

# Train Parameters Study

## Part 1 - Development of Concept and Design Criteria



*Delivering a Step-Improvement in Passenger Experience*



DESIGN TRIANGLE

**HIGH SPEED 2 LTD**

**TRAIN PARAMETERS STUDY**

**PART 1 – DEVELOPMENT OF CONCEPT AND DESIGN CRITERIA**

Presented to: HS2 Ltd  
Eland House  
Bressenden Place  
London  
SW1E 5DU

Prepared by: Design Triangle Limited  
The Maltings  
Burwell  
Cambridge  
CB25 0HB

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## **SYNOPSIS**

### **Aims**

The aim of the HS2 Train Parameters Study is to demonstrate how the train capability requirements associated with Passenger Capacities and Station Dwell Times can be best achievable while delivering a Step Improvement in Passenger Experience.

### **Passenger Capacity**

The report describes a range of alternative interior layouts with capacities ranging from 500 to 600 seats. The effects of articulated and double-deck vehicle formats on capacity are outlined.

### **Station Dwell Time**

The report summarises the results of a research literature survey into the effect of various vehicle design features on boarding/alighting times. Estimated station dwell times are calculated on the basis of this research, but further studies are recommended.

### **Step Improvement in Passenger Experience**

The report outlines a range of proposed new design features, including a series of “zones”, tailored to the needs of various passenger groups. It also proposes how new display, lighting and mobile technologies can be incorporated to bring real passenger experience benefits.

### **Reference Layout**

The study proposes a single-deck, conventionally-bogied Reference Layout, with a capacity of 541 seats in short-distance form and an estimated worst-case station dwell time of 106 seconds. The interior layout is varied, yet symmetrical, with a range of facilities and differentiated zones.

### **Options**

Finally, the study acknowledges that other combinations of features and facilities are possible, and outlines the possible effects of these on seated capacity.



## INTRODUCTION

High Speed 2 Ltd has ordered Part 1 of a Train Parameters Study, to demonstrate how the train capability requirements associated with Passenger Capacities and Station Dwell Times can be best achievable while delivering a Step-Improvement in Passenger Experience.

The study has consisted of 3 main elements:

- concept options and high level design criteria for salon layouts
- specimen vehicle layouts
- a design sketchbook of ideas on the look and feel of the rolling stock which can be achieved while adhering to the design criteria

The study has made the following key assumptions about the service and the vehicles:

- vehicle formats that are currently on the market are preferred
- the ticketing system will distribute boarding/alighting passengers evenly along the train
- maximum numbers of passengers boarding/alighting will be as defined in Section 2.3
- an efficient method of level access from the platform will be provided for wheelchairs

This report summarises the research and studies conducted and explains how the conclusions were reached.

A separate illustrated Design Sketchbook provides a short synopsis of the key conclusions of the study.



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## **1.0 PASSENGER CAPACITY**

- 1.1 Assumed Capacity
- 1.2 Typical Capacity
- 1.3 Achievable Capacity
- 1.4 Factors Affecting Capacity
- 1.5 Seat Pitch
- 1.6 3+2 Seating
- 1.7 Low Floor Vehicles
- 1.8 Articulated Vehicles
- 1.9 Double Deck Vehicles
- 1.10 Classic Compatible Variant



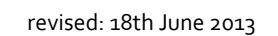
### 1.1 Assumed Capacity

HS2 Ltd have proposed an assumption of 1100 seats in a 400 metre train, with a minimum of 1050 seats. This translates to 550 and 525 seats respectively in a 200 metre unit.

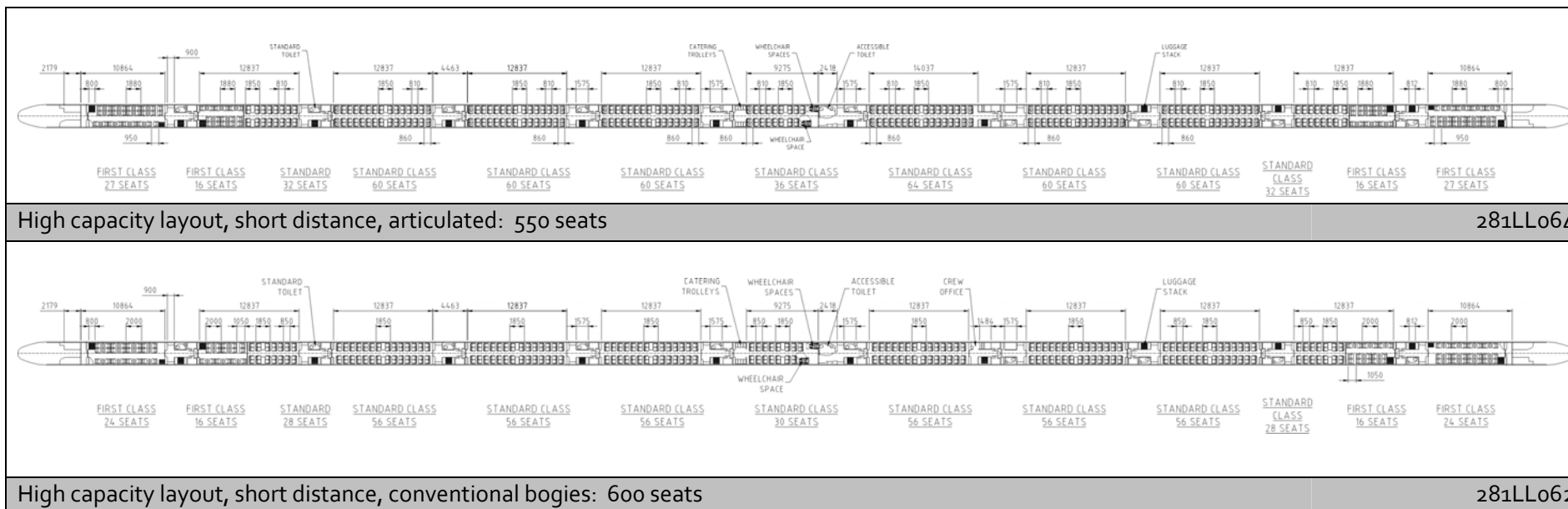
HS2 Ltd have advised that all seats will be booked and there will be no standing passengers.

Commercial interests FOIA s43(2)

Achievable capacity depends on a number of factors, including train format, seating layout, seat pitch, facilities, etc. A range of alternative sample layouts have been prepared, for example:







Please see original layout drawings in Annex B.



#### 1.4 Factors Affecting Capacity

At basic level, achieving seat capacity can be simplified to:

- maximise the vehicle length available for seating
- maximise seat rows per metre length of the vehicle

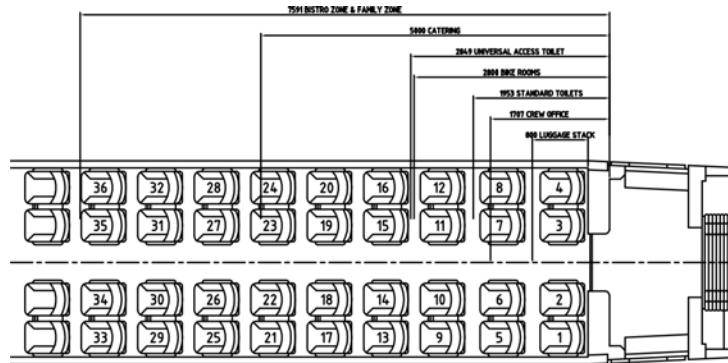
Vehicle format may affect seating capacity significantly:

- driving car utilisation
- articulated vehicle vs. conventional bogied vehicle
- number and width of doors

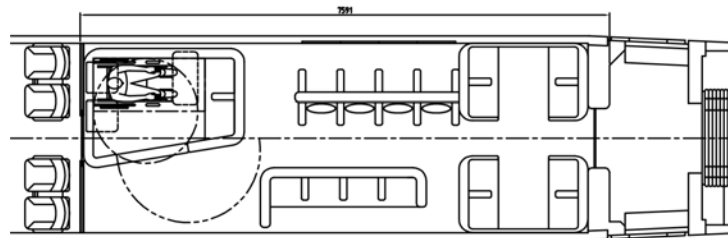
Choices on the interior layout and facilities affect seating capacity:

- seat layout – facing bays in Standard Class
- 2+1 seating layout in First Class
- seat pitch
- facilities:
  - o luggage stacks
  - o standard toilets
  - o catering facility
  - o Family Zone
  - o Lounge Zone
  - o bike rooms

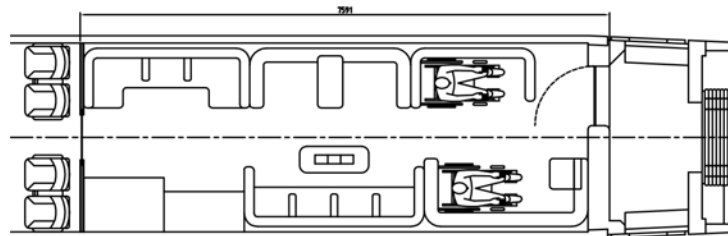
Further details are given in Section 5.1 and drawing 281LL051 in Annex B.



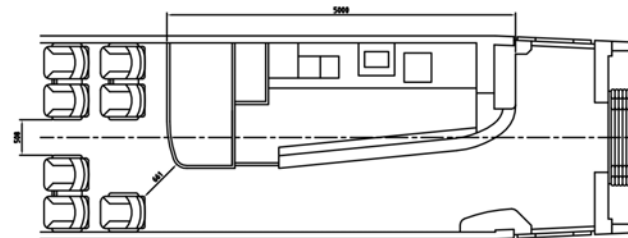
**BASELINE SEATING**



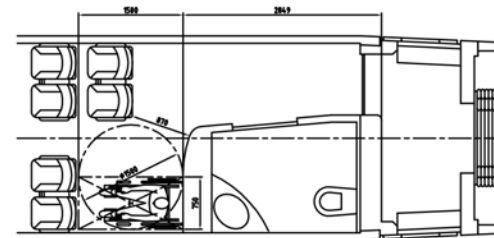
**FAMILY ZONE**  
36-14 = 22 SEAT PLACES LOST



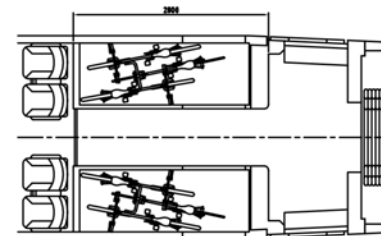
**BISTRO ZONE & 2 WHEELCHAIR SPACES**  
36-7 = 29 SEAT PLACES LOST



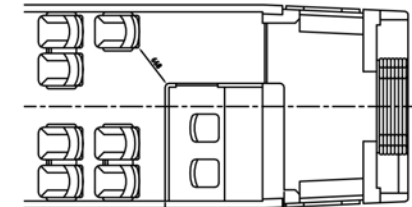
**CATERING**  
25 SEAT PLACES LOST



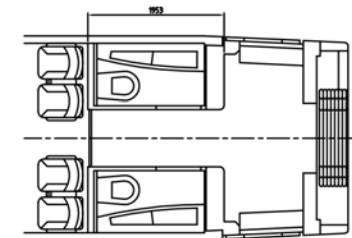
**UNIVERSAL ACCESS TOILET & WHEELCHAIR SPACE**  
18 SEAT PLACES LOST



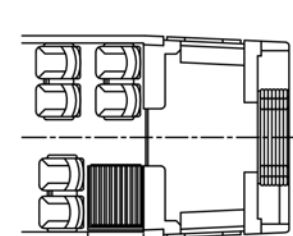
**2 BISTRO ROOMS**  
12 SEAT PLACES LOST



**CREW OFFICE**  
9 SEAT PLACES LOST



**2 STANDARD TOILETS**  
8 SEAT PLACES LOST



**LUGGAGE STACK**  
2 SEAT PLACES LOST



## 1.5 Seat Pitch

Appendix 15 of this report shows that existing and proposed high speed vehicles have Standard Class seat pitches ranging from 800mm to 926mm.

Appendix 9 shows that existing UK intercity trains have seat pitches ranging from 770mm to 840mm.

The Reference Layout outlined in Section 4 is based on a minimum Standard seat pitch of 810mm for short distance trains. This is explained in Appendix 15 and illustrated in drawing 281LL006 in Annex B.

Long distance variants are based on a Standard seat pitch of 850mm, allowing passengers more space to move around on longer journeys.

These seat pitches assume a seat with a comfortable but slim seat squab.

Seats in the Space Zone are pitched at up to 1050mm.

Ultimate seat pitch may be restricted by crashworthiness performance, as passenger impact energy levels increase rapidly with increased seat pitch. This can be mitigated with table design.

The effect of increased seat pitch on passenger capacity is outlined in Appendix 15. For example, increasing the seat pitch from 810mm to 965mm might reduce the capacity from 80 to 64 seats per car. This could reduce the capacity of a 200 metre unit by at least 80 seats (e.g. from 541 to 461 seats). Clearly this is a very significant effect.

Maximising the seated capacity would result in a dense and regimented interior ambience.

The final choice of seat pitch will be a balance between seating capacity and perceived passenger experience, whilst achieving required levels of passenger safety.

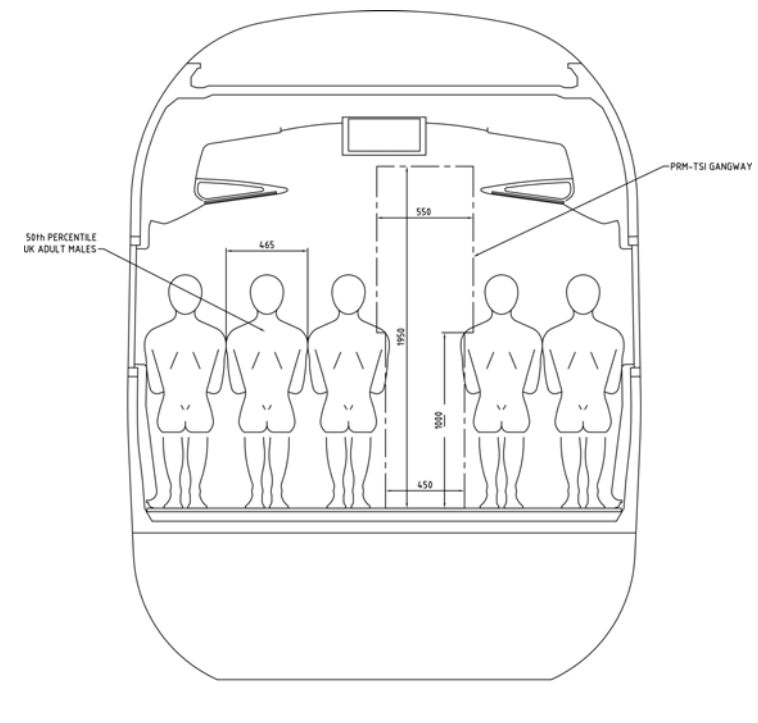
## 1.6 3+2 Seating

In order to achieve comfortable 3+2 seating, passengers must be able to sit without their shoulders touching.

Most European high speed trains, at 2.9-3.0m, are not wide enough to achieve comfortable 3+2 seating.

Talgo Avril, at 3.2m wide, is the only European high speed coach wide enough to achieve comfortable 3+2 seating, as demonstrated in the diagram.

Imaginative attempts to incorporate 3+2 seating by means of staggered layouts have not been productive.





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## 1.7 Low Floor Vehicles

Low floor vehicles lose seating capacity, as equipment normally located under the floor has to be relocated to the power car. The loss of the power car to passengers loses a significant number of seats. Talgo Avril is an example of this.

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### 1.8 Articulated Vehicles

Typical articulated high speed trains consistently return a lower seated capacity than equivalent trains with conventional bogies. This is demonstrated in drawings in Annex B:

Layout Type	Journey Type	Articulated		Conventional Bogies	
		Seated Capacity	Drawing No.	Seated Capacity	Drawing No.
High capacity	Long distance	502	281LL063	546	281LL061
High capacity	Short distance	550	281LL064	600	281LL062
Varied layout	Long distance	469	281LL083	505	281LL076
Varied layout	Short distance	493	281LL084	541	281LL071

Note: These figures should be treated as approximate, as various factors affect the seated capacity.

### 1.9 Double-Deck Vehicles

Current high speed double-deck trains typically have 5 - 6% higher passenger-carrying potential than single deck high speed trains.

The seating capacity of TGV 2N2 Euroduplex is 510. This is 5% higher, for example, than AnsaldoBreda Bombardier V300 Zefiro ETR1000, which has 485 seats.

The seating capacity of TGV Ouigo variant is 634, but with all unidirectional seating, limited luggage space and no buffet area. This is only 6% higher, for example, than versions of Bombardier V300 Zefiro with 600 seats and a buffet/kitchen.

The seated capacity of high speed double-deck trains is limited by a number of factors:

- both power cars are required for equipment, losing all seating in those cars
- large cubicles are required for other equipment, which cannot be located under the floor or on the roof.
- multiple stairwells are required, at least one per car

If double-deck trains were to be developed with distributed traction, this situation could change.



Classic Compatible vehicles could not be double-deck, as they would not be compatible with the classic UK infrastructure.

#### **1.10 Classic Compatible Variant**

In principle, the seated capacity of the Classic Compatible can be identical to that of the Captive version.

However, Classic Compatible versions are, by definition, likely to be used on long distance services, so are likely to have additional facilities and thus fewer seats.





## **2.0 STATION DWELL TIME**

- 2.1 Factors Affecting Boarding Time
- 2.2 Dwell Time Target
- 2.3 Number of Passengers
- 2.4 Distribution of Passengers
- 2.5 Estimated Dwell Time
- 2.6 Articulated Vehicles
- 2.7 Double Deck Vehicle Dwell Times
- 2.8 Classic Compatible Vehicle Boarding Times
- 2.9 Achieving Level Entry
- 2.10 Further Research Required



## **2.1 Factors Affecting Boarding Time**

A number of factors affect boarding/alighting time. These include vehicle features, platform features and passenger behaviour.

To achieve fast boarding times, passengers must be waiting at the correct point on the platform, ready to board at the correct door.

A survey of research literature, outlined in Appendix 1, has highlighted key factors affecting boarding/alighting time:

- exterior door width
- entry step height
- platform gap width
- vestibule congestion

The number of doors will be a key factor affecting boarding/alighting time. Other factors that may affect boarding time include door location, vestibule size, luggage storage location and effectiveness of passenger information on the train and on the platform.

Passengers in wheelchairs and passengers with heavy luggage or pushchairs will extend boarding/alighting times.

Some means of level access will be required for the boarding of wheelchair users, for PRM-TSI. Level entry from the platform to the vehicle is likely to reduce boarding/alighting times, particularly for passengers in wheelchairs.

## **2.2 Dwell Time Target**

HS2 Ltd have specified a station dwell time target of 2 minutes. This is crucially important to the operation of the service. The dwell time at terminus stations will be considerably longer and does not form part of this study.



### 2.3 Number of Passengers

HS2 Ltd have provided assumptions about passenger numbers boarding and alighting at stations:

Typically, a total of  $\frac{1}{3}$  of passengers board/alight at any stop

- this translates into 367 passengers out of 1100 in a 400 metre train

The worst case is at Birmingham Interchange ( $\frac{1}{3}$  passengers alighting and  $\frac{1}{3}$  passengers boarding)

- this translates into 733 passengers out of 1100 in a 400 metre train

### 2.4 Distribution of Passengers

At a typical station, an average of 13 passengers would be boarding/alighting at each door. This assumes 28 doors per side of a 400 metre train.

At Birmingham Interchange, up to 26 passengers would be boarding/alighting at each doorway.

It has been assumed that the HS2 booking system will distribute passengers evenly, within limits. HS2 have proposed an assumption of up to 20% variation (i.e.  $26 \pm 5$  passengers per door), resulting in a worst case of 31 passengers per door.



## 2.5 Estimated Dwell Time

Typical passenger boarding time data, based on available research, is shown in Appendix 1. This data is largely based on metro operations, however some of the data refers to high speed and intercity stock. The reported results sometimes appear contradictory, as there are large numbers of variables. Boarding/alighting results vary from 1.4 seconds to 2.9 seconds per passenger, for passengers carrying a suitcase.

Using the higher estimate of 2.9 seconds per passenger, at a typical station the boarding /alighting time would be:  $13 \times 2.9 = 37.7$  seconds.

Adding 18 seconds for train arrival and departure brings the estimated station dwell time to 55.7 seconds. On the same basis, at Birmingham Interchange the estimated station dwell time would be 93.4 seconds. Allowing for a 20% variation in the distribution of passengers at Birmingham Interchange (31 passengers/doorway) would result in an estimated worst case station dwell time of 107.9 seconds.

Appendix 14 shows the calculations for estimated Station Dwell Times for a range of scenarios.

Note: these estimated dwell times assume that passengers are standing near the correct doorway when the train arrives.

## 2.6 Articulated Vehicles

Vehicles with fewer doors will have a longer dwell time. For example, an articulated train with 20 doors per side would, in the worst case at Birmingham Interchange, result in  $(733 / 20) \times 1.2 = 44$  passengers per door, leading to a worst case station dwell time of  $(44 \times 2.9) + 18 = 145.6$  seconds.

## 2.7 Double Deck Vehicle Dwell Times

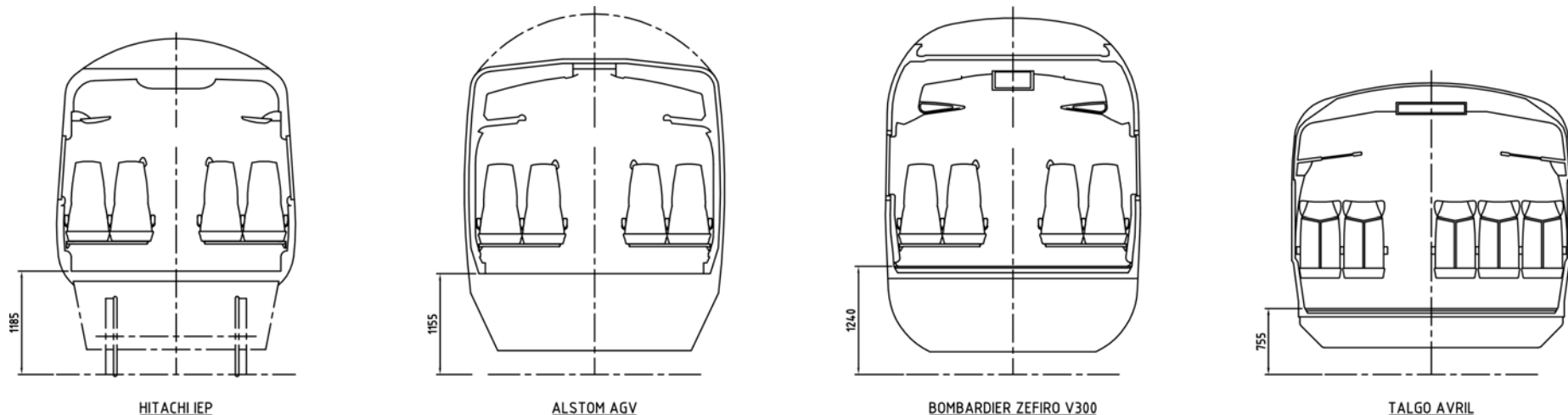
TGV 2N station dwell times are quoted by SNCF as 3-4 minutes. Even the VIRM inter-regional double-deck train does not regularly achieve the 2 minute dwell times required by NS.

## 2.8 Classic Compatible Vehicle Boarding Times

Classic Compatible vehicles are unlikely to be level with the Classic 915mm UK platforms, so will require steps. This will increase boarding/alighting times at Classic stations, especially for wheelchair users and passengers with pushchairs.

## 2.9 Achieving Level Entry

Typical high-speed train floor heights lie within the range 1155 - 1240mm:



Typical platform heights are 760mm (TSI) or 915mm (UK). So there is a mismatch of up to 480mm.

Potential solutions for level entry include raising the platform to the train floor height. For example, Heathrow Express raised their platforms at Paddington to 1100mm. This would be non-compliant with TSI.

Another solution could be low-floor carriages, but this is likely to result in significantly reduced seated capacity. (See Section 1.7).



#### **2.10 Further Research Required**

More data is required, to determine with more certainty the likely boarding time for the proposed design. Options include user trials, in-service observations, or pedestrian flow analysis.



### **3.0 STEP IMPROVEMENT IN PASSENGER EXPERIENCE**

- 3.1 Introduction
- 3.2 Tailored to Passengers' Needs
- 3.3 Improved Facilities
- 3.4 Convenient Luggage Storage
- 3.5 Improved Information
- 3.6 Harnessing Mobile Technology
- 3.7 Improved Platform/Train Interface
- 3.8 Welcoming Entrance
- 3.9 Imaginative Interior Environment
- 3.10 Space at Seat
- 3.11 Enhanced Seat Environment
- 3.12 Accessibility
- 3.13 Low Noise Levels
- 3.14 Crew Facilities
- 3.15 Flexible Layout
- 3.16 Classic Compatible Variant



### 3.1 Introduction

HS2 should redefine rail travel in terms of convenience, frequency, levels of service, personalisation and appearance.

A journey on the HS2 should offer:

- a personalised, tailored experience for individuals
- a flexible range of options, based on passengers' needs, in place of traditional classes
- a convenient service
- an environment pleasing for all the senses

Step change will result from a series of evolutionary and revolutionary improvements.

Design Triangle Limited have worked with CCD Ltd to generate a range of vehicle design features likely to deliver a step change in passenger experience. The Human Factors research is summarised in Appendix 2. A wide range of brainstorm ideas and sketches are shown in Appendix 12 and Annex A.

### 3.2 Tailored to Passengers' Needs

It is proposed that areas of the interior be tailored to passengers' different characters, moods, experience and needs. For example:

- an area specially designed for family groups and children
- a sociable communal space with informal seating
- areas suitable for groups, with a table at every seat
- areas with increased, distributed luggage storage
- quiet zones, with meeting rooms and "smart glass" partitions for privacy
- an area with wider seats at a longer spacing
- compact seating areas for budget-conscious travellers



### 3.3 Improved Facilities

HS2 should offer a range of improved facilities, such as:

- facilities aimed at families, commuters, business travellers and disabled people
- an enhanced catering and drinks service
- a quality food offering, perhaps provided by a premium high street brand
- a fast, self-service shop option
- service at seat option

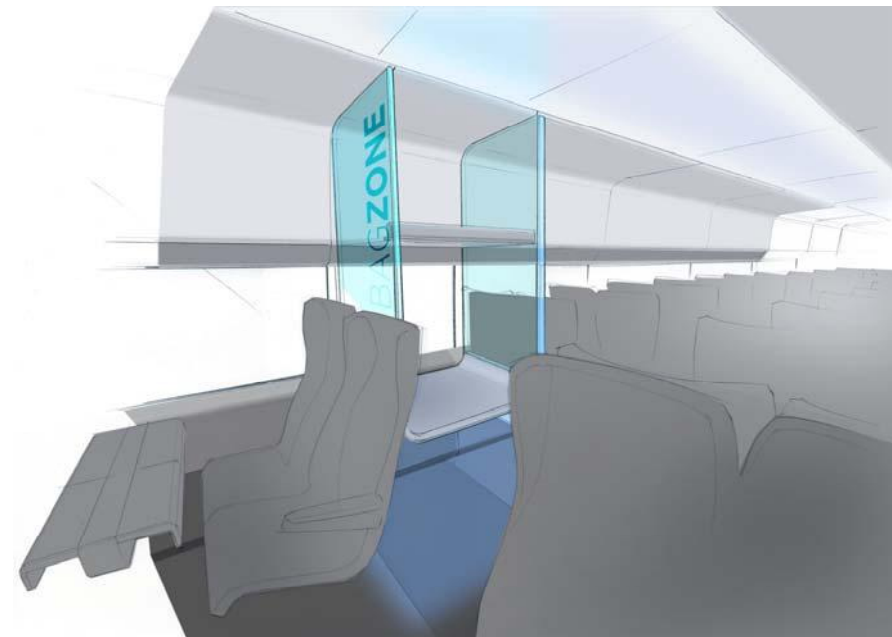
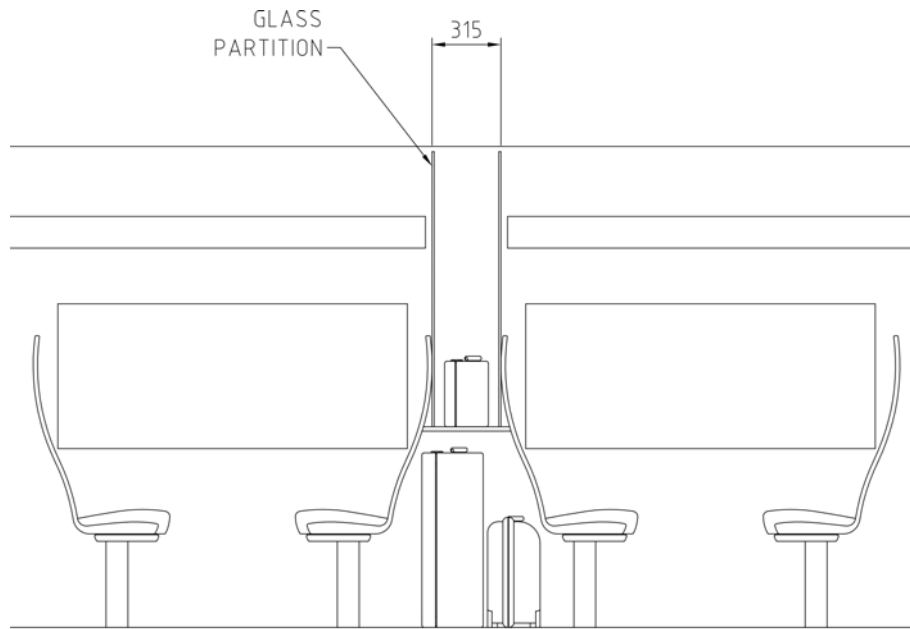
Facilities should be accessible to all passengers.

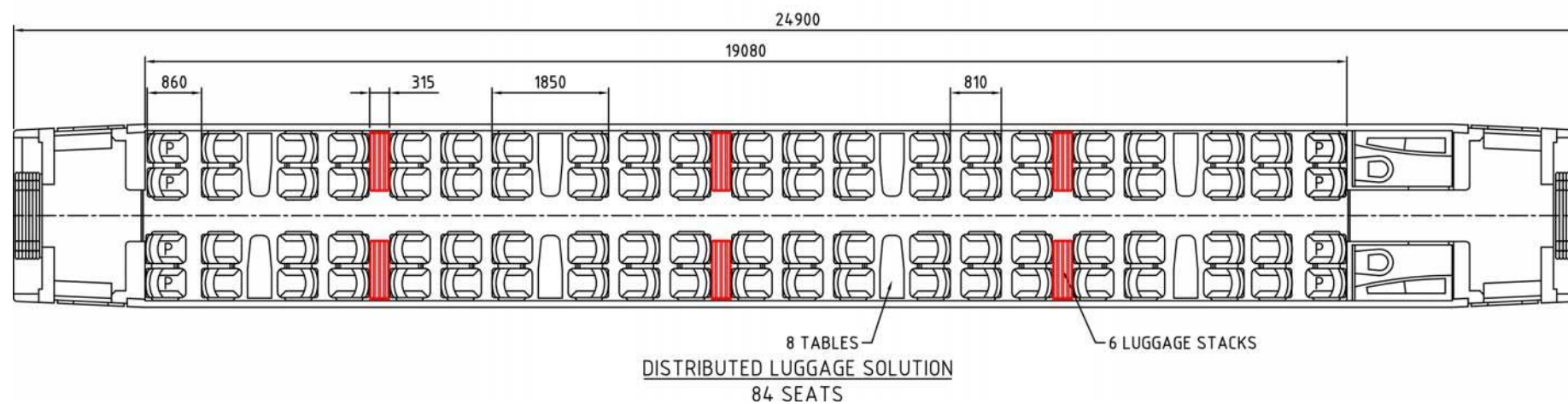
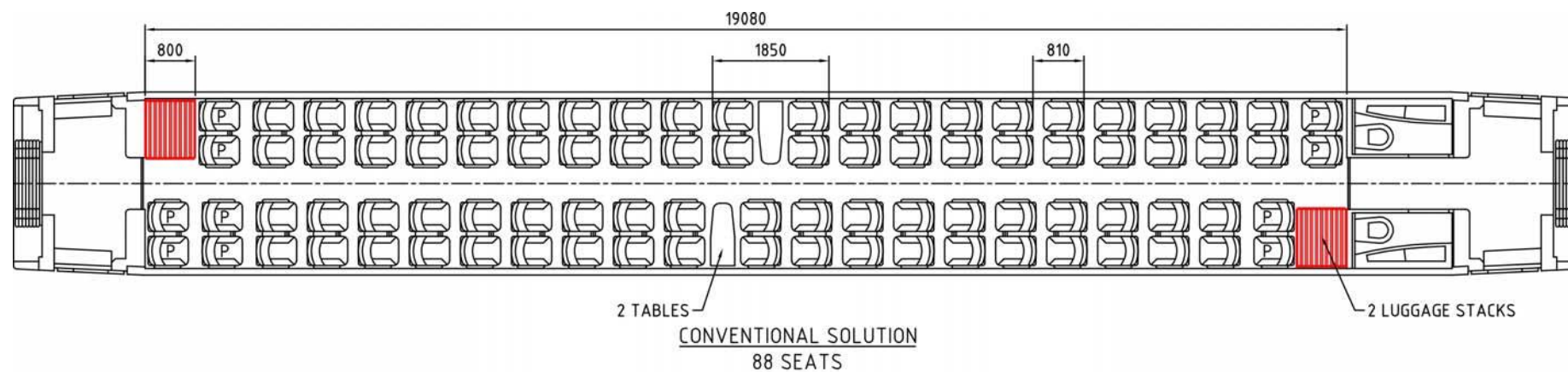


### 3.4 Convenient Luggage Storage

Improved luggage storage solutions are part of an improvement in the passenger experience. The key aim is the provision of a range of alternative luggage storage options near the seat, in sight of the passengers, for enhanced security, convenience and peace of mind.

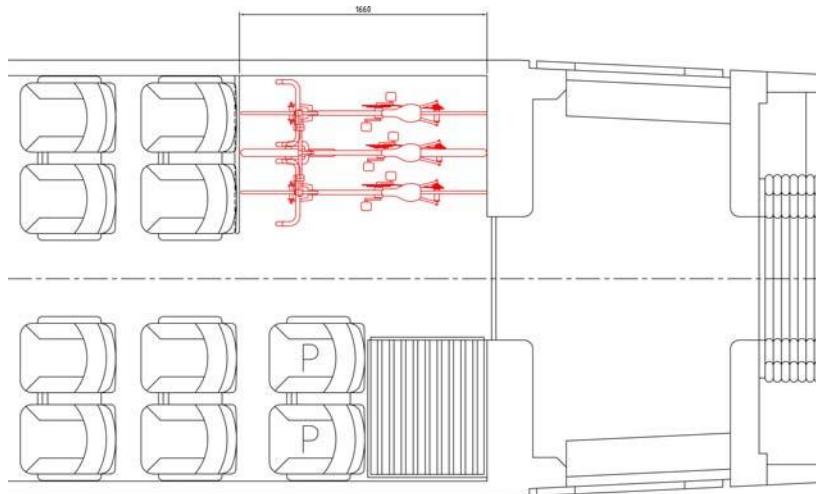
Luggage solutions should encompass large luggage, as well as cabin luggage, but should minimise the impact on seated capacity. Please see drawings 281LL040 and 281LL054 in Annex B.



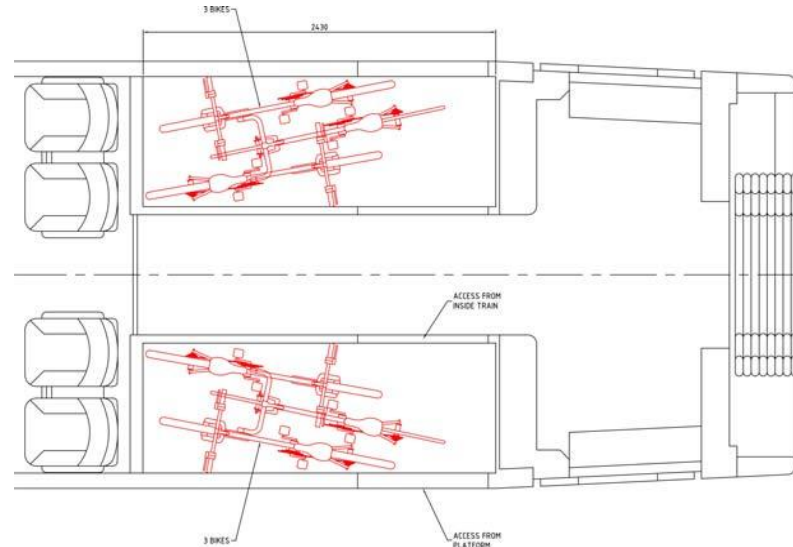




Alternative bicycle storage options may also be incorporated, but loading of bicycles should not be allowed to extend station dwell times. Dedicated loading doors could be one solution.



*Conventional cycle storage provision*



*Cycle storage rooms with dedicated loading doors*

### 3.5 Improved Information

One key aspect of a stress-free journey is the availability of accurate, timely and tailored information on:

- the route
- the next stop
- your seat location
- location for storage of your luggage

Large, clear displays could make use of the latest technology to provide more information, in real time, better presented and with improved legibility.

Large transparent LED displays (e.g. Samsung Smart Window) in doors and windows could provide information and entertainment.



### 3.6 Harnessing Mobile Technology

The HS2 service should harness mobile technology to provide convenient, personalised services and enhanced personal control of the passenger's environment.

Enhanced passenger information could be tailored to each individual and delivered to personal mobile devices.

HS2 mobile apps would allow seat/zone booking, meal ordering, tailored travel information, networking, etc. Mobile apps could also allow passengers the ability to adjust individual environment, lighting levels and temperature at their seat.

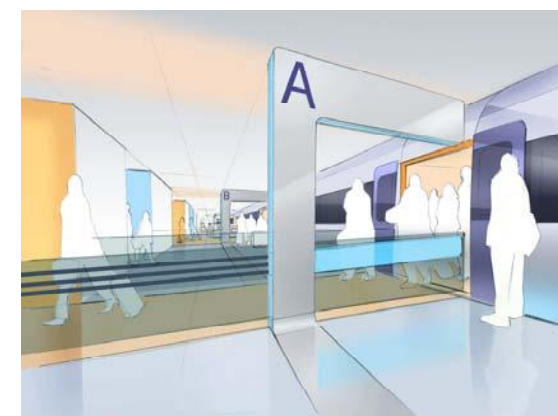


### 3.7 Improved Platform/Train Interface

Passengers should be directed to the correct location on the platform before the train arrives. This is critical for boarding/alighting times.

Improved information and signposting on the platform would reassure waiting passengers that they are at the correct location and will advise them, in advance, of their seat location on the train.

Level entry would ease boarding for all passengers, including wheelchair users.



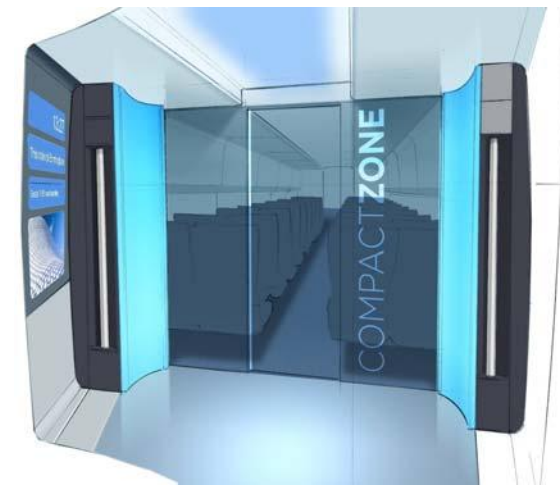




### 3.8 Welcoming Entrance

A wider, better illuminated and more welcoming entrance would give a great first impression on entering the vehicle.

Large information displays could advise passengers of their seat locations.



### 3.9 Imaginative Interior Environment

An imaginative and appealing interior environment would provide a unique visual identity, to support the HS2 brand.

Varied interior layouts would provide interest and will break away from the standard “tube with seats”.

Aesthetics new to rail travel, drawing on automotive and architectural design, would differentiate HS2 from existing rail services.

Areas with differentiated colours, finishes and trim levels will provide the best of modern British design.

Colours based on psychological research would enhance feelings of calmness and relaxation.





Imaginative lighting effects could provide different moods for different areas. Edge-lit LED ceiling and wall panels could provide diffused lighting.

Innovative use of large LED displays in ceilings could provide imaginative effects.



### 3.10 Space at Seat

Increased seat width and armrest width should make best use of the increased internal width of Captive vehicles (see drawings 281LL080 and 281LL079). A relatively high seated capacity target precludes long seat pitch, but thin seat backs would increase the available space without sacrificing comfort.





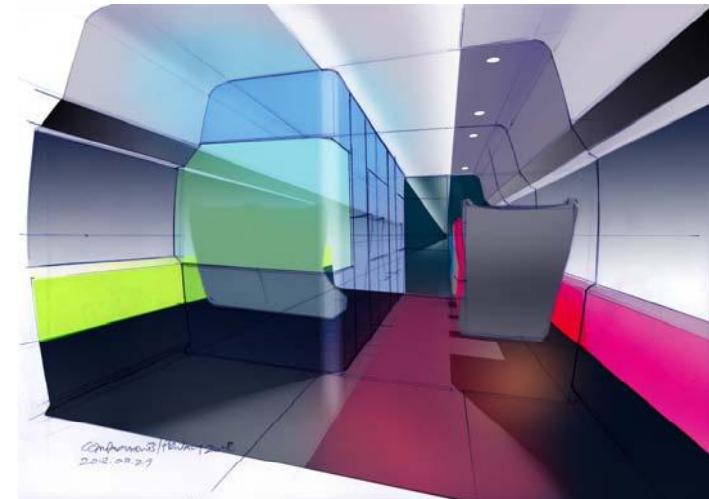
### 3.11 Enhanced Seat Environment

All HS2 seats should provide optimum comfort and space for all customers, based on the anthropometric dimensions of the population, and using optimised ergonomic cushion profiles.

All HS2 seats should offer enhanced seat comfort features, such as wide armrests and wrap-around headrest laterals.

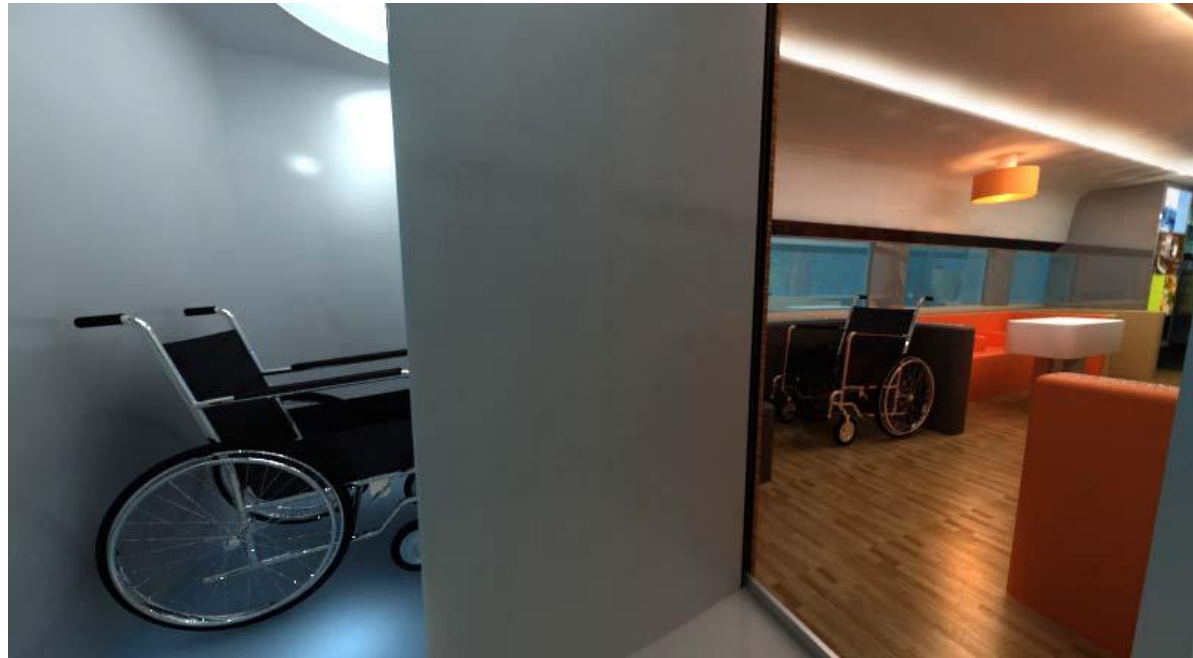
HS2 could offer premium seat width and spacing options, allowing enhanced privacy and a more restful experience.

HS2 could also offer further enhanced privacy options, including sound-proof compartments with electronic “Smart Glass” blinds.



### 3.12 Accessibility

The interior layout of HS2 should provide wheelchair users with accessibility to toilets, catering facilities and a range of other facilities.



### 3.13 Low Noise Levels

Acoustically-designed features could include transverse screens to reduce noise transmission and sound-absorbing textile/foam-trimmed bulkhead panels.

### 3.14 Crew Facilities

A crew office could be incorporated on long-distance trains, with seating to allow staff to take breaks, and with a counter for interfacing with passengers.



### 3.15 Flexible Layout

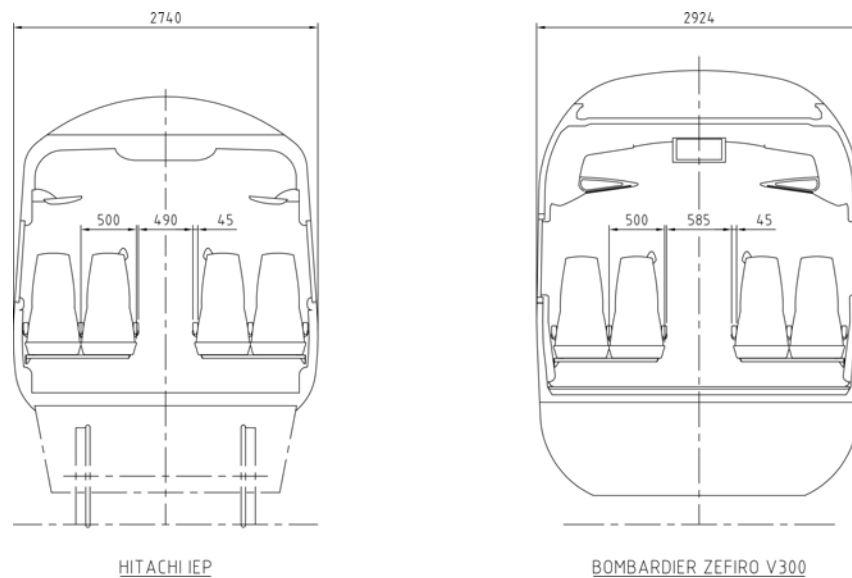
A flexible layout system could allow changes in the future, if required. Seats could be fastened to rails concealed in the floor, allowing seating layouts to be rearranged.

Partitions and screens could be fastened to slots in bodyside and ceiling, allowing areas to be re-sized if the need arose.

### 3.16 Classic Compatible Variant

Classic Compatible trains will be used mostly on the longer routes, so they are likely to have enhanced facilities, including catering facilities and a crew office.

The Classic Compatible bodyside will be narrower than the Captive vehicle by approx 185mm. It is proposed that the difference in bodyside width should be taken up largely by reduced gangway width, not in reduced seat width.





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#### **4.0 REFERENCE LAYOUT**

- 4.1 Introduction
- 4.2 Vehicle Layout
- 4.3 Alternative Environments and Facilities
- 4.4 The HS2 Brand
- 4.5 Exterior Design
- 4.6 Key Data for the Reference Layout

#### 4.1 Introduction

A number of alternative layouts and designs have been considered during this study. Design Triangle Limited have proposed a Reference Layout, which suggests one way in which the combined aspirations could be met.

Different emphasis on dwell time, passenger capacity or passenger experience could result in the selection of different solutions.

#### 4.2 Vehicle Layout

The proposed Reference Layout is illustrated on the next page.

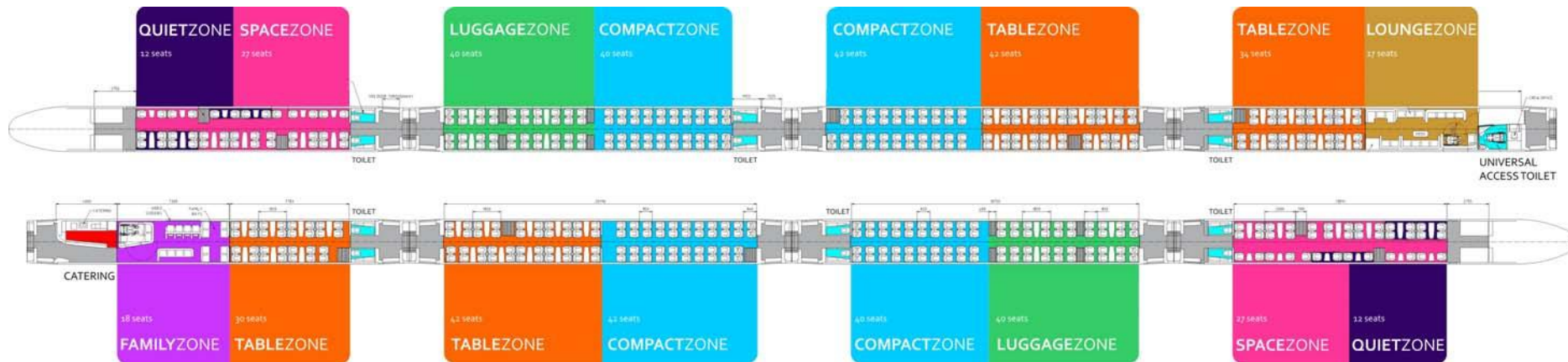
The overall length of the unit is limited to 202 metres by HS-TSI. Each train will consist of two units, totalling 404 metres.

The key dimensions of the proposed train are similar to those of a number of existing high speed trains.

The proposed layout has doors at the car ends to maximise seated capacity and to minimise noise and draughts. 1100mm door width is proposed to optimise the speed of boarding/alighting.

The Reference Layout is virtually identical in each direction, minimising the effect on the booking system if the train arrives reversed.





This shows the long-distance variant, with catering facilities and a crew office. The proposed long-distance and short-distance variants are shown in drawings 281LL076 and 281LL071 in Annex B.

A single-deck train format is proposed, as the passenger capacity of double-deck trains is typically only 5-6% higher, but the dwell times typically exceed the 2-minute target, owing to passengers negotiating the stairs with luggage. Accessibility through a double deck train is constrained by the stairs and large internal equipment cabinets, for passengers and crew with wheelchair and trolleys.

### 4.3 Alternative Environments and Facilities

A range of alternative interior environments are proposed, tailored to passengers' needs

- Family Zone
- Lounge Zone
- Table Zone
- Luggage Zone
- Space Zone
- Quiet Zone
- Compact Zone



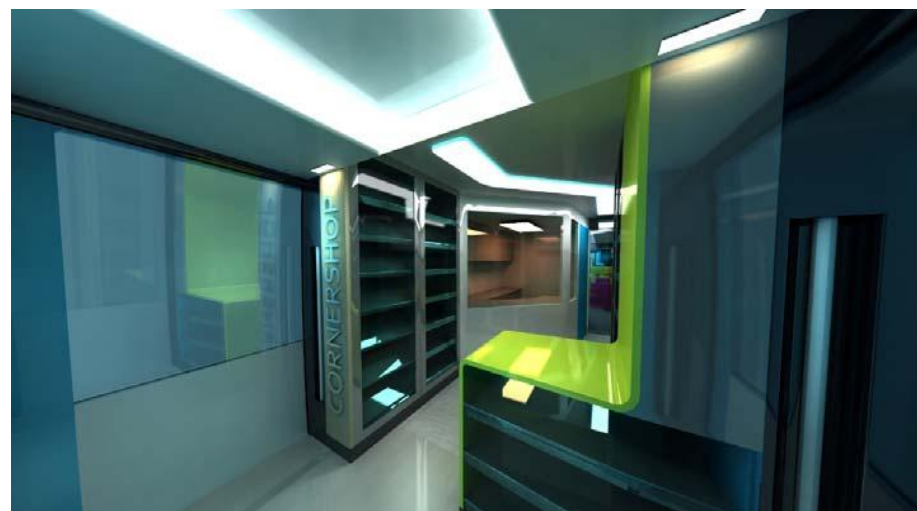
A range of alternative seat types is proposed, including comfortable standard seats with armrests and wrap-around headrests, seats with enhanced features to enhance relaxation, spacious reclining seats and side-facing or forward-facing sofas in the Lounge Zone.

A range of facilities is proposed, including Standard Toilets, a Universal Access Toilet and a Catering Facility with Self-Service Shop in long-distance trains.





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#### **4.4 The HS2 Brand**

HS2 vehicles should be iconic, with a unique visual identity that differentiates them from existing rail services.

The HS2 brand should be innovative and individual yet simple, classic and efficient. It should reflect the best of modern British vehicle design.

The interior and exterior design and the livery of the vehicle will help to define the HS2 brand.

#### **4.5 Exterior Design**

A sleek exterior appearance is proposed, particularly at the front end, reflecting the speed and efficiency of the service.

The proposed design has similar dimensions to existing European high speed trains, allowing easy adaptation from typical existing vehicles, but not identical to any existing product. (See drawing 281LL067 in Annex B.)



The proposed exterior livery is subtle and sophisticated, with a metallic gunmetal silver finish giving an impression of speed and cool efficiency. The Y-shape of the HS2 route is picked out in dark blue, integrating the cab windscreen into a practical, dark roof.

The livery follows the HS2 brand guideline colours. It is deliberately unfussy, without multi-coloured stripes. The warning yellow front has not been shown in the images.



From the viewpoint of travelling passengers the door is a key element, as the entry into the vehicle. The door could also form a large LED information screen, guiding and informing passengers. The proposed livery draws particular attention to the doors, with a surrounding highlight in bright cyan, taken from the brand guidelines. The doors have been placed within a dark blue band around the vehicle, giving a unique look to the vehicle and enhancing PRM-TSI door contrast.





#### 4.6 Key Data for the Reference Layout

The following table proposes desirable but realistic baselines for the capacity, dwell time and level of comfort and facilities on HS2 trains:

Journey Type	Short Distance	Long Distance
Journey Time	<1.5hrs	1.5hrs - 3.5hrs
Vehicle Type	Captive	Classic Compatible
Layout Drawing No.	281LL071	281LL076
Seat Pitch - Standard Class (unidirectional)	810 mm	850 mm
Seat Pitch - First Class (facing)	1880 mm	2000 mm
Seating Arrangement - First Class	2+1	2+1
Seating Arrangement - Standard Class	2+2	2+2
Catering	catering trolleys	buffet kitchen and shop
Toilets (including one UAT)	13	13
Crew Office	no	yes
Bike Space	no	no
Luggage Storage	19 stacks + overhead racks	18 stacks + overhead racks
Door Width	1100 mm	1100 mm
<b>Conventional Bogie Variant</b>		
No. of Seats	541	505
Dwell Time Estimate (14 doors per side)	56-108 seconds	53-102 seconds
<b>Articulated Variant</b>		
Layout Drawing No.	281LL084	281LL083
No. of Seats	493	469
Dwell Time Estimate (10 doors per side)	70-146 seconds	67-134 seconds

Note: Dwell time estimates show mean and worst case (see Section 2.5 for details)  
Dwell time estimates are approximate and require more detailed research.  
All data based on one 200 metre unit.



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## **5.0 OPTIONS**

### **5.1 Optional Facilities and Features**



## 5.1 Optional Facilities and Features

The following table illustrates a range of optional features and their approximate effect on seating capacity:

	Impact on Seat Numbers (approx)		
	Each	Per Car	Per Unit
Driving Cars without seating			84
Level Access with 760mm Platform (Talgo Avril)			79
Facing Seat Bays in Standard Class		12	60
Articulated Vehicles			44
2+2 Seating in First Class		19	33
1100mm wide doors (compared to 900mm)	4	4	32
Lounge Zone with 2 Wheelchair Spaces	29	29	29
Catering Facility (5 metres)	25	25	25
Seat Pitch increase from 810 to 850mm		4	24
Family Zone with 1 Wheelchair Space	22	22	22
UAT Toilet & 1 Wheelchair Space	18	18	18
Luggage Stack in each car (800mm)	2	2	16
Bike Rooms (2x3=6 bikes)	12	12	12
Crew Office	9	9	9
Standard Toilets (pair)	8	8	8
Meeting Compartment (4 seat)	0	0	0
Meeting Compartment (2 seat)	0	0	0

Note: These figures are approximate - the impact on seating capacity will vary depending on a wide range of factors.



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## CONTACT

Personal data FOIA s40(2)

### Prepared by:

Design Triangle Limited  
The Maltings  
Burwell  
Cambridge  
CB25 0HB

Tel: 01638 743 070

[www.designtriangle.com](http://www.designtriangle.com)



## APPENDIX 1 - RESEARCH INTO BOARDING AND ALIGHTING TIMES

### Station Dwell Time Components

Station Dwell Time consists of a number of components:

- unlocking and opening of the doors
- boarding and alighting of passengers
- closing and locking of the doors
- waiting for the train to depart

So passenger flow time is only a proportion of total dwell time. Please see Section 2.5 of this report for further details.

### Example Station Dwell Times

Wiggenraad (Ref.1) conducted research at a number of stations in the Netherlands, including intercity and international services at Tilburg and The Hague HS, on 24 trains, using approximately 20 observers. For the intercity and international services, he recorded dwell times averaging 86-131 seconds.

### Average Boarding Time Per Passenger

In service research into boarding and alighting time on intercity and international trains, Wiggenraad (Ref.1) found that, *"alighting and boarding time is composed of two parts: the first part is alighting and boarding in a cluster, the second part is individual alighting and boarding"*. His analysis showed that, *"The alighting and boarding time per passenger in clusters is about 1 second and, in non-clustered alighting and boarding, more than 4 seconds"*. The latter figure is expected, as 'non-clustered' passengers are by definition spread out (e.g. arriving at the last minute).

Extensive data collection on US rapid transit lines for TCRP (Ref.3) shows alighting times for level entry of 1.38-2.03 seconds per passenger, boarding times of 1.11-2.61 seconds per passenger and mixed boarding/alighting times of 2.10-3.25 seconds per passenger per single stream of doorway width.

Intergo bv recently conducted some research for NS in the Netherlands, on the AnsaldoBreda V250 high speed train, between Amsterdam and Breda. These carriages have 910mm wide doors, 1-2 entry steps and small vestibules. The trial used subjects employed by the railcar builder, each carrying a





suitcase. Their aim was to achieve a 2-minute time for 30 passengers alighting and 30 passengers boarding. Without practice, they achieved 2:48 – 2:55 minutes. This is equivalent to 2.8 - 2.9 seconds per passenger.

User trials on a mock-up of a double-deck train conducted in 1985 by members of the Design Triangle team confirmed that simultaneous boarding and alighting leads to more chaotic passenger flow, resulting in worse boarding times. This vehicle mock-up had very wide doors (1900mm) and a level entry. This study returned boarding times averaging 0.9 seconds per person, and boarding/alighting times averaging 1.22 seconds. (This metro train had a huge vestibule and very wide doors, resulting in low boarding times.)

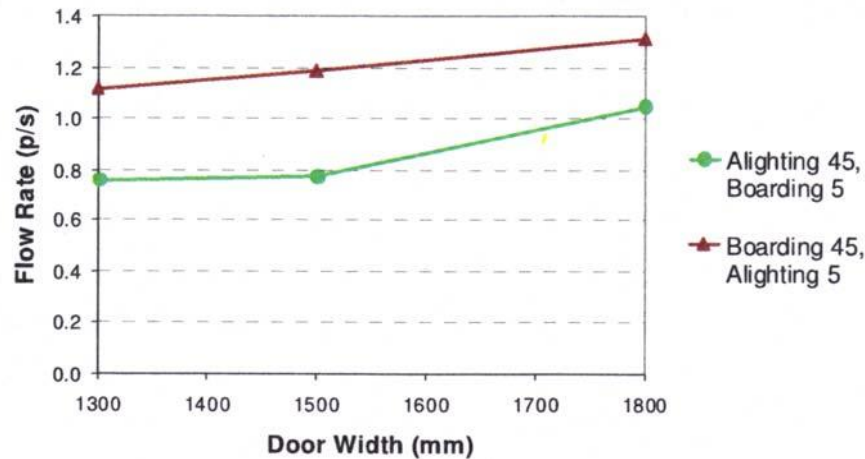
Stock	Boarding/Alighting Time	Notes	Source
NS V250	2.8-2.9 seconds	trial subjects with luggage, 910mm doors, 1-2 steps	Intergo
US Metro	2.10-3.25 seconds	times for a single stream	TCRP (Ref.3)
NS Mixed Stock	about 1 second	time for "clustered" passengers	Wiggenraad (Ref.1)
Tangara	1.22 seconds average	trials on double-deck mock-up 1900mm doors	Design Triangle team
Thameslink	0.8-1.3 seconds	mock-up trials, door width 1300-1800mm	Fujiyama (Ref.2)

### Effect of Exterior Door Width

Wiggenraad (Ref.1) studied the relation between the alighting and boarding time per passenger related to the width of the door throughway. Doorway widths varied from 800mm (single stream) to 1300mm and 1900mm (which he described as 3-passenger lane). He concluded that, *"Trains with wide door passageways show about 10% shorter typical alighting and boarding times and, with narrower door passageways, about 10% longer typical times"*. The times were 0.9 seconds and 1.1 seconds respectively, per passenger, alighting/boarding in clusters.

Wiggenraad quotes studies by Heikoop in 1996 in which, *"He found an average boarding time of 1.4s per passenger for a [level] boarding situation and a door width of 1.30m, and 1.6s per passenger for a difference in height of 70cm and door width of 75cm"*. No further details of this study have been found.

An investigation by Fujiyama et al (Ref.2) for the DfT Thameslink programme concluded that, *"a larger doorway width enabled more passenger movements within the target duration, and the performance of mainly alighting runs especially improved when the doorway was increased from 1500mm to 1800mm"*. Widening the doorways from 1300mm to 1500mm increased passenger flow rate by a maximum of 8.3%, whereas widening from 1300mm to 1800 increased passenger flow rate by 15-20%.



Extensive data collection on US rapid transit lines for TCRP (Ref.3) *"failed to show any meaningful relationship between door width and flow rate, within the 1.14 – 1.37m range of door widths observed – all double stream doors are essentially equal"*.

Research carried out by Intergo for NS on their IRM double deck stock has found that stopping times are typically 2-3 minutes. Experiments to reduce this time to below 2 minutes have so far not been effective. Intergo have concluded that, *"Widening the outer doors would be the best means of reducing stopping times"*.

### Vestibule Standbacks

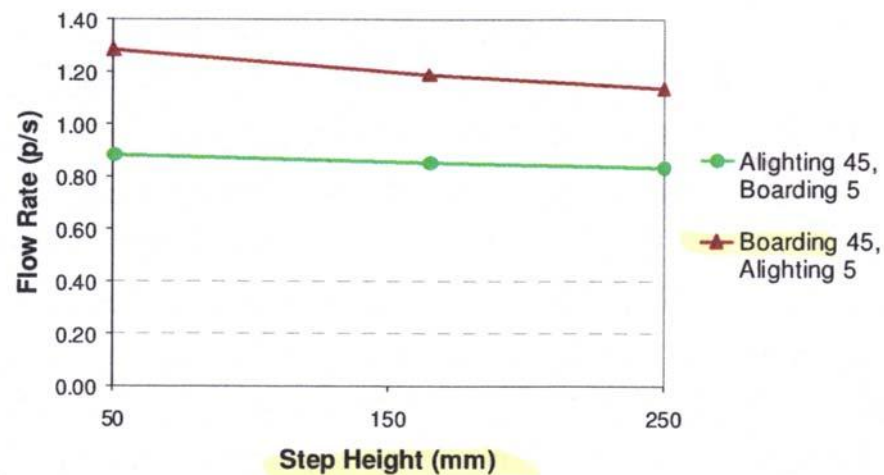
Fujiyama (Ref.2) concluded that a *"larger vestibule setback also enabled more participants to alight/board"* within a given period, *"but the performance did not improve greatly when the setback changed from 400mm to 800mm"*. No further details are available.

See also the Section below regarding the effect of vestibule crowding.



## Effect of Step Height and Stepping Distance

Fujiyama (ref.2) concluded that, “an increase in the vertical gap between the train and the platform led to a lower flow rate. Alleviating the vertical difference from 250mm to 50mm would improve performance by about 10% in the mainly boarding situation”. There was minimal effect in the mainly alighting case.



Data collection on US rapid transit lines for TCRP (Ref.3) suggested that, “Doorway step approximately doubles times for all three categories: mixed flow, boarding and alighting”.

In laboratory experiments, Daamen et al (Ref.7) concluded that, “Increasing the horizontal and vertical [stepping] gap leads to decreases in the [doorway] capacity (up to 15%)”.



## Crowd Management Measures

In his Thameslink study, Fujiyama (Ref.2) tested several crowd management measures, including:

- 1) Indications on the platform for boarding participants to stay clear of the doorway
- 2) Early announcement to encourage alighting participants to move towards the door
- 3) A longer door alert to provide earlier advice of the imminent closure

Fujiyama concluded that none of these measures proved a significant improvement.

## Effect of Vestibule Crowding

In a summary of his Thameslink study, Fujiyama (Ref.2) stated:

*"It was found that, in congested situations, there was no 'magic bullet' that would deliver a step change in performance, but that [passenger] density in the vestibule could be a key factor". "Our results suggest that when the [passenger] density in the destination (e.g. vestibule) becomes 2 people per square metre or greater, the flow rate starts decreasing".*

During in-service trials conducted on Docklands Light Railway in 1995 by Mike Stearn for Design Triangle Ltd (Ref.8), crowding of the vestibules 25 seconds after door opening formed a complete block to passenger flow, leaving passengers on the platform, even though there was standing space inside the vehicle.

A video presentation of user trials on double-deck suburban train vestibules, produced by Comeng, Australia and published on YouTube as, "*ComEng Tangara passenger flow tests*", highlights the advantages of large vestibules and wide stairs, to increase the flow of passengers through the vestibule. Although the vehicle type is not directly relevant, the principles are informative.

## Effect of Wheelchairs

Tong et al (Ref.6), in a paper for the RSSB, outline the effect of using wheelchair ramps on dwell times, the financial penalties that result and the consequent pressures on staff. Table 17 in that report suggests an average delay per assist of 5 minutes, with annual maxima ranging from 8 minutes to 23 and 36 minutes.



Hunter-Zaworski et al (Ref.5), in a report on US transit systems, state:

*"The movement of wheelchairs on level surfaces is generally faster than walking passengers except where the car or platform is crowded."*

However, level access will not be successful if there are large platform gaps. Hunter-Zaworski (Ref.5) states:

*"The vertical or horizontal gap between the edge of the platform and the door is often a major problem for passengers in wheeled mobility aids".*

### **Effect of Luggage**

In laboratory experiments, Daamen et al (ref.7) concluded that, " *When passengers with luggage (suitcases) are present, the [doorway] capacity decreases ..... up to 25%*".

The research by Intergo bv, reported above, used passengers each with a suitcase.

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## APPENDIX 2 - HUMAN FACTORS RESEARCH

### Overview

This Human Factors research is based on a review of available literature and the collation of experience from the Design Triangle/CCD team developed during internal workshops.

### STEP IMPROVEMENT IN PASSENGER EXPERIENCE

#### *Our understanding of passenger experience*

Total passenger experience is made up from:

- Physical experiences
- Mental experiences
- Emotional experiences
- Spiritual experiences
- Social experiences
- Virtual experiences
- Immediacy experiences
- Subjective experiences

Appeal to all of these and we will achieve positive experiences, fail in any one and negative experiences will appear.

In relation to passenger experience in rail vehicles, our human factors research indicates that we will gain most benefit from directing design efforts at delivering improvements in:

- 1 Physical experiences
- 2 Emotional experiences
- 3 Subjective experiences

These we regard as priority passenger experiences that, if positively stimulated by creative and functional vehicle design, will most deliver a step change improvement in the minds/views of HS2 passengers. We will concentrate on identification of design attributes that appeal to these experiences.



Those experiences taking a back seat...for now.

Mental experiences relate to design features that appeal to a passenger intellect, consciousness, perception, memory and imagination (i.e. stimulating changes in environment or challenging interactivity). These tend to challenge passengers and relieve negative experiences such as boredom and disappointment and may become more influential on total passenger experience as journey times increase.

Spiritual experiences do not come out from HF research as key passenger expectations from rail vehicle design, although sensitivity to spiritual customs (food type/preparation, personal space, colour combinations for example) will be important in delivering a multi culturally accepted product.

Social experiences relate to design features that enhance interpersonal, racial, gender, group and/or family interactions. In general social experiences come out from HF research as less influential than subjective (personal) experiences in rail vehicle design.

Virtual experiences as delivered from visual, auditory and/or haptic stimulus directed at the passenger (i.e. simulated feedback of speed or video presentation of external view) are feasible but less likely to deliver a long lasting step change in passenger experience.

Immediacy experiences relate to design features that influence both first and second hand passenger experience (i.e. how passengers who have used the vehicles communicate their experiences to others who have not yet travelled ("i loved the quietness and smoothness...you must give it a go") or how the press/media communicates experiences of the vehicles to new travellers (i.e. through exciting photographs, visual images, positive user quotes etc). Immediacy experiences are enhanced by eye catching design features. Design features targeting these secondary experiences are important but less likely to influence delivery of step change improvements than those targeting primary experiences.

#### *Physical passenger experiences.*

The areas highlighted in Figure 1 are those identified by HF research as the physical properties most likely to positively influence passenger experience in HS2 vehicles. Design improvements in any or all of these vehicle physical properties have the potential to deliver a step change in passenger experience.

#### *Emotional passenger experiences.*

Passenger emotions identified by HF research as the most likely, if positively supported by vehicle design features, to deliver a step change in passenger experience are outlined in Figure 2.





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*Subjective passenger experience.*

Subjective passenger experiences are positively enhanced by those aspects of vehicle design that target a passengers personal situation, needs, requirements and expectations as outlined in Figure 3. They are design features that give passengers the feeling that the vehicle has been 'designed for me' and 'make it easy for me to use and understand'.

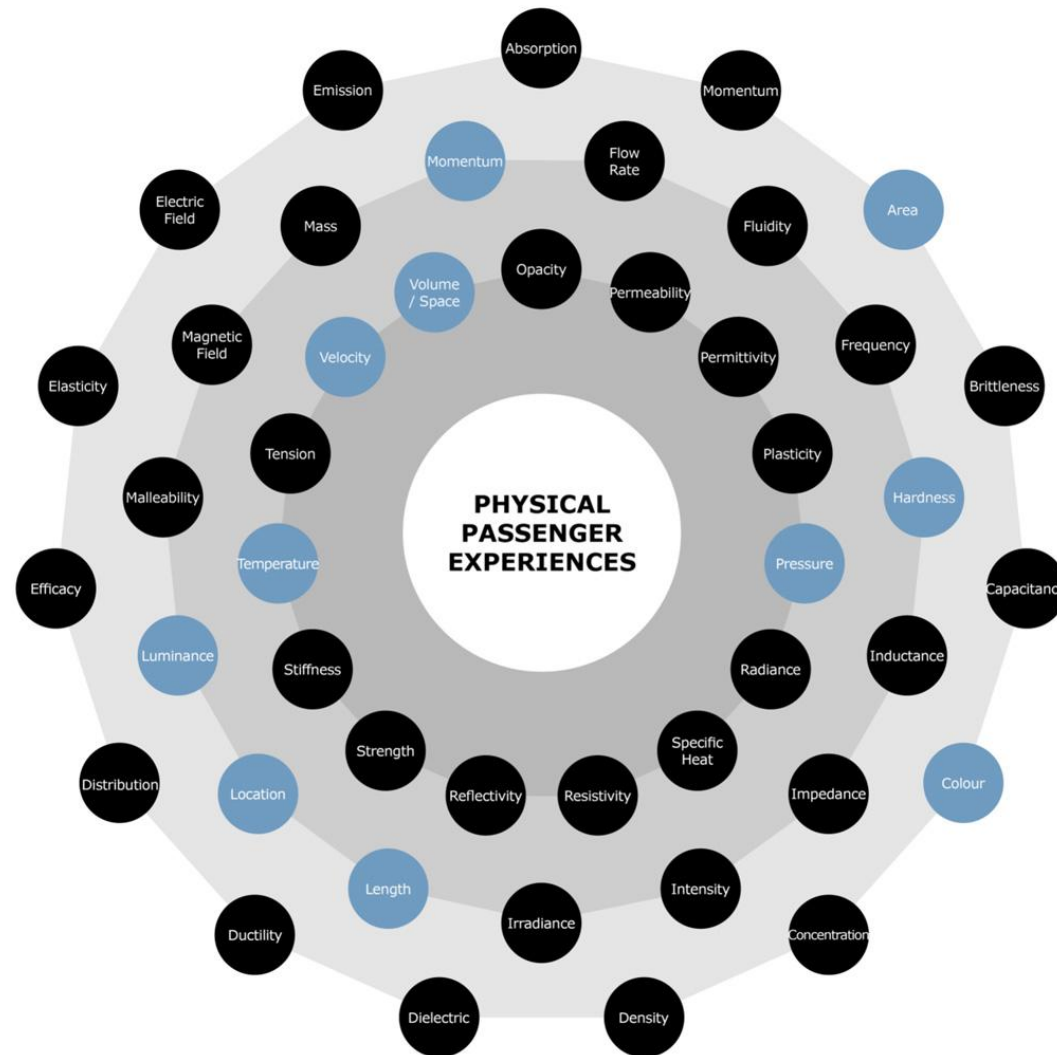


Figure 1

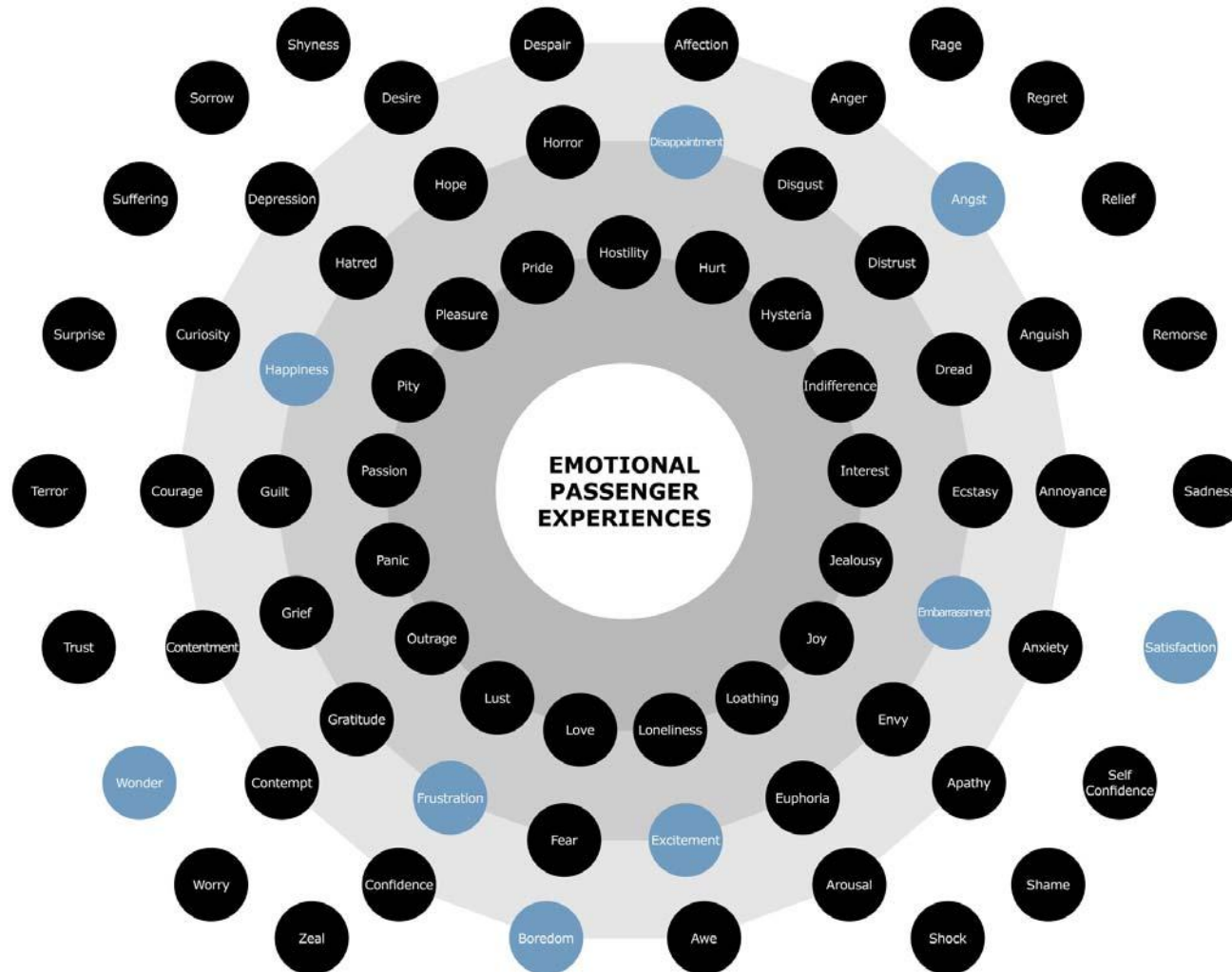


Figure 2

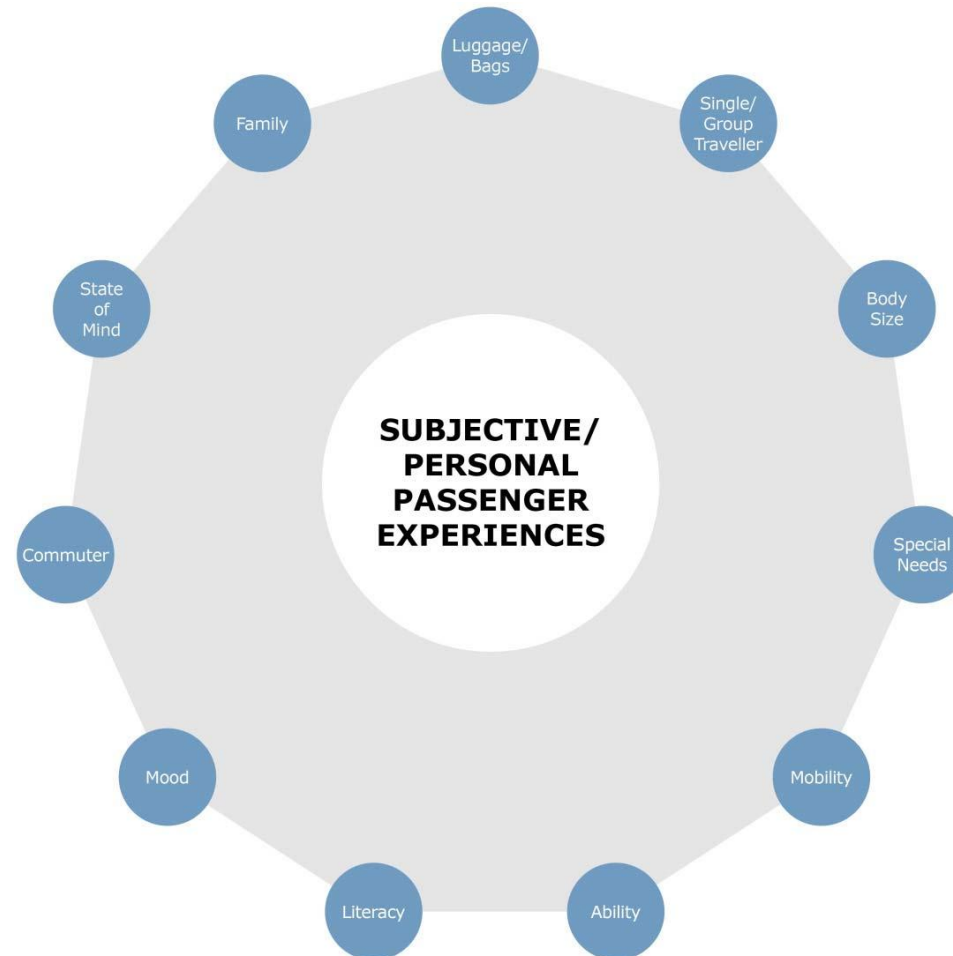


Figure 3



# **Vehicle design features most likely to positively deliver a step change in passenger experience**

Passenger experience research summarised in Figures 1 - 3 indicates primary goals for achieving a step change in passenger experience as outlined in Table 1.

Physical orientated goals	Emotion orientated goals	Personal orientated goals	Design areas
Maximise usable area			specialist areas; flexibility/re configurability; toilets; catering; seat space; seating layout; doors;
Optimise colour			surfaces; seats; interior identity;
Optimise hardness			vehicle ride; seat design; materials selection;
Length			walking routes; facility location;
Location			luggage racks; catering; toilets; doors;
Momentum			ride; sense of speed and progression; windows; information;
Temperature			at seat facilities; doors; windows;
Volume/space			seat design; seating location; luggage racks; vestibules;
Pressure			sealing;
	Reduce angst		information; seat design; luggage racks;
	Reduce boredom		at seat facilities; specialist areas;
	Minimise disappointment		<i>Requires HS2 specific research</i>
	Encourage excitement		<i>Requires HS2 specific research</i>
	Reduce frustration		information;
	Foster happiness		<i>Requires HS2 specific research</i>
	Maximise satisfaction		<i>Requires HS2 specific research</i>
	Foster wonder		<i>Requires HS2 specific research</i>
		Body size and ability	platform interface; luggage racks; walking route; seat design; seating layout; toilets;
		Personal comfort	environment control; seat design; seating layout; ride;
		Personal convenience	catering; toilets; at seat facilities;
		Luggage	luggage racks;
		Special needs	platform interface; doors; walking route; seat design; seating layout; toilets; luggage racks; catering;
		Single, pair or group	seat design; seating layout; specialist areas;
		Regular or occasional	information;
		personal mood	seat design; seating layout; information;

Table 1



HF research undertaken in Phase 1 resulted a fifty eight HF needs statements describing potential areas for improvement in passenger experiences on board rail vehicles. HF needs statements were summarised and prioritised into a 'long list' in Phase 2. Table 2 provides a further summary at Phase 3 of the highest priority HF needs statements which, if addressed by innovative vehicle design, are felt most likely to provide a step change in passenger experience. Note: Table 2 focuses only on HF needs that relate directly to potential vehicle design 'solutions'. Other HF needs which are more appropriately addressed by wider solutions (i.e. service, ticketing, station facilities etc) are presented in the Phase 2 and Phase 2 HF Tables.

Priority	HF need statements and design goal (summary)	Passenger experience benefits	Design areas
1	For my seat space to be obviously mine uninterrupted and uninhabited by other passengers and train staff throughout the journey unless I so choose	Physical; Subjective; Emotional	Seat design; Seating layout
1	To get to, position myself in, and move away from my seat as quickly and easily as possible.	Physical; Subjective; Emotional	Information/signage; Platform/train interface; Door location; Route to seat; Seat layout
1	To discard, store and pick up my luggage quickly, easily and securely	Physical; Subjective;	Luggage racks
1	To have control over temperature and draughts so I feel comfortable throughout the journey	Physical; Subjective	Thermal control
1	To have important comfort and convenience facilities near/come to me	Physical; Subjective; Emotional	Catering location/type; Toilets; Bins; Call facilities; At seat facilities
1	For my seat space to support my personal needs and varying activities throughout the journey	Physical; Subjective;	Seat design; Seating layout; Environment control
1	To have enough personal space to be comfortable, to stretch my legs, to get easy access to my personal effects and to get in and out of my seat without disturbing other people	Physical; Subjective; Emotional	Seat design; Seating layout; Luggage racks
1	To be able to get information about service, facilities or location when I want or need it and in a form that is sensitive to my personal abilities or activity	Physical; Subjective	Information; Environment control; At seat facilities
1	To be able to guarantee that I can sit with my travelling companion(s), face in my preferred direction of travel and have appropriate facilities like tables, reading light and storage spaces to make my journey easy and comfortable		Seat design; Seating layout; At seat facilities

Table 2



### ***Conclusion***

Analysis of occurrence of design areas in Tables 1 and 2 provide a top level priority for specifying areas of vehicle design most likely to result in a step change in passenger experience in future HS2 vehicles.

- 1      Seat design
- 2      Seating layout
- 3      Information
- 4      Luggage racks
- 5      At seat facilities
- 6      Environment control
- 7      Catering/toilet facilities
- 8      Door location
- 9      Platform/train interface
- 10     Ride

**3+2 SEATING**

An analysis of three abreast seating was undertaken against highest priority HF needs statements which, if addressed by innovative vehicle design, are felt most likely to provide a step change in passenger experience. Results are summarized in Table 3.

Priority	HF need statements and design goal (summary)	3 abreast seating HD analysis	Support primary HF need
1	For my seat space to be obviously mine uninterrupted and uninhabited by other passengers and train staff throughout the journey unless I so choose	Three abreast seating compromises personal space or aisle space or both. Designated personal spaces are more difficult. Armrests add to the space compromise issues.	✗
1	To get to, position myself in, and move away from my seat as quickly and easily as possible.	More passengers to pass/disturb for users of the inside seat. Middle seat tends to be disruptive to passengers on either side.	✗
1	To discard, store and pick up my luggage quickly, easily and securely	Access into and out of seats more difficult. Access to overhead luggage storage compromised for two passengers.	✗
1	To have control over temperature and draughts so I feel comfortable throughout the journey	More difficult to split individual temperature and air control although air movement achieved in aircraft.	☒
1	To have important comfort and convenience facilities near/come to me		n/a
1	For my seat space to support my personal needs and varying activities throughout the journey	Middle seat of three potentially restrictive for changes in posture and adaptation of posture to varying activities (laptop use elbows out, cross legs etc)	✗
1	To have enough personal space to be comfortable, to stretch my legs, to get easy access to my personal effects and to get in and out of my seat without disturbing other people	As before	✗
1	To be able to get information about service, facilities or location when I want or need it and in a form that is sensitive to my personal abilities or activity	Potentially more difficult to split targeted information to a three row seat than a two row seat especially in face to face seating layouts	☒





Priority	HF need statements and design goal (summary)	3 abreast seating HD analysis	Support primary HF need
1	To be able to guarantee that I can sit with my travelling companion(s), face in my preferred direction of travel and have appropriate facilities like tables, reading light and storage spaces to make my journey easy and comfortable	Potentially better if three people travelling together, especially two parents and a single child. Worse for pairs as third passenger is felt to encroach on personal space. Single travelers do not, historically, like taking a middle seat. More scope for 'that's my bags seat' and lower utilization of middle seat.	<input checked="" type="checkbox"/>

Table 3

**Conclusion**

Three abreast seating:

- 1 ✖ Fails to support 56% of primary HF goals for a step change in passenger experience.
- 2 ☒ Semi fails to support 33% of primary HF goals for a step change in passenger experience.
- 3 Not applicable to 11% of primary HF goals for a step change in passenger experience.
- 4 ✖ ☒ Fails or semi fails 89% of primary HF goals for a step change in passenger experience.

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Active improvement of high speed train sonic ambiances  
International Congress on Ambiances, 2012



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#### APPENDIX 4 - POTENTIAL SEATING CAPACITY OF EXISTING HIGH SPEED TRAINS

Design Triangle Limited have compared the potential capacity of various, existing high speed trains. This was done by installing seats at the same pitch in each 200-metre train and by incorporating similar facilities, as far as possible. Draft results are shown in the table below:

	Bombardier V300 Zefiro			Alstom AGV			Siemens Velaro D			Hitachi IEP			Talgo Avril		
	Std Class	First Class	Total	Std Class	First Class	Total	Std Class	First Class	Total	Std Class	First Class	Total	Std Class	First Class	Total
<b>Seated Capacity</b>	452	99	<b>551</b>	424	91	<b>515</b>	420	95	<b>515</b>	436	105	<b>541</b>	385	89	<b>474</b>
<b>Wheelchair Spaces</b>	2	-	<b>2</b>	2	-	<b>2</b>	2	-	<b>2</b>	2	-	<b>2</b>	2	-	<b>2</b>
<b>Standard Toilets</b>	10	4	<b>14</b>	7	2	<b>9</b>	6	4	<b>10</b>	5	4	<b>9</b>	6	2	<b>8</b>
<b>Universal Toilets</b>	1	-	<b>1</b>	1	-	<b>1</b>	1	-	<b>1</b>	1	-	<b>1</b>	1	-	<b>1</b>
<b>Luggage Stacks</b>	11	4	<b>15</b>	16	6	<b>22</b>	13	4	<b>17</b>	11	5	<b>16</b>	17	6	<b>23</b>
<b>Bulk &amp; Bike Room</b>	-	-	-	-	-	-	-	-	-	4	-	<b>4</b>	-	-	-
<b>Catering Facilities</b>	4-metre Buffet	-	-	-	3-metre Area	-	5.6-metre kitchen	-	-	Vending machines	5-metre kitchen	-	-	5.6 metre kitchen	-
<b>Crew Office</b>	-	-	-	1	-	<b>1</b>	-	-	-	-	-	-	1	-	<b>1</b>
<b>Crew Toilet</b>	1	-	<b>1</b>	-	-	-	-	-	-	-	-	-	1	-	<b>1</b>

Details of the layouts used are shown in the following drawings in Annex B:

- 281LL043 Bombardier Zefiro (202 metres)
- 281LL044 Alstom AGV (201 metres)



- 281LLO45	Siemens Velaro D	(200 metres)
- 281LLO46	Hitachi IEP	(208 metres)
- 281LLO48	Talgo Avril	(199 metres)

The variation in overall train length (total 4.5%) should be considered when reviewing this data.

The seated capacity varies from 474 (Talgo Avril) to 551 (Bombardier Zefiro). The higher capacities result from full utilisation of the driving car and freeing up the maximum of available space within the trailer cars.

The proportion of First Class seats is approx 18% - 19% in each case.

Other facilities vary slightly. Hitachi IEP has fewer luggage stacks, but 4 Bike Rooms. Bombardier Zefiro has 14 standard toilets.

### **Bombardier V300 Zefiro**

This vehicle has the highest seated capacity, at 551, in the 8-car, 202 metre train. 106 of these seats are in the driving cars. 18% are at a longer (First Class) pitch. This layout includes 14 standard toilets, 15 luggage stacks and a crew toilet, as well as a 4 metre catering facility.

### **Alstom AGV**

This vehicle has a seated capacity of 515 in an 11-car, 201 metre train. 69 of these seats are in the (shorter) driving cars. 18% are at a longer (First Class) pitch. This layout includes 9 standard toilets, 22 luggage stacks and a crew office, as well as a shorter 3 metre catering area.

### **Siemens Velaro D**

This vehicle also has a seated capacity of 515 in an 8-car, 200 metre train. 106 of these seats are in the driving cars. 18% are at a longer (First Class) pitch. This layout includes 10 standard toilets, 17 luggage stacks, as well as a 5.6 metre catering facility.





### **Talgo Avril**

This vehicle has the lowest seated capacity, at 474 in the 14-car, 199 metre train. Despite its 3+2 seating, this is 77 seats less than the Zefiro layout. None of these seats are in the driving cars. 19% are at a longer (First Class) pitch. This layout includes 8 standard toilets, 23 luggage stacks and a crew office, as well as a 5.6 metre catering facility.

### **Hitachi IEP**

Although this vehicle, at 125mph, cannot be considered as true high speed, it is interesting as a comparator. It has a seated capacity of 541 in the 8-car, 208 metre train. (Corrected for the excess length, the seated capacity would be 525.) 85 of these seats are in the driving cars. 19% are at a longer (First Class) pitch. This layout includes 9 standard toilets, 16 luggage stacks and 4 bulk and bike rooms, as well as a 5 metre catering facility.

**APPENDIX 5 - RESEARCH INTO THE EXTERIOR DIMENSIONS OF EXISTING HIGH SPEED TRAINS****Trailing Car Length**

Drawing 281LLo60, in Annex B, shows the dimensions of the Trailing Cars of some existing or proposed high speed vehicles:

<b>Trailing Car</b> (all dimensions in mm)	<b>Bombardier V300 Zefiro</b>	<b>Alstom AGV</b>	<b>Siemens Velaro D</b>	<b>Hitachi IEP</b>
Overall Length - Trailing Car	24,900	17,300	24,615	26,000
Wheelbase - Trailing Car	17,400	17,300	17,337	17,000
Overhang - Trailing Car	3,750	0	3,639	4,500

The wheelbase of the Trailing Cars lies within a narrow 2% range (17,000 - 17,400mm). Apart from the articulated Alstom AGV, the overall length of the Driving Cars lies within a 5% range (24,615 - 26,000mm)

**Driving Car Length**

Drawing 281LLo20, in Annex B, shows the dimensions of the Driving Cars of some existing or proposed high speed vehicles:

<b>Driving Car</b> (all dimensions in mm)	<b>Bombardier V300 Zefiro</b>	<b>Alstom AGV</b>	<b>Siemens Velaro D</b>	<b>Hitachi IEP</b>
Overall Length – Driving Car	26,300	22,735	25,700	25,350
Wheelbase – Driving Car	17,400	17,100	17,336	17,000
Nose Length (from bogie centre)	5,150	5,635	4,950	4,350

While the wheelbase of the Driving Cars remains within a 2% range (17,000 - 17,400mm), the nose length varies over a 25% range (4,350 - 5,635mm). Apart from the articulated Alstom AGV, the overall length of the Driving Cars lies within a 4% range (25,350 - 26,300mm).



## Cross Section Dimensions

Drawings 281LL014 and 281LL015, in Annex B, shows the cross section dimensions of the Trailing Cars of some existing or proposed high speed vehicles:

Cross Section (all dimensions in mm)	Bombardier V300 Zefiro	Alstom AGV	Siemens Velaro D	Talgo Avril	Hitachi IEP
Overall Width	2,924	2,985	2,924	3,200	2,740
Overall Height (above rail level)	4,080	4,125	4,343	3,335	3,844
Floor Height (above rail level)	1,240	1,155	not available	755	1,185

The Bombardier Zefiro and Siemens Velaro have identical 2,924mm widths. Whilst the relatively higher 2,985mm and 3,200mm widths of the Alstom AGV and Talgo Avril reflect their short-car formats, the 2,740mm Hitachi IEP reflects the UK gauge and represents the likely width of the Classic Compatible version.

The overall height of the Zefiro, the AGV and the Velaro lie within a 6% range (4080 – 4343mm). The lower Talgo Avril reflects the 400-500mm lower floor height. The reduced height of the Hitachi IEP reflects the UK gauge and represents the likely width of the Classic Compatible version.



## APPENDIX 6 – COMPARISON OF EXISTING HIGH SPEED TRAINS

Vehicle	Alstom AGV	Bombardier V300 Zefiro	Bombardier V300 Zefiro	Siemens Velaro D	Talgo 350
Variant	NTV italo	Proposal to Network Rail 2010	Dwg. No. 3EGH489008-7500	Siemens brochure	Estimated 200m train
Train Length	201.2m	202.000m	202.000m	200.300m	200m
Car Length – Trailer	17.300m	24.900m	24.900m	24.719m	13.140m
Car Length – Driving	22.735m	26.300m	26.300m	25.997m	20.000m
Overall Width	2985mm	2924mm	2924mm	2924mm	2942mm
Overall Height	4125mm	4080mm	4080mm	4343mm	3365m
Floor Height	1155mm	1240mm	1240mm	?	755mm
Number of Cars	11	8	8	8	12+2
Number of Axles	24	32	32	32	21
Bogie Type	articulated	standard	standard	standard	articulated
Power Type	distributed	distributed	distributed	distributed	locos
Total Seats	448	550	598	495	328
Std Class Seats	288 (64%)	418 (76%)	462 (77%)	342 (69%)	-
1 <sup>st</sup> Class Seats	143 (32%)	132 (24%)	136 (23%) (2+2)	153 (31%)	-
Club Seats	19 (4%)	n/a	n/a	n/a	-
Wheelchair Spaces	2	2	2	2	2
Accessible Toilets	1	1	1	1	1
Standard Toilets	9	14	12	11	-
Catering Area Length	2915mm	4027mm	4027mm	N/A	10422mm
Vending Machines	5	0	0	.....	.....
Luggage Stacks	14	16	8	0	12
Electrical Cabinets	13	.....	.....	.....	.....
Passenger Doorways	10 pairs	13 pairs	13 pairs	16 pairs	11 pairs
Saloon Internal Length	12.787m	19.080m	19.080m	18.100m	8.960m
Seat Rows/car – 1 <sup>st</sup> Class	13	19	19.5	18	9



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Vehicle	Alstom AGV	Bombardier V300 Zefiro	Bombardier V300 Zefiro	Siemens Velaro D	Talgo 350
Variant	NTV italo	Proposal to Network Rail 2010	Dwg. No. 3EGH489008-7500	Siemens brochure	Estimated 200m train
Seat Pitch – 1 <sup>st</sup> Class	955mm	950mm (2+2)	950mm (2+2)	970mm	1000mm
Tables – 1 <sup>st</sup> Class	1 row	1 row	1 row	1 row	1 row
Seat Rows/car – Std Class	13	.....	22.5	19	9
Seat Pitch – Std Class	900mm	890mm	800mm	930mm	1000mm
Tables – Std Class	1 row	1 row	1 row	1 row	1 row



## APPENDIX 7 - RESEARCH INTO EXTERIOR DETAILS OF EXISTING HIGH SPEED TRAINS

### Windscreen

The Bombardier V300 Zefiro ETR 1000 has a relatively small windscreen, with only light curvature. It has black paint to make it look larger.

The Alstom AGV Italo has a relatively small windscreen, with relatively strong curvature in one direction. The windscreen appears to be surrounded by glass panels and black paint. Although the side glass was clear in the Pegase prototype, this is not obvious on the Italo version.

The Siemens Velaro D has a relatively wide windscreen, with some curvature. It has an area of black paint above, to complete the graphic shape.

### Cab Side Windows

The Bombardier V300 Zefiro ETR 1000 appears not to have cab side windows, but perhaps a small hatch on both sides of the cab.

The Alstom AGV Italo may have windows on both sides of the central windscreen, although they are heavily tinted. There appears to be a small hatch on both sides of the cab.

The Siemens Velaro D has a window on each side of the cab, behind the driver. This opens to form a hatch.

### Cab Side Doors

The Alstom AGV Italo has driver access doors at both sides, behind the cab, in the extruded bodyshell. These doors are at a higher level (1424 mm) than the passenger doors (1155mm). They have long, recessed handrails at both sides and 3 recessed steps, of which 2 also have protruding steps.

The Bombardier V300 Zefiro ETR 1000 has driver access doors at both sides, behind the cab, in the extruded bodyshell. These doors are at a higher level (1460mm) than the passenger doors (1240mm). They have long, recessed handrails on both sides and 3 recessed steps.

The Siemens Velaro D has driver access doors which double as passenger doors.



## **Lamps**

The Bombardier V300 Zefiro ETR 1000 has recessed and faired-in lamps. The main cluster appears to include a LED headlamp and a red LED tail lamp. The third lamp is below the windscreen and is also a white LED.

The Alstom AGV Italo has faired-in lamps. These consist of a LED headlamp and a LED marker/tail lamp. The third lamp is above the windscreen.

The Siemens Velaro D has faired-in lamps, consisting of a LED headlamp and a LED marker/tail array. The third lamp is above the windscreen.

## **Coupler Cover**

The Bombardier V300 Zefiro ETR 1000 has a short, rounded coupler cover split vertically on the centreline.

The Alstom AGV Italo has a very short coupler cover, with a central vertical split. The horn of the coupler protrudes through a slot.

The Siemens Velaro D has a relatively short coupler cover, with a horizontal split. The horn of the coupler protrudes through a small slot.

## **Cab Bogie Covers**

The Bombardier V300 Zefiro ETR 1000 has half-height bogie covers, over the upper part of the bogies. It is fixed to the cab bodywork and bulges slightly from the main profile.

The Alstom AGV Italo has half-height bogie covers, over the upper part of the bogies. It is fixed to a flared area of the cab bodywork.

The Siemens Velaro D has only very short cover panels, in line with the main sole bar.

## **Windscreen Wipers**

The Bombardier V300 Zefiro ETR 1000 has a straight twin-arm wiper, with exposed pivots in a flush panel directly below the windscreen. It parks at the side of the windscreen.



The Alstom AGV Italo has a single twin-arm wiper with a heavy crank to allow central pivot mounting in a small flared panel below the windscreen. It parks at the side of the windscreen.

The Siemens Velaro D has a single twin-arm wiper with a cranked arm. It parks in the centre of the windscreen. The pivots are partially concealed within a moulded fairing.

### **Passenger Windows**

The Bombardier V300 Zefiro ETR 1000 has flush, frameless windows with radius corners, wide pillars and a painted black band.

Alstom AGV Italo has flush, frameless windows with radius corners, wide pillars and a painted black band.

Siemens Velaro D has flush, frameless windows with radius corners, wide pillars and a painted black band.

The key dimensions of the windows and window pillars are as follows:

<b>Passenger Windows</b>	<b>Window Pillar Width (mm)</b>	<b>Window Width (mm)</b>	<b>Window Height (mm)</b>	<b>Window Height Above Rail (mm)</b>	<b>Floor Height Above Rail (mm)</b>	<b>Windows Height Above Floor (mm)</b>
Alstom AGV Italo	420	1720	855	1780	1155	625
Bombardier V300 Zefiro	497	1620	800	1990	1240	750
Hitachi IEP (2009)	550	1430	650	2037	1185	852
Siemens Velaro D	504	1508	720	2020	-	-

Note: All dimensions are estimated, based on best information available (see drawing 281LL052 in Annex B)

Alstom AGV appears to have the largest windows and the narrowest window pillars.





The height of the windows above rail results, in part, from the difference in floor height. The height of the windows above floor is calculated in the table.

### Passenger Doors

The Bombardier V300 Zefiro ETR 1000 has flush doors with radius corners and narrow seals. They have an information display in the door, below the door window, visible from the outside. There appears to be a flush-fitting passenger step below the door.

Alstom AGV Italo has flush doors with radius corners and narrow seals. They are of the exterior sliding plug type. They have an information display in the door window, visible from the outside. There appears to be a flush-fitting passenger step below the door.

Siemens Velaro D has flush doors, with a small radius in the upper corners. They are of the exterior sliding plug type. They have an information display in the door, below the door window, visible from the outside. It has a flush-fitting passenger step below the door.

The key dimensions of the passenger doors are as follows:

Passenger Doors	Door Width (mm)	Door Height (mm)	Door Height Above Rail (mm)	Floor Height Above Rail (mm)	Door Distance Below Floor (mm)
Alstom AGV Italo	1150	2405	806	1155	379
Bombardier V300 Zefiro	1160	2450	960	1240	280
Hitachi IEP (2009)	870	1900	1185	1185	0
Siemens Velaro D	1095	2490	986	-	-

**Note:** 1. All dimensions are estimated, based on best information available (see drawing 281LL052 in Annex B)  
2. All dimensions are to external shut lines (not throughway)

For the Alstom, Bombardier and Siemens vehicles, the exterior door width lies within a band 1095-1160mm. The exterior door height lies within a band 2405-2490mm.



## Roof

The Bombardier V300 Zefiro ETR 1000 prototype appears to have discrete roof modules, painted black.

The Alstom AGV Italo has a mainly smooth, painted roof, with wide shut lines around the roof equipment modules.

The Siemens Velaro D has a low roof on the driving cars, with a raised roof on the trailing cars. The bulged roof of the trailing cars is mainly smooth and painted with wide shut lines around some equipment modules.

Bombardier-Sifang Zefiro 380 (China) has a smooth painted roof.

## Inter-Car Area

The Bombardier V300 Zefiro ETR 1000 prototype has wide, but fairly flush, black rubber bellows between the cars.

Alstom AGV Italo has a narrow inter-car gap (approx 100mm) with wide rubber finishers (approx 150mm) on the end of each car. These continue over the roof. It has tandem bogies.

Siemens Velaro D has a relatively wide, open gap between carriages, which continues over the roof.

Bombardier Zefiro 380 (China) has wide, but fairly flush bellows between the cars.



## APPENDIX 8 - RESEARCH INTO EXISTING UK TRAINS

Design Triangle Limited have conducted user research on a number of existing UK trains, travelling on the following types:

- |                            |           |               |
|----------------------------|-----------|---------------|
| - Alstom Pendolino         | Class 390 | Virgin        |
| - Bombardier Super Voyager | Class 221 | Virgin        |
| - Bombardier Meridian      | Class 222 | East Midland  |
| - Hitachi Javelin          | Class 395 | South Eastern |
| - IC225                    | Mk4       | East Coast    |

The main conclusions of the study included:

- Facing seats are popular
- Most people keep their luggage near them
- Toilet odour was unpleasant near virtually all toilets
- Seated passengers must be isolated from toilet odour
- Seat Pitches in Standard Class lie in the range 780-840mm
- Seat Pitches in First Class lie in the range of 1050-1130mm
- Large tables are an advantage, particularly on longer journeys
- Flip-up tables ease access to the seats
- A means to secure your luggage while you go to the toilet would be desirable
- Timely next station announcements would allow timely alighting
- More information on your journey, including stops on the route, would be helpful
- A crew rest area is required for longer journeys
- Seat recline is often very stiff and difficult to use
- Curtains or sunblinds in First Class would be desirable
- A range of catering would be an advantage on longer journeys
- Longer distance trains all have a kitchen
- Some food was offered free with a First Class ticket
- The Standard of First Class food was generally disappointing



- Warm waiting facilities on platform, near the train, would be desirable
- UAT Toilet internal length and width was typically 1670-1870mm

Also, drawing 281LL049 in Annex B shows the layout of a Class 395 Alstom Pendolino. This train is approx 265 metres long and consists of 11 cars. It has a full kitchen, plus a Shop. It has 3 wheelchair areas (as required by law) and 3 universal access toilets. It also has 6 standard toilets, 30 luggage stacks and 2 bike and a bulk rooms. (The 9-car variant has not been studied.)



## APPENDIX 9 - UK RAIL SURVEY

	Mk IV	Pendolino	Super Voyager	Meridian	Javelin
Seat Pitch - typical – Standard Class	-	840	770-790	840	830
Seat Pitch - typical – First Class	1130	1050	1100	1100	NA
Seat Pitch Facing – Standard Class	-	1900	1990		1810
Seat Pitch Facing - First Class	2060	-	-	2110	NA
Luggage Stack – internal width – Standard Class	570	510	-	520/630	-
Luggage Stack – internal width – First Class	890	510	565	900	NA
Exterior Door throughway	910	900	860	850	1130
Catering –overall length	8710/9800	6660(shop)	3200(shop)	2900(shop)	NA
Seat spacing – Standard Class	-	760	-	-	-
General Impressions	2+1 spacious Light Pleasant Seat slide	Seat slide	Similar to Pendolino Lack rack Too shallow Seat slide		Smart Functional No frills Cold lighting



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## **APPENDIX 11 - RESEARCH INTO DISPLAY TECHNOLOGY**

Design Triangle Limited have researched new technology which is currently becoming available:

### **Samsung Transparent Smart Window Technology**

Samsung have developed a device which looks like a normal full-sized, transparent window but is in fact an OLED display which can show images, text, videos, etc like any computer display or television screen. It was first displayed at CES 2010 and 2012 (Consumer Electronics Show in Las Vegas).

### **Curved Displays**

In 2013, Samsung showed large curved OLED displays. These are now being developed by a number of companies and would allow curved body panels to become displays.

### **Formable Thin-Film Lighting**

Thin, formable lighting panels include Light Emitting Capacitors (LEC) and OLED thin-film encapsulating technologies. These would allow curved surfaces of the vehicle to become light sources.



## APPENDIX 12 – BRAINSTORM IDEAS LIST

### 1.0 STATION DWELL TIMES

#### 1.1 Door Locations

- 1.1.1 1/3 - 2/3 door positions
- 1.1.2 separate doorways/vestibules for passenger alighting and boarding
- 1.1.3 pair of doors close together, with luggage stacks between

#### 1.2 Number of Doors

- 1.2.1 4 doors per side (as London Underground)
- 1.2.2 3 doors per side (as proposed Crossrail)
- 1.2.3 single, wider vestibule, with wide doors

#### 1.3 Door Width

- 1.3.1 wide doorways (1500mm)
- 1.3.2 very wide doorways (1900mm) split into two, for streaming

#### 1.4 Vestibules

- 1.4.1 wide vestibules, to reduce congestion near doors
- 1.4.2 wide standbacks either side of doorways

#### 1.5 Central Gangways

- 1.5.1 wide central gangways, to speed passenger flow, especially near vestibules
- 1.5.2 short central gangways, to reduce passenger walking distance

#### 1.6 Obstructions to Passenger Flow

- 1.6.1 allow space for people loading luggage into stacks, without blocking passenger flow
- 1.6.2 think about special cases, which may lengthen dwell time
  - wheelchair passenger
  - blind person





- mother with buggy and 2 children

## **1.7 Passenger Flow Aids**

- 1.7.1 vertical handpole in the middle of wide doorway (for twin stream boarding/alighting)
- 1.7.2 coloured door leaves (for twin stream boarding/alighting)
- 1.7.3 coloured LED lighting (for twin stream boarding/alighting)

## **1.8 Intercar Gangways**

- 1.8.1 wide intercar gangway (with sliding doors for pressure pulses and noise)

## **1.9 Platform Design**

- 1.9.1 platforms on both sides of every train (simultaneous boarding/alighting)
- 1.9.2 passengers move directly away from train after alighting, not along the platform
- 1.9.3 fences on the platform, to guide passengers (e.g. airport immigration)
- 1.9.4 tall totems, to guide passengers to the correct doorway



## **2.0 PASSENGER CAPACITY**

### **2.1 Seating Layout**

- 2.1.1 3+2 seating in some areas, at a lower ticket price
- 2.1.2 staggered seats, with one seat 200-300mm behind adjacent seat
  - allows room for elbows
- 2.1.3 short pitch in some areas, at a lower ticket price

### **2.2 Seat Design**

- 2.2.1 thin seat backrest, for maximum legroom at minimum seat pitch
- 2.2.2 curved back shell section, to allow the longest legs to straddle

### **2.3 Facilities**

- 2.3.1 effect of luggage stacks on seating capacity
- 2.3.2 effect of catering facilities on seating capacity
- 2.3.3 effect of staff facilities on seating capacity

### **2.4 Vehicle Equipment Location**

- 2.4.1 locate all equipment below floor or above ceiling



### **3.0 STEP IMPROVEMENT IN PASSENGER EXPERIENCE**

#### **3.1 Seat Environment**

- 3.1.1 noise-absorbing seat shell
- 3.1.2 privacy screens at seat
- 3.1.3 ear-rests on seat allow private space
- 3.1.4 two separate armrests for each seat (clear personal space)
- 3.1.5 elbow room for laptop use
- 3.1.6 tables at seat
- 3.1.7 double-fold table
- 3.1.8 table plus shelf
- 3.1.9 ownership of the surface in front of the seat
- 3.1.10 individual seats can be rotated to face other passengers, or to face direction of travel
- 3.1.11 twin seats can be rotated to face the opposite direction

#### **3.2 Facilities for Persons of Reduced Mobility**

- 3.2.1 shallow shelf
- 3.2.2 move wheelchair spaces away from toilet
- 3.2.3 make wheelchair spaces as similar to other zones as possible
- 3.2.4 provide a wheelchair space in Lounge Zone

#### **3.3 Seating Layout**

- 3.3.1 mixed seating layouts to suit different travellers, e.g. airline, bay, single, twin

#### **3.4 Facilities for Tall/Small Persons**

- 3.4.1 specific seats bookable for tall passengers
- 3.4.2 lower seat cushion height bookable for smaller passengers
- 3.4.3 offer alternative seats for different people
  - long pitch, high cushion for tall people
  - low cushion for short people
  - standard



3.4.4 have a mix of car-type prone seating

### 3.5 **Windows**

3.5.1 windows change to image displays in tunnels (transparent LED displays)

3.5.2 windows replaced by LED displays (cameras show the exterior view)

### 3.6 **Lighting**

3.6.1 "daylight" lighting from the ceiling

3.6.2 passengers set their own individual light level

3.6.3 switch mood lighting colours on your individual seat

3.6.4 use light to guide people and help people

3.6.5 lighting at your seat gets brighter when you enter the car

### 3.7 **Luggage Facilities**

3.7.1 determine volume of luggage to be housed

3.7.2 luggage stacks near vestibules

3.7.3 space in front of stack to minimise congestion while loading

3.7.4 luggage stowage between seat backs

3.7.5 luggage stowage under seats

3.7.6 seats cantilevered, to provide more space for luggage

3.7.7 facilities under seats to keep luggage off the dirty floor

3.7.8 overhead luggage lockers with doors for crashworthiness safety at high speed

3.7.9 mixed storage of stacks, seat-back, under-seat and luggage racks

3.7.10 remote luggage compartment with CCTV surveillance (like a coach)

3.7.11 checked-in luggage bay with CCTV camera view at seat for passengers

3.7.12 transverse luggage racks above seats

3.7.13 over the seat in front, or over your own seat

3.7.14 luggage rack can hinge down for loading

3.7.15 luggage rack can be counterbalanced

3.7.16 luggage rack can become a table at low level

3.7.17 overhead racks on wall-side seats only, to minimise obscuration of vision through the car



- 3.7.18 buggy storage facilities
- 3.7.19 bicycle storage facilities

### **3.8 Lounge Zone**

- 3.8.1 passengers can book into a Lounge Zone
- 3.8.2 mix of lounge seats and bar stools
- 3.8.3 seats need not be booked, but there are enough seats for the number of passengers booked
- 3.8.4 catering is like Executive Lounge at the airport (drinks, snacks, fruit, etc available self-service)

### **3.9 Toilet Facilities**

- 3.9.1 number of toilets required to be researched
- 3.9.2 consider urinals instead of some toilets, to increase capacity

### **3.10 Children Zone**

- 3.10.1 space to move about
- 3.10.2 a maze of foam pads
- 3.10.3 big padded play floor
- 3.10.4 space to sleep (laying down or leaning)
- 3.10.5 space for pushchairs and nappy luggage
- 3.10.6 "keep them occupied"
- 3.10.7 borrow DVD players
- 3.10.8 staff as entertainers
- 3.10.9 big screen with virtual entertainer
- 3.10.10 games consoles (each child's seat as a gaming machine)
- 3.10.11 Muki seats (mutter/kinder) – 1½ seat width
- 3.10.12 families and children will be seasonal traffic (school holidays)
- 3.10.13 disabled toilet for children?
- 3.10.14 wheelchair space near family zone?



### **3.11 Family Zone**

- 3.11.1 high-backed sofa booth with a table, for families (could also be used for other passengers)

### **3.12 Zones Tailored to Passenger Groups**

- 3.12.1 split car into “different worlds”
- 3.12.2 family / child zones
- 3.12.3 quiet zones
- 3.12.4 zone for quiet and ability to work
- 3.12.5 a general zone, allowing flexibility
- 3.12.6 music zone
  - like train in Lithuania
  - open-mic night
- 3.12.7 more luggage storage in some zones than others
  - tick box for large luggage when booking

### **3.13 Social Networking**

- 3.13.1 log into groups (e.g. Facebook Check-In Deals)
  - ability to swap seats

### **3.14 Catering Facilities**

- 3.14.1 vending machines
- 3.14.2 small buffet bar
- 3.14.3 trolley service
- 3.14.4 dining zone
- 3.14.5 full restaurant
- 3.14.6 ability to order food brought to seat on trolley
- 3.14.7 vending machines as a social experience
- 3.14.8 street vendor of hot dogs
- 3.14.9 MacDonalds catering like a recent airline
- 3.14.10 several vending machines (hot drinks, cold drinks, food)
- 3.14.11 nice environment around machines (e.g. sofas, large screen TVs)



3.14.12 real coffee machines

3.14.13 orange juice in a mixing machines

3.14.14 croissants

### **3.15 Staff**

3.15.1 number of staff

3.15.2 roles of staff

### **3.16 Staff Facilities**

3.16.1 small office

3.16.2 adjoin it to the buffet/kitchen (ability to communicate with bar staff and have coffee/tea)

3.16.3 customer-facing office

- like a purser's office in a ferry
- roller shutter blind