RAILWAYS

Railway network

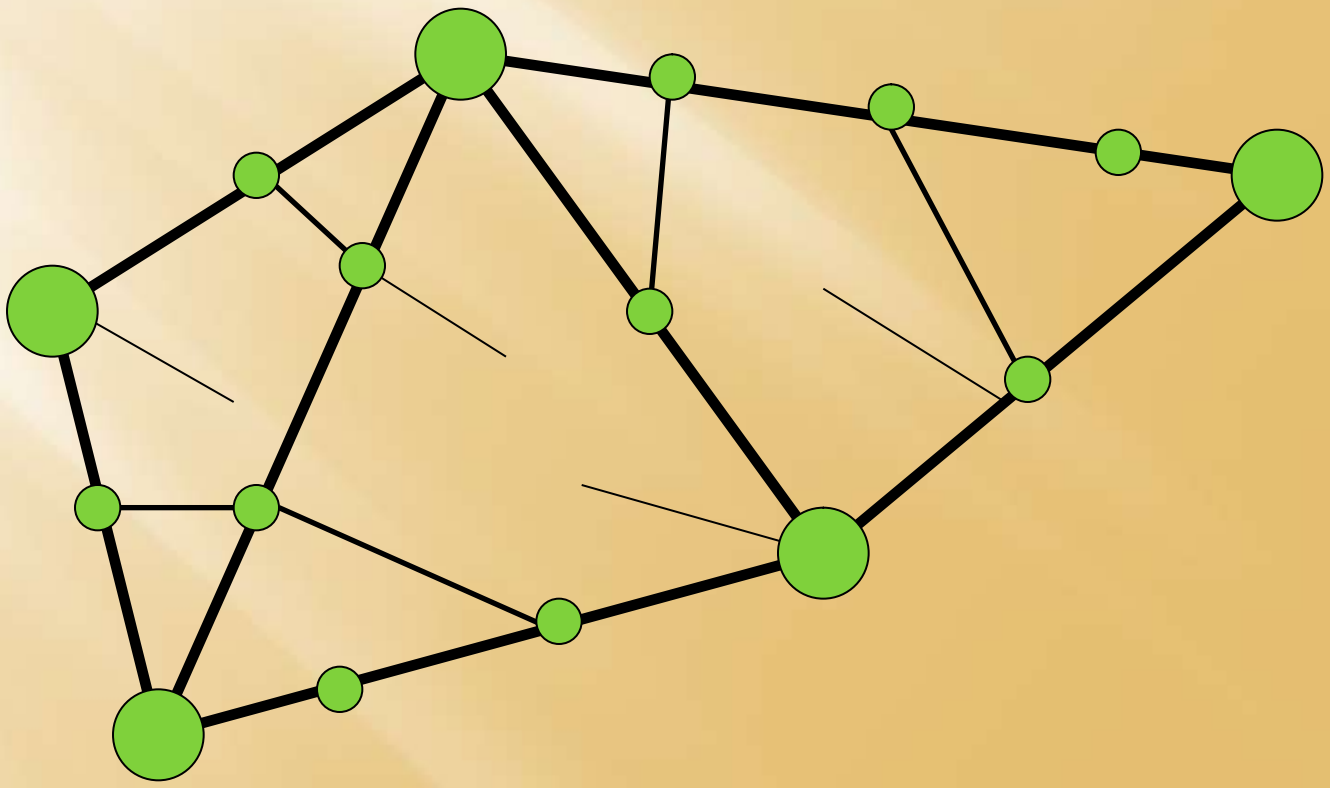
1. Railway network in Poland and in Europe
2. Safety and traffic control
3. Intermodal transportation

PhD CE Jarosław Zwolski

[and you drive??]

Transportation network

A transportation network consists of linear objects, on which nodal objects of various types and importance are spread.
The most important nodes create junctions of the main transportation corridors.



Transportation infrastructure

Linear objects:
roads, railways, midland channels and rivers

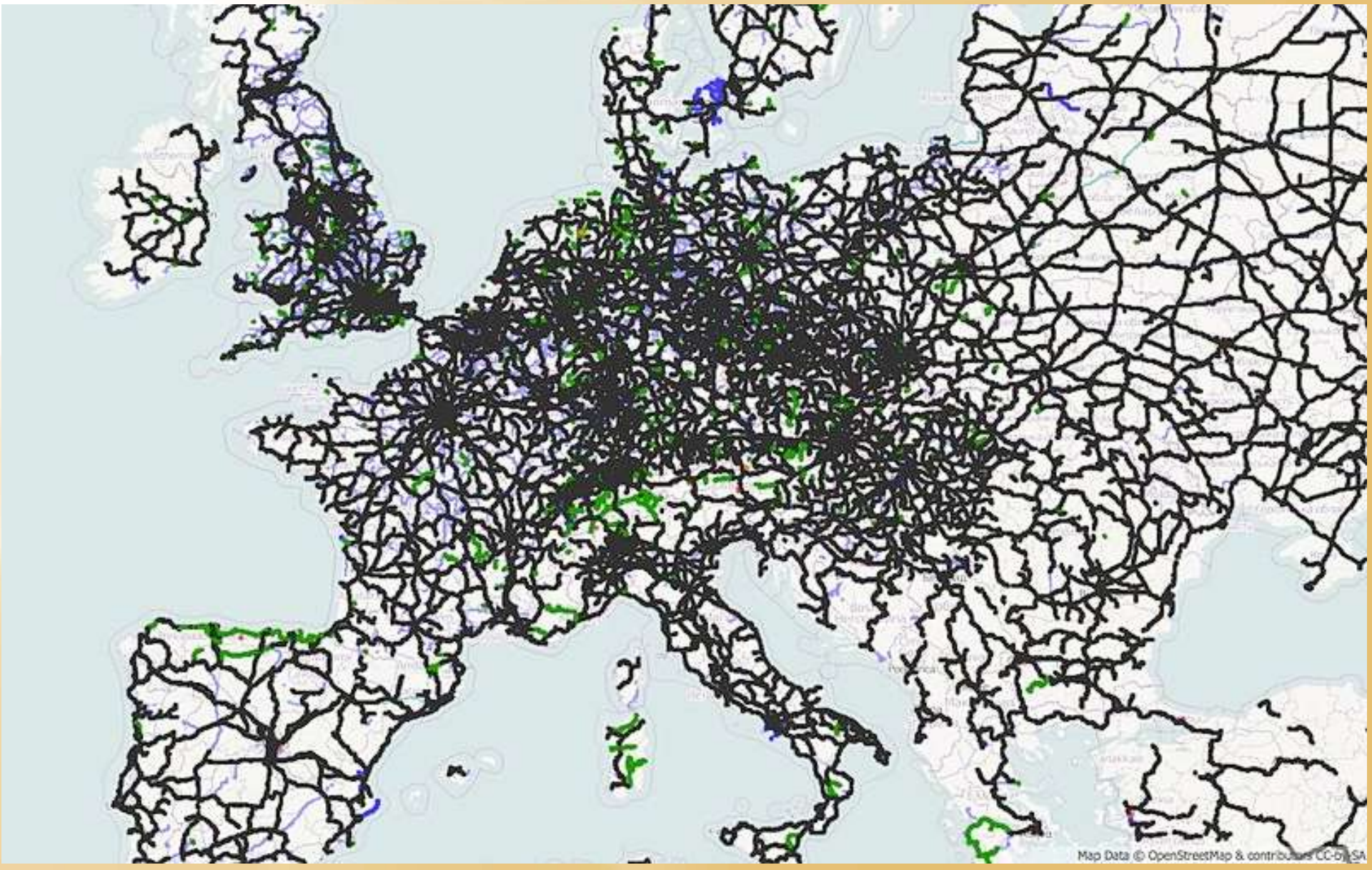


Nodal objects:
railway operational points, rest area at highways, midland harbours, intermodal transportation terminals, logistic centres etc.





European railway network



Cooperation & Agreements

- AGC – 1985 (European Agreement on Main International Railway Lines) – numbering of lines e.g E30, description of the main functional and operational parameters (speeds, axle loads, max. gradients, lengts of platforms and sidings, no grade crossing on main lines).

- AGTC – 1991 (European Agreement on Important International Combined Transport Lines And Related Installations) - numbering of lines e.g C-E 30, description of the main functional and operational parameters (speeds, axle loads, lengths of platforms), location of terminals, ferries, border crossings and gauge interchange stations important for combined transportation.

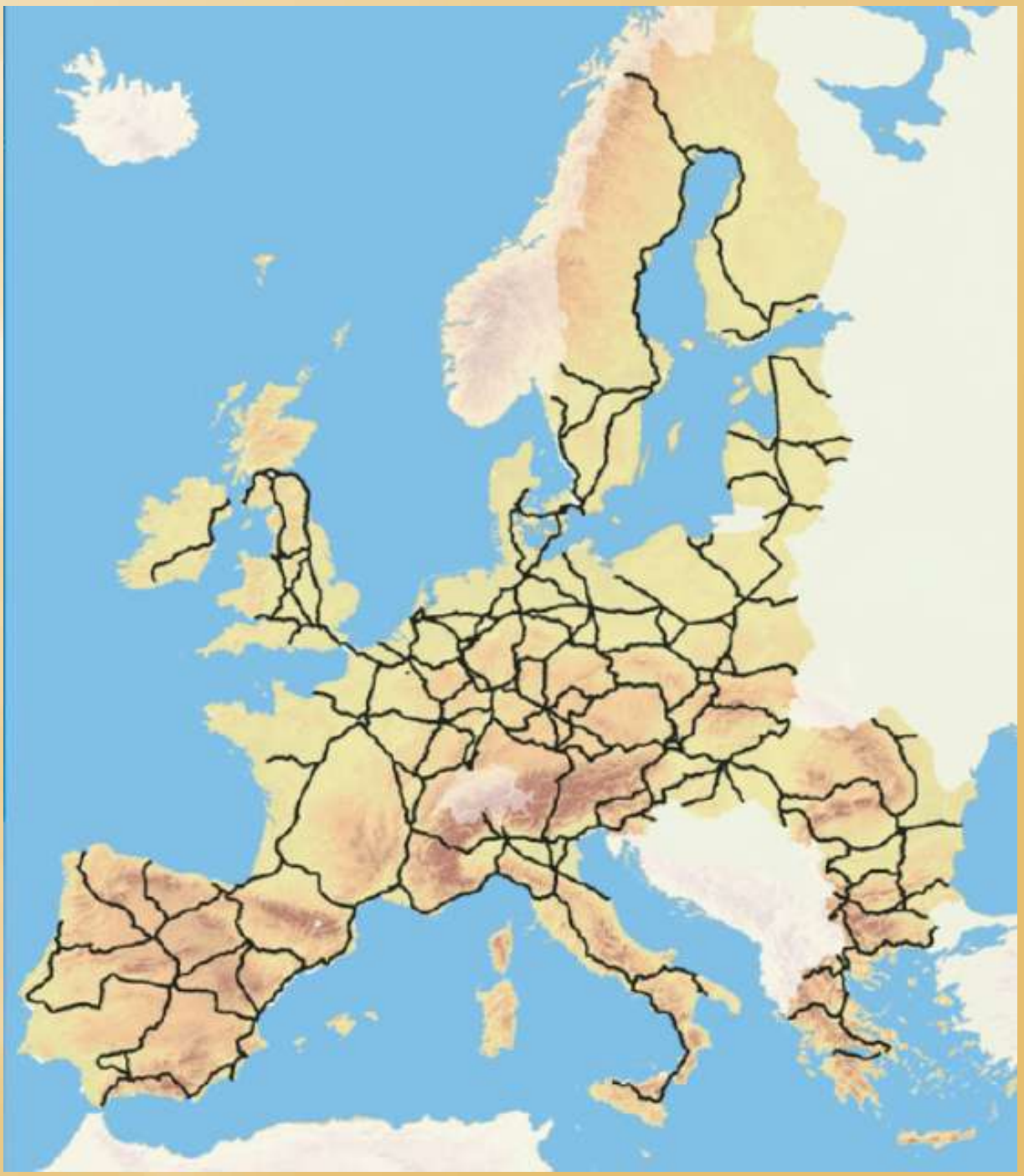
- TINA – 1996 (Transport Infrastructure Needs Assessment) – assessment of the *status quo*, future needs estimation and coordination of the networks development in the new UE members (18 030 km roads, 20 290 km railway lines, 38 airports and 13 midland harbours).

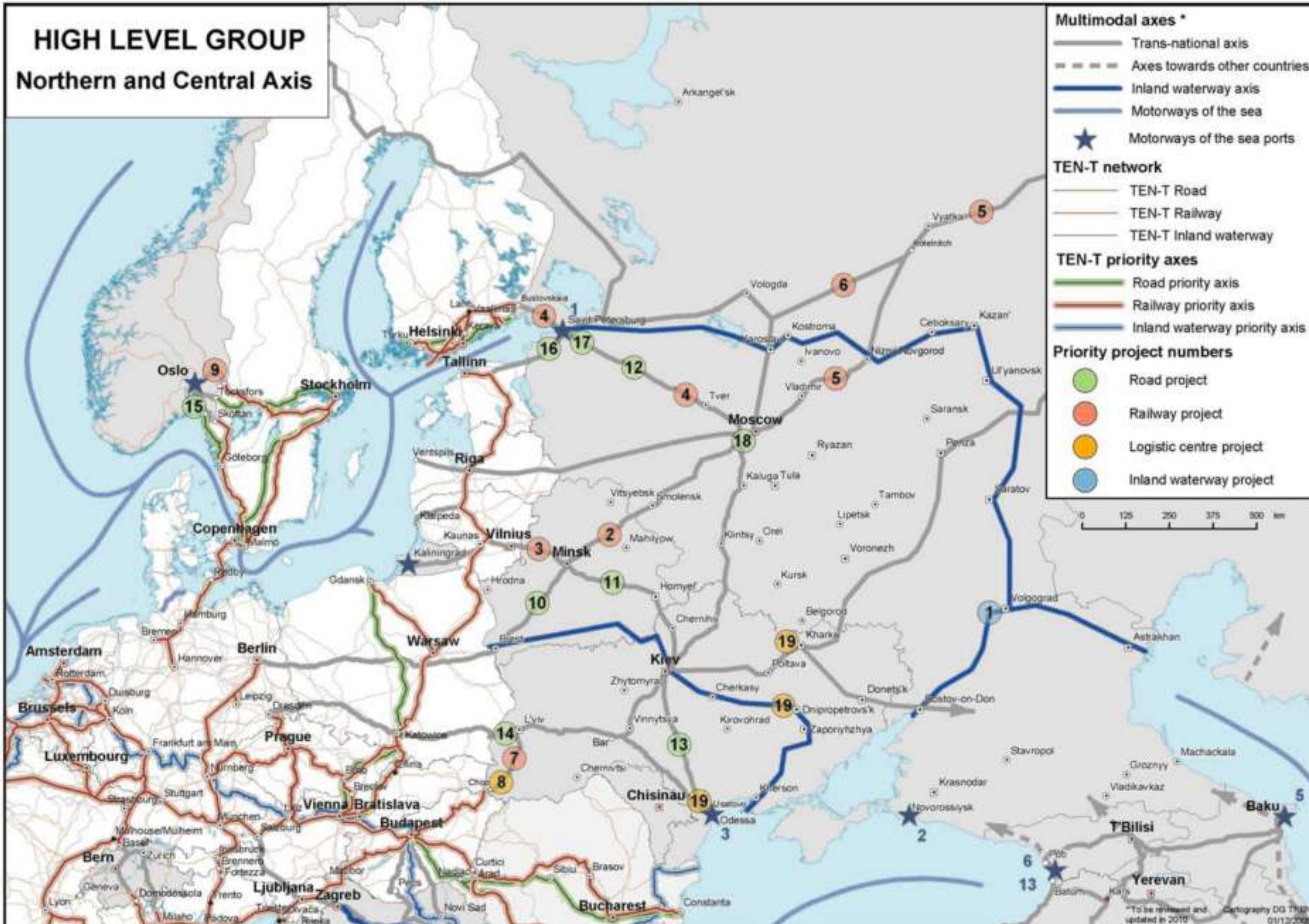
- Conferences of Ministres of Transportation (Kreta 1994 and Helsinki 1997) – setting of Transeuropean Transportation Corridors.

- ETCS – 1989 (European Train Control System) and ERTMS – 1995 (European Rail Traffic Management System) – agreements for common signalling and traffic control systems.

Cooperation & Agreements

Trans-European Transport Network designed for 2030





HIGH LEVEL GROUP
Northern and Central Axis
Multimodal axes *
Trans-national axis
Axes towards other countries
Inland waterway axis
Motorways of the sea
Motorways of the sea ports
TEN-T network
TEN-T Road
TEN-T Railway
TEN-T Inland waterway
TEN-T priority axes
Road priority axis
Railway priority axis
Inland waterway priority axis
Priority project numbers
Road project
Railway project
Logistic centre project
Inland waterway project
Oslo
Stockholm
Helsinki
Tallinn
Riga
Vilnius
Minsk
Moscow
Copenhagen
Amsterdam
Berlin
Warsaw
Kiev
Brussels
Luxembourg
Prague
Vienna
Bratislava
Budapest
Bern
Ljubljana
Zagreb
Bucharest
Chisinau
Odessa
T'Bilisi
Yerevan
Baku
Arkangel'sk
Vologda
Kostroma
Kazan'
Volgograd
Astrakhan
Rostov-on-Don
Kharkiv
Dnipropetrovs'k
Novorossiysk
*To be reviewed and updated in 2010
Cartography DG TREN 01/12/2008

High Speed Lines in Europe

High Speed Lines (LGV) in France are characterized by the following properties:

- designation for passenger trains only,
- speed exceeds 200 (250) km/h, the standard is 350 km/h,
- lines operated by a dedicated rolling stock (TGV units),
- technical compatibility with the existing lines,
- stations of th new lines are located in the centres of cities,
- distance between stops: 200-800 km.

Structure of the European High Speed Lines is built by:

- new lines designed for operation with speed over 250 km/h (ca. 9 000 km),
- existing lines adapted to 200 km/h, operated also with lower speeds (ca. 15 000 km),
- existing lines with passenger and freight traffic, linking the HSL in one consistent network (ca. 15 000 km).


Legend:
320 - 350 km/h
300 km/h
250 km/h
200 - 230 km/h
< 200 km/h
Under construction
Umeå
Trondheim
Sundsvall
Tampere
Lahti
Turku
Helsinki
Sankt-Peterburg
Bergen
Oslo
Skien
Stavanger
Kristiansand
Uppsala
Västerås
Stockholm
Tallinn
Linköping
Göteborg
Nizhny Novgorod
Moskva
Riga
Glasgow
Edinburgh
Newcastle
Belfast
Dublin
Cork
Manchester
Liverpool
Leeds
Birmingham
Cardiff
Bristol
London
Århus
Malmö
København
Smolensk
Vilnius
Kaliningrad
Minsk
Brjansk
Kursk
Gdańsk
Poznań
Warszawa
Hamburg
Bremen
Berlin
Amsterdam
Rotterdam
Hannover
Antwerpen
Bruxelles
Essen
Köln
Liège
Lille
Leipzig
Dresden
Wrocław
Katowice
Kraków
Ostrava
Praha
Lwiw
Kijev
Char'kov
Dnepropetrovsk
Doneck
Rostov
Le Havre
Rouen
Frankfurt
Mannheim
Nürnberg
Stuttgart
Brest
Rennes
Le Mans
Paris
Strasbourg
Brno
Bratislava
Wien
München
Nantes
Tours
Dijon
Basel
Bern
Zürich
Innsbruck
Salzburg
Graz
Budapest
Cluj-Napoca
Chişinau
Odessa
Sevastopol
Braşov
Genève
Lyon
Clermont-Ferrand
Torino
Milano
Verona
Venezia
Ljubljana
Zagreb
Bucureşti
Constanţa
Bordeaux
Genova
Bologna
Beograd
Varna
A Coruña
Oviedo
Vigo
León
Bilbao
Toulouse
Montpellier
Marseille
Nice
Firenze
Sarajevo
Split
Sofija
İstanbul
Porto
Huesca
Valladolid
Salamanca
Zaragoza
Barcelona
Madrid
Roma
Skopje
Thessaloniki
Ankara
Eskişehir
Tiranë
Napoli
Bari
Lisboa
Toledo
Valencia
Adana
İzmir
Konya
Córdoba
Huelva
Sevilla
Alicante
Faro
Cádiz
Málaga
Palermo
Catania
Athina

Railways in Poland

FIGURES:

- 19 000 km of lines (3rd score in Europe, after DB.AG and SNCF),
- 59% lines electrified,
- ca. 50% double track lines,
- density coefficient 6.5 km/100 km^2,
- 9 300 km station tracks,
- 1 004 stations in use,
- 89 500 000 passengers/year,
- 110 100 000 tonnes of cargo/year,
- 3 615 500 000 PLN/year spent on investment.

PKP POLSKIE LINIE KOLEJOWE S.A.

PKP INTERCITY

SKM szybka kolej miejska

PKP Linia Hutnicza Szerokotorowa sp. z o.o.

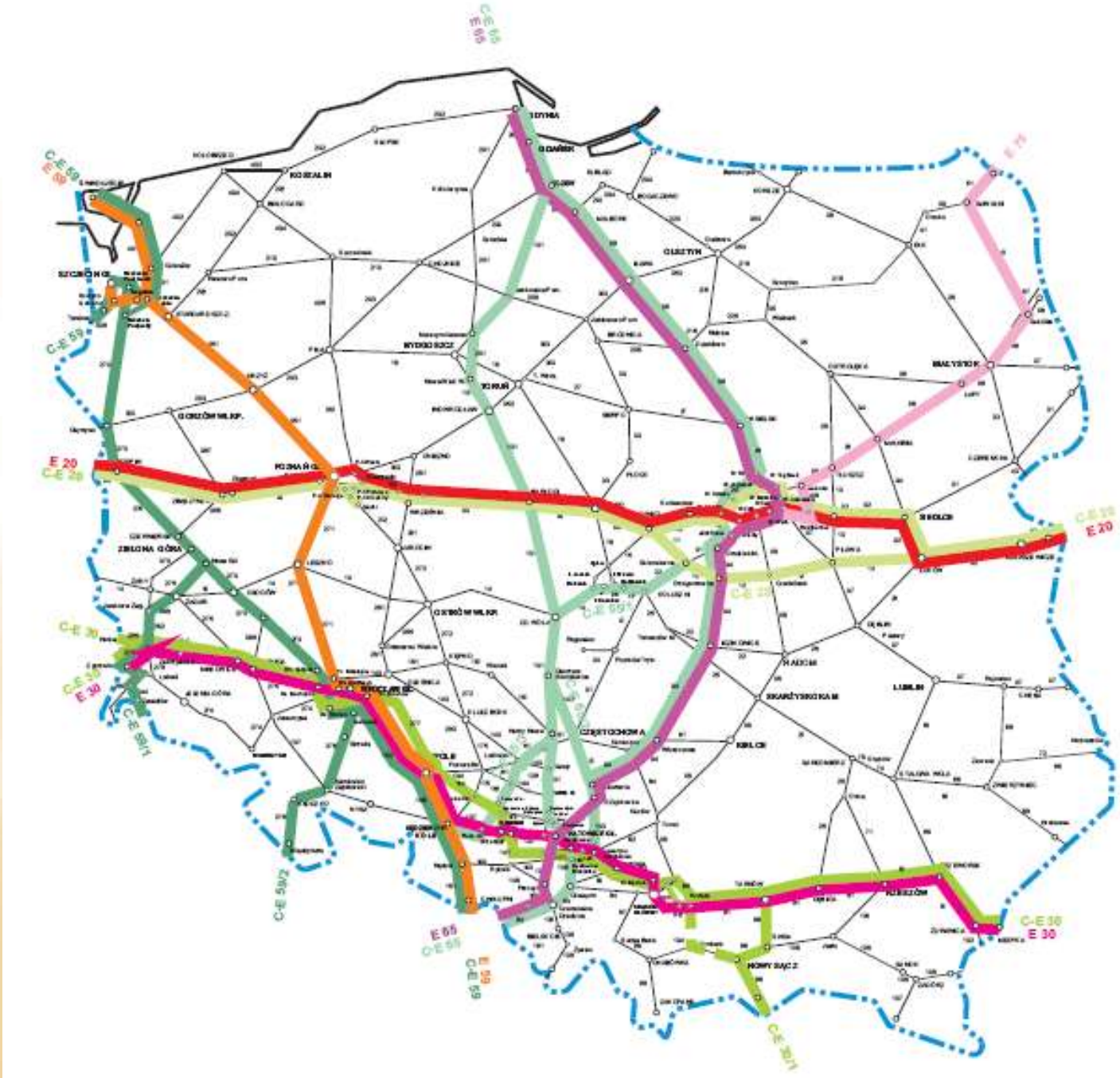
PKP cargo

PKP Informatyka

PKP ENERGETYKA

TK TELEKOM

PKP POLSKIE LINIE KOLEJOWE S.A.



Classification of railway lines

Depending on importance:

1. main lines – the most important in the national network,
2. first category lines – for fast passenger and distant freight traffic,
3. second category lines – for traffic of medium intensity and speed,
4. local importance lines – for local service with low intensity and speed.

Parameters of Polish railway lines

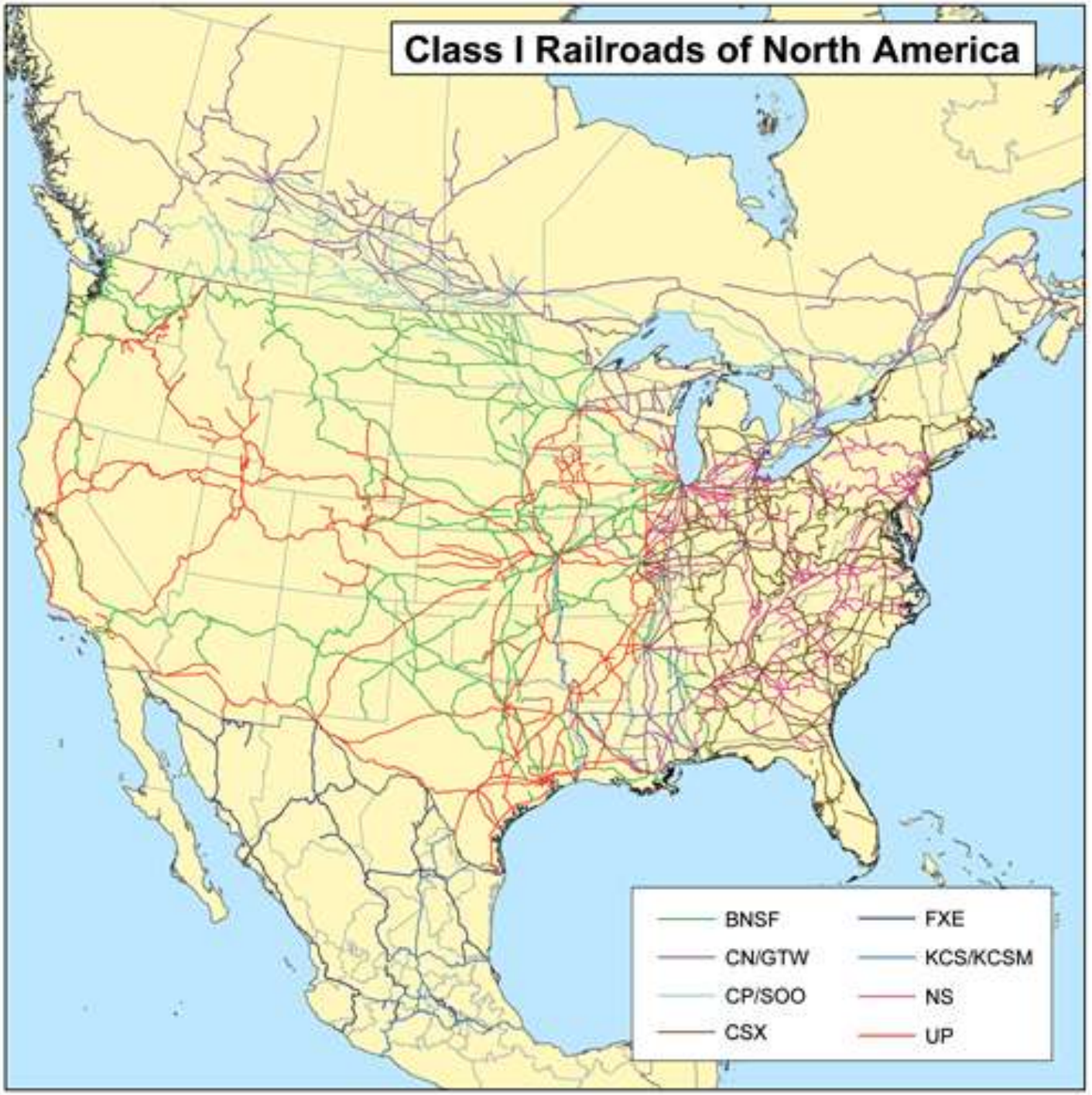
Category	Intensity of traffic	Maximal speed		Axle load
	T	V_{max}	V_f	P
	[Tg/year]	[km/h]	[km/h]	[kN]
main lines (0)	$T \geq 25$	$120 < V_{max} \leq 200$	$80 < V_f \leq 120$	$P \leq 221$
first category (1)	$10 \leq T < 25$	$80 < V_{max} \leq 120$	$60 < V_f \leq 80$	$210 \leq P < 221$
second category (2)	$3 \leq T < 10$	$60 < V_{max} \leq 80$	$50 < V_f \leq 60$	$200 \leq P < 210$
local importance (3)	$T < 3$	$V_{max} \leq 60$	$V_f \leq 50$	$P < 200$

Other examples

- hierarchy
- average density
- local density
- main directions
- following border and cross border lines
- areas of high industrial development

Other examples

- hierarchy
- average density
- local density
- main directions
- following border and cross border lines
- areas of high industrial development
- VARIOUS OPERATORS!



Railway network parameters

- Geographic density of network – tracks length [km] on 100 km^2 of area. In Poland it reaches from 3.4 (south-east) to 17.2 (Upper Silesia) and 6.5 average. In other European countries it varies in range 3.3 – 13.7.
- Average distance from a railway line - in Poland around 15 km.
- Number of operational nodes/area unit.
  In Poland there is 0.32 passenger station/100 km^2.
- Network capacity – maximum number of transportation units which is able to pass the line in a time unit at the defined conditions e.g. 24 trains/h in the peak hour (infrastructure potential).
- Transporting ability of rolling stock – depending on the owned rolling stock units and its usability (rolling stock potential), given in:
  a) tonnes x kilometres /day (for cargo transport),
  b) passenger x kilometres /day (for passenger transport).

Sustainable transportation rules

- ensuring an equal attempt to operational nodes and minimizing of arduousness for community (social factor),
- development of all transportation branches in a way which ensures free competition and supports the economic growth (economic factor),
- stiving for save non-renewable natural resources and sustainable waste management and neutralization (ecologic factor),
- selection of technical standards and quality, safety and capacity of network according to transportation needs (technical factor),
- placing of operational nodes and other infrastructure objects accordingly to existing infrastructure, respectfully to the existing spatial arrangement and minimizing transportation (spatial factor).

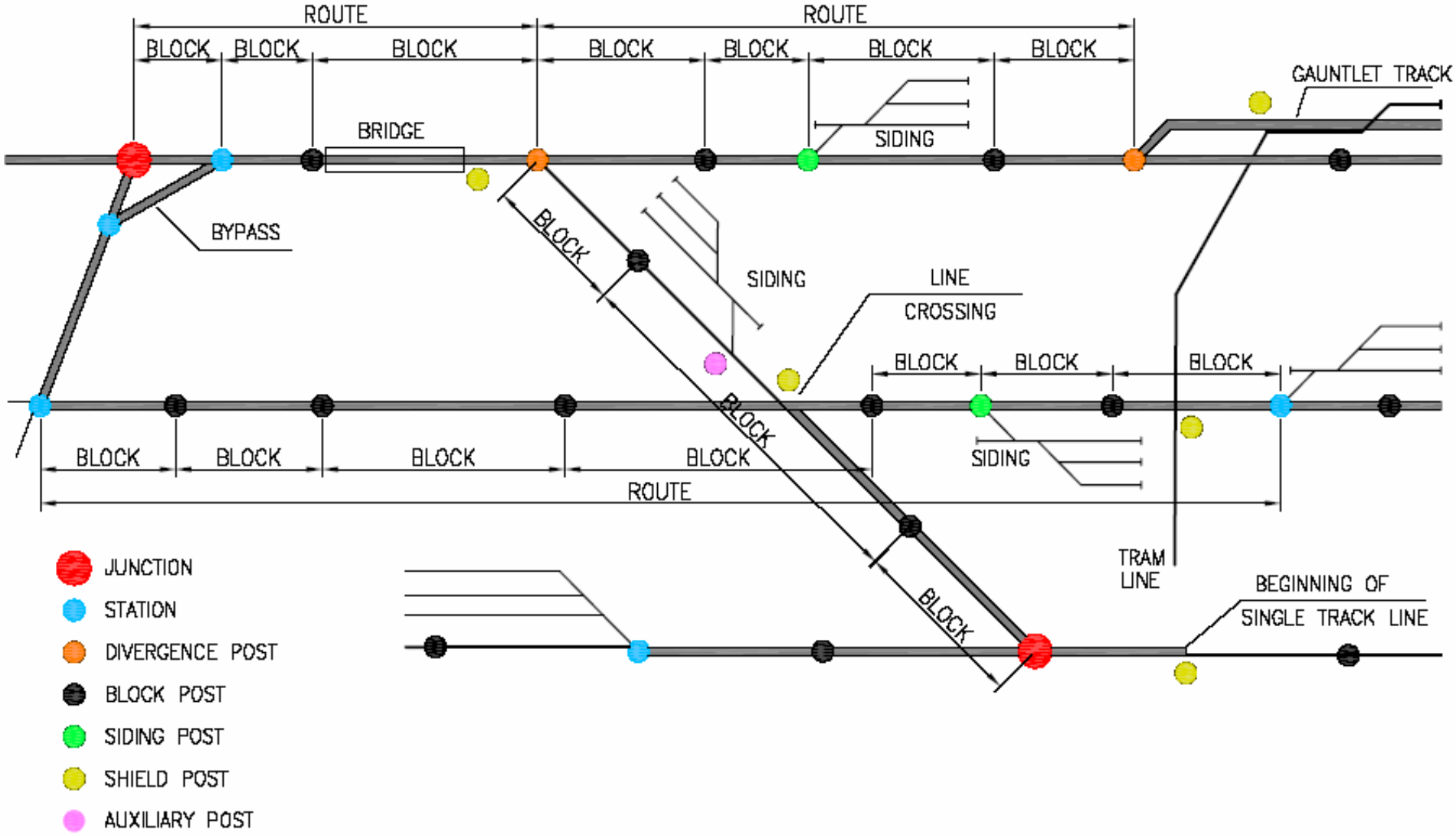
Structure of railway network

Railway line – the main element. The line has a name, a number and mileage (kilometrage). Lines are divided into:

- blocks – a section of track where only 1 train is allowed to occupy due to safety rules. Beginning of the block is guarded by a post with signalling devices.
- routes – a section of track controlled by 1 controlling tower, consisting of few blocks,
- sections – a section of track between main stations, consisting of few routes.

Bypass – a line linking two other lines avoiding the main station.

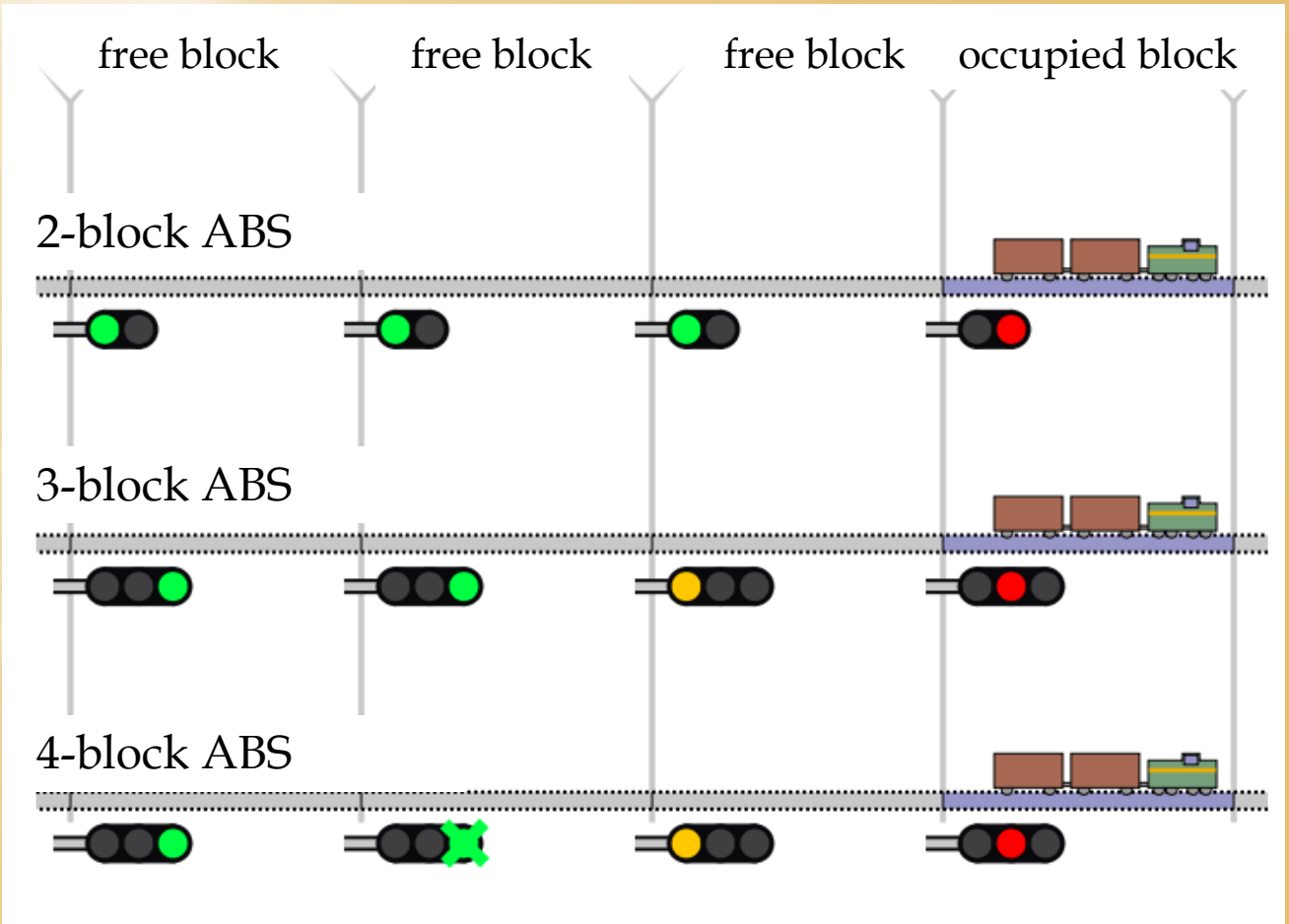
Posts, blocks, routes ...



Automatic Block Signalling

The route without blocks could be occupied by one train only. When the distance between the stations is big the next train has to wait until the preceding train reaches the next station – otherwise an unexpected stop of the first train would cause collision.
Thus the route equipped with ABS is divided on block sections (usually of a length of safe breaking and stop). Every block is equipped with devices identifying trains location.

Types of ABS



Automatic Block Signalling

Automatic Block Signalling is a traffic control and safety system designed to increase capacity of route and to ensure safety for more than one train using the route at the same time.

- 2-blok ABS informs only if the next block is occupied or not – possible signals are „free way„ or „stop!”. This system is the most simple but requires perfect visibility of the signalling device (at least of breaking way).
- 3-block ABS enables informing the motorman in advance of one block that at the entrance of the next block he has to stop. If the semaphore shows „red eye” the preceding signal is orange („slow down”). This type of ABS is applied on most lines in Poland equipped in ABS.
- 4-block ABS is a modification of the 3-block system applied when the breaking way is longer than standard block section. In this case breaking is performed on 2 consecutive blocks. The motorman is informed about the orange signal on the next post by a flashing green signal on the preceding post. This kind of ABS is used in Poland only on the main lines operated with highest speed.

Automatic Block Signalling

The end of a block section

On the selected Canadian and UK lines movable blocks are used. In this case there is no need to use light signals, the instructions are passed directly to the driver. Tachometers and speedometers are used for calculation of actual breaking way and distances between the trains.

Most blocks are of fixed length. Length of block depends on:

- Line speed (the maximum permitted speed over the line-section),
- Train speed (the maximum speed of different types of traffic),
- Gradient (to compensate for longer or shorter braking distances),
- The braking characteristics of trains (different types of train, e.g. freight, High-Speed passenger, have different inertial figures),
- Sighting (how far ahead a driver can see a signal),
- Reaction time of the driver.

Multi- and intermodal transport

Multimodal transport – goods moving by means of at least 2 means of transportation.

Intermodal transport – goods moving in one loading unit (container, exchangeable trailer, semi-trailer) by means of various means of transportation without moving the load from container to container.

Combined transport – intermodal transport variation when the main section of way has to be done by railways, inland waterways or sea and the initial and final sections done on roads are as short as possible (up to 25 km).

Intermodal transport

Essence of the intermodal transport is the rule than the highest effectiveness can be achieved when the cargo is moved „door to door" by one operator, on a base of one agreement and in one container.

Advantages :

- can be cheaper than a few separate operators,
- multiplies possible routes of transportation,
- raising of service quality,
- the delivery is fast and due to deadline,
- probability of the cargo damaging is lower,
- better availability of the transport service
- possibility of bigger cargo transport.

Many years ago handling of any cargo was done manually. While this method was very time and labour consuming, more effective ways were invented. One of the most popular in carrying goods in closed containers of various lengths (20 or 40 ft.) and around 20 kinds.

Modern cargo handling - containers

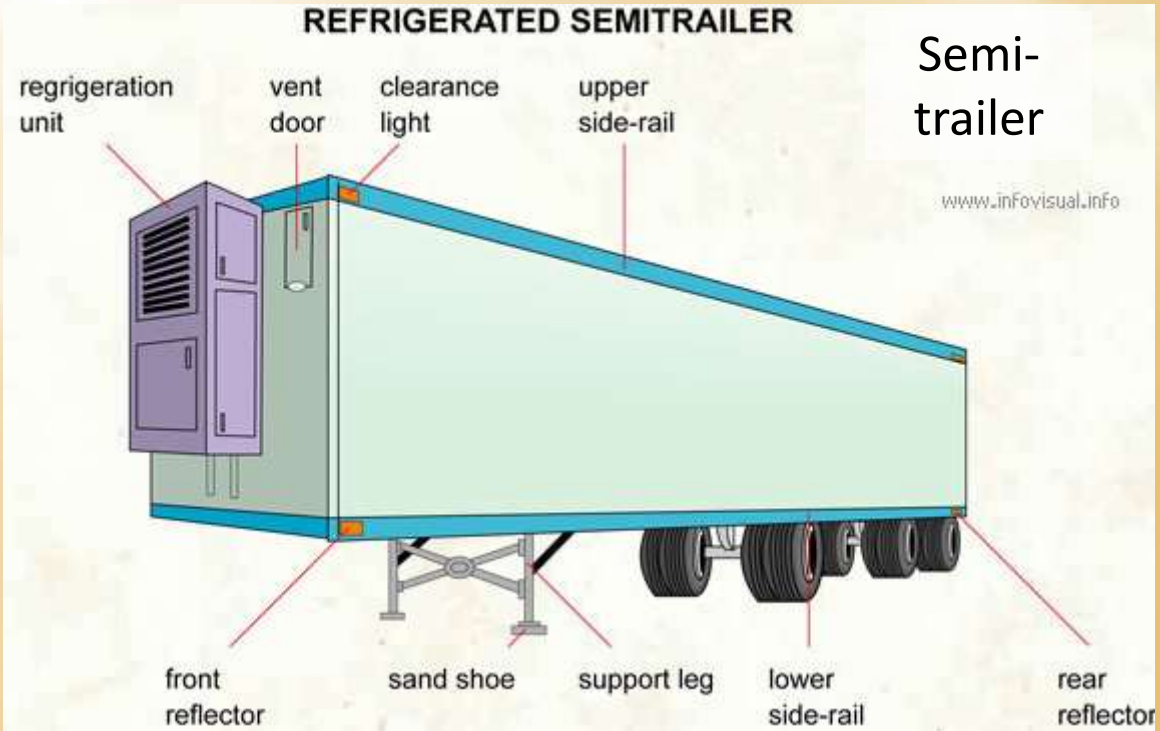
- One of the means of multimodal transport
- Extremely effective, cost- and labor reducing
- Fitting both in road and rail loading gauge
- Multiple sizes of containers: length from 8-foot (2.438 m) to 56-foot (17.07 m) and heights from 8-foot (2.438 m) to 9 feet 6 inches (2.9 m)
- Multiple types: for small items, liquids, refrigerators, ...

Road stuff

Lorry

Trailer

Tractor unit



Semi-trailer

Saddle of the tractor

Road stuff

Swap body

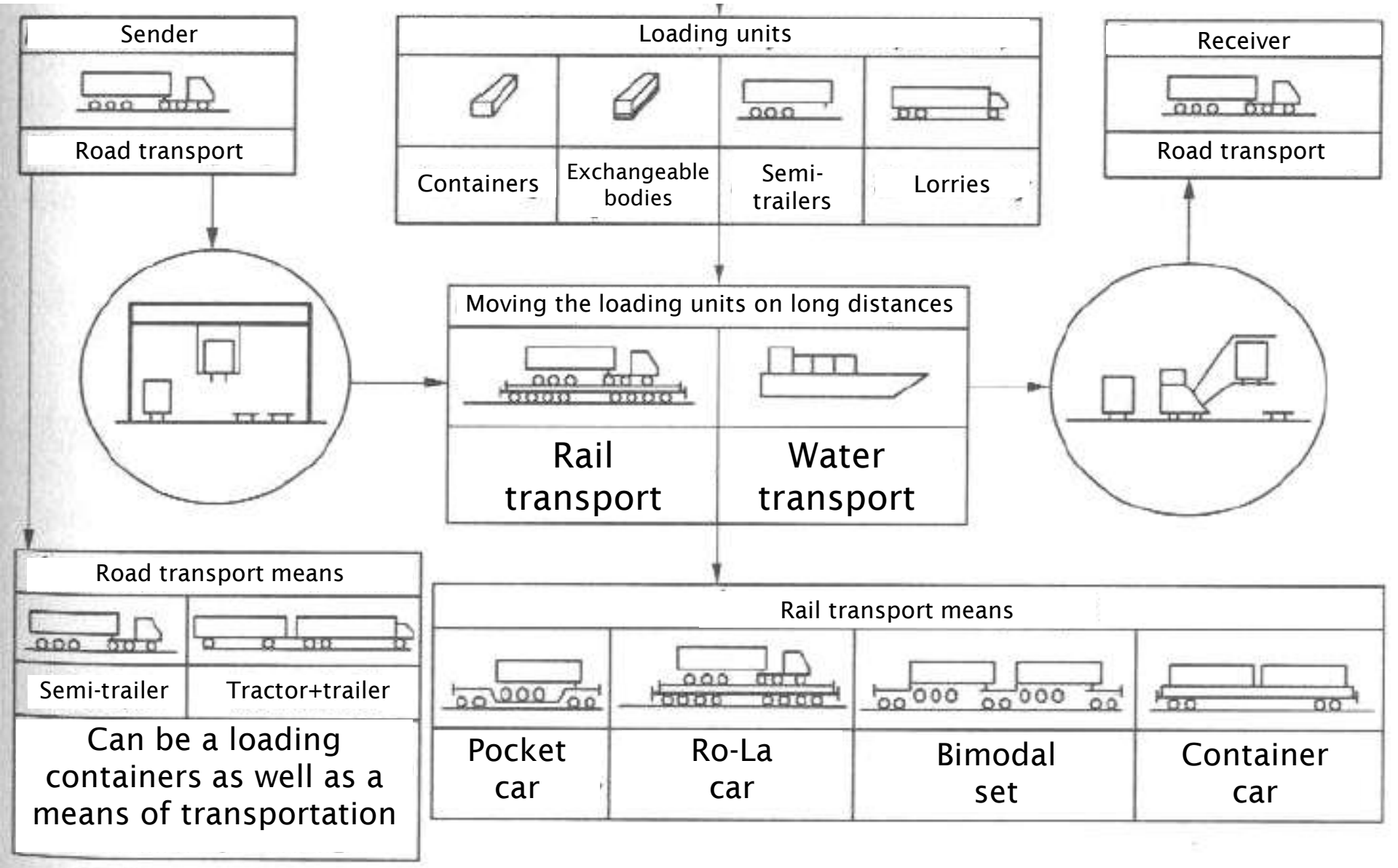
Trailer for containers

Flatbed semi-trailer for containers

Container

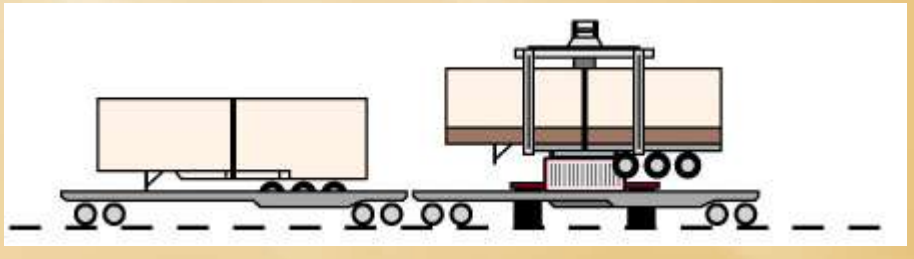
In US, due to the higher loading gauge, carrying of two levels of containers on special low floor cars is possible. Such arrangement is called „double stack”. In Europe due to the lower loading gauge, single stack is the only possible solution

Combined transport



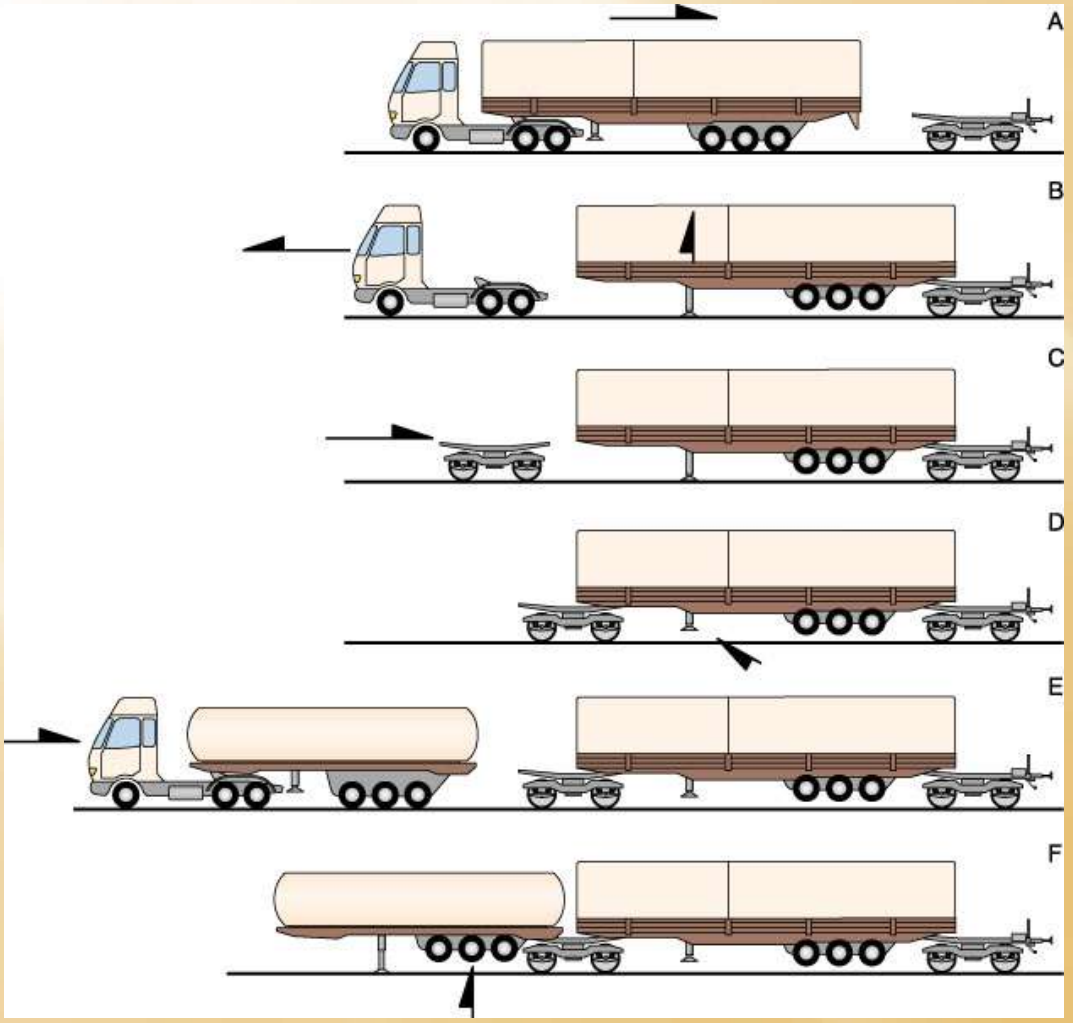
Piggy back/Hückepack

Piggy back/Hückepack – container and semi-trailers transport on pocket carriages and on roads by saddle tractors.



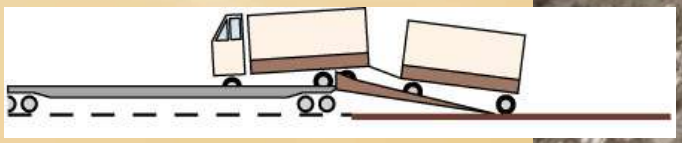
Bimodal Rail-Road transport

Bimodal Rail-Road transport – road semi-trailers and trailers transportation by rail transport with use of special adapters and on roads by saddle tractors.



Rollende Landstrasse

Rollende Landstrasse, Ro-La – road semi-trailers, trailers, containers, exchangeable bodies and whole tractor+semi-trailer sets moved on rail in low–floor cars systems.



Mobiler

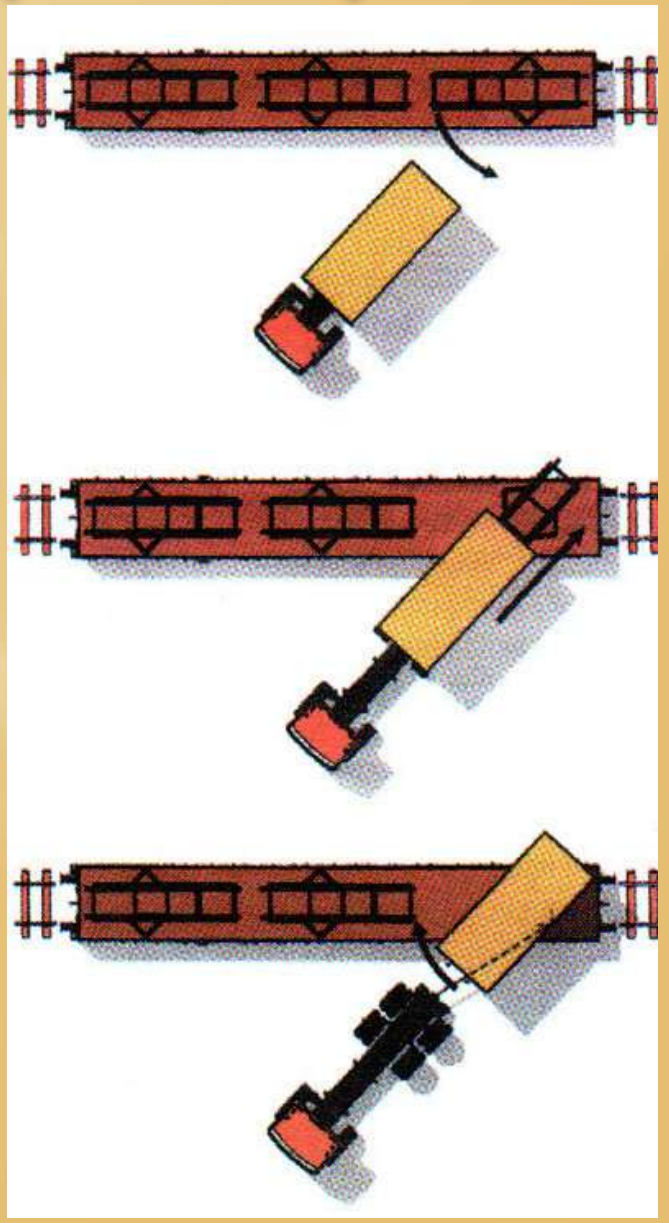
Mobiler – container transport on rail platform cars with special shifting frames and on roads by special self-unloading lorries or on special trailers.


on the wagon

on the lorry

Abroll Container Transport System

ACTS – container transport on rail platform cars with special tilt/pivot frames and on roads by special self-unloading lorries or on special trailers.



Modalohr

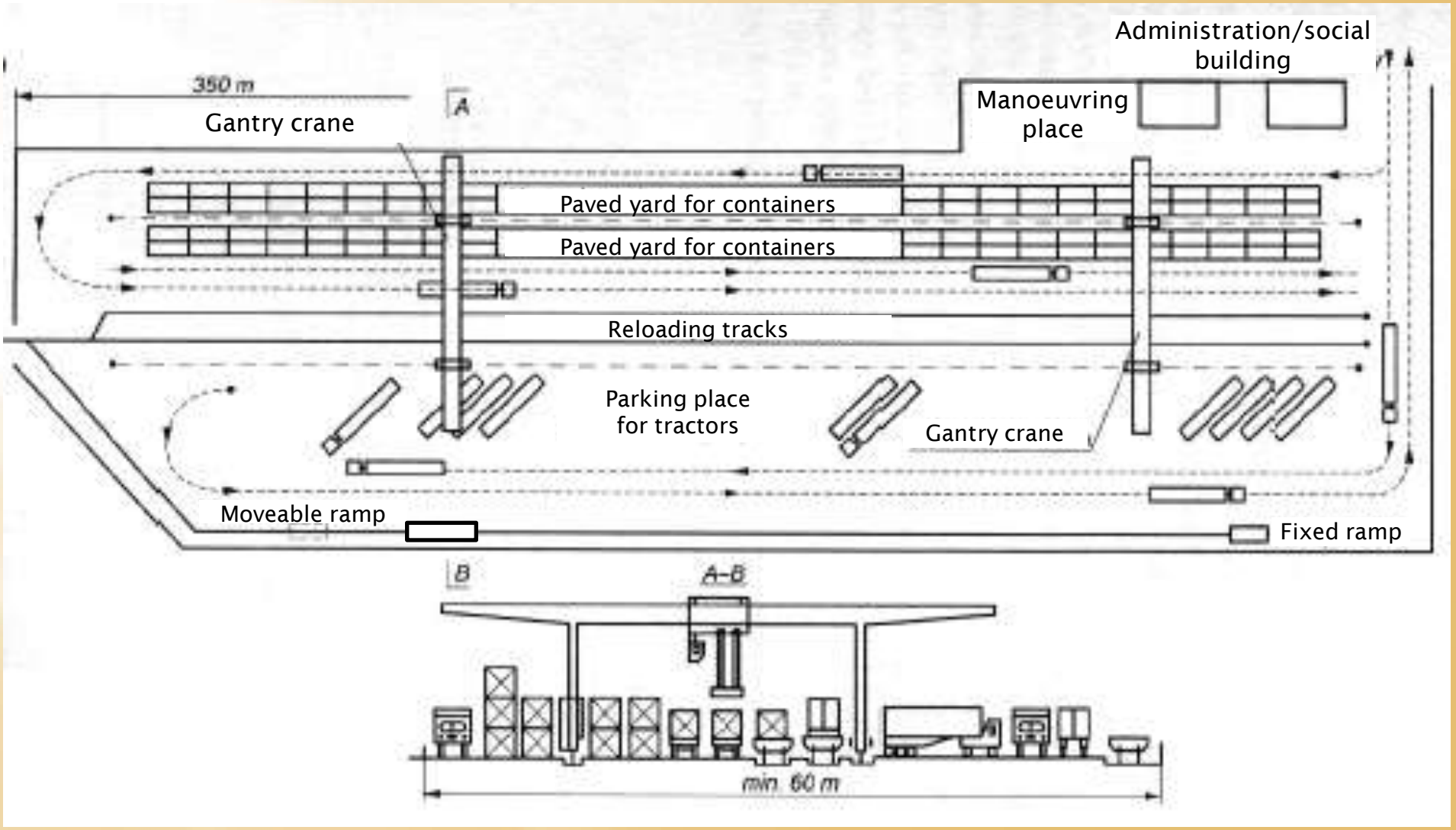
Modalohr system – semi-trailers transport on rail platform cars with special tilt/pivot frames and on roads by standard tractor.

movie

Ferry

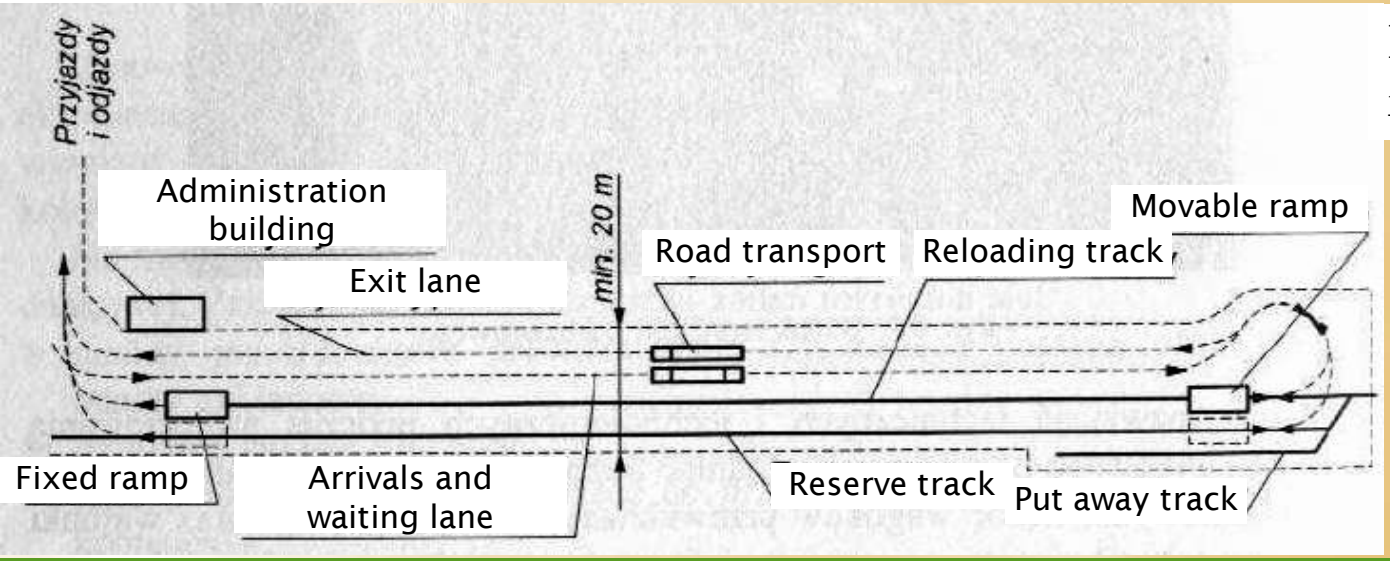
Ferry – trains trasportation by means of boats across sea.

Container terminals

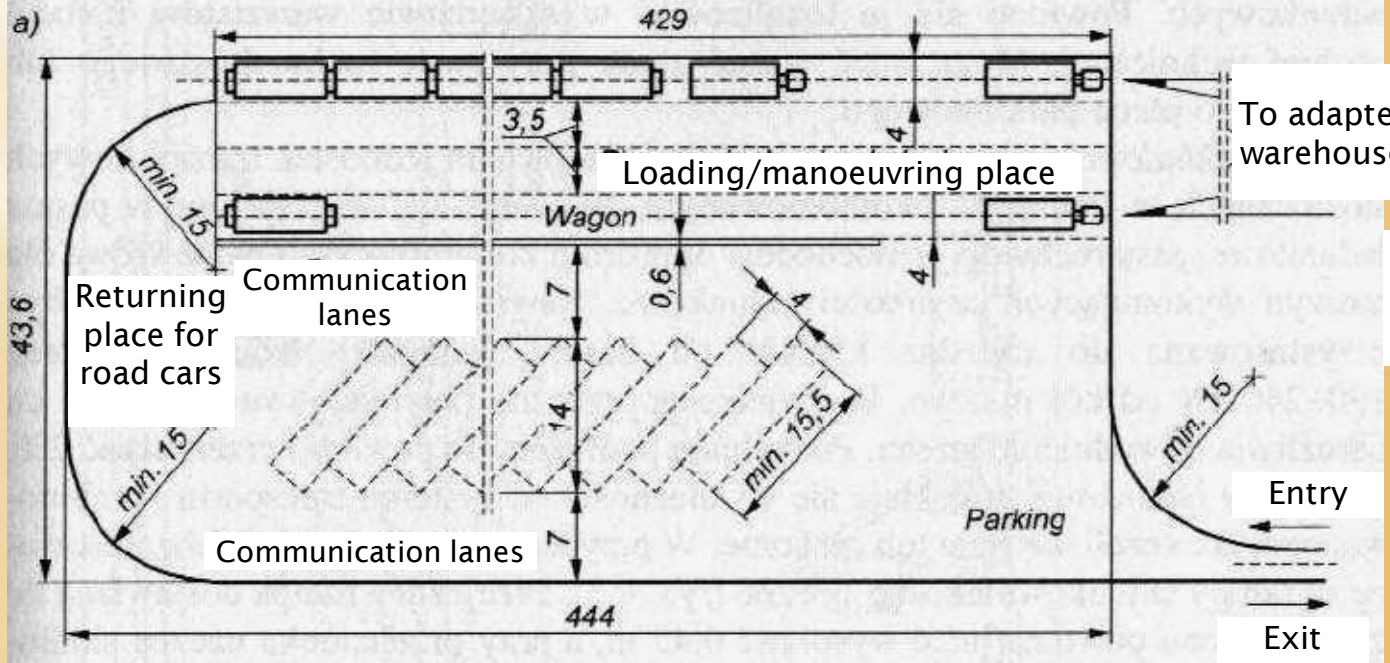


Typical reloading container terminal

Container terminals

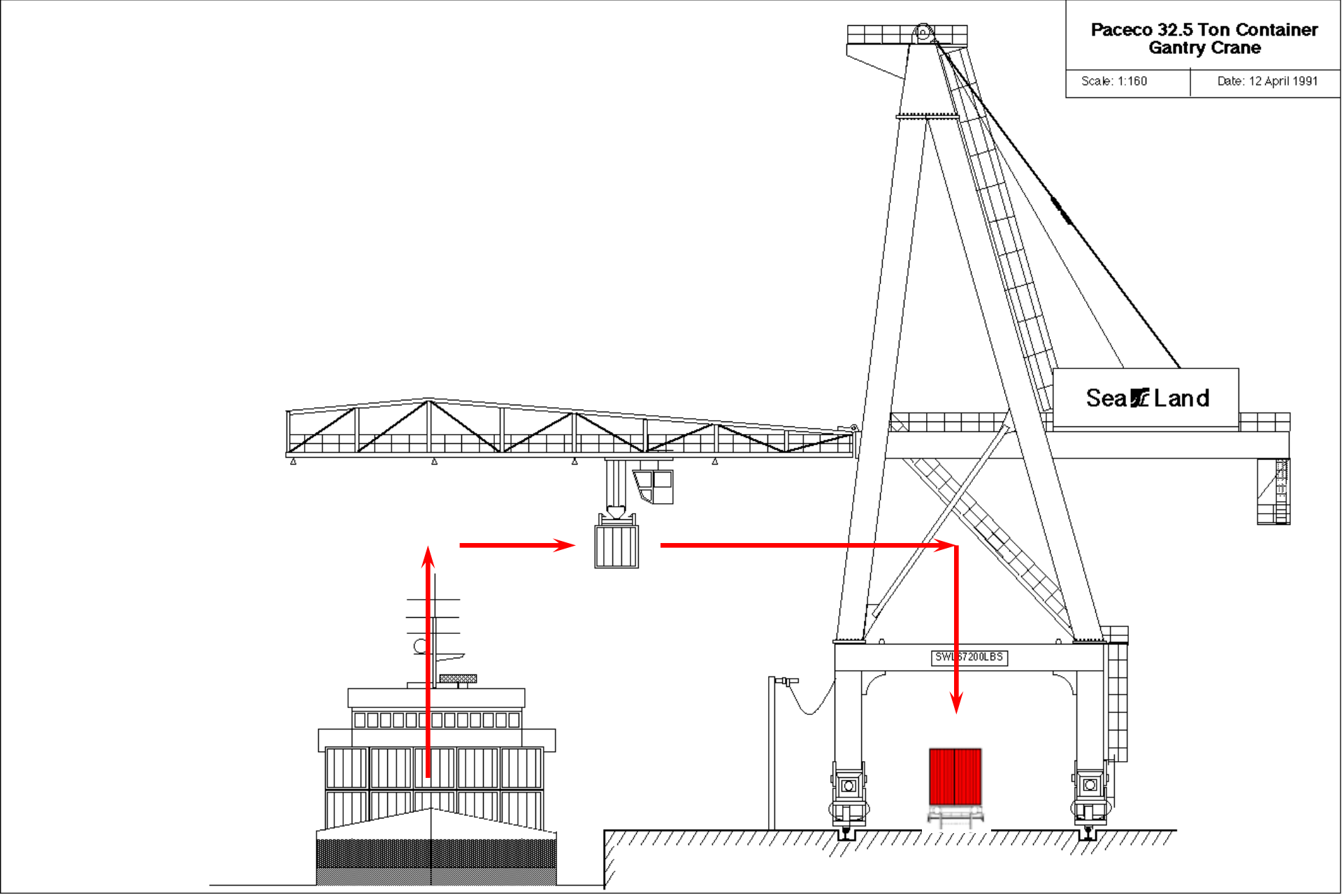


Reloading terminal for Ro-La system



Reloading terminal for bimodal system

A ship loaded with containers has just arrived. Now the high-speed gantry cranes will unload and load the containers in proper order to keep the ship in balance. The containers will be moved then by lorries to the storage facility and unloaded by other cranes.



A principle of gantry crane operation

Just remember to keep the balance…

Gantry crane for rail and truck operations.

When not whole storage facility surface is within the reach of gantry cranes, container forklifts (container handlers vel reach stackers vel container handling forklifts) become useful.

Reachstacker

These machines are built for various container sizes and weights (e.g. empty containers only) and are more universal than gantry cranes as they can rotate a lifted item. Only trackless gantry cranes can do the same trick, yet in terminals where tracks, roads and embankments are parallel, this ability is hardly ever needed.

Trackless, small gantry cranes can stack containers up to three layers, but they are unable to load a train (no side access or reach is possible)

Advantages and disadvantages

+ speed of operations and transport is as high as possible,
+ goods are secured from outside conditions,
+ very high capacity and effectiveness of terminals,
+ containerization greatly reduced the expense of international trade and increased its speed,
+ containers have become a popular way to ship private cars and other vehicles overseas using 20 or 40 ft containers. Unlike roll-on/roll-off vehicle shipping, personal stuf can be loaded into the container with the vehicle, allowing for easy international relocation,

- in some cases additional change of transport mode is needed,
- many containers return empty,
- after containerization, large crews of longshoremen were no longer necessary at port facilities and the profession changed drastically.