La influencia de la accesibilidad en el consumo de energía

The influence of railway interiors on train energy consumption

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ABSTRACT

Both in local and in long distance passenger transportation the passenger-changeover in the station needs a certain time. E.g. in local traffic the time need for enter and exit a train amounts at an average 11 % of the whole travel time. To that effect the total time need of a train stop in the station is even larger.

By reducing the actual time need of the passenger-change over in a station the gained time can be used for slower running among the stations. The effect is lower energy consumption without extending the travel time.

An ongoing project by TU-Wien (Vienna University of Technology) works out the potential capacity of energy efficient train running by optimizing the time need of train stops and passenger-changeovers. First calculation show a noticeable energy reduce.

Furthermore another investigation of TU-Wien deals with the topic of optimizing passenger coaches in order to minimize the time need for passenger changeover in general. In this project case studies analyse the actual behaviour of passengers when entering the train or moving along in the train in order to search for a free place and for space to store luggage.

Railway interiors influences strongly the time need for passenger changeover. Passengers who enter a suboptimal designed coach need double or triple the time compared to a well designed interior. This fact leads to partly large delays on main travel days and causes an inefficient energetic train run. Some simple operational improvements help trains running on time on the one hand and on the other hand improved entrance situations and railway interiors will help reducing the time need in the station clearly.

This article shows the most important influence criteria on boarding time and ways that lead to a strong time reduce.

Passenger exchange process

Figure 1. Boarding passenger onto an ICE on a platform height of 38cm

Passenger exchange can be divided into two parts, on the one hand are the descending passengers and boarding ones on the other. Descending passengers do not have so many restrictions as boarding passengers, besides descending travellers can provide their luggage before the arrival and so the total time needed is nearly linear. One major factor of the time needed for boarding passengers is the vehicle concept. To evaluate the boarding process the vehicle is divided into two parts. The single door includes the door width, steps and the entrance area. The second part is the interior of coaches and its seats. Both parts depend on the number of passengers and subsequently both zones have different influences on the time needed. In this case both the single door and the entrance area are relevant for up to ten persons. For more than ten boarding passengers the interior is the most relevant factor. Bad interior concepts prevent a quick boarding and quickly a tailback arises consequently the stop-over time also increases.

Parameters of the single boarding

The vehicle characteristics influence the stop-over time by the number of steps, the step-ratio and the door width. Passenger characteristics affect the stop-over time such as the age of passengers, their luggage and other possible obstructions.

Entrance area design

The best solution for descending and boarding passengers is a level-free situation. In most cases there is a horizontal gap between the vehicle and the platform. This gap forces the travellers to a higher concentration and a higher energy amount. In general children and older people need longer, because they are handicapped by their height and agility. So this leads to the conclusion that train passengers would prefer a level-free entrance without any kind of barriers and obstacles.

All those theses can be concluded from the analysis of the IC 2000, a double decker coach of the Swiss National Railways, stopping at a platform with the height of 38cm (one step) or 55cm (zero steps). A look on the common vehicles shows that the ICE of the German National Railways, stopping at a platform with the height of 76cm offers the best solution, because of the flat step-ratio and the door width of 90cm. In general the number of steps and its ratio and also the number of pieces of luggage are the most influencing factors.

Passenger characteristics

The major factors of passengers are the age, the number of pieces of luggage and any kind of handicaps. Therefore the passenger's age is divided into three main groups: children (till ten years); juveniles and grown ups (till sixty-five years) and older people (from sixty-five years)

The number of pieces of luggage is categorised into less obstructive luggage, one big piece of luggage and more pieces of big luggage.

Platform – Vehicle, Gap

Because of the construction a gap between the platform and the vehicle is inevitable. But there are some kinds of variations of the gap. Vehicles with a level-free entrance don't show a disadvantage relating to the gap. Also an occurrence of a gap is present by vehicles with steps. In many cases this gap isn't really relevant, because the first step isn't often used.

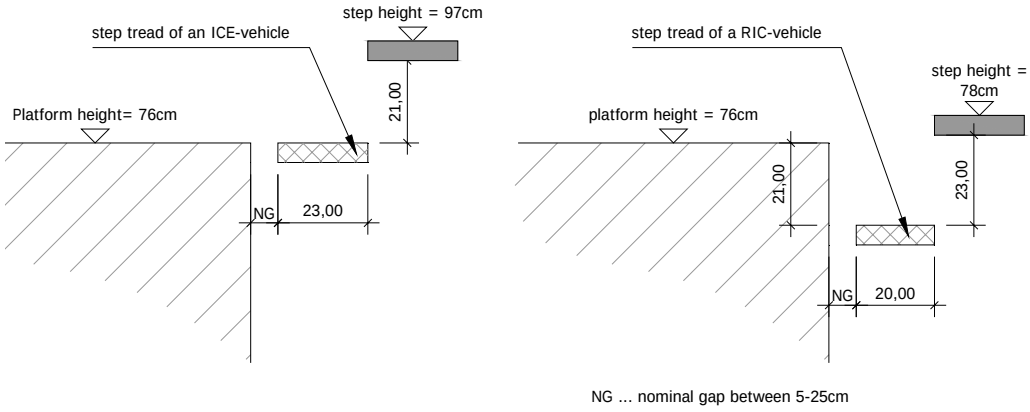

Figure 2. Gap between an ICE and platform with a height of 76cm (left)
Gap between a RIC and platform with a height of 76cm (right)

A special situation is when common RIC-vehicles stop at a platform 76cm high, because the first step is constructed for a platform with a height of 55cm. In this case a gap emerges which is broader than 25cm.

This situation often occurs at German stations. Passengers with big luggage, children or older people often have problems, because the gap demands a higher concentration and energy demand of boarding passengers.

Parameters of the Entrance Area

A tailback, which appears in the entrance area, is limited by maximum ten persons. If the entrance area is dimensioned too small, a tailback will arise. It is necessary, that the entrance area offers a defined way to the seats. This aisle can be situated in the middle or on the side of the coach and it shall be broader than one metre.

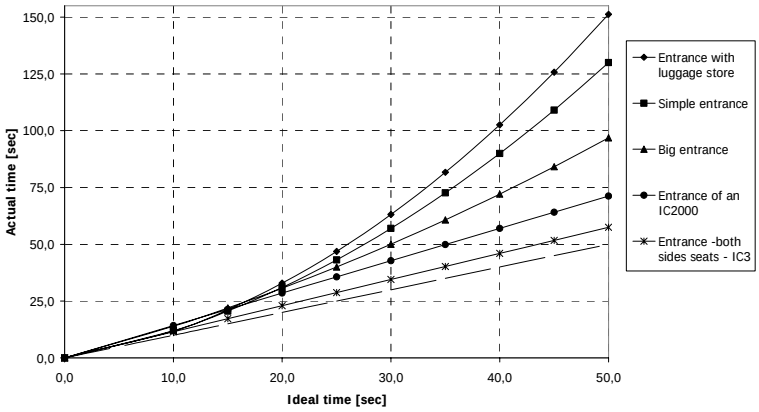

Figure 3. Five entrance areas relating to the actual and ideal time needed

Parameters of the coach interior

The design of coach interior influences the passenger exchange when more than ten persons get on the train one by one. The major parameters are the aisle width, the arrangement of the seats and the luggage storage facilities.

Aisle width

Boarding passengers look for a seat as soon as possible. So the aisle width determines the movement speed. In long-distance traffic the travellers have middle till big sized luggage. If the aisle width is limited to 50cm, the movement speed will be restricted, too, because the luggage is in most of the cases too broad and there are not any passing points.

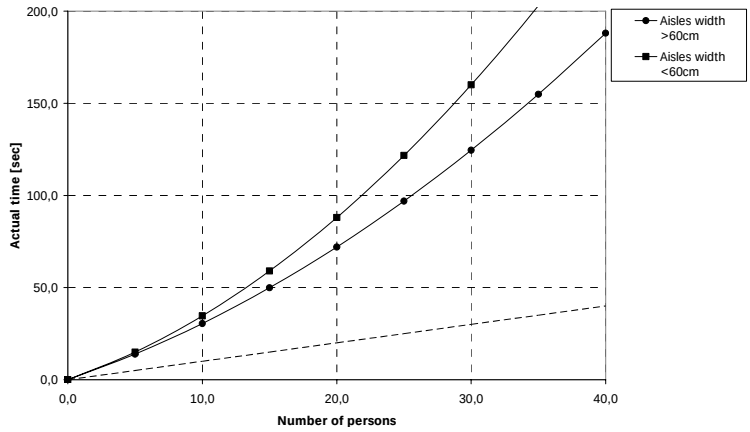

Figure 4. Comparison of aisle width, which are smaller and bigger than 60cm

If the aisle width is dimensioned to 60cm, the movement will be quicker and more comfortable. The research work shows that the passengers' time needed is reduced to 75% of the total time needed in aisle width of 50cm.

A good solution is offered in compartment coaches, which provide an aisle width of 70 till 90cm. In compartment coaches the movement is unrestricted possible and the compartments themselves afford adequate passing points.

Luggage storage facilities

Passengers have two wishes: first they do not want to hoist their luggage and second they want to have a visual contact to their luggage, this shows also. Many coaches offer luggage storage facilities, which are insufficient or not accepted, because they are too small or too high. So a lot of passengers store their luggage in the aisle or on seats, where the luggage is in an obstructive position.

Over-head-luggage-bins mean that the suitcases, trolleys and bags have to be hoisted and this process needs a lot of time.

The best solution would be to distribute the options for luggage stores appropriately in the coach and close to the passengers' seat.

Inappropriate situations of luggage stores are the following

- Luggage racks in the entrance area do not afford a visual contact during the travel. Besides the luggage racks are often too small and so a tailback arises very fast. Further the passengers, which use the luggage racks in the entrance area have to cross the passenger flow, this also includes a conflict potential.
- Nearly the same problems emerge from luggage racks, which are located in the beginning of the coach. This situation also results in a tailback and no visual contact to the luggage.
- Luggage racks in the middle of the coach offer a visual contact for most of the travellers, but the passengers have to pass through the whole coach, which means also too narrow aisles. After the travellers have reached the luggage racks, which are also mostly too small, and have stored it, they want to find a seat. Therefore they have to turn around

and cause oncoming traffic and consequently the movement of passengers gets stuck in a jam.

A good solution would be to locate the luggage racks in the quarter points of the coach length, because then a visual contact and a quick movement would be ensured. The dimensioning of the luggage racks shall be paid extra attention to.

Seat arrangement

All the described factors are mirrored in the total concept. Long-distance trains can be divided into three main categories: seats standing neatly in a row, opposite seats and compartment coaches. Those three categories can also be combined.

Seats standing neatly in a row show most of the described disadvantages. These coaches do not offer adequate luggage stores and because of the narrow aisles passing points do not exist. So tailbacks can arise quickly.

Opposite seats offer luggage stores, which are distributed on the length of the coach in an appropriate way between the back of the seats. The luggage is close to the passengers' seats, visual contact is possible and this option does not have the consequence of hoisting the suitcases, trolleys and bags. But in most cases the space between the seats allows only to store small till middle-sized luggage. Therefore it would be necessary to dimension the distance between the back of the seats a little bit bigger in order to store also big suitcases, trolleys or bags.

The fact, that the distance between the seat backs is too small is established by the results of days with high passenger frequencies. The time needed on such days shows that the passengers' behaviour is nearly the same as in trains with seats standing neatly in a row.

Another advantage of opposite seat concepts is that the groups of four seats, as long as there is no table reaching out till the aisle, offer enough passing point rooms. So the passenger flow can be easily left by the passengers.

In *compartment coaches* the movement is quick also with big luggage because of the broad side aisle (70-90cm). If a big suitcase is put in the aisle there won't be any restriction because of the width. Also oncoming traffic does not cause too many problems. Besides the broad aisle also the fact, that many passengers enter the compartments with their luggage turn out to be an advantage, because the passenger flow can be quickly left in such cases.

In principle compartment coaches offer a better solution than open plan carriages, especially with seats standing neatly in row.

Furthermore the side aisle till the first compartment door also serves as retention room and can be regarded as part of the entrance area.

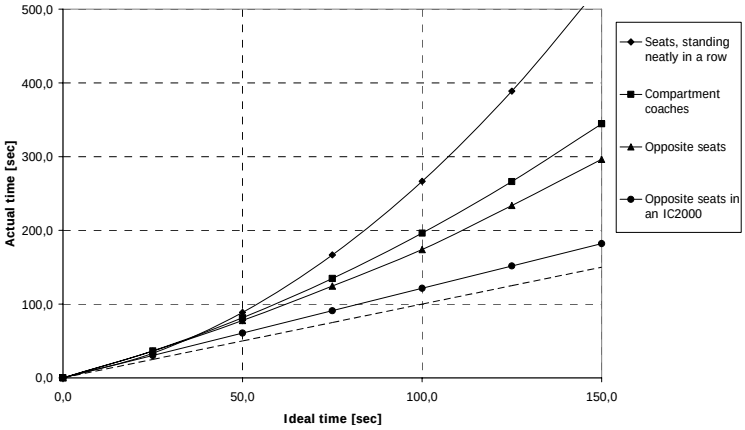

Figure 5. Four coach interiors relating to the actual and ideal time needed

Overall concept

Door arrangement

Another main influence on the passenger exchange is given by the arrangement of the doors. Common vehicles have the doors at the end of the coaches and so every door has to serve half of the coach in one direction. Apart from that the passengers have to go the longest distance to find a seat. The time needed grows with every passenger in an over-linear way and so a big prolongation of the stop-over time occurs.

A positive effect can be noticed with concepts where the passenger flow divides after boarding. This is possible in double-decker coaches or when the doors are arranged at the quarter points of the coach length. The second solution divides the coach into four parts. The passenger exchange time will be reduced in a noticeable way.

A big problem concerns coaches with only one door. This phenomenon is shown by the control coach of the ICE-T or the Pendolino-vehicles of FIAT. Those doors always mark the critical door and the passenger exchange time always depends on the critical door.

Even though the control coach of the ICE-T could be served by the second coach, the passenger do not use this way. So the research clearly shows that the travellers mostly use the door, which leads to the coach where they would like to take a seat. In conclusion, coaches with only one door should be examined in a special way.

Time-optimised overall concept

For any reduction of the stop-over time it is essential to look at all factors which have been described so far. The entrance area, retention area and the interior design shall allow a quick movement of the passengers. A good overall concept has the IC2000 of the Swiss National Railways. In this type the passengers' behaviour shows the ideal stop-over time. The door width of 140cm allows a shifted or side-by-side descending respectively boarding process. The observation shows, that mostly descending passengers prefer the door width,

where as for boarding travellers the door width is still too narrow respectively the door width should be divided by a mechanic installation.

Figure 6. IC2000 on a platform height of 38cm (left)
IC 2000 on a platform height of 55cm (right)

The nearly level-free entrance option may be regarded as a really positive one. Furthermore the separation of the passenger flow is very effective and also the big entrance and retention room result in a short passenger exchange time. All these factors are supplemented by the opposite seat design. Comparing the IC2000 and the common RIC-vehicles the passenger exchange time needed of the IC2000 is less than 70%.

Conclusions

This research work shows that the stop-over time can be reduced to a third compared to the present one, if the following principles are applied:

- A level free entrance solution or a maximum of one step.
- If steps are unavoidable, the maximum shall be limited to two steps.
- The horizontal gap shall be less than 10cm.
- The door widths shall be bigger than 90cm.
- The step ratio shall be as flat as possible (less than 1:1).
- The entrance area shall offer enough tailback-room like aisles
- The aisle width shall be minimum 60cm, better 70-90cm.
- The luggage stores shall be level-free and distributed appropriately along the coach, also for big suitcases, trolleys and bags. Do not use luggage racks in the entrance area, in the coach end or middle.
- The seat arrangement shall be dispersed and the opposite seat concept shall be used more often.

All these principles reduce the stop-over time and offer therefore a high potential for energy-saving driving manners. Due to that fact, both the passenger exchange time and the top speed can be decreased and the travel time can be kept.

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