Attractive and Efficient Train Interiors

Karl Kottenhoff & Evert Andersson - Royal Institute of Technology,
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Gröna Tåget

Trains for tomorrow´s travellers

AUTHORS
Karl Kottenhoff, kotten@infra.kth.se
Evert Andersson, everta@kth.se

COMMUNICATION & GRAPHIC DESIGN
Daniel Eriksson, daniel.eriksson@transformator.net
Martin Ranvinge, mail@martinranvinge.com

PHOTO
Oskar Fröidh, p 5, Kasper Dudzik, SJ, p 25
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This book is meant to be an inspiring source of knowledge and recommendations for the railway industry. Train developing projects are managed under major time pressure and there is a need of fast decisions based on facts.

From scientific research and extensive experiences in the field of train development, KTH pinpoint facts and illustrate conclusions on how to create attractive trains from the travellers' perspective. The travellers' point of view is essential, but sometimes hard to define and easily comes second-hand.

Here we present easily accessible research results and show how cost effective and attractive interior solutions can be integrated in the developing process of trains.

Definitions used in this book

Konstfack The University Collage of Arts Crafts and Design in Stockholm, Sweden

Long-haul trains and long-haul services Travelling time of more than 1.5 hours. Many passengers stay somewhere overnight while they are away.

Regional trains and regional services Maximum travelling time of 1.5 hours. Most passengers make a round trip without an overnight stay.

On regional trains, most passengers bring relatively little luggage and the need for food and drink services is small. On long-haul trains, these needs are significantly greater.

TSI Technical Specifications for Interoperability

Contents

Travellers' choice

Modern passenger services by train can have a great impact for ordinary people, trade and industry as well as regional development.

People can make journeys over the course of a day to work and on business on fast, modern trains. Over medium-range distances trains can be faster than all other travel modes. Travelling time in comfortable trains can also be utilised better than in cars or on buses or planes.

There are also ethical aspects to environment-friendliness and these should be considered when developing modern trains. From society's point of view, it is important that every train can accommodate many travellers so that the railway network's capacity can be fully utilised.

It is possible to get more people to choose the train if the fare is low and the journey standard meets the expectations.

The most important factors in order to get people to choose the train over other travel modes are:

- Low fare (for people paying out of their own pocket)
- Short travelling time
- High frequency (people can travel when they want)

The following factors are also of great importance:

- Punctuality – the train keeps to timetable
- No changes or few changes with good connections
- Good accessibility to the station
- High comfort and functionality
- Good on-board service and information
- That the train is perceived as an environment-friendly alternative to other means of transport.

Attractiveness and costs

Sometimes attractiveness for passengers increase costs. Higher cost must be matched against passengers' willingness to pay.

It is a challenge to operate train services profitably. This is especially true as regards regional train services. Regional transport is usually subject to pronounced peaks in morning and afternoon passenger services. Trains and staff are then generally not utilised satisfactorily on the average.

On train services over longer distances it is easier to achieve higher and more uniform utilisation on the trains and thereby reduce the average cost per passenger.

Many of the conclusions and recommendations in this book are based on research conducted over a period of many years, in particular at KTH. We have tried to establish passengers' behaviour and preferences. We have measured their willingness to pay for a higher standard in various aspects. We have set passengers' willingness to pay against the costs. However, sometimes a higher standard does not cost anything, as long as everything is done correctly from the beginning

This book deals with how to design the passenger environment on trains to be able to maintain a high level of comfort and good functionality for different kinds of passengers, while at the same time taking the cost aspect into consideration. The book also deals in part with how trains environmental load can be further reduced, A reduced environmental load often goes hand-in-hand with greater efficiency and lower costs.

Comfortable, competitive and environment friendly

For more people to choose to travel by train, they want speed, simplicity, comfort and quality at a low price. The choice of vehicle concept is very important in this respect.

Trains are often perceived as spacious and comfortable compared to buses and planes. Passengers can stretch out their legs, vary their sitting position, go for a walk in the train and perhaps have a cup of coffee or a meal. They can do work using a laptop or read a book or a report. All of this is a competitive advantage for the train that we must endeavour to keep.

This book attempts to describe how this can be accomplished without costs running away. The costs are to a great extent synonymous with the space used for each seat – not just for the seat itself but for all the facilities in the train. If more seats can be installed along the same length on the train, it becomes seat for seat more cost-effective. If the same number of seats can be comfortably installed in fewer cars, the cost per passenger is also reduced.

The environment is also affected

As a rule the environmental load also goes hand in hand with reduced costs, counted per seat and per passenger. This is especially true as regards measures that improve space utilisation on the trains. The trains can be made shorter and lighter. The same number of passengers can travel for less cost and energy consumption.

Electric trains are today considered environmentally friendly compared to other modes of transport and we should endeavour to keep this advantage also in the future.

Low cost is important

It is important to develop more cost-effective rolling stock. A motorised passenger car for long-haul or fast regional services costs some 20 – 30 million SEK (2 - 3 million EUR, 2009) to buy. In addition, both maintenance and train crew cost considerable sums. Trains that run relatively little – with low average utilisation and a low average speed – are quite expensive per passenger. This is especially a risk in regional traffic with high peaks in the morning and afternoon on working days. If the costs can be reduced, both the train operators and society are winners. Lower costs also mean that *train services can increase at unchanged costs.*

“Higher efficiency and lower costs go hand-in-hand with a reduced environmental load”

Over longer distances, costs will as a rule be lower per passenger and kilometer. Both trains and personnel are utilised better since they produce more kilometers in the same time. In this case, it is also easier to achieve a higher and more uniform utilisation of the trains. This reduces the cost per passenger and kilometer. The traffic operator's profitability is in such cases dependent on the competitive situation in this part of the travel market as regards air travel, coaches, cars and competing trains. In a deregulated market with several competing train operators, profitability will probably be highest for the one that can produce an attractive train journey at the lowest cost.

How to increase competitiveness

Competitiveness can be increased through a combination of more cost-effective and more attractive trains.

In this book we describe how strong passengers' "preferences" are. More strictly, we talk about "valuations": the value that the passengers place on different changes and measures – positive or negative. This value is often expressed as a percentage of the fare.

The different types of measures can be placed in a diagram of marginal values and costs. The horizontal axis shows passengers' valuations as a percentage of the fare while the vertical axis shows the percentage increases in the costs. As a rule, new features and some services are profitable, i.e. the increase in cost is lower than the perceived value. Better utilisation of space reduces cost without affecting the value to the customers to any great extent. One example of this is to install space-efficient but nonetheless comfortable seats.

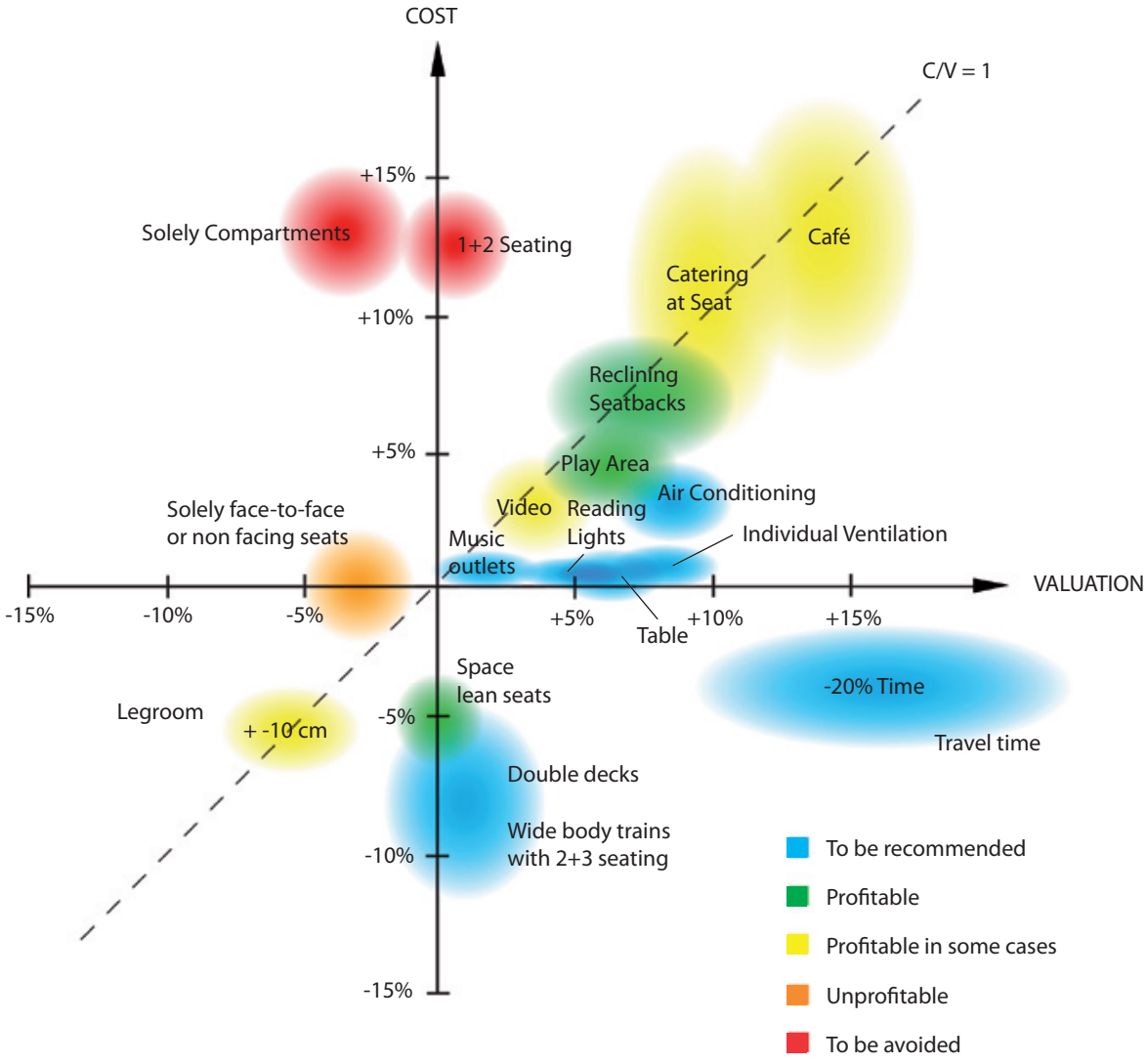
Sometimes costs can be reduced at the same time as passengers' value and willingness to pay increase. An example of this is to reduce travelling time, i.e. increase the average speed. Shorter travel time makes trains and train crew more productive, i.e. produce more for the same cost.

Note that the positions in the figure are not absolute. Firstly, there are uncertainties in the different studies. The valuations differ somewhat in the various sub-markets. Second, the choice of technology may have an impact on costs. This is shown in the diagram by the different sizes of the fields

An interpretation of the diagram gives the focus on:

- Higher speeds – shorter travelling times
- Better space utilisation, e.g. wide-bodied cars or double-decker cars with more seats and space-efficient, comfortable seats
- Comfort-enhancing measures such as good ventilation, softed lighting and functional tables
- Services such as food, children's play areas and socialising areas – that take up just a little additional space.

In this book, we will deal with each of the last three groups of measures in turn. We will also summarize how trains can be adapted for people with reduced mobility.



Passengers' valuations of different characteristics or measures on the horizontal axis and their marginal costs on the vertical axis. All valuations and cost are shown as percentages of the fare and the total operator's cost.

Double decker trains and wide-body trains for reduced costs

Double-decker trains have existed almost since the train was invented. There are good reasons for this solution, that is attracting great interest around the world. Wide-body trains is another alternative that can be used on certain railway networks

Several countries have introduced double-decker cars in local and regional services in recent years and double-decker high-speed trains also exist for long-haul services. Double-decker trains contribute to higher competitiveness through lower cost per seat. As a rule, a double-decker car has 20 – 50% more seats with the same level of comfort as an equivalent single-decker car. The cost per seat kilometre is estimated to be 5-10% lower. The lower figures apply approximately for multiple units (with power units in the same car as the passengers) while the higher figures apply for loco-hauled trains. Short motorised double deck units may be even less efficient. Double decker trains have some advantadges but also some drawbacks.

A cost reduction per seat of the same magnitude (approx 10%) can be achieved by using wider cars. They must then be wide enough to accommodate another seat per row. The illustration below shows a conventional loco-hauled train with three cars and a wide-body multiple unit train with the same number of seats. The latter has roughly the same amount of space for seats despite being significantly shorter. This is partly due to the extra width and partly to the fact that an extra vehicle (locomotive), merely to provide propulsion, is not needed. This is *one* important example of designing trains with good *space utilisation*.

The example below is not always practicable, but it clearly illustrates the principles.

The train operator's costs for running these wider and shorter trains are substantially lower than for conventional trains. Wider trains (approx. 3.3 m as opposed to 2.7 m inside) have room for approx. 25% more seats in each car if the seats are arranged 2+3 across in second class (2+2 in first class). This reduces the cost per seat for investment, maintenance and energy.

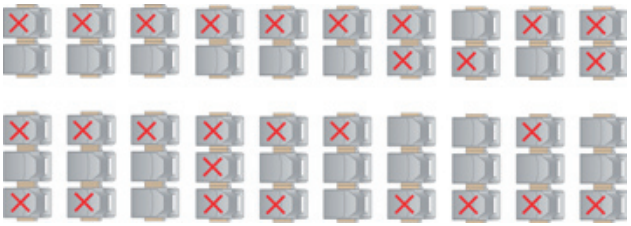
Train with wide carbody gives about 10% lower cost per seat

Loco-hauled train with traditional carbody

2+3 seating - a sometimes questioned solution

The issue of whether three seats abreast on one side is perceived negatively has been the subject of much discussion. We have therefore interviewed passengers in a number of studies and also observed their behaviour – how they choose to sit. Our findings show that the 2+3 layout in second class is appreciated almost as much as the traditional 2+2 arrangement. The difference is small. For the average passenger it makes almost no difference, if properly done. Why is this so?

Firstly, there are groups of passengers who *of their own accord and spontaneously prefer to sit three abreast*. For example two adults and a child, or three teenagers, or three adults travelling together. This was shown in one of our studies where we observed how passengers choose to sit of their own accord.



Example of how passengers spontaneously choose to sit in a car with a 2+3 seat layout.

Secondly, other passengers value three seats abreast positively so long as the seat in the middle is empty. If both aisle seats are empty, most passengers prefer to sit on the side with three seats. An empty adjacent seat is valued positively at approx. 12% of the price of the ticket. In cases where the middle seat is finally occupied (by a stranger) this is valued negatively by the aisle passenger, but at only 5% of the ticket price.

Thirdly, the *"airy" wide interior* seems to be valued positively, even if it is difficult to quantify the value.

In practice, this type of train is not down-valued until it is more than 80-85% full. People have different preferences but on average their willingness to pay to travel in a wide car with a 2+3 layout is only 1-2% lower than for a normal car with a 2+2 layout. This has been found in several studies. This is almost negligible in relation to many other factors that are valued much more highly. The valuation of the middle seat can also be impacted positively with realistic measures (see section on comfortable seats).

In another studie, passengers were asked to choose between two alternatives: 2+3 layout or 2+2 layout.

Most passengers chose the slightly cheaper alternative. Not having to travel in a 2+3 layout was not something they were prepared to pay even 2 SEK (approx. 3 %) for.

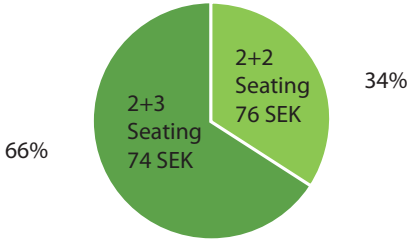
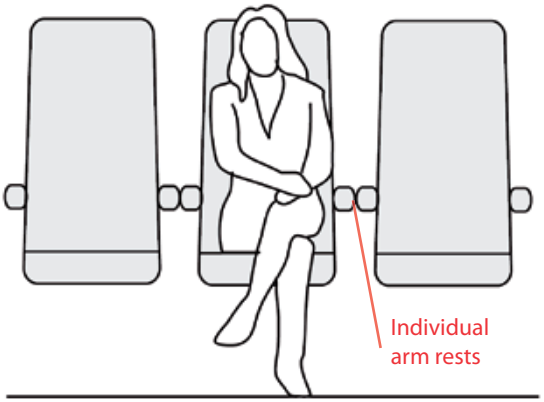


Illustration of passengers' choice. 66 % of passengers were not willing to pay 3 % higher fare for travelling in a train with 2+2 seat layout, compared to the 2+3 solution. (Results from interview 2002 in the wide-body train "Regina").

The relatively low reduction in value of 1-2% for the 2+3 alternative should be compared to the fact that it is possible to reduce costs – and thereby fares – by 8-10%. The gain may be 6-9% in the passengers' or the train operator's favour. Such a low reduction in value can easily be compensated.

In another study, a great number of test subjects tried out different seat variants, all in a three abreast layout. The experiments showed that it was possible to eliminate the slight disadvantage of sitting in the middle seat by making the middle seat wider, installing individual arm rests and ensuring adequate legroom. The middle seat was ranked as highly overall as the other seats.

On the other hand, when seat spacing was tight and seats were narrow, then the middle seat felt narrow and uncomfortable. The factors measured were perceived comfort, spaciousness and privacy. Note that the middle seat was always occupied in the experiments. On a real train it would often be unoccupied.



Design recommendation: Individual, foldable armrest.

Conclusion:

The average passenger does not very much care whether the layout is 2+3 in a wider train or 2+2 in a conventional train. It is principally an issue of cost and environmental load per passenger as well as the train's capacity.

Comfortable seats

Passengers have different preferences as to whether they want to sit facing or behind each other.

Unidirectional or facing seats

Unidirectional means that passengers sit in rows of seats behind each other, facing in the same direction. The back of the seat in front faces the passenger behind. This is the normal solution in buses and airplanes.

In ***facing*** seats, the passengers in two different rows sit facing each other, usually with a table between them. Facing seats require the creation of a comfortable clearance for passengers' knees.

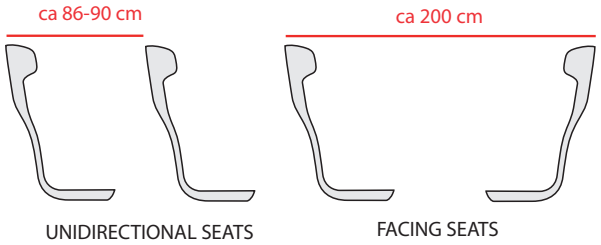
Studies conducted at KTH about both regional and long-haul trains shows that:

- About 1/3 of passengers want to sit facing each other
- About 1/3 prefer to sit behind each other in unidirectional seating
- 1/3 do not much care.

Of the two thirds that prefer one or the other, their valuations are relatively high. A passenger who prefers a unidirectional, bus-type layout and is forced to sit facing someone else is prepared to pay up to 10% more to avoid having to do so (or demand a 10% discount on the fare). In the same way a passenger who prefers a facing arrangement is willing to pay 7-8% to avoid a unidirectional layout.

Groups of travellers often want to sit facing each other so that they can talk to each other. People travelling alone often want to read, listen to something with headphones, or rest. In the later case, seats arranged behind each other give more privacy.

Facing seats with inclining seatbacks require a relatively large amount of space. In order to allow sufficient space between passengers' knees, two facing seats usually need to occupy more space than two unidirectional seats.



With facing seats the distance between the rear surfaces of the seatbacks should as a rule be at least about 200 cm in second class. This allows space for seat inclination and for passenger's knees.

Some passengers prefer to travel facing forward. An earlier hypothesis that there are fewer incidences of travel sickness on trains if passengers face forward has been preliminarily discarded since the opposite appears to be true. An argument in favour of swivelling seats is thus invalidated.

At this stage it is worth mentioning passenger valuations regarding different seat characteristics. The table below shows the average result of several passenger surveys.

SEAT COMFORT	
Facing: lone passenger sits facing unknown person	- 9%
Facing: passengers who prefer facing seats	+ 7%
Reclining seatback	6 – 10%
10 cm more or less legroom	4 – 7%
5 cm wider seat	4%
"Comfortable seats"	6-10%

The table shows that passengers place a high value on several positive characteristics of the seat.

Conclusions:

About 1/3 (at most) of the seats should face each other for passengers who prefer this arrangement. Having more than this, entails unnecessarily high costs because comfortable facing seats usually take up more space.

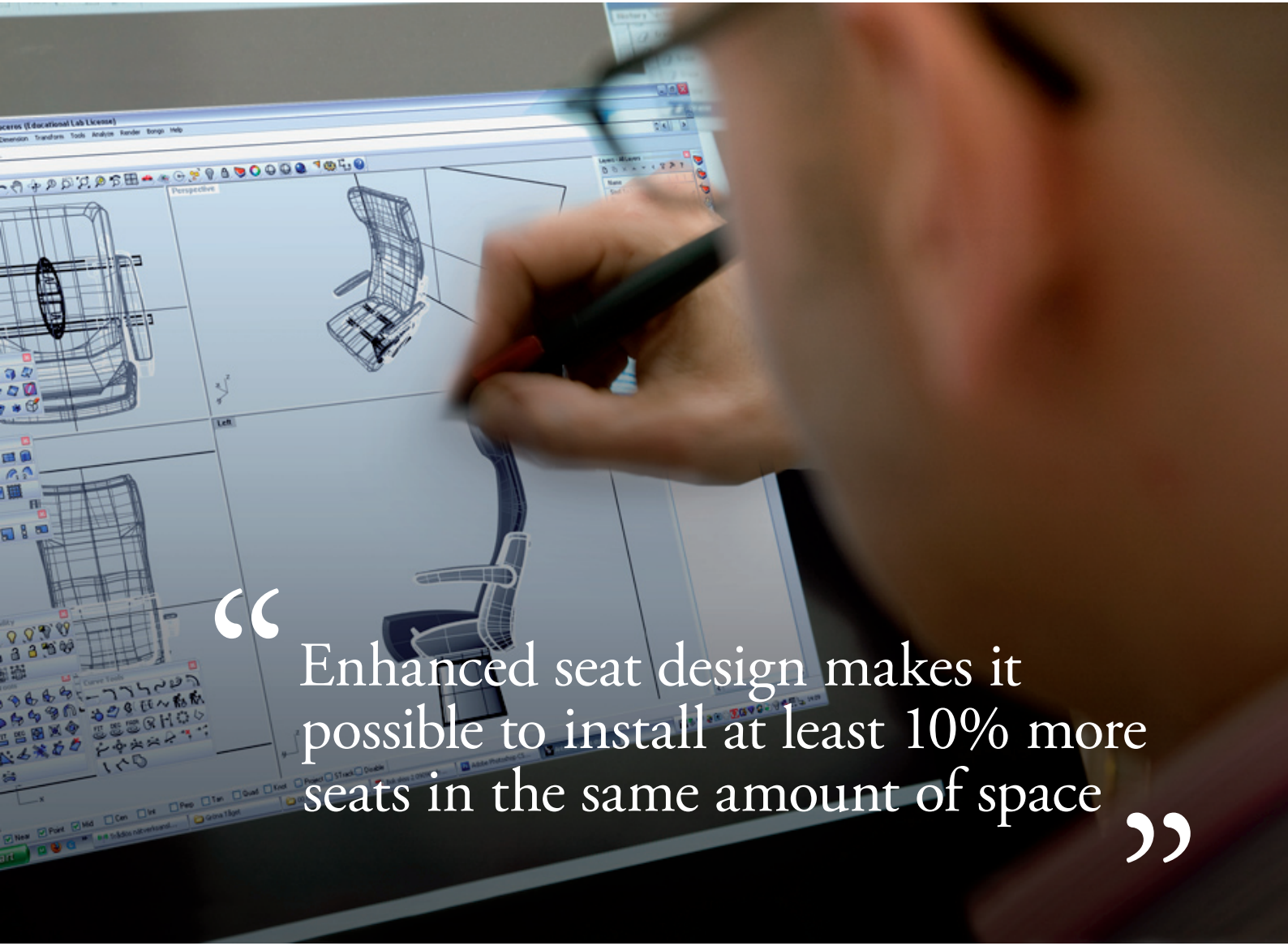
Space-efficient seats with a high comfort

The starting point is the desire to provide a high level of comfort in as little space as possible. The task is not to provide maximum comfort but to achieve *as high level of comfort as possible within the range of what different passengers are wiling to pay*. In some cases the trade-offs will show that a lower ticket price is more important to a majority of passengers than a certain measure to achieve a higher comfort.

The discussion in this section refers primarily to seats in 2nd class for private passengers choosing their mode of transport from train, car, coach and plane on medium-to-long journeys (1-5 hours). Such people are as a rule price-sensitive. This is also true of people commuting to and from work with a journey time of 0.5 – 1.5 hours. Commuters are both price-sensitive and demanding – they spend a great deal of their time on the train and expect to be able to use that time for both work and rest.

In order to reduce the cost of operating train services and also the average fares, the space on the trains should be utilised well. One way of doing this is to by means of efficient seat arrangements in the area available. The figures below illustrate how efficient seating with a high level of comfort, a feeling of spaciousness and privacy can be achieved.

It is important to design the seat and the area around it so that the passenger can vary its position and his or her activities, especially on longer journeys. The passenger must be able to rest or read, perhaps write or eat, use a laptop, etc. For rest, passengers should be able to change their position in the seat: lean back, have lateral support for their head, stretch their legs out, cross their legs, place their feet low or high, etc. Two important issues are the ability to incline the seat backwards and the perceived *legroom*.



“Enhanced seat design makes it possible to install at least 10% more seats in the same amount of space”

Ability to incline the seatback
Being able to incline the seat backwards has a high value among the passengers. This has been shown in a large number of studies. The seat back should have an intelligent inclining mechanism to avoid reducing the legroom of the passenger behind when the back is inclined. The seat back's centre of rotation should be at least at knee-height, i.e. at least 55-60 cm above the floor.

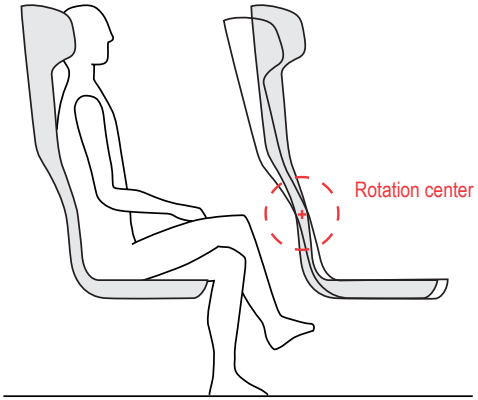
Perceived legroom
The other important issue is perceived legroom. The way the inclining mechanism works affects the legroom for the passenger behind. But there are more ways to increase the feeling of legroom.

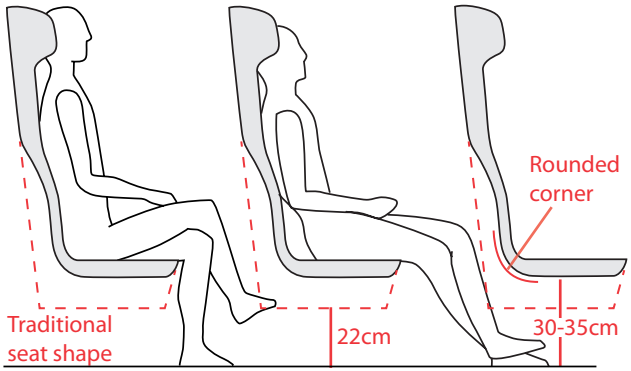
Rounded seatbacks and space under the seat
Seatbacks should be *rounded at the bottom* so that passengers can extend their legs under the seat in front. Further, the minimum distance between the floor and the bottom edge of the seat should be at least 30 cm, preferably 33 cm. Airplane seats are without exception designed to save space in this smart way.

KTH and Konstfack have conducted a series of tests where the distance from seat to floor was increased from 22 to 30 cm. In addition, the bottom edge of the back of the seat in front was rounded. These changes proved on average to be just as important for space and comfort as an extra 9 cm between the seats.

A conventional train seat is illustrated to the right. The seat in front is usually quite close to the floor (20 – 24 cm). It is difficult to stretch out one's legs, and there is hardly room for any luggage under the seat.

Intelligent seat adjustment





Rounding the bottom edge of the seatback and raising the space under the seat gives even tall people ample legroom and room to cross their legs.

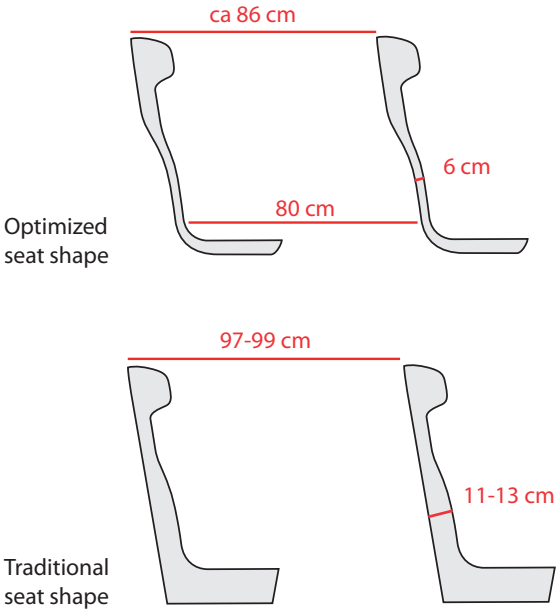
Recommended measures

KTH's studies show that current train passengers are generally willing to pay what it costs to retain today's relatively spacious perceived legroom on trains. In general, a passenger being some 10 % taller than average – with today's conventional seats – has approx. 20-22 cm between their knees and the seat in front. This is equivalent to an internal distance of about 86 cm between the seatback surfaces at knee-height.

If the back of the seat in front is 11-13 cm thick (which is the normal thickness, including a foldable table), a seat-pitch of 97-99 cm is required in the case of conventional train seats. This will allow about 86 cm of internal seat space at knee height.

With more space-efficient seats – rounded and with a height under the seat of at least 30 cm – our studies indicate that 77 cm of internal seat space at knee-height would be sufficient to achieve the same perceived comfort and feeling of space. A passenger being some 10 % taller than average can then stretch his legs out and cross them. With a thinner seatback, say approx. 6 cm at knee-height, approx. 83 cm would then be needed as seat pitch . All these figures should be considered to be minimum requirements. To improve passengers' perceived comfort and feeling of space, a few cm extra are preferable, say approx. 86 cm. This is also approximately the distance needed to have room for a foldaway table large enough for a laptop (see the separate section on tables).

In the wide-body trains with a 2+3 layout in 2nd class, it is preferrable to have some 3 – 5 cm greater seat pitch on the side with three-seat rows. This makes it easier to get to the window seat and also compensates for a possible narrow feeling when sitting in a 3 seat row.



Conclusion:

With a suitable seat design (rounded and raised at the bottom, a thinner seatback and an intelligent reclining mechanism) it is possible to considerably reduce the distance between the seats – the pitch – without detracting from the perceived comfort. If desired, the level of comfort can be increased at the same time as the pitch is reduced.

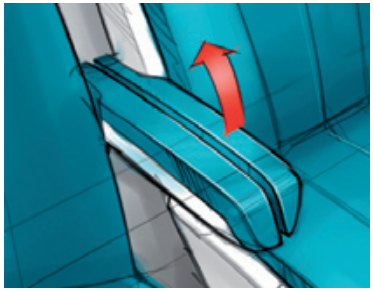
Width and armrests

Armrest to armrest width may be as little as 42-44 cm in buses and economy-class aircraft. Modern 2nd class trains in Europe, like the airlines' long-distance planes and "European Business Class" sections, typically have 45-46 cm, which is thus a generally accepted measurement. In older Swedish railway cars, the typical measurement is about 48 cm.

The armrests themselves are typically 4-5 cm wide in 2nd class trains. Very comfortable trains may have double armrests, i.e. with a total width of 8-10 cm. The reason is that there would otherwise be too little room for elbows and shoulders between two passengers sitting beside each other. Armrests should be foldable to make it easer to get in and out of the seat, especially for older people who cannot move so easily. Investigations have also shown that passengers want soft, padded armrests.

Individually foldable armrests

Some studies [Dziekan & Kottenhoff, 2009) have shown that individually foldable armrests are much appreciated. Every passenger can adjust his or her armrest to their own liking. Two adjacent seats should therefore have double armrests. This is especially important as regards the middle seat in a row of three.

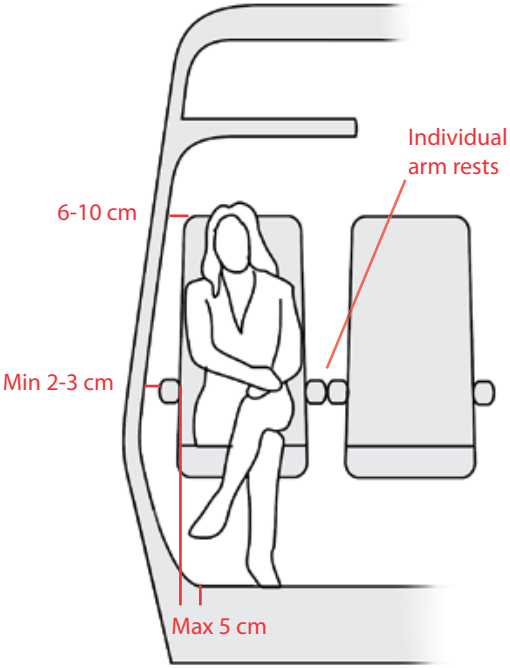


Individual foldable armrests

Other aspects

Another important detail is that there should be some free space between the armrest and the car wall. There will then be some room between the back of the seat and the wall so that clothes can be hung on a hook without encroaching on the seat itself. This distance should be at least 6-10 cm.

The lower part of the wall, including any ducts for air and cables, should not encroach too much on space for passengers' feet. If it does – by, say, more than approx. 5 cm – a "shelf" could be provided on which passengers can rest one of their feet.



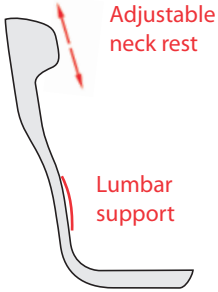
Other important aspects regarding the seat's comfort
In KTH's and Konstfack's studies of focus group test subjects, extensive interviews were conducted regarding their perception of various aspects of the seats. Some important conclusions can be drawn from this study and other experiences.

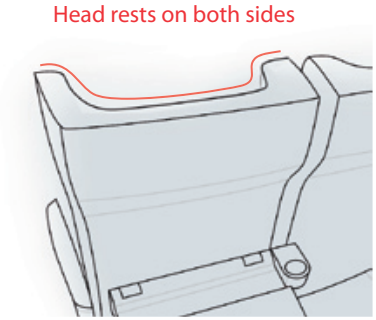
Foldaway footrests
For passengers' comfort a support for the feet is desirable. This is mainly possible in a unidirectional seat layout. The foot support should be able to be folded away to allow passengers to stretch their legs out under the seat in front. When folded away, it should therefore be at least 35-40 cm off the floor.

Lumbar support
Support at the base of the back is important to many passengers. Individually adjustable support is best from the point of view of passengers' comfort.

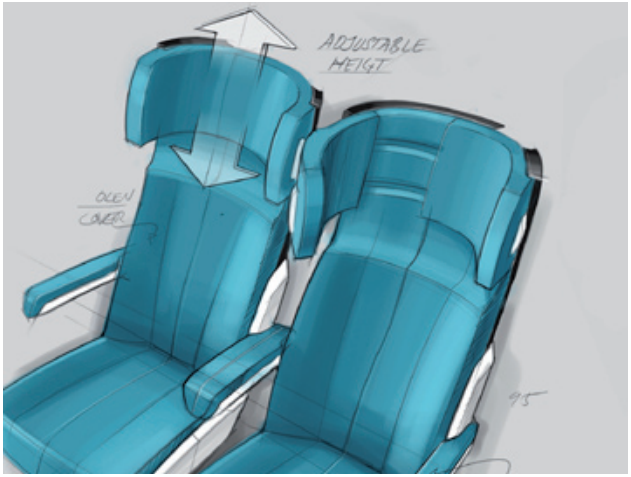
Head support
There should be some form of *support for the head* on both sides. This is especially attractive when you want to rest.

Where a *head support* exists, it should be *vertically adjustable* to suit most adult passengers regardless of how tall they are.





Screens
A large number of test subjects have showed great appreciation for an adjustable screen for their eyes and face. The solution makes it easier to relax and create a feeling of privacy related to the surroundings. Such screens must be able to be folded in and out according to the passenger's needs and preferences. It must be vertically adjustable to suit different passengers irrespective of height. The device must therefore be robust and easy to use and also easy to keep clean and fresh.



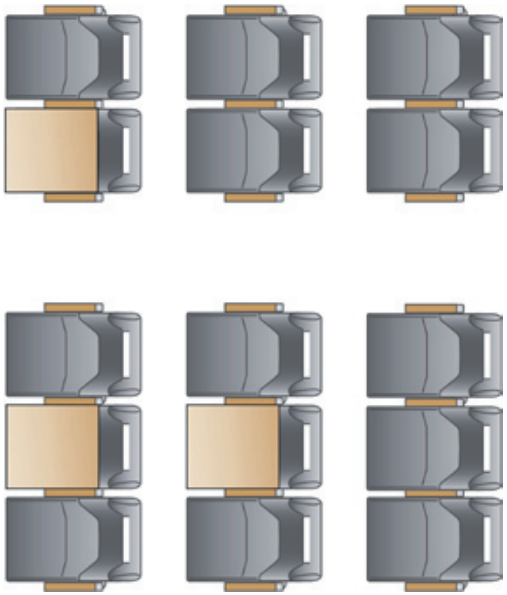
Seating variations

In a wide-bodied train furnished with five seats abreast (at least 3.3 m interior width at elbow level) the seating layout can be varied to suit different needs by blocking one or two seats with a table or some other amenity for passengers' use. The car can then be used as a 1st or 2nd class car and 2nd class car with more private seats. (see the figure below).

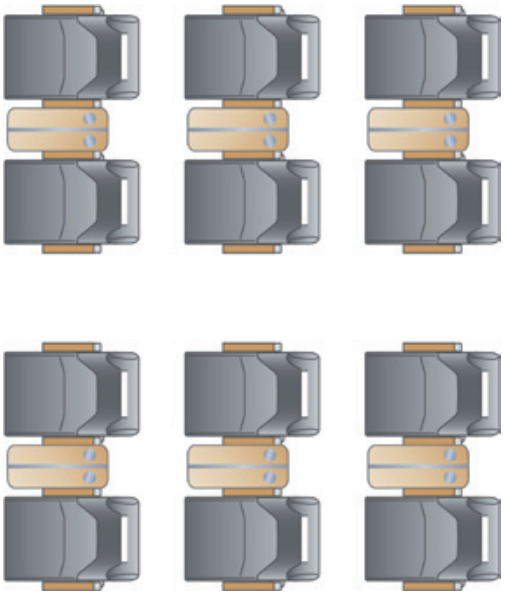
The advantage of this flexibility is that the train operator does not need to have as many cars. The interior of a train can be varied to suit the day of the week or the departure time depending on the category of passenger. A further possibility might be to arrange seats according to booking status in cases where reserved seats are required.

In 1st class a wide-bodied train can be laid out to satisfy economy requirement while at the same time giving passengers a feeling of integrity and personal space by arranging the seats 2+2 and inserting a small table approx. 20 cm wide between the armrests. The width of the seats and the centre aisle will be roughly the same as in 2nd class.

This solution is a more efficient solution than the current 1+2 layout employed in 1st class. It is especially appropriate for regional services (0.5 – 1.5 hours) where it is particularly important to reduce costs.



Layouts: 1st class, 2nd class+ 2nd class



Possible layout in 1st Class with small tables.

“On a deregulated market
it will be crucial to produce
attractive journeys at low cost”

Functionality for comfort and useful travelling time

Measures to enhance comfort often increase passengers' willingness to pay by more than they cost.

For example, the diagram on page 7 shows that passengers want air conditioning and/or individually adjustable ventilation and their willingness to pay far exceeds the costs. This goes almost without saying on modern trains.

Another example: Subdued lighting with individual reading lamps costs considerably less than what most passengers are willing to pay. It is probable that lower noise and vibration levels – up to a certain limit – also cost less than passengers' relatively high valuations of these factors, if the measures are implemented in the right way.

A challenge with regard to these issues is that some companies ordering trains mainly considers first cost (train investment) and not the long-term benefit for passengers and their willingness to pay.

Something that is very appreciated, by all passengers and especially by women, is tidy and properly cleaned toilets. It is an important factor as regards passengers' impression of quality.

About on-board service and cost

Service measures may turn out be expensive if they require personnel or large amounts of space. It should therefore not be taken for granted that a high level of service will be profitable merely considering willingness to pay. An example of a facility that would possibly be profitable, according to our analysis, is the provision of special play areas for children on long-haul trains. These and similar facilities, however, must not reduce the number of seats excessively.

Tables

It is important to have functional *tables* at the seats, both to put food, drinks and other small items on, but also to have somewhere to put reading and writing material and – not least – to work on a laptop.

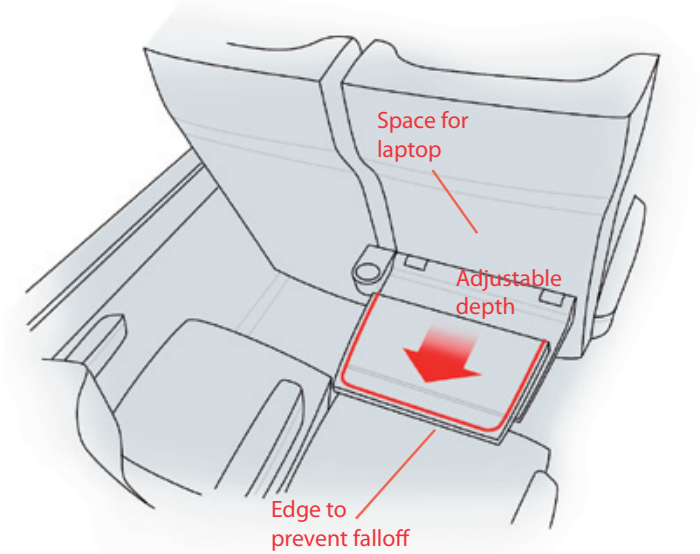
In a facing seat layout tables should reach all seats, including those closest to the aisle. The edges of the table should be foldable so that the seats closest to the windows can be reached easily. The alternative of having a greater distance between table edge and seat leads to an uncomfortable sitting position when the table is used. In addition this solution will also require more space and thus a higher overall cost per seat.

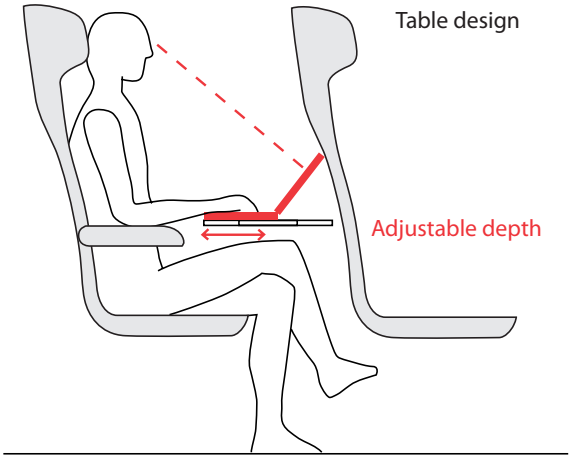
In a unidirectional layout, the table should be so deep as to allow a laptop to be placed on it with the screen properly angled towards the user. In such a solution the angle of the back of the seat in front may be a problem. One way of solving it is to have a table that can be pulled out towards the seat. The distance between the edge of the table and the back of the seat in front should be 42-45 cm for a laptop with a 14-16" screen.

The tables should preferably be large enough to accommodate a laptop and some other small item beside it. This requires a width of at least 40 cm, preferably 45 cm. The table should fold down towards the user. If the position of the table when folded away is too low, it will encroach on knee space.

All tables – whether in a unidirectional or facing seat layout – should have a raised edge on all sides to prevent things sliding off when running through curves or when the train brakes and accelerates.

Approximately 2/3 of the passengers on today's trains feel that *vibrations* disturb their ability to read, write or work on a laptop. This is especially true as regards the tables, which often vibrate more than the train's floor and walls, i.e. the tables can at times amplify the vibrations. Particular attention should therefore be paid to the vibration problem.



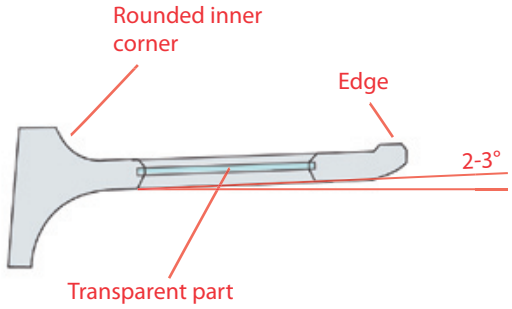


Luggage

Generally speaking, *long-haul trains* – and trains where a high proportion of the passengers are travelling to and from airports – need a good deal of space for luggage. *Regional trains* (except for airport shuttles) need a relatively small amount of space for luggage.

On long-haul trains every passenger carries an average of 1.5 pieces of luggage according to KTH's studies. This is true regardless of the time of year. In holiday seasons however, passengers carry more heavy luggage: roughly every third piece of luggage is then a large suitcase, large backpack or a pram. This means that for every 100 passengers there should be space for about 50 large pieces of luggage. Most of these should be placed in special luggage racks in the compartment, with a moderate lifting height about 130 cm. Some may be placed on shelves above the seat.

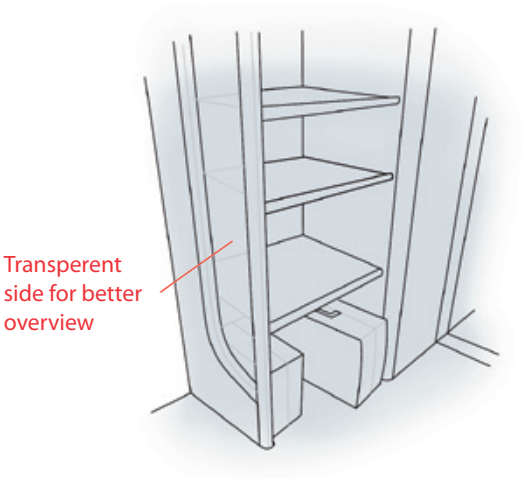
Our studies have shown that passengers generally want to have their luggage at or *close to their seat*. They want to have parts of their luggage within easy reach during the journey and also be able to see it due to a perceived risk of theft.

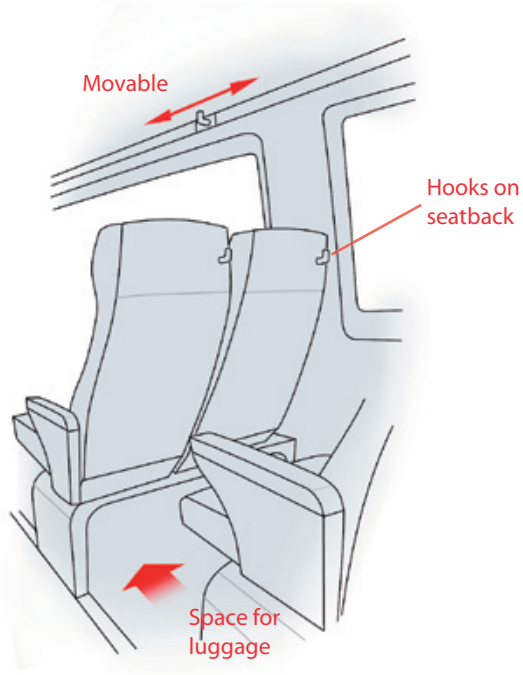


Recommendations:

- Provide space for smaller luggage under the seat in front. Space is therefore needed between the floor and the seat (at least 30 cm).
- To be easily accessible the shelf should be 165-170 cm from the floor. It should slope inwards slightly towards the wall and have a raised edge to prevent luggage from falling off. It is an advantage if the shelf is transparent so that any luggage on it is visible from below. Medium-size pieces of luggage can be placed here. Airplane-type locked shelves may also be used.
- Provide special luggage racks on the floor for larger items. Long-haul trains should have room for approx. 40 large pieces of luggage per 100 seats. It is an advantage if some of these racks can be placed inside the car instead of at the doors, but bear in mind that passengers placing their luggage in the racks must not hinder the flow to and from entrance doors. Exchange of passengers should be able to be done quickly and easily and there must be room to get past.
- There should be space for at least one pram in every 2nd class car. If the train does not have special areas for families with children, there should be space for at least one pram per 50 seats in every car. in long-haul trains.

Regional trains do not need as much space for luggage: for purely regional trains, the estimated need is only about 10 large pieces of luggage for every 100 seats. Space for prams should however be provided as for long-haul trains.





Clothes

Placing clothes in a satisfactory manner is not easily accomplished. Clothes cover everything from small hats to large overcoats. During winter, almost every passenger will have a sizable coat, overcoat or heavy jacket. In addition, approximately 1/3 of them want to hang their indoor jacket somewhere.

Passengers generally want to store their clothes close to their seat, like their luggage. They do not want their clothes falling into their face or in front of the window.

Recommendations:

- Provide wardrobes (with functioning hangers) in the seating area. As an option, this can be done only in 1st class.
- Provide a small hook on the seat in front, slightly offset so that the table can be folded down, on which to hang jackets, cardigans, etc. This is possible in a unidirectional layout but is not possible in a facing seat arrangement.
- Provide "normal" hooks on the wall beside the seat, preferably movable so that can be adjusted to the exact seat placement. Bear in mind to leave some free space between seat and wall (at least 6 cm but preferably 10). Otherwise there is a risk that clothes will drape themselves over the seatbacks.

Food and refreshments

Food and drink services are appreciated but any type of refreshment/meal service on a train requires space. It is therefore important that the food and drink function is designed according to the need and passenger's willingness to pay.

However, some form of food and drink service should be offered on most trains with travelling times of over one hour.

The values of different levels of food and drink service are shown in the table below. These values should not however be taken as exact. What is interesting is that even a simple food and drink service has a considerable value.

FOOD AND REFRESHMENTS	WILLINGNESS TO PAY
Coffee machine (relative to no service at all)	3-6%
Free coffee and tea in each car	approx. 6%
Food and drink trolley	approx. 11%
Cafeteria	approx. 14%
Restaurant with hot food	approx. 17%

It seems that a high-quality trolley service could be an appropriate solution in many cases, if cost and passenger valuations are considered. At least in 1st class also hot food can be served at the seat.

Computer connections etc

Electrical outlets at every seat, mainly to power laptops, are always a "must" on modern trains. The outlets should be placed so that cables do not prevent or hinder passengers in the seats alongside from getting past. The best place is on the seat where it will be used.

Other facilities that passengers more or less expect include an Internet connection and amplification of the signal strength in the mobile telephone system.

Heating, ventilation and air conditioning

Temperature and humidity are very important factors as regards comfort. The technical term for the climate control system on trains is HVAC (Heat, Ventilation and Air Condition). We will not go into all the technical details here, merely touch upon those aspects that are of interest as regards interior design. The requirements regarding HVAC systems on long-haul and regional trains are set out in European Norm EN 13129, that should be seen as minimum requirements. Note that operators and train leasing companies may have more complex demands.

Inside the railway car, we define a "comfort envelope", stretching from 10 to 170 cm above the floor in seating areas. Within this envelope, the normal temperature must be +22 °C with some possibilities for adjustment. When the outside temperature is high, the inside temperature shall also rise to some degree. Humidity must be 65% at most up to 23 degrees, and lower at higher temperatures.

“Passengers want speed, simplicity, comfort and quality at low price”

Within the comfort envelope the speed of air-flow must be low to avoid the ventilation being perceived as "draughty". At the lowest temperatures (approx. 20°) the air-flow speed inside the climate envelope should not exceed 0.1 m/s. At for example 23°, 0.3 m/s is permitted. These low air-flow speeds require the outlets (usually in the ceiling) to have a large area. The air change rate is often of the magnitude of 30 m^3 (min. 20 m^3) per passenger and hour. In a car with 100 passengers an air change rate of approx. 3,000 m^3 an hour, about 800 liters a second, is required.

Surfaces not too cold, not too hot

Air temperature is not the only important factor. It is also important to ensure that passengers are not forced to sit in contact with hot or cold surfaces on walls and window frames. The temperature of the walls must not differ by more than ±7 degrees from the air temperature. The temperature of the window frames must not be more than 9 degrees below the air temperature. All the above-mentioned applies also when the outdoor temperature is at its lowest or highest limit. Note that this is minimum requirements.

These requirements mean, among other things, that

- The air blowers for cold and warm air should not be located within the passengers' access radius. A limited amount of warm air should, however, be extracted below windows at low temperatures to prevent downdraughts.
- There should not be any "cold bridges" inside partitions and window frames. The risk of this occurring is especially great if the partitions and window frames are made of metal.

Aisles

The aisles between the rows of seats should be wide enough to allow people to meet and carry luggage without too much trouble. In the European standards (TSI) minimum aisle width is 0.45 m below a level of 1.0 m, and 0.55 m above that height. In Nordic countries however (usually having a wider carbody than continental Europe) the width at low levels is normally 0.50 – 0.55 m. Compared to aircraft and long-haul coaches all these dimensions are generous.

Walls and windows

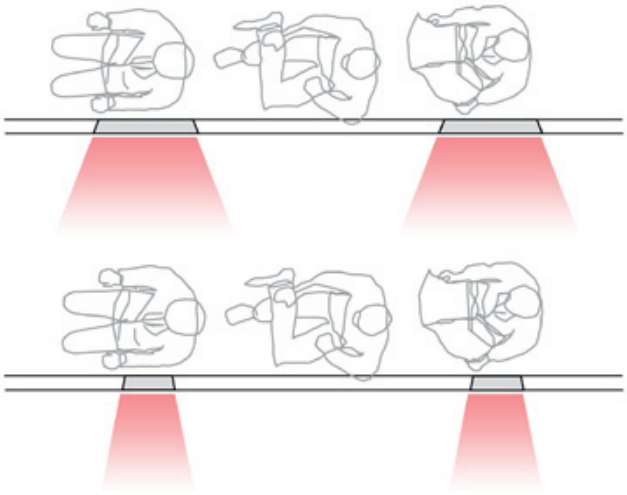
Flexible layouts are often desired, with possibilities to arrange seats unidirectionally or facing each other. This sometimes means that the positions of the windows are not in alignment with the positions of the seats, There are often wide "window pillars" between the windows, making up of a wall section and not a real window. These are typically half a metre wide.

The window pillars obscure the view for those passengers unlucky enough to be sitting there; the "window seat" they were promised turns out be a "wall seat" instead.

The reason for these wide wall sections is that they stiffen the shell of the carbody and suppress vibrations.

A means of satisfying the stiffness requirements other than by wide window pillars would be desirable. Also other means of suppressing vibrations should be considered.

For safety, costs and stiffness reasons it is desirable not to have too high windows. A window height of 0,6 m - 0,7m would in most cases be acceptable, in particular as passengers in this type of train is usually sitting, not standing.



Window pillars should preferably be narrow, in order not to obscure the view through windows.

Inclusive design - Adaptation for passengers with reduced mobility

A modern perception is that a "handicap" does not arise until the demands imposed by the surroundings become greater than the individual's functional capability. KTH has presented this view and some design solutions in its report entitled "Trains that Reduce Handicaps" If a person, for example, has reduced mobility due to impaired legs or because he or she has a pram or wheelchair to manoeuvre, there is no problem – or handicap – until an obstacle is encountered that makes demands the person cannot fully cope with.

We have also shown that cars with level entrances hardly caused any handicap situations at all while those with steep stairs (cars built in the 1960s) caused an apparent handicap for 7% of the passengers. On comparison, the X 2000 train from the 1990s with moderately steep stairs, 2-3% appeared to experience a handicap when boarding or deboarding.

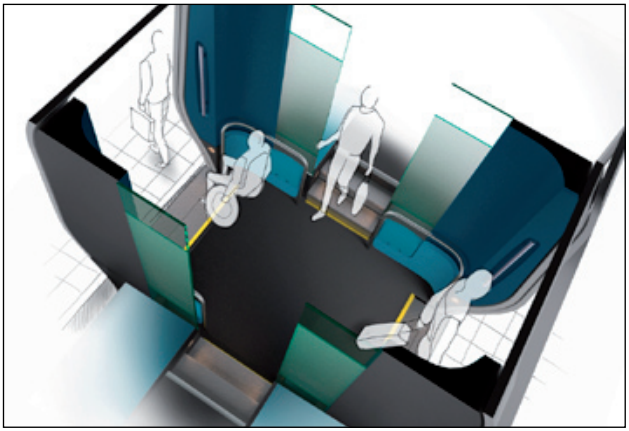
"Inclusive Design" requirements have been drawn up both in Sweden and internationally. Banverket (the Swedish Rail Administration) has summarised the Swedish requirements in its "Guidelines and recommendations for increased accessibility for disabled people in new multiple units and passenger cars in long-haul and regional traffic" (Banverket, 2003). A similar international summary of requirements is "Rolling Stock: Accessibility for People with Reduced Mobility (PRM)" (TSI 2007-03-06). In many aspects the Swedish requirements go further than the international, so these are the ones primarily referred to here. Since the requirements are extensive, we refer the reader to the sources given for more detailed descriptions. Here we present only a few examples of important requirements and design solutions.

Entrance

In the European TSI standards it is accepted that wheelchairs are lifted onto the train by train staff using various lifting devices, within the train or outside. This is not considered desirable in Sweden, where passengers in wheelchairs should preferably be given the possibilities to manage by themselves.

Moreover Swedish requirements prefer that door openings and passages to wheelchair places should be min. 900 mm while the corresponding width in the European TSI is 800 mm.

There are a number of concepts that, to varying extents, reduce handicaps in the vehicle-passenger interface. The most far–reaching is to have the whole floor of the train and the platform at the same level, but this requires high platforms (1,1 m – 1,2 m). This would in turn create difficulties in most European railway systems where the platform height is becoming increasingly standardised at 550 mm. Solutions with a low entrance floor are therefore of great interest.



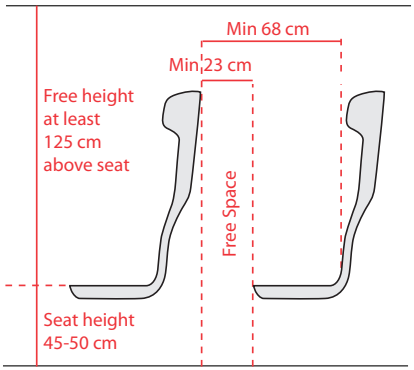
Concept of entrance, self adjusting to the platform height.

Industrial designers at Konstfack in Stockholm, has developed the conceptual idea of an entrance with self adjusting floor. The solution is an answer to many requirements from both passengers and train operators.

The floor adjusts automatically to the platform level and travellers can easily access the train. This is an advantage for wheelchair users and people with prams and heavy luggage. Moreover the efficient solution contributes to shorter stops at the stations.

Places for disabled passengers

People with other disabilities than reduced mobility should be able to use all the seats on the train. People with reduced mobility (although not using wheelchairs) should be able to use at least 10% of the seats, preferably those close to the doors. Recommendations regarding seats given in this book can be made to satisfy these requirements, with seatbacks in upright position.



Banverket (2003) recommends the dimensions shown above. These mainly concern ability to access and exit seats easily.

Trains up to 205 metres in length must have at least two places for passengers in wheelchairs and at least one toilet that can accommodate a wheelchair.

Food and refreshments
A disabled passenger must be able to reach the cafeteria, alternatively to order and eat food at the seat at comfortable tables.

Toilets
A toilet for disabled must be easily accessible close to the wheelchair places and fulfil certain minimum interior space requirements. For details, see TSI/TSD or (Banverket, 2003).

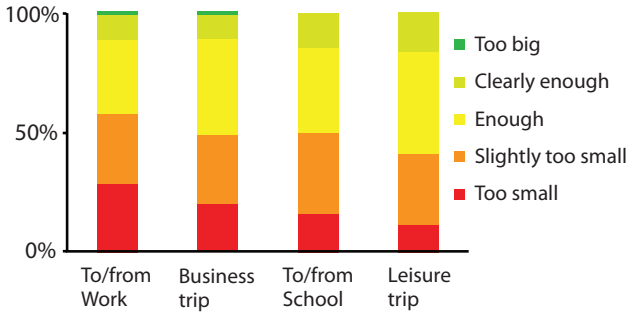
Information and intelligibility
Studies using focus groups has shown that disabled people need more detailed information and often extra information on trains and buses. This extra information might also make travelling easier for other passengers.

Banverket requires that information about destination, next stop, any delays etc be both provided visually and spoken. Announcements over the 'Public adress' system should have a sound le vel of 10-15 dB(A) above the normal noise level.

Other things to consider is good semiotics – designing handles and controls in such a way that they are easy to understand – to all passengers' advantage. For example, a knob that should be manouvered by turning it must by its design show this. Especially important for people with impaired vision is contrast marking of certain guide rails and handles.

The value of travelling by train is increased for all passengers when all facilities easily can be understood and used.

Regional commuters are most demanding
In many of KTH's studies we have found that commuters have particularly high demands as regards comfort and different on-board facilities. Comparisons have been made with both business travellers and private travellers. The commuters' demands exceed those of leisure travellers and are similar to those of business travellers. Regional commuters with a travelling time of 0.5 – 1.5 hours spend much of their time every year on trains and expect to be able to both work and relax.



Different groups of travellers' assessment of legroom in tests on double-deckers in 1998. Regional commuters are the most demanding group.

The double-decker trains that were tested in Mälardalen (up to 200 km west of Stockholm) in 1998 had relatively cramped seats. As can be seen from the chart above it is the commuters who were least satisfied with the legroom on these trains.

This study also reflects that the commuters had the highest willingness to pay for comfort- and work-related factors like "more room", "reclining seats", "higher seat comfort" and "possibility to choose between unidirectional and facing seats". Reclining seats appear to be of particularly high value to

commuters.

Simpler service on regional trains – but not less comfort
On-board service demands differ between regional and long-haul traffic. This is mainly because travelling time is longer when we travel greater distances. Another reason is that most regional journeys are made without an overnight stay. The differences are mainly in the need for food and drink service and in luggage space (needs are lower in the case of regional service). The lower demands for food and luggage service in regional trains (in relation to long-haul trains) do not refer to comfort or possibilities for work and rest.

Our studies have confirmed that there are good reasons for having the same level of comfort and thereby train type for several market segments, from the regional market to the long-haul market. Research have shown that passengers' demands regarding comfort etc in both market segments are high and fairly similar. It should be possible to have a train concept that is flexible enough to be used in both of these two cases.

We do not really need the same levels of comfort and space utilisation on the train at all times for all types of passengers. We should therefore first and foremost adapt comfort levels to the most demanding groups: business travellers and regional commuters. Secondly, it is desirable to be able to adapt space utilisation according to capacity needs.

	LONG HAUL	REGIONAL
WEEKDAY	Business travellers demand comfort and service	Commuters demand high comfort
WEEKEND	Leisure travellers need low-cost comfort and service	Train as an alternative to cars?

Four different markets that demand a high standard of trains at weekends and weekdays in both regional and long-haul services

To conclude:

Business travellers demand both high comfort and a high level of service. Regional commuters are just as demanding as regards comfort and possibilities to work. Both groups travel extensively by train on weekdays, while leisure travellers to a greater extent go at weekends and during holiday periods. People who travel long distances need a high level of comfort, and also space for luggage. People who make slightly shorter journeys at the weekend should be enticed to take the train instead of their cars. All the groups find trains of high standard attractive, but it must be affordable.

“Regional commuters are at least as demanding on comfort as business travellers”

Recommended interior measures

A modern train concept should be suitable for both regional traffic and long-haul traffic and permit easy adaptation of the interior layout and on-board service. This can be done by using two versions of basically the same interior design. Better is if the design is flexible and quickly adjustable to fit needs that vary over time and different markets

Recommendations:

- A combination of unidirectional and facing seats with 25-35% facing.
- About 86 cm pitch and space-efficient seats: rounded seatback bottom and space under the seat in front as well as thin back supports. (Without space-efficient seats, a 10 - 15 cm greater pitch may be needed, i.e. 95 -100 cm. This would increase the total cost of operating the train by 5 – 8%.)
- A further 3-5 cm pitch if and where there are three seats abreast (on wide-bodied trains).
- "European standard" seat width, i.e. approx. 46 cm between the armrests. Total width including armrest 54-55 cm. Individually folding armrests at all seats.
- Ergonomically designed seats including lumbar support and adjustable neck rests that provide high comfort for most adult passengers (approx. 155 – 190 cm tall).
- A solution that makes it easier to relax and create a feeling of privacy related to the surroundings. It must be adjustable according to the passenger's needs and preferences.
- Good tables at the seats so that travelling time can be used for work, including comfortable use of laptops.
- Well-considered luggage space, close to passengers

- Well-considered clothes hanging arrangements
- Individual reading lights combined with subdued general lighting
- A solution to increase the feeling of privacy with screens out visual and audible noise
- Inclusive design – for convenient use also by passengers with reduced mobility. At least one door should have a level entrance from a medium-high platform. Inside the train disabled people (including those in wheelchairs) must be able to access areas with functional attractive passenger environment, as well as drink and food service.
- Good heating and ventilation with air conditioning at least in summertime and no excessively warm or cold surfaces on walls or windows.
- Low levels of shaking, vibration and noise, to make the journey restful and provide the possibility to read, write and work on a laptop.
- Interior design that contribute to a pleasant visual experience and provides high esthetical quality in details.

Measures that should NOT be implemented include

- Only unidirectional or facing seats
- Compartments with a small number of seats. However, compartments for families with children may be provided.
- Simpler seats or less functionality on regional trains than in 2nd class on long-haul trains. Such simplification would be in contradiction with regional passengers' preferences.

Research on passenger requirements

Penetrating passengers' requirements and wishes a little further, we discover several things. One is that saying that one factor is more important than another is uncertain.

A second thing is that people have different preferences – our priorities are different.

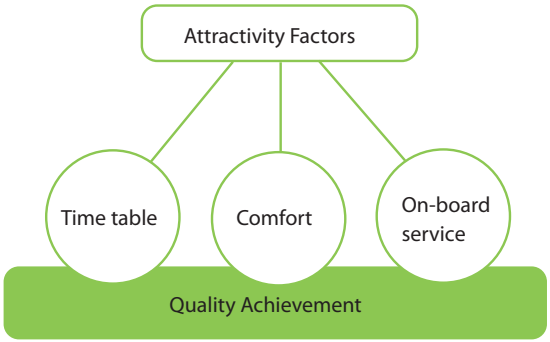
A third is that we often cannot have everything. We have to choose, between price and quality for example.

It is not really possible to say that one factor is more important than another. What is the most important measure depends on how great the improvement is. For example, it is more important for most passengers to reduce travelling time by half (i.e. 50%) than reduce the fare by only 5%. On the other hand, it is more important to reduce the fare by half than to reduce travelling time by only 5%. It is thus not easy to say whether for example lower fare or shorter travelling time is the most important measure for passengers.

On occasions when train services fall short quality-wise, the shortcomings then stand out as the most important factors. When trains have been seriously delayed for a while, politicians and others will normally say that the most important measure of all for the development of the railways is to eliminate the

delays. If the trains were in poor condition, the most important measure is to restore them to good condition.

Is this sufficient to improve quality? That depends on what we mean by quality. If we mean all the factors or characteristics of a train journey then it is sufficient. In our work we use the concept "standard" or "journey standard" for all the characteristics that describe a journey. We speak about low or high standard (and all levels in-between). Journey standard can be divided into, for example, timetable factors, comfort, service and quality achievement.



Here we use the concept of quality to group together different deficiencies in the journey standard perceived by the passengers. Examples of quality factors include delays, damaged tables at the seats or an unfriendly conductor.

Different preferences

In some respects, different people have different preferences. For example, some might want to sit by themselves in seats arranged behind each other while others prefer to sit opposite each other, perhaps even in an old-fashioned compartment. It may also be so that the preferences vary in strength. Everyone wants shorter travelling time but some consider one hour's shorter travelling time not so important that they are willing to pay 100 SEK extra. Others are prepared to do so – and more besides.

One might ask why someone prefers one particular product to another. The product that is chosen is said to have a higher value for that individual.

Help to prioritise can be found in economic theory and methodology. Among other things, economists make the assumption that different products – the characteristics of a journey in our case – can be exchanged for each other in certain relationships. Someone might for example be willing to exchange 5 minutes' longer travelling time for (at least) a 5 SEK lower fare.

When we study people's requirements as regards trains we see that different requirements must be weighed against each other. Sometimes, however, solutions can be found that satisfy apparently contradictory requirements.

There are different ways to investigate the market.

The train journey market can be investigated in different ways. We can investigate how many people chose to travel by train, i.e. how people actually chose to travel. Or we can ask them what choices they would make in hypothetical situations. We can ask them about what they want from a good train journey or about what they feel are deficiencies. We can ask about their attitudes to travelling in different ways, about their perceptions, or about their values. We can ask potential passengers who are not travelling or ask actual passengers during or after their journey.

Travel demand statistics – ticket statistics

We can learn a lot by collecting statistics of how people have travelled by train. The data collected includes for example starting and destination stations, fares, etc. A study was conducted at KTH where, among other things, the conclusion could be drawn that there was approximately 25% less actual travelling in relations where passengers needed to change trains.

Focus groups

Focus groups are a purely qualitative method where a structured interview is conducted with a group of about ten people. The discussion centres around one particular issue. We have used the method when evaluating a couple of Konstfack's design proposals for the Green Train. At Konstfack a mock-up was constructed with an extra-wide body and three seats beside each other. Two design proposals were chosen and built into the mock-up in order to test them on (future) customers:

1. A screen that makes it easier to shut oneself off, rest or sleep.
2. A partition that would make it better to sit three abreast.

First, three test subjects were asked to try out the design solutions in question and at the same time fill out a questionnaire. Their experiences were then discussed under the guidance of a trained focus group facilitator.

Two of Konstfack's proposed design solutions were tested by test subjects who later took part in a focus group where their experiences were discussed.

The results of the discussions were taken into consideration in the design directives in this report. It can nonetheless be mentioned here that the discussions clearly showed that one of the solutions was perceived to have many positive characteristics, while the other was misunderstood and was regarded as less interesting/attractive.

PDS

PDS stands for *Problem Detection Study*. In a PDS, users are asked about what problems they perceive. A PDS study commissioned by SJ in the 1980s showed that delays were worst. The PDS technique places the focus on quality deficiencies, e.g. delays. Other factors such as lower fares, shorter travelling time or greater comfort onboard, are not considered to the same degree using this method.

Attitude surveys

Attitude surveys investigate people's attitude towards different phenomena such as car, train, bus and plane journeys. Research has shown that the relation between general attitudes and what people ultimately decide to do is not always very strong.

One shortcoming with this method is that it is not particularly easy to use attitude-based theories to predict what will happen when the service standard, e.g. travelling time, changes.

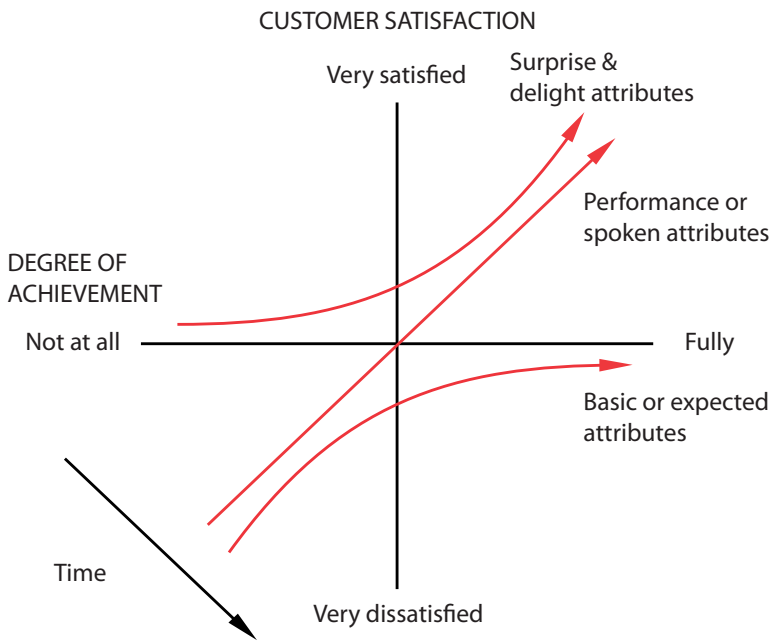
Customer satisfaction

Asking customers how satisfied they are is called a customer satisfaction survey. They are asked how satisfied they are with different aspects or attributes of the product. In the same way as the PDS technique, this method of asking people how satisfied they are tends to highlight the things they are dissatisfied with – quality defects.

The Kano model

There are many different models that deal with customer satisfaction. A good example is the Kano model, the theory behind which is that there are three types of attribute (approximately equivalent to characteristics in the case of a journey). The first level is basic: *expected attributes*. Then come the more explicit *performance attributes* and finally *surprise and delight attributes*.

The figure below shows that the Kano model assumes that satisfaction does not increase linearly but decreases for imperative expected attributes such as trains running to timetable. For the surprise and delight attributes on the other hand, satisfaction increases progressively – people can be "more than satisfied" when they are given something they did not expect. Only the performance attributes, e.g. travelling time and walking distance, affect customer satisfaction linearly.



If the Kano model is correct, companies can achieve a very high level of customer satisfaction if they a) increase the journey standard and b) surprise and delight their customers.

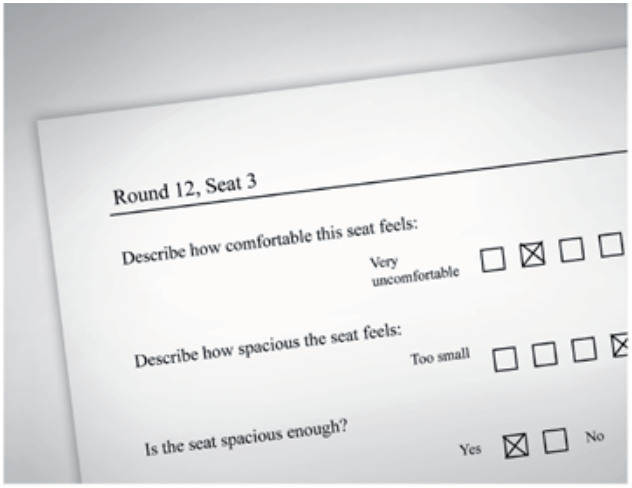
Determining customers' perceptions

For various reasons, we might sometimes want to find out how passengers perceive different factors or characteristics. A company that produces vehicles and traffic services might want to know whether the passenger/customer sees the product in the same way as the producer. A study conducted by KTH showed that passengers were not at all aware of certain possibilities that are available on the Regina train. Only half, for example, know that seats could be adjusted despite this being a very commonly expressed wish.

Another reason for ascertaining people's perceptions was to find out how to design a spacious interior for the Green Train, in particular with regard to the seating arrangements. The Konstfack mock-up mentioned earlier contained a number of different seating arrangements of different sizes and design. The test subjects were asked to give their perceptions, and more specifically their "feeling" of comfort, room and personal space.

The results of this study of perception of comfort, room, and personal space have been taken into consideration in the design recommendations.

The test subjects were asked to try out the different seating arrangements and state their perception of comfort, room, and personal space for each.



By evaluating the different scores for comfort, room, and personal space we were able to determine for example how much each cm of legroom, under seat height, seat width and back inclination means.

Measuring utility and willingness to pay

How important are different factors and measures? Using quantitative studies we can sort factors with varying degrees of accuracy on different scales, for example ranking scales, interval scales or relative scales. We can say for example that attribute A is valued twice as highly as attribute B. Example: a reduction of one minute journey can be worth twice as much as a one SEK higher ticket cost.

"Revealed" and "Stated" preferences

To determine the weight of different factors we can investigate how passengers behave or say they would behave. The first method is called *revealed preferences* (RP) In this case, the investigator collected data on how people actually travelled,

Interviews using the *Stated Preferences* method (SP) involve having subjects choose between hypothetical alternatives. They say how they would choose between different journeys when travelling times, comfort and prices are combined in different ways.

The figure below shows the role played by attitudes and perceptions. A person's attitude to the train and what he or she has perceived or believes that he or she knows about the train's characteristics are thus important to their valuation of the train.

What affects our attitudes, travelling and choice of travel mode?

Different theories exist regarding how people choose a travel mode. In psychology, qualitative methods are common while in economics it is usual to use quantitative methods.

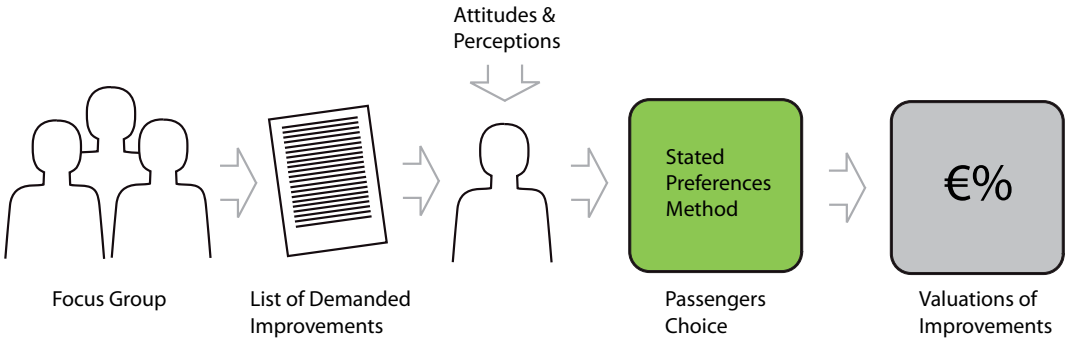
Transport economic models assume that people are rational beings and choose the travel mode that gives them the most utility. Many psychologically oriented researchers consider that people choose a travel mode largely on the basis of feelings such as perceived control and habit. In the psychological theories the individual is the focus of interest.

Why do people travel?

What needs lie behind mobility – moving from one place to another or travelling? Mobility functions both as a primary need (movement in itself) and as a secondary need. On the one hand, people travel for pleasure and on the other journeys are undertaken to be able to fulfil other needs. Economic theory often assumes that all journeys are made solely to satisfy other needs – needs at the journey's destinations. Some journeys have a value in themselves.

Methods based on utility maximization and choice

In these methods, the traffic system and its benefit to travellers are the focus of interest. Travellers choose a transport mode, e.g. car, bus, plane or train, depending on how great they perceive the utility to be – how they value the travel modes and the journey offered by each. The travel mode with the highest utility is the one that is chosen most often and by the most people. Behaviour is steered by the benefit to the individual.



The utility in the case of the train is influenced by the travelling time, the fare and the service, comfort and quality offered in connection with the journey. The supply's standard, e.g. travelling times and proximity to stops and stations, can be expressed relatively easily in utility measures.

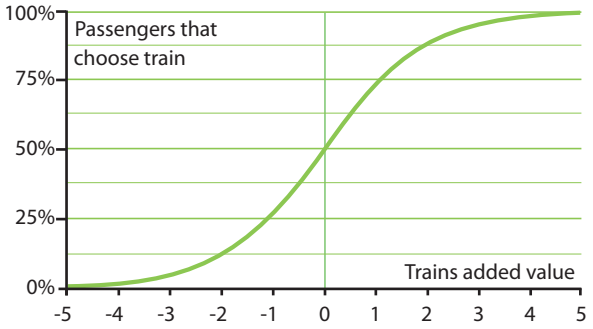
We assume that the individual can weigh his or her own utility from the different characteristics that the alternatives have against each other. Even if the individuals do not do so, it is possible to make statistical estimations of the importance of different characteristics. We can for example obtain the weight of one minute shorter travelling time or the weight of 10 cm more legroom.

The utility of different factors varies from individual to individual. This is why not all people choose the same product, type of home or way to travel.

The Logit model can reveal valuations and predict choices

The logit model is the most common economic model used to describe how individuals choose between different alternatives. It tells us that the probability of an individual choosing a particular alternative is dependent on its utility in relation to the utility of all other alternatives. The logit model assumes that individuals choose the alternative that gives them the greatest utility.

The logit model shows the *probability* (P) that people will choose, for example, to travel by train, depending on how highly they value trains compared to other alternatives.



The Logit model here shows probability as a function of "utility" in comparison with other alternatives.

Rational interviews using mini-laptops

The Department of Traffic Planning conducted its first Stated Preference interviews in the late 1980s. Since the early 1990s passengers have been interviewed using small computers handed out to them.

A passenger interview being conducted by computer on the "Kustpilen" train.

A computerised interview normally takes 10 minutes to complete and we often conduct about 100 such interviews a day on trains when we have 4-8 computers in use. Using mini-laptops enables interviews on trains (and other forms of transport) to be conducted quickly and cheaply. People are also almost always willing to participate – response frequency is around 90%.

What is "willingness to pay"?

This report describes travellers' willingness to pay for different things. What does this mean?

Economic theory states that "utility", or in terms of money "willingness to pay", is the sum of money that makes half a group of people choose a particular measure if that was the cost they had to pay. The other half would value the measure lower and would thus not be prepared to pay so much.
An example:

Two trains are standing at the same platform. They have the same departure and arrival times but one of them has a much higher level of comfort due to its interior design. One the other hand, it costs 50 SEK more to travel on this train. If half of the passengers then choose the simpler, cheaper train and the other half the more comfortable, more expensive train, we say that the passengers value the difference in comfort at 50 SEK per journey. That is "willingness to pay".

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This book is meant to be an inspiring source of knowledge on attractive interior design of long-haul and regional passenger trains. The authors address all the important issues of comfort, functionality and operating cost. Recommendations are based on extensive research and experience gathered during more than 15 years. It is shown that attractive and cost effective design solutions can be integrated in the development process of passenger trains.

Gröna Tåget (the Green Train) is a research, development and demonstration programme for tomorrow's interregional and regional passenger rail services. It is primarily aimed for the European Nordic market. Gröna Tåget should serve as a bank of ideas, proposals and technical solutions for operators, infrastructure managers and vehicle supply industry.

Attractive and Efficient Train Interiors - Royal Institute of Technology, KTH Railway Group

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