

Summary Rail transport

1.1 From Transport to Traffic

1.2 Door to door journey

Train can be a connecting mode (to plane or HSL) or main leg (intercity service)

Intercity service to connect areas in which sprinters/trams/metros open up the area

Radii catchment areas

Tram	400-500m
Metro	700-1000m
Sprinter	2 km
Intercity	5 km

Transport (passengers and ton-km) are handled by NS and DB

Traffic (trains) are handled by NS and DB

Infrastructure is handled by ProRail

Freight traffic usually over seas and land inwards by train. New silk route in progress

1.3 Product – market combinations 1

International night train	1000 km	1/day	Beds	
International train	300-1000 km	6/day	Business class	Restaurant
National train	100-300 km	1/h		
National train	30-100 km	2-6/h	Power sockets	
Multicity	10-30 km	4-8/h	Toilets	1 st class
Regional train	10-30 km	2-4/h		
Urban metro	3-10 km	8-16/h	WIFI	Power sockets
Urban tram	1-3 km	8-16/h	Small seats	Standing capacity

International train	3 doors	2 minutes
Multicity train	7 doors	45 seconds
Urban (metro)	9 doors	20 seconds

No more screens / wifi → 220V and USB

1st class difference (when no modularity)

2 seats 37 cm

4 seats 40/53 cm

No handles to hold on attached to seat head

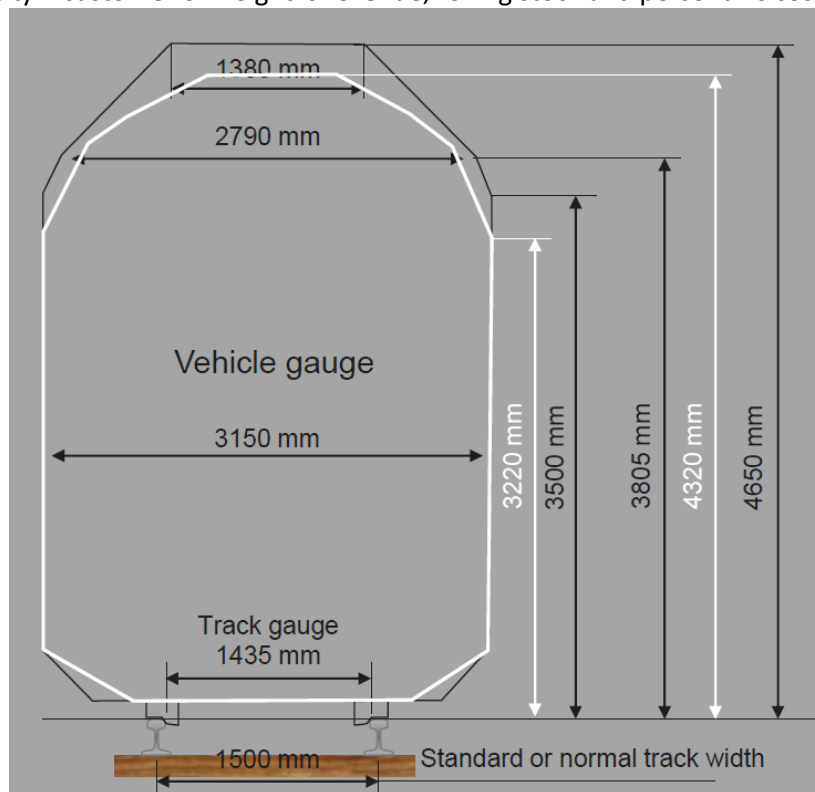
1.4 Product market combinations 2

Logistic principles

- Full train load
 - One customer, one train, No other mode needed, No freight, no train
- Unit cargo
 - Individual wagons brought to collection point, timetable basis, shunting needed
- Intermodal transport
 - Container, swap bodies, trailers – Shuttle concept, fixed composition, regular freq

2.1 Rolling stock 1

Transport capacity – customer or freight is revenue, rolling stock and personal is cost



2.2 Rolling stock 2

Length passenger train max 400-450m

Length freight train EU 750m

Capacity

Bus	50-80
Tram (urban	70-500
Metro/lightrail	80-800
Double stock	600-1200
HST	350-750
Airplane	100-400

Truck	2 TEU
Train	70-90 TEU
Barge	100-400 TEU

Wheelsets move over the tracks in the form of a self-oscillation about an equilibrium
Smaller diameter of wheels needed on inner track compared to outer track

Bogies enable longer wagons in curves
An articulated bogie combines two wagons on one wheelset

2.3 Rolling stock 3

Shortest multiple unit 25,5 meters, longest about $2 \times 200 = 400\text{m}$

Advantages NON articulated bogie - More payload, longer car body, individual unit

Advantages articulated bogies – Cheaper, less chance of derailment, higher comfort, better interior design

Automatic coupling for freight trains

- Heavier & longer trains (within existing infra limitations)
- Increased payload (elimination of buffers, new design)
- Increased speed via improved longitudinal forces
- Increased speed via better braking performance
- Train integrity (ETCS L3)

3.1 Characteristics Guided Transport systems 1

- Only a single degree of movement.
- Infrastructure determines direction and position.
- There is no steering wheel inside the vehicle!
- Long: Trains up to 400 m. passengers and up to 750 m. freight (Europe)
- Heavy: Freight trains up to (gross) 5400 ton (Europe)
- High top speed: HST 200 - 350 (400?) km/h
- Slow: Acceleration and deceleration
- Limited gradient: 2,5 - 4 % maximum
- Power: Diesel, electric (external supply), hybrid or hydrogen!
- High safety standard:
 - Network (almost completely) equipped with signalling / train protection systems.
 - Only open to qualified personnel / organizations
- Limited land use

Diesel electric

- Plus - Diesel generates electricity (optimal use of diesel engine), Modular concept, suitable for hybrid use (DE and E)
- Minus - Needs alternator

Diesel hydraulic

- Plus - Low purchase costs
- Minus - Lower tractive power, Higher maintenance costs, Less fuel efficient

Diesel mechanic

- Plus - Low purchase costs (truck and bus components)
- Minus - Lower tractive power, Higher maintenance costs, Shorter lifespan

3.2 Characteristics Guided Transport systems 2

Battery equipped electric locomotive for last miles in ports, no feeders needed anymore

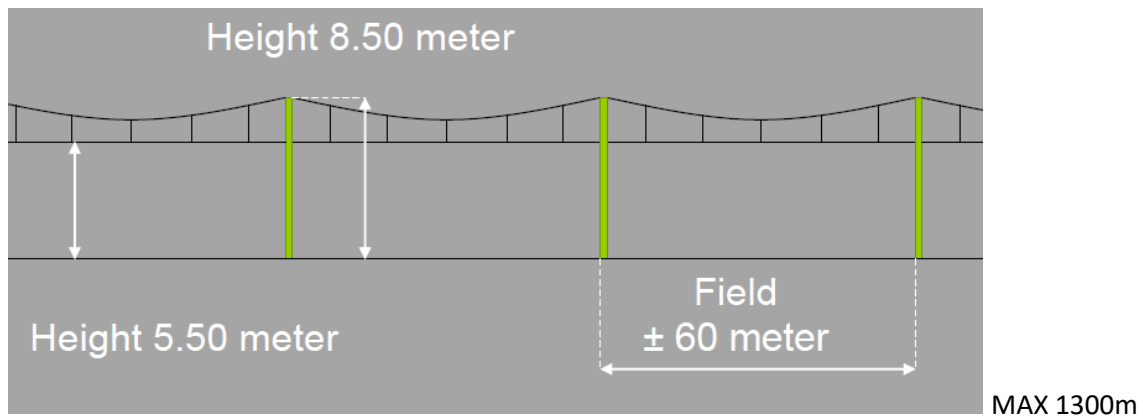
4 specials and pioneers

5 Traction power supply

Train NL 1500 V DC

HSL NL 25 kV AC

Tram, Metro NL 600-750 V DC



Transition field 60m

Total transition length min 180m

6.1 Network structure 1

Network elements

- Transfer node
 - Station, freight terminal – Length based on maximum train length
- Link
 - Speed as main characteristic
- Junction node
 - Speed, relations, synchronism

6.2 Network structure 2

Max centrifugal acceleration 0,8 m/s²

Cant allows for higher speeds in curves

Transition curve

- Offers a smooth transition from rectilinear to curvilinear motion, no sudden change of curvature
- Building up cant
- Tilting train technology reduces cant deficiency in curves by tilting the vehicle body in relation to the wheel base.

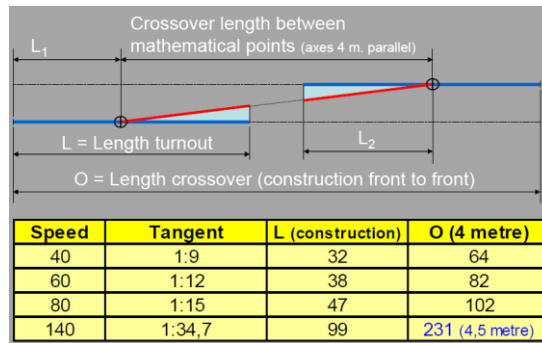
Interlocking

Definition: At a point where one or more routes meet or cross, an arrangement of signals and signal appliances (remote controlled point machines), so interconnected that their movements must succeed each other in proper sequence, train movements over all routes being controlled by signal indication.

7 Turnouts and crossings

Front has one rail, rear, two

Frog in centre of turnout



8.1+8.2 Stations and stops 1+2

Terminal main functions

- Forecourt (municipality is responsible) – Recognisable, Interchange to other modes of transport
- Terminal hall – Travel information, Buy and validate tickets – Waiting area, restroom, shops
- Pedestrian route
 - Maximum 18 steps on stairs
 - Minimum 2,4m
- The platform - minimum width 3,36 meter
 - Safety zone 0,8
 - Walking zone 0,8
 - Standing zone min 0,8
 - 40% circulation space

8.3 Stations and stops 3

9.1 The railroad and it's environment 1

9.2 The railroad and it's environment 2

Level crossing starts alarm bells 25 seconds before train passing based on maximum allowed speed
 Station before crossing? Distinction stop and trough or move platform behind crossing

Required free height

- 5,8m (1500V)
- 6,3m (25kV)
- 9,0m (free of frame)

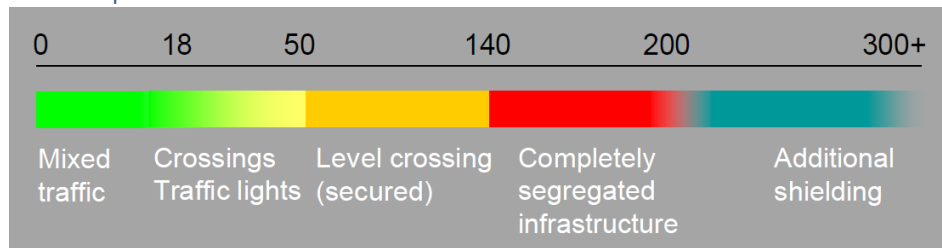
Maximum gradient

- Tram/metro – 4%
- Train 2,5%
- Cargo 0,5%

9.3 The railroad and it's environment 3

- Social topics
 - Visual hindrance
 - Spatial planning
 - “Healing” city structure
 - Noise reduction
 - Vibrations
 - Hazardous goods

10.1 Track concepts 1



Balance between Speed, Safety measures and Required space

Integrated track

- No specific space required
- Track is no barrier, random crossing
- Maximum access to city centre
- During late hours higher social safety + economic upgrade for shops
- However: Low speed + Flow depending on other traffic
- No safety measures
- Using different pavements to outline the structure gauge

Shared track

- Higher speed than integrated track
- Higher reliability
- Track is no barrier
- However: specific space is required + reliability still on flow of busses
- Crossings with traffic lights
- Track on different heights

Segregated track

- High speeds possible
- High reliability
- High safety level
- However: Specific space required
- Crossings with traffic lights or barriers
- Track shielded with shrubs, fences or ditches

Isolated track

- Highest speeds possible
- Highest reliability
- Highest safety level
- Suitable for automated driverless operation
- However: Specific space required + Costs + the complete line is at a + or – 1 level
- No level crossings
- Tracks are not accessible

11.1 Command, Control and Signalling basics

Limitations in infrastructure

- Speed in curves
- Bufferstops
- Switches and turnouts
- Movable infrastructure
- Train separation

Basics in CCS

- Safety
 - Train (vehicle) position (where is the train?)
 - Separate trains
 - Control objects (mainly switches)
 - Movement authority (tell the train driver what to do)
 - Safety net (in case something goes not as planned)
- Traffic management
 - Sending the train at the right time in the right direction

IXL – makes sure no collisions happen

TMS – Route setting

11.2 Train position

Blocks (400-1800m) with signals (free or occupied)

Train detection based on track circuits or axle counters

11.3 Movement authority

Different forms:

- Spoken
- Written
- Procedures
- Tokens
- Semaphore
- Light signals
- Cab signalling
- Machine – Machine (ATO)

The message is always the same:

- “From – to” and maximum speed allowed

Flashing green light is for route over wissel

11.4 ‘Safety net’

Limit the effects of passing a signal at danger

- Crosslocks in combination with a trap point
- Additional safety length with flank protection

11.5 ERTMS Basics

- Interoperability
- Enhance capacity
- Enhance safety
- Cost reduction

11.6 ERTMS Levels

Level 1 Limited supervision

Level 1 Full supervision

Level 2 Overlay (soplex+expensive, freedom for fleet, different systems at once)

Level 2 Only (proven technology, fast migration)

- Continuous supervision
- Trackside train detection outside scope of ERTMS

Level 3 Hybrid (increase capacity, no redesign block section, train integrity solved)

- Continuous supervision for integer trains
- Blocks with lineside detection for non integer trains

Level 3 (max capacity, minimum trackside assets, not for non integer trains)

- Continuous supervision
- No lineside signals or train detection

Level STM or NTC

- Best business case
- Early investment in vehicle
- Two systems in cab

Trackside

- Balises - Point position marker that transmits data
- Radio block center – Centralised, transfers train position to interlocking, gets route information and movement authorities and sends it to trains
- GSM-R network

Trainside

- EVC (European vital computer) info over train
- Odometer – pulse generators in wheels, doppler radar, optical sensor
- Train Interface unit – between EVC and train systems (eg brakes)
- Balise transmission module – reads balises
- Euradio – data transmission to radio block centre
- DMI – driver machine interface

Migration strategies

- Trackside overlay
- Vehicle migration
- Parallel migration (green field)

Module 12.1 Rail system design / capacity 1

Black infrastructure – needed for operation

Grey infrastructure – non essential

Red infrastructure – required for partial blockade

Yellow infrastructure – required for complete blockade