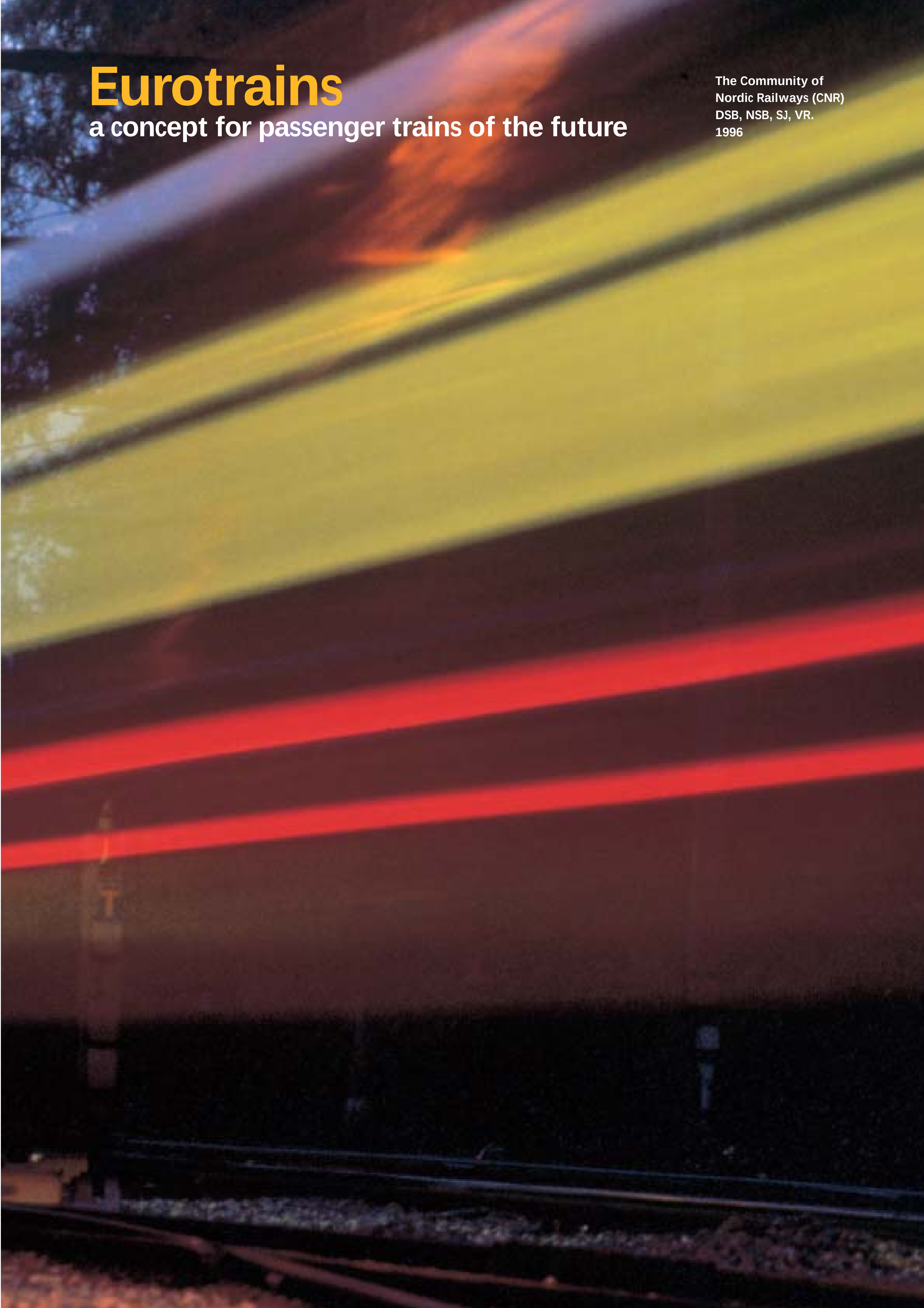
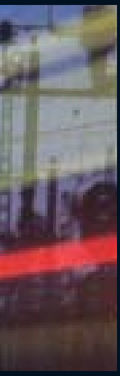
Eurotrains

a concept for passenger trains of the future

The Community of
Nordic Railways (CNR)
DSB, NSB, SJ, VR.
1996





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Foreword

The Community of Nordic Railways (CNR) is a cooperative organisation of the four railways DSB, NSB, SJ and VR. The purpose of the organisation is to make the businesses that form these railways more efficient and competitive.

A number of joint activities are in progress. One such effort concerns common strategies for the acquisition of traction and rolling stock, one of the most important resources of our railways. Here, design is of importance both for the attractiveness of the service and for the operating costs of the railways. It is evident that joint efforts in this field have great potential for improving the position of the railways.

In presenting the “Eurotrains” concept in this booklet, the CNR wishes to propose ideas for future standardised but flexibly built vehicles that can be used by most European railways or easily modified to meet their needs. The goal is to reduce the costs related to the traction and passenger rolling stock of the railways. The vision is that Eurotrains should become standard types of vehicles which can be manufactured in long series and which can be bought more or less directly “off the shelf” from various European manufacturers. Even if, for some reason, a railway cannot make use of the full Eurotrain concept, it may benefit from parts of this modular system.

While the objective of this booklet is to support the common strategies and actions of the CNR railways, we also hope that this vision will have an impact on European development and standardisation in this field. We consider this to be of vital interest to most European railways for ensuring the future viability of rail transport.

May, 1996.

SVEIN O. RINGØEN
Director, Technical Advisor, NSB

ERKKI NIEMINEN
Director of Production Departement, VR

JOHANNES PEDERSEN
Head of DSB Rolling Stock

BERNT ANDERSSON
Director of Mechanical Engineering Division, SJ

The “Eurotrains” concept is one result of the CNR project “Rolling Stock Strategy”. Based on the results, this booklet has been prepared by:
Per Leander, Transrail Sweden AB
Terje Meyer, industrial designer, Norway
Stein Longum, industrial designer NSB Design
Iacob Heiberg, design manager NSB Design

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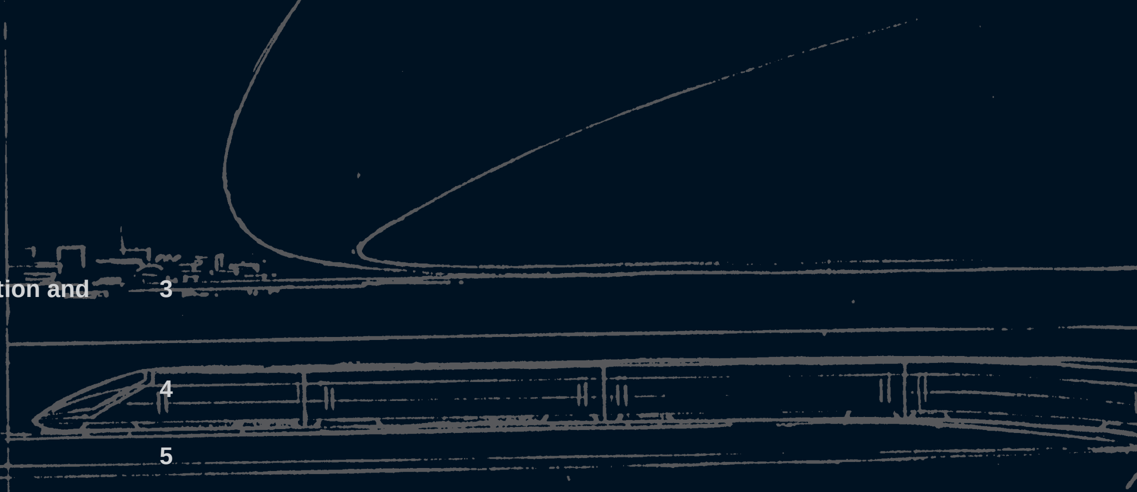
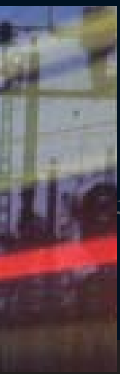




A Nordic Strategy for Traction and Rolling Stock

The Community of Nordic Railways (CNR) is a co-operative organisation of the four railways DSB, NSB, SJ and VR. The purpose of this organisation is to make the businesses that constitute these railways more efficient and competitive.

A number of joint efforts are in progress in the technical field. The purposes are to:

- provide better and more cost-effective traction and rolling stock,
- make common use of the technical resources of the CNR railways,
- influence international development and standardisation in the field of railway technology.

Many of the activities for reaching these goals focus on common strategies for the acquisition of traction and rolling stock for the CNR railways.

In Europe, acquisitions of traction and rolling stock have so far mainly been based on strong national traditions and links with the national industry. In the Nordic countries, this has led to small, specialised equipment series. It is considered necessary for CNR traction and rolling stock to be developed and purchased in a different way in the future.

Studies show that the market requirements for passenger rolling stock are very similar in the Nordic countries. This is also likely to be true on the European scene. From this point of view, one strategy is to develop a common system of rolling stock that can meet these requirements.

The purpose of this booklet is to outline such a concept of a standardised but flexible technical platform, a “box of bricks”, by which trains and rolling stock may be assembled and rebuilt to meet different demands. We have chosen to call this concept “Eurotrains”.

The proposals for the Eurotrain concept are given in spite of current acquisitions of traction and rolling stock for the CNR railways. It is obvious that a new strategy, such as that proposed in this booklet, will require a long process of co-

The Eurotrains concept

It is quite clear that, if rail transport is to be viable in the future, one requirement is to reduce vehicle costs, and costs associated with the vehicles.
There are three main ways of doing this:
– reducing investment / capital costs,
– reducing operating and maintenance costs,
– increasing utilisation of the vehicles and their capacity.
As will be shown in this booklet, the design of the trains themselves will influence all these factors.

The Eurotrain concept could provide a means of obtaining:
- trains of higher quality and reliability,
- trains of lower cost (acquisition, maintenance etc),
- large scale production even with small individual orders,
- shorter delivery times,
- flexibility regarding usage of rolling stock,
- trains suitable for border crossing traffic (interoperability),
- a second-hand market.

Trains available “off the shelf” may sound like a Utopian scheme allowing lower prices, greatly reduced delivery times of rolling stock, and reduced acquisition effort for the buyer. To some extent this may be true, but the Eurotrain concept does not relieve the buyer from the important duty of making studies to define the train he needs for his service. However, if the buyer makes mistakes or if his market changes, the Eurotrain concept should be more open to later modifications than present trains.

One may ask why Eurotrains are not a reality already. To some extent there are already certain trains which have more or less reached such status because they are good, general designs. The Eurofima coach is one example. However, generally speaking, most railway equipment has been developed to order based on the specific needs of a railway. We think that product development in the railway sector needs to be driven in another direction in the future, and we think this would be of advantage to the railways.

The main components of our vision for a Eurotrain concept are described in the column to the right. Some of the details will be further discussed in other sections of this booklet.

It is a delicate matter to set a standard. On the one hand, it must provide a basis for lower costs and interoperability, while on the other hand it must not hinder development and adaptation to customer needs. The purpose of this booklet is not to set a new standard, but to provide some input to such work. A number of questions that need pre-standardisation studies are raised.

The Eurotrain concept as shown in this booklet:

Our vision for the train of the future is a modular system resembling a box of building blocks on different levels:

- on the train level, see pages 12- 13
- on the vehicle level (external doors, vehicle end sections, interior layout and fittings), see pages 18-23
- on the sub-system level (running gear, traction, heating, ventilation etc), see pages 26-29

The various blocks are specified in terms of their interfaces to other systems, for example:

- vehicle external profile, see page 15
- entrance levels, see page 16
- gangways between vehicles, see pages 19-29
- fastening of interior modules and fittings, see pages 22- 23
- external design, see page 24
- electrical power supply systems, see page 28

The Eurotrain concept should ensure economies of scale in addition to flexibility in meeting various customer requirements.

Eurotrains in brief

Eurotrains is a conceptual draft for:

- a possible future family of CNR (possibly also European) traction and passenger rolling stock,
- a complete assembly system, a "box of bricks", for vehicles and trains,
- a system providing flexibility for building and / or rebuilding rolling stock to meet different demands,
- a possible future standard for traction and rolling stock.

Trains as components of a system

Efficient services should be operated with a varying number of trainsets (single or in multiples) during the day. The capacity of each trainset should be essentially less than the required peak performance of the service. Possible variations in train size during the day or along the line should be achieved by multiple coupling of complete trainsets. For the Nordic railways this means that the trainsets should in general be fairly small.

It should be possible to change the size of the trainsets during their lifetime. Even their usage as suburban, regional or long-distance trains should be modifiable during their lifetime.

Service and maintenance (by exchange of modular components) are to be performed within approximately 4 hours.

The trainsets should have driver cabs at both ends for rapid coupling / uncoupling and reversing at end stations.

One rolling stock family for every need

The Eurotrain system forms a series of modules by which any trainset can be assembled to meet the requirements of the particular service to be run. The family of vehicle modules consists of a series of compatible motor coaches, driving coaches, intermediate coaches and locomotives.

The future development of rolling stock is likely to go in two directions. One will be towards tilting trains in order to obtain the best possible running time performance, the other towards double-decker trains in order to achieve the lowest possible price per seat.

In many ways, the double-decker coach should be regarded as the future standard as long as curve overspeed operation is not necessary. A decision for the more expensive tilting trains must be carefully examined in relation to the particular line and the value of reduced running times.

National, Nordic or European vehicle gauge?

The loading gauge affects the largest possible cross-sections of the vehicles. The Eurotrain concept points to the need to increase the standard profile primarily in height but also in width. Double-decker coaches will become a more interesting solution in the future. Their drawbacks today are primarily necessarily low ceiling heights in compartments, as well as reduced space in upper (and lower) corners.

It is also advisable to adopt a standard European cross-section for rolling stock used by the CNR railways.

Train boarding conditions

In the future, vehicle entrances must be arranged for comfortable level boarding of the trains. Coach floors should be on the same level as the platform. It is advisable to use standard 550 mm platforms for the best possible matching of both single- and double-decker trains.

The car body design

The Eurotrain car body is expected to have the form of a tube, to which the end sections can be mounted.
The tube may be made of any type of material, but should use standard interfaces for bogie suspension, side doors and windows, shape of external cross-section etc. The idea is that the same tube should be suitable for suburban as well as regional and long-distance trains.
Different end sections may be chosen for various reasons:

- If the vehicle is to be coupled to another vehicle of the same trainset.
- If it is to form a head or tail of the trainset,
- To form head and tail end design, depending on aerodynamic considerations,
- Whether train crew and passengers are to be able to pass between multipled trainsets or not,
- Aesthetic demands of an individual railway.

Interior with flexibility

The Eurotrain concept comprises a standardised assembling system that reduces the costs of interior equipment, installation work and future refurbishing. Interior installations must be easily adaptable to various requirements. Each traffic service may impose its own requirements on the passenger environment.
Passenger areas need to be rebuilt during the service life of a coach in order to be kept up-to-date, fresh-looking and attractive. The utilisation of a coach may change many times during its service life.

Train aesthetics

To be competitive travelling by train must, among other things, offer a sense of status to the passengers. Careful aesthetic design is essential for comfort and attractiveness. The design must be perceived as modern when delivered, but timeless in character and quality. This calls for careful attention to detail, design and workmanship. The exterior of the Eurotrain car body (the tube section) should be standardised.

The Green Trains

The Eurotrain concept focuses on more cost-effective train services, partly through better use of the rolling stock. This strategy will create less environmental impact per passenger kilometre.
The Eurotrain system should also make it possible to meet traditional environmental issues, such as reduced exhaust emissions, noise and vibrations, and energy consumption, as well as the use of more environment- friendly materials.

Promising economy of the Eurotrain system

One factor in making rail transport viable in the future is to reduce the costs of the rolling stock and its operation and maintenance. A comprehensive view of the system, its trains, maintenance resources and the traffic service is essential. The trains must be regarded as part of a total system, which is designed for efficient use of its components. The trains themselves clearly influence the possibility of creating such a system.
Economic calculations for the Eurotrain concept indicate a possible reduction of the CNR railways’ rolling stock costs by approximately 40%.

Nordic market requirements on rolling stock

Studies show that market requirements for passenger rolling stock are very similar within the CNR railways. However, four different types of rolling stock can be distinguished, i.e. trains for :

- suburban services,
- regional services,
- long-distance daytime services,
- night services

Also when it comes to train design, the three train types related to daytime services show more similarities than differences.
Since the trains for night services involve many very specific considerations they will not be treated in this booklet. It should be mentioned, however, that efforts should be made to combine the functions of night trains with daytime functions to avoid exclusive, special solutions.

Some results of a joint CNR survey on market requirements will be presented in this section. They serve as a background to the concepts set forth in this booklet.

Train capacities point to smaller units but also to double-deckers

As regards train passenger capacity, all CNR railways specify trains with a minimum size of 200-250 seats and a maximum size of 600-1000 seats per train. These are present ranges for local and long-distance trains. Some studies show that it is of interest to operate even smaller units, especially for regional trains.
Cost-effective trains are partly a matter of coaches with a large number of seats as long as passenger comfort is not reduced. From this point of view, double-deckers are acceptable for the CNR railways in most services.

Increased maximum train speeds

There is a general tendency to require increased maximum speeds for trains. Today, the demands on local trains are in the range 130-180 km / h. For regional and long-distance trains on main lines, they are as high as 200 km / h or more.
NSB emphasises the use of tilting trains for regional and long-distance services in order to decrease train running times on their lines.
Due to increasing train speeds in tunnels, it is also necessary for trains on such lines to have pressure tight car bodies in the future.

A matter of time

Maximum stopping times at stations (including door opening and closing) are expected to be approximately 30 seconds for suburban trains and 60 seconds for long-distance trains. One external side door per 50 seats is considered to be sufficient if the minimum clear width of the doorways is 800 mm for long-distance trains and 1600 mm for suburban trains. Page 19 contains a proposal on how these requirements might be met within the same car body structure.

Passenger comfort, a matter of competitiveness

Comfort is of major concern. Ergonomics is vital and must be taken into consideration in all functions, as for instance in the passenger compartments: for instance related to seating, luggage handling, moving into and out of a seat, eating, reading, etc.
Certain “new” demands on interior fittings in regional and long-distance trains are now emerging, at least on an optional basis. These include items such as:

- 220 V 50 Hz UPS wall sockets for personal computers,
- children’s play area,
- TV / video,
- conference compartment,
- screened-off telephone booth with
- radio telephone,
- aerial sockets in compartments for mobile telephones,
- FM public radio system for earphones and channel selection switches on all seats,
- alarm system by which passengers can contact the train crew,
- inductive loop for hearing aids,
- remote controlled destination,
- displays on train fronts, entrance doors and in compartments,
- remote controlled seat reservation.

All railways require one or more of the vestibules to have a floor level at (standard) platform height.
Special arrangements designed for handicapped persons will be a natural part in any train solution, to facilitate boarding as well as travelling. Lifts, comfortable compartments encouraging social life, toilets adjusted to wheel-chairs, access to services as bistros etc. will be incorporated.
The aim is to give possibility of independent travelling also to handicapped people, or, if necessary, to bring helpers along and get staff support onboard.
CNR requires the interior climate and noise levels of the coaches to be similar to those of buildings. Future gangways between cars should follow the same requirements. Doors

between gangways and passenger compartments should not be necessary.

Aesthetic design is considered to be of great importance and is essential for a feeling of comfort and attractiveness. Attractive design is also important for the satisfaction of the train crew, improving their service to passengers.
Clean passenger areas are essential for the passengers' sense of comfort. Designs must permit easy cleaning.

Miscellaneous aspects of functional design

The CNR market requirements for car interiors call for a mounting system that allows flexible layout arrangement and positioning of seats and partitions.

For the service staff, it is essential to facilitate cleaning and washing by using easily cleaned materials and by enabling the staff to work in ergonomically correct positions.

The procedure for coupling/uncoupling trainsets must be rapid and it must be possible for the driver to perform this by himself. DSB is at present the only CNR railway to require a gangway between trainsets coupled together.

Maintenance should be easily performed in ergonomically correct positions at platforms or on stabling tracks. It should be possible to exchange modular components in a few hours from the inside of the vehicle.

The next chapters contain a number of functional requirements for the trains. Some of them are reflected in the demands raised by the market study.

The environment is of great concern and is further discussed on page 25.

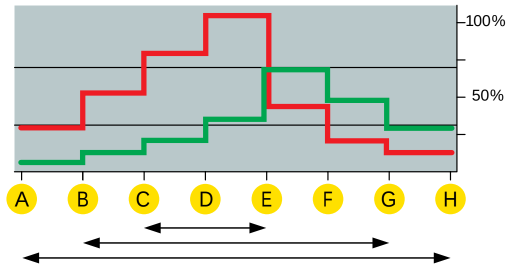
The trains are just components of a system

Some examples ....

The examples to the right illustrate the fact that efficient and attractive traffic depends not only on the trains. They are just one component of the system, and their design just a part of the system design.
The examples are highly simplified, but will raise some important questions about requirements for the trains.

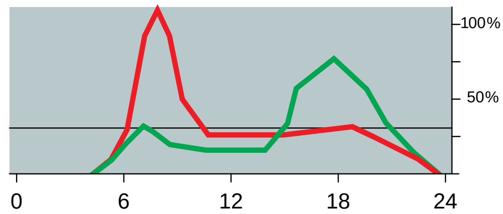
Example 1:

This example illustrates passenger flow within a traffic system on a line.



The first diagram shows the number of passengers travelling on each section of the line and in each direction within a certain time interval, e.g. the morning peak hour.

The diagrams indicate that the service may be operated with one set of trains running A–H, another set running B–G and a third set running C–E. In this example, each of the sets could have a third of the total capacity needed.

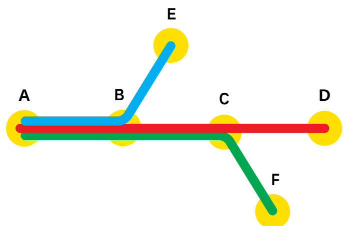


The second diagram shows the number of passengers per hour on section D–E during the day. The morning peak related to the daily average depends on the type of service, e.g. suburban or long-distance.

The diagram also indicates that the C–E shuttle(s) only need(s) to be run during the morning peak, and the B–G shuttle(s) only during morning and afternoon peaks. The rest of the day may be used for maintenance and cleaning, provided such activities do not require too much time.

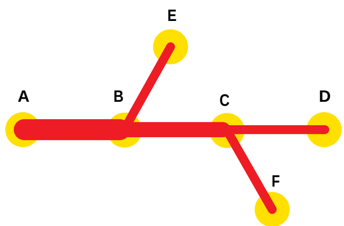
Example 2:

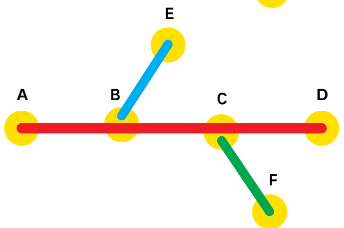
A number of stations (B–F) are to be linked to A by train services. This can be done in a number of different ways, and there are many aspects of this design.



Passenger requirements will obviously be met best by the traffic alternative to the left, i.e. direct services A–D, A–E and A–F, say with one train every hour. Such operation would give two trains per hour to C and three per hour to B.

The next alternative may depend on many aspects besides customers' needs. Such constraints may include efficient use of resources, traffic capacities on the lines etc. The situation may, for example, be that the trains need to be operated in multiples on sections A–B and B–C.





Finally is shown a solution where the traffic is operated as a direct service A–D with connecting services B–E and C–F.

.... and what we learn from them

What general lessons can be learnt about train design from these two simplified examples?They are formulated as a series of postulates below:

– Efficient services are likely to be operated with a varying number of trainsets (single or in multiples) during the day. Operation with single trainsets, i.e. not using multiple coupling, is optimal for achieving the highest possible service frequency. In spite of this fact, one might want to have a facility for rapid coupling/uncoupling in order to run trainsets part time or part distance in multiples.

– It may in some cases be desirable to enable train crews and possibly also passengers to pass between multipled trainsets. However, this is unlikely to be a general requirement if it cannot be easily met.

– The capacity of each trainset should be essentially less than the required peak performance of the service. For the Nordic railways, this means that the trainsets should in general be fairly small

– Passenger flow will change with time, and the pattern of operation may need to be changed. This means that it should be possible to change the size of the trainsets, not daily but during their lifetime. It should also be possible to change their usage as suburban, regional or long-distance trains during their lifetime.

– The trains should be built so that service and maintenance (perhaps by exchange of modular components) can be performed within approximately four hours, i.e. the time usually available between morning and afternoon peak traffic.

– Possible variations of train size during the day or along a line should be enabled by multiple coupling of complete trainsets, not by coupling/uncoupling of separate coaches.

– The trainsets should have driver cabs at both ends for rapid coupling/uncoupling and reversing at end stations.

– From an operating viewpoint, it is in most cases unimportant whether the trainsets are multiple units or locomotives and coaches in push-pull operation, but this may be a question of capital costs (see page 12).

– Unfortunately, it may also be stated that few trains, even new deliveries, meet the above requirements. Thus, the trains themselves tend much too often to impose major constraints on the system design, leading to a loss of efficiency and attractiveness for the service.

One rolling stock family for every need

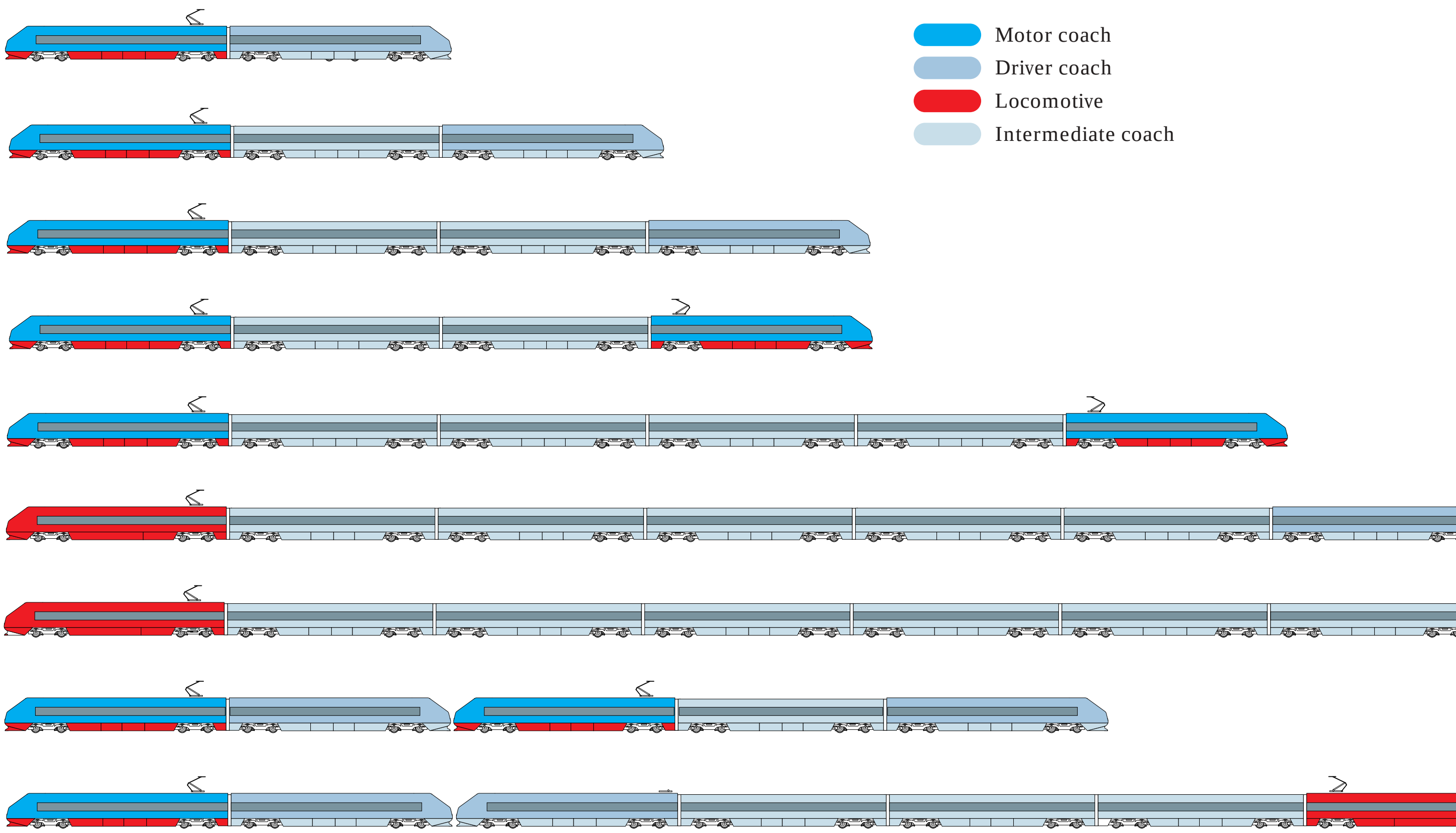
Complete vehicles form the top level of the Eurotrain modular system.. The family of vehicle modules should consist of a series of compatible motor coaches, driver coaches, intermediate coaches and locomotives. The motor coaches have the same function as small locomotives .
Combinations of these vehicle modules will allow the necessary flexibility to assemble suitable trains for any traffic demand. The demands may depend on factors such as passenger volumes or power requirements for necessary acceleration and / or speed. It should also be possible to couple the trainsets in multiples in any combination.

Vehicles to be chosen for all purposes

The figure below shows the general principles for coupling the various vehicles and trainsets. The vehicles of the trainsets are assumed to be semi-permanently coupled. They may even be of an articulated type. All of the trainsets are assumed to have driver cabs at both ends, i.e. also trains hauled by locomotives are operated in push-pull and could more or less be regarded as multiple units. One should be able to choose the vehicles for a trainset from a purely economic point of view.

The motor coaches have the same function as small locomotives (power units). Conceptually, these power units should carry all the systems necessary for traction and auxiliary power supply to the whole trainset.

As other modular standards might be better, this matter should be subject to further studies. However, the ability to assemble a trainset of suitable size and at low cost must not be reduced. Among other things, this will make it possible to adjust the size of the trains for optimum efficiency, even if their use may change with time or if the passenger flow of a service changes. The Eurotrain system should make it possible to buy new additional vehicles even in small



General principles for semi-permanent coupling of trainsets for push-poll operation, with driver cabs at both ends.

series.

Two directions predicted for the development of rolling stock

It is our judgement that the future development of European rolling stock will go in two directions. One will be towards tilting trains, the other towards double-decker trains. These two types correspond to two different demands, which unfortunately cannot be combined into a single train type (c.f. discussion on pages 14-15).

The two demands are:

– tilting trains in order to achieve the best possible running time performance,
– double-decker trains in order to achieve the lowest possible price per seat.

Capital costs

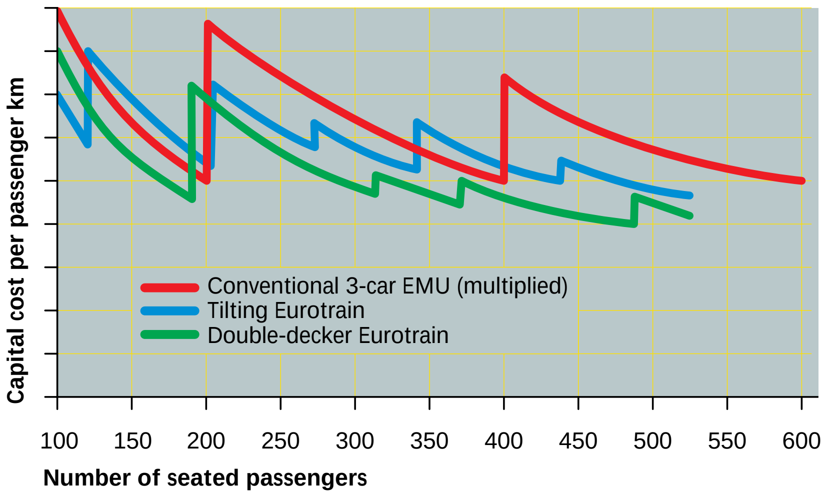
The costs per seated passenger of the two Eurotrain families and a "conventional" electrical multiple unit (EMU) are compared in the following diagram.

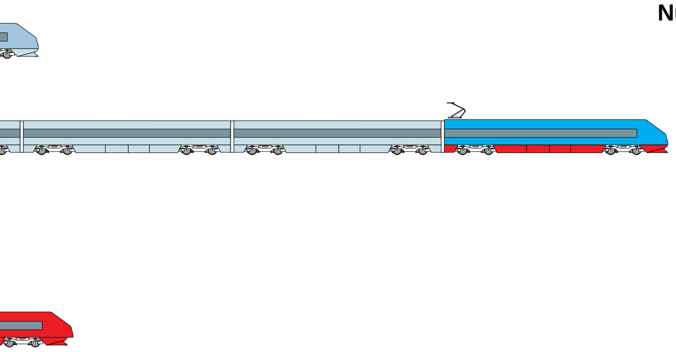
The diagram must be regarded as indicative only, and may appear slightly different depending on the products compared. Only capital costs are considered. The diagram does not take into account the expected reduced costs of the Eurotrains due to factors such as larger production series etc. This is further discussed on pages 32.

The differences between the two Eurotrain families in the diagram may appear marginal, but represent a 10-20% reduction of capital cost depending on train size. Other advantages / disadvantages of the two types are not considered in this presentation. For many reasons, double-decker trains should be regarded as the future standard as long as curve overspeed operation is not necessary.

Tilting trains can admit a curve speed increase in the order of 20%. However, the total reduction of running time on a line will depend on the total percentage of speed restricting curves for non-tilting trains. A decision in favour of the more expensive tilting trains must be

The step increases in costs represent the number of seated passengers at which another vehicle must be included in the trainset. For the "conventional EMU" this represents the point where another 3-car EMU must be multipled.

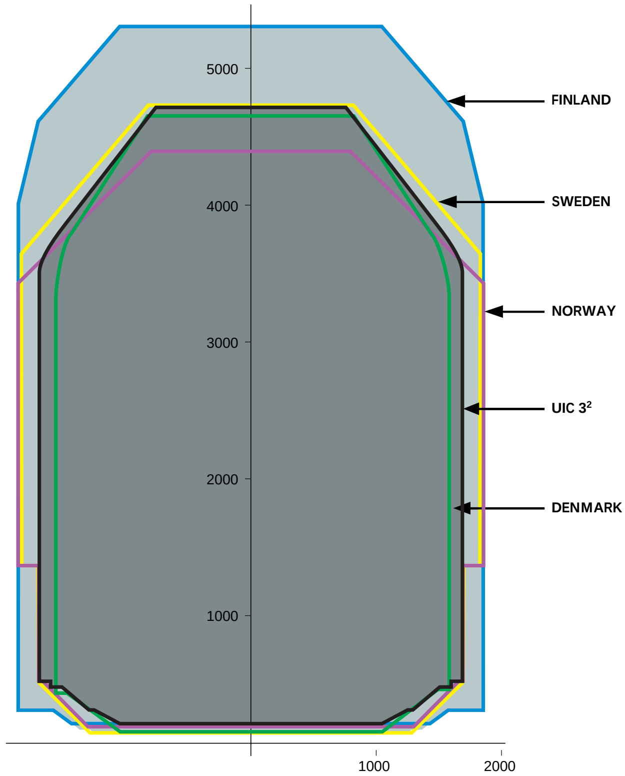


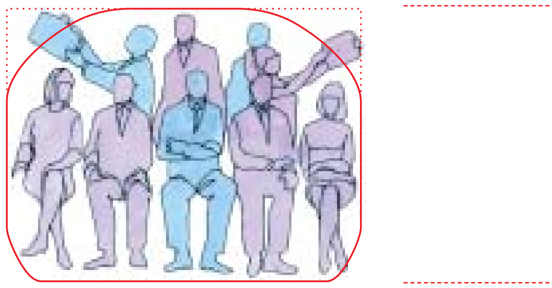


National, Nordic or European vehicle gauge?

The loading gauge is one of the most important differences between the European railways. This affects the size of the largest possible cross-sections of the vehicles. The vehicle gauges in the Nordic countries as compared to the European profile UIC Table 32 is illustrated by the figure below.
The Swedish, Finnish and partly the Norwegian railways have the advantage of already using relatively large vehicle gauges, which are wider and higher than in other European countries. This results in a competitive edge for national freight traffic and better comfort in passenger coaches.

However, it may be an economic advantage to use the Table 32 profile for passenger coaches in the Nordic countries also, in spite of the fact that the external width of the vehicles will be approximately 300 mm less than possible. The Eurotrain concept points towards such a strategy.
It is advisable to study standardization according to the vehicle gauge in Table 32 in spite of the fact that this gauge is higher than the international loading gauge, i.e. the dominant profile in France and Italy (UIC Table 31; the smallest in Europe except for England). However, it will be possible to use vehicles that comply with the Table 32 gauge on a reasonably large number of railways (on page 27).

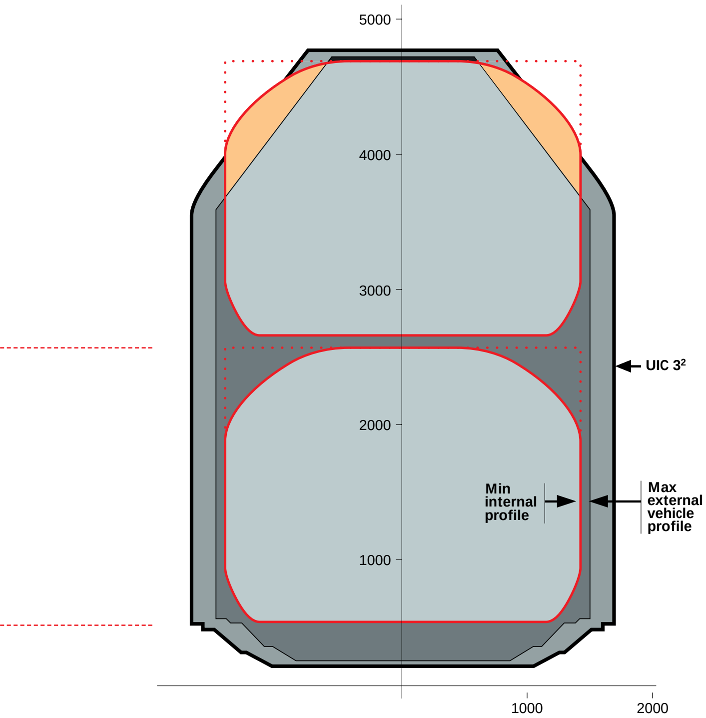


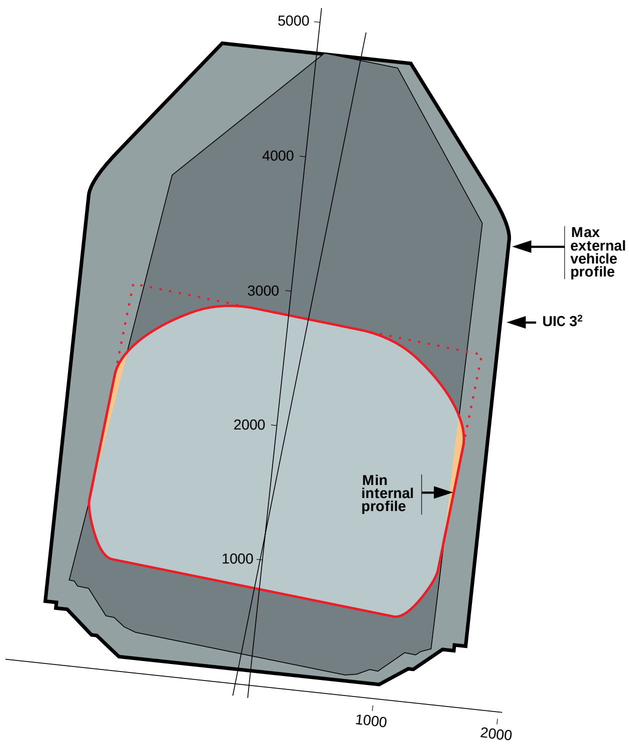


Required space for passenger compartment.

As can be seen from the figures on this page, it will be of interest to increase the standard profile, primarily in height but also in width. We believe that double-decker coaches will become a more interesting solution in the future. Their drawbacks today are primarily the necessarily low heights of compartment ceilings, as well as reduced space in upper (and lower) corners.

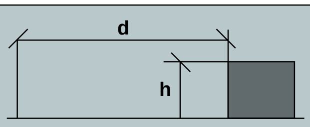
The two figures below show existing conflicts between requirements for interior space and available external vehicle profiles in order to comply with the Table 32 gauge. The figure to the left shows the situation with a double-decker, while the figure to the right shows the situation with a tilting car body.
The various figures also show the advantages and disadvantages for the various CNR railways if they were to use trains standardised to the Table 32 gauge. In that case, the Finnish railways would not make use of their higher vehicle gauge. As can be seen





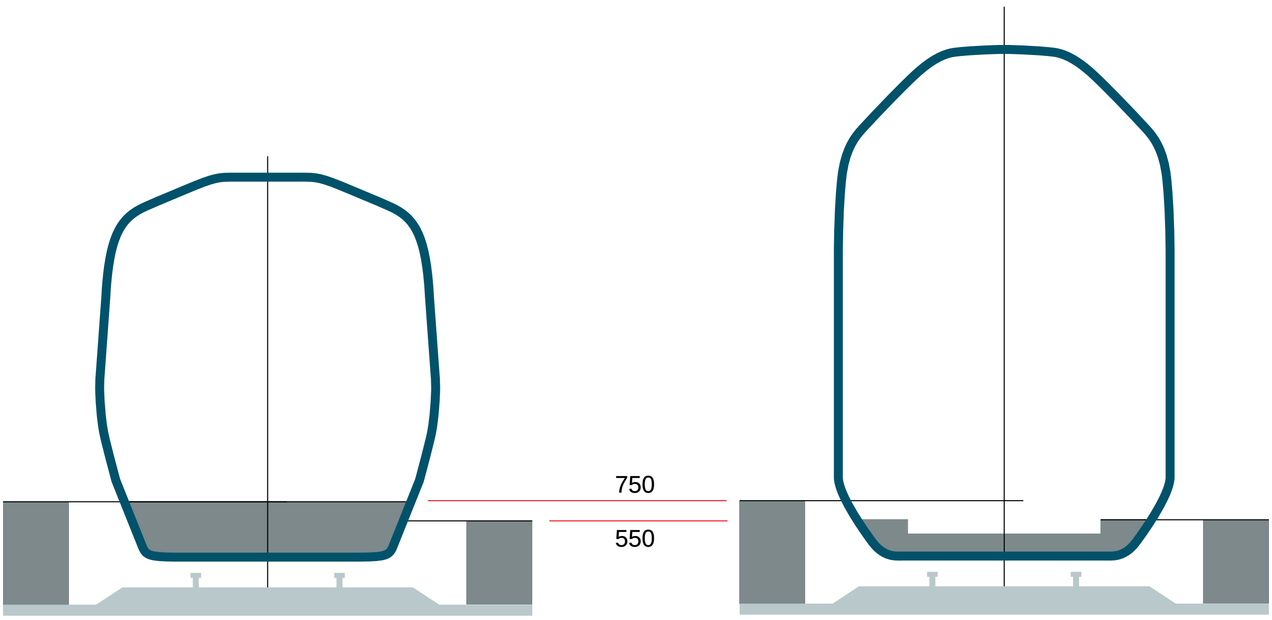
Train boarding conditions/platform levels

There is a large variation in platform standards in Europe. The situation in the Nordic countries is shown in the following table along with the UIC standard. The recognized standard is indicated in bold letters.
Vehicle entrances must be arranged for comfortable boarding from platforms with heights of approximately 350, 550 and 750 mm. 550 mm is regarded as standard. 700-750 mm is used for suburban traffic in a number of the major Nordic cities.

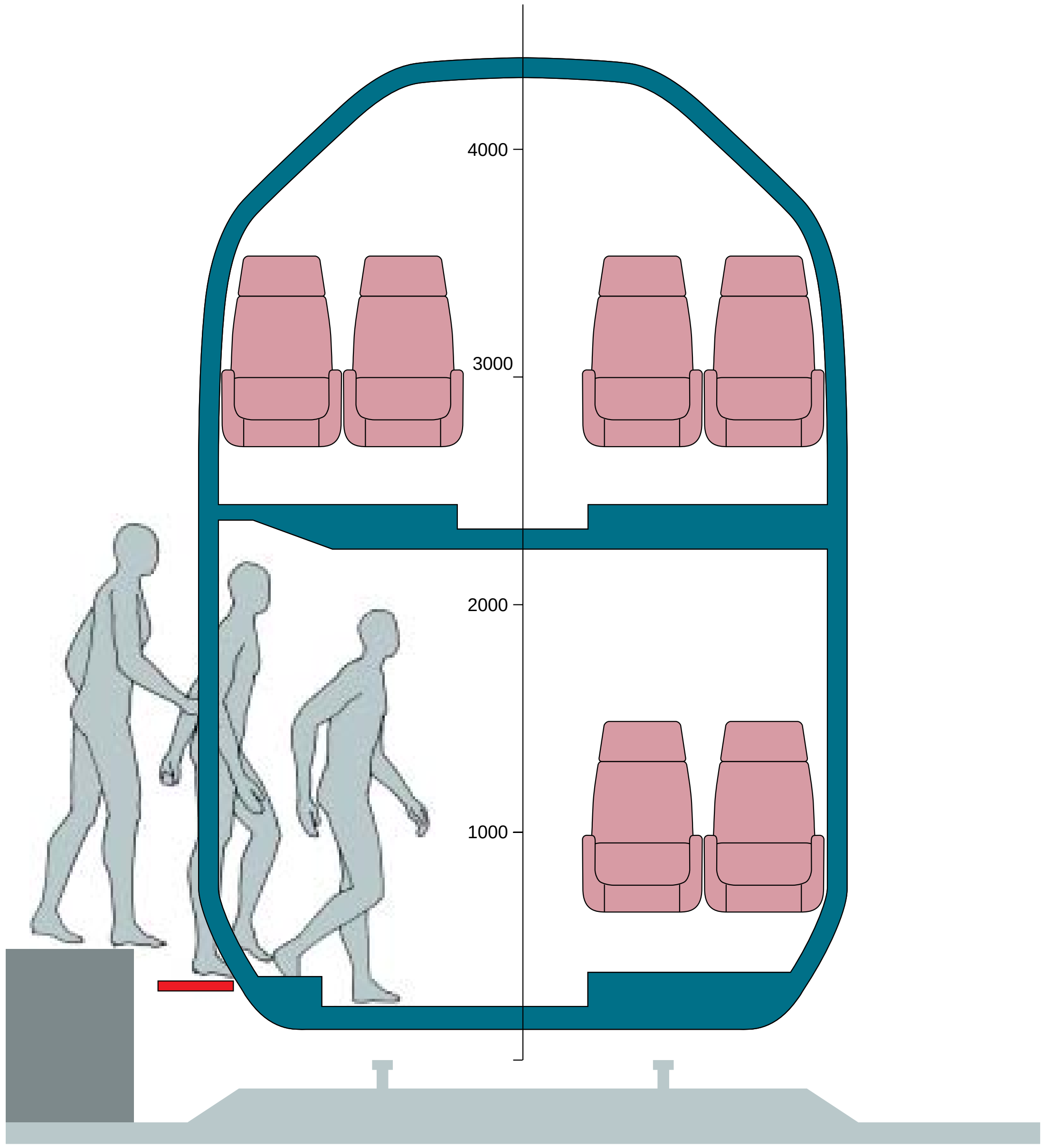


	Low platform		Medium platform		Heigh platform	
	h	d	h	d	h	d
Denmark			**550**	**1657,5**	720	1667,5
Norway	350	1520	**570**	**1660**	700	1700
Sweden	350	1550	**580**	**1700**	730	1700
Finland			**550**	**1800**		
UIC			**550**		**760**	

550 mm platforms will allow the best possible boarding conditions
At present all the CNR railways require one or more of the train vestibules to have a floor level at (standard) platform height.
The demand to be able to use both double and single-decker coaches creates a certain problem. For double-deckers, the limited vehicle height results in a requirement that the lower level floor must be less than 400 mm above rail level, i.e. platforms should be low. In the case of single-deckers, such as tilting trains, the best choice would be a floor level higher than 900 mm. This would make it possible to have the same floor level throughout the whole train. New designs of running gear might make it possible to reduce train floor levels to approximately 700 mm or even lover.
Various demands make it necessary to compromise by using standard 550 mm platforms and allow one step when entering the train. 700-750 mm platforms will be acceptable with the single-decker, but require two steps to enter or leave the double-decker.
Even with this compromise on platform heights the problems with double-decker roof levels remain.
The situation is illustrated by the figure on the next page.

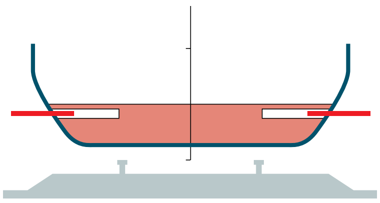


Entrance conditions single-decker. *Entrance conditions double-decker.*



Cross-section by the entrance area in a double-decker.

A matter of safety, comfort and time
A movable device at entrances to bridge the gap between the platform and the train is a new component for which there is increasing demand.

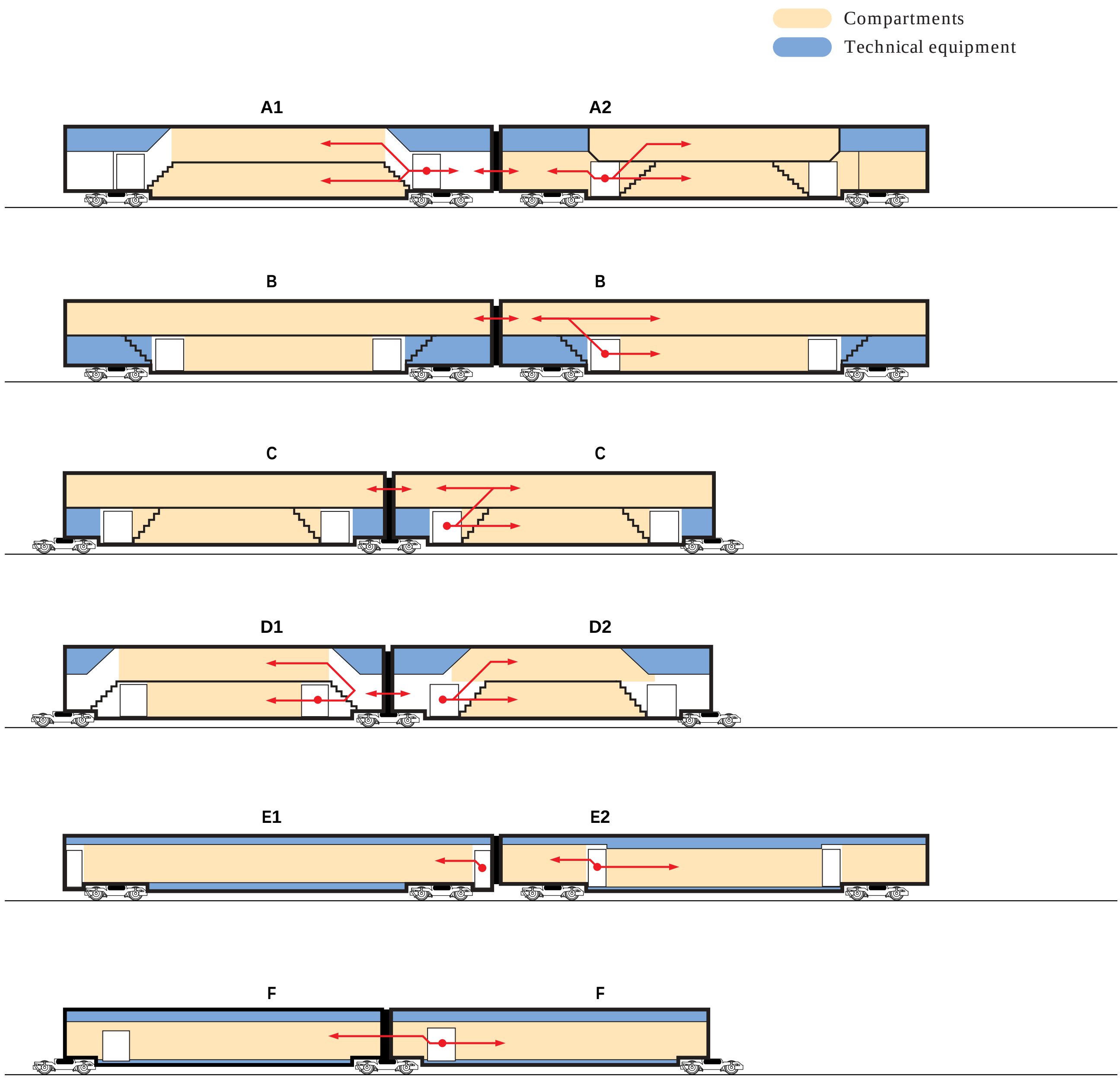


General layout and design of the vehicles

The purpose of this chapter is to outline a few items relating to the general layout and design of the Eurotrain vehicles.
The principal drawings below show a number of alternative solutions to double and single-decker coaches. The drawings show traditional designs as well as the new low-floor designs.
Orange areas show compartments and blue areas show available spaces for the technical equipment.
Boarding conditions are indicated by red arrows. Some general items of concern for to the layouts are:

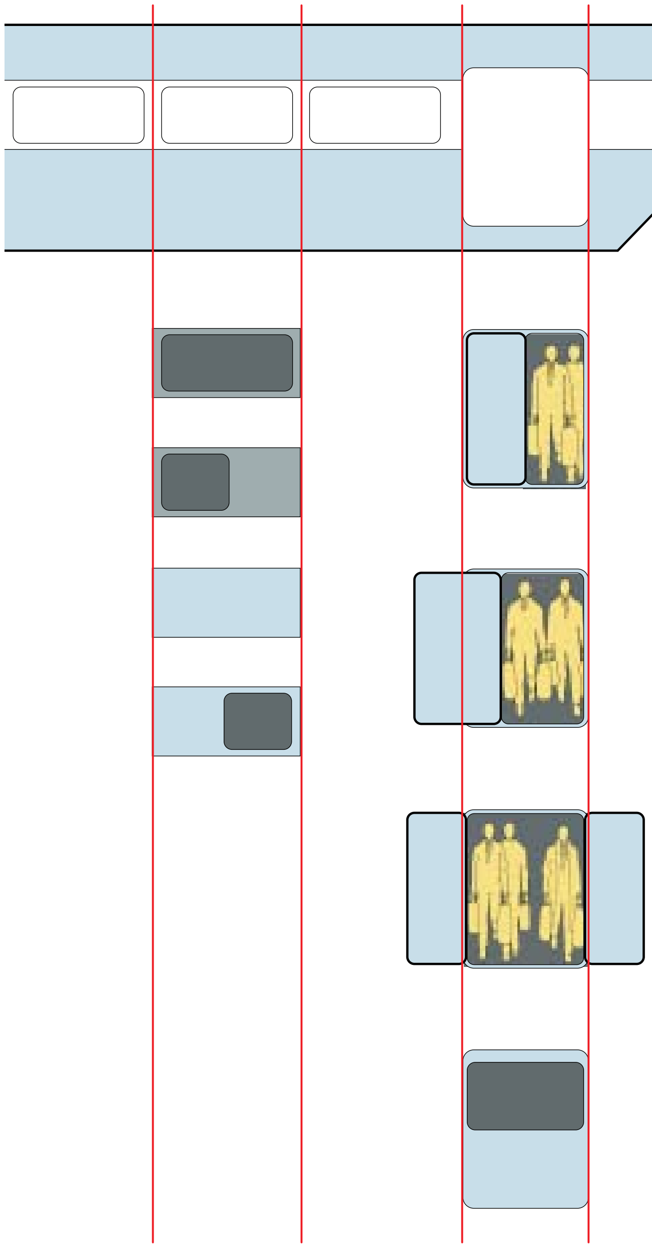
– Boarding on level with the platforms neccesitate vestibules between the bogies.
– The compartment sections should be as long as possible. This will make it possible to install seats and other interior equipment in a flexible way, for example to install various numbers of seat rows.

From these drawings it is clearly seen that the double-decker version “C” allows the largest available compartment length compared to train length. Version “B” allows an upper-deck level floor through the whole train. Another advantage is that technical equipment can be arranged relatively low and close to the bogies.
A possible drawback with the articulated designs (“C”, “D” and “F”) is that the coaches cannot be easily separated for maintenance as long as conventional bogies are used. On the other hand, the gangways between coaches will be more comfortable and



The Car body - a one for all and all for one tube

simple.
The Eurotrain car body is expected to have the form of a tube, to which the end sections can be fastened. The tube may be made of any type of material, but should use standard interfaces for connections to end sections,bogie suspension, side doors and windows, shape of external cross-section, etc.
This concept enables use of the same tube for suburban as well as for regional and long-distance trains (shown below with various side door and window components).
The door openings should for example be able to fit with doors of variable width. It should also be possible to insert a window section instead of a door, thus changing the vestibule into a part of the compartment area. The whole wall section with the door and the door mechanism could perhaps be a premanufactured component.
Window openings should be able to fit with full-length windows, or other sections depending on interior layout and installations.
On the inside the tube should have a standardized system for flexible fastening all interior installations.



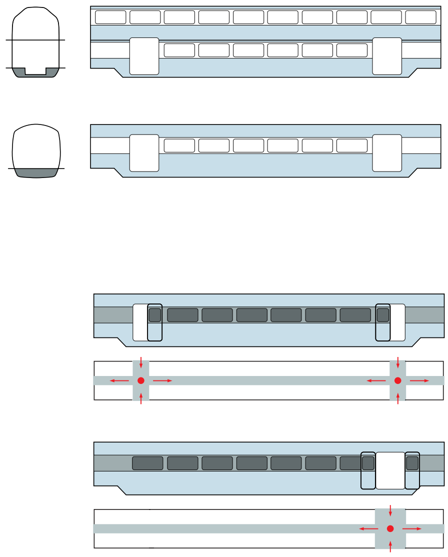
Number of persons passing throught at the time.

Door width 900-1100 mm. 1 person

Door width 1200 mm. 1.5 persons

Door width 1600 mm. 2 persons

Window



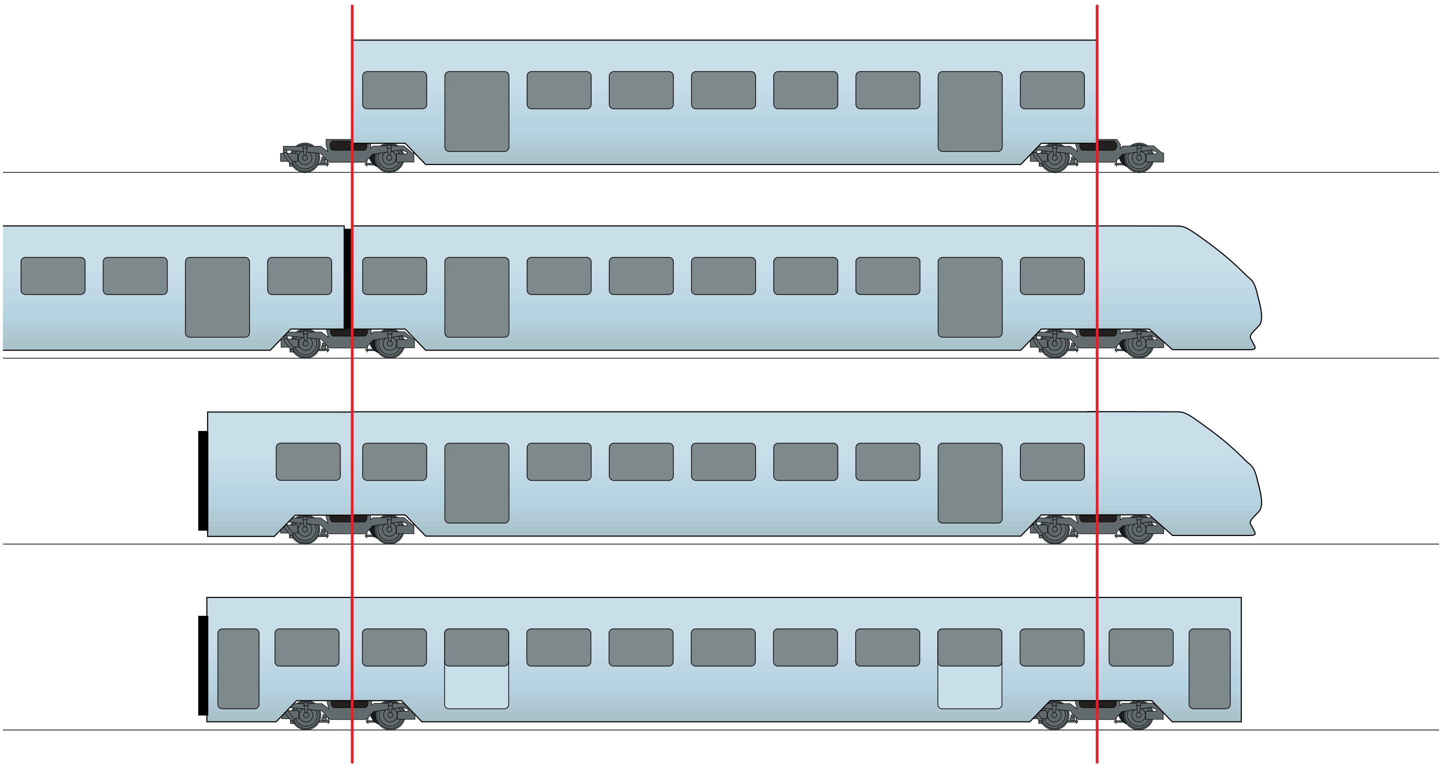
The standardized car body allows variations suiting different purposes and services.

Front and rear ends

The concept here allows various end sections to be fixed to the tube. The figures on these pages show some examples.

The standardized car body, together with the series of different but compatible end sections, will make it possible to assemble various vehicles. An end section may be chosen on the basis of:

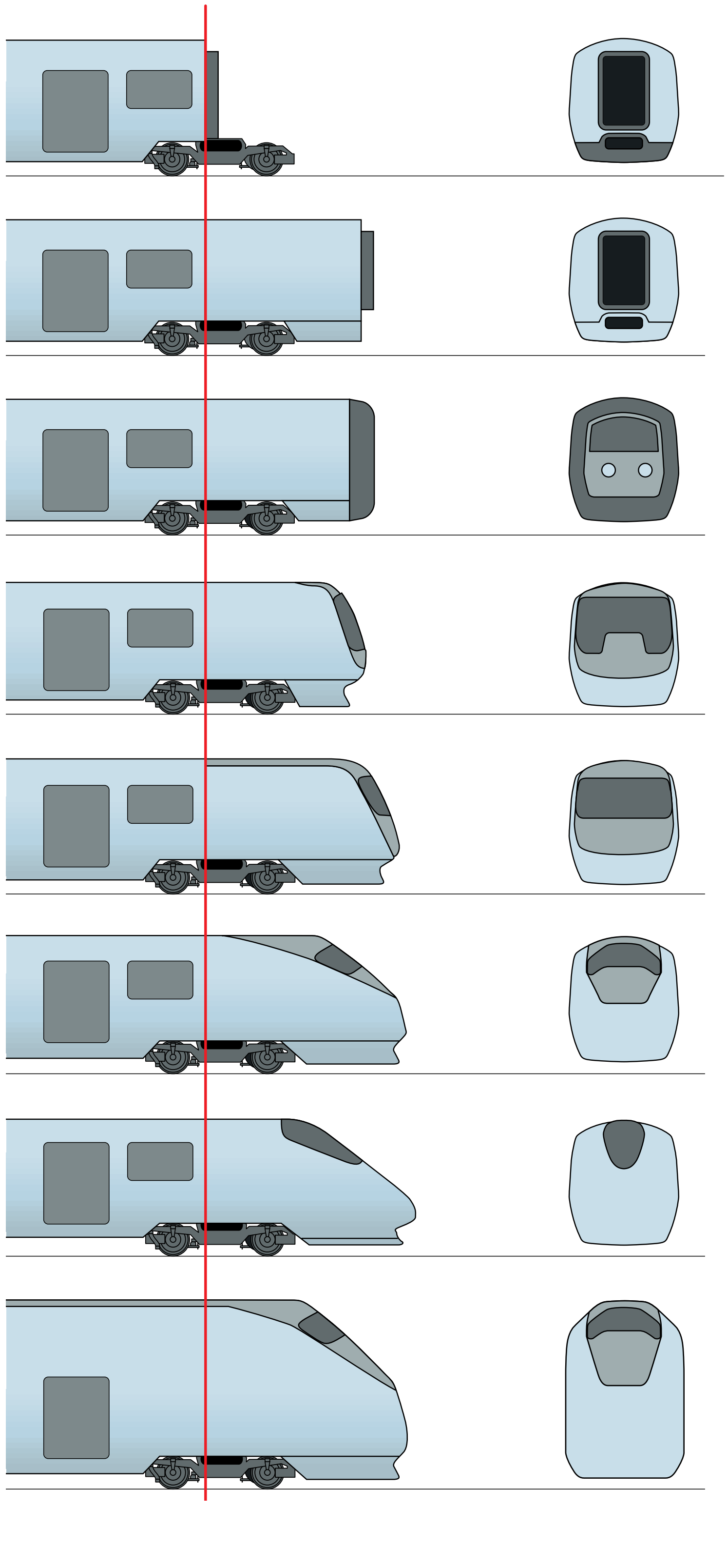
– Whether that end of the vehicle is to be coupled to another vehicle of the same trainset or is to form a head or tail of the trainset.
– Head and tail end design depending on speed and aerodynamic considerations.
– Whether train crew and passengers



are to be able to pass between multipled trainsets or not.

– Crashworthiness.
– Aesthetic demands of an individual railway.

The end sections and car bodies should, of course, have standard interfaces, such as cross-sections, assembly method, subsystem connections, etc. The exact design, and the most suitable location of the interface between car body and end sections remains to be developed. It may be possible to fix the end section to the car body as an almost final step in assembling the vehicle. This might facilitate the erection of the interior of the vehicle.



End section car body on Jacobs-boogie

End section ordinary car body

Train head local train (DSB)

Train head for local traffic

Train head Intercity

High speed train heads

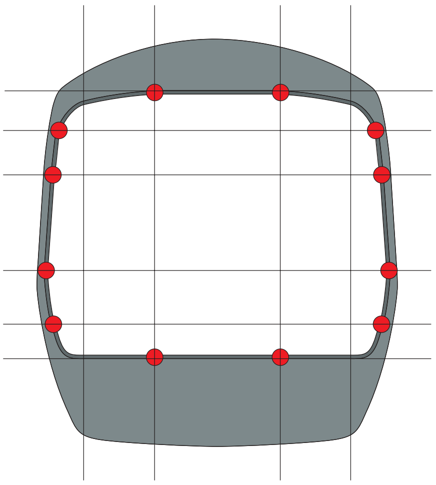
Train head double-decker

Interior with flexibility

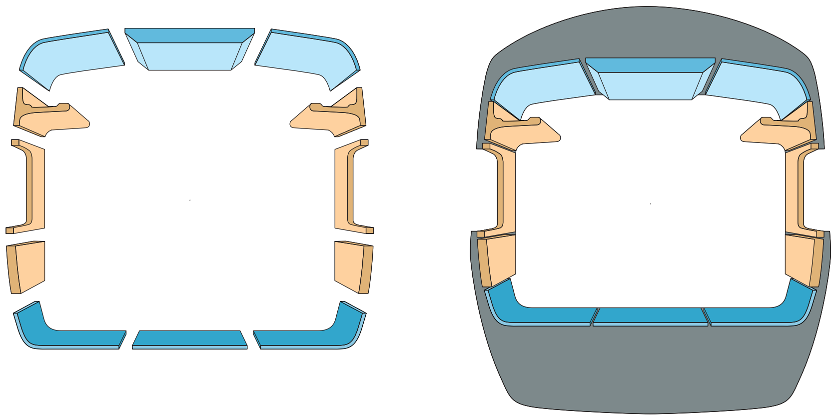
The CNR market requirements on seating arrangements demand flexibility, i.e. 2+1, 2+2, 2+3 if possible, facing, non-facing and variable pitch between seats. In the future, there may be demands for layouts quite different from the standard seat rows of today.
Other CNR requirements call for a flexible assembly system for partitions, thus allowing flexible layout arrangements of passenger compartments, use of food dispensers or a galley / bistro, a train staff compartment, lavatories, an express goods compartment and areas for transportation of bicycles and skis.

A standardized, flexible building system for vehicle interiors
A system is needed that makes interior installations easily adaptable to various requirements. Each traffic service may impose its own requirements on the passenger environment. Passenger areas need to be rebuilt during the service life of a coach in order to be kept up-to-date, fresh-looking and attractive. The use of the coach may change many times during it's service life.

A standardised module and assembly system should reduce the costs of interior equipment as well as installation work.
For obvious reasons, the car body will be modular in the longitudinal direction (cf. figures on page 19). The interior, however, will have a cross-section which is split into modular segments as shown in the figure below. Each segment will have standardized longitudinal bars to which floor, wall and roof sections as well as various other interior

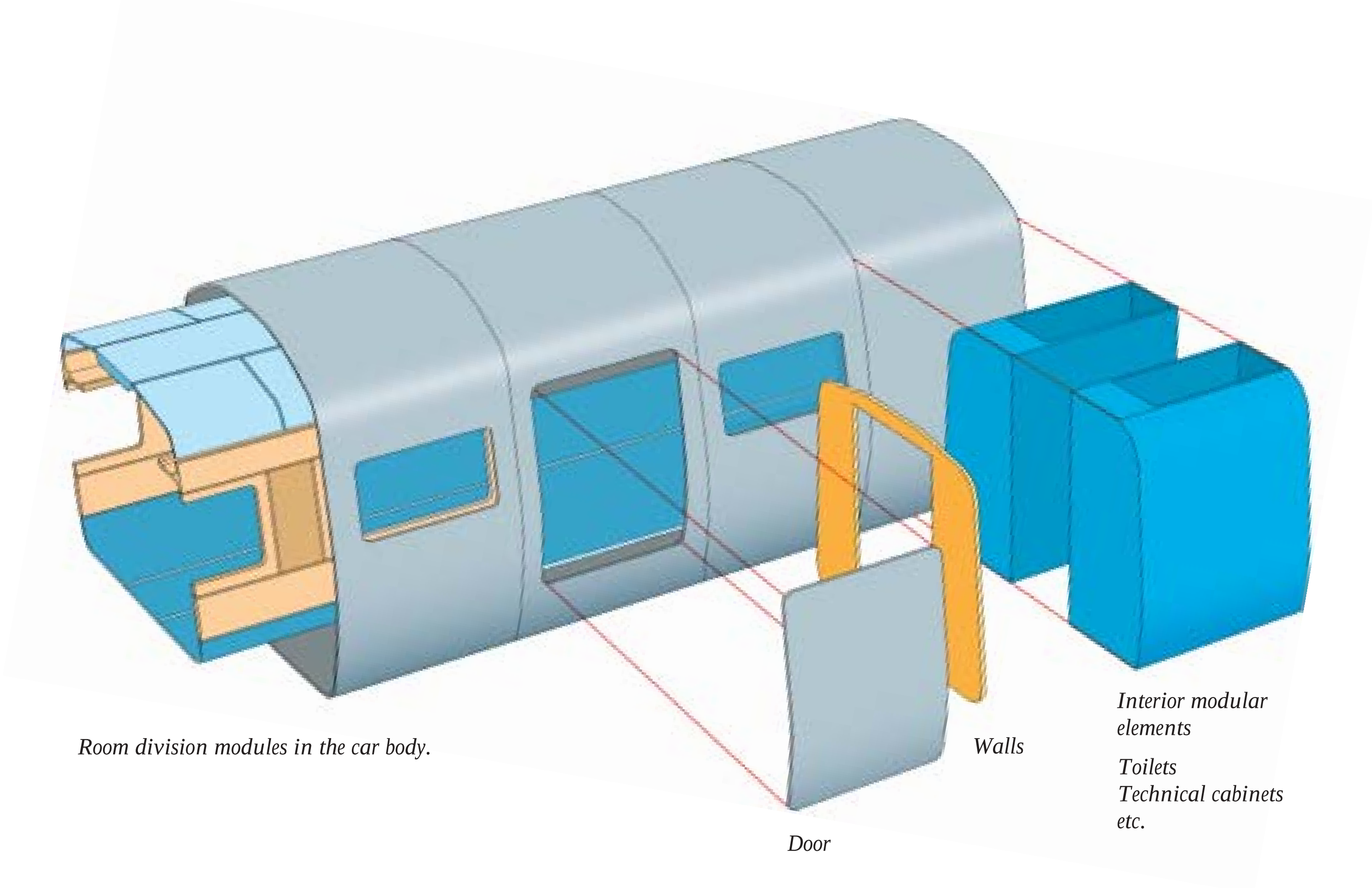


Mounting rails in the cross-section.



Modular elements for a flexible interior.

equipment are fixed. Interior assemblies can be placed anywhere in the longitudinal direction.
Ideally, but not necessarily, the positioning of interior elements will correspond to the window modules of the car body. Interior modules may have various shapes, materials, colours etc, but with the same standard fittings.
A proposal for an interior assembly system is illustrated on this page.



Room division modules in the car body.

Train aesthetics to be taken seriously

Modern, functional and attractive design stimulates people to travel by train. To be competitive, travelling by train must, among other things, present a certain status to the passenger. The train design should also produce satisfaction and a feeling of pride in the train crew, improving their service to the passengers.

Careful aesthetic design is essential to impart a feeling of comfort and attractiveness. The automobile industry has realised this. There are also many good examples in the public transport sector, at least not in the Nordic countries, but much remains to be done.

Fortunately, people have varying tastes and feelings when it comes to style. However design should be left to professionals. There are many important common issues:

– The design must be perceived as modern when delivered, but timeless in character and quality. This calls for careful attention to detail, design and workmanship.
– Shape, colour, surface character and function must combine to form a clean and harmonious whole. Surfaces must fit together in such a way that total harmony is not lost. The choice of materials and components must as far as possible contribute to an aging process experienced as a positive patina rather than dull wear.
– The external design must express a character of advanced technology: fast, safe, comfortable, aerodynamic and environment friendly. It should create a perception of the whole train as a harmonious entity, attractive to enter.
– The entity concept calls for common specifications regarding external design and surface finish. The vision is that a train can be formed from vehicles purchased from different suppliers at different times, but coupled together to form an entity.
– Interior design may differ from one vehicle to another. However, human needs are always in focus.

Eurotrain must convey a good impression at long, medium and short distances. The aesthetic design must cover all.

“Green Trains”

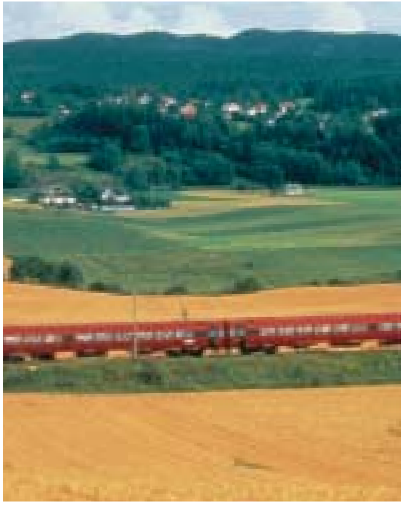
Public transport, especially rail transport, is highly environment-friendly. The purpose of this section is not to repeat general arguments on this matter. Instead, we will present some of the advantages that the Eurotrain concept should offer in terms of the environment. Eurotrains will be more “green” than conventional trains.
It has been argued that traditional requirements for railway vehicles have led to products with an excessively long technical life. According to the same arguments, train costs could be reduced if vehicles were built from components with shorter lives, resulting in larger profits for railways.

Today, the arguments are beginning to turn around completely. “Green products” must be recyclable. The most environment-friendly situation would be when recycling or re-usage takes place at the highest possible level. The ability to refurbish and modernise rolling stock is being included in the agenda. Today, the traditional railway requirements for robust design and consequently long lives go more or less hand in hand with concern for the environment. From this standpoint, the future task of train designers will be to find solutions that can provide long lives along with attracting customers and providing comfort during the entire lives of the trains.

Less environmental impact

The Eurotrain concept focuses on more cost-effective services, partly through the ability to minimise the necessary resources for a specific traffic service. This will also produce environmental advantages since the strategy leads to less environmental impact per passenger kilometre.
The Eurotrain system presented in this booklet should make it possible to meet these two demands on top of “traditional” environmental issues, such as:

- Reduced exhaust emissions.
- Reduced noise and vibrations.
- Reduced energy consumption.
- Choice of materials.
- Wastes and other operation-related parameters.



The concept of “sustainable development” requires a great deal of rethinking in terms of the production, use and scrapping of materials, components and products related to train operation. The principle of “Life Cycle Analysis” – LCA – is becoming increasingly important. It will obviously be one of the future design parameters.

We believe that Eurotrains will offer many environmental advantages through the expected thoroughness of their development.

The technical heritage of the European railways .... and associated Eurotrain modules

A proposal for a possible future standard of European trains cannot be persented without a brief discourse on existing deficiencies in technical harmonisation between the European railways. The technical heritage is of course partly a problem that is not easily overcome. It definitely affects the possibility of standardization.

The European railways have been developed over a period of more than a century, characterized by rapid technical progress. Their starting position in the middle of the 19th century was not the same. Standardization and interoperability were not major issues at that time, but the choice of efficient technical systems was. For various reasons, the choices became slightly different for different railways. Development since then has to a large extent been a question of extensions of previous investments. It is not surprising that there are problematic shortages in the technical standards of the European railways today, even if important work on harmonization has been done by the UIC (the International Railway Union). Efficient border crossing railway traffic will become more important in Europe in the future. The standardization efforts of the railways are being encouraged by the European Commission, which is now taking a number of initiatives towards interoperability in the European railway network. The first step will consist of directives and technical specifications for interoperability in the European high-speed network. Other areas will follow.

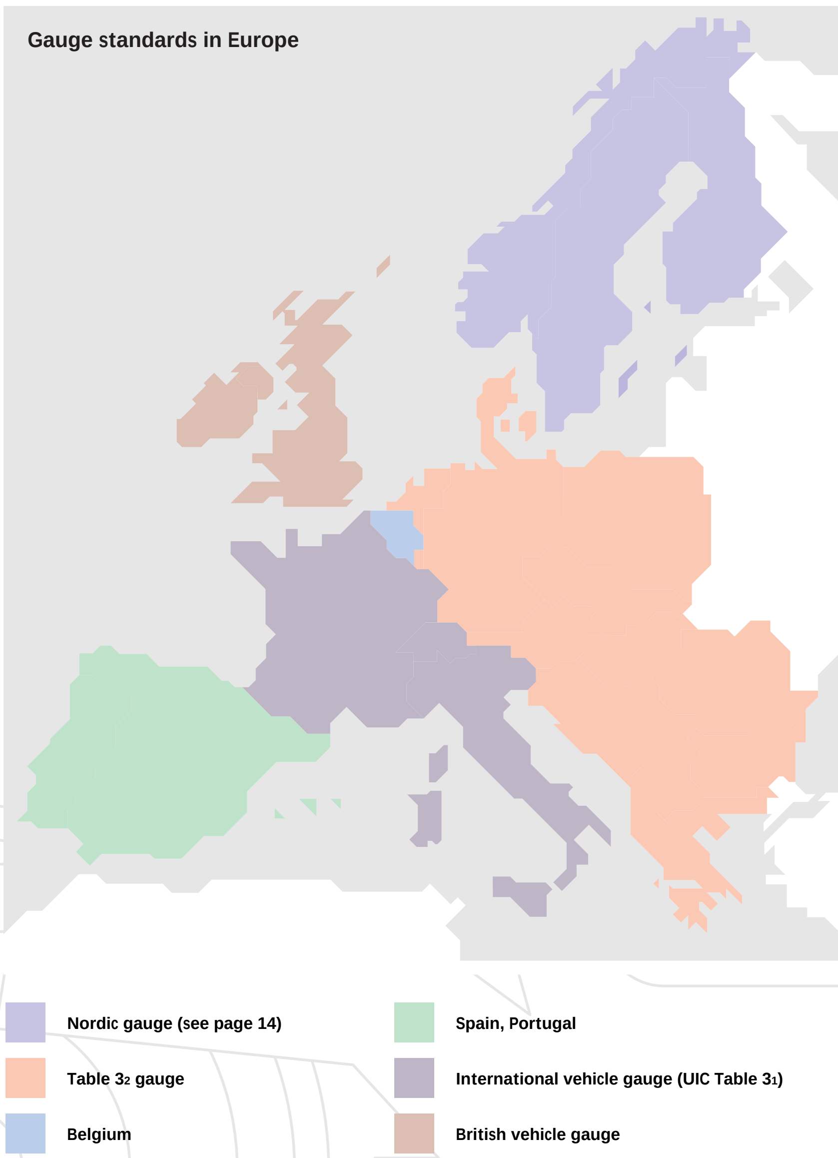
However desirable, the possibility of creating a pan-European standard for the railway infrastructure remains limited owing to the costs of the necessary rebuilding of existing equipment.

This section provides a brief description of certain items that will affect the Eurotrain concept. Some of these items have been treated in greater depth in earlier sections.

Track and running gear

Fortunately, the track gauge is the same on most of the European national rail networks. The broad gauge networks of Russia, Finland and Spain are important exceptions.

The differences in track gauge do not constitute an obstacle to the Eurotrain concept. Running gears are expected to take the form of modules with compatible interfaces to the car bodies. However, interoperability of



the systems will remain problematic even if there are both existing and emerging technical solutions to the problems of automatic wheel gauge adjustments.

Even if the main part of the European railway network has approximately the same track gauge, there are other important deviations in track standards. The rail inclination, rail head and wheel profiles show differences between the various networks. These factors affect the running properties of the rolling stock at high speed, which means that a vehicle with good running properties on one railway line or network does not necessarily demonstrate the same properties on another line.
Variations in track stiffness in combination with vehicle suspension is another area which might create problems.

The Eurotrain concept will include running gear modules that differ not only in regard to track gauge, but also in other respects, such as:

– Maximum speed.
– Quality of track alignment on the lines where the trains are to run.
– Driving or trailing.
– Tilting body or not.

Loading gauges

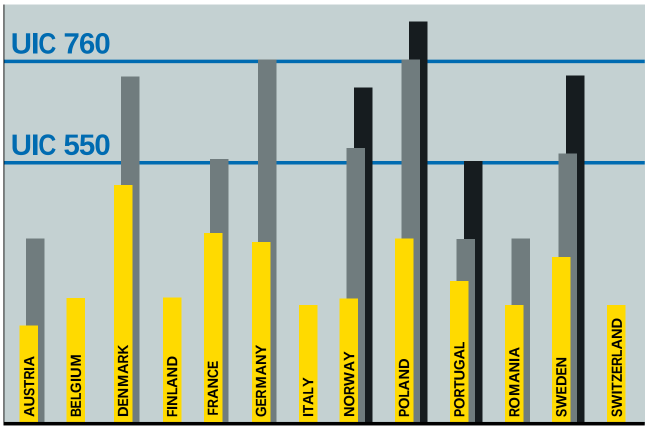
The loading gauge is one of the most important differences between the European railways. This affects the size of the maximum cross-section of the vehicles.

The map below shows the main loading gauge standards in Europe. Larger loading gauges may be permitted on specific lines.
The Swedish and Finnish railways have the advantage of already using relatively large loading gauges, which are wider and higher than in other European countries. The Eurotrain concept calls for a common standard for loading gauges. These issues are discussed on pages 14–15.

Platforms

There is a large variation in platform standards in Europe. The situation is shown in the diagram below. It shows platform heights in various European countries as well as the UIC standard heights. As can be seen, there is a large difference between countries, but also within some of the countries. The large variations create certain problems for interoperability and do not meet modern requirements for passenger comfort and accessibility for people with restricted mobility.

The current tendency regarding train boarding conditions is that all the CNR railways require train vestibules to have their floor level at platform height. This is of course difficult to achieve with the existing variation in platform standards.
Aspects of train boarding and platform height standards are discussed on page 16.

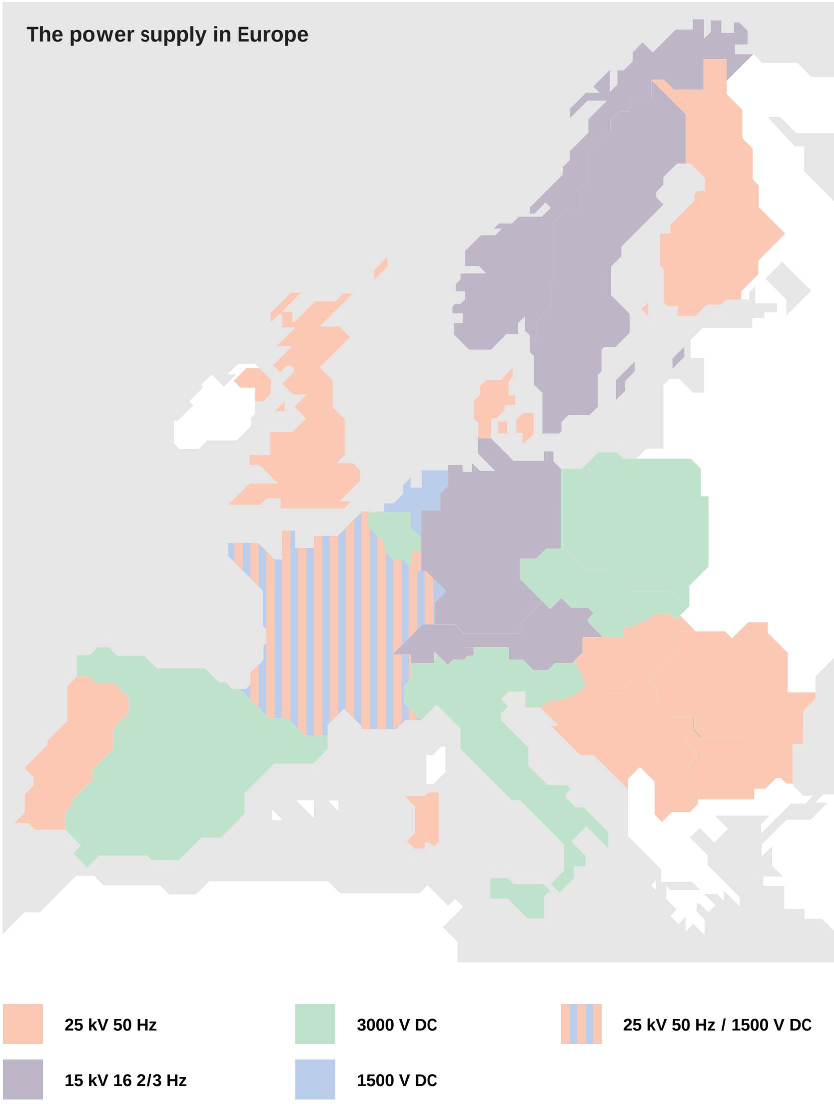


Platform standards in Europe

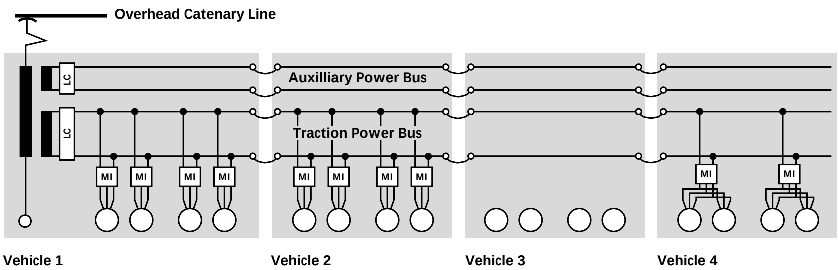
The power supply systems

The electrification of the railways started at the beginning of this century. Available technology at that time made it necessary to use either direct current (1500 or 3000 V) or low-frequency single-phase alternating current. The latter system was chosen in Sweden and Norway, among other countries. By the '60s, rectifier technology had reached a level which made it possible to build locomotives for 50 Hz alternating current. This has been chosen for electrification in Finland, Denmark and certain other countries.
The result of this development can be seen in the heritage of the European railways. At present, there are four major electrification systems and the European railway electrification map resembles a patchwork quilt as can be seen in the figure below.

It is of course possible to build railway vehicles that can operate on various combinations of these power supply



In the Eurotrain concept, the traction system is one of the modular subsystems. It might have configuration shown in the figure.



systems, but so far this cannot be done without technical and economic disadvantages. However, it is possible that future electronic power conversion devices will reduce the problems of designing traction systems which can operate on different voltage systems.

One idea is that the future traction motor drive system should allow the use of any number of driven axles in the train. Such a design might take the form of a traction bus system as shown in the figure. The Traction Power Bus corresponds to the DC link in today's conventional induction traction motor drives.

In this system, the number and power ratings of the motor modules (MI), as well as the line power in-feed modules (LC), can be chosen as optimal from case to case.
The line power in-feed module(s) must be chosen according to the required total power rating of the traction motor drives and also the electrification system(s) where the train is to operate.
The different power supply systems affect not only the traction motor drives of the trains but also the power supply to auxiliaries and heating. A new standard Auxiliary Power Bus (either DC or 50 Hz three-phase AC) through the train should be developed.

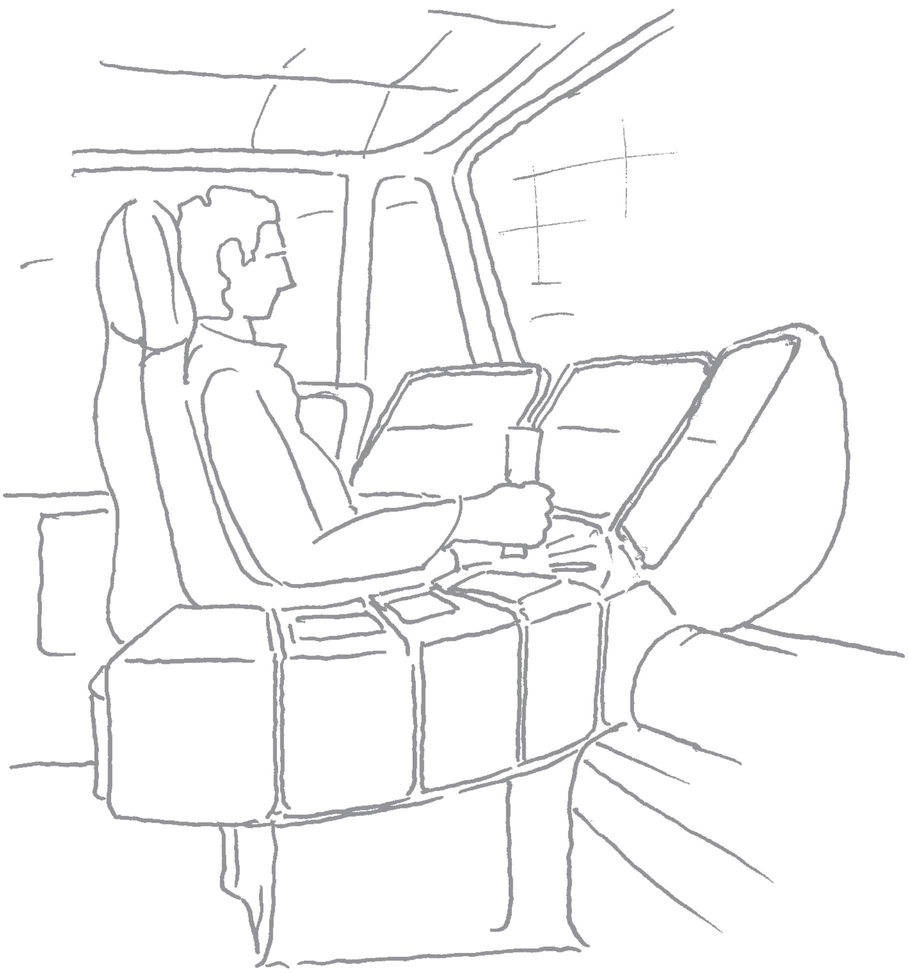
Like the track, the Overhead Catenary Systems (OCS) of the railways follow different standards regarding design and the pantographs on the vehicles. This creates certain problems for interoperability. Rebuilding of the OCS on some lines may be neccesary.

Train control systems

The above aspects of technical heritage have been concerned with systems having great influence on the Eurotrain concept. There are, however, a number of other systems that greatly influence interoperability.
Train control and safety systems are of spesial importance. These are:
– ATC systems (Automatic Train Control),
– Radio systems,
– Cab signalling.
Work is in progress in Europe to establish new standard systems in these fields. The question remains of how long it will take to introduce these systems and convert present systems so that they are interoperable with the new ones.

Operation and safety rules

Operation and safety rules, including driver cab instrumentation, is another domain which introduces complications for interoperability.
It is possible that future on-board computer systems will be part of the solution for interoperability in this field. Computer systems could enable man-machine interfaces (MMIs) to provide various presentation modes, such as linguistic, depending on the network where the train is running.



Specific CNR requirements?
Possibly for Nordic winter conditions!

As previously stated, the market requirements of the CNR railways for passenger rolling stock are very similar. It is difficult to believe that the situation would be very different on a European level. This is one reason for the CNR railways to propose the Eurotrain concept.
At the same time, it must be seriously questioned whether there are any specific factors or demands from one or more of the CNR railways that would prevent a standardized European train from being accepted. Various aspects of the differences in railway infrastructure in the Nordic countries have been discussed in this booklet. It is believed that most of them can be overcome with a modular system.

Special demands
One parameter that might create problems is use of the trains in Nordic winter conditions. However, it is possible that these conditions are not exceptional and that the Eurotrains can be built to meet these demands without major drawbacks to trains operating under less demanding conditions.

Large parts of Scandinavia have long periods with temperatures below -10°C and even monthly averages below this temperature. There is snow on the ground for more than six months in large areas, and the snow varies from very wet to dry and powdery. Each of these conditions creates its specific problems for train operations.
Winter climate requirements on rolling stock have been studied by the CNR. Some major issues are presented here.

All components and systems of the vehicle must operate faultlessly in a temperature range of -40°C to +35°C. Thermal insulation should be used so that the total K-value does not exceed 1.5 W/m^2/K. Special attention must be paid to electronic components, batteries and water systems.
In winter conditions, packed snow and ice in the underframes, bogies, doorways and between vehicles often becomes a problem. Among other things, the vehicles should be built with smooth, covered bottoms, and the bogies should be designed in such a way that snow packing and ice formation is minimised. The design should allow the removal of snow and ice with warm water.

The list of design topics related to the brake system is a long one. Specific attention should be paid to the following items:

- Freezing of the brake system, i.e. mechanical parts in the bogies, as well as pneumatic brake cylinders etc.
- Efficiency of the braking system in snowy conditions.
- Freezing of brake blocks to the wheels.
- Inadequate tightness of the pneumatic brake system (cylinders, seals, etc.).
- Ice formation in tubes and components.

Other design parameters of importance are:

- Sucking of snow into air inlets.
- Penetration of powder snow at doorways, hatches or other openings.
- Possible condensation, especially in electric equipment when cold vehicles enter warm and humid workshops or tunnels.
- Damage due to impact by ice or ballast from the trackbed.

Economy of the Eurotrain system

One factor in making the railways viable in the future is to reduce vehicle costs. It is essential to find ways in which resources, such as the total number of vehicles, can be reduced. It is also necessary to find ways of reducing their price and acquisition costs along with costs of operation and maintenance.
These issues have been covered by this booklet. It has been shown that the design of the trains themselves has an influence on all these factors. It is also important for the trains to be regarded as part of a total system, designed with due consideration to the efficient use of its components. A comprehensive view of the system, its trains, maintenance resources and traffic service is crucial.

It is the opinion of the CNR railways that the Eurotrain concept could be a means of obtaining:

- Trains with a lower price:
  - long production series (even with small custom deliveries)
  - reduced acquisition costs
  - a competitive market
- Better use of train resources:
  - trains adaptable to a specific type of traffic
  - trains adaptable to optimal size
  - possibility of performing maintenance at off-peak hours,
- Trains of higher quality and reliability:
  - reduced maintenance costs
  - reduced costs related to operating failures
- Other advantages:
  - shorter delivery times
  - a second-hand market
  - easily refurbished and modified trains

Total costs

The following is a recapitulation of train costs:
The diagram below shows typical values for splitting costs per kilometre into various components:

- Investment,
- Maintenance & cleaning,
- Operation
  - energy
  - driver
  - infrastructure charges.

The example of the present train system shows a three-car EMU. The operating costs relate to Swedish conditions.

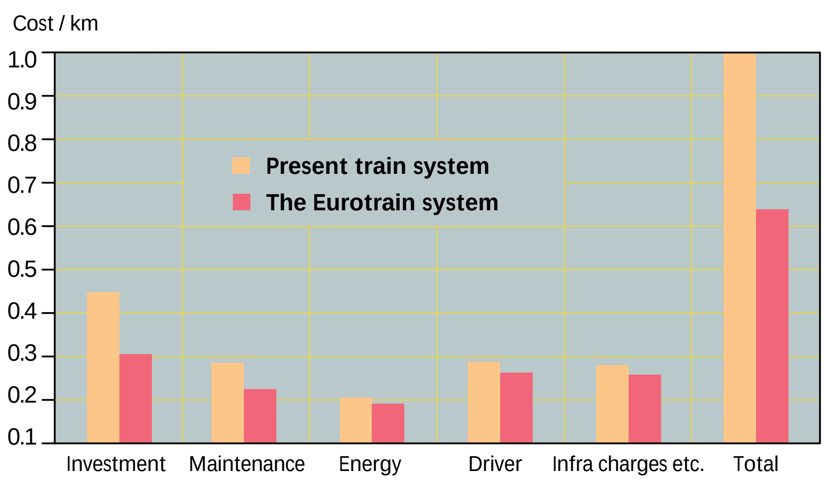
The cost of invested capital is significant and depends to a large degree on the financing structure. This calculation is made with an interest rate of 7 %, 25 years depreciation and a residual value of 10 % of the investment.

The annual running distance has of course a direct influence on the capital cost per km. In this example, the EMU that represents present train systems in the diagram is running 200,000 km / year, Studies show that it should be possible to increase this annual utilisation of the trains by a factor of 1.5-2, It should be possible to use them more, and it should be possible to run them within a higher average passenger load than today.
Some of the factors for achieving this are:

– A maintenance system enabling 99% of the trains to be in service at peak hour. This requires the trains to be designed so that necessary maintenance can be performed in many short intervals instead of a few long ones:

- Suitable train size so that the number of trains in traffic can follow passenger fluctuations during the day and week. (c.f. page 10- 11)
- Adaptability of train size to passenger capacity for each specific service. See pages 12- 13.

It is clearly shown on pages 10- 13 that the choice of train for a specific traffic service can have a significant influence on costs. The proposed Eurotrain concept should have these capabilities. It stipulates a train design enabling any size train to be assembled to match any demand in the best way possible.
It is expected that the Eurotrain



Approximate relative costs per passenger km of present trains and the Eurotrains system.

concept will make it possible to reduce costs as shown in the diagram.