DCA

# Keeping HF on track

## A case study of the Hitachi Class 800/801 intercity express train

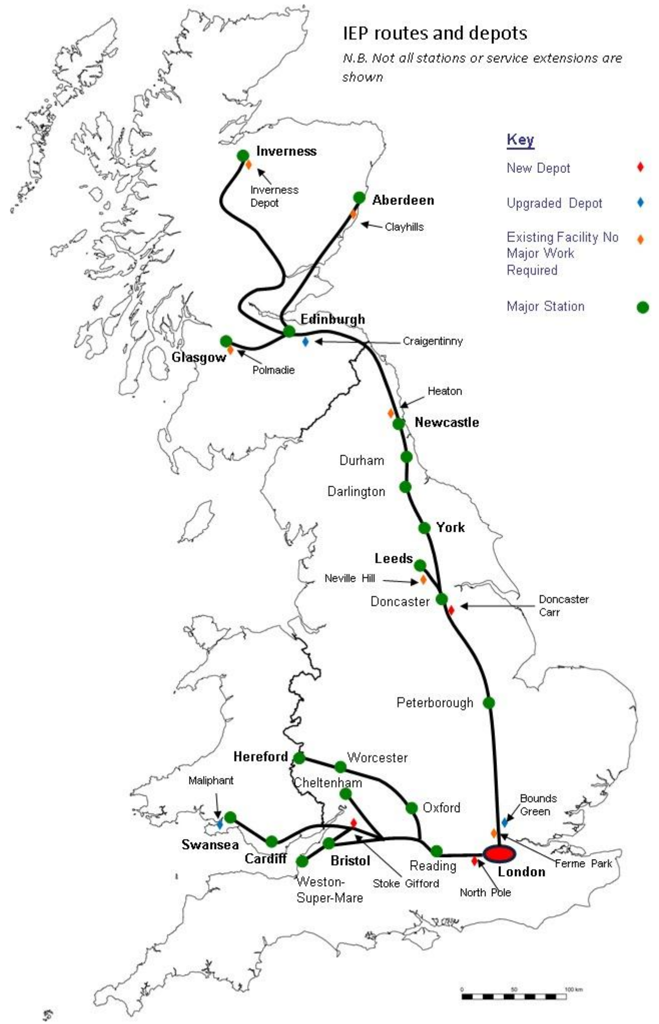

A version of this presentation was originally delivered at the CIEHF conference on the 14th of April 2015. This document has been reformatted to allow it to be read independently.


# High level summary

# Hitachi Class 800/801 trains

The Hitachi's Intercity Express Trains has been designed specifically for the UK market to replace the fleet of Intercity 125 and 225 trains that operate on the Great Western Main Line (GWML) and East Coast Main Line (ECML). There are two variants of the train, the Class 800 bi-mode and the Class 801 Electric, which are faster, higher capacity and more environmentally sustainable, to improve the passenger experience and support growth along the corridors they serve, through their manufacture and supply chain.

The design of the train is complete and the first train arrived in the UK on the 12 March 2015. The first train is expected to go into service in 2017 on the Great Western Main Line. The trains are to be built in a new factory in Newton Aycliffe in the UK



# Stakeholders

The project had multiple stakeholders, that include DCA's client Hitachi along with their clients – Agility Trains, the train operating companies, (VTEC and First Great western) and the department for transport.

At a user level it also includes the staff, train drivers and crew along with maintenance and cleaners.

At a passenger level, the design also explicitly considers the whole UK population along with tourists, that includes commuters, families, cyclists, pushchair users, wheelchair users and a whole host of physical and cognitive impairments

## Staff representatives

- Train drivers
- Train crew
- Maintenance
- Cleaners

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## Passenger groups

- Commuters
- Families
- Cyclists
- Pushchair users
- Wheelchair users
- Visually impaired users

agility trains

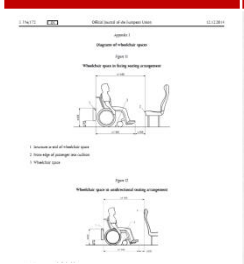
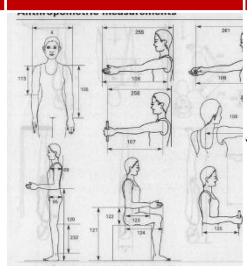
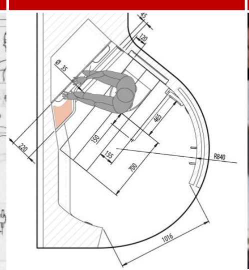
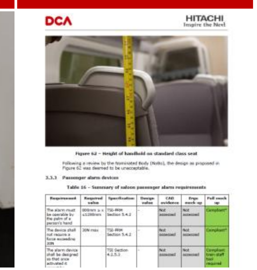
Virgin trains east coast

First Great Western

Department for Transport

## Approach

The approach adopted throughout the project has been one of integrated and iterative design. This has involved a multidisciplinary team from DCA including designers, engineers, model-makers and human factors practitioners. The focus throughout the project has been on identifying and addressing any issues as early in the design process as possible. With regards to HF, we have followed a seven step process:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Review of all relevant standards and guidelines | Development of additional requirements based on analysis of the train user population | Desk-based assessment of initial train design using 2D drawings and 3D CAD models | Design, build and evaluation of low fidelity mock ups (participatory design) | Evaluation of full scale ergonomic mock ups (task analysis, fitting trials, ethnographic, user surveys) | Evaluation of high fidelity full sized model (representative fit and finish – fitting trials, user serveys) | Document compliance |
|  |  |  |  |  |  |  |

# Methods employed

A wide range of traditional human factors methods have been applied throughout the project. These include:

- Ethnography – observation of drivers and passengers using in-service trains.
- Semi-structured interviews with drivers and train staff.
- Anthropometric assessments of the design against the target audience
- Task analysis – a full Hierarchical Task Analysis (HTA) was conducted to describe the driving task
- Participatory design exercises to evaluate and re-design early cab prototypes
- Expert reviews of mock-ups
- Passenger focus groups in the train mock up
- User surveys in the mock up including a range of passengers (cyclists, users of prams, wheelchair users, visually impaired user, etc.)
- Force assessments
- Environmental assessments (light levels)

In addition, we also developed two new methods to support the process:

- Glare assessment (published in Applied Ergonomics)
- Task-based control assessment (Published in Journal of Rail and Rapid Transport)

# Exposure & promotion of HF

### Journal Papers

Jenkins, D., Baker, L., Harvey, C. (in press). *A practical approach to evaluating train cabs against task requirements.* Journal of Rail and Rapid Transit

Jenkins, D., Baker, L., Harvey, C. (2015). *A practical approach to glare assessment for train cabs*. Applied Ergonomics. 47, 170-180

### Magazine articles

Jenkins, D. P. (2015). *Inclusive Design*. Rail Professional, February 2015, p107-108.

Jenkins, D. P. & Harvey, C. (2014). *Designing the UK's next intercity express train*. The Ergonomist, November 2014, p12-13.

### Conferences

Jenkins, D. P. (2015). *Keeping human factors on track - The design of the next generation intercity express train*. The Ergonomics Society Annual Conference. 13 - 16 April 2015 Daventry, UK. Plenary Lecture

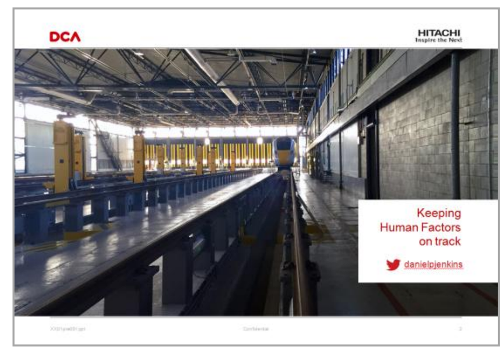
Jenkins, D. P. (in press*). The value of prototyping in train cab design*. Fifth international rail human factors conference

### Blogs

Jenkins, D., & Harvey, C. (October). *Key role of human factors in the development of the UK's next intercity express train*. HF Transport Blog. http://www.hf-transport.org.uk/







# Detailed description

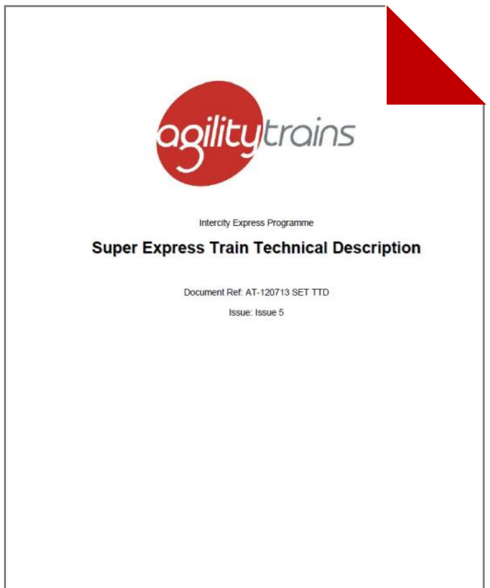
# Detailed description

# 1. Cab

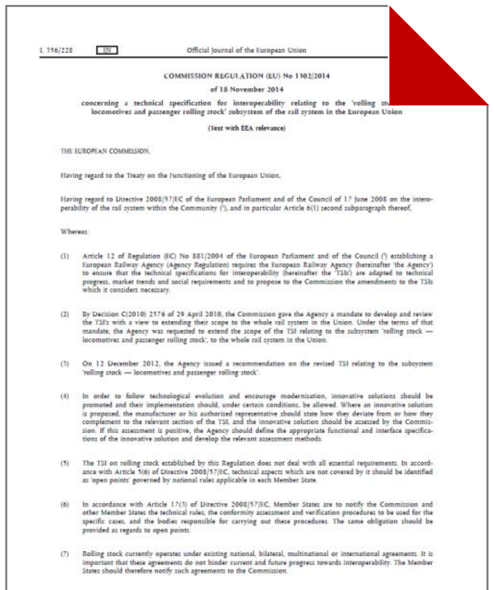
# Step 1 – Contractual & regulatory requirements

In consultation with the Department for Transport and the train operating companies, a train technical description (or TTD) was written that outlines a specification for the train. This forms a relatively detailed description of what the train should be capable of. It includes details like the number of seats and luggage requirements. There is also a long list of applicable regulations and standards, however, the most commonly used ones are shown here.

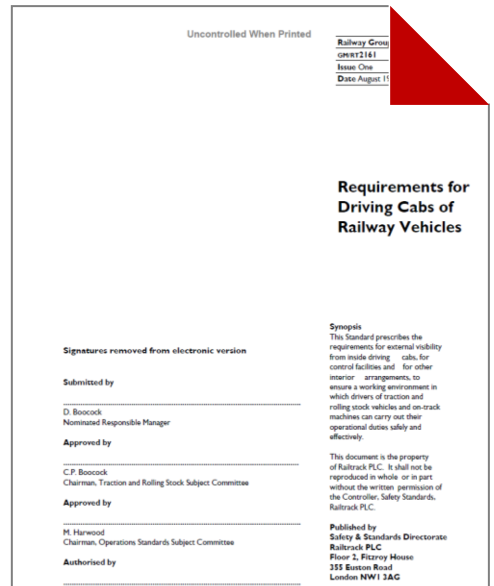
These provide fairly detailed descriptions of what the cab should achieve in terms of a safe and effective driving posture. They include descriptions of external visibility requirements as well as clear zones to protect drivers in the event of a collision.




TTD




TSI LOC & PAS

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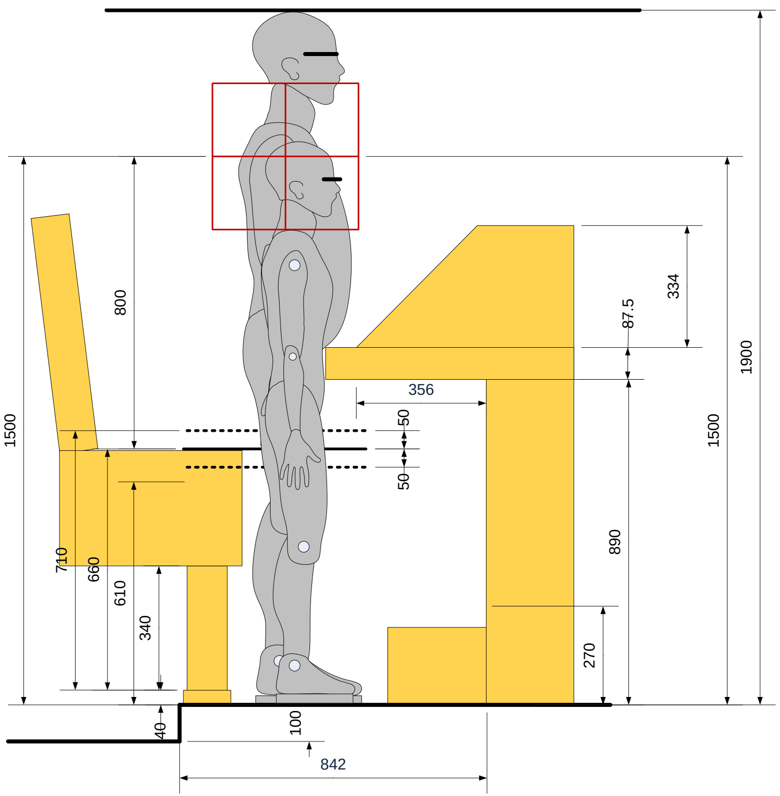
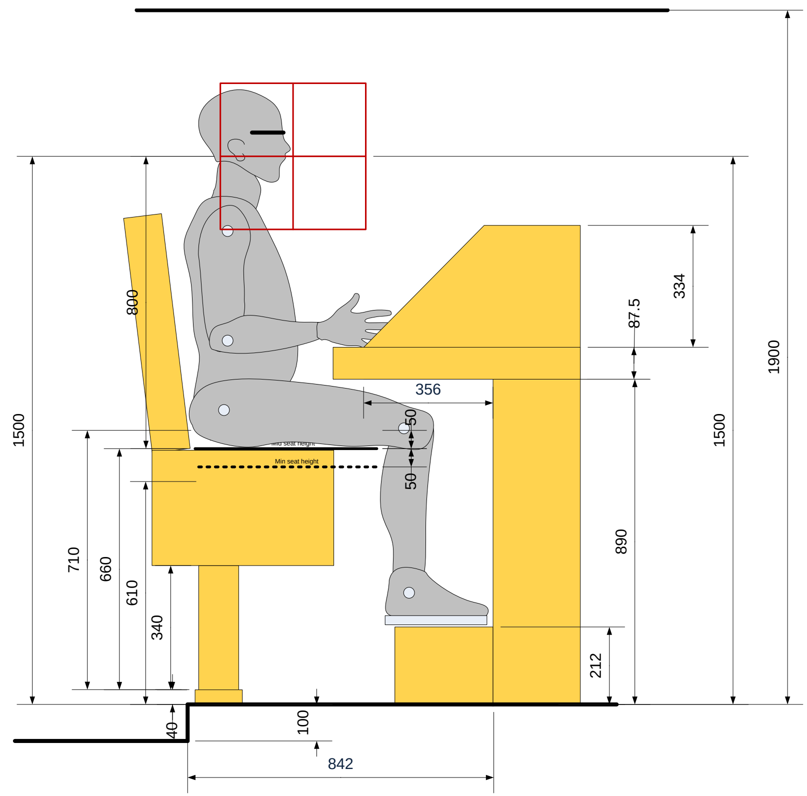
# Convert requirements into pictorial representations

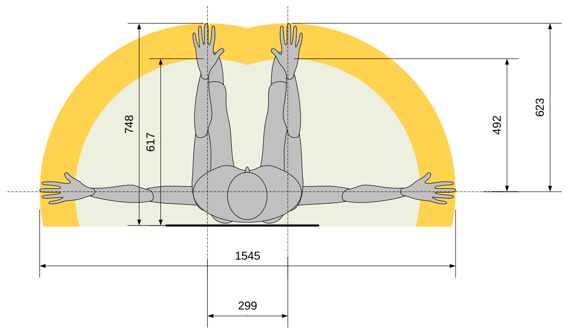
As part of digesting these requirements, we found it particularly useful to summarise them into a series of simple diagrams. This also helped to communicate the details to the project team

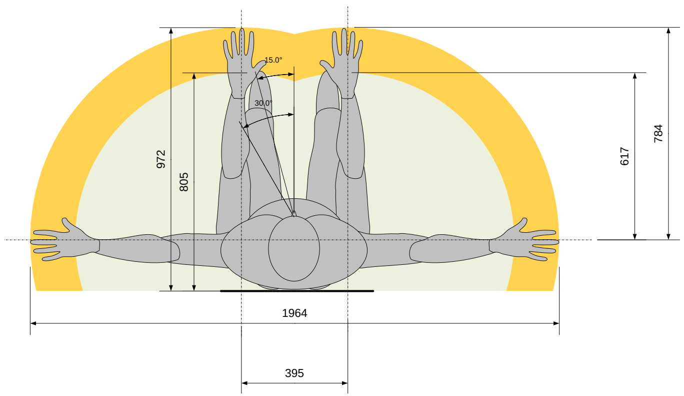


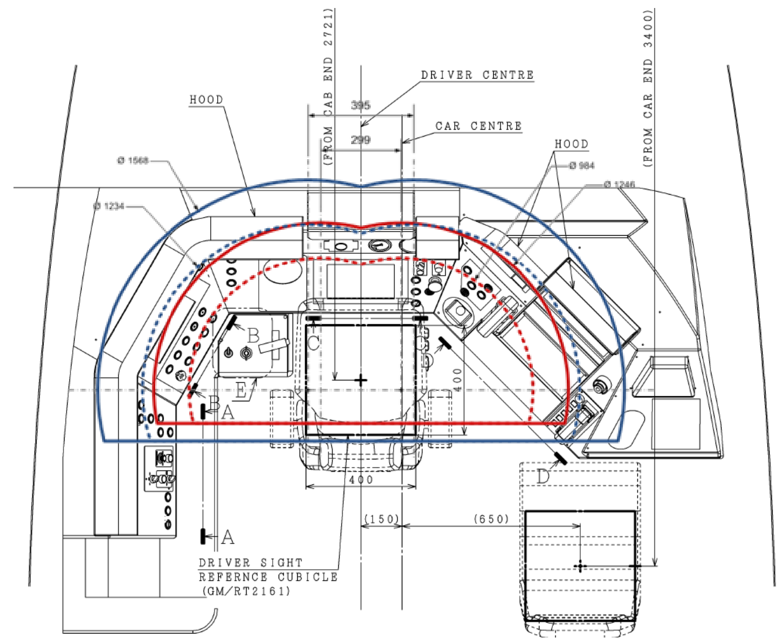



# Step 2 – Derive additional requirements based on anthropometry

In a number of cases, the requirements provide generic statements, for example the cab shall be useable by 5th to 95th percentile driver. While this is a useful starting point, more measurable and testable requirements are needed to feed the design process. Accordingly, the next step of the process is to detail up the requirements using anthropometric data sets. Simple reach envelopes can be constructed to estimate the suitability of controls based on grip and finger tip reach.



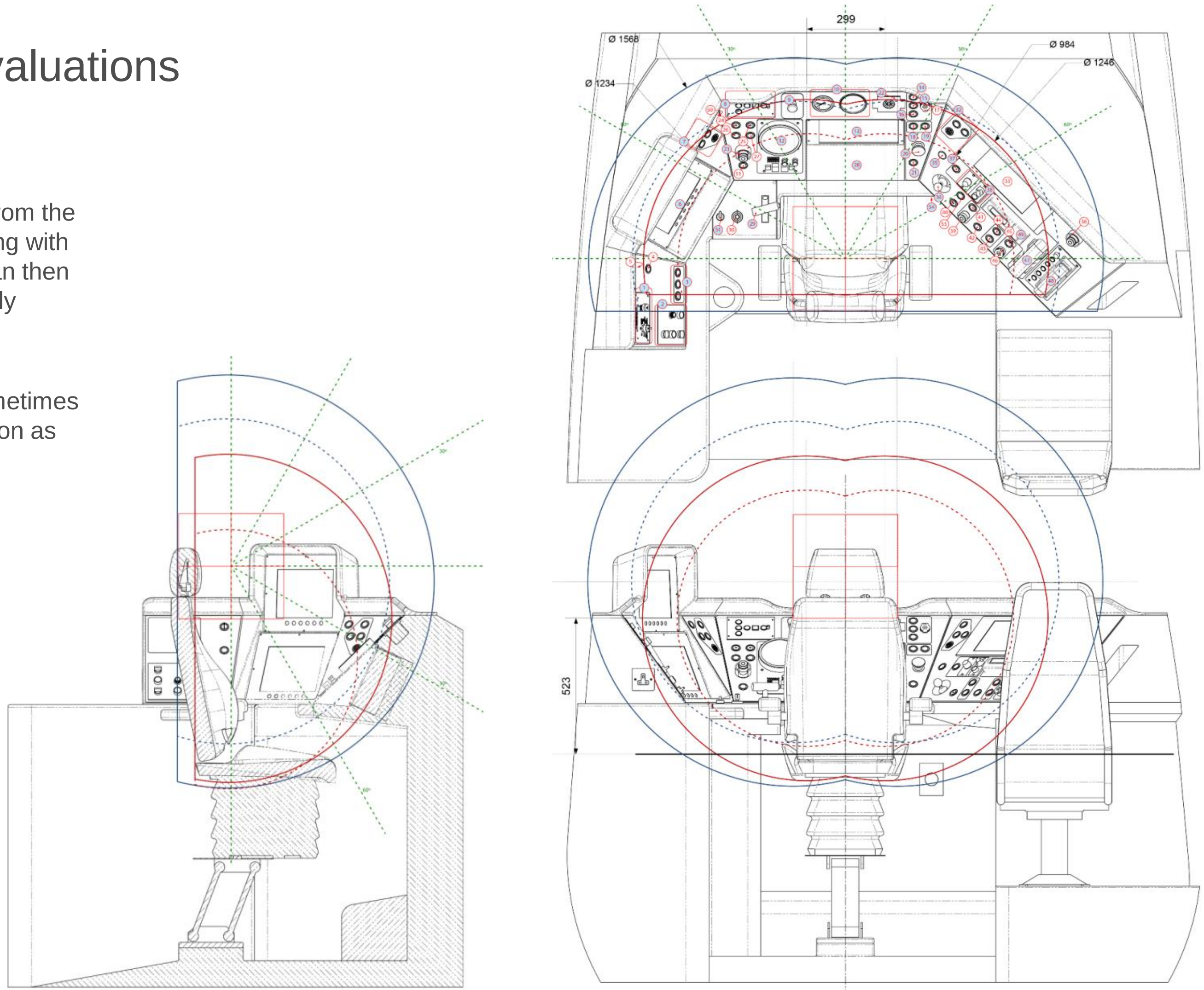



## Step 3 – CAD evaluations

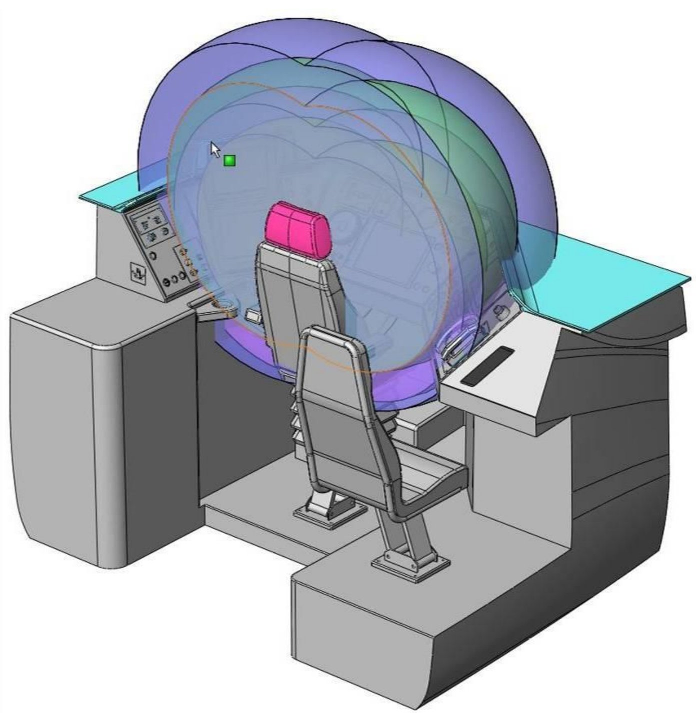
The combined requirements from the standards and guidelines, along with the additional requirements can then be used to inform and test early design concepts.

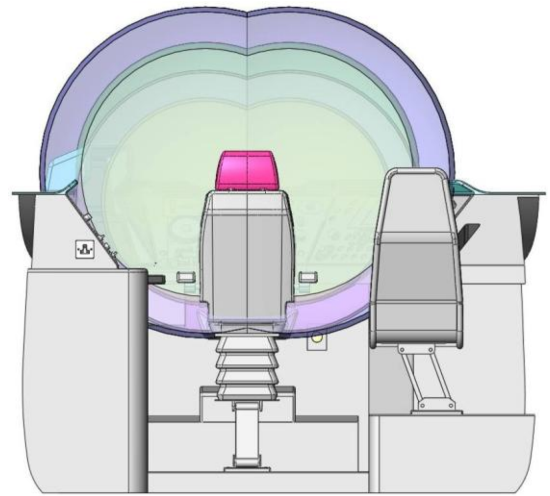
At the project infancy, it is sometimes easier to start with 2D projection as they can be faster to update.

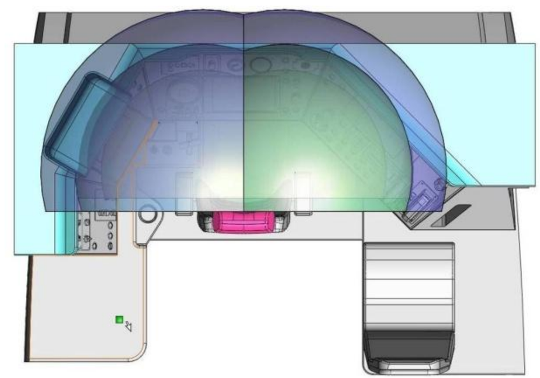


# 3D Assessments

As the design  develops, 3D assessments provide a greater level of confidence.

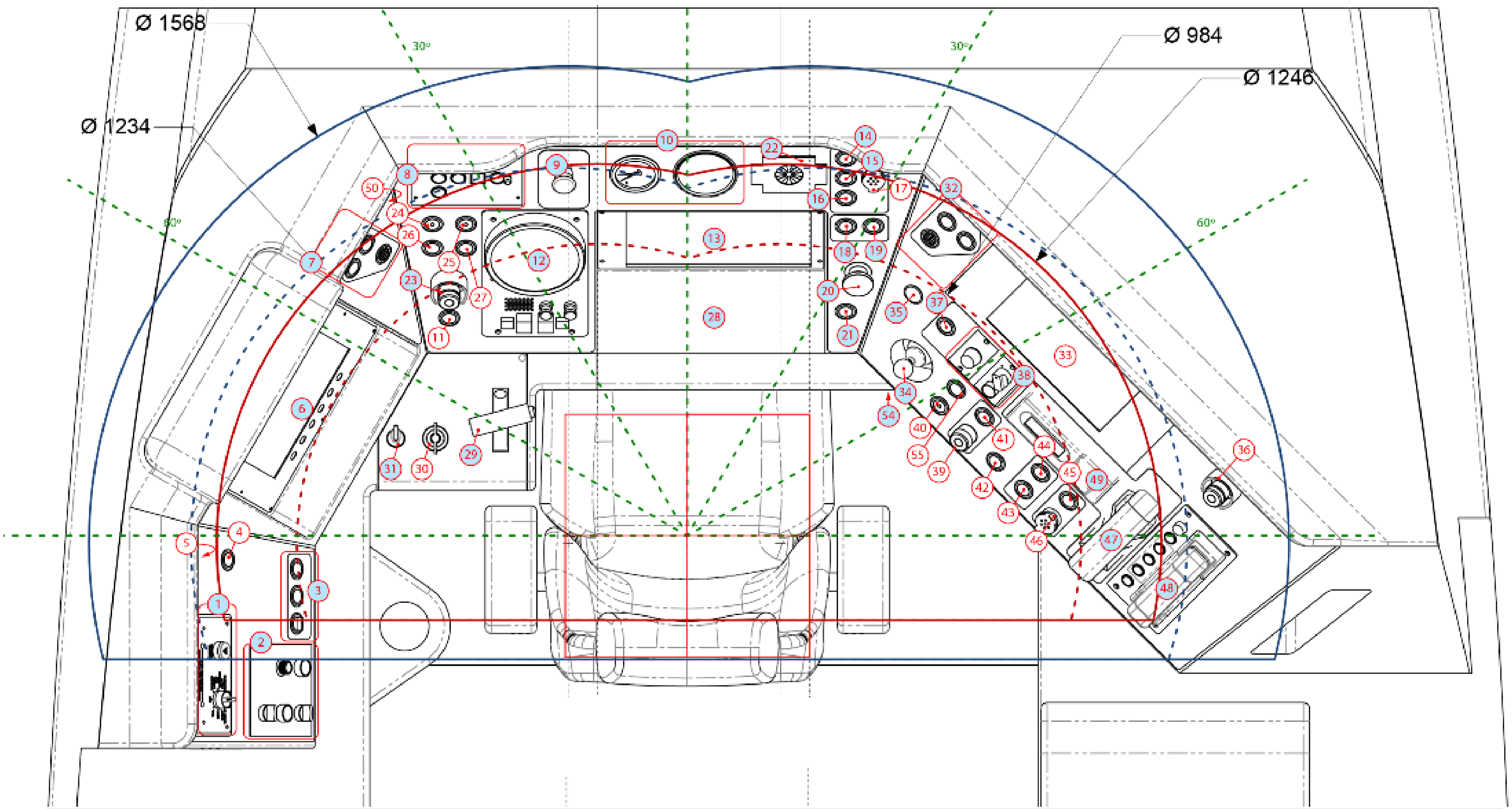






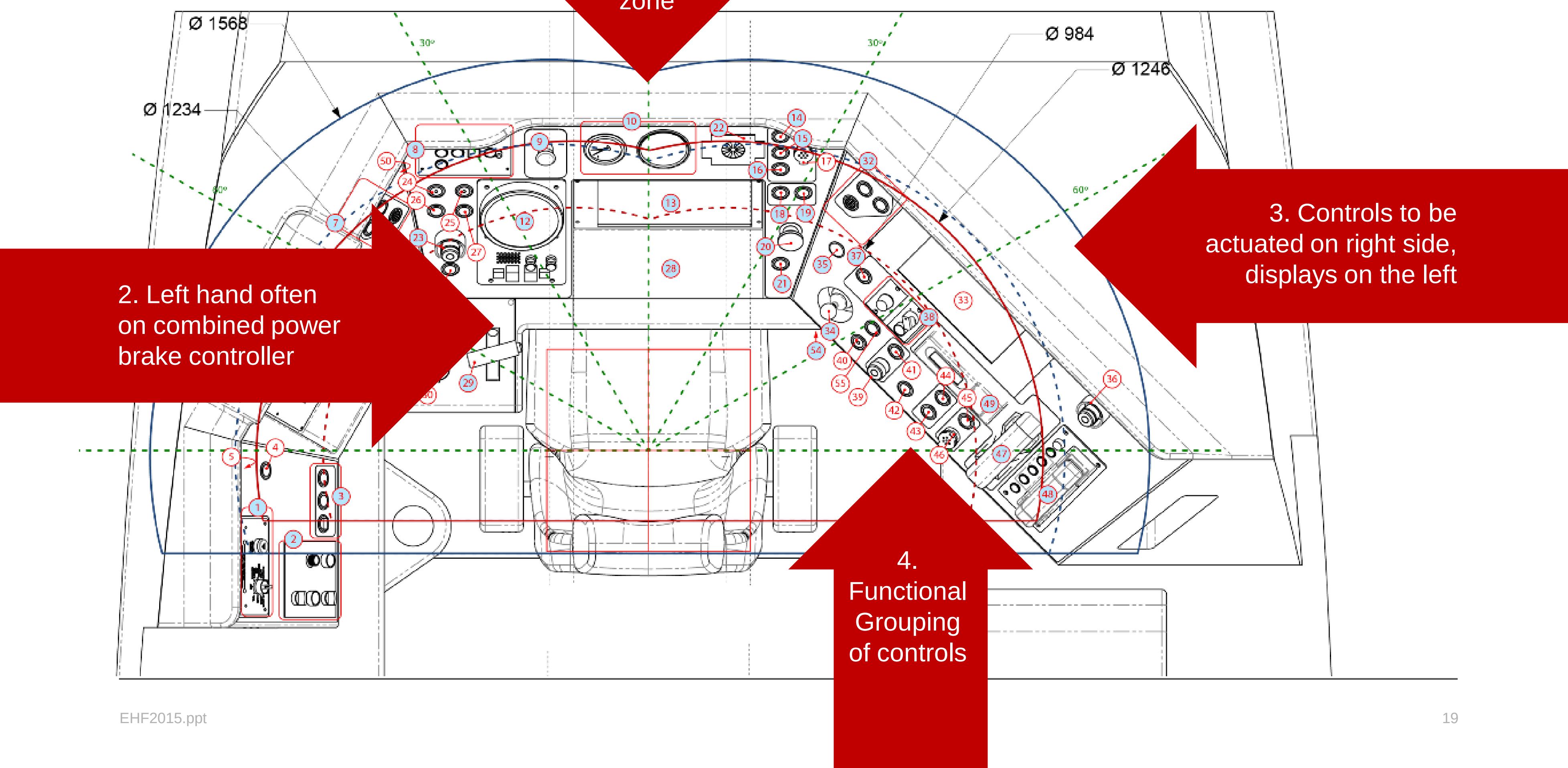
# Initial layout philosophy

The development of structural panels and the control layout need to happen together to ensure that they are compatible.
The reach envelope forms the basis for the panel location and size.

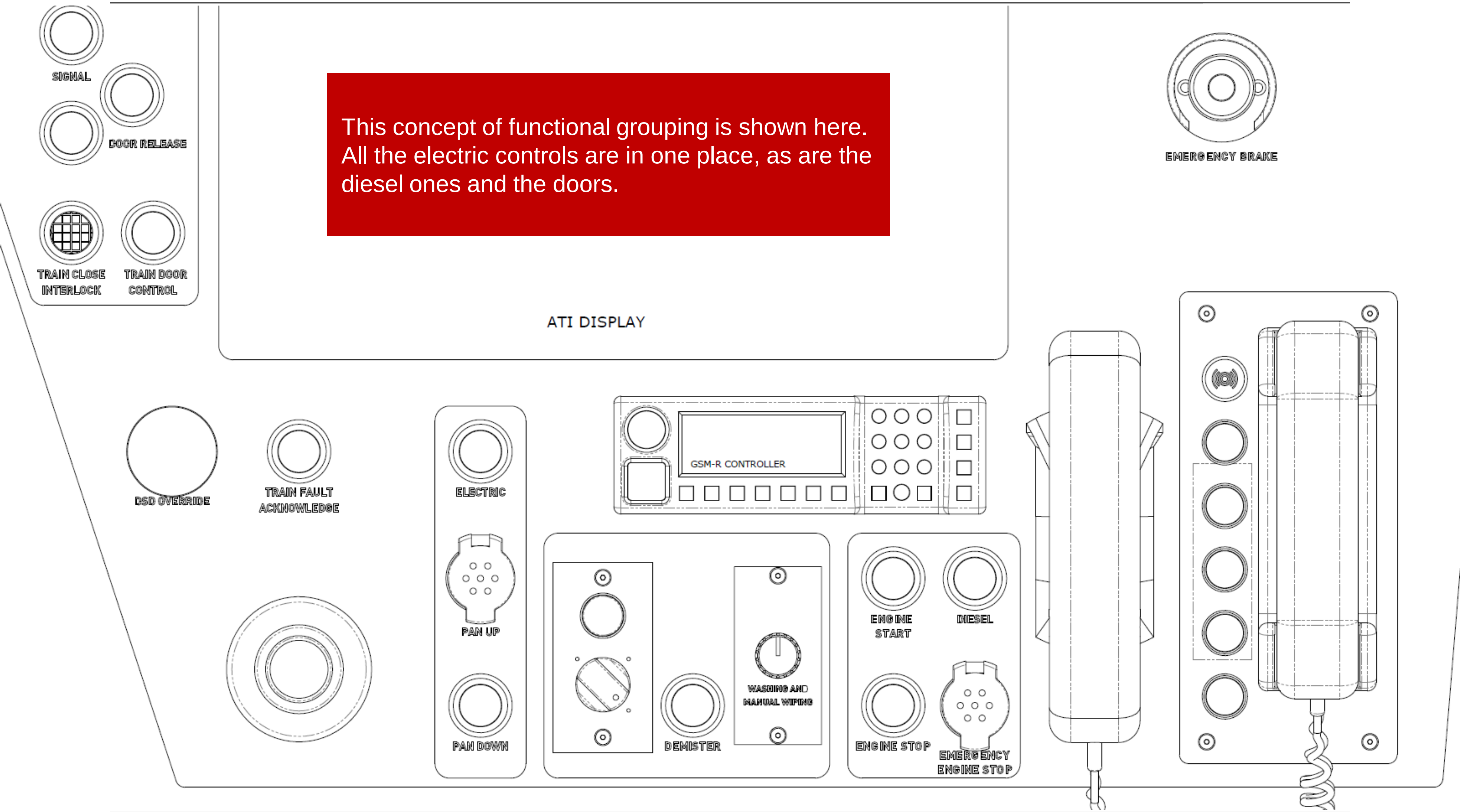


# Initial layout philosophy

In this case, the control layout was dominated by a number of core philosophies, the key one being that all pertinent information and controls are presented in the primary zone directly in front of the driver.
The next philosophy derives from the fact that the user is required to operate the combined power brake controller with their left hand. Accordingly, controls that require actuation are biased to the right, whereas display only features such as CCTV screen and indicator lamps have been placed to the left. The final philosophy is to cluster controls by their function for example all engine controls together in one place



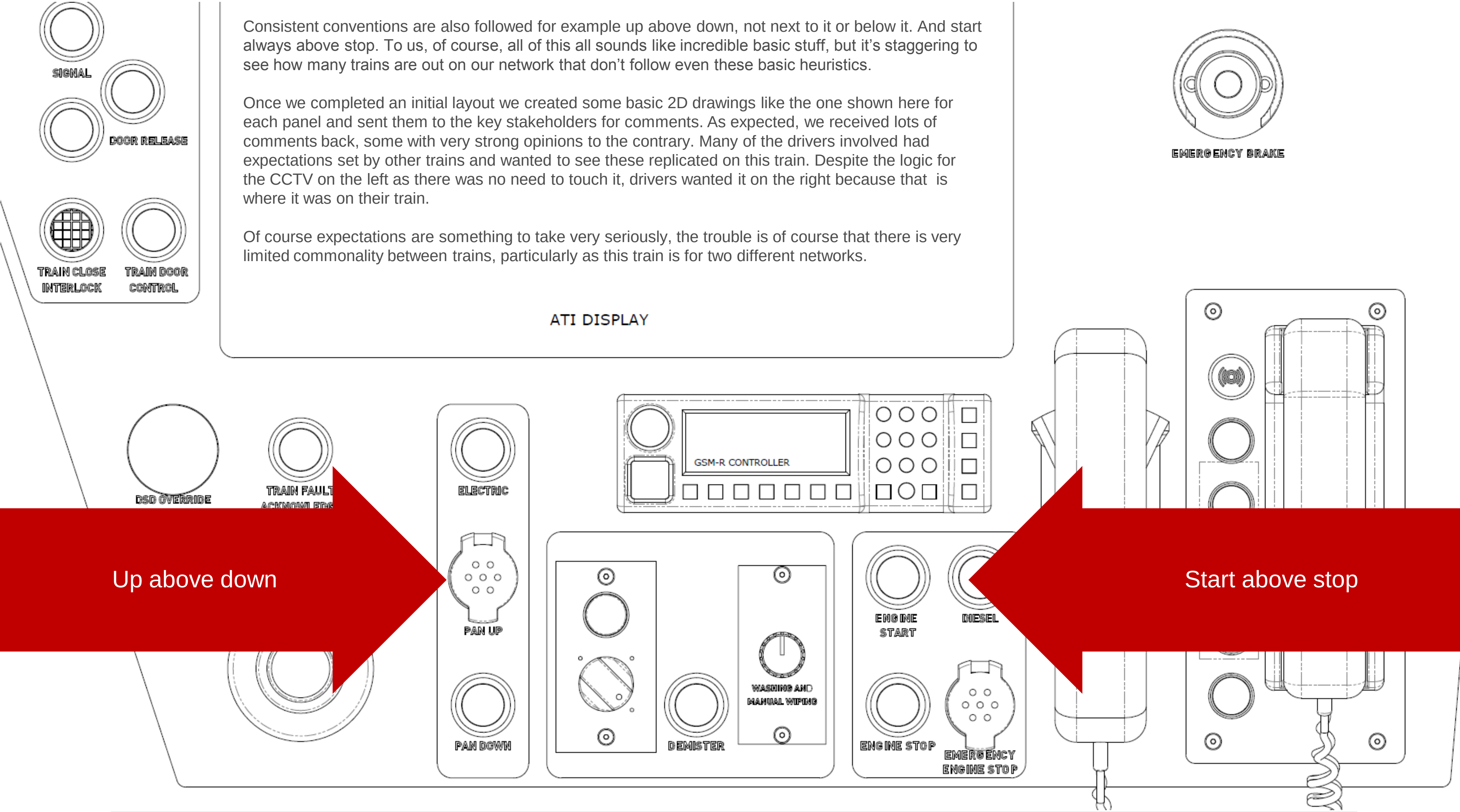
This concept of functional grouping is shown here. All the electric controls are in one place, as are the diesel ones and the doors.



Consistent conventions are also followed for example up above down, not next to it or below it. And start always above stop. To us, of course, all of this all sounds like incredible basic stuff, but it's staggering to see how many trains are out on our network that don't follow even these basic heuristics.

Once we completed an initial layout we created some basic 2D drawings like the one shown here for each panel and sent them to the key stakeholders for comments. As expected, we received lots of comments back, some with very strong opinions to the contrary. Many of the drivers involved had expectations set by other trains and wanted to see these replicated on this train. Despite the logic for the CCTV on the left as there was no need to touch it, drivers wanted it on the right because that is where it was on their train.

Of course expectations are something to take very seriously, the trouble is of course that there is very limited commonality between trains, particularly as this train is for two different networks.



# Step 4 – Low fidelity rig assessment

To get a more accurate assessment of the cab layout we created a simple scale mock up out of foamboard. We printed off each of the controls on paper and used bluetack to position them.


As a result it was very quick and easy to re-position the controls, this proved very useful for engaging the drivers in the task.


Having the engineers on hand was great as we were able to keep the design grounded to what was technically feasible behind the panels

And it proved great for group discussion that involved a diverse range of stakeholders. Much of the debate came from the two train operating companies. Each had different expectations based on legacy vehicles and slightly different task distributions with guards.

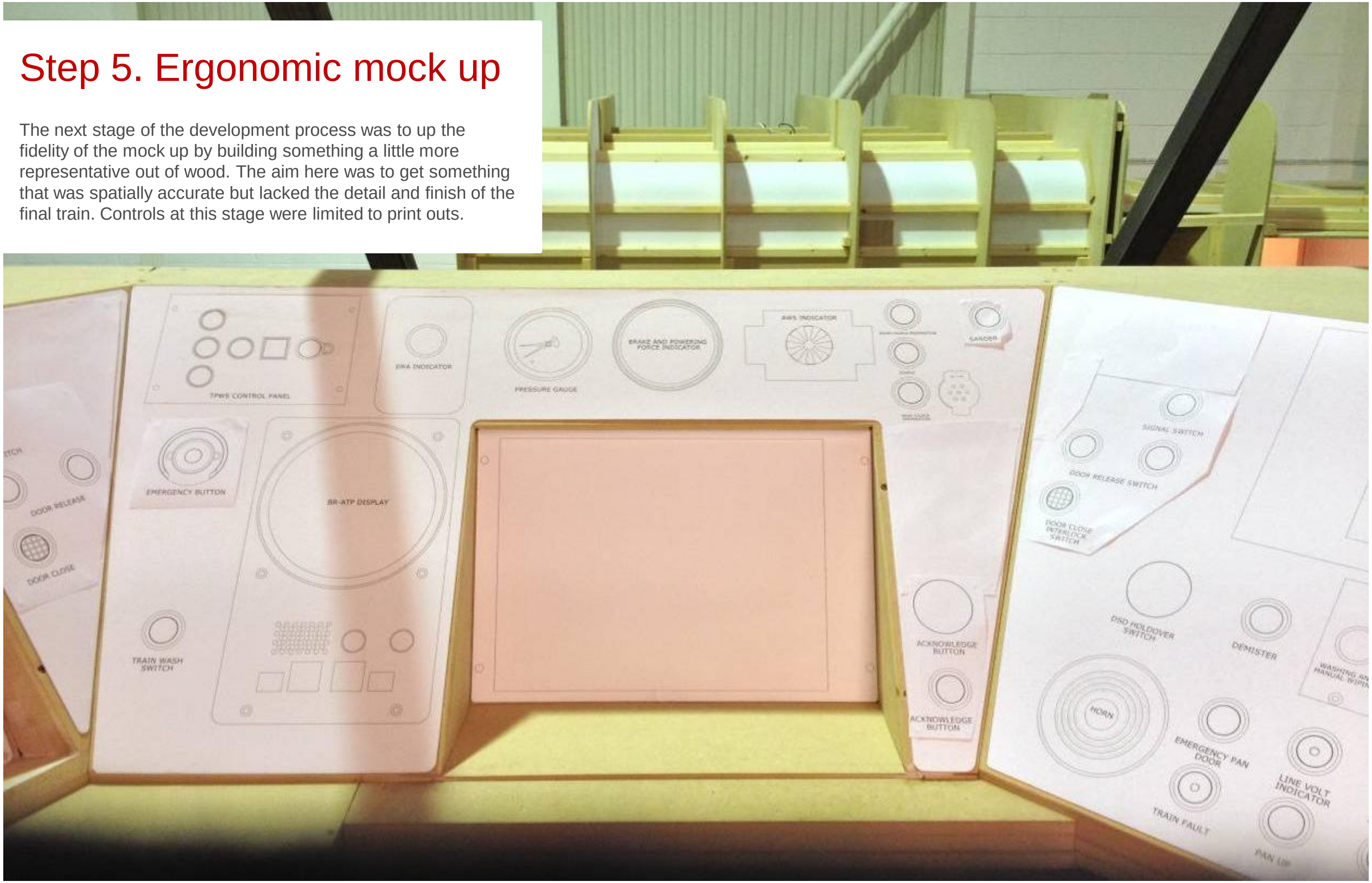
## Excellent mechanism for group discussion


- Stakeholder engagement
- Challenge initial concerns
- Fast iteration
- Stakeholder consensus

This then formed the basis for the final control layout. The approach was incredibly useful as it made sure that each stakeholder had a voice, and perhaps more importantly understood why the final configuration was the way it was.
We were able to challenge initial concerns by asking drivers to play out common tasks
Within a few hours we were able to reach a happy consensus

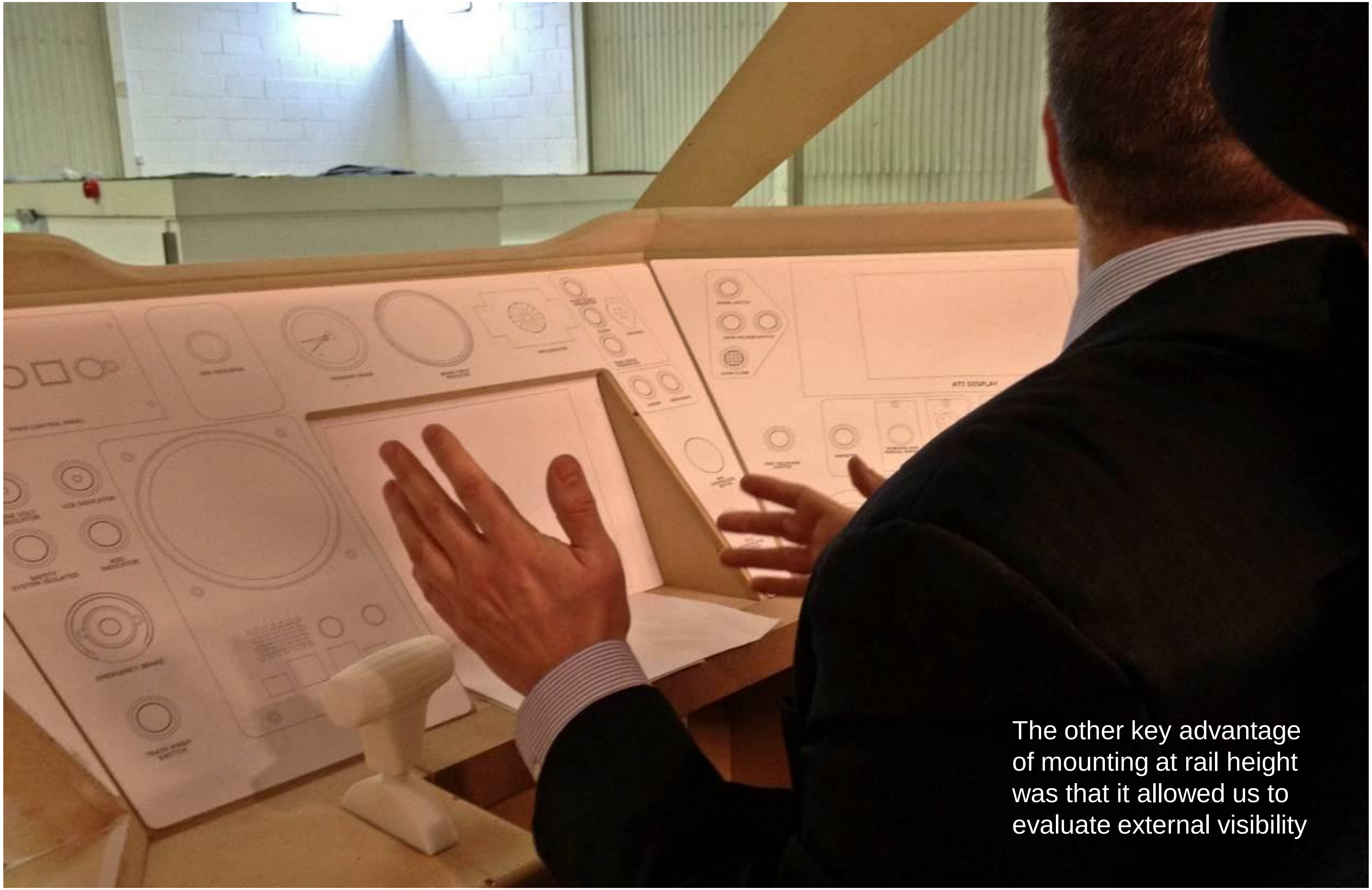
# Step 5. Ergonomic mock up

The next stage of the development process was to up the fidelity of the mock up by building something a little more representative out of wood. The aim here was to get something that was spatially accurate but lacked the detail and finish of the final train. Controls at this stage were limited to print outs.

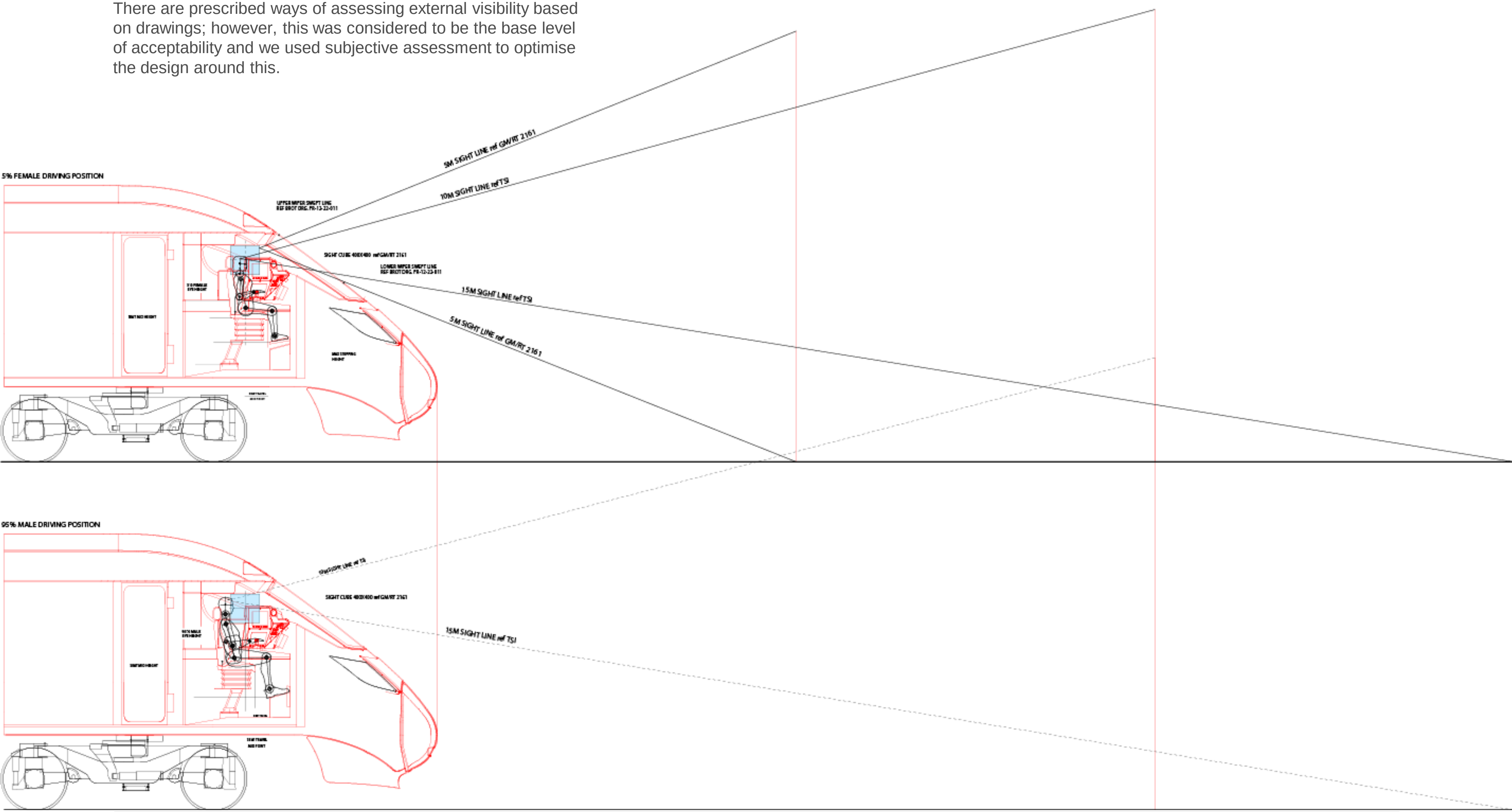



# Full-size mock-up at rail height

We mounted the mock up at rail height as this allowed us to start to consider ingress and egress. We also started to explore driver postures in more detail

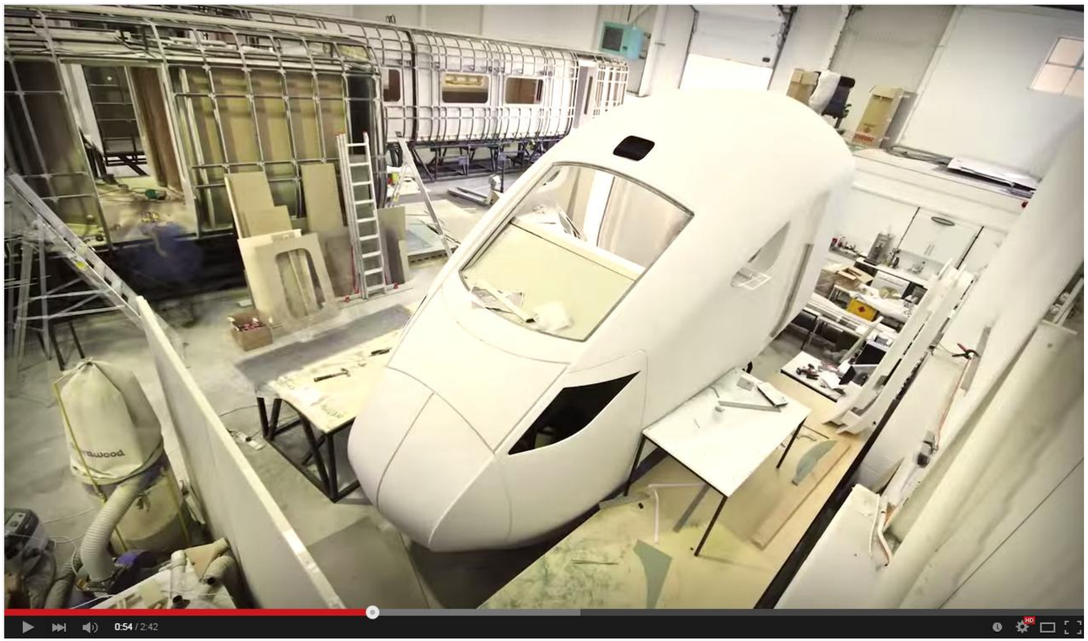

The other key advantage of mounting at rail height was that it allowed us to evaluate external visibility

There are prescribed ways of assessing external visibility based on drawings; however, this was considered to be the base level of acceptability and we used subjective assessment to optimise the design around this.



# Step 6. Full mock up

After a few iterations of the wooden mock up we moved on to develop a cab that was intended to very closely represent the final cab. We used production seats switch gear and controls, while the main structure was wood painted to give a representative finish.




https://www.youtube.com/watch?v=0-WDSWWCtxI

# Control based static assessment

We used a structured approach looking at each of the 87 cab controls in turn assessing it for its visibility, reach, suitability, and risk of inadvertent operation

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| | | Pre-assessment categorisation | | | Assessment comments | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Control** | **Location** | **Frequency** | **Dynamic** | **Risk** | **Visibility** | **Reach** | **Suitability** | **Risk of inadvertent operation** | **Posture** | **General** | **Action** |
| Uncouple button | Centre panel | Low | Static | Min | Fine to see | Leaning in to get to it - should be two hand operation | | No risk due to cover | Infrequent no more than 4 times in a shift | | Look at functional operation of buttons is inadvertent operation with other coupling a problem |
| Sanding button | Centre panel | Medium | Dynamic | Medium | Clear | Could be slightly closer push and hold | | Might confuse with train wash at low speed | | | Look at bringing the sander button down the panel |
| Snow brake | Centre panel | Low | Dynamic | Medium | Can't read in a braking , fine normally | Easy to read | Good | Low , nothing nearby , nothing to catch | No issues | Should be blue | |
| Acknowledge (AWS) | Centre panel | High | Dynamic | Medium | In primary line can't miss it | Fine - good relationship with PBC | Good | No consequence | No issues | | |
| Acknowledge (ETCS) | Centre panel | Low | Dynamic | Medium | Fine clear of AWS unique colour | fine | Clear of other controls | Might hit AWS but that's fine | | | |
| AWS sunflower | Centre panel | High | Dynamic | | Glare from AWS - shiny surface - seems rather small | | | | | Not facing driver | Look at recessing |
| Emergency brake (driver) | Centre panel | Low | Dynamic | Medium | Primary - related to controller | Lean in slightly to reach it | Clear what it is | Well clear of other controls | | Can't tell if it has been pressed - limited height difference between deployed and not | |

We recruited a range of drivers from both train lines to help.

# Detailed HTA development

Alongside the static assessment we wanted to explore how the cab layout met the requirements of the driving task. The first stage of this was to develop a task model. Rather surprisingly, we struggled to find anything in the public domain that described the driving task. As a result we had to create a Hierarchal Task Analysis of our own based on training materials and discussions with train drivers.
The resultant model contained :

- 551 Nodes
- 387 Child

- Start up
- Routine driving tasks
  - Departure
  - Transit
  - Stop train
  - Arrive at station
  - Departure from a station
  - Drive from standing position
- Manage communications
- Unit disposal
- Emergency situations

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# Task-based sequenced assessment

The HTA then informed the task based assessment. Each task was read out in turn and the driver performed it, after each activity they were asked to report any comments, good or bad.

| Renumber | Description | Level (auto) | Reports to (auto) | Parent or child (auto) | Plan | Sequenced assessment | Comments assessmnet 1 |
|---|---|---|---|---|---|---|---|
| 1 | **Driving task** | 1 | | Parent | | | |
| 1.1 | **Start-up** | 2 | 1 | Parent | | | |
| 1.1.1 | **Boarding** | 3 | 1.1 | Parent | | | |
| 1.1.1.1 | Locate cab | 4 | 1.1.1 | Child | | No | |
| 1.1.1.2 | **Enter cab** | 4 | 1.1.1 | Parent | | | |
| 1.1.1.2.1 | **Enter from platform** | 5 | 1.1.1.2 | Parent | | | |
| 1.1.1.2.1.1 | Use keys to unlock train cabin door | 6 | 1.1.1.2.1 | Child | | No | |
| 1.1.1.2.1.2 | Open train cabin door | 6 | 1.1.1.2.1 | Child | | No | |
| 1.1.1.2.1.3 | Enter train cabin | 6 | 1.1.1.2.1 | Child | | No | |
| 1.1.1.2.2 | **Enter from ballast height** | 5 | 1.1.1.2 | Parent | | | |
| 1.1.1.2.2.1 | Use keys to unlock train cabin door | 6 | 1.1.1.2.2 | Child | | No | |
| 1.1.1.2.2.2 | Open train cabin door | 6 | 1.1.1.2.2 | Child | | Yes | Handle seems a little far into the middle of the door |
| 1.1.1.2.2.3 | Switch on lights | 6 | | Child | | Yes | Hard to find light switch |
| 1.1.1.2.2.4 | Place bag in train | 6 | 1.1.1.2.2 | Child | | Yes | |
| 1.1.1.2.2.5 | Climb up | 6 | 1.1.1.2.2 | Child | | Yes | |
| 1.1.1.2.2.6 | Enter train cabin | 6 | 1.1.1.2.2 | Child | | Yes | Width fine good hand rails |
| 1.1.1.2.2.7 | Close cab door | 6 | | Child | | Yes | |
| 1.1.1.3 | **Store luggage** | 4 | 1.1.1 | Parent | | | |
| 1.1.1.3.1 | Store coat | 5 | 1.1.1.3 | Child | | Yes | On rear coat hook to make it clear of switches |
| 1.1.1.3.2 | Store bag | 5 | 1.1.1.3 | Child | | Yes | By bin |
| 1.1.2 | **Aux start up** | 3 | 1.1 | Parent | | | |
| 1.1.2.1 | **Turn on Aux power** | 4 | 1.1.2 | Parent | | | |
| 1.1.2.1.1 | Press the Aux On pushbutton for 10 seconds (back wall) | 5 | 1.1.2.1 | Child | | Yes | |
| 1.1.2.1.2 | Ensure the TMS begins its self test | 5 | 1.1.2.1 | Child | | Yes | |
| 1.1.2.2 | **Check the main reservoir pressure is 7 bar or rising** | 4 | 1.1.2 | Parent | | | |
| 1.1.2.2.1 | If or when the main reservoir pressure has reached 7 bar ensure the driver's seat has risen and is fully operational | 5 | 1.1.2.2 | Child | | No | |
| 1.1.3 | **Perform pre-seated checks** | 3 | 1.1 | Parent | | | |
| 1.1.3.1 | **Check switches on back wall** | 4 | 1.1.3 | Parent | | | |
| 1.1.3.1.1 | Safety System isolation switches are in the normal position | 5 | 1.1.3.1 | Child | | Yes | |
| 1.1.3.2 | Check all Cab MCB's are set BR-ATP or ETCS mode (located on cab back | 4 | 1.1.3 | Child | | Yes | |
| 1.1.3.3 | Confirm if in BR-ATP or ETCS mode (located on cab back wall) | 4 | 1.1.3 | Child | | Yes | |
| 1.1.3.4 | **Check auxiliary equipment** | 4 | 1.1.3 | Parent | | | |
| 1.1.3.4.1 | Check all Emergency Equipment is present and security sealed as appropriate | 5 | 1.1.3.4 | Child | | Yes | |

Assessments with representative users

Evacuation assessments

The task of building the task model was relatively time consuming; however once created, it proved to be a very efficient way of assessing the cab and ensuring that a suitable range of tasks had been considered.

We also found the task based assessments gave us some interesting insights that we missed on the static assessment.

If anyone is interested in more detail we published a description of the approach in the Journal of Rail and Rapid Transport

*Original Article*

Institution of MECHANICAL ENGINEERS

Journal of RAIL AND RAPID TRANSIT

## A practical approach to evaluating train cabs against task requirements

*Proc IMechE Part F: J Rail and Rapid Transit*
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**Daniel P Jenkins[1], Lisa M Baker[1] and Carl Harvey[2]**

**Abstract**

The link between train cab design and driver performance is well established. Physical assessments of cabs for reach and visibility have, for many years, been key considerations in cab arrangement. As such, techniques for performing assessments based on anthropometric models and reach and vision envelopes, are well defined. On a cognitive level, however, there is less prescriptive guidance. This paper describes a structured approach for assessing a train cab against task requirements. The assessment is divided into two stages; the first assesses the location of each of the cab controls in turn against their frequency of use, functional grouping, and risk of inadvertent operation. The second assesses the cab against routine tasks based on a hierarchical task analysis model. Although both methods have their relative merits, the task-based assessment was found to reveal additional insights, based on the sequence of operations, which were not detected in the static assessment.

**Keywords**

Rail, train, cab design, control layout, hierarchical task analysis, cognitive tasks

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### Introduction

Well-designed cabs take account of both the physical and cognitive needs of the driver. Historically, guidance on appropriate driving postures and control layouts have been dominated by the anthropometry of the drivers.[1–3] On a physical level, controls should be arranged so that they are clearly visible and readable by the target population. Likewise, they should also be arranged to ensure that driving tasks do not require poor postures that may result in musculoskeletal injuries.

As discussed by Tichon[4] the task of train driving is becoming more complex and progressively dominated by cognitive and perceptual skills. As such, the cognitive aspects of the driving task play an increasingly important role. Cab layouts should ensure that controls are easily identifiable, and that the mode of actuation is highly intuitive, with minimal risk of confusion or inadvertent operation. Controls can be assessed individually based on simple heuristics. The shape, colour and location of the controls can each be controlled to reduce the probability of inadvertent operation. This was clearly articulated in the work of Chapanis[5] who, by retrofitting aircraft controls with shape-coded controls, removed all instances of Boeing B-17 aircraft pilots mistaking flap controls for landing gear.

In the case of the B-17 bombers, Chapanis was able to devise an effective and low cost means of retrofitting the existing driving environment. However, this represents the exception rather than the rule. Late changes to existing designs often come at considerable cost and result in compromised solutions. Given the costs associated with late design changes and rework, an approach is required that is better able to predict potential issues early in the design process. Furthermore, beyond the absence of error, a well-designed cab that considers both the cognitive and physical aspects of the task should result in improved usability and, in turn, greater efficiency and reliability.

As previously stated, the use of anthropometric models and heuristic checklists is commonplace, largely due to their effectiveness in identifying potential issues at an early stage of the design process. Both approaches focus on the functions to be performed in the cab, rather than the tasks undertaken. To do

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Glare assessment


# Glare assessment

We were a little surprised that no standard approach to assessment was available. So we spent a little extra time developing one.

The approach we adopted was very simple, for the internal assessment, we blacked out the windows and assessed any instances of glare from the internal lights and illuminated controls and displays. For external, it involved taking a very bright light and repositioning it around the cab to represent a range of external light sources

- 25 windscreen locations
- Side windows
- Side door windows

## Subjective assessments

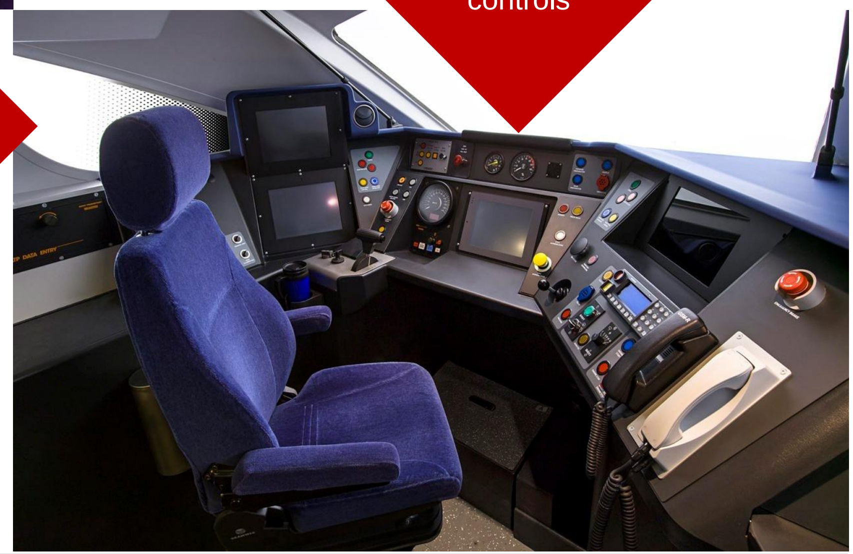
- Internal light sources
- External light sources
- Considering potential mitigations (sunblind, cowling changes, eliminating light sources)

Raising the cowling & recessing controls

1 – Unbearable
2
3 - Disturbing
4
5 - Just Acceptable
6
7 – Satisfactory
8
9 - Unnoticeable

Patterned film to the side windows (initially right side only)

Recessing the interior lights

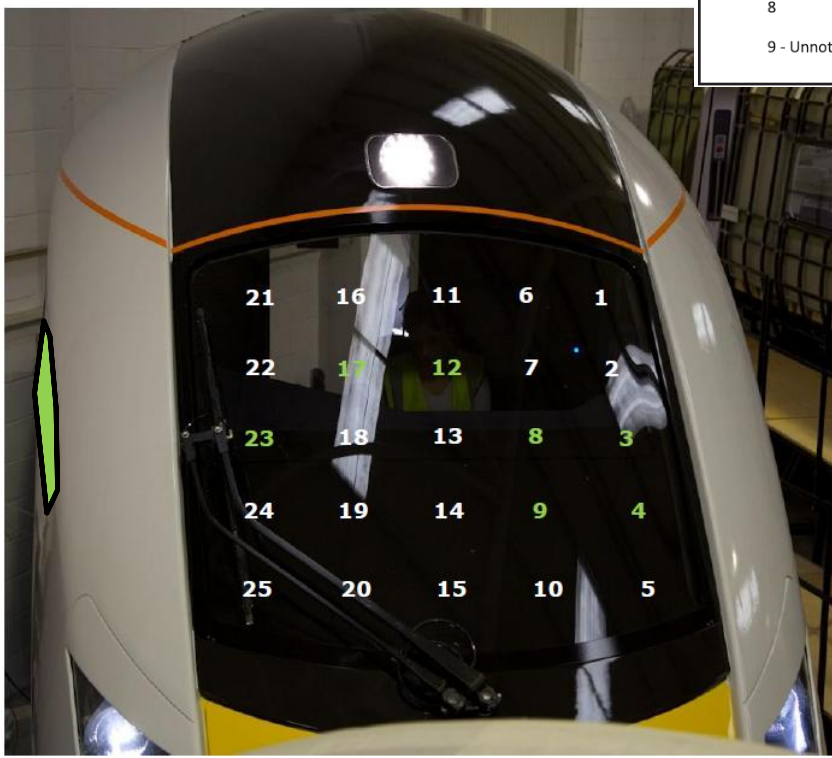


# Impact of mitigations

Reduced internal glare

Reduced glare along top of console

Reduced glare from side window with film




1 – Unbearable
2
3 - Disturbing
4
5 - Just Acceptable
6
7 – Satisfactory
8
9 - Unnoticeable

| Light location | Assessment 1 De Boer score | Assessment 2 De Boer score | Difference |
|---|---|---|---|
| Screen pos 1 | 3 | 3 | 0 |
| Screen pos 2 | 3 | 3 | 0 |
| Screen pos 3 | 2 | 4 | -2 |
| Screen pos 4 | 5 | 7 | -2 |
| Screen pos 5 | 6 | 5 | 1 |
| Screen pos 6 | 3 | 3 | 0 |
| Screen pos 7 | 3 | 3 | 0 |
| Screen pos 8 | 1 | 3 | -2 |
| Screen pos 9 | 3 | 5 | -2 |
| Screen pos 10 | 6 | 7 | -1 |
| Screen pos 11 | 3 | 3 | 0 |
| Screen pos 12 | 1 | 3 | -2 |
| Screen pos 13 | 1 | 2 | -1 |
| Screen pos 14 | 5 | 3 | 2 |
| Screen pos 15 | 6 | 6 | 0 |
| Screen pos 16 | 2 | 3 | -1 |
| Screen pos 17 | 1 | 3 | -2 |
| Screen pos 18 | 1 | 2 | -1 |
| Screen pos 19 | 3 | 3 | 0 |
| Screen pos 20 | 6 | 7 | -1 |
| Screen pos 21 | 3 | 3 | 0 |
| Screen pos 22 | 3 | 4 | -1 |
| Screen pos 23 | 3 | 5 | -2 |
| Screen pos 24 | 6 | 7 | -1 |
| Screen pos 25 | 7 | 7 | 0 |
| Left side | 2 | 3 | -1 |
| Left door | 9 | 9 | 0 |
| Right side | 2 | 5 | -3 |
| Right door | 9 | 9 | 0 |

It is a subjective rating, so there are certainly some limitations to the approach; however, it was found to be a very effective way of identifying issues in a relatively quick time frame.

If you would like to read more about the approach and its limitations, we published this in Applied Ergonomics.

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## A practical approach to glare assessment for train cabs

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ABSTRACT

The assessment of glare is a key consideration in the design of a railway driver's cab. However, unlike assessment of other factors, such as forward visibility, there are no standardised approaches for performing assessments of glare. This paper describes an approach for assessing the impact of glare in a full size mock-up of a railway cab. While it is unrealistic to evaluate every possible lighting condition that may potentially occur in the vehicle cab in service, a pragmatic and practical approach is taken to provide a good level of indicative information about the cab design's likely glare performance. This involves assessing internal light sources, such as internal lights and illuminated controls, and simulating external light sources (e.g. the sun, other trains' headlights) by illuminating the cab mock up windscreen, side and door windows with a single light source manually located in a sequence of discrete positions and orientations and assessing the resulting glare impacts. The paper describes a structured process for assessing and recording the impact of glare and recommending mitigations.



### 1. Introduction

Regardless of the mode of transport, be it trains, planes or automobiles, the link between cab or cockpit design and driver performance is clear. A well designed train cab provides reach to all controls, good visibility of well organised controls and instruments, and a suitable view of the external environment.

Well designed cabs have an established positive impact on safety, reliability and efficiency. On a physical level, cabs that provide suitable driving postures reduce the likelihood of a range of driver discomfort and musculoskeletal injuries. On a cognitive level, the layout of the cab has a clear link to performance.

To negate the need for modifications after the train is put into service; an iterative design process should be employed to optimise the design. In addition to reducing the need for rework, identifying potential issues early in the design cycle greatly reduces the overall cost of design. Designs typically start as CAD models and are evaluated through 2D projections and 3D digital models (e.g. Summerskill et al., 2008). As the design develops, simple, low-resolution models are normally built to allow the design to be explored in true 3D. Given the costs associated with the design of a train, full-size mock ups are also usually built. These non-functional models have representative controls and finishes allowing the cab to be assessed before committing to the full production version of the train.

Throughout the design process, some aspects of the cab are easier to assess and demonstrate than others. Reach envelopes and mannequins based on anthropometric data (e.g. Adultdata, 1998) can be used to assess the suitability of the design for the target user group. 2D projections can be used demonstrate reach and visibility of controls. Likewise, in terms of external visibility, standards exist (GM/RT2161 Requirements for driving cabs of railway vehicles, 1995) that describe largely unambiguous test criteria for assessing forward visibility. As such, with each of these aspects of the design, it is relatively simple to devise and test against test criteria to demonstrate the suitability of the design.

When attention is turned to assessing glare, however, the means of assessment is less clear. While it is a widely acknowledged concern (RSSB, 2009; Fullerton, 2009; Thompson et al., 2013), there are no prescribed methods for its assessment.

#### 1.1. What is glare?

Glare is described in ISO 9241-6 as:

> "Condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution of range of luminance, or to extreme contrast".

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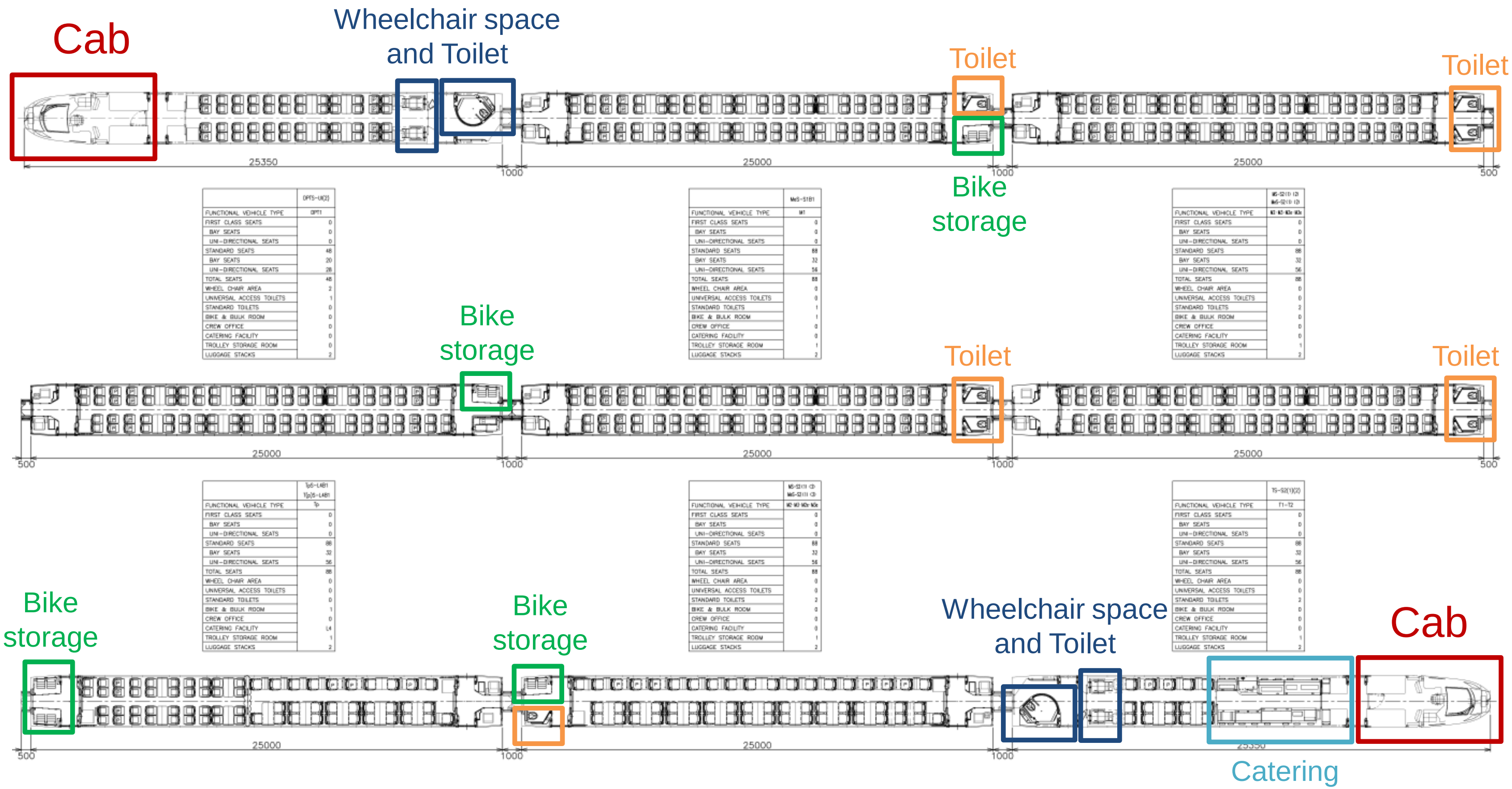
*Cab layout informed by…*

- Anthropometric requirements of driver population
- External visibility requirements
- Functional grouping
- Compatibility with the driving task
- Careful consideration of environmental factors


menu
menu
2.
Saloon

# Train formation

The design includes first and standard class seating areas, wheelchair spaces and Universal Access Toilets, and Space Saver Toilets




| | DPTS-U(2) |
|---|---|
| FUNCTIONAL VEHICLE TYPE | DPT1 |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 48 |
| BAY SEATS | 20 |
| UNI-DIRECTIONAL SEATS | 28 |
| TOTAL SEATS | 48 |
| WHEEL CHAIR AREA | 2 |
| UNIVERSAL ACCESS TOILETS | 1 |
| STANDARD TOILETS | 0 |
| BIKE & BULK ROOM | 0 |
| CREW OFFICE | 0 |
| CATERING FACILITY | 0 |
| TROLLEY STORAGE ROOM | 0 |
| LUGGAGE STACKS | 2 |

| | MeS-S1B1 |
|---|---|
| FUNCTIONAL VEHICLE TYPE | M1 |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 88 |
| BAY SEATS | 32 |
| UNI-DIRECTIONAL SEATS | 56 |
| TOTAL SEATS | 88 |
| WHEEL CHAIR AREA | 0 |
| UNIVERSAL ACCESS TOILETS | 0 |
| STANDARD TOILETS | 1 |
| BIKE & BULK ROOM | 1 |
| CREW OFFICE | 0 |
| CATERING FACILITY | 0 |
| TROLLEY STORAGE ROOM | 1 |
| LUGGAGE STACKS | 2 |

| | M5-S2(1)(2)<br>M6-S2(1)(2) |
|---|---|
| FUNCTIONAL VEHICLE TYPE | M2·M3·M2x·M3x |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 88 |
| BAY SEATS | 32 |
| UNI-DIRECTIONAL SEATS | 56 |
| TOTAL SEATS | 88 |
| WHEEL CHAIR AREA | 0 |
| UNIVERSAL ACCESS TOILETS | 0 |
| STANDARD TOILETS | 2 |
| BIKE & BULK ROOM | 0 |
| CREW OFFICE | 0 |
| CATERING FACILITY | 0 |
| TROLLEY STORAGE ROOM | 1 |
| LUGGAGE STACKS | 2 |

| | Tp5-L4B1<br>T(p)6-L4B1 |
|---|---|
| FUNCTIONAL VEHICLE TYPE | Tp |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 88 |
| BAY SEATS | 32 |
| UNI-DIRECTIONAL SEATS | 56 |
| TOTAL SEATS | 88 |
| WHEEL CHAIR AREA | 0 |
| UNIVERSAL ACCESS TOILETS | 0 |
| STANDARD TOILETS | 0 |
| BIKE & BULK ROOM | 1 |
| CREW OFFICE | 0 |
| CATERING FACILITY | L4 |
| TROLLEY STORAGE ROOM | 1 |
| LUGGAGE STACKS | 2 |

| | M5-S1(1)(3)<br>M6-S1(1)(3) |
|---|---|
| FUNCTIONAL VEHICLE TYPE | M2·M3·M2x·M3x |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 88 |
| BAY SEATS | 32 |
| UNI-DIRECTIONAL SEATS | 56 |
| TOTAL SEATS | 88 |
| WHEEL CHAIR AREA | 0 |
| UNIVERSAL ACCESS TOILETS | 0 |
| STANDARD TOILETS | 2 |
| BIKE & BULK ROOM | 0 |
| CREW OFFICE | 0 |
| CATERING FACILITY | 0 |
| TROLLEY STORAGE ROOM | 1 |
| LUGGAGE STACKS | 2 |

| | TS-S2(1)(2) |
|---|---|
| FUNCTIONAL VEHICLE TYPE | T1–T2 |
| FIRST CLASS SEATS | 0 |
| BAY SEATS | 0 |
| UNI-DIRECTIONAL SEATS | 0 |
| STANDARD SEATS | 88 |
| BAY SEATS | 32 |
| UNI-DIRECTIONAL SEATS | 56 |
| TOTAL SEATS | 88 |
| WHEEL CHAIR AREA | 0 |
| UNIVERSAL ACCESS TOILETS | 0 |
| STANDARD TOILETS | 2 |
| BIKE & BULK ROOM | 0 |
| CREW OFFICE | 0 |
| CATERING FACILITY | 0 |
| TROLLEY STORAGE ROOM | 1 |
| LUGGAGE STACKS | 2 |

# Step 1 – Contractual & regulatory requirements

The main requirements for the passenger areas come from a document called the Persons with Reduced Mobility Technical Specification for Interoperability (PRM TSI). Along with the Train Technical Description (TTD)

Intercity Express Programme

**Super Express Train Technical Description**

Document Ref: AT-120713 SET TTD

Issue: Issue 5

TTD



**COMMISSION REGULATION (EU) No 1300/2014**

**of 18 November 2014**

**on the technical specifications for interoperability relating to accessibility of the Unio[n rail] system for persons with disabilities and persons with reduced mobility**

**(Text with EEA relevance)**

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community [1], and in particular Articles 6(1) and 8(1) thereof,

Whereas:

(1) Article 12 of Regulation (EC) No 881/2004 of the European Parliament and of the Council [2] requires the European Railway Agency (the Agency) to ensure that the technical specifications for interoperability (TSIs) are adapted to technical progress, market trends and social requirements and to propose to the Commission any amendments to the TSIs which it considers necessary.

(2) By Decision C(2010) 2576 [3], the Commission gave the Agency a mandate to develop and review the technical specifications for interoperability with a view to extending their scope to the entire rail system in the Union. Under the terms of that mandate, the Agency was asked to extend the scope of the TSI relating to accessibility of the trans-European conventional and high-speed rail system provided for by Commission Decision 2008/164/EC [4] for persons with disabilities and persons with reduced mobility to the entire rail system throughout the Union.

(3) On 6 May 2013 the Agency submitted a recommendation on the adoption of the TSI relating to persons with reduced mobility.

(4) The United Nations Convention on the Rights of Persons with Disabilities, to which the Union and most Member States are party, recognises accessibility as one of its general principles. It requires, in Article 9, States Parties to take appropriate measures to ensure that persons with disabilities have access on an equal basis with others. These measures must include the identification and elimination of obstacles and barriers to accessibility and apply, inter alia, to transportation.

(5) Directive 2008/57/EC establishes 'accessibility' as an essential requirement of the rail system within the Union.

(6) Directive 2008/57/EC provides for a register of infrastructure and registers of vehicles, indicating the main parameters, to be published and updated on a regular basis. Commission Decision 2008/164/EC further defines the parameters for the TSI relating to 'persons with reduced mobility' to be included in these registers. As the objectives of these registers are linked to the authorisation procedure and technical compatibility, it is considered necessary to establish a separate tool for these parameters. This inventory of assets should enable obstacles and barriers to accessibility to be identified and their progressive elimination to be monitored.

(7) Directive 2008/57/EC establishes the principle of gradual implementation, in particular providing that target subsystems indicated in a TSI may be set in place gradually within a reasonable timescale and that each TSI should indicate an implementation strategy with a view to making a gradual transition from the existing situation to the final situation in which compliance with the TSI will be the norm.

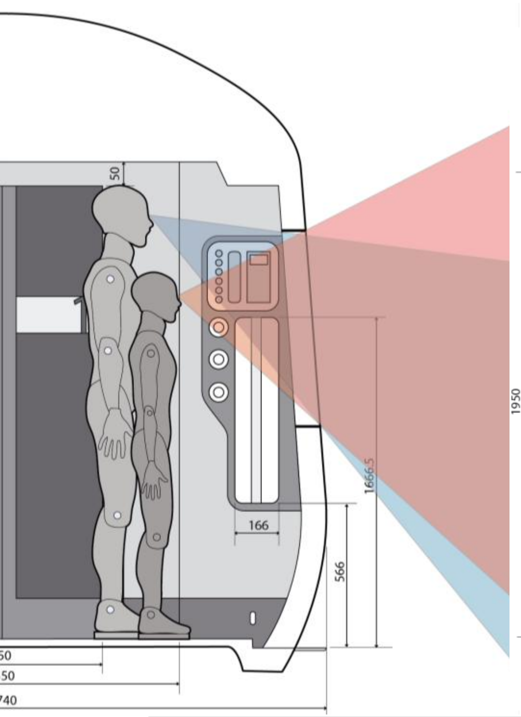
(8) With a view to progressively eliminating within a reasonable timescale, all identified barriers to accessibility by way of a coordinated effort to renew and upgrade subsystems and by deploying operational measures, Member States should establish national implementation plans. However, since these national implementation plans cannot be in sufficient detail and are subject to unpredictable changes, Member States should continue to submit

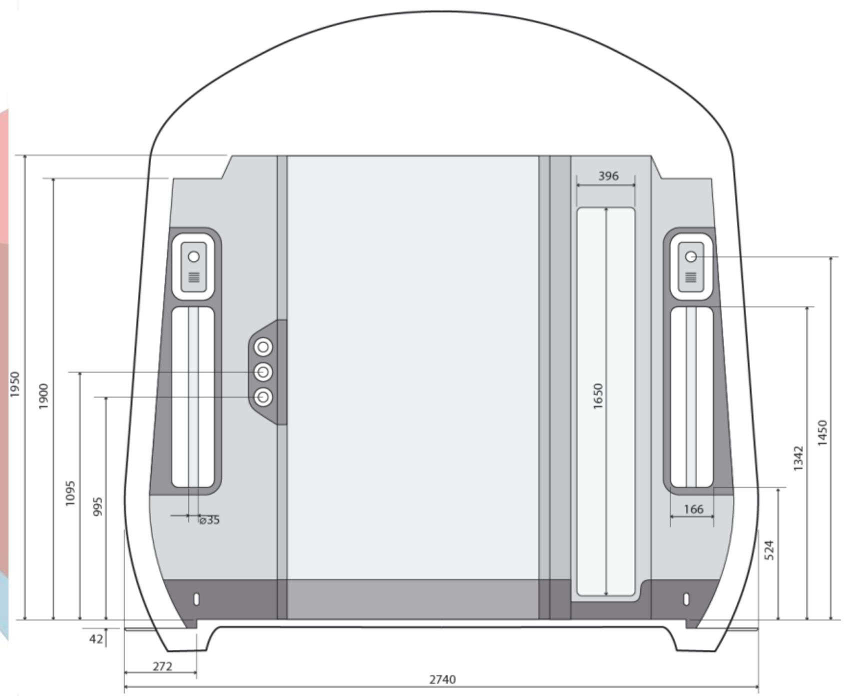
PRM TSI

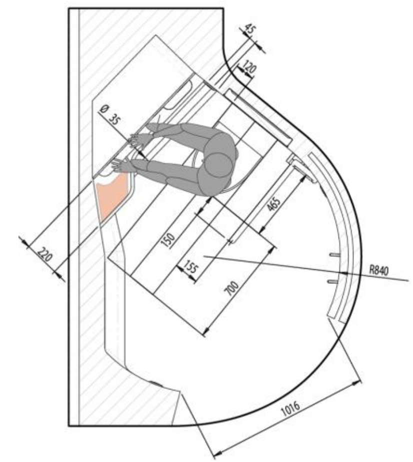
# Steps 2&3

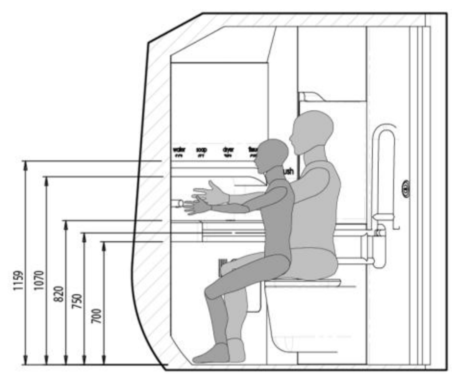
As with the cab, we tried to summarise the requirements pictorially wherever possible, we added additional anthropometric data where appropriate to perform CAD assessments .

The great thing about the PRM TSI regulations is that they are, in most cases, measurable and testable, removing much of the subjectivity.



# Step 4 – Low fidelity rig assessment

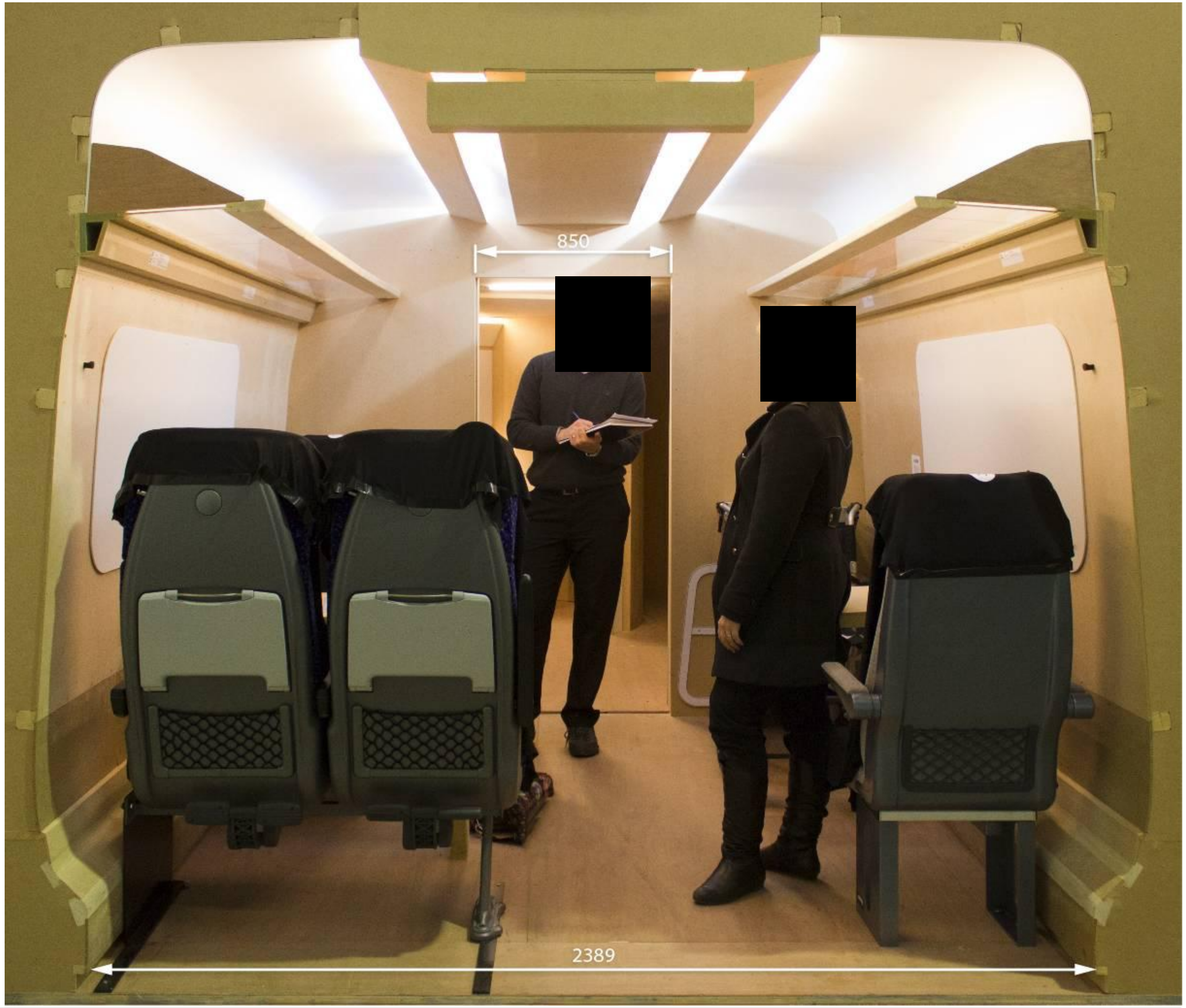
We prioritised the build of the wooden mock up to focus on the areas that posed the most uncertainty.

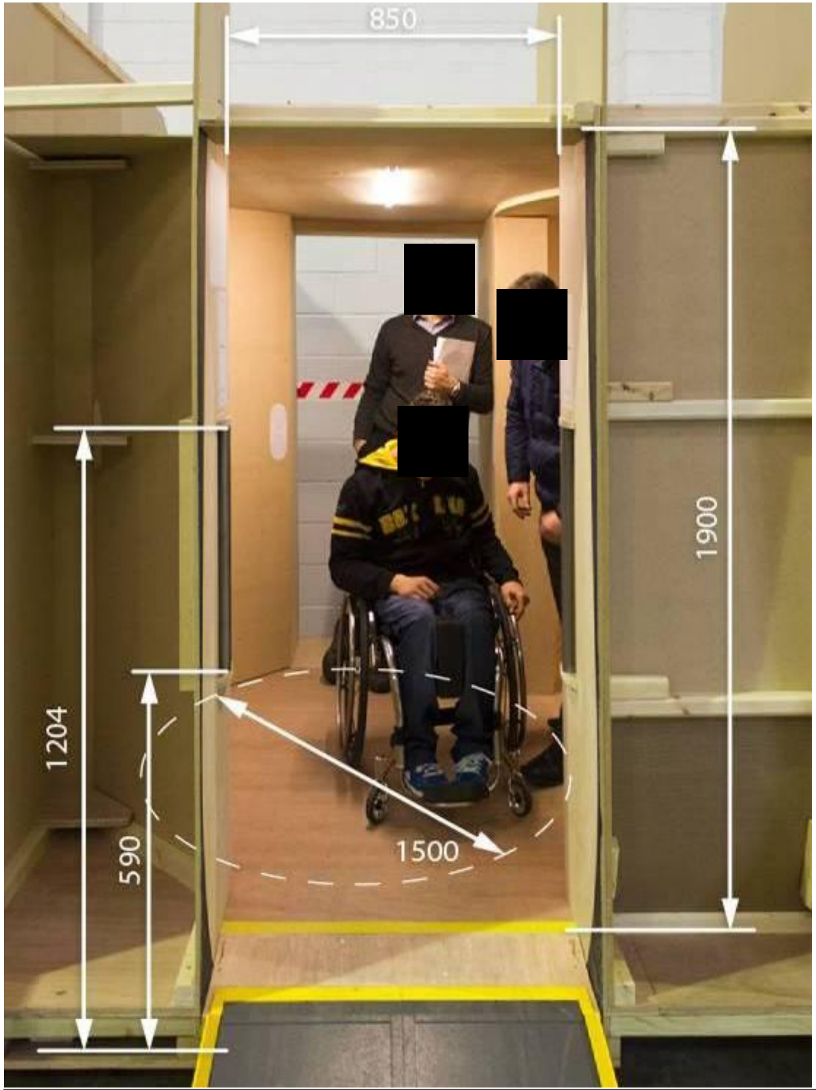
There is always a conflict between the space inside the universal access toilet and the width of the corridor along the side. By swinging the wall in and out, we were able to optimise the position.

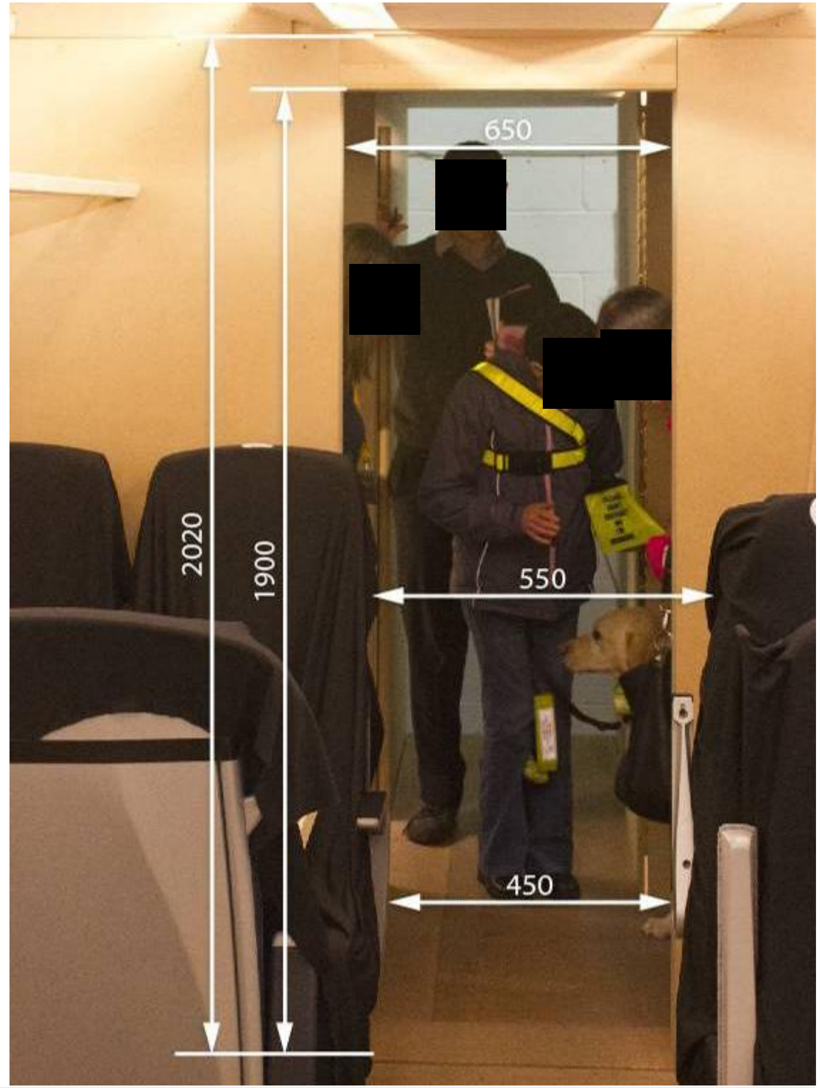
# Step 5 – Ergonomic rigs

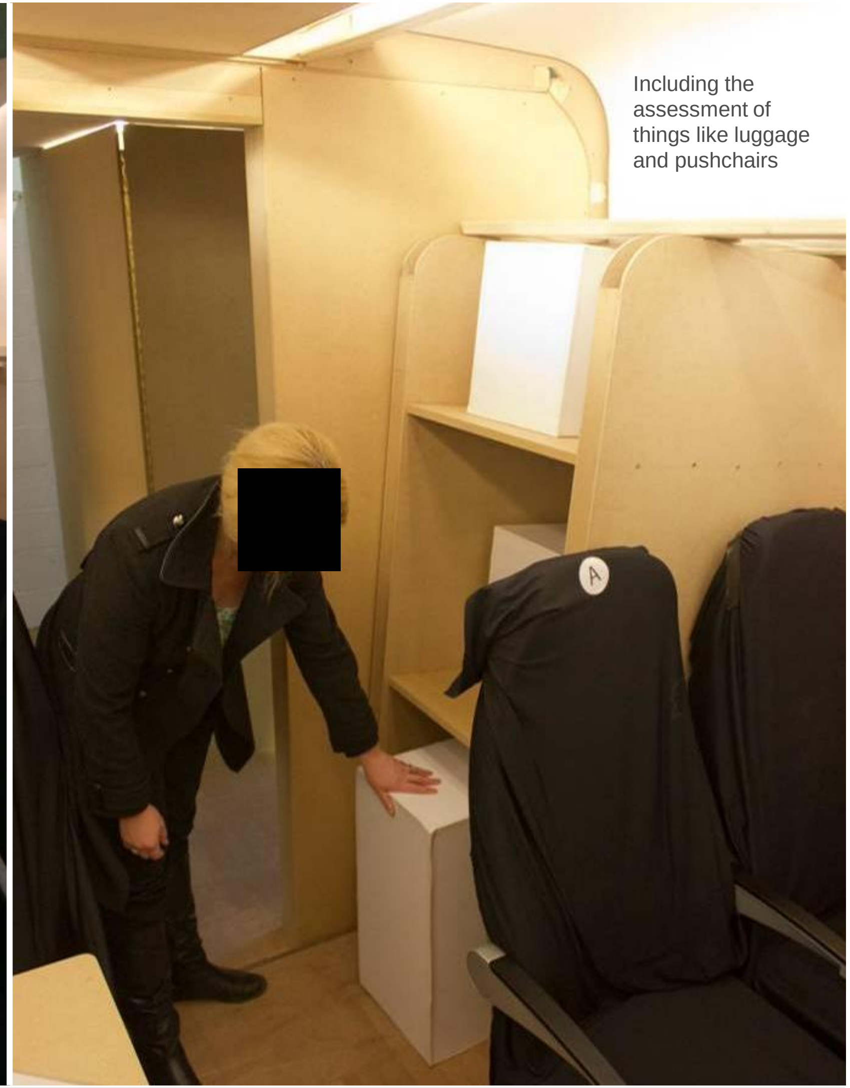
We then developed a more detailed rig of the toilets


…and the saloons which were evaluated with passenger groups




850
1900
1204
590
1500


650
2020
1900
550
450

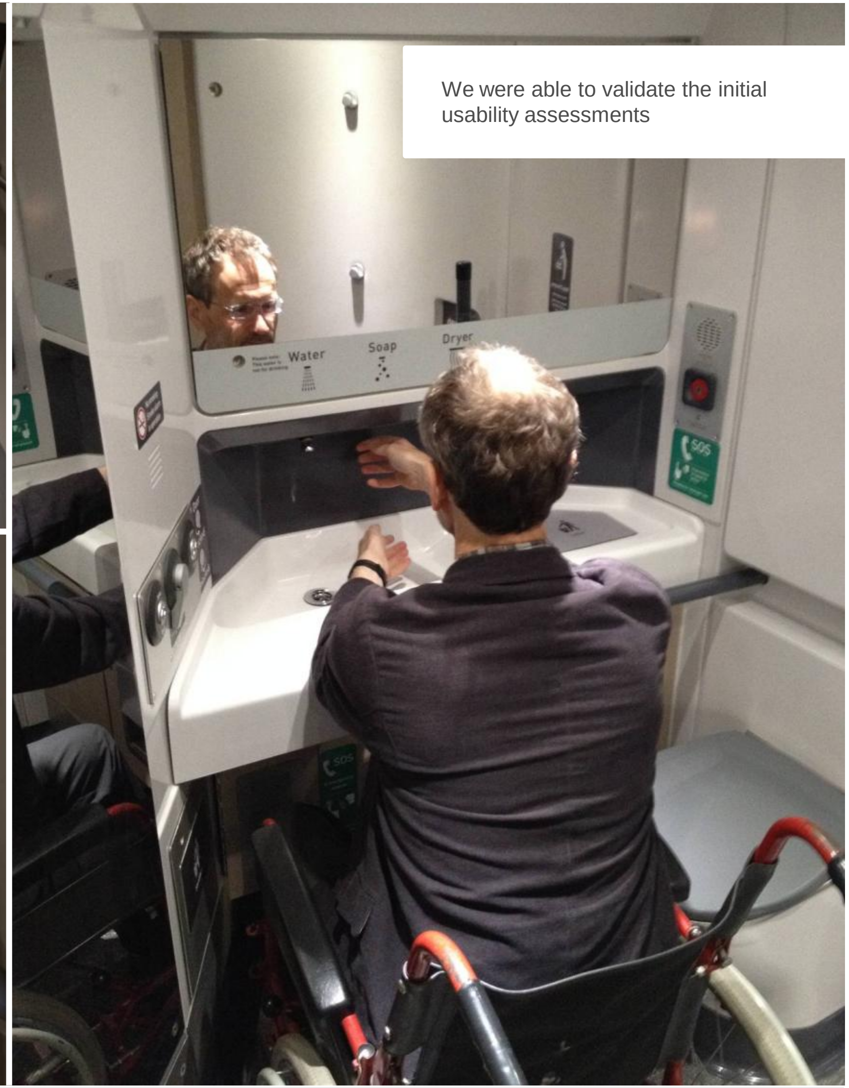


Including the assessment of things like luggage and pushchairs

# Step 6 – Final mock-up

The final design was verified in a detailed mock up


As with the cab, we used representative controls and components where possible

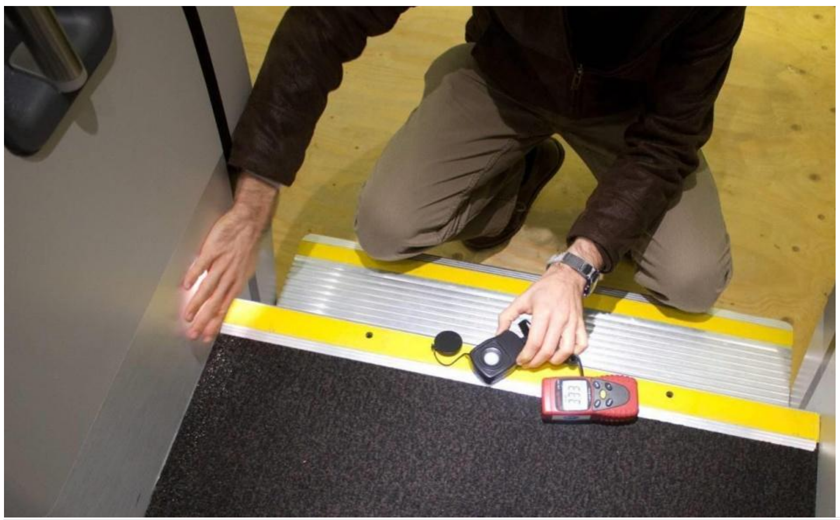

We were able to validate the initial usability assessments

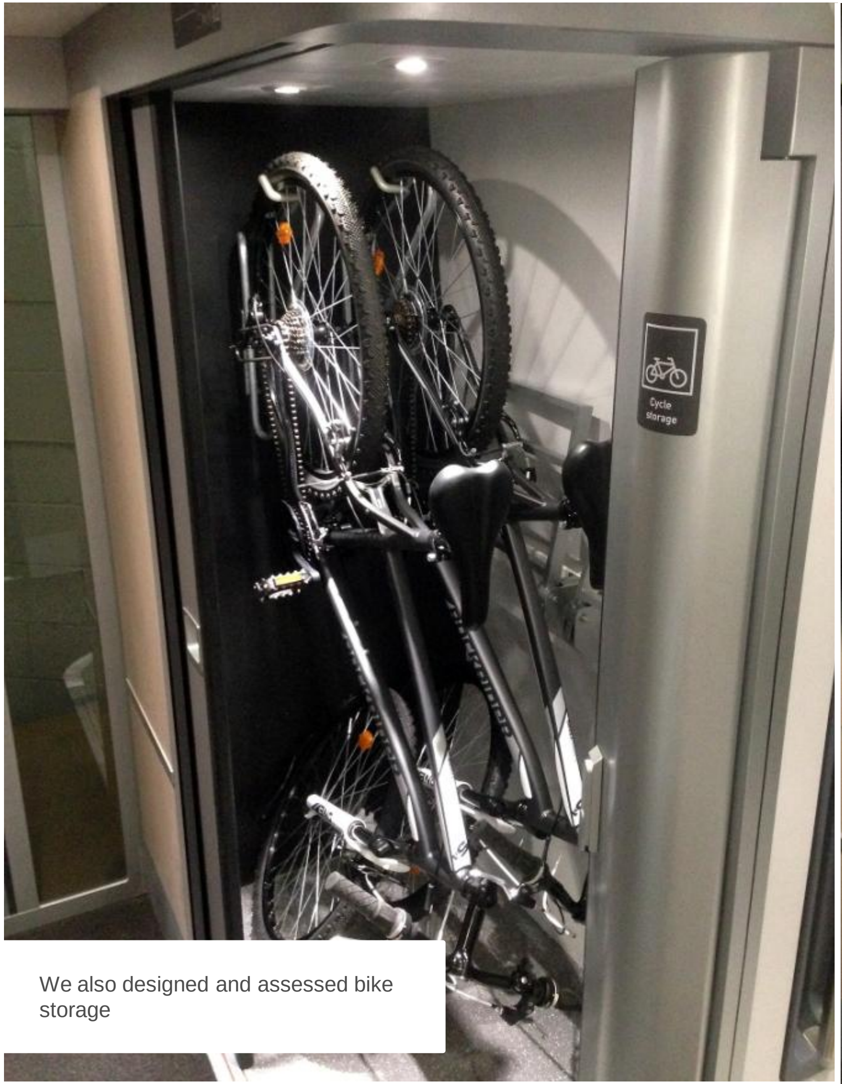
# Step 7 – Compliance demonstration

The final stage was to demonstrate compliance, this was largely done against drawings; however, the mock up proved an invaluable part of demonstrating the more subjective aspects of the design

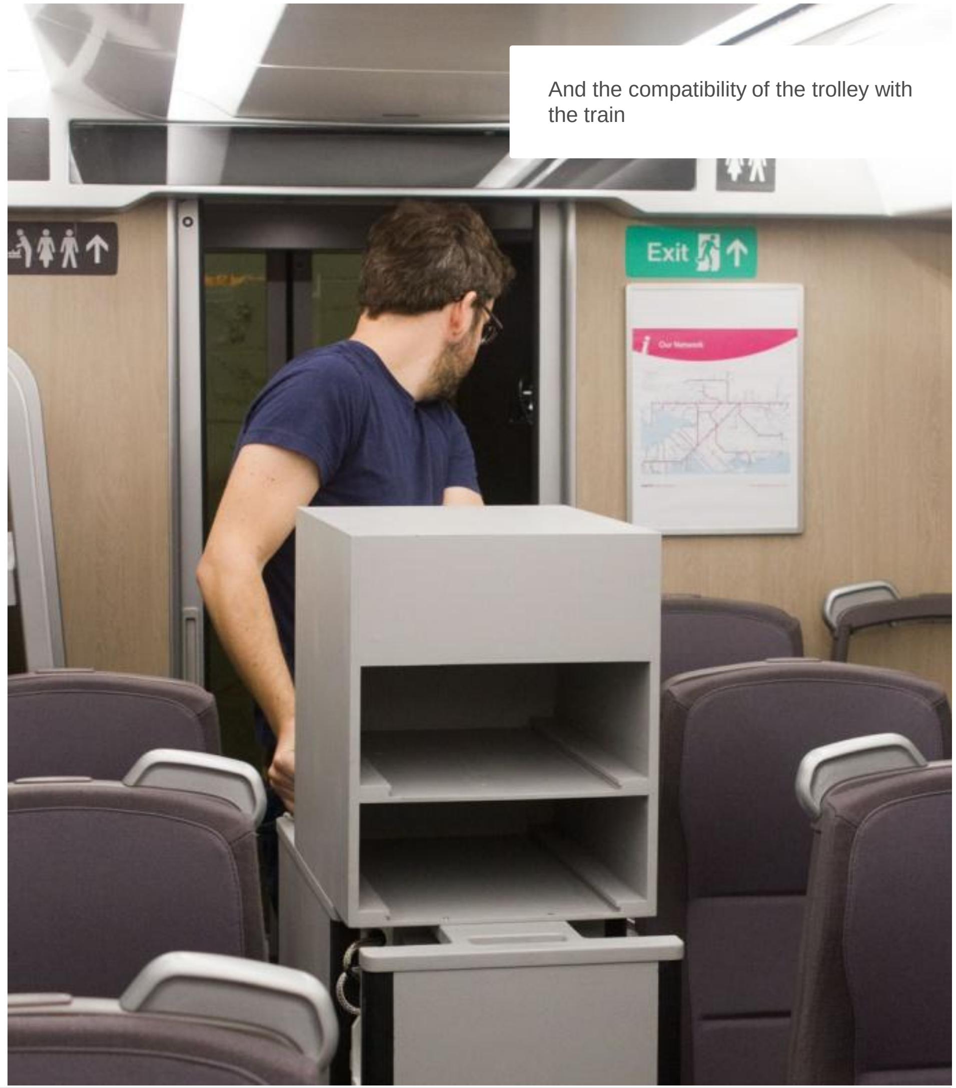

Force meters were used to
ensure forces were within limits


The same with light levels






We also designed and assessed bike storage

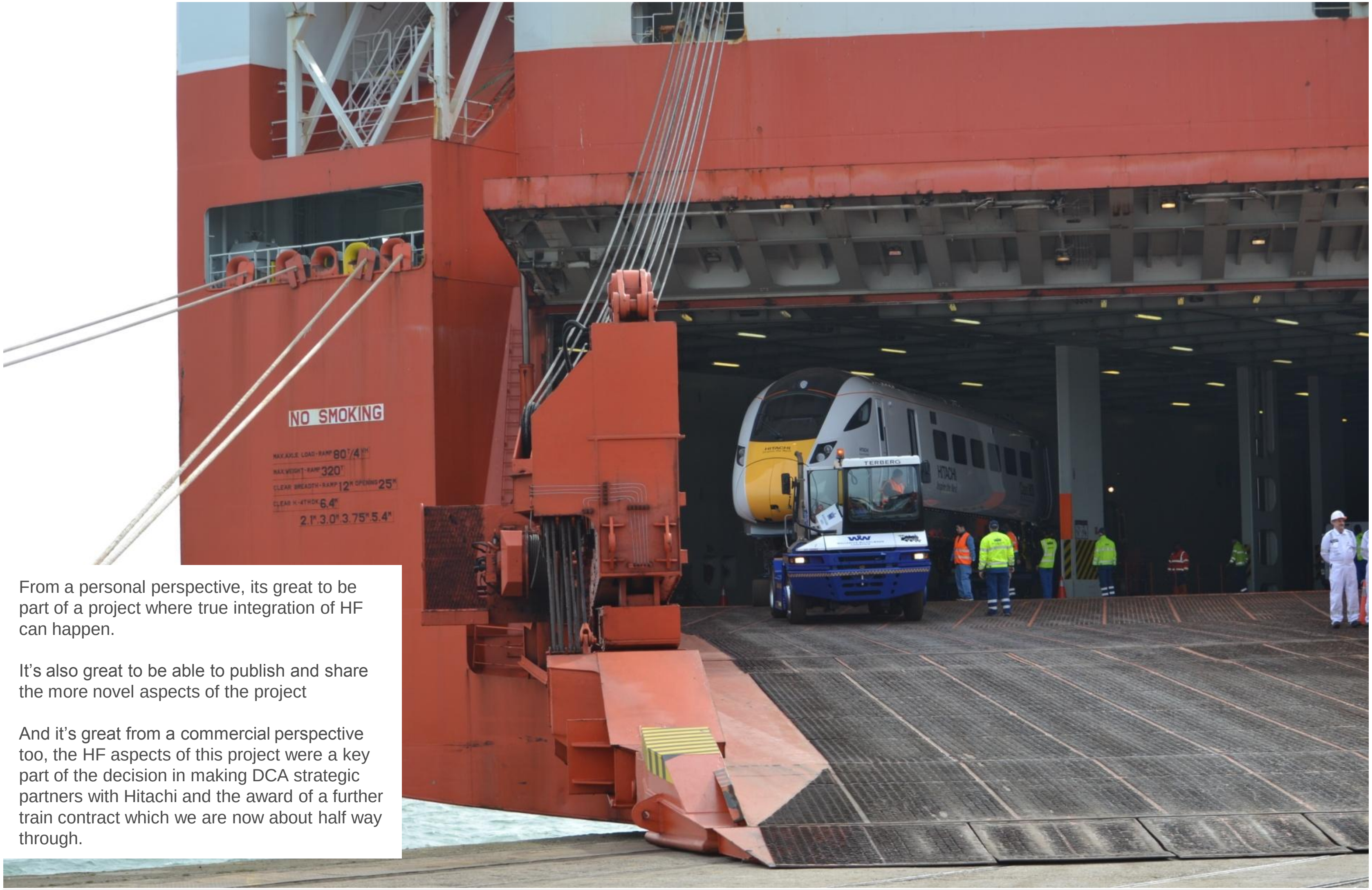



And the compatibility of the trolley with the train

It’s been a really exciting project to be involved with right from the drawings through to the first train being manufactured.

As a team of designers, engineers, model-makers and HF people we have been able to deliver the project.

Early and frequent HF assessments have been a key part of this ensuring that stakeholders were consulted and engaged with the process and that any issues of non-compliance or poor usability were uncovered early in the project .




From a personal perspective, its great to be part of a project where true integration of HF can happen.

It’s also great to be able to publish and share the more novel aspects of the project

And it’s great from a commercial perspective too, the HF aspects of this project were a key part of the decision in making DCA strategic partners with Hitachi and the award of a further train contract which we are now about half way through.


For further information please contact
daniel.jenkins@dca-design.com

DCA