Bernhard Rüger, from Austria’s TU-Wien, outlines the findings of a recent study into better arrangements for luggage racks.

**ATTENDS ARE OFTEN** made to increase the number of seats in railway carriages to increase the capacity. The consequence, however, of increasing seat numbers is that only the overhead racks are available for stowing luggage. This fact has proved important, as shown by an extensive study by the Institute for Railway Engineering at the TU-Wien. The study took place on long-distance trains across Austria, and dealt with passenger behaviour under a variety of conditions. The change was discovered: firstly, travellers dislike having to lift their luggage up to the overhead rack and so are prepared to put up with uncomfortable inconvenience to other passengers and themselves in order to avoid this. Secondly, passengers always want to be able to see their luggage.

If these two basic principles are disregarded when a train is being designed, then serious disadvantages arise for the passengers and operator during daily use. Loading too many cases also increased discomfort but also a drop in efficiency.

**Human behaviour**

It is all possible, passenger to passenger, to avoid lifting medium-sized and large pieces of luggage. The consequence is that areas on the floor are used to deposit luggage. If there are no suitable areas, such as corridors, then areas between the seat or individual racks on the floor, then other areas like open racks or the empty area are used.

As a rule, the displacement of the free seats is done in such a way that they can only be made free at great expense, and so are unusable. As well as the passengers having to sacrifice comfort, that has the result that the maximum possible utilisation rate of the seats in the carriage is limited to 70 to 80%. At least 20% of the seats are unusable and the trains that the passengers have to stand up, despite the fact that these are theoretically free seats available.

Luggage, which is left in the aisle and near the entrances, stops these passengers who wish to move about on the train. This problem gets worse when the moving passengers have luggage as well. A further difficulty is that the aisles are too narrow to accommodate movement when luggage is present. With a width of less than 60cm, passengers find it more difficult to move about. When people are boarding, these circumstances quickly lead to queues – a situation aggravated by their not being enough free seats.

**All change**

The queue, which is caused by these design flaws in the interior, as well as narrow entrances and when the large number of steps to be negotiated (sometimes up to five) when people are getting on and off, leads to increased passenger changeover times at stations at peak travel times. The delay of trains increases by a few minutes at every station. Depending on the distance, this can add up to delays of up to one hour. Then delays affect approaching and following trains and even unanimous arrangements for a whole day. Unleashed, placed luggage blocks the various emergency exits, which represents a high risk to safety. The emergency exits are further restricted by aisles which are too narrow. The serial layout of the doors at both ends of the carriage has a similarly disadvantageous effect, as the emergency exit for people who sit in the middle of the wagon is along way off. Suitable ways of improving potential can be drawn from the study of passenger behaviour and can lead to a marked improvement in the study mentioned. The two main critical points refer to passengers getting on, and the seating arrangements in general.

The position of the doors on newly built trains should be reconsidered. If the two entrances are put at the respective quarter points, instead of at the end of the carriages, the floor of passengers can be better spread, which leads to a tangible reduction in the queues. In order to speed up passengers getting on, the entrance doors must have a minimum width of 80 cm.

**Step on it**

(50 equal importance is the number of steps from the platform to the interior of the train. Depending on the luggage that is carried, negotiating four steps takes two to three times longer than two steps before the next passenger can follow a passenger with a heavy case takes on average 12 seconds to negotiate four steps. The passenger makes an average five seconds to negotiate two steps. A gentle gradient in the angle of the steps also contributes to a reduction in the queues.

When getting on an ICE train with a door width of 80cm and a step height of 60cm, a passenger needs an average 15 to 20 sec less time than when getting into a RIC-carriage with a door width of 90cm and a rise of 21.23cm.

In order to avoid queues, the immediate entrance area inside the train must fulfil the function of taking on and distributing passengers. It is therefore necessary that this area has no free seats. Passengers with luggage must be able to sit in them. As a further consequence, the width for access between the seat must be at least 60 cm to not restrict the passengers too much.

The seat/rack ratio

The minimum number of seats should not be dictated by the wishes of the operator, which will likely want to offer as many seats as possible per carriage. The basis for the maximum number of seats is in the number of passengers and their behaviour under various conditions. Most passengers have luggage with them, especially on holidays which are airports or holiday destinations. The amount of luggage on board is measured by the average passenger destination in long distance trains in Germany: 212 holiday journeys, 15% longer journeys, 50% short journeys and the rest are business trips of one or more days. Each passenger averages 12 pieces of luggage. This can consist of big or medium-sized cases, travel bags or rucksacks. Each passenger also averages 0.7 pieces of hand luggage – smaller cases, travel bags and rucksacks.

This area needs to be equipped with a luggage rack, which is not available on all RIC trains. The luggage racks are designed for putting luggage on them, but it is not unusual to find luggage on the floor or in the aisles.

The luggage racks must not be situated in the immediate vicinity of the entrance areas at both ends of the carriage.
were prepared to lift their luggage and stow it in the overhead racks, there would not be enough luggage space on those days with an increased number of holidaymakers. Since there are many passengers who are not prepared (or able) to lift up their heavy luggage, then only the light pieces of luggage and clothing are lifted up and the heavy stuff stays on the floor, or in front of the seat. Accordingly, in this compartment only 70 of the 88 seats would be available. On holidays there would be even less.

The degree of efficiency to be expected is 94% on holidays down to 89%. The upper limit for seats to be built in, in order to get around 100% efficiency, is about 80 in this type of carriage on an average travel day. In this case four luggage racks can be built and on the basis of the analysis of passenger behaviour, one can predict a possible seating efficiency of 100%.

So, by giving up eight of the 88 seats, there will be 10 more seats available! This increases the efficiency, and with this the economy, and also passenger comfort and customer satisfaction.

Arrange a re-rack

The luggage racks must not be situated in the immediate vicinity of the entrance areas at both ends of the carriage. Passengers only accept these racks grudgingly even though they offer storage space on the floor. The reason lies in the fact that the passengers always want to keep an eye on their luggage.

In normal trains (with doors at each end of the compartment) it is best to arrange the luggage racks in the quarter points of the carriage opposite each other, whereas to get optimum efficiency they should be placed next to each other. This arrangement guarantees the best possible flow of passengers who are getting on and in this way reduces the queues.

The final choice of number and size of luggage racks depends on the respective conditions like the distribution of the destinations. As a general rule the installation of 4 luggage racks each with an inside width of at least 100cm has proven to be most advantageous. One must be aware that the bottom rack, which is mainly meant for large and heavy pieces of luggage, is at least 75cm height. Above this are 2 racks arranged with an interior height of 55cm and 45cm and here the smaller upper rack is suitable for travel bags and rucksacks. If the minimum measurements are not met, the racks cannot be used efficiently.

When building the racks one must take care to have them sloping backwards so that the luggage does not fall down. Since the backrests have a certain angle, one can use the space that is left between the two seats for storing luggage. Passengers like these areas and gladly make use of them. One must not make the mistake of placing headrests next to each other – the space left is much too small and cannot be used. The seating arrangement is only efficient if there is space left, measuring from the floor, to a height of 60cm and a width of 35cm.

If the side fittings do not go down to the floor then the load is carried through to the back area, and the angle of the seats can be used for a broader area on the floor to store luggage.

The studies have shown that if the ideas used in this article are used to their full potential, then rail services can be optimised and managed more efficiently in many areas.

Find out more about the project (and meet the author) at 10.50 on 28 November in Köln, Germany at the Railway Interiors Expo Open Technology Forum.