The interior space of railway carriages - balancing act between sense and operating efficiency

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Inition

- Vienna University of Technology (Research Centre for Railway Engineering), in cooperation with netwiss, has a 15 years’ experience on rail vehicle interiors.

- Aim of all projects:

  Finding of the optimum between passengers’ ↔ operators’ needs and expectations
What do we want?

- **Ultimate ambition:** Having an **efficient rail system**!
  - The railway is an holistic system!
  - Optimizing single parts is inefficient!

- As University and as researcher we are independent

- Our aim is to be discerning in order to develop efficient rail systems
Efficient rail system - interiors

• Many things are important!
• Very important – knowledge about passengers’:
  • needs and expectations
  • experiences
  • actual behaviour in their environment

Only if the rail vehicle interiors meets the passengers‘ needs in all phases it can be efficient!
Methods of our research projects

• Passenger behaviour analyses
  • **Actual behaviour** of about 200,000 passengers in trains
    (Who is sitting where? Where is baggage stored? Where are the immediate problems? Which seats are preferred? etc.)
  • **Exact measurement** of passenger change over **time need**
    of more than 20,000 passengers
    ➔ In more than 60 **different types** of vehicles in Europe

• Passenger needs and expectations – questionnaire
  • More than 35,000 passengers EU-wide
Methods of our research projects

• Calculation model
  • Input:
    • Number of passengers
    • Distribution of passenger data (age, sex etc.)
    • Distribution of travel purpose
    • Exact vehicle interiors layout
  • Output:
    • Exact dwell time
    • Baggage distribution (number, types)
    • Baggage storing (which baggage is stored where?)
    • Which seats are taken, which are blocked?
    • Possible actual occupancy rate
    • Efficiency of the vehicle design
Requirements – train operators

- Short **dwell time** – quick passenger change over
- High **occupancy rate**
- Maximum **revenue**
- (hopefully) **satisfied** passengers
Expectation of industry and operators

- **Expectation**: Industry develops systems and passengers behave as the industry and operators expect.

- **Reality**: Passengers have a lot of (conscious and unconscious) needs.
  - Passengers will use the environment they find in the vehicles as it fits best to their needs!
Requirements – passengers

- Easy access
  → if not, boarding time will increase

- No lifting of baggage

- Having baggage close (visual contact)
  → if there is no suitable storage, passengers store baggage close to them on the floor, in the corridor, on or in front of seats etc.

- Many different comfort needs
  - Adjustable seats; possibilities to sleep; enough space for working (tables, trays etc.); WIFI; individualized heating, cooling and air condition, lightning and much more
Focus of further presentation

- Passenger needs and resulting behaviour against operational effects for train operator

- No focus on the different comfort needs
  - Most of the comfort needs are not really observed in most trains.
  - Big effect on satisfaction and dissatisfaction!
  - For efficiency **satisfied passengers** and so the best possible attention on the comfort needs is required!
Overall interiors concepts - effects

- Passengers' comfort and NO problems in operation
- Expected revenue for the operator
- Efficiency, comfort, number of seats
  - Low efficiency, high comfort, low number of seats
  - High efficiency, low comfort, high number of seats

Optimum point:

- low efficiency, high comfort, high number of seats

Symbolic drawing:

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Baggage – two dogmas

- Passenger try to **avoid lifting** baggage
- Passengers want to have **visual contact** to their baggage!
Willingness to lift baggage

20% (heavy) to 40% (medium baggage) are willing to lift baggage to the overhead bin.

Up to one meter: willingness to lift is higher.
Willingness to **store baggage disturbing** (on floor, seats, in the corridor etc.) **to avoid lifting?**

![Bar chart showing willingness to store baggage disturbing by age group.](image-url)
Importance of visual contact

- Very important: 45%
- Important: 43%
- Less important: 10%
- Unimportant: 2%
Willingness to store baggage disturbing (on floor, seats, in the corridor etc.) to guarantee visual contact?
Offer of baggage storage

- **Overhead bins**
  - Frequently the only offer
  - **Not liked** by passengers

- **Baggage racks**
  - Sometimes offered, especially in new coaches
  - **Liked** by passengers

- **Between seat back rests**
  - Hardly offered
  - **Very liked** by passengers
Overhead bin

Height of overhead bin

Width of seats, large diagonal

Baggage weight

Large torque, large force!

Safety risk for sitting passengers

- Large exertion
- Safety risks
  → negativ sensation
Effect

Although some seats are theoretically free: Passenger has to sit on his suitcase!

50% of the overhead bin is not used, however: Baggage is stored on seats and in the corridor!
Baggage racks

- Are liked by the passengers

Main problems:
- **Location** – at the end of the vehicle or in the entrance area
  → NO visual contact
- **Dimensions** of the rack often do not match today’s baggage
  → inefficient
Effect of racks close the entrance

Utilisation of the baggage rack

Occupancy rate of passengers

Ideal utilization rate of the rack (relative to occupancy rate)

Actual utilization rate of the rack
knowledge about baggage - size

trolley upright

< 35 cm

< 65 cm

< 85 cm

35 cm

85 cm

cross-section

maximum

large 95%

large 75%

medium

small

95%
knowledge about baggage - size

large carpetbag

< 43 cm

< 85 cm

medium carpetbag

< 43 cm

< 43 cm

< 100 cm

< 35 cm

< 30 cm

large rucksack

43 cm

37 cm

37 cm

cross-section
bad example

not efficient
Between seat back rests

- Very liked by the passengers!
  - Easy storing, no lifting, close to passengers

- Main problems:
  - **Space** between the seat back rests does not match today’s baggage (especially larger items)
    -> inefficient
Space between seats – today’s examles

Bad solutions – no space for large items!
Space between seats – today’s examples

0 cm

0 large suitcase
0 trolley upright
1 small suitcase
1 medium carpetbag
Space between seats — hardly to find anymore

**moderate solutions – few space for large items**
Space between seats — hardly to find anymore

- 1 large trolley tilted
- 0 trolley upright
- 1 medium suitcase
- 1 large carpetbag

18 cm
Space between seats – past!

Good solutions – enough space for large items
Space between seats – past!

no lost space

32 cm

2 trolleys upright

2 medium trolleys tilted

3 large carpetbags
Effect of the overall vehicle interiors

Arrangement of

- Seats
- Baggage storages

→ has got a big influence on:
- Occupancy rate
- Dwell time

Following some examples:
Row seating – only overhead bin

Many large items are stored on floor level → ON or IN FRONT OF SEATS / IN THE CORRIDOR

Hindrance in the corridor → Time need

Seats are blocked!
Row seating

3rd problem: oncoming passengers

No passing room
Row seating

Baggage in corridor, on seats
Oncoming passengers
Overhead bins

Tailback after view passengers, long time need
Row seating + baggage rack close entrance

No visual contact

Tailback after view passengers, long time need
row seating – time need

- Seats standing neatly in a row
- Opposite seats
- Compartment coaches
- Opposite seats in an IC2000

Ideal time [sec]

Actual time [sec]

row seating
Vis-a-vis seating

Baggage storing between the seats

enough space required
→ Very fast and easy storing
Coach interiors

Vis-a-vis seating

Oncoming passengers

+ Passing points
Seat arrangements

- Seats standing neatly in a row
- Opposite seats
- Compartment coaches
- Opposite seats in an IC2000

**Row seating**

**Vis-a-vis seating**
Dwell time – different concepts

Boarding time, approximately 30 passengers

Today's situation

Row seating (no racks)

Mixed seat concept (rack close to entrance)

Mixed seat concept (rack away from entrance)

1st big difference between theory and practice

Dwell time needs double to three times longer!

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Occupancy rate - Seat maximum (operators’ which)

- 20 % blocked
- 100 % actual occupancy!
- 80 % occupancy
2nd big difference between theory and practice

- Seat maximum (maximum expected revenue)
  - actually max. 80% of the seats can be taken!
  - Rest is blocked by baggage
Theory versus practice

- Operators wish:
  - Best possible efficiency
    - Short dwell time
    - High occupancy rate
    - High revenue (as many passengers as possible)
  - Today’s approach
    - Maximizing number of seats (like air industry does!)

- Practice:
  - Much longer dwell time (train stop time up to 5 minutes)
  - Lower occupancy rate (maximum 80%)
  - Dissatisfied passengers
Solutions

- Reducing number of seats:
  - Reduction of approx. 10% of the seats
  - Using space for well designed baggage storage
  - Mixed interiors concepts

  → On most days 100% occupancy rate is possible
  → Dwell time can be reduced

  - Further concepts like changing of the door locations or car body types leads to even more benefit
Requirement for designing

- For redesigning or designing new vehicles:
  - Passengers’ *behaviour* must be taken in consideration from the beginning
  - Also passengers’ *needs* and *expectations*
  - Exact *calculation* of the optimum number of the seats
    - Knowledge of passengers (main travel purpose etc.)
    - Knowledge of baggage distribution
  - **Start** the vehicle designing *from inside* (the interiors must be fixed first) – the *car body must match the interiors*, not the other way around!
Five typical designing errors

- **Error 1: Volume calculation**
  - Baggage has a volume AND three dimensions
  - *How big are 0,15 m³?*
Our baggage is not able to do that:

Source: https://www.youtube.com/watch?v=A8UghGFar6w and www.youtube.com
Just volume calculation:

0,50m² x 1,00m = 0,50m³

Large trolley ➔ 80x55x35cm = 0,15m³

theory:
Space for 3 big or 4 medium trolleys

practice:
Space for one medium trolley (if passengers are able to tilt (corridor width))

Error: Industry adds all – even the little „umbrella“ storages - to a total sum! Actually only 1/3 to 1/4 of the calculated space is available!
Five typical designing errors

- **Error 2: Disregard of passenger behaviour**
  - Passengers do not want to lift baggage
  - Passengers want to have visual contact

- **Practice:**
  - Most of the storages do not meet these requirements!
  - Storages are inefficient because they are used bellow average
  - Passenger store baggage everywhere it is “forbidden”
Five typical designing errors

- **Error 3: False awareness of luggage volume**
  - Every situation is unique, you cannot use general numbers of baggage
  - It is required to know exactly about the baggage quantity for the area of operation
  - **Practice:**
    - Usually the baggage distribution and the quantity is underestimated!
    - False number of baggage in combination of false dimensioning of storages is potentiating the problems
Five typical designing errors

- **Error 4: False dimensioning**
  - All baggage storages must be designed well-considered
  - 5 cm to narrow rack can reduce the efficiency for about 30% or more!
  - **Practice:**
    - Baggage racks and other storages (e.g. between seat back rests) are the remaining result of the vehicle designing
    - The car body is designed first, the window divider is fixed, all other is remaining → in most cases **only inefficient storages remain!**
Five typical designing errors

- **Error 5: False evaluation criteria for orders**

  - Criteria must be e.g.:
    - Maximum available seats
    - Shortest possible dwell time
    - Satisfied passengers
Five typical designing errors

- **Error 5: False evaluation criteria for orders**
  
  - **Practice:**
    
    - “Funny” and not logically comprehensible numbers which are only “psychological numbers” (like prizes in the supermarket) are often very important criteria:
    
    - **Example:** “The train must have at least 500 seats!”
      
      → Actually only 450 seats may be taken, if you reduce the number to 470 seats all these 470 seats can be taken!
    
    - **Big problem:** If those numbers are fixed in call for bits the industry has no chance to offer innovative and much more efficient concepts!
Conclusion

- Meaningful criteria in call for bids that allows the industry to think about innovative solutions!

- Less is more (less seats, more efficiency)

- There is no panacea at all - Each area of operation needs an exact calculation of expected baggage items (e.g. Commuters vs. air passengers)

- The passengers’ needs and expectations must be taken into consideration!
Consulting references

Evaluation of the interiors concept regarding

- efficient baggage storage
- highest possible occupancy rate
- low dwell time

- DB (German Rail)
- SBB (Swiss Rail)
- ÖBB (Austrian Rail)
- Bombardier
Thank you for your attention!

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