High Speed Rolling Stock

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High speed Passenger Trains
General approach

- today: trains for speeds higher then 155 mph
- lightweight vehicle design (18,7 tons s.o.a)
- commonly electric power supply
- fixed bidirectional trainsets of different types
- length commonly up to 440 yds
- special aerodynamic designs, single or double deck
- high developed onboard diagnostic systems
- interoperable, if necessary
High speed Passenger Trains

Commercial and Technical Requirements
Commercial und Technical Requirements (1/5)

- Commercial:
  a. Definition of seat capacity
  b. Definition of average journey time intended (as well as assumed distance of service per passenger)
  c. Definition of maximum speed
  d. Definition of comfort level
Commercial and Technical Requirements (2/5)

a. Definition of seat capacity (basic parameters)
   - intended frequency of service
   - assumed daily emergence of customers/service
   - projection cost/seat (cost/seat to be met)
   - planned service levels (classes)

Benchmarks:
   - Europe (normal gauge/clearance; trainlength ~220 yds):
     single deck: ~385...460 (550 high density layouts proposed)
     double deck: 515 realized
   - Far East (normal gauge/ wider clearances, ~440 yds):
     single deck up to 1,300 (class 700, N 700 JR West/Central)
     double deck up to 1,230 (12 coaches ~330 yds, class E1 JR Central)
b. Definition of average journey time intended (as well as assumed voyage distance per passenger):

- Depending on the total line length intended
- Influenced by the mix of customers identified for the business case
- Parameter influencing as well the seat pitch as the corridor spacing and width of entrance areas
- Influencing also the comfort level/offer

Benchmarks:

- All over the world ~ 4hrs max accepted for regularly customers
- Europe: Stopping distances between 40–80, up to 500 mls in Europe
- Far East: up to 800 mls (Beijing – Shanghai), normally 7 stops
c. Definition of maximum speed

- Depends on:
  - distance to be covered and intended travel time limits
  - Infrastructure characteristics (limits) to be used
  - has to be judged in relation with acceleration and brake performance
  - has to be judged in relation to number of stops planned regularly
  - Parameter of high relevance for operational and life cycle cost

Benchmarks:

- Europe: regularly 155…186mph (Germany, Italy, Netherlands) up to 198mph (France)
- Far East: 186 up to 217mph (China)
Commercial und Technical Requirements (5/5)

d. Definition of comfort level:
- depending on customer mix identified in market studies
- depending on established service and comfort level (competition (incl. intermodal), historic evolutions, expectations)
- means for “making the difference”
- more than interior and service offers: airconditioning quality, running behavior, noise damping, pressure tightness

Benchmarks:
- Europe: met completely, upgraded ~ ev. 12..15 years
- Far East: following latest technology, easier on tourist classes (interior, service)
High speed Passenger Trains

Types of trains
### Types of trains (1/11)

**General patterns/characteristics:**

- a. concentrated or distributed power
- b. single deck coaches
- c. double deck coaches
- d. articulated or non-articulated
- e. tilting or non-tilting
- f. multiple unit capability typical for 220 yd units to establish double capacity
Types of trains (2/11)

a. concentrated or distributed power

<table>
<thead>
<tr>
<th>Benefits:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ motorized vehicle with all traction installation at one or both ends</td>
<td>➢ loss of trainlength for passenger capacity (typically 25 or 50yds)</td>
</tr>
<tr>
<td>➢ if wanted “easy exchange” of power head</td>
<td>➢ installable tractive performance is more limited</td>
</tr>
<tr>
<td>➢ maintenance more easy</td>
<td></td>
</tr>
<tr>
<td>➢ crash safety for passengers easier to maintain</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ nearly all trainlength usable for passenger capacity</td>
<td>➢ maintenance somewhat more expensive</td>
</tr>
<tr>
<td>➢ every axle of the train may be used for tractive effort</td>
<td>➢ double deck trains raise construction complications</td>
</tr>
<tr>
<td>➢ possible tractive/brake performance supported by available number of driven axles</td>
<td></td>
</tr>
</tbody>
</table>
Types of trains (3/11)

a. concentrated or distributed power

Examples:
- SNCF, TGV POS
- DB, ICE 2

Example:
- JR West, N700
Types of trains (4/11)

b. single deck

Benefits:
- floor height continuous and stepless
- spacious room impression
- sufficient space for distribution of auxiliary equipment underbelly
- easy access for passengers/service
- stepless entrance (for instance Japan, Taiwan)

Disadvantages:
- “limited” passenger capacity
- deadweight per seat slightly higher

c. double deck

Benefits:
- maximal use of clearance for passenger capacity
- shorter trains possible
- best seatweight ratio achievable

Disadvantages:
- height of rooms strictly limited
- intercirculation not on two levels
- upper deck not accessible for handicapped people or wheelchair
- complications for service at seat
Types of trains (5/11)

b. single deck
c. double deck

examples:
- JR West, E4
  - Photo: © wikipedia, Sui-Setz
- SNCF, TGV Duplex
  - Photo: © Konstantin Menschikow
- RZD, Sapsan
- China, CRH380A
  - © by club.metrofans.sh.cn
  - http://club.metrofans.sh.cn/
- JR East, E4
- SNCF, TGV Duplex
### Types of trains (6/11)

#### d. articulated or non articulated

**Benefits:**
- number of running gear installations „reduced to the max“
- noise induction to the interior might well be ruled
- running behaviour can be maintained well by sophistic designs

**Disadvantages:**
- rake disconnection rather complicated
- axle load difficult to be ruled
- distribution of brake performance more difficult
- interconnection between cars long and often rather tight

**Benefits:**
- maximal use of car body length for passenger capacity
- Maintaince supported be easier splittabilty of the train
- axle load limits easier to maintain

**Disadvantages:**
- higher number of running gear raises potential cost and maintenance
- somewhat raised amount of running resistance (energy cost)
Types of trains (7/11)

d. articulated classic bogie

example:

Europe, TGV PBKA

single wheel set

example:

Europe, Talgo Pendular
### Types of trains (8/11)

#### e. tilting or non-tilting

**Benefits:**
- Higher line speed obtainable
- Faster service on classic or upgraded infrastructure possible
- Provision of higher comfort

**Disadvantages:**
- Running gear of high complexity
- Complex control systems
- Use of clearance shortened
- Very strict limits for axle load
- Lines and signalling need upgrade for full efficiency nevertheless

**Benefits:**
- Once more maximal use of clearance for passenger capacity
- Running gear needs less maintenance concentration
- Maximal use of lineside axle load limits possible

**Disadvantages:**
- Curve speed limited by normally accepted lateral acceleration
- Aim for line speed upgrades raise higher infrastructure costs
Types of trains (9/11)

e. tilting trains & main design principles

passive, „natural“ technology

active technology
Types of trains (10/11)

f. multiple unit capability typical for 220 yd units to establish double capacity

Benefits:
- smaller units available for adapting on variable appearance of customers
- getting split/coupled on the way from/to different targets
- smaller loss of capacity in case of failure possible
- management of standby/maintenance fleet more economic
- risk for starting up new markets better terminable

Disadvantages:
- twice the number of drivers cabs and signalling equipment
- automatic end couplers cause need of intensive maintenance
- control command system more complex
Types of trains (11/11)

f. Multiple unit capability typical for 220 yd units to establish double capacity

examples:

DB, ICE 2

SNCF, TGV Duplex
High speed Passenger Trains

Traction & Brake Requirements
Traction: operational preconditions – power supply

- for commercial use above 155 mph today only electric power supply used
- type of supply very often depending on infrastructure conditions
- very often need to cope with different “voltages”
- commonly widespread systems on high speed services (examples):

<table>
<thead>
<tr>
<th>DC 1500 V</th>
<th>DC 3000 V</th>
<th>AC 15 kV 16,7 Hz</th>
<th>AC 20 kV 50 Hz</th>
<th>AC 25 kV 50 Hz</th>
<th>AC 25 kV 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>Germany, Switzerland, (Austria, Scandinavia)</td>
<td>Japan, China</td>
<td>France, Italy Great Britain, Belgium Netherlands</td>
<td>South Korea Taiwan</td>
<td></td>
</tr>
</tbody>
</table>

- traction equipment technology today is able to deal “with all”
Traction & Brake Requirements (2/2)

Traction: operational preconditions – line gradients

- for commercial use in mixed operations commonly up to 12...15 ‰
- for passenger use only up to 35...40 ‰
- core task: assure a safe amount of resting acceleration capability (∼ 0,16 ft/s²)
- definition of accepted degraded mode operation (incidental loss of traction):
  - Europe: 50% reduction as standard
Traction Requirements (1/1)

state of technology

- three phase power supply for traction motors (and generative brake) (most recent IGBT converters), installed up to 9.6 MW per 220yd train
- either synchronous or asynchronous drive (motors ~ (300)500 ...1.200kW)
- supply of traction converters AC using main transformer, DC directly
- traction motors arranged in separable groups
Brake Requirements (1/3)

**operational preconditions:**
- predefined stopping distances (signalling systems, infrastructure)
- emergency brake regulations (activation methods, aimed distances)
- line gradients (Europe: up to 35...40‰)
- park brake regulations (duration, gradients, methods)
- possibility of generative brake with feed back to the power supply
- accepted exploitation of adhesion coefficient (Europe: ≤0,15)
- magnetic brakeshoes accepted or not
- eddy current rail brakes accepted or not
- seat reservation obligatory or open access (overload accepted)
- all to be judged in relationship to accepted lateral and longitudinal track movement (shifting) resistance values (infrastructure parameter)
contemporary technology:
- high performance automatic pneumatic brake system as “backbone”
- regenerative brake either feeding back or rheostatic or combined
- magnetic friction brake shoes for emergency brake support
- eddy current systems as frictionless high performance system
- spring loaded parking brake systems
- integrated computer controlled activation of all available onboard systems
- different independent brake activation functions due to automatic cruise control or emergency brake control and passenger alarm
- functions for automatic parking brake, immobilising functions, roll away prevention
Brake Requirements (3/3)

solution examples:

1. regenerative brake
2. eddy current brake (if enabled)
3. pneumatic brake

eddy current brake systems

Germany, ICE 3
rail brake

Taiwan,
THSR 700T
axle mounted

Brake force (kN)

running resistance

regenerative brake

pneumatic brake

eddy current brake

actual speed (km/h)

deceleration (m/s^2)
High speed Passenger Trains

Generic Framework
Generic Framework (1/1)

**general influence parameters (specs, contracts):**

- valid technical/industrial standards
- relevant infrastructure interfaces
- commercial regulations (tendering procedures, local content etc.)
- authorisation regulations and procedures
- financial funding (credits, subvention programmes etc.)
- payment conventions (rates, at approval, after testings)
- warranty legislation, warranty contracting
- intended duration of service /use
- ownership models (operator eq. owner, leasing models etc.)
- maintenance models (by owner, by contract with supplier or service provider etc.)
- end of use (scraping, sale, lending/leasing etc.)
Planning New Trains 1/2

- by experience; today there are no offers in the market “ready to buy” – if not for an already thoroughly existing and operated system
- starting with a specification an extensive process is established
- necessary characteristics not contracted cause serious drawbacks and extra cost
- abdication of prototyping causes severe risks and can only be recommended if vehicles are familiar and appropriate
Planning New Trains 2/2

1st year
- est. commercial spec: 3 month
- est. technical spec: 3 month
- call for tender: 6 month
- establishing bids: 3 month
- sifting offers: 1 month
- negotiate bids/contracts: 6 month
- deciding/signing contract: 3 month
- clearing technical design and verification: 6 month

2nd year
- fabrication of prototypes: 12 month
- testing prototypes: 49 month
- serial manufacturing: 40 month
- starting 1st service: 40 month

3rd year

4th year

5th year

combined with homologation/authorisation & approval tests
Thank you very well for your attention!