scenario 2 - the trends for commodities follows general developments to a large extent.

Table 3.17:
Modal split by Scenario and Commodity

in %	CG 2 - Raw materials and mat. Intensive products	CG 1, 3-6 Other Commodities	All Commodities
Year 1995	14.8	5.8	10.0
Prognosis 2010			
Scenario 1 - Pessimistic	14.7	6.3	8.8
Scenario 1 - Optimistic	14.6	6.0	8.6
Scenario 2 - Optimistic	19.2	9.2	12.1
Scenario 3 - Optimistic	18.2	7.9	10.8
Scenario 4 - Optimistic	22.9	11.1	14.4

It also should be noted that the generous definition of the Danube region relations include all relations having little potential to be shifted to the Danube to their whole course or by using intermodal transports. Thus more significant numbers of inland navigation shares are obtained when comparing Danube transport volumes with a narrower defined Danube Corridor.

3.5.2 Results by Danube Sections

The final step of the prognosis has been the assignment of transport flows to the network. The task attributes:

- potential future transport volumes to the Danube River (‘inland navigation transport volume’)
- potential future transport volumes in the Danube corridor in general (‘overall transport volume)

The results given for the ‘cornerstone’ scenarios 1-P, 2-O and 4-O, show the following volumes by Danube section:

Table 3.18:
Transport Volume of Inland Navigation

Danube Section '000 tons	1995	2010 Sc.1-P	2010 Sc.2-O	2010Sc 4-O
Frankfort - Bamberg (Main)	4 020	6 627	11 589	13 461
Bamberg - Kehlheim (MDC)	4 290	7 001	12 346	14 337
Kehlheim - Linz	5 161	8 285	14 688	17 852
Linz - Vienna	6 533	8 304	14 890	16 936
Vienna - Bratislava	5 455	8 294	14 448	18 925
Bratislava - Györ	5 270	8 194	14 064	16 938
Györ - Budapest	5 359	8 160	13 813	16 654
Budapest - Mohacs	4 719	7 100	10 951	13 114
Mohacs - Belgrade	4 652	6 996	10 361	12 571
Belgrade - Prahovo	4 744	6 393	9 119	10 430
Prahovo - Lom	4 487	6 110	8 617	9 782
Lom - Russe	4 056	5 848	8 196	9 415
Russe - Cernavoda	2 898	4 265	5 705	6 667
Cernavoda - Galati	1 809	2 353	3 098	3 702
Galati - Ismail	1 501	1 420	1 668	2 164
Cernavoda - Constanza Canal	1 033	1 930	2 629	3 049

Note: When interpreting the results, it should be kept in mind that this and the following tables contain international transport relations, but do not include domestic traffic.

Future transport on the Danube River shows a considerable growth potential which should be realised depending on economic growth perspectives and infrastructure measures. Background is growth in overall transport demand in the corridor. Between 1995 and the year 2010 it is expected to grow at a factor ranging from 1.8 to 2.3 in the Upper Danube corridor and 1.5 to 2.0 in the Lower Danube corridor.

If no measures are taken (Scenario 1), Danube transport potential would rise between 65% (Upper Danube) to 30% (Lower Danube).

The improvement of nautical conditions (Scenario 2) would enable a growth ranging between factor of 2.6 to 3.3 on the Upper Danube and of 1.7 to 2.2 on the Lower Danube. The findings show that although measures were only considered on the Upper Danube, the high share of long-distance relations would spread the effects over the whole course of the river.

The additional improvement of transhipment would also raise the potential number of transports along the whole course of the Danube River thus raising share of the Danube from 18% up to 28% of the total corridor volume.

Overall transport in the corridor

To enable a comparison of overall transport flows with transport flows on the Danube, a corridor has been defined by aggregating parallel transport links.

3.5.3 Share of Inland Navigation

Transport volume on the Danube River and overall transport volume in the corridor matched with each other show the following share of inland navigation (which can be interpreted as the modal spilt of the Danube in the corridor):

Table 3.19:
Share of inland navigation, main sections

Danube Section	in %	1995	2010 Sc.1-P	2010 Sc.2-O	2010Sc 4-O
Kehlheim - Linz		18.2	15.8	23.0	27.9
Linz - Vienna		16.9	12.8	18.1	20.6
Vienna - Bratislava		13.8	12.7	17.3	22.7
Bratislava - Györ		13.5	13.5	18.2	21.9
Györ - Budapest		15.8	15.3	20.3	24.5
Hungarian border (YU+RO)		10.2	9.8	11.5	13.9
Black Sea Border (RO+BG)		16.0	16.0	15.7	18.4

3.5.4 Danube Potential - Summary

The Results may be summarised as follows:

- Calculations of a shifting model show that the Danube could acquire a considerable transport volume, thus strengthening its position as a key European waterway.
- The amount of overall economic development will have an impact on the transport potential of the Danube River.
- Transport potentials vary considerably by section - in general stronger growth is expected on Upper Danube. This is caused, on the one hand, by larger differences in overall growth perspectives in the Lower Danube countries, on the other hand, by a modest development of low-value commodities, which dominate actual transport on the Danube.
- Depending on the measures taken, the Danube will be able to attract a significant amount of transports of 13 - 28% on Upper Danube and of 10 - 19% on Lower Danube.
- Most important will be the improvement of nautical conditions to create a waterway with sufficient reliability for transports.

The graphs on the following pages show inland navigation on the Danube River for the year 1995 and for the prognosis scenaries. 1995 data are actual volumes. Note, all data contain only international transport data (figures 3.20 to 3.25).

Figure 3.22:

Danube transport volume 2010

Scenario 1 - no Danube upgrading

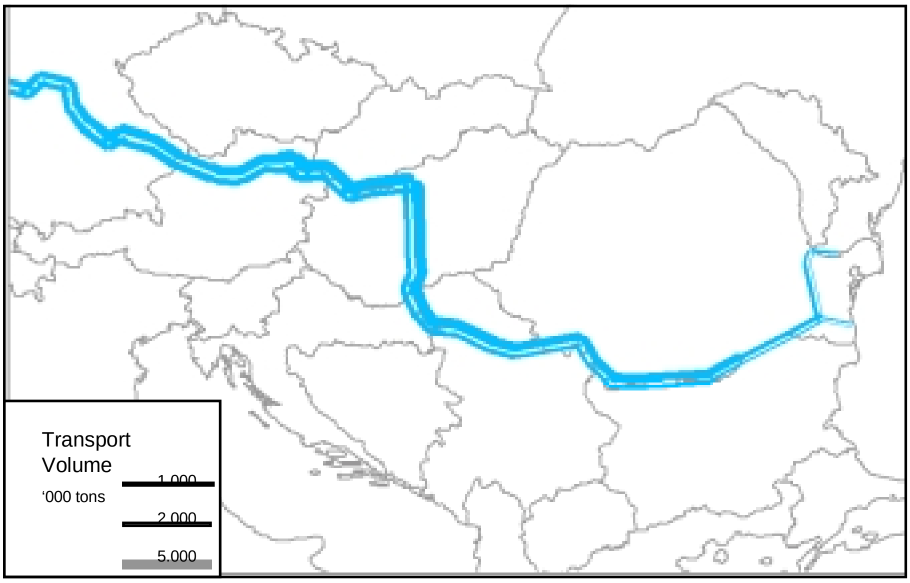


Figure 3.23:

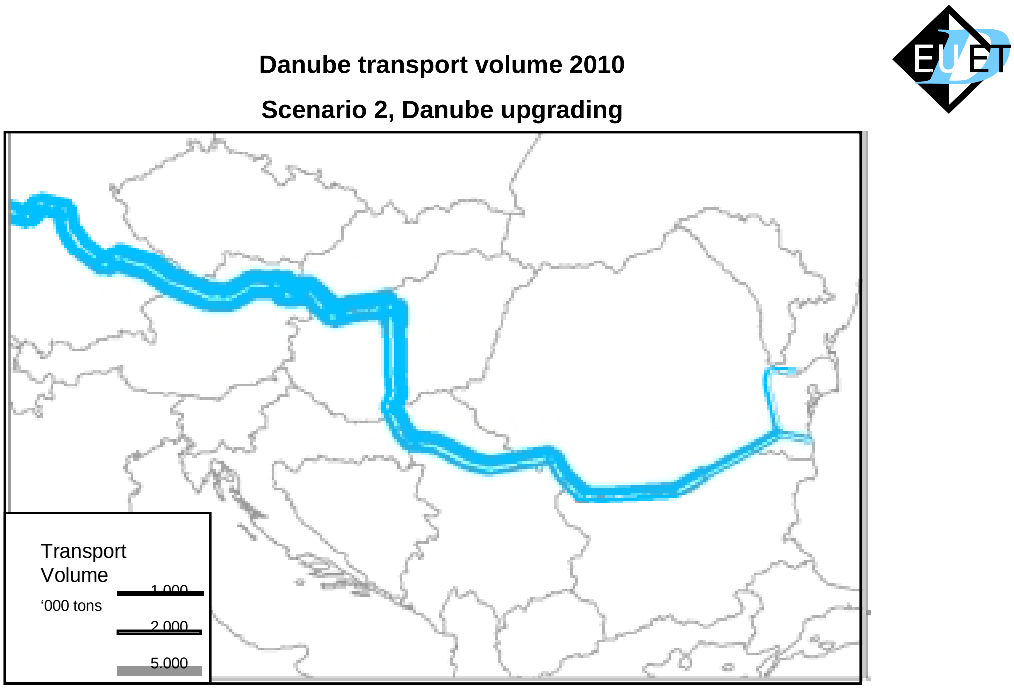
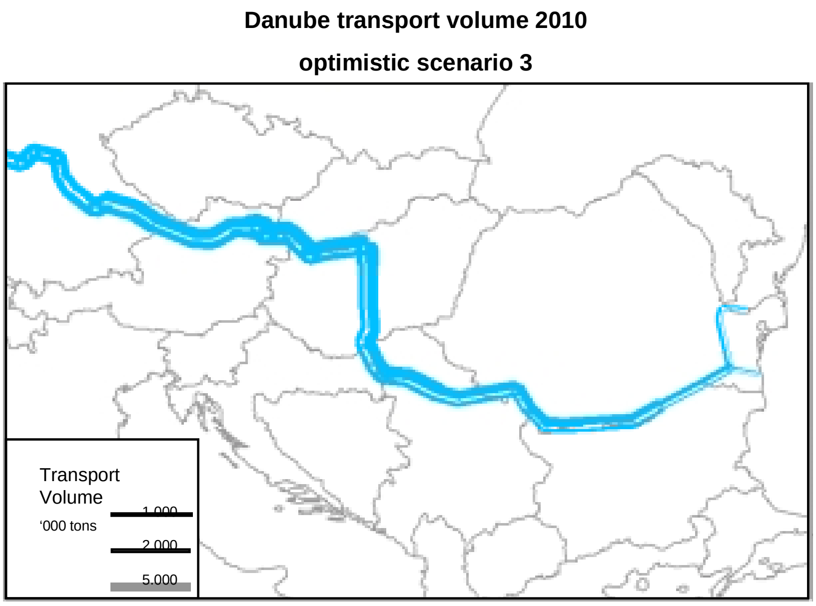

Danube transport volume 2010
Scenario 2, Danube upgrading
EUET
Transport Volume
'000 tons
1.000
2.000
5.000

Figure 3.24:


Danube transport volume 2010
optimistic scenario 3
Transport
Volume
'000 tons
1.000
2.000
5.000

3.6 Conclusions

The transport market in the Danube region is characterised by

- a strong position of rail transport in Upper Danube region and in the Ukraine, a weak position in international transports in Central and Lower Danube countries
- a strong position of inland navigation in a few relations, preliminary transporting of raw materials (iron, coal) to a few large industrial plants situated on the river;
- although inland navigation on the Danube has a weak position in high-value commodities, inland navigation on the Upper Danube has succeeded in acquiring market niches (transport of automobiles);
- container transport on Danube still has a low shore.

The dynamic development of transport demand actually leads to growth of all transport modes (IWW, rail and road). The rapidly changing structure of goods alone - growth of intermediate and finished goods - has caused inland navigation to lose market shares and roads to gain.

The prognosis expects this trend to continue. Inland navigation therefore has to make great efforts to acquire these emerging markets. With the improvement of the rail and road network in Central and Eastern Europe - a goal of the countries and also backed by the Commission - inland navigation will have an even harder time keeping its share in transports. In other words, existing bottlenecks of other modes will tend to be eliminated, Danube transport will have to improve its market position by its own efforts.

The study has defined scenarios of future inland navigation infrastructure. The scenarios would result in different costs for the transport of inland navigation. Costs in this approach are understood to be generalised costs, integration costs in monetary terms, time and reliability.

Figure A
Growth Potential of Danube Transport until 2010

1995 = 100; all commodities, optimistic economic scenario

		Waterway Conditions: as present	Waterway Conditions: improved
Transshipment	as present	(1) 166 (137)*	(2) 232
Transshipment	improved	(3) 208	(4) 278

Figure B
Modal Split of Inland Navigation within the Danube Transport Relations for 2010

(all commodities) 1995 = 10 %

		Waterway Conditions	
		as present	**improved**
Transshipment	**as present**	**①** **8.6** **(8.8)***	**②** **12.1**
	improved	**③** **10.8**	**④** **14.4**

*** pessimistic economic scenario**

The growth potential of River Danube in international transport shown in figure A. The Scenario are shown by numbers within circels.

Scenario 1 defines the actual situation prolonged - no substantial investments in infrastructure. The model calculations show that this would result in a (slightly) decreasing share of inland navigation in overall transport market in the Danube region.

The analysis has shown that present nautical bottlenecks on the Upper Danube do not only raise prices in certain seasonal periods, but above all diminish the reliability of transports. The transport of medium and high-value goods is impeded to a high extent. The water depth conditions pose a severe draw back to reliability (need to lighter, interruption of navigation) and efficiency (significantly lower draughts mean reduced profitability, market attractivity and flexibility in operation) of westbound Danube navigation, for conventional cargo as well as for combined transportation. Scenario 2 assumes an elimination of these bottlenecks. The results of the model calculations show a considerable potential rise in the inland navigation share if the Danube River is upgrated according to the recommendations of the Danube Commission.

Scenario 3 takes into consideration the improvement of transhipment of Danube ports. A substantial improvement of transhipment time, costs and associated logistics would also, but to a lesser extent, raise the shore of transport in inland navigation.

Besides the assumptions used in the model, other measures, which are able to raise the share of inland navigation have not be included. On of these issues is regional planning, which could support a better distribution of transport demand by locating new industries within ports.

4. Towards an Agenda for Danube Navigation

4.1 Identification of Investment Needs

4.1.1 Improvement of Waterway Conditions

The majority of infrastructural bottlenecks on the waterway dealing with navigational aspects have been identified in chapter 2. Even today at comparatively low intensity of traffic some of these bottlenecks pose serious hindrances on particular sectors and hamper the waterway's attractivity. In the case of a favourable development of the overall economy in the region, expansion of trade relations and thus increasing transport demands through the Danube corridor, such hindrances could dramatically rise in the near future. This could even lead to an undesirable consequence that instead of increasing the utilisation of the Danube for transport purposes, the users of transportation services may start to shift their shipments to other modes. This trend has been observed in some cases recently despite of theoretically enormous free capacity of the river and its potential role as a key natural transport resource in this part of Europe.

Future transport volumes, prevailing types of commodities and transport quality demands may differ on the different sectors of the river and as a consequence, due to the different traffic densities, ship types with all their characteristics like size, speed and manoeuvring abilities, different priorities for waterway improvements on particular sections may be established.

For instance, in some sectors the sequence of priorities will start with the elevation of low bridges reflecting the expected increase of container transport or demand for uninterrupted river-sea services, while on the other river sections, the first priority will be given to the dredging (deepening the waterway) due to the estimated increase on demand of bigger conventional ships, better utilisation of their loading capacity and speed performances. However, certain measures will be proposed especially those on the sections where the high seasonal variations of the water level strongly interfere with the navigation of standard vessels within the range of their nominal draughts during a considerable period of the year. The same will be applied to the relatively short sections with especially unfavourable conditions as compared with those on the adjacent stretches in order to provide more uniform conditions along the longer river stretches.

The bottleneck identified for navigation refers to the physical conditions of the waterway, such as:

- Waterway width
- Waterway depth
- Bending radii of the waterway
- Air clearance and span of the bridges crossing the river
- River and canal locks

Waterway width

Comparing the desired waterway widths with the actual situation at LNRL, the Danube stretch between Straubing (river km 2324) and Vilshofen (km 2249) has been found to be "narrow“ regarding to its navigable width. Although there are other sections with waterway widths narrower than those determined by the above calculation, they cannot be assigned as bottlenecks and are not even "problematic“. Namely, the water depth on those other stretches are not as critical and allow a certain decrease of safety margins at by-passing. Besides, other "narrow“ stretches are of higher ECE classes (VI and VII) and in practice the probability of two large convoys by-passing on narrow spots is very low. Moreover, in the last 10-15 years, large convoys having three barges abreast have become a rarity on the Danube.

The general recommendation for overcoming the problem of narrow stretches is to make the waterway deeper and simultaneously to perform construction works on the river banks. This would considerably reduce the necessary safety margins at by-passing. The situation now is that due to the low water depth, if a ship heading downstream does not reduce its speed, the vessel in navigation upstream must slow-down or even stop in order to give way to the ship from opposite direction. Otherwise, the danger of collision or grounding due to hydrodynamic effects in restricted waterways may occur.

For the critical Straubing-Vilshofen stretch this practically means the erection of two dams (Waltendorf, Osterhofen) with river locks and thus reducing the average stream flow rate from current 4-5 km/h to a moderate 1-2 km/h similar to that on a fully canalised river Main. Single measures such as building dikes and warfing on river banks could just slightly improve the situation through a negligible deceleration of the stream flow rate and an insufficient rise in the water level. Dredging itself does not bring about the expected results due to the high slope of the river, the high stream flow rate would remain unchanged. Besides, rocky river beds at certain spots would present additional difficulties.

For the reasons of safe turning manoeuvres on waterways having ECE classes Vb and VIa on the upper Danube, at least a 600 m long stretches with minimum width of 140 m have to be ensured, usually located upstream and downstream of bridges with narrow spans, as well as upstream of anchorages. Anchorages themselves have to be located on wider stretches of the waterway near to river banks. The length of each anchorage has to be about 500 m and an additional width outside the waterway about 60 m. The mutual distance between two adjacent anchorages has to be arranged so that the vessel can reach the next anchorage heading upstream in about one hour. That means that on each 5 to 10 km of the waterway one wider stretch must be provided as anchoring site.

Building confining dikes and warfings are recommendable on sections where the river bed and banks are unstable. These are the long stretches between Vienna and Budapest as well as between the Iron Gates II and the mouth. These measures to reinforce river banks also combined with dredging at the critical spots in order to remove sediments, are part of a continuos and permanent set of actions that are common for waterway maintenance. In this respect they are being performed since long and the only obstacles are the usual ones of limited funds for such works. However, these stretches are much more problematic regarding water depths.

Waterway depth

In order to make the Danube more attractive for commercial navigation, minimum waterway depths on the Danube must be compatible to those on river Main and the Main-Danube Canal. Several years ago, the Danube Commission set up as objective to ensure a minimum water depth of 2.5 metres (at LNRL) along the whole Danube course. Unfortunately, this goal still remains to be achieved. Table 9 in Chapter 1.4 of the WP1 shows the most critical stretches of the Danube regarding the water depth. It is obvious that in relation to the much more intensive westbound transports, stretches between river km 2338 and 2319 (within Straubing - Vilshofen section) and km 2022 and 2013 (directly downstream the new Vienna-Freudenau lock) are the most problematic (see also map 1).

Two aspects of shallow waters must be considered. The first is the utilisation of a vessel's carrying capacity as a function of the loading draught. The allowed draught between port of origin and port of destination is determined here by the shallowest waterway stretch. If just one relatively short stretch along the route enables loading up to only 1.5 m draught while simultaneously on the whole remaining route the allowed draught is 2.5 metres, the economic position of inland navigation on such route becomes very unfavourable. For instance, following the ECE classes of waterway links between Frankfurt on Main and Vienna (at least Vb), ships loaded up to 2.5 m draught should be reasonably engaged. But on this approximately 1000 long route, two relatively short stretches having together no more than 100 km (Straubing - Vilshofen with 69 km and Melk - Dürnstein with 30 km) or about 10% of the whole distance determine the loading mark which is very often under 2.0 m. For some standard European inland navigation vessels the dead-weight reduction as a function of reduced draught is shown in the table below.

Table 4.1:
Dead-weight as a function of draught for some typical inland vessels

	Length	Breadth	Approx. dead-weight (t) at draught of:		
Ship’s type	(m)	(m)	2.5 m	2.0 m	1.5 m
large inland motorship	110	11.4	1 800	1 200	600
standard "Europe“ motorship	85	9.5	1 350	930	570
"Europe II“ barge	76.5	11.4[1)]	1 660	1 250	850

1) Standard "Danube-Europe II“ barge has a breadth of 11.0 m, but due to a usually lower own weight has approximately the same dead-weight at corresponding draughts

It is not very reasonable to utilise only 30-50% of the loading capacity over 90% of the route with water depth sufficient for the full load. On the other hand, partial discharge of the vessel just in front of the short shallow section eliminates the advantage of favourable transport prices of the inland navigation through additional transhipment costs and makes already long transport times even longer.

The minimum tolerances recommended are the values of 0.2 m for sandy bottoms and 0.4 m for river beds covered with gravel (having an average size bigger than 50 mm) between the ship's bottom (for vessels in motion, i.e. including dynamic immersion) and the river bed.

Damming the waterway at two selected sites on the Straubing - Vilshofen section in order to obtain stable and higher water depths is strongly recommended.

Reinforcing the river banks, warfing in order to reduce stream flow rate and as a side effect to obtain slight, but still a positive rise in the water level as well as the regular dredging of the waterway are the only measures recommended for a medium term for the remaining critical stretches, especially those between Vienna and Budapest.

Air clearance and span of the bridges crossing the river

Several extremely low bridges on the Danube hinder the navigation of river ships carrying containers, passenger liners and especially some types of river-sea vessels with their high freeboard, superstructures and deckhouses. Concerning recent traffic development trends as well as future perspectives, river container, Ro-Ro and river-sea shipping are strongly faced with this problem. Westbound container transports upstream of Budapest are as a rule restricted to only two layers of ISO containers at extremely high waters (about 60 TEU) and in optimal cases of medium water level on max. 3 layers (90 TEU). But that does not mean that these 3-layer transports can arrive directly from river Rhine, because there are three bridges on Main river which allow the passage of just two layers (near Hanau 4.39 m and 4.90 m, near Würzburg 4.81 m). Among other reasons, this was why direct container shipping between North Sea ports and Austria failed and why the stretch between Mannheim and Regensburg had to be "bridged over“ by trains. Downstream the junction of the Main-Danube Canal, all the Danube bridges except for two (at Bogen, river km 2311 and at Deggendorf, km 2286) have air clearances over the HWL of more than 6 metres. This is standard height for the bridges on Main-Danube Canal with the exception of one near Bamberg with 5.49 m. Considering the low probability of extremely high water (above HWL) of just 1%, one may say that for the reliable passage of container river ships with three layers of boxes, just two of the above mentioned bridges represent a problem.

Looking from the mouth to the Black Sea upwards, in respect of bridge height there is no problem for usual river-sea vessels or large river container ships (built according to the modern Rhine standards) with 4 layers of containers up to the Port of Novi Sad. Further upstream to the Austrian/German border, the lowest bridge by far (6.07 m above HWL) is one at Danube km 1255, just 500 metres upstream the entrance to the Port of Novi Sad[20]. All other bridges on this section have a height over the HWL of at least 6.70 m (one at Budapest and one at Bratislava), others have a clearance of 7.30 m or more. Due to the short and medium-term perspectives of traffic development between the Black Sea ports and those on the upper Danube it is not likely that considerable river container shipping will occur on that route. Therefore, the bridge at Novi Sad represents the bottleneck only for direct river-sea shipping, large passenger liners and eventually special transports of bulky cargoes or Ro-Ro shipping with multi-deck vessels.

Disregarding the problem of low bridges on the Main and Main-Danube Canal, steel-constructed railway bridges at Bogen and Deggendorf have to be elevated to at least 6.0

20 All three bridges of Novy Sad though have been destroyed in spring 1999 by NATO bombings.

metres above the local HWL in order to enable a more reliable three-layer transport of containers downstream of Regensburg. In the event that estimated traffic flows and the need for more reliable river-sea transports between Austrian, Slovak, and Hungarian ports and the Black Sea Region are confirmed, an urgent measure will be to ensure that the road bridge at Novi Sad (km 1255.0) will have more reasonable 8.20 m.

River and canal locks

The overview of the locks, their technical features and estimated annual locking capacity on the Danube, Main-Danube Canal and Cernavoda - Constanta Canal are given in the 1st Interim Report. Downstream Regensburg all the locks are in continuous operation - 24 hours a day. Furthermore, all the Danube locks downstream of Straubing have two parallel chambers thus enabling (theoretically) smooth and reliable locking even in the case that one chamber is out-of-service due to regular maintenance work or unexpected technical failure. Some negative experiences with a new lock at Gabcikovo since it went into operation in 1992 may be treated rather as an accident than as a rule.

Studying the logbooks of some randomly selected continuous trips between the lower and upper Danube (Izmail - Linz and v.v.) it was noted that the only considerable waiting times (about 1-1.5 hours) occurred at the biggest lock - Iron Gates I. This is the only double-stage lock with an elevating height of 25-30 metres, depending on the water level in front of the dam and here the locking itself reasonably lasts about three times longer than on all other locks - about 75 minutes. But the reasons for additional waiting times only at this lock are difficult to identify.

Comparing capacities and traffic flows, both current and in the medium-term future, the Danube locks cannot be defined as bottlenecks. Possible capacity shortages may be expected in the future only on the Main-Danube Canal and the Danube locks at Bad Abbach and Regensburg. The first remedy should be the operation of these locks round-o-clock, on working days, weekends and holidays as is the case at all other Danube locks nowadays.
Besides, if due to the waiting times, the lock at Iron Gates I or any other in the future could represent a potential bottleneck, a solution has to be looked in the area of improvements in the organisation, communications and exchange of information. It will be especially important for the densely distributed single-chamber locks along the Main-Danube Canal.

4.1.2 Danube Fleet Improvements

In considering the existing fleet structures of the Danube riparian countries (with the exception of Germany and partially Austria) it became obvious that the existing Danube fleet despite of its impressive nominal carrying capacity is unable to respond accordingly to current market demand. Certain changes in the kinds of commodities and shipment sizes have occurred in recent years and they underlined the shortage of some kind of vessels like self-propelled cargo ships of bigger and moderate size technically harmonised with the requirements valid on the West European waterways. This problem is also emphasised by all interviewed ship operators on the middle and lower Danube.

Furthermore, ships designed for special transports (heavy cargoes, containers) or the transport of certain hazardous goods (chemical tankers) are very rare on the Danube.

Of a total 4.78 million tons of cargo capacity of the Danube fleet (since the opening of the Main-Danube Canal it is probably better to say "ships with the port of registry on the Danube"), only 0.39 mill. tons or only 8.16% of total tonnage belongs to the fleet of self-propelled ships (including hereby also river/sea vessels registered in the Danube ports). The share of tonnage of pure river self-propelled dry cargo ships is even lower - only about 7.4%.

The average age of pushboats, self-propelled dry cargo ships, river-sea ships and pushed barges is between 15 and 16 years and may be considered moderate.

The average age of river tugs, pusher-tugs and towed barges is about 35 years (between 31 and 38 per individual category). These types of ships functionally belonging to the obsolete, but still not completely abandoned towing.

The ratio between total number of pushed barges and total number of pushboats (pusher-tugs are not included although still sporadically in use for pushing convoys) is approximately 7. Excluding those pushboats with less than 1000 kW installed output (not convenient for pushing larger convoys in long range service), the barge to pushboat ratio rises to 10.

The huge majority of vessels are not allowed to enter Rhine through the Main-Danube Canal and river Main.

Since the mid of the nineteenth century with the mass introduction of steam-powered tugs, Danube shipping started to use towing convoys. The pioneer in this technology was the Austrian DDSG and was followed at the end of the century by the bigger companies of other Danube riparian countries. Mechanical propulsion, a wide but relatively shallow river and for the times a very intensive trade volume of mainly materials imposed such a solution. After the Second World War all countries on the middle and lower course of the Danube adopted planned economy systems, nationalised the fleet under domestic flag and usually established one single state-owned river shipping company on the Danube. The prevailing commodities in transports remain solid and liquid bulk cargoes (ores, coal and coke, timber, sand and gravel, liquid fuels). Since the introduction of pushing technology in the sixties, only additional cargo space in non-self-propelled (now pushed) barges has been added. The share of commodity groups in waterborne transport through the Danube corridor remained mostly unchanged. The general philosophy that one ton-kilometre is considerably cheaper using the pushed convoys than self-propelled river vessel (what is principally true) was also kept firmly not considering the overall step-wise changes in shares of different commodity groups in favour of general cargo and rising demands of transport service customers for improvements of transportation quality - first of all tight time requirements.

The above describes the background for the very unfavourable structure of cargo space in the Danube fleet nowadays. On the one hand, a huge overcapacity in all type of barges exists, and on the other, an urgent need for flexible, modernly-equipped and considerably faster self-propelled river cargo ships exists.

The towing technology has almost completely been abandoned on European inland waterways as economically less effective than pushing due to the considerably higher number of crew and higher resistance to the motion through the water (more energy consumption per ton-km). The Danube is one exception even though it was one of the first rivers in Europe where the pushing technology "imported“ from the USA was implemented on large scale. The reason for maintaining towing technology and corresponding fleet units is for emergency cases. In periods of extremely low waters, especially on the sections between Budapest and Vienna, the shipping companies having small draught tugs (about 1.5 m loaded with supplies) that offer transport services, which are not possible for long-range pushboats having an average 1.8 m draught or more. By towing, towed barges produce less resistance than box-shaped push barges and this is the reason why also obsolete towed barges are still not completely decommissioned.

Age of self-propelled tankers

Since the beginning of eighties, considerable transports of liquid fuels (mostly crude oil from the Ukrainian Port of Reni to destinations in Yugoslavia, Hungary and Czechoslovakia) no longer exist. The transports have been shifted to new built pipelines and/or to the railway. This is the reason why many relatively modern (aged 5-8 years) pushed-tank barges were decommissioned some 15 years ago. New tank motorships have also not been ordered since that time.

Pushboat to barges ratio

Like for LASH barges, it may be said that for each propulsive unit (LASH vessel as "mother“ ship respectively pushboat in inland navigation) at least three sets of barges must be available. This means that one set has to be berthed for loading/unloading at the port of origin, one set berthed for the same reason at the port of destination and the third one under way pushed by the pushboat. In long-range navigation on the Danube, convoys having between two and six barges are usual. Larger convoys with nine or more barges have been rare exceptions for several years. If one assumes that four barge convoys may be considered as "the mean of means“ and ideal for cheap mass goods transportation along the whole course of the Danube (up to Regensburg in ideal circumstances, but in any case to Passau or Linz), the following conclusions may be drawn:

- For each long-range pushboat on the Danube at least 12 pushed barges must be available
- Pushboats under 1500 kW are underpowered for pushing convoys of four standard loaded barges
- The ratio between total number of barges and really convenient pushboats (output of 1500 kW or more) is 20 and may be considered as good

The problem here is the huge overcapacity of the barge fleet in respect to market demand and the fact that powerful pushboats able to operate with four or more barges have too big a draught for the Danube during the long-lasting periods of low waters.

Shortage of specialised ships

Economically less-developed region of south-east Europe in the past did not express the need for considerable transports of commodities other than traditional low-value bulk along the Danube. Following the recent changes, the need for transport of containerised goods, chemicals which are usually varieties of hazardous goods and require special treatment and storage during transports, passenger cars, bulky cargoes like heavy and voluminous one-piece industrial plant facilities etc. gradually on the rise. Despite very favourable pre-conditions for long-distance Ro-Ro river traffic confirmed by the success of existing services, the capacity of the Ro-Ro fleet is by far below potential market demand.

Equipment on board

Despite the age of the Danube fleet, which in general cannot be considered as too old, only very small number of vessel are properly equipped with devices required the navigation on the Rhine and other West European waterways. First of all, the ships and leading barges entering the Main-Danube Canal are strictly required to have additional steering device on the bow part. This requirement is very reasonable due to narrower waterway widths, sharp bends and considerably denser traffic. Therefore, the ships and convoys should be able to maintain manoeuvring standards which exceed those on the principally much wider Danube with its lower stream flow rates (lower than those on river Rhine) and low traffic density.

Certain standards regarding transport of dangerous goods, which are precisely defined by the ADNR (regulations for transports of dangerous goods on the Rhine river) and implemented practically on the entire waterway network of the EU member states, set requirements for ship construction (e.g. double-hull tankers) and some additional equipment on board. The ADNR rules are implemented on the Danube only in the form of a recommendation (so-called ADND, which are in the process of harmonisation with ADNR) and there are still a huge number of vessels, which are used for such transports on the middle and lower Danube course, but not allowed to cross the EU border.

Fleet structure optimisation

It is undoubtedly true that the Danube fleet suffers from a shortage of self-propelled river cargo ships. That is valid also for general (multi-purpose) dry cargo vessels, as well as for tankers (not only conventional for liquid fuels, but also for different chemicals and liquefied gases) and ships for special transports (Ro-Ro vessels, for passenger cargo transports, container ships, heavy voluminous cargoes). These vessels can either be ordered as newly built ones taking account of present market demands and specific navigation conditions, or acquired as second-hand ships (purchased or taken over in charter from other waterway systems where they are in surplus at the moment).

Regarding newly built vessels, state-of-the-art knowledge in the field must be applied. Shallow water hydrodynamics is the branch of applied hydrodynamics dealing with problems of ship motion (resistance, propulsion, steering and generally behaviour) in extremely unfavourable conditions of confined waterways. In recent years, the VBD, an Institute in Duisburg highly specialised in this field, developed a series of optimised hull forms for extremely shallow water under the common name VEBIS[21] Project. The final results are new hull forms for pushed barges, pushboats and self-propelled river ships. Beside the optimisation of hull forms in respect of resistance, new types of propulsion units suitable for shallow waters have also been tested. It deals with so-called "pump-jets“ designed for the range of speeds usual for the conventional river cargo vessels and competitive in performance with standard ship propellers, but with considerable advantages in extremely shallow waters. The results of this project should be taken into consideration always when designing any new vessel for the inland waterways, especially on the Danube nowadays.

An other topics that must be reconsidered is the concept of the hull structure for river ships. Pushed barges built in accordance with the rules of the GL are in principle even 10% heavier than those built according to the rules of the Russian Register. The reason is very simple. To obtain the same longitudinal and torsional strength of the hull either thicker shell plates (bottom, bilge, side plates and deck) with bigger spacing of longitudinal bars (girders and frames), or thinner plates but with considerable smaller spacing of bars can be used. The first solution results in more weight of the steel structure, but requires considerably less work and less welding than the second one. Less work and less welding means cheaper barges if manpower is expensive, but results in a greater own weight of the vessel. Before the recent economic changes, the building rules of the Russian Register had preference in all countries of the Danube region except for Germany and Austria or certain compromises between the GL and RR rules were adopted, as in the case of own national rules in ex-Yugoslavia. Barges built according to the GL rules are more robust, the periods between replacement of some shell plates being damaged by corrosion are longer, the use of grabs for unloading of bulk like ore, coal or gravel cause less deformation on the inner shell (cargo space in open-top barges), but the draught in empty condition is few centimetres bigger. On the one hand, for the "Europe II“ barge each centimetre of immersion means about 8 tons of load. Thus a roughly 10% heavier barge of the GL means about 40 tons less dead-weight by the same draught. This fact speaks in favour of light-weight construction principles of the RR rules. It is impossible to state an ad hoc preference for any of these two different philosophies as recommendable for the Danube before a serious economic analysis is made. In any case, there are possibilities for optimisation either in draught or in building costs with consequences on the efficiency of the ship in operation.

One of the possibilities in the range of the Danube fleet optimisation is to introduce a new generation of long-range pushboats with extremely small draught and sufficient propulsion power for pushing at least 4 loaded "Europe II“ barges with a speed of 12 km/h in streamless shallow water. This means that such a pushboat should have some 1500 kW and a full-loaded draught of less than 1.4 m, which is nothing extraordinary, even using conventional propulsion with ducted propellers. The problem is to maintain this small loaded draught with sufficient supplies (fuel, lub oil, water, provisions) for long-range trips along the Danube. Assuming the consumption of 200 grams of diesel per kW and hour (a little bit high is reasonable for modern engines but including a diesel-powered generator and oil-fired boiler for water heating), one 1500 kW ship needs 7.2 tons of fuel oil per day. In 24 hours heading upstream with a speed of 10 km/h such a convoy could not achieve more than 240 km. Over 12 days are needed for the voyage between Izmail and Linz in ideal circumstances without any stops. Therefore, the big long-range Danube

21 **V**erbesserung der **E**ffektivität der **BI**nnen**S**chiffe

pushboats have a fuel tank capacities of 100 tons or even more. If the length of such a pushboat is about 35 m and width 11 m, the immersion is less than 3.8 t/cm, which means more than 30 cm for 100 tons of supply (or the difference between the light and fully-loaded condition).

In other words, it would be required to design the pushboat able utilise its 1500 kW at a draught of only 1.10 m. Such a task is not feasible with conventional propellers and within the range of acceptable lengths, breadths and other principle particulars of the pushboat. One solution is to implement other types of propulsion devices (as proposed by VEBIS study) or to reduce the capacity of supplies drastically. This second solution would, however, require a considerably better organisation of fuel and other supplies along the Danube than exists today. In this case even existing pushboats could be used in less favourable water depth conditions taking supplies for, e.g., only two or three days.

Cargo-handling equipment

One of the problems predominant on the Danube especially on its middle and lower course is the lack of the efficient container transhipment facilities (container bridges) at the ports. What is usually available for ship-to-shore transhipment of containers are conventional portal cranes with spreaders. But the problem is that either the available cranes have a low-lifting capacity or that the ports with suitable cranes are located on very long distances from each other and for this reason many shippers decide to use other transport modes rather than inland navigation vessels.

A relatively simple and cheap solution was proposed recently for the reloading of ISO containers to and from inland navigation vessels. The idea is to install a hydraulic gantry crane on tracks located on deck side stringers. This crane can move along the whole cargo hatch and thus pick up any box from the ship, bring it over the bow and drop it onto the shore or vice versa. Small adjustments have to be made on the side of waterfront. This own container cargo gear aboard the ship will make the vessel itself a bit more expensive, but at the same time much more flexible and competitive. The main objective is to make it possible to reload containers almost anywhere, independent of the availability of suitable transhipment facilities at the port. This could be very important for the Danube to promote the faster introduction of container transports. Namely, due to the low volume of container traffic on the Danube nowadays it is not reasonable to invest in effective (but expensive) transhipment facilities on the shore. Ships with own container cranes would promote any port or convenient transhipment place with road access to a "container terminal“. If once the container turnover in such one port starts to rise due to the high level of acceptance by the market, it is a matter of routine to make the optimal selection of container transhipment facilities, which will satisfy the rising demand.

Deck and navigation equipment

In order to increase their competitiveness in general, the ships of the Danube fleet have to be modernised. First of all, existing vessels in good technical condition and of relatively young age have to be equipped with all necessary devices needed for obtaining allowance to access the Main-Danube Canal and West European waterways. By replacing engines on self-propelled vessels, the possibilities for higher output and installation of pushing horns on bows (for pushing one additional barge) always have to be considered. The installation of bow thrusters on existing motorships and a certain number of barges have to be considered too. Systems for bilge and waste water have to be rearranged in accordance with the latest CCNR rules, which by no means conflict with national rules and regulations on the Danube and the recommendations of the Danube Commission. The same has to be done with navigation and signalling lights and communications devices (radar and VHF devices as well as the "blue flag", which have been part of the usual equipment of the Danube vessels for the long time).

In general, although compatibility with the CCNR rules and regulations are nowadays only "recommended" by the Danube Commission, these should be observed by any new built vessels. This would be a considerable contribution to the overall safety of navigation and harmonisation of standards on the interlinked pan-European inland waterway network. Moreover, the shipowners that place this additional requirement for such standard levels for their newly built vessels will get more chances on the transport market due to higher freedom of mobility and flexibility of their vessels.

4.1.3 Improvements of Ports

With some exceptions in Germany and Austria, port services in the most of Danube ports have to be modernised and adopted to the transport market demands. Three aspects have to be considered here:

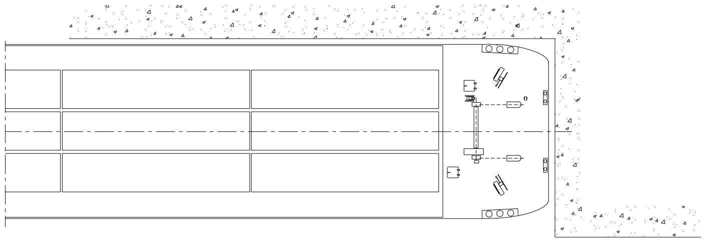
- reloading equipment (berths, cranes, facilities for horizontal transhipment)
- storage, internal transport
- other services - organisation, operation procedures, marketing etc.

Reloading equipment

In general, ports on the Danube are well equipped with conventional portal cranes. The length of berths and their condition may be also considered as satisfactory. A problem is the lack of cranes suitable for container handling. This does not mean that special high-capacity container bridges are missing, but that their number and distribution do not match current demand. Conventional portal cranes of higher capacity are those which should be present in greater number at the rather distant ports along the middle and especially lower Danube.

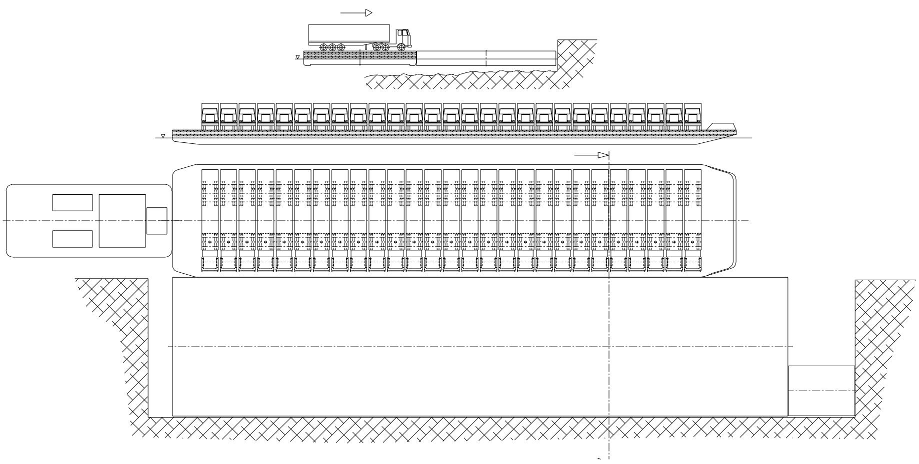
Regarding the transhipment of containers, the Danube ports without specialised equipment up to now are open for implementation of any new concept. One option already described, comprises transhipment facilities on board container ships. This concept requires only negligible construction works on the waterfront or in many cases none (figure 4.1). This concept offers a high level of flexibility and seems ideal for the ports with relatively small and sporadic container business. Road mobile cranes with high-lifting capacity and outreach owned by individual independent operators and chartered from the port as needed may also be used. In the case of a future increase of container transport on the Danube, instead of installing expensive container cranes, new ideas with horizontal transhipment of container pallets (8 to 12 TEU in one move) should be considered. This concept is suitable in cases of regular point-to-point services of a larger number of containers. Investments are comparable with those needed for container bridges, but the time requirements for transhipment are double or maybe shorter. An additional advantage of the Danube corridor is the possibility of using the huge overcapacity in barges, which have to be reconstructed and thus changed from their original purposes.

Figure 4.1:
Shape of berth for container transhipment using ship's own cargo gear



Ro-Ro services on the Danube have an excellent perspective at present and this outlook is sure for at least the next 25 to 30 years. The Ro-Ro ships of the first generation, in use since 1982, have proven this concept very successful. New ideas which would eliminate the identified weak points in current services are being worked out. Their main quality is a much higher flexibility and faster procedure at the ports (figure 4.2). Investments required on the shore side are of the same level as for existing solutions (Ro-Ro ramps as concrete slopes, i.e., pretty low). Ship operators are the ones who must decide to introduce a new generation of Ro-Ro river vessels or not. In any case, shippers and freighter are quite interested in this new concept already in its initial phase of feasibility elaboration.

Figure 4.2:
Principal sketch of the river Ro-Ro transport with transversal stowage of trucks



Storage facilities

A certain number of ports suffers from a lack of covered warehouses, especially on the lower river course. A sufficient number and capacity would enable further development of activities at the ports like the packing and even final assemblage of certain products.

For the transhipment of goods sensitive to precipitation, the warehouses with bridge cranes under their roofs have to be extended over the waterfront for one ship's breadth (about 10 metres).

Other port services

Due attention should be given to the organisation of efficient internal transport with high-reach stackers, fork-lift trucks, container platforms, mobile cranes etc. as well as to the improvement of road access to the harbour area (links to the main road network). The ports with qualitative and quick access for trucks and in the vicinity of the main highway nodes will have considerably better chances to integrate their services into oncoming transport market demands. The quality standards of the following services like cargo tracing, customs and port-to-ship information management and means of communication must raised. Most of these services require a higher implementation of advanced transport telematics procedures.

Regarding customs, operating hours must become more flexible. It does not make much sense that all of the Danube ports operate 24 hours a day including weekends and holidays "in line with customers' needs“ if customs close their offices each day in the early afternoon and remain closed over the whole weekend until Monday morning.

For the ports in transition countries, the process of privatisation and deregulation must be continued. Independent operators must be offered the port facilities on a charter basis and so as to enable them to establish and develop their activities at the port zone. Such action would considerably accelerate the improvement of service quality introducing competition among individual operators within the same port.

4.1.4 Telematic Procedures

State-of-the-art and specific demands on information exchange management in transport via the Danube corridor (not only the inland navigation mode) leave a plenty of possibilities to implement sophisticated and tailor-made telematic procedures in order to improve the overall efficiency, reliability and safety of transports and especially the attractiveness for the market.

A special challenge lies in the many different languages being used in ship-to-ship and ship-to-shore communications, which were the cause of many misunderstandings in the past, sometimes even with serious consequences (accidents).

The second group of problems to be identified are within the capacity of river locks, which represent the only limiting factor on certain sections. For instance, the theoretical locking capacity of the Iron Gates I group is considerably lower than that of the Iron Gate II despite the chamber's same size. Otherwise, relatively long river stretches upstream and downstream the Iron Gates I have practically no capacity limits. The implementation of suitable information exchange rules and procedures between the lock operator and the ships under way could contribute considerably to increasing the overall locking efficiency of the mentioned river lock. Another type of telematic procedure, but with the same objectives could be applied to the sections with densely located locks in Austria and Germany, especially on the Main-Danube Canal.

Considerable improvements could also be made in the field of combined and multimodal transports bringing benefits to the forwarding agents whose activities and possibilities for optimal transport solutions are nowadays often restricted due to a lack of proper communication among different transport modes and low individual efficiency of each of them.

The general state-of-the-art in communications, excluding the terrestrial developments, is based primarily on satellite communications and GSM. Within these categories Inmarsat plays a major role for sea communications and Eutelsat (through the Euteltracs service) is the primary leading land-based mobile market for data exchange in Europe. In addition, several new developments in satellite community exist now (Low Earth Orbit - LEO systems), and more spacecrafts will be launched in the coming years. However, the pan-European coverage of the GSM in mobile communications, which is reality, at least in the Western parts of Europe, provides an able competition to the European and the international satellite communication markets. It is also worthwhile mentioning the fact that a number of products and by-products as well as services in the area of surveillance, cargo tracking and tracing, etc exist. In the light of this, there are numerous products available for which their applicability to inland waterways has recently (some of them) been tested in certain parts of the European inland transport network. A brief description of the major services in Europe follows as part of the available telematic infrastructure for the inland navigation market.

All of these technologies provide part of the state-of-the-art in communications. The existing communications in the Danube region are primarily voice via VHF radio communications and in certain cases GSM (mobile phones). It is difficult to utilise GSM, especially in the regions downstream of Budapest, where the coverage is still not sufficient and therefore GSM reliability in these areas questionable. In relation to any other special equipment, on-board PCs and even more advanced systems, is still “science fiction” for a very conservative market, sometimes reluctant to adopt new technologies, even in the Western part of Europe only few ships are equipped with new systems. The reluctance to install sophisticated devices on board occurs even in Germany and Austria before the potential users become fully convinced of their benefits. For the Eastern part of Europe, in addition to these problems a lack of budget is also an issue.

4.1.5 Existing Inland Telematic Systems for Navigation

There are a number of information systems already operating in inland waterways, and of course within the Danube corridor. The following are some systems currently in use for information transmission:

CONDOR (CONtainer - Duisburg - Opti-modal-Rotterdam) system has been developed to serve container transport between Duisburg and Rotterdam. It is incorporated into the EDI system and it works in the INTIS (International Transport Information System) Dutch data network.

DAKOSY (Daten Kommunikation Systeme) - electronic system for the exchange of information and data transmission, which was establish in 1982 for the port of Hamburg. At present, the system is connected with Prague, Dresden, Berlin, Bremen, Rotterdam, and even the USA and Asia.

The system includes eight applications subsystems. There are as follows:

- SEEDOS (Seehafen-Dokumentations-Systeme) - a version intended for forwarding agents - addresses, offers, invoice codes, standard messages, and specimen documents concerning export, import and accounting;
- SHIPS (Schiffsabfahrts - und Informations-System) - a version for agents of sea lines in Hamburg, who announce the planned departures of their ships;
- ZODIAC (Zoll-Dokumentations-System) - a version for customs officers and importers - it offers the processing of data necessary for customs clearance, transmission of data to customs offices, and the printing of customs documents;
- TALDOS (Tally-Dokumentations-System);
- GEGIS (Gefahrgut-Informations-System) - a version for registration of dangerous cargo;
- HABIS (Hafenbahn-Betriebs-und-Informations-System) - version for port railway transport;
- ACTION (Agent’s Container Transport Improving and Organising Network) a version intended for container transport;
- DATABRIDGE INTERNATIONAL (Globales Datenkommunikations system) - international communications system linked with networks in other continents.

DOCIMEL - a system for the electronic transmission of data, documents and other information concerning transport.

VTS, VT-MIS systems are available in Holland and Germany and have to be taken into consideration for the inland water navigation. The existing regional dispatch centres for traffic management as well as the larger dispatching system in some countries are a good example.

HERMES - European network for data transmission in railway transport; TRAXON - air communication system for air cargo transport, which offers its services to freight forwarders, airports, custom officers, etc.

VNS (Veronique Network System) based on PCs (IBM AS/400), which is used by the Union of French Hauliers associated in Editransport. These are transport and forwarding companies, such as Air France, SNCF (French railways), Chronopost, Rhone-Poulenc or Philips. At present, the VNS system is used also by smaller companies; METIS - a software product for data transmission based on EDI system. The system, developed by the "Zoll und Transport" working group, Vienna for Austrian forwarding agents and customs officers, is able to communicate in three languages. The developer of the system has made an offer for its implementation in the Czech Republic, the Slovak Republic, Hungary and Slovenia.

IVS 90 - information system for inland navigation introduced in the Netherlands in 1994
MIB - information system used in water transport in Federal Republic Germany.

In addition, there is a systems presently demonstrated and developed further in taking into account particularly Danube condition called INDRIS, which is also financed under the 4th Framework Programme for RTD of the EU. The demonstrator in the Austrian sector intends to:

bring a tactical traffic image on board
bring a strategic traffic image on board and on shore
provide fairway information on board
use the same communication media for all communications between vessels and shore
use the same electronic reporting formats according to the agreed provisional standards (to be defined)
use a provisional standard (ingis format) for all traffic images (strategical and tactical) and on shore.

4.1.6 User Needs

The general objectives of the implementation of advanced telematic procedures can be defined as to achieve a higher effectivity of the transports systems and existing infrastructure keeping in mind safety requirements and environment protection, to automate certain operations of particular traffic systems and to integrate transport systems and achieve the interoperability of equipment and their performance.

The following components of the inland navigation system should be viewed in connection with the attempts to make improvements using the telematic applications:

transport service performances
fleet management
individual ship control
traffic control
control and maintenance of infrastructure (waterway, ports, locks, bridges)

On the other hand, all the information requested from different users and user groups in inland navigation can be divided into three groups:

nautical information for the skipper
management information
other information

According to this, each particular group of users has its specific interests. These are first of all:

for skippers:	safe navigation and optimisation of trip schedules
for fleet managers:	effective utilisation of the company's fleet
for terminal operators:	optimal utilisation of resources (personnel, equipment, stowage facilities)
for lock operators:	optimal utilisation of the lock capacity
for authorities:	general safety
for freight forwarders:	assessment of offers, organisation of transports
for shippers:	assessment of quality of transport, comparison with his requirements etc.

The contents of each group of information is described in details below.

Concrete Measures

The traffic density on the Danube, especially on its middle and lower course is still far lower than that of West European waterways. Although safety standards must be observed in any case, the main and most urgent objective for the implementation of telematic procedures on the Danube is reliability rather than safety of transport.

The greatest challengers that can be met through the application of advanced communications and data processing technology are listed below:

- **reliable forecast about water level variations**

Providing reliable medium-term forecasts that are highly relevant for the skippers is not likely due to the fact that the water level on the Danube sometimes changes very quickly (even 100 cm within 24 hours).

On the other hand, long distances on the Danube cause the trip to sometimes last even more than a week. What can be done here is to up-date information on water level gauge readings more frequently (every six hours, for instance, instead of only once a day with a reading of the previous day which is usual practice now). Furthermore, more precise information could be given about tendencies of water level behaviour. Now, it usually consists of communications of low information content such as "rising“, "stagnation“ or "sinking“. The information should also consist of the rate of rising or sinking in the last six hours with the overview of such rates over the last few days. Data about the current stream flow rate would also be very useful. Such a set of information coupled with a meteorological forecast on precipitation and temperatures would enable the skipper and/or fleet dispatching officer to work out trip plans and loading allowance much more precisely than nowadays. However, VHF voice communication is not suitable for such data transfer and instead a GSM network and fax device or even better, a computer on board would be recommendable.

- **strategical traffic image**

Establishing an effective system that supplies information of relevance for various users as described in the previous chapter is highly recommended. As at the traffic monitoring stations, the lock towers could also be used in the first instance. All information coming from the locks could be collected and processed at one traffic control centre. Due to the length of the river and the very uneven distribution of locks, one centre would be required for the German sector, one for the Austrian and one for the Iron Gates canyon. Such systems are already in use in Germany (NIF and MIB) and partly on the Cernavoda-Constanta Canal and have need to be enhanced with sophisticated information exchange management. On other sections without locks, the strategically most important hydrological stations could be properly equipped and promoted for such service.

- **tactical traffic image**

There are some stretches on the Danube where due to the morphology of the surrounding terrain it disables the reception of a clear image on the display of an on-board-installed radar. These stretches are found in Germany, Austria and Iron Gates. The ship must be led with extreme caution and it often means slowly. But in downstream navigation, the effective steering of the ship can be achieved only if the speed relative to the ground is considerably high. Such stretches require traffic monitoring and regulation by means of on-shore-installed devices like radars, TV-cameras and active traffic signals like, e.g., traffic lights at road crossings. Such modernly equipped systems called RTIS (Regional Traffic Information System) do exist in the Netherlands and in Germany on the Rhine between Oberwesel and St. Goar.

Of valuable assistance for the skippers would be board computers for trips over the longer Danube stretches. The PC-based computers with interfaces to different sensors and loaded with tailor-made software, which are now in the development phase, may be used for:

- **trip optimisation**

calculation of the optimal rpm of the propulsion engine in given waterway conditions picked-up by sensors in order to be at the desired place at the desired time, however, within the range of the ship's performance, vice versa a calculation of the ETA giving a different throttle

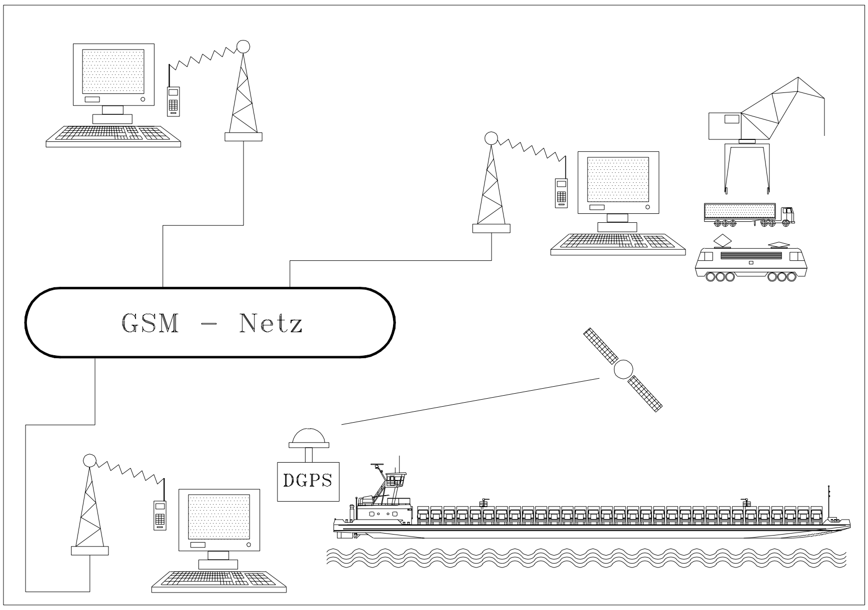
engine room monitoring

trip recording (recording of engine and other system parameters during the trip)

load calculation (as "load master“ on sea-going ships)

displaying of ECDIS (Electronic Chart Display Information System) as a tactical navigation mean

Figure 4.3:
A concept of data transfer for inland navigation



For the optimal utilisation of a system's performance, a DGPS (Differential Global Positioning System) and a GSM network are required. The Danube corridor downstream Austria is not yet covered by GSM relays and the only way to communicate is by using mobile telephone links via satellite to transfer data on board. Such equipment would also considerably improve the strategical information exchange among ships under way, ship operator dispatching offices, port terminals, traffic control centres, river locks, forwarding agents etc. - respectively all actors in the inland navigation business.

- **terminal operation**

The number ports on the Danube have to promote themselves as "freight distribution villages“. This means that those ports which can offer a variety of services besides traditional ones such as transhipment and storage of goods will have good development outlooks. Especially important in this context are the interfaces with the truck mode. Possibilities to enlarge river Ro-Ro services are very promising on the Danube, but the main prerequisite for such a venture is the existence of one reliable and efficient information management system to which all participants in a assignment would have access including even the individual truck drivers on their long journeys from, e.g., Greece, Turkey, Bulgaria or Romania. Otherwise, the advantages of new sophisticated concepts of multimodal transport are not feasible.

Higher reliability, punctuality and to a lesser extent also the forwarding speed and safety as a consequence of the implementation of an advanced transport telematics would considerably improve the image of the inland navigation mode. That could win back customers who have switched over to other modes of transport in recent times, mainly to trucks. Well-designed telematic systems and procedures could also contribute to creating new kind of services or to the expansion of those which do not perform as the expected on the Danube, as e.g. container transports.

4.2 Market Restructuring

4.2.1 Intermodality Requirements

The conditions of the intermodal and combined transport referring to the transport policy and especially in view of the present and the future problems of the road haulage, intermodal and combined transport gain in significance. Therefore, many member states provide advantages, within their transport policy for these approaches. For example, the Austrian transport policy includes measures in order to support transport modes causing less air pollution like rail, inland navigation and combined transport. Among these are:

- Investment aid: The extension of the combined transport is forced, in order to reduce the road haulage. Investments in the combined transport are financed and supported. Austria co-finances also the extension and the support of such initiatives in CEE countries.

- Discharge of the non-profit services in the combined transport including different types of the ROLA (services, which are of public interest because of the environmental protection)

Although considerable steps forward have been made in the field of intermodal transports with the participation of inland navigation within the Danube corridor in the recent years, the utilisation remains still far behind the real potential. Considering the relatively low efficiency of each single mode especially downstream of the Austrian-Hungarian border, certain efforts should be made to propose such logistic solutions which can optimally utilise the specific unique advantages of the particular mode. It is evident that inland navigation can offer an advantageous mean of transport, which in collaboration with rail and road through intermodal interfaces (considering advancements and enhancements on the inland ports) can even become the major player in European transport schemes.

There are a number of organisational and infrastructural requirements for the development of the intermodal transport. These needs are considered against the obstacles for the overall development of the inland navigation transport and the interfaces to the rail and road transport.

Constraints, such as:

- The long-term investment required in some sectors, particularly in transport infrastructures, necessitates new types of partnerships between private and public financing.

- The absence of an open and competitive markets is hampering, to differing degrees, the optimal use of existing networks and their completion in the interest both of consumers and operators.

- The sluggishness of the preparation, planning, authorisation and evaluation procedures and regulatory obstacles hamper the implementation of large projects.

In fact the analysis of the national policies confirm the continuing existence of the problems identified by the Commission in 1993. While additional issues were identified as problematic to the, improvement of the transport system:

- The strong focus on the TEN at the European level is considered problematic by many relevant actors, especially in Central Europe. The most radical among the opponents insist that prior to judging the necessity of further corridor developments, it would first be necessary to resolve the question of pricing European-wide.

- There is a broad consensus throughout all the Member States that the gap between available sources and the demand for investments in transport infrastructure, telematics, policies and environmental action programmes is a major constraint for the development of the transport sector. The promotion of private-public partnerships has not been successful in any of the Member States so far. Out of this bottleneck, the availability alone of financial resources might come to determine decisions about the realisation of transport projects at the detriment of the quality or scope of the project.

- Despite the wide consensus on the necessity for the rapid improvement of intermodal transport networks on the national level and the existence of encouraging growth statistics from combined transport operators in most countries, the realisation of necessary interfacial infrastructure and technological adaptations is progressing at a rather slow pace, not least because, critics claim, the emphasis is instead placed on the operationalisation of modal infrastructure plans.

- Policies to reduce the negative environmental impacts of transport are best characterised as operating as `end-of-pipe technologies', i.e. in a repair, rather than a preventive, fashion. More advanced approaches such as internalising external costs, changing spatial patterns or economic policy or even taxation policies are notoriously difficult to agree upon and more difficult to implement.

- In connection with the latter point, it is also relevant that there is a lack of harmonisation or even of coordination with regards the use of assessment techniques; moreover, there has been little systematic elaboration on the combined use of quantitative and qualitative indicators: Germany, displays a very advanced form of project assessment, yet only consider quantitative indicators; in other countries, like Austria, the Netherlands, and, as of recently, France, use also qualitative criteria.

- The amelioration of public participation has in the majority of cases not kept pace with the growing environmental concerns on the local level.

- A series of problems arise around the deregulation and privatisation of transport services and infrastructure operators. Lacking are guidelines regarding efficiency and equity issues, relevant when the state retreats from operating transport services. Decisions on how to deal with competition issues between the different modes in relation to the varying speeds in the process of market deregulation and pricing are pending.

The current transport system has developed according to the conditions set by economic policy and urban development. New organisation of industrial production, the globalisation of the economy (disparities/competitive advantages of economies) and spatial/urban development (increasing distances traveled) have shaped the current situation of transport with its benefits and problems. Therefore solutions to the actual problems cannot be found within transport policy alone; the interaction of various policy areas have instead to be considered.

Obstacles to intermodality

The major obstacles in the intermodal transport are primarily allocated to the efficiency, the organisational and administrative problems especially in the central and eastern part of Danube and at the least but not last the absence (in certain areas) of marketing and business schemes to bring cargo into this mode of transport. Road and rail connections to most of the small and medium size Danube ports is very limited. To this effect, a number of infrastructural developments have been considered but few materialized and implemented.

In addition, the competitiveness of the intermodal (inland waterway) transport compared to road or even rail transport is low since very often the costs are higher, the efficiency is lower, the organisational aspects of the business are not sufficient and the strategic marketing approaches of these services remain still unclear.

4.2.2 Harmonisation of Technical Standards and Legal Regimes

Two aspects have to be considered: technical standards dealing with the rules and regulations for building and equipment of ships and harmonisation and whenever possible also standardization in different procedures like communication and information exchange, appointment to the police and customs authorities for vessels in transit and transportation of hazardous goods.

There have been certain developments in terms of navigation (ECDIS), in terms of safety requirements (Distress signals), in terms of position location (especially in the maritime world and for the hazardous goods shipments), and other harmonised approaches in communications (for example, satellite means). In addition, there are developments which will undergo standardisation procedures, such as message exchanges (EDI messages primarily for maritime exchanges), language independent systems, etc. which also have to be considered in the inland navigation transport.

In relation to the navigation standardization, ECDIS is the one standard that will be developed also for inland navigation and regulations have to be developed within this approach.

- **The Danube Commission and the CCNR**

The Danube Commission has been established with the Belgrade Convention signed in August 1948 by the governments of Bulgaria, ex-Yugoslavia, Romania, ex-USSR, ex-Czechoslovakia, Ukraine and Hungary. Nowadays, the participating states of the Danube Commission with offices in Budapest are Austria, Slovak Republic, Hungary, Yugoslavia, Romania, Bulgaria, Ukraine and Russia - all with full membership status. Germany, Croatia and Moldova have observer status. The Danube Commission brings forward recommendations referring to the technical and legal matters on the waterway Danube, traffic regulations, ship equipment etc. These recommendations and resolutions need not to be accepted by the national administrations of the member states but permits them to set different rules for services and traffic policy on the sector under their own jurisdiction.

The Central Commission of the Rhine Navigation (CCNR) had been set in 1868 after the convention signed in Mannheim. The Mannheim Convention settled the principles of a navigation system on the Rhine still being in force today. Participating states of the Mannheim Convention and the bodies of the CCNR with headquarters in Strasbourg are the Netherlands, Germany, Belgium, France and Switzerland. Austria is interested in joining the group.

The CCNR has created time by time a complete Regulation Act for inland navigation which comprises:

- Regulations for the operations of vessels navigating on the Rhine which are supplemented by special technical rules
- Inspection Regulations for vessels on the Rhine to ensure an unified way of inspecting vessels and the delivery of the vessel's certificate of the Rhine
- Regulations of shipmaster's licence for the Rhine navigation to state an uniform examination procedure for the acquisition of the shipmaster's licence
- the ADNR rules to apply in addition to the regulations mentioned above to all vessels carrying dangerous goods on the Rhine

The resolutions, rules and regulations brought in the bodies of the CCNR have the force of the law for all the vessels navigating on the Rhine.

There does not seem to be much disagreement as to the necessity to a harmonisation of these two regimes now being in farce within the Union, only the way to achieve this sometimes causes conflict. Eventually the Commissions procedure of harmonisation within the internal market by adopting the more elaborate and stringent rules and concluding bilateral agreements with non EU-countries seems the most promising though time consuming it may be.

- **Rules and regulation for building and equipment of vessels**

The Working Group for the Inland Navigation as a body of the Committee for Inland Transport of the UN/ECE issued in 1993 the codex of valid resolutions (TRANS/SC.3/131) which contains all resolutions and their amendments issued by this institution and dealing with inland navigation, waterways and different standards to be applied on inland vessels since August 1957.

The Danube Commission usually adopts these resolutions and proceeds them to the member states in a form of recommendations which means that their strict implementation are left to discretion of the corresponding national authorities. These authorities set-up national rules which in the case of the Danube are much lesser harmonised than for instance in the case of river Rhine where the rules and regulations once issued by the Central Commission for the Navigation on Rhine must be applied (implemented) in the national rules of all member states.

When considering the steps to be done towards harmonisation of the national rules and regulations for construction and equipment of the Danube vessels in the future, several aspects have to be taken into account. Those are:

- Integration of the Danube waterway into the all European inland waterway network through putting into service the Main-Danube Canal in September 1992
- Goods' structure changes caused by the economical changes overall and additionally political changes in most of the former Eastern countries in the Danube corridor since the end of eighties, beginning of nineties
- Overall technical and technological development in shipbuilding science in recent times
- Admission of Germany into the Danube Commission in 1998 as well as Croatia and Moldavia whereby all the Danube riparian countries became the full members of that body

It is however the interest of all the Danube riparian countries that their vessels are at least technically aligned with minimum of requirements needed for allowance to enter international and national waterways on the territory within the entire integrated European inland waterway network. As far as the rules and regulations which must be satisfied for the navigation on Rhine are the most advanced and most completed, (the ships which satisfy them are allowed to enter all other West-European inland waterways if nautical conditions on the link and vessel's size are compatible, the first concrete steps to be recommended would be alignment of the Danube technical recommendations with the rules and regulations on the Rhine and giving the power of rule (obligation) to such defined Danube prescriptions. Recent admission of Germany as a member of the Central Rhine Commission to the full membership of the Danube Commission can much contribute to the acceleration of such initiatives.

Quite reasonably, national rules may retain some additional requirements but these requirements must not be applied to the foreign vessels in transit on domestic and especially on international waterways like the Danube which otherwise fulfil the minimum of the mutually agreed and harmonised rules.

In any case the harmonised technical rules should be applied to the features dealing with safety standards for crew, traffic, ship and her equipment, cargo and environment such as for instance:

- Stability and freeboard requirements
- Speed and manoeuvring performances (propulsion and steering gear)
- Size limits
- Hull structure (longitudinal, torsional, local strength, double hull execution in case of tank vessels)
- Deck equipment (anchoring, mooring, cargo gear, hatches etc.)
- Life-saving equipment, gangways, stairs, railings, manholes etc.
- Machinery (propulsion, electric generators, systems for machinery like fuel, lubrication oil, cooling, exhaust etc.)
- Ship systems (bilge, drainage, fire-fighting equipment, systems for hydraulics, sounding system etc.)

- Noise level requirements
- Signalling systems, communication systems

as well as the variety of other technical elements. Thereby standards have to be defined for the functionality respectively performance (output) and not for the kind of execution of device itself. For example in regard of the manoeuvring performances of the ship, her ability to perform for instance change of heading course for certain number of degrees at certain speed and within the certain time interval has to prescribed but not a kind of device which must be installed. In that respect the requirements for so-called “crash-stop” manoeuvre on the Rhine are clearly defined but the rule that all ships exceeding certain length must be equipped with bow thruster device when entering the Main-Danube Canal has to be altered in requirements for manoeuvring abilities. Namely, ships having two propellers are principally able to perform change of course much more efficient than the vessels with one propeller and bow thruster. The question is here to define the preconditions for certain action: mutual relations among the size of vessel, instant speed of advance relative to the ground, rate of turn (change of heading course in time unit) and various side effects (e.g. drifting, trajectory). If the scenario for output would be prescribed, it will be left to discretion of designer to choose the most beneficial technical solution which fulfils the output requirements.

To conclude, the rules and regulations for construction and equipment of vessels have to be based on functionality (operational and safety requirements) and not on specific technical solution itself. Technical solution should simply satisfy operational and safety requirements – pure existence of certain device may be found as necessary but not enough prerequisite for the satisfaction of prescribed functional output. And finally, all national rules despite of their mutual differences in details must be harmonised on the minimum of these functionality level in order to achieve a smooth service interconnectivity Europe-wide

- **Additional regulations covering the transport of hazardous goods**

The international regulations for the transportation of the hazardous goods are not applied today on the Danube. The Danube Commission made certain efforts to officially introduce ADN standards on the Danube since 1992. The ADNR rules prescribed for the Rhine by the CCNR and based on the ECE's "Development of the European agreement about the International transports of dangerous goods on the Inland Waterways" are valid on the German sector of the Danube since July 1992. Austria and Germany made the mutual agreement for the transition period whose technical prerequisites correspond to the ADNR rules in large extent.

National rules and regulations are issued in Yugoslavia, taking also into account the international convention about protection the humans during transports of dangerous goods. These technical prescriptions which have the power of the law are issued by the Yugoslav Register of Ships.

The national rules had to be accomplished in the Slovak Republic up to the end of 1993, but the results are not available up to now.

The other Danube countries either have not their national rules or (in case of Romania and Ukraine) the data are not available.

For German and Austrian ships there are usually no restrictions of transports of dangerous goods through the domestic waterways as well as on the Danube downstream the Austrian border. The ships of other Danube flags when entering Austria or Germany must either fulfil the ADNR regulations must have an official document with the confirmation that the ship matches the ADNR safety requirements. The waterway police in Austria and Germany is responsible for checking such statements.

4.2.3 Market Access

In principle access to inland navigation markets on the Danube is liberalised. There are no such regulatory procedures like the tour-de-rôle system. The Belgrade Convention stipulates that the Danube may be used freely by the persons, the merchant navy and the commodities of all countries. A principle that was reaffirmed by the members of the Danube Commission informally. This principle could prevent a division of the Danube waterway into an EU port and non-Union port.

In practice, though, this principle is mitigated - if not counteracted - by a number of bilateral and multilateral agreements which basically aim at market division and at fending off competition. The most important of these agreements is the Bratislava Treaty which seems to serve as a quasi-cartel of the (formerly) state owned operators. It's basic intention is the determination of quota of cargo volume to be transported by each member company on a basis of mutual proportionality. The bilateral agreements, e.g. that between Germany and Hungary, work in a similar way. It can only be a matter of time till someone will attempt to gain a court-decision whether these regulations are conform to Union competition rules.

However, market access for third countries, resp. their carriers seems to be rather restricted to the established service providers, whereas third parties and/or newcomers are confined to niche activities or are barred off completely.

Privatisation of inland navigation operators that has been effected in some of the Danubian Countries did not change this situation. It neither could bring new impetus to the (national) inland navigation market nor loosen the regulatory framework of the Bratislava Treaty.

Mainly for economic reasons - lack of resources for investment and/or innovation - the privatised companies remained trapped in their traditional behaviour. Also the profits expectations do not attract fresh money and hence tend to reduce rather than enhance the competitive drive within the industry.

A mere comparison of numbers sheds a light on the differences between Danube and Western Europe navigation. Whereas e.g. in Germany more than 9000 company's, are active as ship operators, all the Danube riparian countries together count scarcely more than two dozens. Among those state-owned or only recently or partly privatised enterprises dominate. Thus there is an entrepreneurial gap both in quantitative and qualitative respect regarding Danube navigation having severe impacts on the performance of the mode possibly affecting the modal split - and its future development -

as much as relative cost structures or commodity structure changes in trade which are the basis of the simulation model and the prognosis.

Firstly the low propensity to innovate is further decreased because of the low level of competition within the inland navigation. The competitive advantage of the industry, e.g. vis-à-vis other transport modes, where a lot of competition is felt, is entirely seen in the price (freight rates). But furthermore beside the lacking pressure for innovation there is also a lack of lobbying power in order to achieve the (public) infrastructure investment necessary in competition with other (public) necessities. The social return on inland waterway investment is certainly higher than the profitability of the operators. The relative low weight of the industry within the transport sector, though, makes it hard to convey this

Certainly an accelerated opening of market access alone will not suffice to change this since attractiveness of the sector will not simultaneously rise but it will be a strong signal of confidence in the future prospects of the market. If those (entrepreneurs and public service providers) engaged in the market seemingly do not trust in that future the reluctance to allocate investment (public but also private) to the sector is unavoidable.

4.3 Strategic Actions Recommended

This last chapter of the Final Report tries to wrap up the main findings of the study in the form of policy recommendations. These recommendations certainly cannot address the level of individual project decisions or even a particular countries' national policy. The have to address the Danube waterway as a whole and thus single out the actions (and measures) relevant for the transnational level or for all the concerned parties.

Despite the adverse effects of the Kosovo war on Danube navigation there appears to be a window of opportunity for the pursuing of a co-operative strategy for the development of Danube transportation. „Co-operative“ encompassing both the different countries and (transnational) institutions as well as different players on the relevant transport markets. This window of opportunity may disappear when road infrastructure in the CEE countries comes closer to Western standards, or when cargo volume is diverted away from the water especially on the lower Danube as a consequence of eduring weaknesses of the local industry and permanently low adaptability of the relevant companies. Today the situation still seem less serious and chances are that after reopening of the Serbian stretches of the Danube not only the Yugoslavian inland navigation industry can be integrated again into the European but also that the other operators and service providers of the CEE countries can quickly resume their former connections/relations and restart a positive IWT development.

Three group of actions seem to be most important. Their successful implementation will in the mid- to long-term determine the development of Danube inland waterway transport in absolute and relative terms. They are:

- Creation of a single European regulatory framework
- Promotion of investment in infrastructure and fleet
- Closing the entrepreneurial gap

- **Creation of a single European regulatory framework**

On the one hand this may seem utopian, since it would have to integrate countries that will for the foreseeable future remain outside the European market regulations (e.g. Ukraine) but on the other side this is an area where in the last years considerable progress has been made.

The harmonisation of the legal frameworks envisaged by recent EU initiatives and supported by the increasing number of simultaneous membership in the CCNR and the Danube Commission is a decisive step in this direction. With the accession of most of the Danube riparian countries to the EU becoming imminent further steps seem easier than before.

The importance of such a harmonised framework has to be acknowlodged also from the non-EU members and therefore must not be used entirely as a defensive instrument. The technical requirements for ship equipment, licences, etc. must eventually create a level playing field for all market participants. Particularly since a large share of the Danube fleet is practically excluded from Western European waterway-system by the mere characteristics of waterway(s) and the type(s) of construction or dimensions.

If this is clearly envisaged and gradually approached the single steps and the direction of these steps or probably more important than the final stage or form of the framework. The unifying vision will exert a strong cohesive power for the Danube system.

- **Promotion of infrastructure and fleet-investment**

The simulation of future transport demand and it's affinity to waterborne transport make out a good case for the improvement of the waterway infrastructure. Though the cost of investment have not been covered in the study it can be assumed that in a comprehensive evaluation each of the prime investment projects would create a considerable positive return. As it is the case in all large interconnected investment projects the evaluation on a case to case basis may yield distorted results due to problematic allocation of the benefits.

This is but one reason why the necessary infrastructure investment should be organised on a transnational basis. The other reason being that the priorities of these investment can only be decided rationally when considered taking account of their mutual dependencies and each single project's network-effects.

A transnational investment programme for the Danube waterway would therefore be the adaquate instrument for the promotion of relevant infrastructure spending for the countries concerned - within and outside the Union. By the mechanism of co-financing the steering effect of the money allocated to such a programme would be considerable. It would possibly have a positive effect on private investment into inland navigation too.

A number of institutions have been working at least implicitly towards such a programme, e.g. the corridor 7 working group within the TINA.

Beside infrastructure investment the necessity to restructure and modernise large parts of the Danube fleet is also deemed indispensable. Alt least the accession countries should be supported to have their fleet adapted to European standards.

The mechanism to reduce overall capacity in Europe and at the same time increase the quality of the remaining fleet can not automatically be transfered from Western Europe (scrapping premium) to the Danube because of the completely different technical and economic structure of the industry. New ways to achieve the restructuring goal without further market distortion have yet to be found. Maybe the proposed transnational Danube investment programme would be the right framework to develop adaquate and politically feasible ideas for the promotion of Danube fleet modernisation.

Particular scope is seen in the telematic procedures and equipment where inland navigation on the Danube has to go a very far way just to catch up with neighbouring regions and sectors.

- **Closing the entrepreneurial gap**

The fact that in all relevant countries of the Danube (except Germany) inland waterway transport is concentrated in a handful of operating companies, sometimes privatized sometimes still state-owned, has been labelled as entrepreneurial gap.

Assisted by multilateral and bilateral agreements and by high market entry cost competition within the sector has been kept next to zero. Today market entry at least in the CEE countries is further reduced by low (short term) profit expectations.

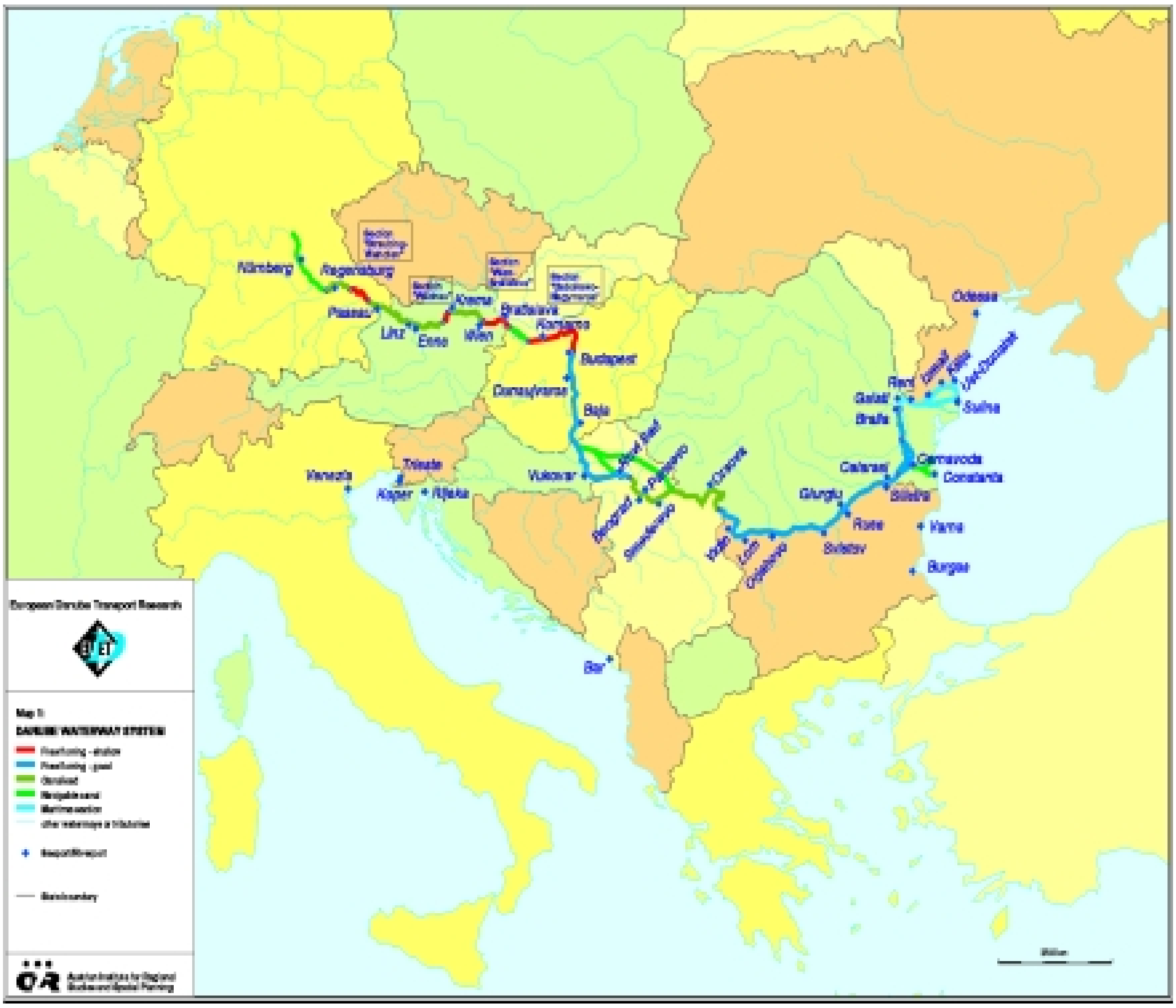
This is a situation that can not easily be changed, but nevertheless if left untouched threatens the economic future of the sector as a whole.

Two ways to tackle the problem might be suggested. One aims at a better integration of the ports into the operating business using the synergies they produce by their privileged (territorial) position.

The other possibility lies in the support and development of logistic chains that go (far) beyond the inland navigation industry thus creating and developing the market instead of administering it merely. Such a support cannot be created by existing institutions or a single company alone. Some sort of co-operative approach on national level or internationally organized could point a way out of the entrepreneurial gap. The Austrian Ministry of Transport is planning to create and back such an institution (Danube transport development agency.)

ANNEXES

MAP 1:



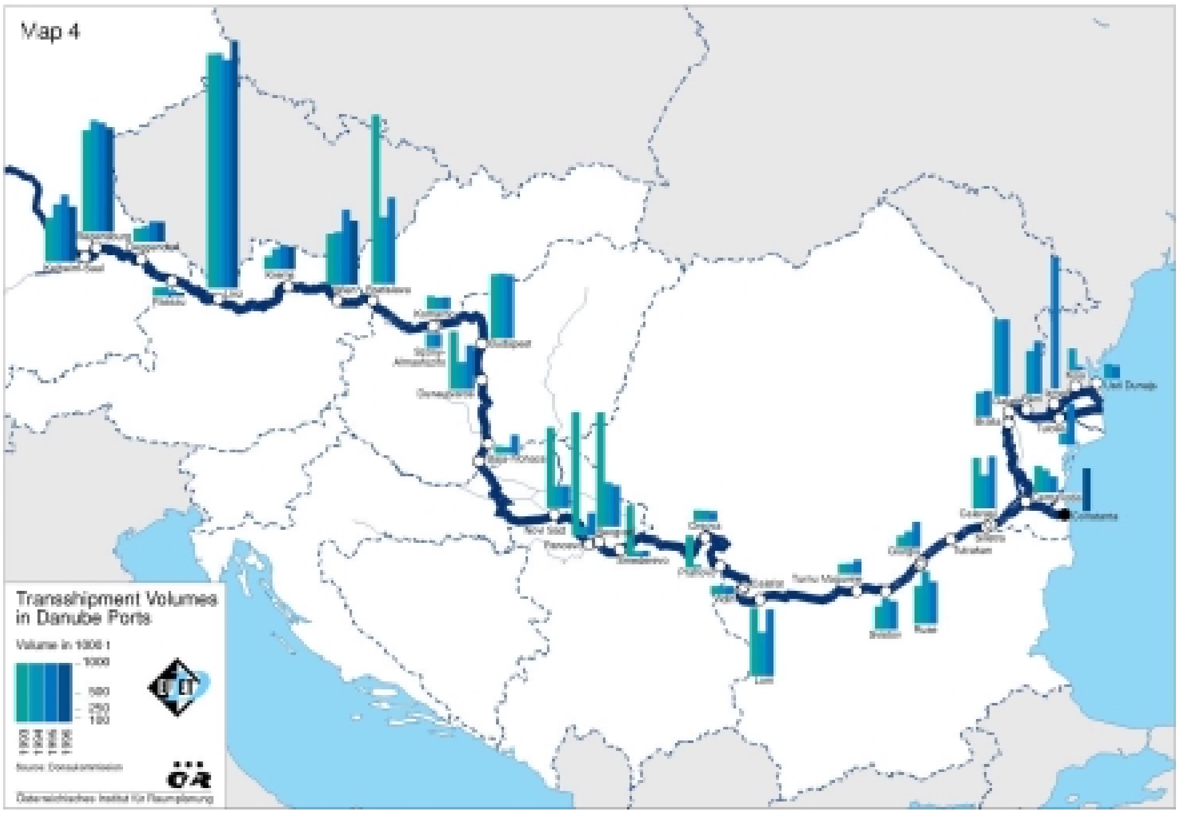
Map 2:


European Danube Transport Research
Map 2:
SELECTED PORTS AND LOCKS
Nürnberg
Regensburg
Passau
Linz
Enns
Ybbs
Krems
Wien
Bratislava
Budapest
Dunaujvaros
Baja
Mohacs
Vukovar
Novi Sad
Beograd
Smederevo
Orsova
Prahovo
Calafat
Vidin
Lom
Giurgiu
Ruse
Calarasi
Silistra
Cernavoda
Constanta
Braila
Galati
Tulcea
Sulina
Odessa
Varna
Burgas
Bar
Thessaloniki
Venezia
Trieste
Koper
Rijeka

Map 3:


European Danube Transport Research
Map 3:
CLASSIFICATION OF WATERWAYS
FRANCE

Map 4:


Map 4
Transshipment Volumes in Danube Ports
Volume in 1000 t
1000
500
250
100