

A Qualitative Study on Providing Alternative Solutions for Handling the HSR Passenger's Luggage

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Abstract The objective of this paper is to look at the problem of high-speed rail (HSR) passengers' luggage and provide alternative solutions to improve luggage handling. A qualitative study is carried out to assess the current state of HSR practices, analyse existing issues with HSR passenger luggage and provide alternative solutions, including modification of the passenger unit, double-deck rolling stock, an additional train for transporting luggage, and repositioning of passenger seats. Four solutions are discussed that could solve the problem of HSR passenger luggage handling and evaluated from four aspects namely passengers, railway operator, cost and passenger comfort level. The solution of additional trains for transporting luggage may be the preferred solution when compared with other options, without compromising the comfort of the passengers or the profit of the railway company.

Keywords Rail passenger · High-speed rail (HSR) · Luggage · Qualitative study

1 Introduction

After a few decades of intensive railway development, high-speed rail (HSR) is well developed in many countries, including Germany, France, Japan and China. Germany's HSR system is one of the most famous and well-developed rail networks in the world. After the successful construction of the HSR network, Germany is now targeting international markets by selling HSR technology to other countries such as Russia, Turkey and China. Germany's HSR network (connected to other European countries) is known as the Intercity Express (ICE). ICE3 (Siemens Velaro) is a variant of ICE that was developed with a maximum speed of 360 km/h (225 miles/h) [27–29]. Japan is another country that has been successfully developing HSR networks, beginning in 1964 when they became the world's first country to build an HSR network and rolling stock. Japan's HSR network is called Tokaido Shinkansen and is operated by the Central Japan Railway Company. Tokaido Shinkansen is focused on the safety and timeliness of their trains. They have recorded no fatalities or injuries since the start of operation in 1964. They also have a reputation as the most punctual HSR system in the world, with an average annual delay of 0.9 min per operational train, including delays caused by natural disasters [6]. ICE and Tokaido Shinkansen exemplify the evolution of HSR through implementation of advanced technology to improve speed, punctuality, safety and passenger comfort (tilt technology). However, baggage storage in HSR may still need to be improved to satisfy future HSR developments and to further address passenger satisfaction and demand. Situations may arise where the luggage area and cabin-size baggage racks lack adequate storage space for passengers' baggage when the train is full, such as during travel seasons (e.g. holiday periods). To overcome this

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problem, some railway companies have introduced measures to limit the number and size of luggage permitted. For example, Virgin Trains East Coast in UK limits luggage to three pieces, including two large items (up to 90 cm x 70 cm x 30 cm) and one piece of hand luggage (East Coast Main Line Company) [2]. But these measures have proved ineffective. Because of the lack of space, many passengers still need to store their luggage in the lounge or near the entrance of the carriage, making it inconvenient for other passengers when going to the toilet or to other carriages. Also, large suitcases can be a problem for families travelling by train during the holidays, who may find it difficult to take care of their children and luggage at the same time. Parents have to take the time to load and unload their baggage from the luggage area, ignoring the care of their children, and are forced to tend to their luggage and their children simultaneously after arriving at the station of their travel destination. As an increasing number of passengers travel by HSR every year now, the luggage issue has become more serious. Thus a solution must be devised to overcome the issue without compromising the comfort of the HSR passengers and the profit of the train operating companies. This study explores alternative ways of storing and handling passenger luggage on the HSR. Specifically, four solutions are discussed and qualitatively compared in order to choose the option which provides the optimum outcome.

Can HSR provide a better way to increase the storage space for passenger luggage and improve the comfort of passengers?

The aim of this paper is to find alternative solutions that improve baggage handling and increase the capacity of luggage storage areas on HSR trains. Different options are proposed and compared to determine the most suitable solution for increasing luggage capacity whilst minimising total costs for the railway companies.

To achieve this aim, a systematic qualitative approach is implemented to identify and evaluate possible solutions: Firstly, a better formulation of the problem is undertaken. The storage area on HSR trains does not currently meet the needs of passengers. Secondly, better analysis of the problem of insufficient luggage storage is conducted. Information and evidence is also provided to assist in solving the problem. Thirdly, alternative methods, ideas and solutions are developed to overcome the problem(s) identified. Finally, after careful qualitative evaluation of the four scenarios, a decision is made as to the idea or solution most suitable for implementation.

This study was conducted to potentially develop:

- Measures and changes that are convenient for all HSR passengers

- Extra capacity to increase luggage storage areas on HSR trains
- Extra storage area for HSR passenger luggage without sacrificing the number of passengers (standard or first class) per high-speed train
- Solutions that minimise the operational cost for railway companies.

2 Current Situation with Storage of Passenger Luggage on Trains

A previous study on passengers' opinions regarding luggage storage on HSR trains (Rüger n.d.) showed that 90% of passengers carry at least one piece of either medium-sized or large luggage for long journeys, and that storage space is insufficient to accommodate the luggage of all passengers. Note that medium-sized luggage is between 71 cm (28 in) and 104 cm (41 in), whereas large luggage is 167 cm (66 in). Factors that might affect a passenger's decision to use a train during summer and winter are shown and quantified in Fig. 1. It is apparent that a major contributor to the decision-making is the transport of luggage (in the summer or winter). Figure 2 presents decision criteria that affect passengers travelling by train on holidays only. The combination of luggage and other criteria was found to be the most important factor for passengers who travel by train.

Figure 3 shows the functional efficiency of the HS train interior design by looking at the number of seats available. In this way, we can attempt to understand the interdependence between the railway company's offering and the passenger's expectation. The results show that the railway company's offering is inversely proportional to the passenger's expectation. Train operators need to maximise profit, which in many cases and situations jeopardises the passengers' comfort and limits storage space for luggage. Passengers expect more comfort and adequate areas for storing luggage. An optimum solution must be able to balance the needs of train operators and passengers.

Figure 4 shows that almost 50% of passengers are willing to lift medium-sized and large luggage to waist level. On average, 70% of passengers are not willing to lift medium-sized luggage to the overhead rack. These results show that the rack for large luggage should be below waist level. However, because of the limited storage space on HS trains, passengers would typically need to lift medium-sized luggage above waist level.

The pie chart in Fig. 5 shows that 88% of HSR passengers believe that having their luggage within sight is important. Results have shown that any large luggage rack placed near the entrance of the carriage is not safe (luggage

Fig. 1 Decision criteria when choosing mode of transport [23, 24]

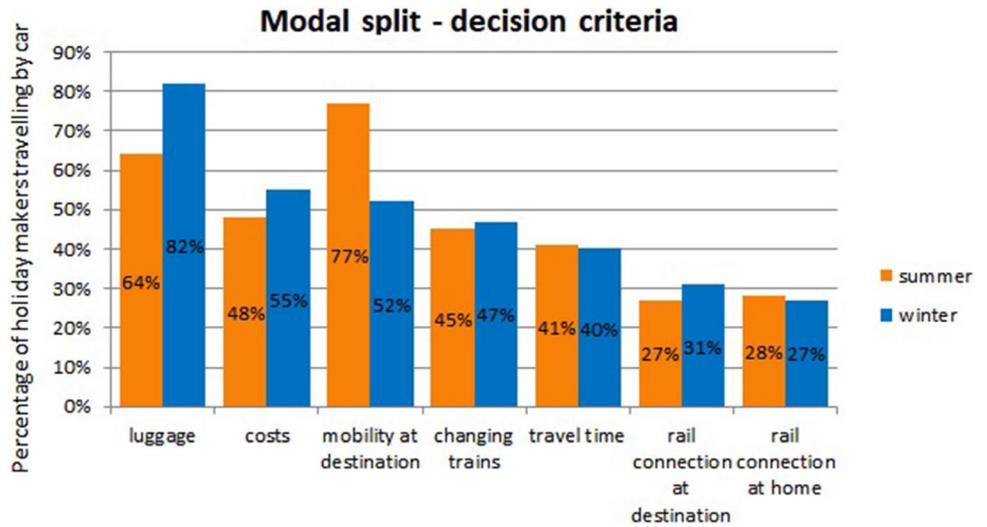


Fig. 2 Decision criteria when choosing to travel by train [23, 24]

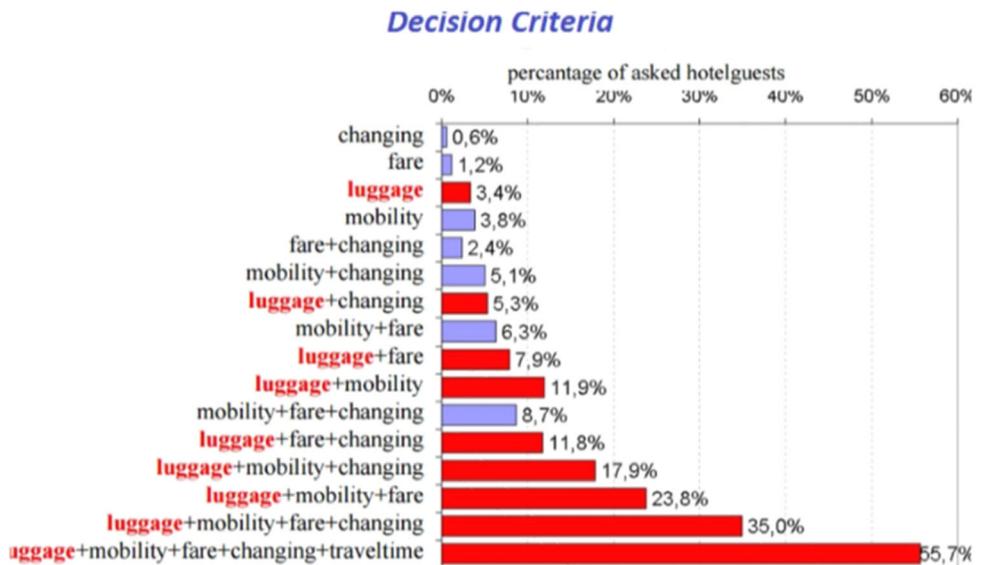
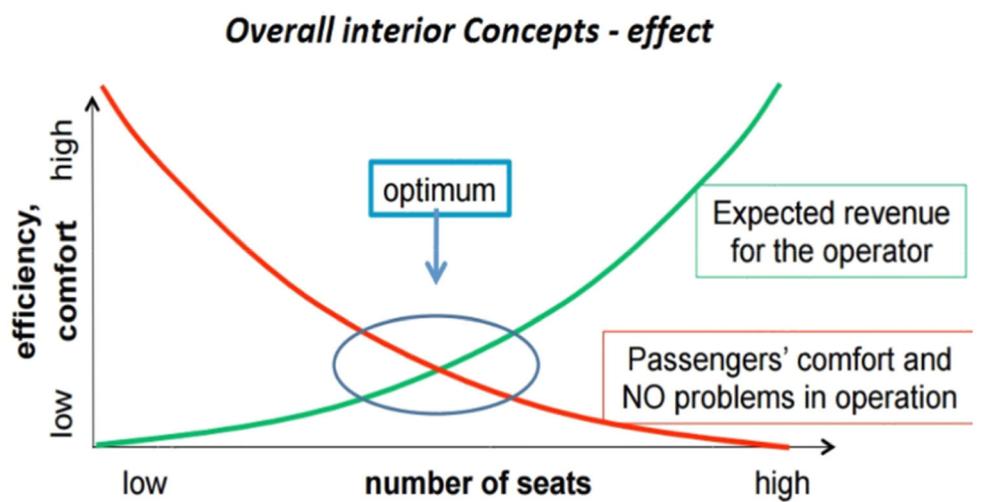


Fig. 3 Efficiency versus number of seats in HS train interior design [23, 24]



could be stolen by other passengers during the train's arrival at the station).

2.1 Types of Luggage and Baggage

Before solving the storage problem, the size of luggage must first be addressed. There is no standard size for luggage, and dimensions differ for different manufacturing companies. However, public transport cannot allow passengers to carry an unlimited number of bags due to space constraints (especially rail and air travel). Therefore, train companies must limit the size and number of the luggage items permitted onboard per person.

As shown in Fig. 6, luggage can be divided into three size categories: cabin (54 cm x 37 cm x 20 cm), medium (67 cm x 45 cm x 28 cm) and large (78 cm x 50 cm x 32 cm). The three luggage sizes are generally accepted by different modes of public transport. For example, according to aircraft luggage policy, passengers can store cabin-size luggage in the cabin area. The other two sizes cannot be stored in the cabin (must be stored in other sections of the aircraft). The luggage storage situation on trains is similar. Cabin-size bags can be stored on the hand luggage rack, and the other two luggage sizes need to be stored in the luggage storage area.

Figure 7 shows the maximum dimensions of medium-sized suitcases. The middle diagram presents a visual

comparison of the different sizes. The bold blue rectangle represents the dimensions of UIC (Union Internationale des Chemins de fer) Leaflet 562. The slightly larger light blue rectangle represents the medium suitcase. The dimensions of the large suitcase are shown by the green rectangle. The largest rectangle is for the upright trolley (the red rectangle). The problem is that the UIC code, which is used for dimensioning the baggage racks, now specifies baggage dimensions that are too small. As a result, the dimensions of baggage racks in today's trains are insufficient.

Backpacks or rucksacks are available in different sizes suitable for different activities or travel. Backpack capacity is measured in litres, and according to the Mountain Warehouse guide [16], backpacks can be divided into four types:

- Mini and small backpacks
Capacity: 6, 8 and 10 litres
Feature: sports, days out
- Daypacks
Capacity: 10–30 litres
Feature: outdoor activities, hiking and expeditions
- Medium backpacks
Capacity: 35–50 litres
Feature: camping for 3–4 Days
- Large rucksacks (Fig. 8)
Capacity: greater than 65 litres
Feature: camping for 1 week

Willingness to lift baggage

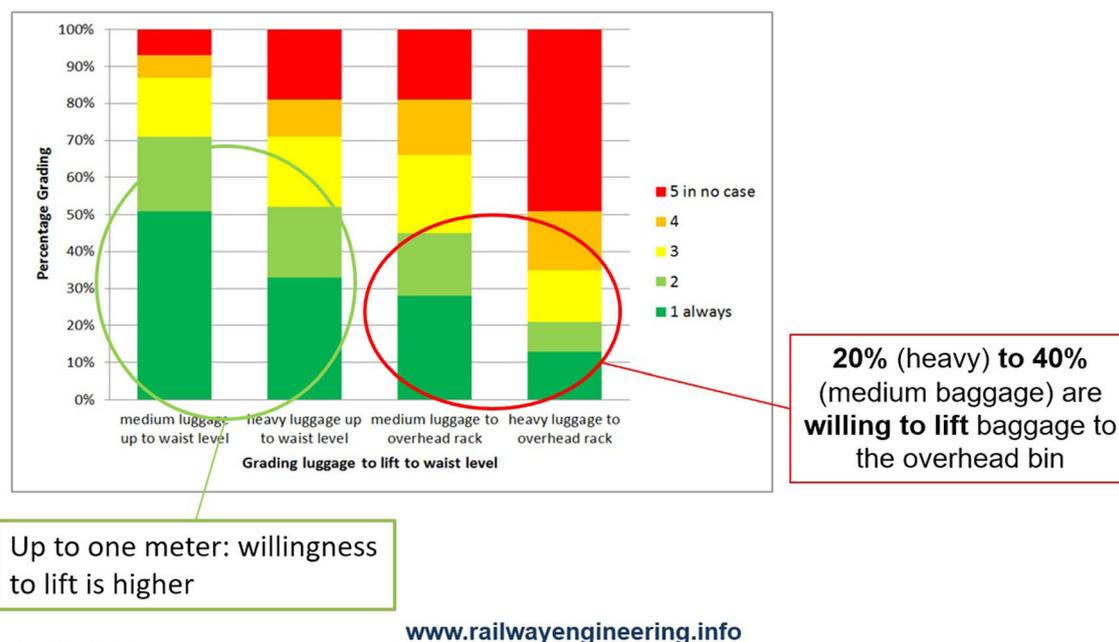


Fig. 4 How do passengers feel about lifting luggage? [23, 24]

Fig. 5 Do people want to be able to view their luggage whilst in transit? [23, 24]

Importance of visual contact

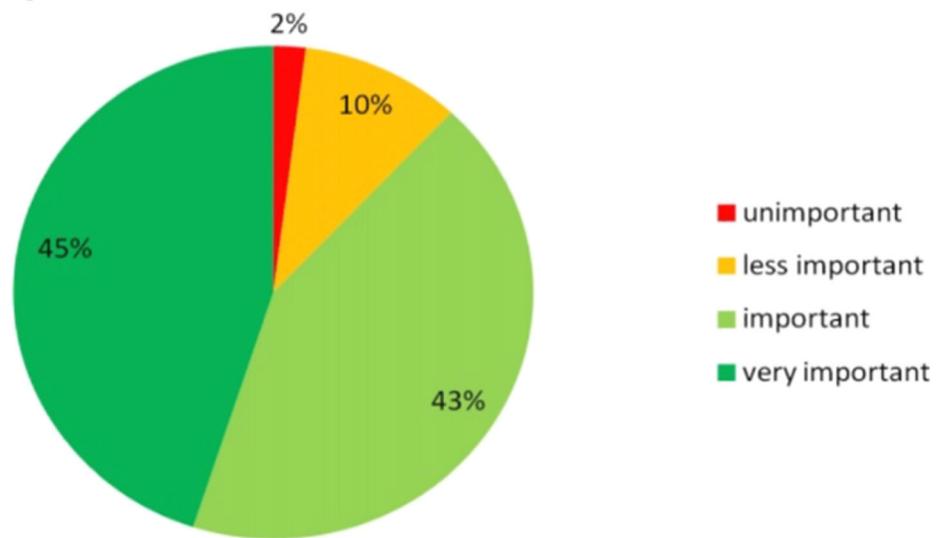
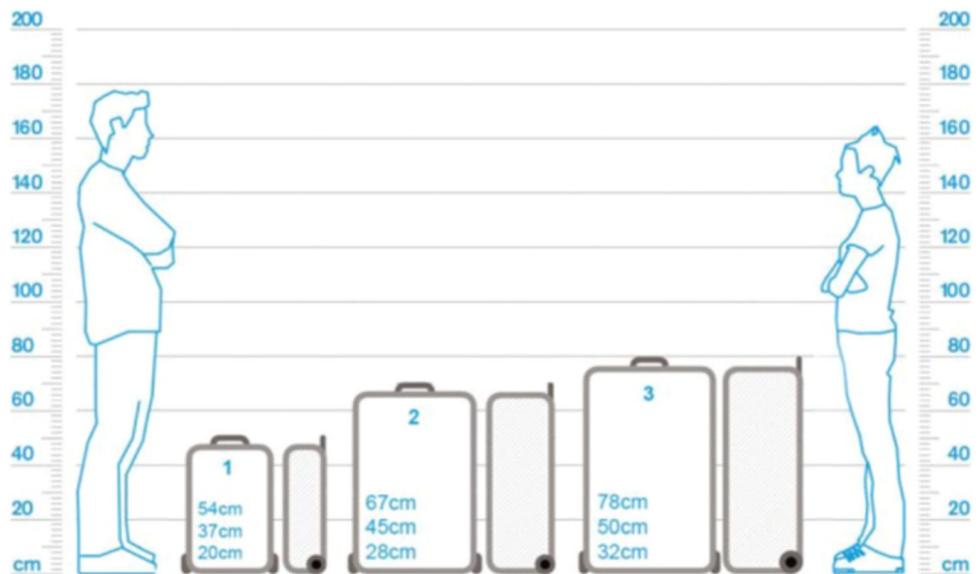


Fig. 6 Average suitcase sizes (Quality Suitcases and Travel Bags) [17]



2.2 Interior Design of Passenger Trains

The interior design of passenger trains and issues with baggage handling were studied by Kelly and Marinov [7] and Toal and Marinov [30]. Figures 9, 10 and 11 show the interior structure of different passenger train units. As can clearly be seen, storage space for passenger luggage is located near entrances, as this was thought to allow passengers to store luggage more conveniently during train travel. The storage area is quite small considering the number of passengers a train can carry. Consider this:

On average: in a normal situation, we assume that the transport unit is at full passenger capacity and every third

passenger carries one large suitcase. Take class 800/801 as a data example, there are 88 standard seats in a unit, we assume that the transport unit is at full passenger capacity and every third passenger carries one large suitcase, therefore, the luggage volume is calculated for 30 people carrying luggage. Calculation (suitcase volume for 30 passengers)

Take class 800/801 as a data example (Fig. 10)

Passenger capacity of standard class unit: 88

Large suitcase: 78 cm × 50 cm × 32 cm

$$V_{largesuitcase} = 0.78 \times 0.50 \times 0.32 = 0.1248 \text{ m}^3$$

Fig. 7 Dimensions of luggage [22]

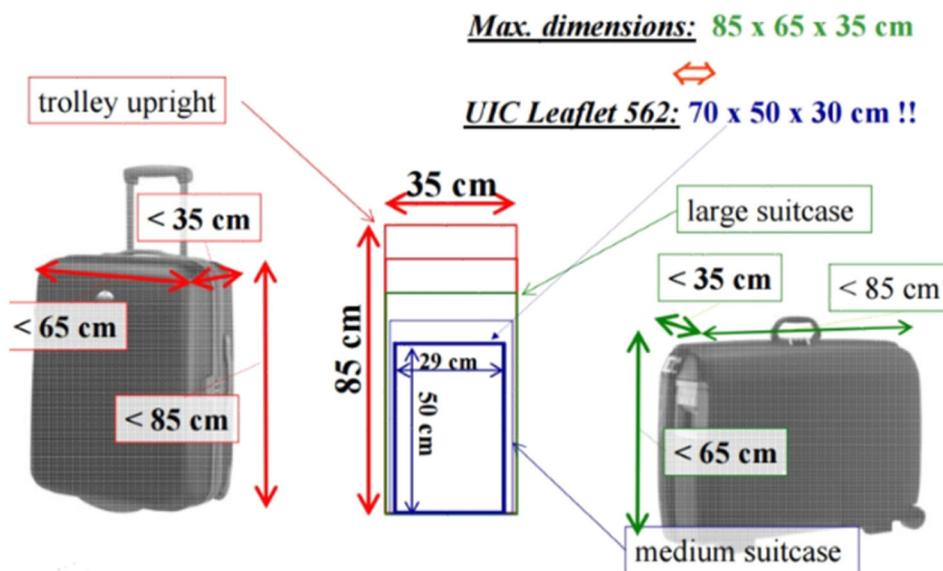


Fig. 8 Dimensions of large rucksack luggage [23, 24]

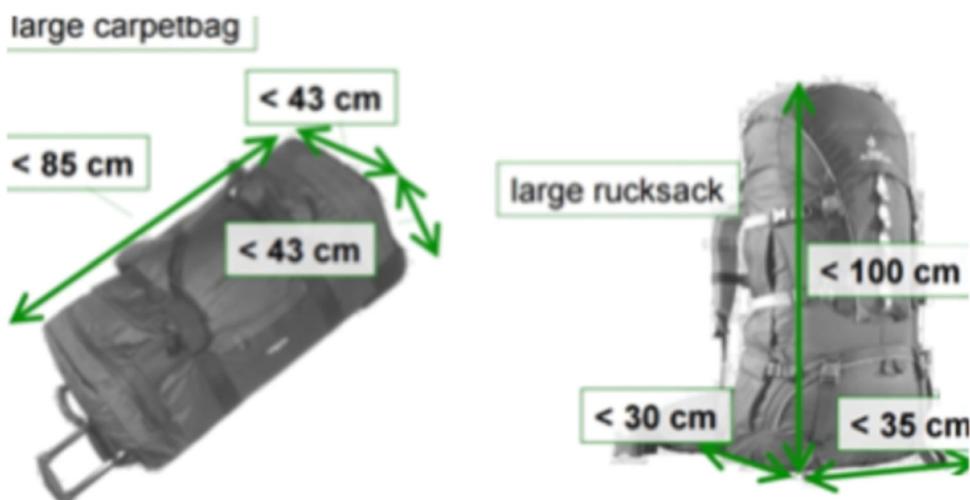
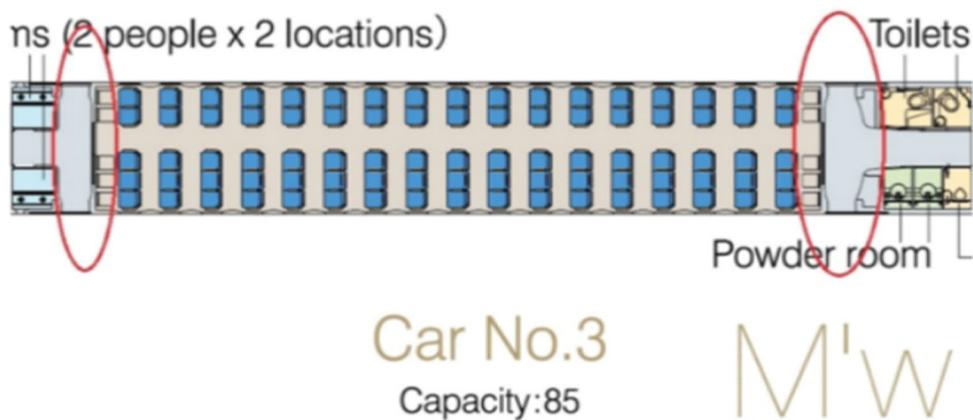


Fig. 9 Seating plans of series N700 [6]



Volume for storing 30 pieces of passenger luggage:
 $V = 30 \times V_{largesuitcase} = 30 \times 0.1248 = 3.7 \text{ m}^3$

Therefore, 3.7 m³ of excess storage volume must be provided by railway operators. Passengers need to place

Parameter Specification		
Vehicle type for UK	Class 800 (dual-mode train), Class 801 (electric train)	Trainset: 5 vehicles (DPTS + MS + MS + MC + DPTF); 9 vehicles (DPTS + MS + MS + TS + MS + TS + MC + MF + DPTF).
No. of seats: 5-vehicle configuration: 45 first class, 270 standard class; 9-vehicle configuration: 101 first class, 526 standard class.		

Fig. 10 Seating plan of Class 800/801

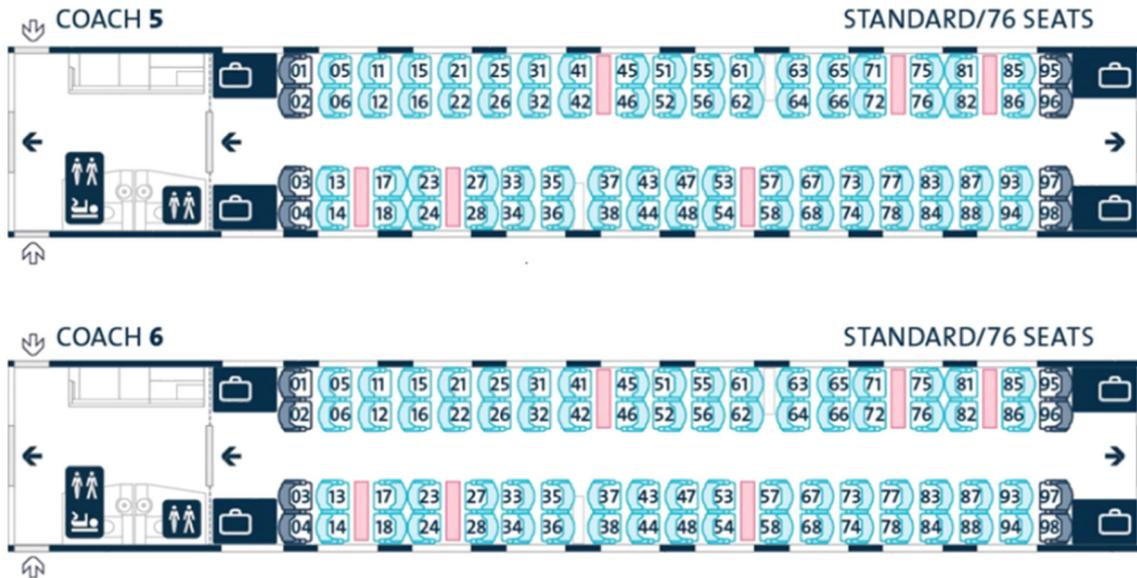


Fig. 11 Seating plan of Eurostar e320 (Eurostar4Agents [3])

luggage near the entrances so that it does not disturb other passengers walking along the carriage. The calculation of total volume for baggage is common practice in the industry, but in reality it is highly problematic. Luggage is three-dimensional and not just one volume. If all the areas, some of them small, that could in principle be used for baggage are added, the result appears to be a large capacity for accommodating baggage. In practice, only half or a third of the luggage can often be stowed.

Due to the limited storage space for luggage on high-speed trains, the size and number of bags that each passenger can carry is restricted. For the general case, two large suitcases or rucksacks and one cabin-size item for each passenger can be on board a high-speed train, though a few railway companies allow only one large suitcase for each passenger. However, luggage racks close to the boarding area are not popular with passengers, as there is little to no line of sight from the seat to the luggage. From an operational point of view, luggage racks near the boarding area are bad, as they cause a backlog after a few

passengers have boarded, and passengers' changeover time is noticeably longer.

2.3 Storage Space on HS Passenger Trains

Three types of storage space are available on HS passenger trains. These are hand luggage racks, large luggage racks and storage underneath passenger seats, as depicted in Figs. 12, 13 and 14, respectively. Figure 15 shows luggage that is improperly stored.

3 Alternative Solutions for the Luggage Storage Problem in HSR

Four solutions are developed and proposed for solving the luggage storage problem in HSR.

1. Modification of passenger unit
2. Double-deck design of passenger unit

3. Operating an additional train to transport passengers' luggage
4. Repositioning of passengers' seats.

3.1 Modification of passenger unit

To increase the luggage storage space, the front or rear units can be modified for luggage storage. Passenger seats are removed in order to provide extra space that allows for installation of luggage racks for storage of large suitcases.

A Hitachi Class 800/801 interior design original technical drawing is shown in Figs. 16 and 17, where the DPTS unit is designed to hold 56 standard class seats. To increase the luggage storage space, all 56 standard seats can be removed and modified to create luggage storage space, and large luggage and hand luggage racks can be installed. The space should be adequate for passengers to store the luggage when racks are full in other units. Hong Kong Airport Express is one of the first railways to implement this new concept. One of the units is designed for luggage storage for onboard check-in service.

The idea is to work with old-model rolling stock in which it may not be necessary to remove the passenger seats; the electric multiple unit (EMU) technology is not as mature in older models. The rolling stock was used with the electric locomotive acting as the front or rear unit, meaning the locomotive could couple with passenger units. The locomotive might have free space that allows for luggage storage.

The British Rail Class 91 is an example of one success. Class 91 is powered by an electric locomotive that can push or pull the train. However, when required, the locomotive can uncouple and move to another end of the passenger unit. The design for a driving van trailer (DVT) allows



Fig. 12 Dimensions of hand luggage rack (TravelChinaGuide.com [31])



Fig. 13 Dimensions of large luggage rack [34]

drivers to operate the train without moving the locomotive. The DVT is only an extra unit for driver control on the train at the other end. Therefore, an empty space can be provided for storing passengers' belongings. Figure 18 shows a photo of the interior of a DVT MK4.

3.2 Double-Deck Design of Passenger Unit

Another solution for increasing storage capacity is the use of a double-deck design. The lower deck can be used for luggage storage to avoid passengers having to lift large suitcases to the upper deck. Therefore, the upper deck would maximise passenger seat numbers without concerns for luggage storage. Figure 19 shows the concept of the double-deck train.

SNCF TGV Duplex is the first double-deck high-speed train design. The aim of the double-deck design is to increase passenger capacity by 20 to 40% when compared with single-deck rolling stock. Taking the SNCF TGV Duplex seat plan as an example, the concept of luggage storage on the lower deck is illustrated in Fig. 20.

The original seating plan shows that both decks contain seats for passengers. With the double-deck design, more space is available for storing luggage (shown by the plans). In order to free more luggage storage space for passengers, the lower deck could be reconfigured with fewer passenger seats.

3.3 Operating an Additional Train for Transporting Passengers' Luggage

In addition to interior design modifications to provide more space for passenger luggage, new services for baggage handling can be set up [15, 1, 19, 20, 35, 36], and a specific train unit could be operated for transporting passenger luggage instead of carrying the luggage onboard the same

Fig. 14 Dimensions of a passenger seat [37]

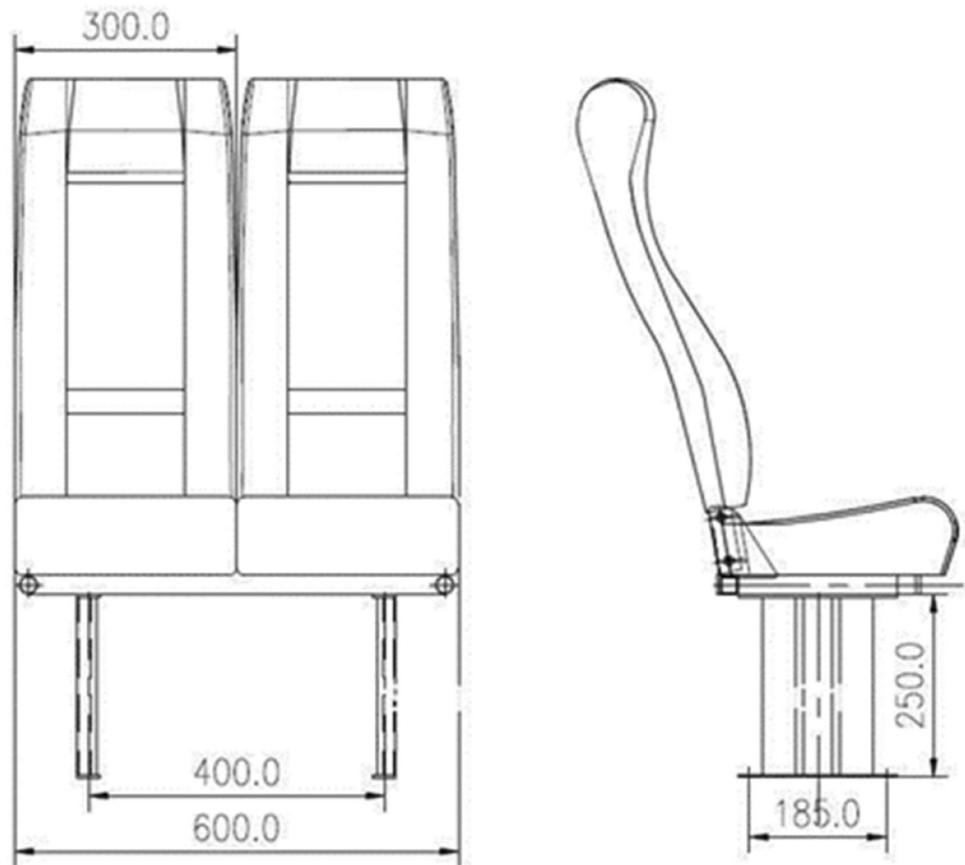


Fig. 15 Photo of blocked rail entrance [22]

train. The concept and procedure for transporting luggage by a separate train unit could include the steps below:

1. Passengers can check the large luggage when they arrive at the station.
2. Passengers will be able to board the train without carrying the large luggage.
3. The check-in sends the luggage to the transporting rolling stock (on every third train) and waits for the

next passenger to check in luggage, which is transported to the same destination.

4. Passengers arrive at the destination without having to carry any large luggage.
5. The luggage-transporting rolling stock arrives at the station after a certain period of time.
6. Passengers can collect the luggage immediately after the luggage arrives or it can be stored at the station (after a period of time) for collection. Delivery methods could be implemented by the railway companies for sending the luggage to specific locations such as hotels.

3.4 Repositioning of Passengers' Seats

Rüger [23, 24] explored ways to redesign the position of passenger seats to allow enough space for storing large luggage. He suggests that the space between two opposite passenger seats is too small for storing large luggage. The only space that could store cabin-size luggage is the space between two opposite passenger seats, which can store three large carpetbags or two upright trolleys (Fig. 21).

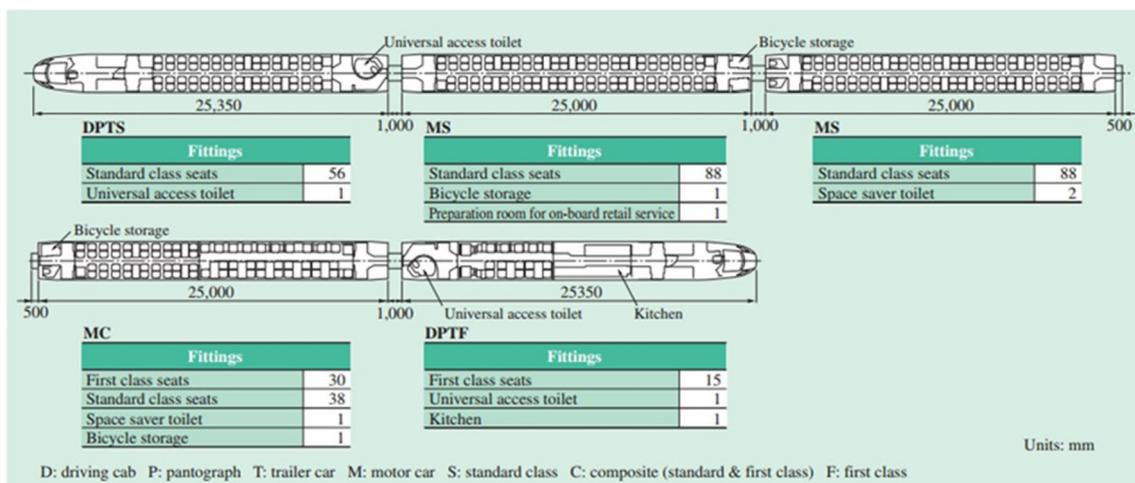


Fig. 16 Engineering drawing of class 800/801 [21]

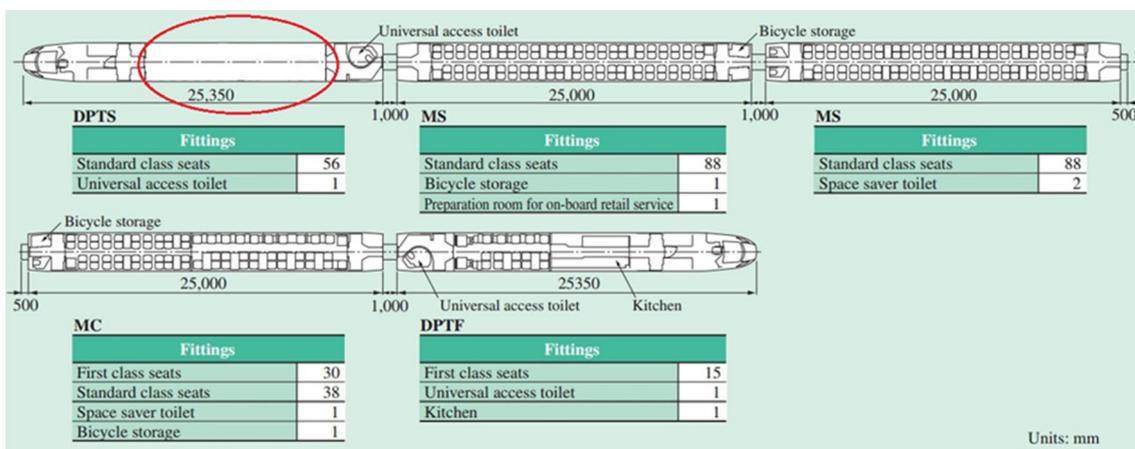


Fig. 17 Modified engineering drawing of class 800/801 [21]

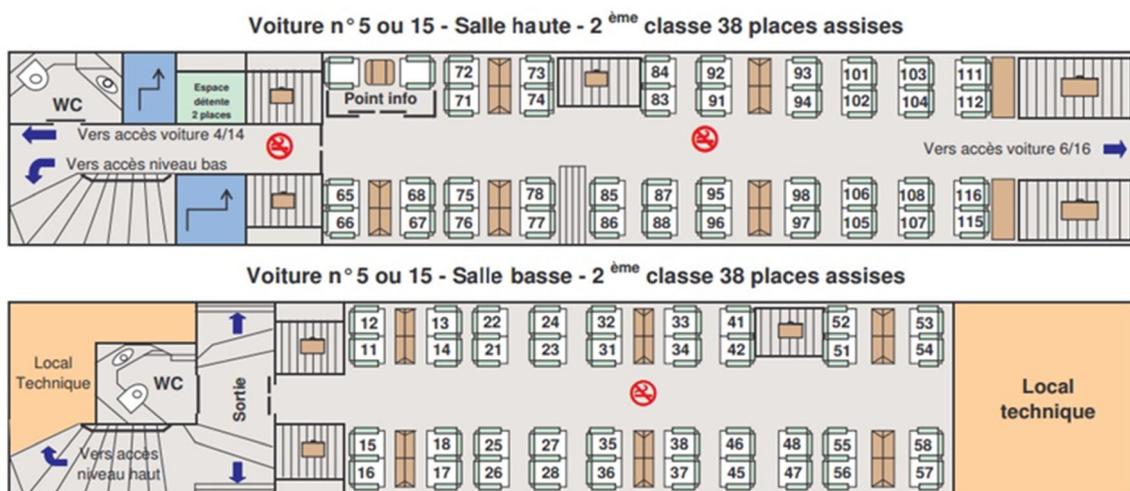


Fig. 18 Class 82 (MK4) interior—Cycle and additional luggage storage leading to guard compartment (82211—East Coast) [4]

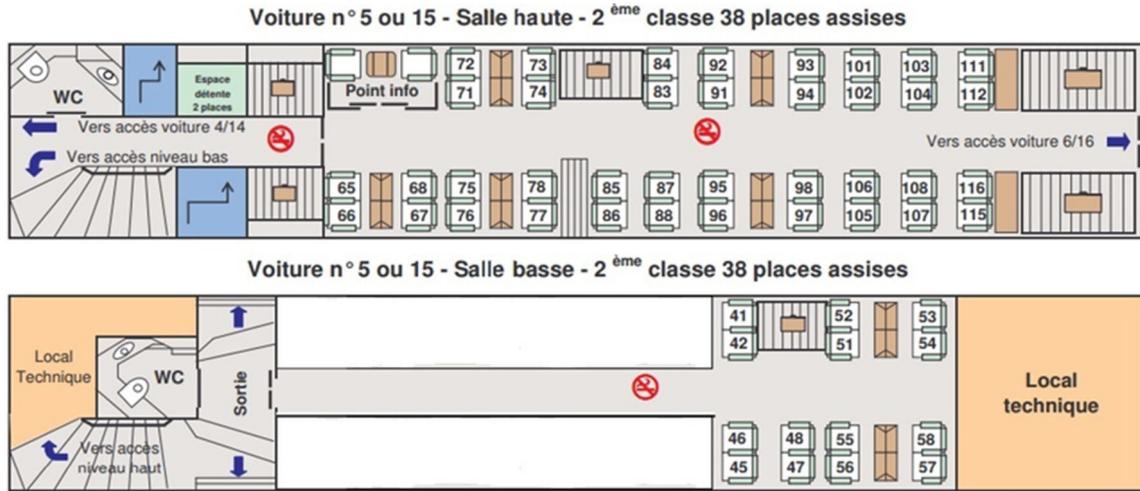
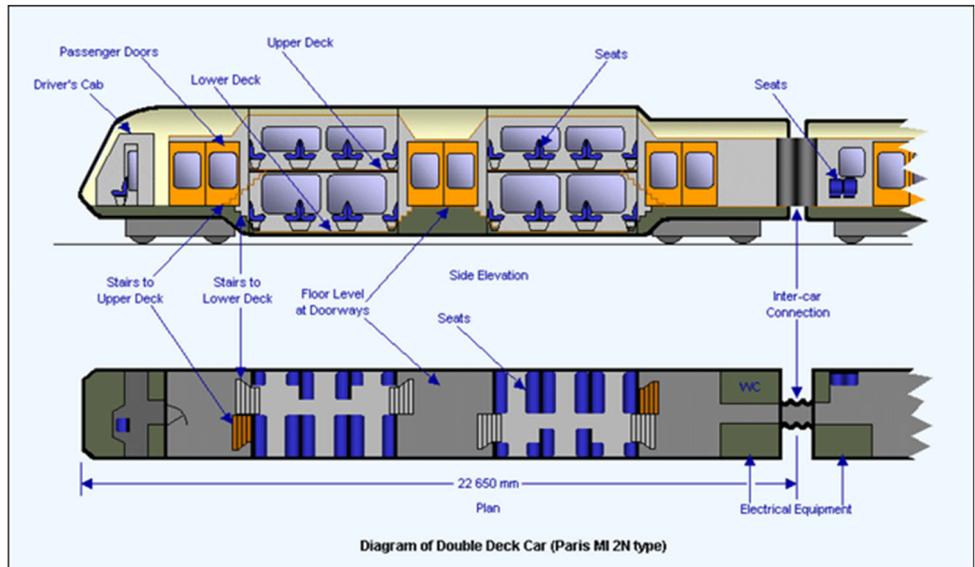


Fig. 19 Concept of double-deck passenger trains (Railway Technical Website) [18]

Fig. 20 Seating plan of TGV duplex [26]



3.5 Optimised Luggage Racks and Efficient Interior Layout

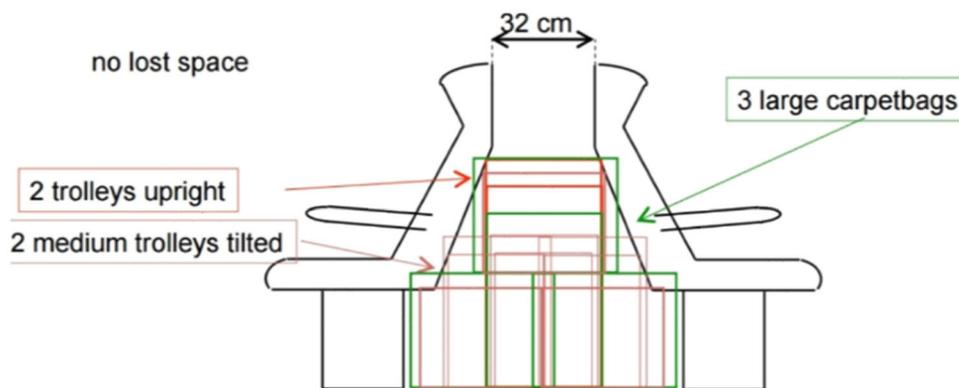
In general, the majority of passengers still prefer to have their luggage with them on the train. In this respect, the best possible use of space should not reduce the number of possible seats, but at the same time should create sufficient luggage racks to meet the requirements. One of the essential factors (as already mentioned) is that passengers do not want to lift their luggage too high (a maximum of about one meter is acceptable) and want to maintain visual contact with their luggage.

The space between the seats as described above can be used even more efficiently with luggage racks, as this allows luggage to be stored on several levels. With the same amount of space required between the seats, luggage

can be stored on up to four levels, thus creating a more efficient use of space. The compartment at floor level is more suitable for large upright trolleys; the lower two compartments above that are for horizontal and medium trolleys and travel bags, and the top compartment is for travel bags only. Passengers are also more likely to want to store luggage in these compartments if they are close by (so they can always keep an eye on their belongings).

To make luggage racks efficient, it is important to consider the exact dimensions of luggage items. On current trains, the luggage racks are often smaller by a few centimeters, making them very inefficient. This is illustrated in Figs. 22 and 23. Currently, large trolleys with wheels have a height of about 80 cm; however, racks are not yet built to these dimensions, so the lowest compartment cannot be

Fig. 21 Luggage capacity between two seats [23, 24]



used for upright trolleys (despite the popularity of this type of storage).

Conversely, the top two compartments are often larger than necessary, and thus inefficient, because empty space is left. Since the luggage racks always follow existing seat dividers, the problem remains that luggage racks are just narrower by a few centimeters. Approximately ten centimeters greater width, and a different division of the heights would allow a much more efficient use of luggage storage.

Figure 23 illustrates how to solve the problem of luggage racks by adjusting the space between seat dividers. If the rack is first planned and fitted according to the appropriate dimensions and the seats are then added, the available space can be used much more efficiently.

In addition, train operators need to make sure that the luggage racks onboard are evenly distributed. This would

allow good visual contact for most passengers and also help to speed up passenger changeover (Figs. 24, 25).

4 Evaluation

To qualitatively evaluate the four solutions as discussed, four aspects are considered, namely passengers, railway operator, cost and passenger comfort level.

4.1 Solution 1: Modification of Passenger Unit

4.1.1 Passengers

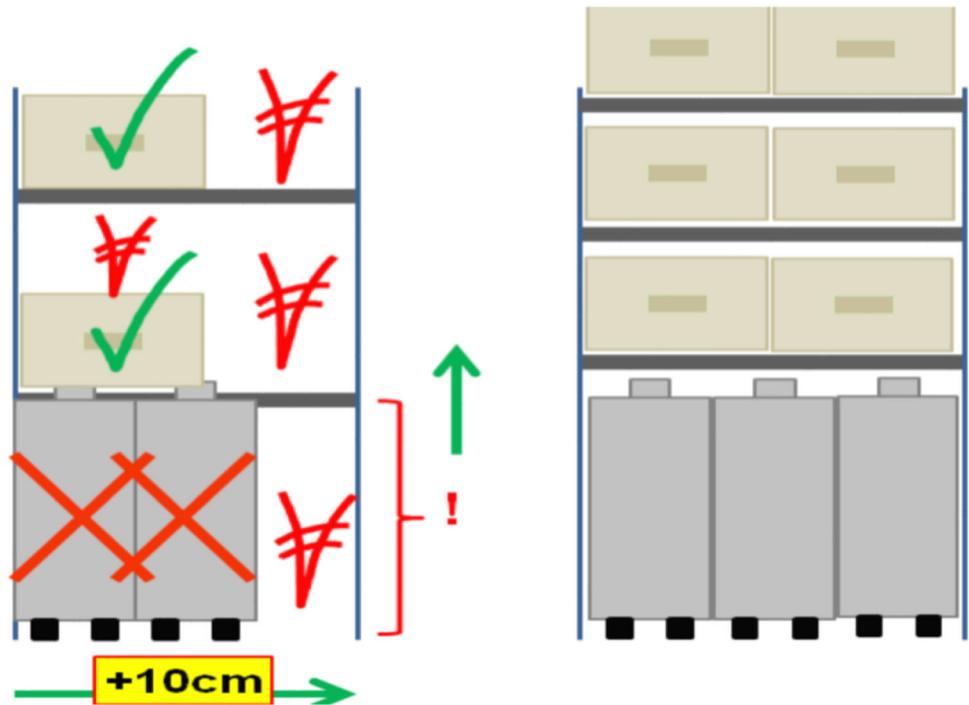
Passengers who sit near the luggage unit may be disturbed by other passengers moving luggage in and out of the unit. This situation is assuming that the unit is passenger-accessible. If the unit does not allow passengers access to

Fig. 22 Popular way of using the baggage racks [23, 24]

Baggage racks – passenger behaviour



Fig. 23 Inefficient (left) and efficient (right) baggage rack [23, 24]

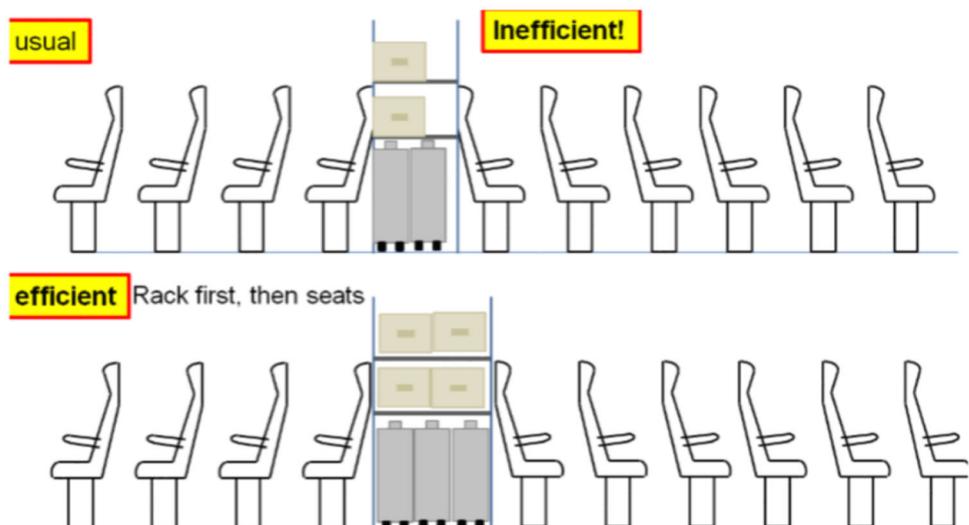


luggage storage, a check-in procedure for passengers should be introduced. Therefore, passengers may need to spend time checking in luggage. The check-in service might not be suitable for passengers who travel short journeys. If the luggage storage unit is placed at the middle of the rolling stock, passengers may not be able to move through carriages and access the restaurant bar. Passengers may have concerns about luggage security if the unit is passenger-accessible.

4.1.2 Railway Operator

If railway companies modify the passenger unit for luggage storage, the revenue of railway operators may decrease. To modify the passenger unit, passenger seats may need to be removed and luggage storage facilities installed for the luggage rack or cycle storage. Also, as the number of passengers decreases, the railway company would lose revenue through the modification of the passenger unit.

Fig. 24 Inefficient (top) and efficient (bottom) baggage rack [23, 24]



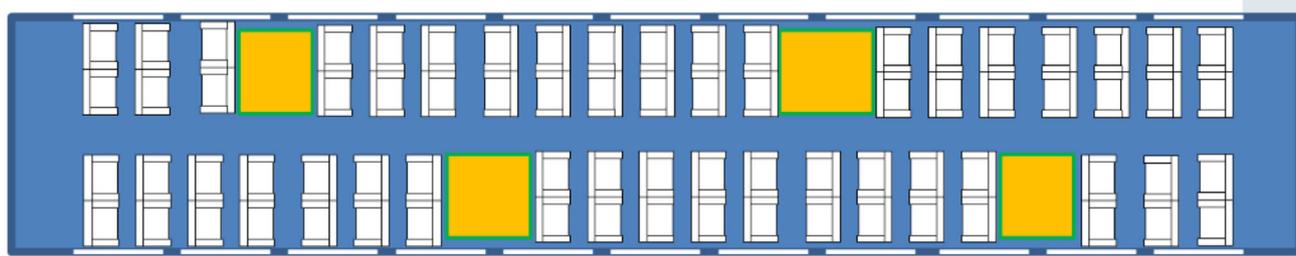


Fig. 25 Reasonable division of the luggage racks in the wagon [23, 24]

4.1.3 Cost

The cost for both the railway operator and passenger would be greater if the passenger unit were converted to luggage storage units. The railway operator would incur the cost to modify the unit, subsequently shifting that cost to the passenger through increased prices (and the number of passengers would decrease as well). Also, an additional cost is added by implementing a check-in service (if the storage unit is inaccessible to passengers).

4.1.4 Comfort Level of Passengers

Passengers may be more comfortable if the luggage is stored in carriage units. It would also mean that the corridor and the entrance are less likely to be blocked by luggage. There would also be no need for passengers to keep luggage on seats.

4.2 Solution 2: Double-Deck Design of Passenger Unit

4.2.1 Passengers

The double-deck design could be more convenient for passengers, as the luggage could be stored in the same unit as where the passenger is sitting, unlike the solution of modifying the passenger unit. However, the upper-deck passengers may have luggage security concerns due to the lack of visual contact with their luggage. The queuing time for storing and collecting luggage may also be longer if luggage is stored on the lower deck.

4.2.2 Railway Operator

The aim of the double deck is to increase the passenger capacity of rolling stock. However, the space is now used for luggage storage, not improving passenger capacity. Also, rail infrastructure would need to be modified if operators were using the double-deck design. The standard height of tunnels and other equipment would need to be

redesigned due to the dimensions of the double-deck compared to a single-deck rolling stock.

4.2.3 Cost

The cost for both the railway operator and passenger is greater if modification of the passenger unit is chosen. This is because the railway company would need to reduce the number of seats to free extra space for luggage storage. The railway company would also need to invest capital into modifying other infrastructure for the double-deck rolling stock.

4.2.4 Comfort Level of Passengers

Passengers would also have to be comfortable with storing luggage in a lower-deck storage space. Therefore, upper-deck passengers would not have to lift and store the luggage on the top deck. This would mean no more luggage blocking the corridors and entrances (allowing passengers to access other units more easily).

4.3 Solution 3: Operating an Additional Train for Transporting Passengers' Luggage

4.3.1 Passengers

The luggage transport rolling stock could provide passengers a stress-free ride without worrying about luggage. However, passengers may need to arrive at the station earlier than usual for the check-in service. The check-in service may not be suitable for short-journey passengers, but could be an advantage for families travelling by train. Parents could take care of their children without having to move and watch their large luggage. Additionally, businesspersons or tourists might like to use the service because luggage can be stored at the station or delivered to a specific location (e.g. a hotel).

4.3.2 *Railway Operator*

The railway company would need to implement a new rolling stock for luggage transport. The rolling stock would also need to be modified to contain luggage racks or cycle storage. The number of units per train should be the same as passenger units. The rolling stock is not only for transporting luggage but also to help other companies move items such as food and low-density goods. This way, new business arrangements could be created for the railway companies to earn more profit. The timetable would also need to be amended by launching an additional train between the normal service. The luggage should arrive at the station as soon as possible. As this service is for long-journey passengers, the train should be non-stop to the destination.

Two railway companies, SNCF in France and Gatwick Express in the United Kingdom, are now providing similar services. SNCF and Gatwick both require passengers to book the service a few days in advance. Also, SNCF can collect the luggage at specific locations such as from home, at work and from hotels. Therefore, passengers do not need to carry their luggage to the station, which is more convenient for them when making travel arrangements. Luggage delivery provided by Gatwick Express is similar to that for SNCF in France. However, Gatwick Express transports the luggage using vehicles rather than trains. Therefore, the delivery can potentially be delayed during rush hour.

4.3.3 *Cost*

The operating costs would increase by implementing an extra service for transporting luggage. However, the railway company could earn additional profit by helping other companies transport products. The operating cost may be offset by the additional revenue from helping other businesses. The operating costs would not increase significantly by adding an extra service for transporting luggage. The major cost of the service would be the check-in procedure and the luggage delivery. The railway would possibly need to employ more staff to handle luggage check-ins and employ workers to manage the luggage deliveries, which is a good thing. The service might be considered “free of charge to the passengers”, but passengers should be charged if they do not collect their luggage immediately (or after a certain time period of time). A charge price should also be introduced for locker storage services at the station in case such a service exists.

The energy cost as a percentage of total expense would increase to about 6.86%, which means the operating costs would not increase significantly by adding an extra service for transporting luggage. The major cost of the service

would be the check-in procedure and the luggage delivery. The railway would need to employ more staff to handle luggage check-ins and employ workers to manage the luggage deliveries.

Therefore, the service might be free of charge to the passengers, but passengers should be charged if they do not collect their luggage immediately (or after a certain time period). A charge price should also be introduced for locker storage services at the station.

4.3.4 *Comfort Level of Passengers*

Passengers should feel more comfortable without having to carry their luggage when boarding and leaving the train. The luggage could also be sent by delivery to a specific location. However, passengers may need to allow extra time for check-in procedures, and would therefore need to arrive at the station early.

The problem with this solution, however, is that passengers would not check their baggage immediately before their journey and collect it immediately after their arrival, as is the case in air travel, but may have to wait for the arrival of the next train carrying the luggage. This is not attractive for most passengers. However, it is expected that this option would be preferred for passengers on holiday trips with a great deal of luggage and by families with children, as holiday travellers are less time-sensitive and may also be willing to return to the station to pick up their luggage after arriving at their holiday destination and finding their hotel. In many other cases, it may be better to offer door-to-door delivery, where luggage is collected at the home and delivered to the holiday destination. However, these services should also include the additional option of dropping off luggage at partner shops or automatic terminals, or even at the train station, if travellers do not have the time to wait several hours at home for baggage drop-off or delivery service.

4.4 **Solution 4: Repositioning of Passenger Seats and Baggage Racks**

4.4.1 *Passengers*

Passengers still need to carry the luggage on board and store it in the areas provided by the railway company. But more space would be available in the gap between two opposite passenger seats. However, the space is not guaranteed to accommodate all passengers' luggage. Passengers would again need to place their luggage at the entrance or even in corridors during the travel season. Alternatively, well-designed luggage racks could offer an efficient way of storing luggage as desired by travellers, and not block the corridors and entrances.

4.4.2 Railway Operator

The railway company would need to spend time modifying the seats. As the gap between seats will be larger than before, the number of seats should decrease while the length of unit carriages remains unchanged. Railway companies typically try to maximise the number of seats in order to earn the largest profit. The introduction of greater seat spacing and the installation of well-designed luggage racks is particularly suitable for new vehicles when it comes to redesign, as the size of the luggage compartments can be easily adapted to meet the required frame conditions in terms of luggage size.

4.4.3 Cost

Repositioning the passenger seats would increase the operational costs.

4.4.4 Comfort Level of Passengers

Passengers may still experience the same issues as before, because the luggage storage space is still not sufficient. Luggage might need to be placed under passengers' seats or by their feet.

5 Results

An additional train for transporting passengers' luggage may be the best solution when compared with other options. The solution could satisfy both passengers and railway operators. The trains for transporting passengers' luggage would be able to handle a large volume of luggage without affecting other passengers. Also, no passenger seats would need to be removed or modified. Passengers would not need to worry about the luggage storage during their journeys on HS trains, which should be more convenient. Operational cost is the major concern of railway companies; however, the solution could minimise operational costs by offering the railway company extra capacity to further transport some low-density high-value goods if passengers' luggage does not fill up the whole train. Alternatively, since passengers often like to have their luggage with them, passengers could take their luggage with them and use the well-designed luggage racks onboard the train. These can be found between the seats and at the end of the carriages. Luggage racks must be well thought out in terms of dimensions so that they meet customer requirements and provide sufficient accommodation for baggage.

6 Conclusions

To conclude, this paper has discussed the problem of handling and storing passengers' luggage on HS trains. Four solutions were briefly introduced and qualitatively analysed, ultimately leading to the one that would have the greatest impact upon passengers and that the railway companies would most likely consider.

The solution of additional trains for transporting luggage may decrease the level of inconvenience for HSR passengers by increasing luggage storage capacity. Operational costs would be high for an additional train to transport passenger luggage. However, this additional cost could be greatly reduced if the railway company agreed to do business with other companies delivering products and goods to other locations. Compared to the other solutions, it would be more expensive for passenger seats to be removed to free more space for luggage storage.

As for further research, a quantitative study should be conducted to build upon the conclusions proposed and underpin the analysis with statistical data.

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