Level Access at the Platform-Train Interface (PTI)

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Abstract

The Platform-Train Interface (PTI) is an important factor in the performance of a High Speed Railway (HSR) and an unavoidable part of a passenger's journey. The majority of existing train services in Europe and the UK require passengers to negotiate steps between the platform and the train, which prevents many people from using the service with ease or with independence. A well-designed PTI can reduce dwell time and enhance passenger experience.

Providing level-access at the PTI is core to HS2 Ltd.'s design vision for the proposed HSR in the UK. It is essential for creating a high-capacity, reliable service that can provide an exemplary passenger experience, allowing people to travel independently and with dignity. HS2 Ltd. aspires to create a PTI that most people can cross without assistance and that does not impede those with luggage, small children or reduced mobility.

The majority of high-speed trains on the market have floor heights of circa 1200 mm. Existing European legislation mandates the adoption of either a 550 mm or 760 mm platform height at new HSR stations. Two or three steps are therefore needed due to the height difference. These steps may be at the doorway, or further into the train and present a barrier to individuals of reduced mobility.

Train manufacturers have indicated that lowering their train floor height even by a small amount presents significant technical challenges. While high speed trains with low floors exist, their layout involves significant compromises, due to the lack of space under the floor for equipment and wheels. To provide an equivalent seating capacity to conventional high-speed trains, low floor trains require a very dense seating layout, compromising comfort for passengers. Further, such a seating layout would not be possible for HS2, where a narrower car body will be required on a large proportion of the fleet to allow them to operate on the UK existing rail network.

Features such as ramps and lifts are available but they require staff assistance and do not help all passengers, such as those with luggage or mobility impairments that do not require the use of a wheelchair. Deployment of ramps and lifts can also cause delays in the service. They do not provide the optimal, simple and effective solution desired.

Building HS2 to a platform height which aligns with the floor height of most typical trains would enable delivery of level access. Investigation has shown that a platform height of circa 1200 mm provides optimal accessibility for all , and for Persons with Reduced Mobility (PRMs), negates the need for boarding ramps and associated pre-booked assistance, without compromising on the benefits of HSRs. Its introduction would not hinder interoperability across Europe.

Executive Summary

Delivering a step-free Platform-Train Interface (PTI) is a core objective for the proposed HS2 network: it allows for optimal compliance with accessibility requirements and legislation[1], whilst mitigating the need for boarding aids and pre-booked assistance for persons with reduced mobility. Level access is integral to HS2's design vision of a high-performing service that all passengers can use independently and with dignity.

European legislation mandates the adoption of one of two defined platform heights (either 550 mm or 760 mm), neither of which would allow delivery of step-free access on HS2. Investigation has shown that an alternative platform height of circa 1200 mm would enable delivery of level access while adopting standard, proven European high-speed train designs, and that its introduction would not hinder European interoperability.

Why is level access important?

A two-step or three-step PTI, typical of existing HSRs, is a problem for a wide range of people, including individuals with disabilities, elderly people, families travelling with young children, and passengers carrying heavy luggage. Steps at the PTI present an unavoidable hurdle to all of them.

In contrast, level access makes it quicker and easier for most passengers to board and alight from the train (see section "10.4 Dwell time"). It reduces the need for assisted boarding and alighting – a process which can cause anxiety or fear, as well as introducing a risk of injury for passengers and the staff members helping them. Level access also makes good operational sense. By allowing the highest passenger flow rate across the PTI, it reduces dwell times at stations, which is a crucial part of running a reliable, high-capacity service. Research undertaken in the last year on behalf of HS2 Ltd, using both laboratory based experiments and observations of railway services, provides evidence that the choice of PTI has the potential to significantly influence dwell time (see section 3.3 "Effect of level access on the PTI").

How can we provide level access?

We can avoid the need for steps, ramps, lifts or assisted boarding for PRMs on the new high speed network, by using higher platforms that are level with the train floors. Building new infrastructure with a high platform height has a negligible impact on infrastructure cost and in some cases could reduce rolling stock cost (see section "4.3 Cost of level access").

Most high speed trains have a floor height of between 1150 and 1250 mm, so a platform height of circa 1200mm is proposed.

[1] This principle of universal and inclusive design is set out in the UN Convention on the Rights of Persons with Disability. The European Union enforces this provision for access through the Commission Directive 2013/9/EU. The UK's Equality Act 2010 makes provision of requirements to prevent discrimination and reduce inequality.

Can we achieve it?

To deliver this solution, it is proposed that a new platform height is added to the pan-European Technical Specifications for Interoperability (TSIs) agreed by the Member States, which currently allow only two heights: 550mm and 760mm. There are no obvious grounds for a derogation from the existing TSI.

Some HSR networks in other countries comply with the TSIs by using steps and assisted boarding, or by running low-floor trains. However, low-floor trains introduce significant challenges to achieving passenger capacity, leading to the need for more dense seating layouts which compromise passenger comfort (see section "4.5 Existing level access solutions"). Moreover, HS2's classic-compatible services will run beyond the high speed network and serve stations on Britain's existing network – low-floor trains are not suitable for these services.

Crucially, adopting a high platform standard for HS2 would allow level access to the majority of existing European high speed rolling stock designs with relatively minor design changes (see section "4.9 Achieving Interoperability with an additional platform height"). Further, stepping distance requirements could still be achieved for many existing trains already in service and designed to serve lower platforms, although it is recognised that modification to cover the train's steps would be needed to optimise this interface should it ever be required.

UK classic platforms have a nominal height of 915 mm. This report demonstrates that trains optimised for level access at high platforms can deliver the stepping distance requirements whilst operating on the UK classic network. Furthermore, HS2 Ltd. intends to work with the UK rail industry to explore options to deliver level access for HS2 trains while operating on the classic network.

What is the alternative?

If HS2 platforms are built to either of the existing TSI heights, steps would be required at the PTI – the only place on the whole HS2 network where passengers would encounter unavoidable step access. Ramps or lifts would be required on the platforms or trains and passengers with reduced mobility would need assistance to board.

Using the 550m mm or 760 mm standard would put an extra demand on inspection, maintenance and staff resources, due to the extra equipment and assistance required to aid passengers across the non-level PTI. More importantly, many passengers would be disadvantaged by needing to pre-book their travel, just to be sure of getting the help they need.

As this report shows, there is no satisfactory solution at the existing TSI platform heights which provides a level-access PTI without compromising on other factors beneficial to a railway network.

The way forward

Our Inclusive Design Policy supports the right of all people to use the HS2 network. HS2 will be a brand-new, purpose-built environment, and should not compromise on accessibility. It should set an example for convenient travel, open to all. A change in the TSIs to allow high platforms and step-free access for HS2 makes sense in terms of rail safety, performance, operation and passenger experience – all aspects of railway systems quality that the TSIs promote.

We want HS2 to be a safe railway network. We want it to address the demand for capacity. And we want to encourage people to choose high speed rail, by providing travel that is designed around their needs.

HS2 Ltd have until December 2015 to determine the platform height which will be adopted: changing the platform height after this point will impact on the programme and cost of HS2. We propose that the precise height of a new high platform should be discussed, approved and added to the TSIs, and that this process should begin as soon as possible.

1 Introduction

1.1.1 The Platform-Train Interface (PTI) is an unavoidable part of a passenger's journey and its design has a critical effect on the railway service. A sub-optimal PTI can risk the economic and social benefit High Speed Railways (HSRs) can bring to a country, by hindering transport reliability and resilience and limiting a railway's capacity.

1.1.2 Existing HSRs which are compliant with the TSIs (Technical Specifications for Interoperability) typically provide a PTI with at least two steps between the platform and the train. This can introduce delays to station dwell times by increasing boarding and alighting times and creates difficulties for some passengers, such as persons with reduced mobility (abbreviated in the relevant TSI and elsewhere to 'PRM').

1.1.3 The European Railway Agency (ERA) develops procedures within the framework of railway safety and interoperability. It is responsible for contributing to the implementation of European Community legislation aimed at supporting a competitive, open market for rail. The ERA develops the TSIs in conjunction with Member States. A TSI is a common, harmonised, technical specification required to satisfy the essential requirements of interoperability which include safety, reliability and availability, health, environmental protection and technical compatibility. A new European HSR system must comply with the TSIs. Two of the main objectives of the ERA are to:

- increase the safety of the European railway system; and
- improve the level of interoperability of the European railway system.

1.1.4 Accessibility is an essential requirement of a new HSR system under the 2008 Interoperability Directive. The European Union (EU) Commission Directive 2013/9/EU (included in "Appendix A: Commission Directive 2013/9/EU") mandates that access on an equal basis is ensured. This is in accordance with the United Nations Convention on the Rights of Persons with Disabilities which states parties take appropriate measures to ensure persons with disabilities have access on an equal basis with others. The PTI must comply. National legal requirements such as the Equality Act 2010 in the UK also mandate accessibility.

1.1.5 The UK government is developing HS2, a new HSR network which will improve connectivity between the major cities in the UK and provide increased rail capacity, providing through services onto the existing classic railway network. High Speed Two Limited (HS2 Ltd) is responsible for developing proposals for the network. HS2 Ltd is committed to providing a network which can significantly improve passengers' experience of rail travel in the UK. Inclusive and accessible design is a core requirement and a foundation of the design. HS2 Ltd is also committed to achieving interoperability as defined by the European interoperability directive, whilst also addressing the wider compatibility issues with the existing UK classic network. It is legally bound to comply with the TSIs.

2 Purpose of this document

2.1.1 This document:

- defines level access;
- presents the benefits and challenges of implementing level access on European HSRs, particularly with regards to the EU directive on interoperability (please see "Appendix A: Commission Directive 2013/9/EU");
- discusses how level access at the PTI could be achieved without hindering interoperability; and
- gives recommendations on further action.

3 Level access

3.1 Definition of level access

3.1.1 Level access is achieved when the interface between the platform and the floor of the train is step-free. This can be seen in Figure 1.

Figure 1 Level access on the Shinkansen E5, Tokyo

3.1.2 The TSI on Passengers with Reduced Mobility (PRM) sets a rule for boarding aids: they are required when the gap between the edge of the door sill and the edge of the platform is more than 75mm horizontally and more than 50mm vertically. These parameters, along with the requirement that rolling stock have no internal step between the door sill and the vestibule, can be regarded as the TSI definition of 'level access'.

3.1.3 HS2 Ltd.'s aspiration is to mitigate the need for booked assistance by designing infrastructure and choosing rolling stock which will allow wheelchair users to traverse the PTI independently. Please see "Appendix B: The PTI gap and step" for an explanation of why the platform cannot be flush to the train and the sources and relevant excerpts from the literature research.

3.2 Non-level access

3.2.1 If the PTI is not step-free, additional features are needed on the train or platform. These may be ramps or lifts. Figure 2 shows a three-step transition across the PTI.

Figure 2 Three-step PTI on the Alstom AGV, shown here at Rome Tiburtina

3.3 Effect of level access on the PTI

3.3.1 The design of the PTI impacts key areas of railway operations including:

- accessibility and inclusivity;
- passenger experience;
- boarding and alighting times and hence dwell times and service capacity; and
- staff and operations, allowing for greater operational efficiency.

3.3.2 Level access at the PTI, in comparison to step access, facilitates the quickest boarding and alighting times and gives the best passenger experience. This is backed up by research both in a laboratory environment and through observation of live railway services (CCD Design & Ergonomics Ltd, 2014).

3.3.3 Level access creates a non-discriminatory PTI which users of varying age and ability can navigate with ease and without additional effort and stress (please see research in "Appendix C: Effect of level access in comparison to non-level access"). This allows for compliance with accessibility legislation including the UK's Equality Act 2010 and the EU Interoperability Directive 2013/9/EU. Non-level access would require boarding aids to comply.

3.3.4 Good passenger experience encourages repeat custom and growth in passenger numbers. Without level access, the railway service removes some passengers' independence. Level access mitigates the risk of injury and the anxiety, due to time constraint and handover of personal autonomy to a stranger, which are associated with the use of ramps across the PTI (RSSB).

3.3.5 Level access contributes to a system where the dwell time is resilient to variance in passenger demographics, including age and luggage load (please see "Appendix C: Effect of level access in comparison to non-level access"). Research has shown that the level access PTI does not discriminate between passengers of differing ability, they can all traverse the PTI at the same speed. Given that the HS2 network will serve an aging population, level access – allowing people of all ages to traverse with equal effort - would be a great advantage.

3.3.6 Level access requires less staff and operational resource than step-access, due to the diminished need for booked assistances. Delays would be minimised as time for deployment, use and stowing of ramps and lifts and attendance of staff is not required. It also reduces anxiety and risk of injury for staff, which they can experience whilst providing assistance for boarding and alighting. Without level access, additional boarding aids are necessary which introduce an inspection and maintenance requirement.

3.3.7 A comprehensive description and explanation of all the points in this section (3.3) are available in "Appendix C: Effect of level access in comparison to non-level access".

3.4 Challenges of level access

3.4.1 There are consequences to providing level access which present challenges.

3.4.2 Providing level access by adopting a higher platform may require a greater platform offset, and hence a greater gap between the train floor and the platform edge. However, this offset, if needed at all, has been shown to be negligible, as discussed in section 4.8.

3.4.3 Doors that move out before sliding open also necessitate a gap between the train floor and the deployable step/bridging plate, so that the train door can open after the step is deployed as required by the TSIs. However, other solutions are available - in Japan, for example, the doors slide inside the vehicle on opening. Internal sliding doors can present noise and aerodynamic drag issues, whilst also taking up space inside the train; however the solutions in Japan have overcome these issues.

3.4.4 A bigger gap is required for curved platforms. Preliminary modelling has shown this could range from a decrease of 21 mm (leading to the train violating the platform) or a 28 mm increase when changing the track from straight to a 1000 m radius. However, an acceptable level access PTI can be achieved even on curves by carefully considering the location and size of the step(s) or bridging plates on the train at the PTI. If necessary, the gap can be further managed by:

- Reducing the number of curves or making them larger
- Using platform-based devices to bridge the gap at the PTI
- Special process at locations where tight radii cannot be avoided. There would be a need to work with the whole railway industry to develop the correct standards.

3.4.5 If level access were to be provided based on a specific train floor height, it has the potential to present interoperability issues for trains serving other infrastructures. However it is possible to design new trains to accommodate the range of platform heights, through use of features such as retractable steps. For existing high-speed trains, depending on the intended operation, modification would be feasible in most cases so that they can accommodate a different platform height, for example by installing a manual cover over the steps. This is discussed further in section 11 and "Appendix E: Interoperability".

3.4.6 There should be no impact on the interface with tunnel walkways. However, as is already the case, consideration will be needed on a project by project basis as to how detrainment will be facilitated from any train design to the chosen tunnel walkway height.

3.4.7 The requirement for speed restrictions as trains pass through stations with higher platforms has been considered. Even with existing platform heights, it is typical for speed restrictions to apply when trains pass adjacent to platforms.

3.5 The case for level access

3.5.1 Level access allows for the best use of a new-build network, maximising potential service capacity and delivering resilience to change in demand.

3.5.2 In comparison to step access, level access provides low boarding and alighting times, leading to greater reliability in the achievement of dwell time.

3.5.3 Level access encourages people to use rail service no matter what the purpose or nature of their journey – family outings, transporting large luggage or last-minute visits. It also diminishes hardship for passengers, which improves the experience for all passengers using the service. A desirable passenger experience encourages repeat custom and preference over other transport methods.

3.5.4 Access on a truly equal basis can only be provided by level access. Level access improves accessibility for all passengers and diminishes the need for assistance and hence pre-booking for such assistance.

3.5.5 If level access is not provided, the following issues are apparent:

- The PTI presents barriers to some passengers, which are not there for others, particularly for those with different mobility capabilities. This diminishes the ability to provide access on an equal basis for PRM passengers.
- Passengers are subject to stress and anxiety due to lack of independence in travel, and separation from their luggage or from young children while negotiating steps.
- Staff are subject to stress, anxiety and injury when providing assistance to passengers.
- Passengers are subject to injury during assistances which require the use of a ramp.

- Consistent achievement of dwell time will be a greater challenge.
- Passenger experience is dampened by the presence of steps.

3.5.6 It is evident that only level access will create a PTI that fully satisfies the desire to provide for independent travel, allowing all passengers to board and alight without requiring boarding aids or pre-booked assistance.

3.5.7 Additional benefits include improving passenger experience, reducing dwell times and reducing risk of injury, making achievement of level access at the PTI a valuable objective.

4 Achieving level access

4.1 Options for level access

4.1.1 For HS2 Ltd. there are three options for level access:

- At TSI endorsed platform heights 550 mm or 760 mm and by using a low-floor train;
- At 915 mm platform height, a UK specific case and by using a low floor train; and
- At a higher platform height circa 1200 mm, aligned with floor heights of typical trains

4.2 Level access on other railways

4.2.1 A number of railways have incorporated level access to high train floor heights, demonstrating that it is achievable:

- In Japan, a platform height of 1100 mm Above Rail Level (ARL) is used on the conventional network and 1250 mm on the HSR Shinkansen network. This allows for level access at the PTI, as seen in Figure 3. Being an HSR network, this example is similar to the scenario HS2 Ltd. wish to replicate.
- In the UK, the Heathrow Express line uses a platform height of 1100 mm at all stations. It has been noted that there are an abnormally high number of incidents at the PTI on the line, however analysis of the data shows that this large number of incidents is confined to Heathrow Terminal 5 station only suggesting that the cause is not directly related to level access. Heathrow Express are investigating the causes of this, and hypotheses include passengers being tired from flights, late-running passengers running for the trains as the can see it from the lifts, a lack of a knowledgeable user base and passengers having a false sense of security due to the unique open and light environment at T5.
- Crossrail in the UK is currently under construction and due to open in 2018. It is being built to provide level access using platform heights of 1100 mm.
- In North America: California High Speed Rail is going to use a nominal platform height of 48 inches which is approximately 1200 mm. It is anticipated that Caltrain will update its rolling stock and platforms to match this when renewal is required.

Note that all the above use platform heights above 1000 mm.

Figure 3 Level access PTI (JR East Shinkansen, Japan)

4.2.2 Figure 4 shows the only low floor train available on the HSR market providing level access at a TSI-compliant floor height. The low floor height is achieved using a novel train design, where all the equipment is located in the locomotive cars rather than under the floor and the wheels are located between the vehicles rather than under them.

Figure 4 Level access at a low TSI-compliant floor height, Talgo train

4.3 Cost of level access

4.3.1 A level access PTI has areas which may incur or reduce cost in comparison to other PTI alternatives.

4.3.2 Increasing the height of a platform has a negligible cost impact for new or remodelled stations. Raising the height of existing platforms however is costly.

4.3.3 Trains could be cheaper if they are serving only the high platform height as they will not require such complex step arrangement at the PTI. This will not be true if the train needs to serve more than one platform height however. Removing or reducing the complexity of steps will improve reliability and operational resilience and can reduce dwell times.

4.4 HSR TSI-compliant options for train floor and platform height

4.4.1 This section discusses the options for the critical components at the PTI: the platform height above rail level (ARL) and the train floor height ARL.

4.4.2 The TSI on high speed infrastructure mandates that one of two platform heights be adopted for new HSR projects:

- 550 mm ARL; or
- 760 mm ARL.

A specific platform height of 915 mm is allowed in Great Britain. It is specified in combination with a horizontal offset which infringes the European "GC" structural gauge which is being adopted for HS2.

4.4.3 The floor height of high speed trains is typically between 1150 mm and 1250 mm ARL because:

- the floor needs to pass over the bogies of the train. Wheels on high speed trains are usually between 900 mm and 950 mm in diameter;
- equipment needs to be fitted under the floor, such as traction or auxiliary systems; and
- the floor is generally level and cannot vary in height significantly without causing further impediment to accessibility

4.4.4 Train manufacturers have indicated that they are unlikely to lower their floor heights and support a higher platform height to achieve level access and full accessibility at the PTI.

4.5 Existing level access solutions

4.5.1 There are solutions available which are TSI-compliant and provide level access. The following have been considered:

- Low-floor trains
- Double-deck trains
- Ramps or lifts (stored on platform or train)

- Dedicated doorways

4.5.2 While low-floor trains may be appropriate for some HSR networks, they can be incompatible with any non-HSR networks on which they may need to operate, as is the case in the UK. Low floor trains also compromise on passenger capacity (please see next statement with regards to double deck trains which can provide low floor areas). Whilst there are existing non-HSR trains that have distributed traction and low-floors, allowing for increased passenger capacity, a product has not been developed for HSRs.

4.5.3 Double deck trains can provide level access at a low platform but have steps inside to the upper and lower decks or between carriages, as the floor rises over the bogies, creating a train interior which segregates passenger according to their mobility. This prevents movement between carriages for some PRMs and also operational equipment, such as catering trollies. Existing high speed double deck trains rely on locomotive based traction due to space constraints in the passenger vehicles. This configuration introduces challenges with respect to achieving very high speeds and high acceleration as is required for HS2. Double deck trains may not be compatible with non-HSR networks, as is the case in the UK.

4.5.4 Ramps and lifts introduce a risk of injury for both staff and passengers (RSSB). They require manual handling skills for staff and extra physical effort for the passenger. These solutions only address specific issues which some passengers have, not the general issue of creating an accessible PTI that provides the same experience to all passengers and is optimised to reduce dwell times.

4.5.5 Dedicated doorways are a number of doors on the train which are level with the platform. This solution only reduces the barrier for wheelchair users and not for all PRMs. They can also be incompatible with non-HSRs, as is the case in the UK classic network, and do not contribute to reducing dwell times.

4.5.6 There is no optimal solution at the existing TSI platform heights which provides a satisfactory method for boarding and alighting passengers with mobility difficulties.

4.5.7 A comprehensive description and explanation of all the points in this section (4.5) are available in "Appendix D: Level access solutions that are TSI-compliant".

4.6 Non-TSI-compliant level access solutions

4.6.1 Platform humps have been used in the UK in two ways:

- to decrease the vertical step between the train floor and the platform edge (without providing level access)
- to provide level access at specific points on the platform

4.6.2 They are a good solution for existing stations, but are not preferred for new-build projects where a more optimal solution can be adopted.

4.6.3 Due to their fixed nature, they are compatible only with the trains to which they are designed.

4.6.4 Building humps into a platform would make it non-compliant with the TSIs.

4.7 Introduction of a third platform height to the TSIs

4.7.1 The HS2 network's requirements are best supported through adoption of level access at the PTI. Section 3 explained why level access is a desirable requirement for new build HSRs in order to maximise accessibility and have a design which is as inclusive as possible.

4.7.2 The case for the HS2 network is based on technology and methods that are already in use and have been shown to be robust. This rules out creating a design that provides level access using novel or hypothetical features. Section 4.5 looked at TSI-compliant solutions available and concluded that level access could not be achieved at the platform heights currently endorsed by the TSIs. Hence, in order to achieve the performance, passenger experience and accessibility requirements for the HS2 network, a platform height that is higher than those endorsed by the TSIs will need to be used. Level access will be possible at this height, as will a train that can meet the performance requirements and passenger environment for the HS2 service.

4.7.3 Most trains have a floor height between 1150 mm and 1250 mm ARL. It is logical therefore that the TSIs should endorse a platform height which matches these floor heights.

4.8 Platform offset at a higher platform height

4.8.1 Based on structural gauging approaches for some rail networks, the platform may need to be offset further if the platform height is increased. For the European standard structural gauges, above 1170 mm, the kinematic reference profile widens 25 mm on each side so the platform needs to be offset at least by this value.

4.8.2 At platform heights that are currently endorsed by the TSIs, the platform offset is 1650 mm on straight track with standard gauge (1435 mm). This applies regardless of track quality and type (ballast/slab).

4.8.3 Investigation using BSEN15273-(Parts 1-3):2013 and the Infrastructure TSI has shown that at 1200 mm the platform offset would have to be offset an extra ~30 mm. 25 mm of this is due to the kinematic reference profile widening and 6mm must be added due to the additional height above rail (and therefore the greater effect of cross level difference between tracks). Hence below 1170 mm, the platform would need to be offset ~5 mm. This applies for ballast track that is of a quality less than "very good", on a straight track with a line speed > 80 kph.

4.8.4 Table 1 gives the values found for the platform offset (b_q, semi-width of the platform installation) from preliminary calculations. Note how for the 760 mm platform height on ballast of "Other tracks" (as opposed to very good quality tracks) the platform offset is 1650 mm which aligns with the value calculated from the infrastructure TSI:

Table 1 Platform offset with two track types and two platform heights (values in mm) on straight track, with a line speed of >80 kph

	PLATFORM HEIGHT	
TRACK TYPE/CONDITION	**760 mm**	**1200 mm**
Ballast, "Other tracks"	~1650	~1680
Slab	~1625	~1655

4.8.5 "Appendix F: Platform offset at a greater platform height" covers these calculations in detail.

4.8.6 Once the value of the height for the new high third platform height is decided, the exact platform offset can be calculated and rolling stock designs can respond to this.

4.9 Achieving Interoperability with an additional platform height

4.9.1 Introducing a third platform height of circa 1200 mm would not in principle be a barrier to interoperability.

4.9.2 If the track is curved the horizontal distance between the train floor and the platform edge may increase or decrease. In a desktop comparison of 1000 m radius track with straight track, the gap increased by 28 mm on the outside of the curve and decreased by 21 mm on the inside of the curve for a conventional train. The approach to these changes can be discussed and resolved. On the Heathrow Express line they allow for boarding aids at Paddington station for the lengths where track curve radius is small. This station is a terminus and dwell times will not be of critical importance. These increased gaps may not affect new build HSRs, such as the proposed HS2 network in the UK, as most of the platforms are straight.

4.9.3 Four types of train have been assessed against a combination of platform dimensions. These combinations are representative of the potential interface scenarios which could occur if a third platform height is adopted. The four types of train are:

- Captive: a train which operates only on the UK HS2 network
- Classic Compatible: a train which operates only on the UK network, including both the classic (where platform heights are a nominal 915 mm ARL) and the HSR network
- Existing European train: a train which already exists and operates to 550 mm and 760 mm platforms, and might also serve 1200 mm platforms
- New European train: a train which could be designed with three different platform heights in mind, 550 mm, 760 mm and 1200 mm

4.9.4 The vertical and horizontal distances between the train floor and the platform have been examined. They have been assessed against the definition of level access in Section 3.1 – both the minimum requirements for compliance with the TSIs and the aspirational requirements for unassisted wheelchair boarding and alighting.

4.9.5 A nominal platform height of 1200 mm ARL has been assumed.

4.9.6 For the purposes of this assessment, the platform offset examined at the 1200 mm platforms height is the same as for the lower platforms.

4.9.7 Existing HSR train floor heights range between 1150 mm and 1250 mm. Major HSR train manufacturers have stated a preference for floor heights of 1245 mm, hence this value has been assumed for the train floor height.

4.9.8 Table 2 provides a summary of the findings:

Table 2 Summary of interoperability investigation

TRAIN TYPE	PLATFORM HEIGHT ANALYSED	MEET TSI MIN REQUIREMENTS?	NOTES
CAPTIVE	1200 mm	✓	Meets the PRM stepping distance requirements for no boarding aids, without any modifications to the train. For it to meet the maximum 50 mm horizontal gap requirement, desired by HS2, a deployable step/bridging plate will be needed to bridge the gap. The possibility of such a deployable step/bridging plate has been discussed and confirmed with HSR train manufacturers. Platform based technology to bridge the horizontal gap so that wheelchairs can independently traverse the PTI is also available for consideration.
CLASSIC COMPATIBLE	1200 mm	✓	Could also provide level access at a 1200mm platform. However, it is accepted that step-access could not be avoided at the classic platforms, though a TSI- and RGS stepping distance-compliant step solution is achievable. No deployable step/bridging plate is required to meet the PRM stepping distance requirements at the 1200 mm platform, as the distance between the train floor and the platform edge already falls within the boundaries. However, to allow wheelchair users to traverse the PTI independently, the horizontal gap would need to be bridged at the 1200 mm platforms using either a deployable step/bridging plate or platform-based technology.
	915 mm	✓	

EXISTING EUROPEAN TRAIN	1200 mm	✓	Could provide level access to 1200 mm platforms but would need a modification such as a deployable cover over the existing internal step to be able to do this. The TSI stepping distance requirement may be achieved without any train modification, depending on the exact dimensions of the existing steps. Low floor trains would not be able to serve 1200 mm platforms. However as the TSIs already state sets of standards for trains serving only one platform height (e.g. statement 4.2.2.12.1 in the PRM TSI defining the envelope for the step), it is proposed that this concession could be extended to include a third platform height.
NEW EUROPEAN TRAIN	1200 mm	POSSIBLE	Features such as internal retractable steps could be incorporated. The train floor lies within the stepping distance requirements for the 1200 mm platform without additional steps on the vehicle. A single deployable step/bridging plate could not be positioned to satisfy the PRM stepping distance requirements at all three platform heights. Hence a two deployable steps/bridging plates would be required, at appropriate heights, to be able to serve all three platform heights (1200 mm , 760 mm and 550 mm).

4.9.9 Based on these initial findings, it is feasible that the TSIs could include a third high platform height without introducing a barrier to interoperability.

4.9.10 A comprehensive description and explanation of all the points in this section are available in "Appendix E: Interoperability".

5 Recommended strategy

5.1 The requirements of a new high speed railway system

5.1.1 Level access is essential for a truly accessible PTI, maximising the benefits from a railway network. Level access PTIs have much shorter boarding and alighting times than step access PTIs leading to shorter dwell times and the opportunity for more capacity on the line. Passenger experience is also improved, not only for PRMs, but for all passengers who will benefit from fluid intuitive boarding and alighting.

5.1.2 Whilst accessibility can be achieved to a limited standard without level access, the PTI is not a satisfactory or elegant design, and compromises in other operational areas, such as staff resource and dwell times. Ramps, humps and lifts introduce risks to both passenger and staff. Platform humps are a barrier to interoperability, as they can only serve the door configuration and floor height of a single train type. Double deck trains, whilst meeting high passenger capacity needs, are not flexible in use on non-HSR networks and are not currently developed sufficiently for the performance profile required on HS2.

5.1.3 Trains with high floor heights need to be used in order to meet passenger capacity and experience requirements and achieve compatibility with the UK classic railway network.

5.1.4 Therefore, high platform heights are the only viable solution for providing level access and optimal accessibility, whilst cultivating the dwell time and capacity benefits such a PTI exhibits.

5.1.5 High platform heights are proposed as the optimal solution for any high speed railway network.

5.2 Recommendations

5.2.1 It is recommended that a high platform height be added to those endorsed by the TSIs. There are no obvious grounds for derogation from the TSI; therefore, a change to the TSI is the only available route.

5.2.2 A platform height of circa 1200mm is recommended on the basis of this being well aligned with the floor heights of existing high speed trains.

5.2.3 If a third platform height cannot be endorsed in the TSIs, the UK seeks an additional specific case for its HSR network, HS2, on the grounds that trains operating on HS2 will also need to be compatible with the existing UK platform heights. Therefore, providing level access with a low train floor height is not feasible.

5.3 Open issues for discussion

5.3.1 Following approval of the principle for inclusion of a third platform height in the TSIs from relevant stakeholders, including Department for Transport, Office of Rail Regulation (ORR), European Railway Agency and European Commission, it is recommended that a discussion be undertaken to determine the specific value for the new platform height to be adopted in the TSI.

5.3.2 Individual Member States will need to calculate platform offsets required for the new floor height based on the type, radius and quality of track used on their line and the line speed, using the guidance in the Infrastructure TSI and BSEN15273-(Parts 1 – 3):2013.

5.3.3 As with existing rolling stock design, a focus will be needed in future designs to ensure that the gap between the train and the platform does not increases or decreases unacceptably with respect to different curvature of track to verify that wheelchair accessibility and stepping distances can be achieved under all necessary scenarios.

6 List of acronyms

Acronym	Meaning
ARL	Above Rail Level
DfT	Department for Transport, UK Government
ERA	European Railway Agency
EU	European Union
HS2 Ltd	High Speed Two Limited
HSR	High Speed Railway
PRM	Persons with Reduced Mobility
PTI	Platform Train Interface
ROGs	Railways and Other Guided Transport Systems (Safety) Regulations
RSSB	Rail Safety and Standards Board Ltd
TSI	Technical Specification for Interoperability
UCL	University College London

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8 Appendix A: Commission Directive 2013/9/EU

12.3.2013 EN Official Journal of the European Union L 68/55

DIRECTIVES

COMMISSION DIRECTIVE 2013/9/EU

of 11 March 2013

amending Annex III to Directive 2008/57/EC of the European Parliament and of the Council on the interoperability of the rail system within the Community

(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 Article 30(3) thereof,

Whereas:

(1) Measures designed to amend non-essential elements of Directive 2008/57/EC and relating to the adaptation of Annexes II to IX to that Directive are to be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 29(4) of Directive 2008/57/EC.

(2) The United Nations Convention on the Rights of Persons with Disabilities, to which the European Union is a party ([2]), establishes, in Article 3, accessibility as one of its general principles and requires, in Article 9, that States Parties take appropriate measures to ensure to persons with disabilities access on an equal basis with others. These measures shall include the identification and elimination of obstacles and barriers to accessibility and shall apply, inter alia, to transportation. In accordance with Article 216(2) TFEU, agreements concluded by the Union are binding upon the institutions of the Union and on its Member States, and Directive 2008/57/EC — as an instrument of European Union secondary legislation — is subject to the obligations deriving from the Convention.

(3) Regulation (EC) No 1371/2007 of the European Parliament and of the Council of 23 October 2007 on rail passengers' rights and obligations ([3]) states in recital 10 that disabled persons and persons with reduced mobility have the same right as all other citizens to free movement, freedom of choice and non-discrimination and should have opportunities for rail travel comparable to those of other citizens. Article 21 of the Regulation requires railway undertakings and station managers to ensure, through compliance with the TSI for persons with reduced mobility, that stations, platforms, rolling stock and other facilities are accessible to disabled persons and persons with reduced mobility.

(4) An adaptation of Annex III to Directive 2008/57/EC is necessary in order to include therein an explicit reference to accessibility. Accessibility is an essential requirement that is both a general requirement for the interoperability of the rail system and applies specifically to the infrastructure, rolling stock, operations and telematics applications for passengers' subsystems. Annex III to Directive 2008/57/EC should therefore be amended accordingly.

(5) The measures provided for in this Directive do not in any way affect the principle of gradual implementation set out in Directive 2008/57/EC, notably that target subsystems indicated in a TSI may be obtained gradually within a reasonable timescale and that each TSI should indicate an implementation strategy in order to make a gradual transition from the existing situation to the final situation in which compliance with the TSI will be the norm.

(6) The measures provided for in this Directive are consistent with an approach to achieving access on an equal basis by applying technical solutions or operational measures or both.

(7) The measures provided for in this Directive are in accordance with the opinion of the Committee established pursuant to Article 29(1) of Directive 2008/57/EC,

HAS ADOPTED THIS DIRECTIVE:

Article 1

Annex III to Directive 2008/57/EC, which sets out Essential Requirements, is hereby amended as follows:

([1]) OJ L 191, 18.7.2008, p. 1.
([2]) Council Decision 2010/48/EC of 26 November 2009 concerning the conclusion, by the European Community, of the United Nations Convention on the Rights of Persons with Disabilities (OJ L 23, 27.1.2010, p. 35).
([3]) OJ L 315, 3.12.2007, p. 14.

L 68/56 EN Official Journal of the European Union 12.3.2013

(1) the following paragraphs shall be added to Section 1:

'1.6. *Accessibility*

1.6.1. The "infrastructure" and "rolling stock" subsystems must be accessible to persons with disabilities and persons with reduced mobility in order to ensure access on an equal basis with others by way of the prevention or removal of barriers, and by way of other appropriate measures. This shall include the design, construction, renewal, upgrade, maintenance and operation of the relevant parts of the subsystems to which the public has access.

1.6.2. The "operations" and "telematics applications for passengers" subsystems must provide for the necessary functionality required to facilitate access to persons with disabilities and persons with reduced mobility on an equal basis with others by way of the prevention or removal of barriers, and by way of other appropriate measures.';

(2) the following paragraph shall be added to subparagraph 1 of Section 2:

'2.1.2. Accessibility

2.1.2.1. Infrastructure subsystems to which the public has access must be accessible to persons with disabilities and persons with reduced mobility in accordance with 1.6.';

(3) the following paragraph shall be added to subparagraph 4 of Section 2:

'2.4.5. Accessibility

2.4.5.1. Rolling stock subsystems to which the public has access must be accessible to persons with disabilities and persons with reduced mobility in accordance with 1.6.';

(4) the following paragraph shall be added to subparagraph 6 of Section 2:

'2.6.4. Accessibility

2.6.4.1. Appropriate steps must be taken to ensure that operating rules provide for the necessary functionality required to ensure accessibility for persons with disabilities and persons with reduced mobility.';

(5) the following paragraph shall be added to subparagraph 7 of Section 2:

'2.7.5. Accessibility

2.7.5.1. Appropriate steps must be taken to ensure that telematics applications for passengers subsystems provide for the necessary functionality required to ensure accessibility for persons with disabilities and persons with reduced mobility.'

Article 2

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 1 January 2014 at the latest. They shall forthwith communicate to the Commission the text of those provisions.

When Member States adopt those provisions, they shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication. Member States shall determine how such reference is to be made.

2. Member States shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive.

3. The obligations for transposition and implementation of this Directive shall not apply to the Republic of Cyprus and the Republic of Malta for as long as no railway system is established within their territories.

Article 3

This Directive shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

Article 4

This Directive is addressed to the Member States.

Done at Brussels, 11 March 2013.

For the Commission
The President
José Manuel BARROSO

9 Appendix B: The PTI gap and step

9.1.1 This appendix presents the literature research on the gap and step wheelchair users can independently traverse at the PTI.

9.1.2 It is not possible to have the train floor completely flush with the platform, with no gap (horizontal distance) or step (vertical distance). This is due to:

- limitations imposed on fixed train-borne steps by the vehicle gauge;
- possible further constraints imposed on deployable steps/bridging plates by space requirements for door opening;
- different trains having different floor heights; and
- variation in train floor height due to position on track, suspension movement, track tolerance and other variables.

9.1.3 Therefore, it is important to define the maximum gap and step that can be present in a level access PTI.

The following terminology is used:

V = vertical step height

H = horizontal gap distance

9.1.4 Table 3 presents a summary of the findings. Sources 4 and 5 are most similar to the scenario HS2 Ltd wish to create (see Section 3.1). They also fall within the parameters set by the PRM TSI as requiring no additional boarding aids and London Underground as most accessible parts of their network. Hence 50 mm has been selected as the maximum step and gap requirement for level access.

Table 3 Summary of maximum step/gap for wheelchair users literature research

ID	AREA/SOURCE	SCENARIO DESCRIPTION	MAX "V" (mm)	MAX "H" (mm)
1	PRM TSI	No additional boarding aids required	50	75
2	London Underground	Most accessible parts of the network	50	85
3	UK Gov "Inclusive Mobility" (2005)	Lift stop accuracy	10	20
4	Accessibility to public transport: a best practice guide, New Zealand (2010)	Wheelchair users can board independent of assistance or additional boarding aids	50	50
5	Barrierefreier ÖPNV in Deutschland / Barrier-free Public Transport in Germany	Wheelchair users can board independent of assistance or additional boarding aids	50	50

9.1.5 PRM TSI: In the PRM TSI it is stated that boarding aids are not required when V < 50mm and H <75 mm:

> 4.1.2.21. Boarding aids for passengers using wheelchairs
>
> 4.1.2.21.1. Subsystem requirements
>
> When a platform in a station that has obstacle free access routes in accordance with 4.1.2.3.1 is intended to receive trains stopping in normal operation with wheelchair-compatible doorway, a boarding aid shall be provided to be used between that doorway and the platform to allow a passenger in a wheelchair to board or alight,
>
> — unless it is demonstrated that the gap between the edge of the door sill of that doorway and the edge of the platform is not more than 75 mm measured horizontally and not more than 50 mm measured vertically;
>
> and
>
> — unless there is a station stop within 30 km, on the same route, provided with boarding aids.

9.1.6 London Underground: London Underground's "most accessible" category defines H and V as V<50 mm and H<85mm

http://www.tfl.gov.uk/cdn/static/cms/documents/step-free-tube-guide-map.pdf

> **Step**
> The step between the platform and the train is shown by the following symbols:
>
> 0 - 50mm (0 - 2 inches)
> 51 - 120mm (2 - 4.7 inches)
> Over 121mm (4.7 inches)
>
> **Gap**
> The gap between the platform and the train is shown by the following letters:
>
> A 0 - 85mm (0 - 3.3 inches)
> B 86 - 180mm (3.3 -7 inches)
> C Over 181mm (7 inches)

9.1.7 UK Gov "Inclusive Mobility" document (2005)

https://www.gov.uk/government/publications/inclusive-mobility

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3695/inclusive-mobility.pdf

For lift stop accuracy: H<20mm and V<10mm

The stopping accuracy of a lift is important because, if inaccurate, it could prevent a wheelchair user accessing the lift or trip an ambulant user. The maximum vertical distance should be **10mm** and any horizontal gap should be kept to **20mm** or less.

9.1.8 Accessibility to public transport: a best practice guide, Pinnacle Research & Policy Ltd, Wellington, New Zealand (October 2010) . This information is a result of the 3 year study COST 335 completed in 1999, in which 17 COST countries participated.

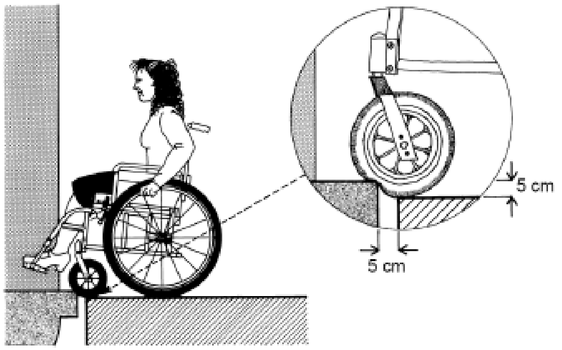
http://www.pinnacleresearch.co.nz/research/audit/PTaudit_PracticeGuide2010.pdf

H< 50 mm and V < 50mm

B7.4 Horizontal and vertical gaps, ramps and steps

The recommended horizontal and vertical gaps between the platform and carriage for wheelchair users are illustrated in figure 21B.

Figure 21B Illustration of vertical and horizontal gaps between platform and train carriage (source: COST 335 1999)



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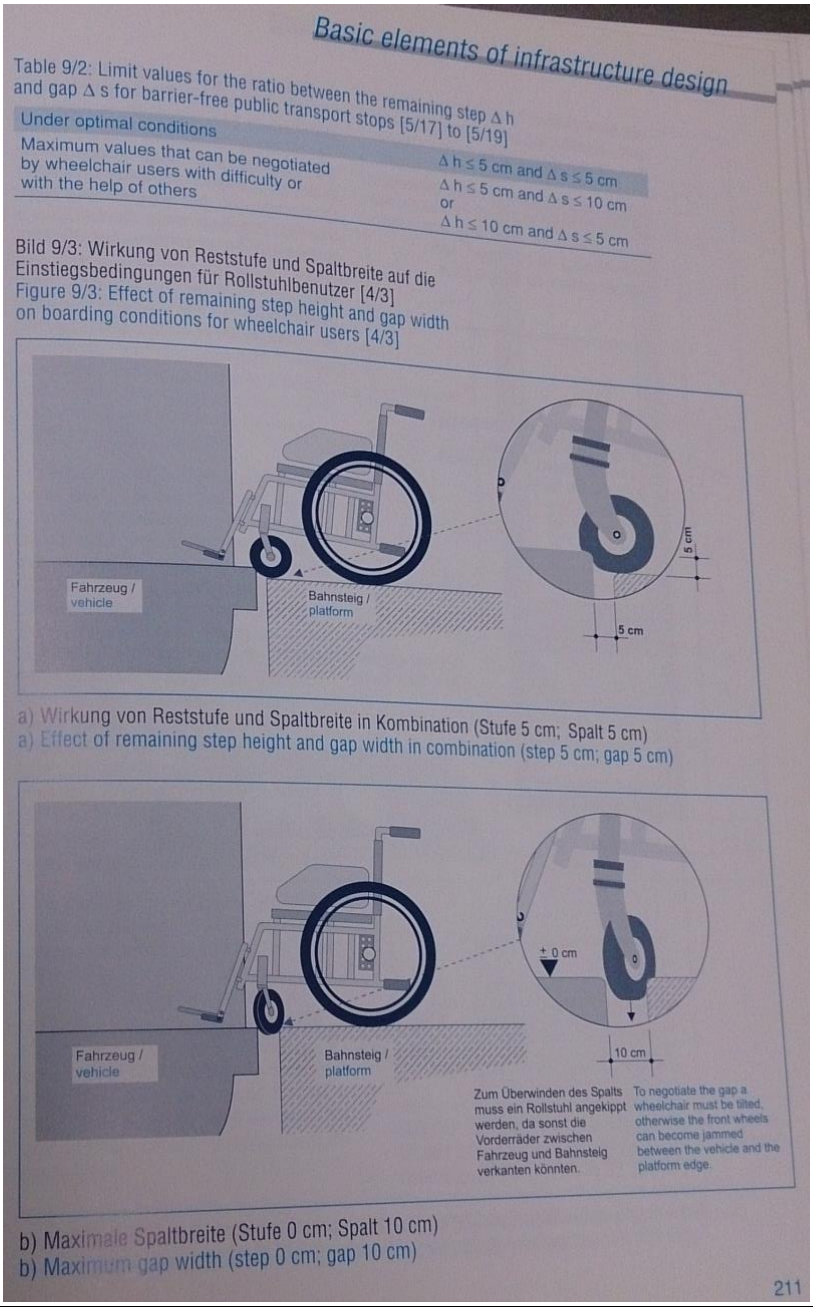

Basic elements of infrastructure design

Table 9/2: Limit values for the ratio between the remaining step Δ h and gap Δ s for barrier-free public transport stops [5/17] to [5/19]

Under optimal conditions	Δ h ≤ 5 cm and Δ s ≤ 5 cm
Maximum values that can be negotiated by wheelchair users with difficulty or with the help of others	Δ h ≤ 5 cm and Δ s ≤ 10 cm or Δ h ≤ 10 cm and Δ s ≤ 5 cm

Bild 9/3: Wirkung von Reststufe und Spaltbreite auf die Einstiegsbedingungen für Rollstuhlbenutzer [4/3]
Figure 9/3: Effect of remaining step height and gap width on boarding conditions for wheelchair users [4/3]

a) Wirkung von Reststufe und Spaltbreite in Kombination (Stufe 5 cm; Spalt 5 cm)
a) Effect of remaining step height and gap width in combination (step 5 cm; gap 5 cm)

b) Maximale Spaltbreite (Stufe 0 cm; Spalt 10 cm)
b) Maximum gap width (step 0 cm; gap 10 cm)

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10 Appendix C: Effect of level access in comparison to non-level access

10.1 Introduction

10.1.1 This appendix provides further detail and evidence on the implications that level access would have for different aspects of the railway and the service it will provide.

10.2 Accessibility and inclusivity

10.2.1 HS2 Ltd is committed to an inclusive design policy and to providing a service that can be used safely, independently, easily and with dignity by everyone. Further information can be found in the "Inclusive Design Policy" information paper.

10.2.2 The following principles of inclusive design will be used and promoted:

- Place people at the heart of the design process,
- Acknowledge diversity and difference,
- Offer choice where a single design solution cannot accommodate all users,
- Provide for flexibility in use,
- Provide buildings and environments that are convenient and enjoyable to use.

10.2.3 Non-level access is contrary to this inclusive design policy. Such a PTI provides a different experience to passengers depending on their ability to navigate a vertical gap between the platform and the train.

10.2.4 Step-free access is a design requirement across HS2 infrastructure. If it is not achieved at the PTI, the transition between the platform and the train will be the only step barrier in an HS2-passenger's journey.

10.3 Passenger experience

10.3.1 Passenger experience is a key factor in customer retention and growth in passenger numbers. As a minimum, the passenger experience must be sufficiently positive to attract passengers from other modes of transport.

10.3.2 HS2 Ltd aims to deliver a step change in passenger experience for the UK railway industry.

10.3.3 Level access allows those with mobility disabilities and difficulties to board and alight from the train independently.

10.3.4 If level access is not available, steps, ramps or lifts are necessary. If passengers are unable to use the steps they will need help from staff when using a ramp or lift.

10.3.5 The need to use ramps and lifts suppresses a passenger's independence and introduces stress and frustration to the experience of travelling.

10.3.6 Non-level access is particularly difficult for people who have mobility difficulties, but are not wheelchair users. For them, boarding or alighting using a ramp can be more difficult than using steps.

10.3.7 Passengers who cannot use step access easily or require the use of a ramp can feel as though they are an impediment to other passengers and staff, contributing to feelings of anxiety.

10.3.8 There is a weight limit on these ramps and lifts. Hence people who have wheelchairs that, combined with their own weight, exceed this limit cannot board the train.

10.3.9 Passengers may find ramps scary to use for a range of reasons, which have been investigated in an RSSB report (RSSB). The gradient of the ramp, the trust required in the operational staff to deploy the ramp correctly, and time pressure from other passengers may all contribute to a feeling of anxiety.

10.3.10 As described in an RSSB report (RSSB), incidents have occurred where the passenger being helped has been tipped out of their wheelchair onto the floor due to:

- the gradient of the ramp;
- a member of staff losing physical control of the process ; or
- the ramp being connected to the incorrect part of the train, or the wrong type of ramp being used – this may make the ramp unstable, or may even allow the doors to close and the train to move while the ramp is still attached.

10.3.11 Sometimes passengers do not receive the assistance they have booked and must attempt to board or alight by themselves or with the help of other passengers. This is hazardous and can lead to injury.

10.3.12 Non-level access inhibits people with reduced mobility. This does not only affect people with physical difficulties: passengers who are carrying luggage or travelling with small children may also find non-level PTIs difficult to negotiate.

10.3.13 When passengers are travelling with multiple items of heavy or bulky luggage, they are obliged to separate themselves from the luggage as they carry each item onto the train separately, potentially causing stress and anxiety. Similarly, passengers travelling with a child in a pushchair must remove the child from the pushchair and carry each on board separately.

10.3.14 Level access allows passengers to board with multiple items of luggage, or with children in pushchairs, in one go.

10.3.15 HS2 Ltd. commissioned an experimental and observational study (CCD Design & Ergonomics Ltd, 2014). CCD Design & Ergonomics Ltd and UCL undertook an experimental and observational study researching:

- the effect of level access, one step and two steps at the PTI on dwell time;
- the effect that passengers ages had on the dwell time across these three different PTIs; and
- the effect that different luggage loads and the proportion of passengers carrying luggage had on the dwell time across these three different PTIs.

10.3.16 The study also provided opportunities to observe the experience of individuals while they negotiated the platform-train interfaces. The full study is captured in the document "Passenger Boarding and Dwell Time Research Report" [C240-PBR-HF-REP-000-000004] in the HS2 Enterprise Bridge document library.

10.3.17 The study observed the following:

- Passengers with large luggage hesitated and felt uncertain about how to board when faced with step access at the PTI.
- Queues formed as people blocked the train door while they carried luggage or pushchairs across the PTI, or because they stopped on the platform after alighting (see Figure 5 and Figure 6).

Figure 5 Passengers stopping after alighting

Figure 6 Queue forming at Derby

- Older passengers frequently had difficulty and experienced discomfort alighting down steps (see Figure 7).

Figure 7 Elderly passenger helps partner to board before collecting luggage

- If a passenger was travelling with both luggage and a young child in a pushchair, they had to undergo the time-consuming process of removing the child from the pushchair and then boarding each item separately. At times, this left the passenger separated from the child and luggage (see Figure 8).

Figure 8 Passenger boarding at St Pancras with pushchair & luggage

10.4 Dwell time

10.4.1 On the HS2 network, consistent achievement of a two-minute dwell time will be critical for delivering railway capacity, the planned end-to-end run times and a reliable service for passengers. It is an important part of sustaining the likely revenue model for the railway.

10.4.2 The focus on dwell time is expected to increase in other HSR systems outside the UK, in response to demand for increased capacity and shorter overall journey times.

10.4.3 The two-minute dwell time is from wheel-stop to wheel-start. This leaves approximately 95 seconds for passengers to board and alight.

10.4.4 For a single station stop, each door on the train will need to accommodate a maximum of 26 passengers boarding and alighting – or 31 if a 20% allowance for variation is applied. This value is based on the following assumptions, made in a study of train parameters undertaken by Design Triangle (Design Triangle):

- there are 28 doors per side of a 400 m train; and
- one-third of the maximum number of passengers will board and another one-third will alight at Birmingham Interchange.

10.4.5 The research undertaken by CCD and UCL has shown that the dwell time is achievable under normal loading conditions across a level PTI and a one-step PTI. However, even a small difference in the demographics of boarding and alighting passengers (e.g. more elderly passengers) or in the individual luggage load (e.g. more suitcases) will result in the dwell time exceeding the maximum of 95 seconds. (CCD Design & Ergonomics Ltd, 2014)

10.4.6 Table 4 shows how many people can board and alight at the same time across the different types of PTI whilst carrying all types of luggage. It should be noted that other factors, such as the layout of the interior of the train, affect dwell time as well. These results show the effect of varying the level of access only. The relationship discovered will exist in combination with the other factors that affect dwell time.

Table 4 Passenger boarding/alighting numbers across different PTIs (CCD Design & Ergonomics Ltd, 2014)

TYPE OF PTI	TIME (seconds)	NUMBER OF PASSENGERS WHO CAN CROSS THE PTI
Level	95	33
One-step	95	27
Two-step	95	24

CONDITIONS: mixed boarding and alighting, with all luggage types carried:

46% Rucksack, 17% Small suitcase (wheeled airline-style hand luggage), 17% Large suitcase (large wheeled suitcase), 9% Pushchair (a weighted stroller style pushchair), 12% No luggage [sum 101% due to rounding]

10.4.7 Table 4 shows that only a level PTI meets the necessary passenger flow requirements for a two-minute dwell time. This is under the loading scenario described, which has been chosen as a typical scenario. The actual loading scenarios in each alighting/boarding event could be lighter or heavier.

10.4.8 The more luggage carried by passengers, the longer it took them to traverse the PTI. It was seen in the experimental studies that the increase was proportionally greater across PTIs that used steps. Increased luggage produced a greater delay when there were steps rather than level access.

10.4.9 The time taken varied with the age of passengers. If there are more passengers who are older, more time is required for boarding and alighting. However, this effect is not observed when there is level access: the age of the passengers has no effect on the boarding and alighting time in this case.

10.4.10 Given that the HS2 network will serve an aging population, level access having the characteristic of allowing people of all ages to board and alight with equivalent ease - would be a great advantage.

10.5 Staff and operations

10.5.1 If a passenger cannot travel independently, assistance is required from operational staff. This puts resource pressure on the service provider and time pressure on the individual staff member. It can lead to financial penalties:

- £163 is the average financial penalty for pre-booked assistance. (RSSB)
- £254 is the average financial penalty for un-booked assistance. (RSSB)

10.5.2 The service provider may also put additional onus on the passenger to book assistance in advance if the infrastructure does not allow for independent travel. This can become complex for the service providers to communicate between the necessary stations and teams, particularly if the passenger's journey takes in more than one service provider's station. The passenger may find it difficult to know which service provider to contact, as it is not always obvious.

10.5.3 If there is no level access, ramps or lifts need to be provided. This introduces an inspection and possibly a maintenance requirement. Ramps require secure storage, or else they can be a hazard on the platform. Ramps are vandalised and require replacement. Resourcing pressure can mean that vandalised or damaged ramps continue to be used which is unsafe both for passengers and members of staff. Ramps and lifts take time to deploy, use and stow. (RSSB)

10.5.4 The pressure to provide a satisfactory level of customer service sometimes pushes staff to undertake assistance that is beyond their physical capability – for example when the wheelchair and wheelchair user are too heavy for the member of staff to push up the ramp. Injuries sustained by staff in this manner may have a severe impact on their life, particularly if such an activity was not covered in the insurance agreement. The staff member providing assistance can experience anxiety and stress when they refuse assistance in such circumstances.

- £400,000 is the cost to the industry of injuries associated with boarding/alighting wheelchair users (using the DfT 2010 value of preventing a fatality). This figure was calculated in June 2012. (RSSB)

10.5.5 Staff members providing assistance feel obliged to assist the passenger and help them with their luggage, pets and/or children in one go, due to time constraints and pressure on the service. This presents a manual-handling hazard for the staff.

10.5.6 The passenger can also sustain injury if control of the wheelchair is lost during the assistance.

10.5.7 Ramps are normally designed to be used occasionally. In reality, they can be used several times a day for catering trollies. This leads to early deterioration of the ramp. Level access would negate the need for a ramp when taking catering trollies on and off the train. Figure 9 shows a catering trolley being loaded across a level-access PTI in Japan.

Figure 9 Trolley going on to level-access train (JR East Shinkansen, Japan)

10.5.8 Ramps and lifts may require manoeuvring space on the platform. This can place additional restriction on where the passenger can sit in the train and requires staff to rush to different points along the platform, as they frequently do not know the formation of the arriving train.

11 Appendix D: Level access solutions that are TSI-compliant

11.1 Introduction

11.1.1 This appendix discusses the options available for creating an accessible PTI when the train floor height and the platform height do not align.

11.2 Low-floor trains

11.2.1 There is a currently available high speed train which has a low floor height, corresponding to the TSI platform height of 760 mm.

11.2.2 Low-floor trains have floor heights that match the TSI platform heights. However, the following limitation would apply:

- Two of the cars must be locomotives, as a distributed traction system cannot be used due to lack of space under the train floor. This reduces passenger capacity. Whilst there are existing non-HSR trains that have distributed traction and low-floors, a product has not been proven for HSRs.
- Low floor heights are not appropriate for HS2, as the classic compatible trains also need to serve 915 mm platforms on the existing UK non-HSR network. There may also be a captive fleet which serves only the high speed parts of the network and does not call at 915 mm platforms.
- This limits the options for procuring rolling stock.

11.3 Double-deck trains

11.3.1 Double-deck trains have low floor heights on the lower deck, but the issues mentioned above would apply. Stairs between the two passenger seating levels also present a barrier to accessibility.

11.3.2 Double deck trains may not be able to run on a conventional network, as is the case in the UK. This prevents full utilisation of the potential service capability.

11.4 Platform humps

11.4.1 Parts of the platform can be raised into a hump shape, so that the top of each hump matches the floor height of the train. Platform humps have been used on infrastructure in two ways:

- on UK classic network infrastructure to decrease the vertical step between the train floor and the platform edge but not providing level access
- on the UK London Underground network to provide level access

11.4.2 Humps have been used to provide level access where there is a small vertical difference between platform and the train floor (circa 200 mm). Humps are not appropriate for larger vertical height differences, such as the circa 500 mm difference present at a 760 mm platform.

11.4.3 Humps cannot be used on an interoperable railway, as the height of the platform edge would no longer be TSI-compliant.

11.4.4 The humps need to align with train doors. Compatibility is an issue when the platform is expected to receive different types of train. Humps improve the interface only at specific doorways and are specific to individual train types.

11.4.5 Humps can present a hazard and require physical effort. The hazards associated with ramps, as discussed in Sections 10.3 and 10.5, are also present when using humps.

11.5 Ramps or lifts (stored on platform or train)

11.5.1 Platform ramps and lifts (both manual and electric) that can be stored on the platform or on the train can facilitate access to the train for people with reduced mobility

11.5.2 There are concerns related to vandalism, injury, and resource demand when using ramps and lifts, see "Appendix C: Effect of level access in comparison to non-level access".

11.5.3 Ramps and lifts can only be used on level surfaces.

11.5.4 If a train-borne fixed boarding ramp cannot be stowed away, the train must be taken out of service.

11.6 Dedicated doorways

11.6.1 Dedicated doorways are doors on the train which have a lower floor in comparison to the other doors, providing level access to the platform. For example a train with a higher floor height than the platform could mostly have doors with step access and some dedicated doorways which are level to the platform. They could provide access to sections of the train with a lower floor height.

11.6.2 This limits the choice of trains. Additional doors introduce structural design difficulties and consume seating capacity.

11.6.3 The level-access parts of the saloon will need steps to the rest of the saloon, thus restricting PRMs. The passenger's choice of where to sit is severely limited and they may be prevented them from sitting with the people they are travelling with. The solution only really serves wheelchair users and does not address the needs of other PRMs.

11.6.4 Dedicated doorways would be incompatible with UK platform heights.

12 Appendix E: Interoperability

12.1 Introduction

12.1.1 If a third platform height is added to those allowed by the TSIs, there is the potential to introduce a barrier to interoperability. On the European high speed network, trains may need to serve three different platform heights when they travel across borders. In the UK, trains will need to operate both to high speed platforms and to the UK classic network platforms.

12.1.2 This section provides an assessment of compatibility for the potential combinations of train type and platform dimensions.

12.1.3 The GC gauge can be seen in Figure 10. Please see Section "Appendix F: Platform offset at a greater platform height" for information on the required platform offset at higher platform heights. For this section the standard offset for straight track on 1435 mm gauge is used, which is 1650 mm.

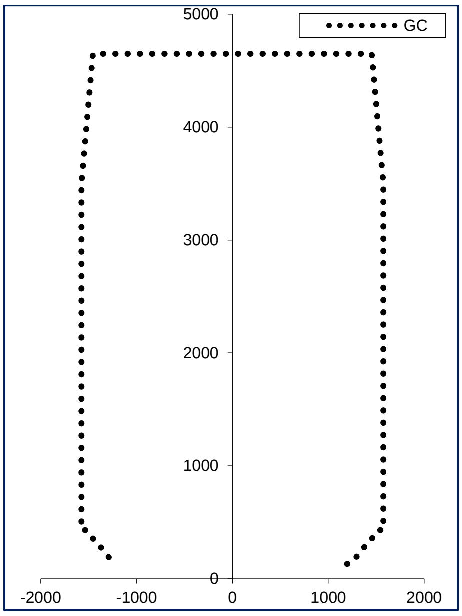

Figure 10 GC gauge

12.1.4 For the purposes of this section, it is assumed that the third platform height is a nominal 1200 mm ARL. There are four possible scenarios for trains operating to 1200 mm platform heights, which are discussed in this section. The classic compatible scenario is specific to the HS2 network.

12.1.5 Each scenario is examined to see whether it can accommodate the required minimum gap and step requirements specified in Section 3.1.

12.1.6 The horizontal gap and the vertical step are assessed against the following parameters:

12.1.7 The PRM TSI non-level requirements have been taken from the TSI for persons with reduced mobility, of which the relevant paragraphs are presented in "Appendix G: PTI related requirements from the PRM TSI". These can be considered to be the minimum requirement for all scenarios.

12.1.8 The wheelchair step/gap requirements are those discussed in Section 3.1 and "Appendix B: The PTI gap and step". These are the requirements associated with delivering true level access.

Table 5 Maximum gap and step definitions

	MAXIMUM VERTICAL GAP	MAXIMUM HORIZONTAL STEP
Wheelchair step/gap requirement	50 mm	50 mm
PRM TSI non-level step requirement	160 mm (step-down from platform) 230 mm (step-up from platform)	200 mm (if serving only one platform height) 380 mm (if serving more than one platform height)

12.2 Captive train

12.2.1 A train operating only on a HSR network with 1200mm platform heights.

12.2.2 Figure 11 shows the PTI for this train. The floor height of the train is higher than the platform:

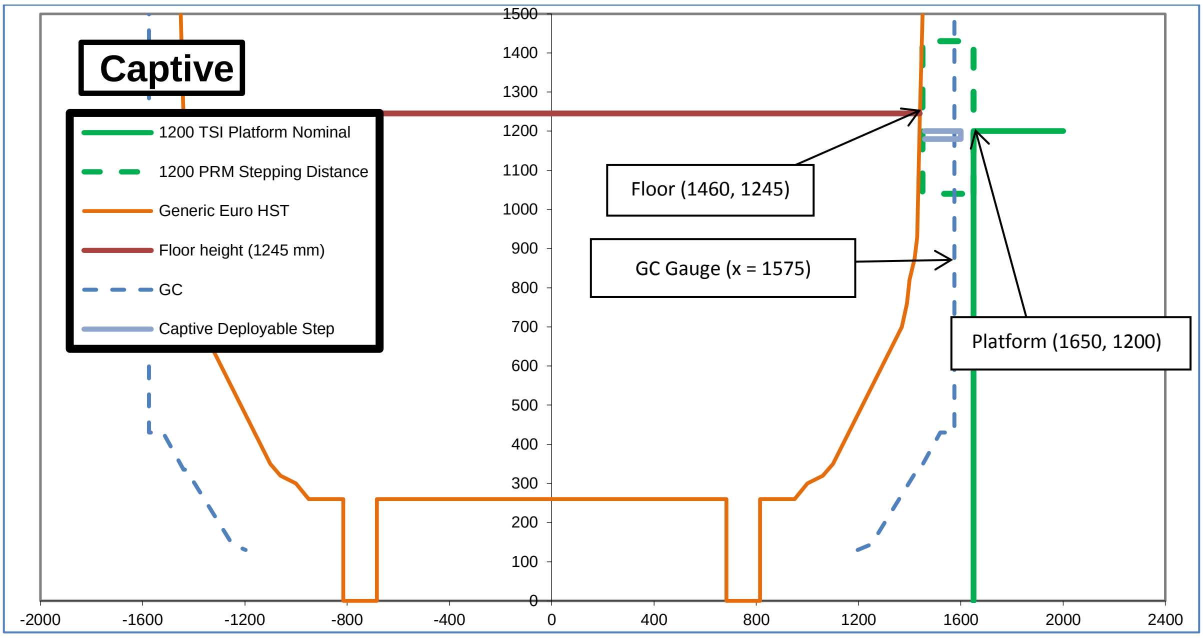

Figure 11 PTI for captive train: 1200 mm platform

12.2.3 A fixed step is not feasible in this scenario as it would exceed the structural gauge under dynamic conditions.

12.2.4 From Figure 11, the information in Table 6 can be ascertained:

Table 6 Gap and step for a Captive train at 1200 mm platform

TRAIN-BORNE INTERFACE	INFRASTRUCTURE-BORNE INTERFACE	VERTICAL GAP (mm)	HORIZONTAL GAP (mm)	CONFORM TO WHEELCHAIR STEP/GAP REQUIREMENT?	CONFORM TO PRM TSI STEP REQUIREMENT?
Train floor with no deployable step/bridging plate	Platform	45	190	YES for vertical NO for horizontal	YES
Deployable step/bridging plate (level with platform)	Platform	45	<50	YES	YES

12.2.5 A deployable step/bridging plate will be needed to meet the necessary requirements for wheelchair access and egress without boarding aids. However it is not needed for the PTI to conform to the PRM step distance requirements.

12.3 UK HS2 'classic compatible' train

12.3.1 HS2 train operating on existing UK main lines and the proposed high speed lines, this would serve platform heights of:

- 915 mm; and
- 1200 mm.

12.3.2 Figure 12 shows the PTI for this train at a 1200 mm platform. For the vehicle profile, the UK MKIII coach is used as an approximation for the (as yet unknown) HS2 Classic Compatible train profile. The train floor is higher than the platform and there is a large horizontal gap between the two:

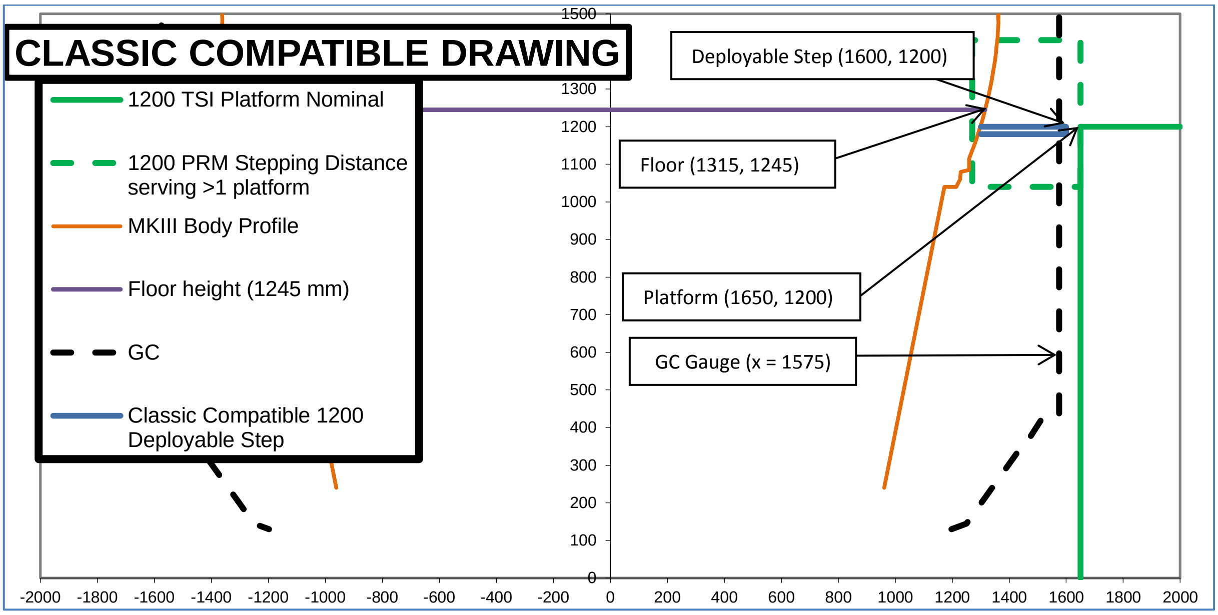

Figure 12 PTI for Classic Compatible train: 1200 mm platform

12.3.3 From Figure 12, the information in Table 7 can be ascertained:

Table 7. Gap and step for a Classic Compatible train at a 1200 mm platform

TRAIN-BORNE INTERFACE	INFRASTRUCTURE -BORNE INTERFACE	VERTICAL GAP (mm)	HORIZONTAL GAP (mm)	CONFORM TO WHEELCHAIR STEP/GAP REQUIREMENT?	CONFORM TO PRM TSI STEP REQUIREMENT?
Train floor with no deployable step/bridging plate	Platform	45	335	YES for vertical NO for horizontal	YES for vertical NO for horizontal
Train floor height and edge of deployable step/bridging plate (level with platform)	Platform	45	<50	YES	YES

12.3.4 Figure 13 shows the PTI for this train at a 915 mm platform with the UK offset of 730 mm from the inside rail, where the gauge is 1435 mm[2]. This means that the platform is 1447.5 mm from the centreline. The train floor is higher than the platform and there is a large horizontal gap between the two. It is recognised that level access is not achievable at the UK classic platforms due to them being so much lower than HSR train floor heights (approximately 280 mm lower). A TSI-compliant and RGS stepping distance-compliant, non-level solution is required.

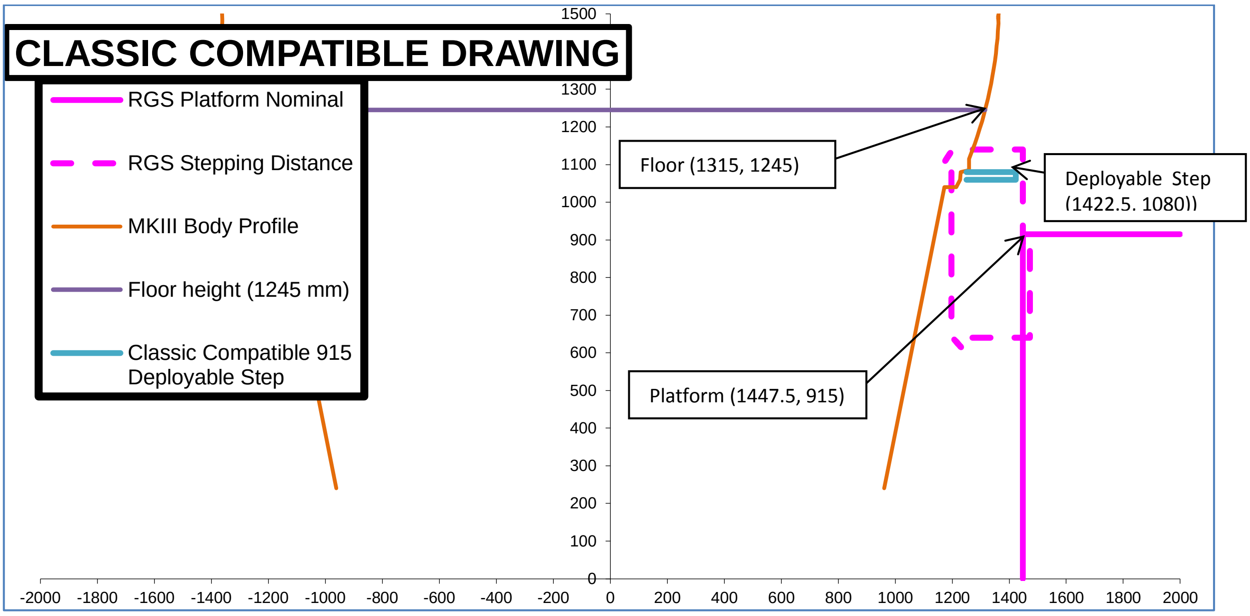

Figure 13 PTI for Classic Compatible train: 915 mm platform

12.3.5 From Figure 13, the information in Table 8 can be ascertained:

Table 8 Gap and step for a Classic Compatible train at a 915 mm platform

TRAIN-BORNE INTERFACE	INFRASTRUCTURE -BORNE INTERFACE	VERTICAL GAP (mm)	HORIZONTAL GAP (mm)	CONFORM TO WHEELCHAIR STEP/GAP REQUIREMENT?	CONFORM TO PRM TSI STEP REQUIREMENT?
Train floor	Platform	330	132.5	NO	NO for vertical YES for horizontal
Deployable step/bridging plate (halfway between floor and platform)	Platform	165	<50	NO for vertical YES for horizontal	YES

[2] Please see [Network Rail "Track Design Handbook" NR/L2/TRK/2049 ISSUE 12], [ROGS GC/RT5212 "Requirements for defining & maintaining clearances] and [ROG GI/RT/7016 Interface between station platforms, track and trains"]

12.3.6 A single-position deployable step/bridging plate serving both platform heights is not feasible, as it would:

- be outside the RGS stepping distance for the 915 mm platform if it were level with the 1200 mm platform;
- present an awkward interface at the 1200 mm platform if vertically placed to satisfy the requirements of both the 1200 mm platform and 915 mm platform. It would be a step down from the car floor and then back up to the 1200 mm platform.
- not be suitable for all classic network platforms, as there is a wide variation in UK classic network platform height

12.3.7 A PTI which conforms to the PRM step requirements is achievable. At a 1200 mm platform a deployable step/bridging plate is not necessary as the train floor lies within the step requirements. A deployable step would be required to serve classic platforms.

12.3.8 A deployable step which adjusts for the two platform heights would satisfy the wheelchair step and gap distance requirements and also provide level access at the 1200 mm platform height. This step or an alternative step would need to deploy at a different height to achieve the stepping distance requirements at classic platforms.

12.4 Existing European train

12.4.1 Existing European trains currently serve HSR networks in mainland Europe at platform heights of both 550 mm and 760 mm. If there were HSR networks using 1200 mm platforms, a Train Operating Company (TOC) may opt to extend their service onto the network. In this scenario, their train would serve platform heights of:

- 1200 mm
- 550 mm; and
- 760 mm

12.4.2 This section looks at how existing European HSR trains that are already in service could serve platform heights of 1200 mm.

12.4.3 Existing European trains have an internal step and use deployable steps to create a PTI that conforms to the PRM TSI step requirements.

12.4.4 Figure 14 shows the PTI for this train. An internal step of arbitrary dimensions is shown, but it should be noted that it could vary in height and fall within the stepping distance boundaries for the 1200 mm platform or 760 mm platform. However it could not satisfy both.

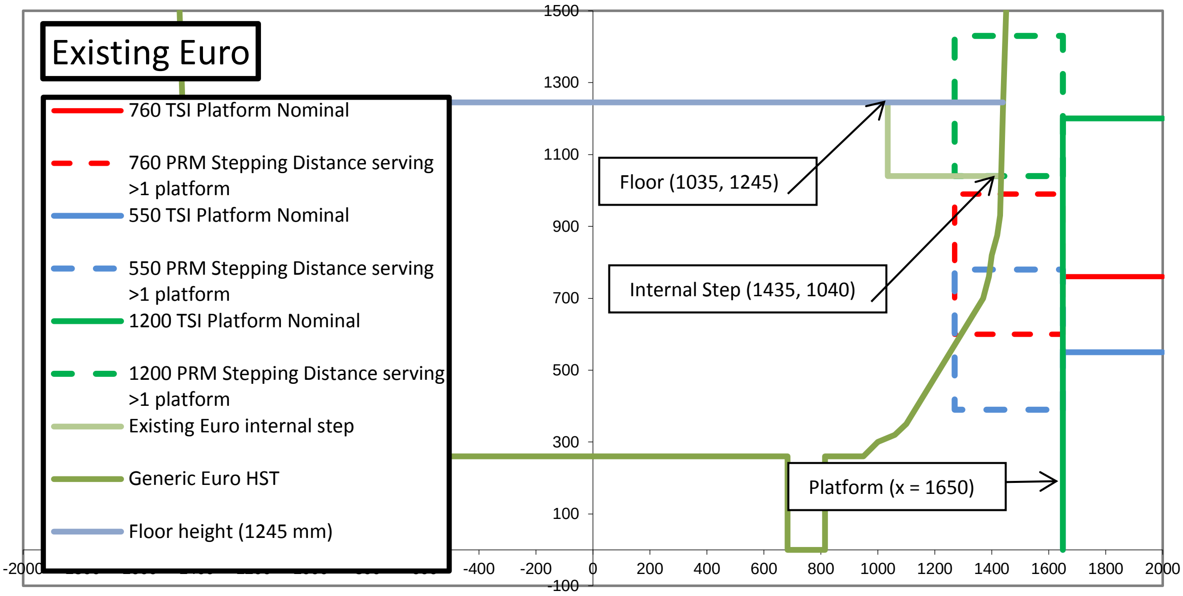

Figure 14 All possible PTIs for Existing Euro train

12.4.5 From Figure 14, the information in Table 9 can be ascertained:

Table 9 Gap and step for an existing European train at a 1200 mm platform

TRAIN-BORNE INTERFACE	INFRASTRUCTURE-BORNE INTERFACE	VERTICAL GAP (mm)	HORIZONTAL GAP (mm)	CONFORM TO WHEELCHAIR STEP/GAP REQUIREMENT?	CONFORM TO PRM TSI STEP REQUIREMENT?
Train floor	1200 mm platform	45	615	YES for vertical NO for horizontal	No
Train floor internal step	1200 mm platform	-160	215	NO	YES

12.4.6 An existing European train could comply with the TSI stepping distance requirements and serve all three platform heights depending on the exact dimensions of the internal step. Otherwise, a modification could be installed to fill-in the internal step. This could take the form of:

- an automatic cover;
- a manual cover deployed by operational staff:
- A semi-permanent modification (depending on the operational flexibility needed)

Further discussion with rolling stock manufacturers is necessary if it is deemed necessary for existing trains to provide compatibility to all three platform heights. However it should be noted that it is feasible that existing European trains could serve a new high platform height mandated by the TSIs.

12.5 New European train

12.5.1 A new European train serving mainland Europe would serve platform heights of:

- 1200 mm;
- 550 mm; and
- 760 mm.

12.5.2 Figure 15 shows the PTI for this train. The stepping distance requirements for the 1200 mm platform do not overlap at all with the stepping distance requirements for the 760 mm and 550 mm platforms.

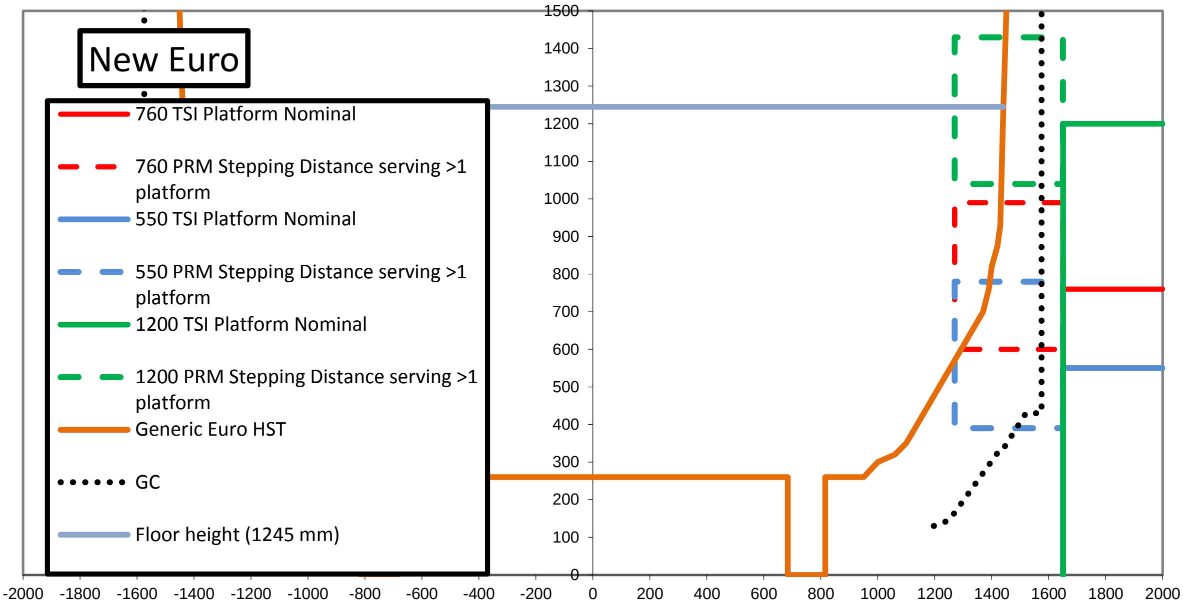

Figure 15 All possible PTIs for New Euro train

12.5.3 A single deployable step would not be able to conform to the stepping distance requirements of all three platform heights.

12.5.4 A single deployable step of 220 mm height, could allow a train to serve the 1200 mm platform (without the step deployed) and the 760 mm platform (with the step deployed), as shown in Figure 16:

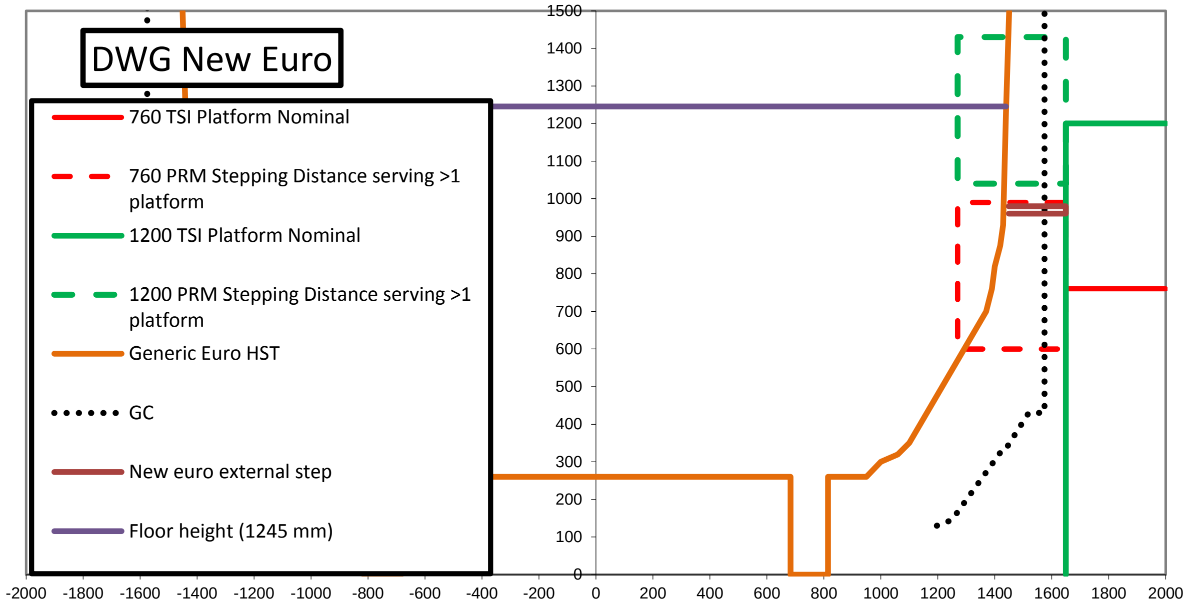

Figure 16 Single deployable step on a new European HSR train at 1200 mm and 760 mm platform

12.5.5 A combination of retractable and fixed internal and external steps could be designed so that a new European train could serve all three platform heights whilst providing level access at the 1200 mm platform height. The Nooriro train, which operates in South Korea, uses automatic retractable steps (Figure 17).

Figure 17 Hitachi Nooriro retractable steps

12.5.6 It is technically and operationally feasible for a train to serve all three platform heights. Further development would be needed to find an optimised solution should this scenario be required in the future.

12.6 Gaps on curves

12.6.1 On curved track the offset of the platform is greater and the gap between the vehicle and the platform increases or decreases.

12.6.2 This section takes a hypothetical conventional train and an articulated train and examines the difference in the horizontal gap between straight track and curved track (1000m).

12.6.3 An articulated train with the parameters in Table 10 will have (see Figure 18 for schematic):

- a gap INCREASE of 23 mm on the OUTSIDE of the curve on 1000 m radius track (in comparison to straight track)
- a gap DECREASE of 16 mm on the INSIDE of the curve on 1000 m radius track (in comparison to straight track)

Table 10 Articulated train parameters

Parameter	Value (m)
Unit Length	17
Unit Width	3
Bogie centre distance from unit centre	9
Door centre distance from unit centre	6

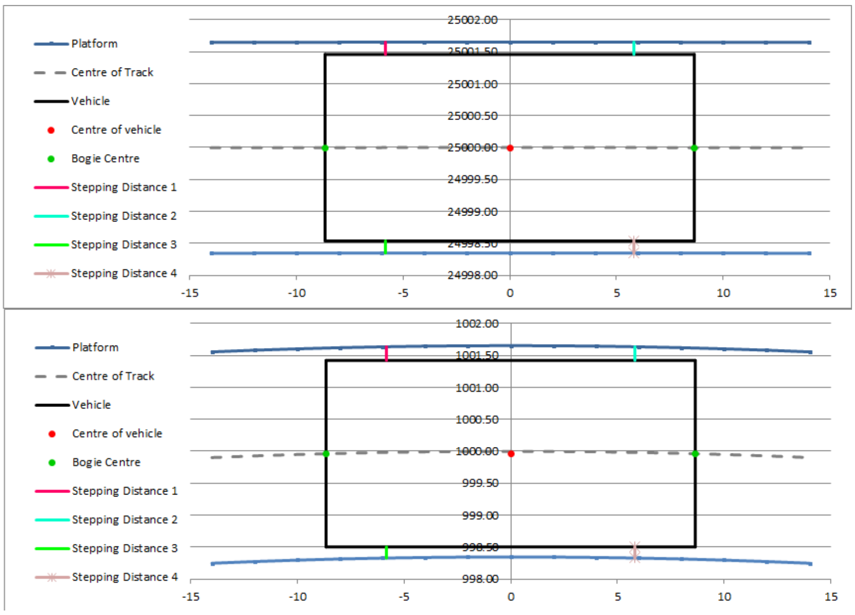

Figure 18 Articulated train on straight and curved track

12.6.4 A conventional train with the parameters in Table 11 will have(see Figure 19 for schematic):

- a gap DECREASE of 21 mm on the OUTSIDE of the curve on 1000 m radius track (in comparison to straight track)
- a gap INCREASE of 28 mm on the INSIDE of the curve on 1000 m radius track (in comparison to straight track)

Table 11 Conventional train parameters

Parameter	Value (m)
Unit Length	17
Unit Width	3
Bogie centre distance from unit centre	9
Door centre distance from unit centre	6

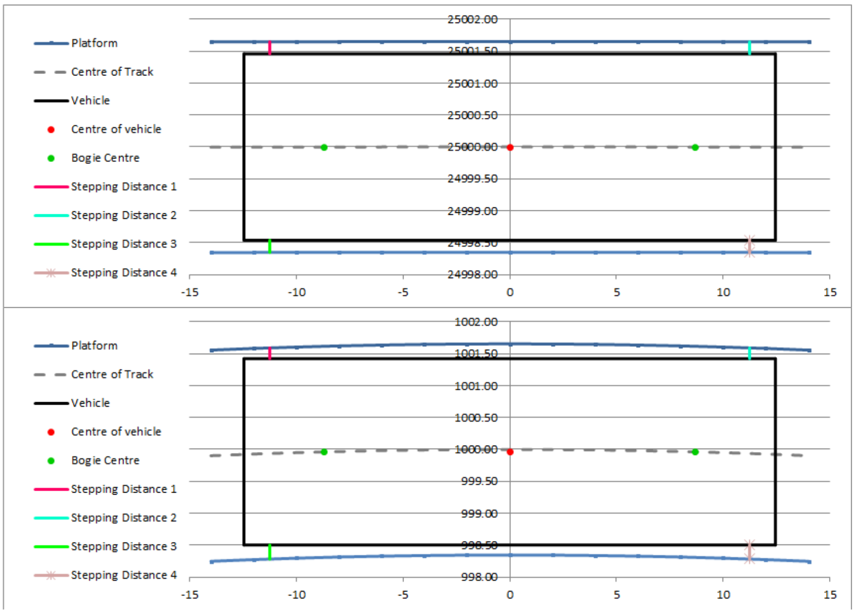

Figure 19 Conventional train on straight and curved track

12.6.5 An increase in the gap may bring the door step outside of the definition of level access. A decrease in the gap may bring the door step in breach of the gauge requirements. These increases and decreases can be managed by:

- Careful consideration of the location and size of the step(s) at the PTI
- Reducing the number of curves or making them larger
- Using platform-based devices to bridge the gap at the PTI
- Special process at locations where tight radii cannot be avoided

13 Appendix F: Platform offset at a greater platform height

13.1 b_q, semi-width of the platform installation

13.1.1 BSEN15273-(1, 2, 3):2013 gives guidance on how to calculate platform offset, i.e. b_q, semi-width of the platform installation.

13.1.2 The G1 (the GC gauge is G1 below 3220 mm)[3] kinematic gauge can be seen in Figure 20. It should be noted that above 1170 mm, the profile extends out a further 25 mm each side. Hence a platform offset will have to accommodate this:

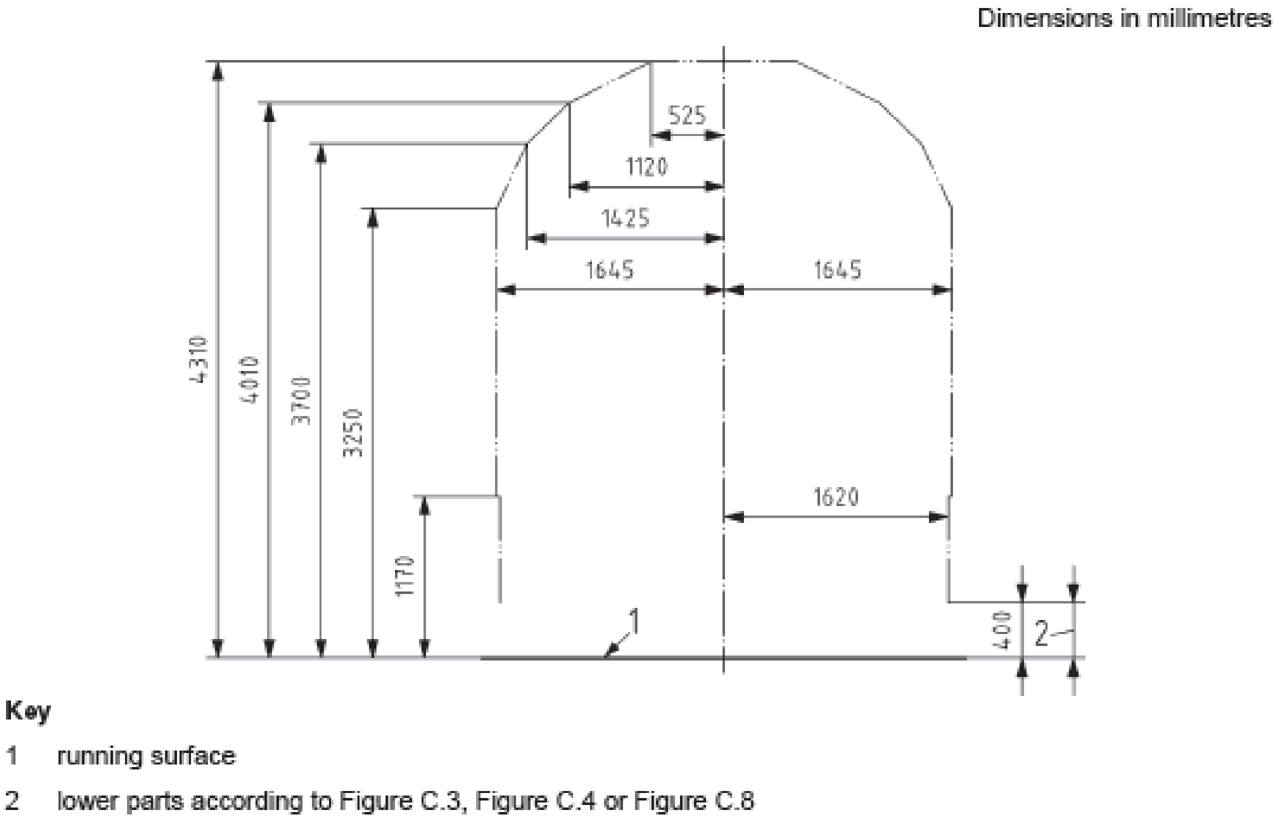

Figure 20 Reference profile of kinematic gauge G1. From Annex C BSEN15273-1:2013

13.1.3 HS2 Ltd calculated b_q for straight track on ballast, running speeds >80kph, "Other tracks" (as opposed to "very good quality tracks"). The following formula was used:

For kinematic gauge: $b_q \geq b_{CR_{cin}} + [qs_i \text{ or } qs_a] + \sum_{2_{cin}}$

[3] See Figure B.5 in Appendix B BSEN15273-1:2013

Where:

- b_q is semi-width of the platform installation;
- $b_{CR_{cin}}$ is semi-width of the kinematic reference profile;
- qs_i *or* qs_a is "Displacement due to the quasi-static roll taken into account by the infrastructure on the inside or outside of the curve"; and
- $\sum_{2_{cin}}$ is Root square of sum of squares of M_1, mandatory allowance, and M_2, infrastructure maintenance allowance. (not including M_3, Additional infrastructure allowance)

For simplification, and as we do not know which rolling stock will be used, qs_i *or* qs_a has been assumed as zero. Values for the constants for the calculation of $\sum_{2_{cin}}$ were taken from Table B.1 "Coefficients of the allowances recommended for the kinematic gauge" in Appendix B of BSEN15273-3:2013. The roll height centre was assumed to be 760 mm from the running rail, as BSEN15273:2013 advises that roll can be ignored as it is usually around the platform height.

13.2 $\sum_2$, probabilistic sum of tolerances

13.2.1 $\sum_j$ is the sum of the tolerances that corresponds to M_j:

M_1 = grouping of parameters taken into account for the "**structure verification limit gauge**" that ensures safety of operations during control with the parameters measured on-site. Includes widening and certain allowances

M_2 = grouping of parameters taken into account for the "**structure installation limit gauge**" that ensures clearance is maintained between maintenance and checking operations. Includes displacements and wear

M_3 = grouping of parameters taken into account for the "**structure installation nominal gauge**" that ensures clearance is maintained in practically all conditions and allows more possible uses such as for special consignments, temporary structures.

13.2.2 $\sum_2$ *can* be found using the following formula (from BSEN15273-3 annexe A.2.2 page 69):

$$\Sigma_{2,i} = Max\left[\Sigma'_{2,i} + K(D - D_0); \Sigma''_2; (\Sigma'_{2,a} - K.I_0)\right] - qs_i$$

$$\Sigma_{2,a} = Max\left[\Sigma'_{2,a} + K(I - I_0); \Sigma''_2\right] - qs_a$$

Where:

$$K = \frac{s_0}{L}\left[h - h_{c0}\right]_{>0}$$

$$\Sigma'_{2,i/a} = k\sqrt{T_{voie}^2 + \left[\frac{T_D}{L}h + s_0\frac{T_D}{L}[h - h_{C0}]_{>0}\right]^2 + \left[\tan(T_{susp})[h - h_{C0}]_{>0}\right]^2 + \left[\tan(T_{charge})[h - h_{C0}]_{>0}\right]^2 + \left[\frac{s_0}{L}(T_{osc})[h - h_{C0}]_{>0}\right]^2}$$

$$\Sigma''_2 = k\sqrt{T_{voie}^2 + \left[\frac{T_D}{L}h\right]^2}$$

Where:

- $qs_{i/a}$: Displacement due to the quasi-static roll taken into account by the infrastructure outside the reference profile on the outside/inside of the curve
- D: Cant
- D_0: Fixed cant value taken into account by agreement between the rolling stock and the infrastructure with regard to the kinematic gauge
- I: Cant deficiency
- I_0: Fixed cant deficiency value taken into account by agreement between the rolling stock and the infrastructure with regard to the kinematic gauge
- s_0: Flexibility coefficient value taken into account in the agreement between the rolling stock and the infrastructure
- L: Standard distance between the centrelines of the rails of the same track
- h: Height in relation to the running surface
- h_{c0}: Value of h_c (Roll centre height) used for the agreement between the rolling stock and the infrastructure
- k: Factor of safety to take into account track irregularities
- T_{voie}: Transverse displacement of the track between two periods of maintenance
- T_D: Track crosslevel difference between two maintenance periods
- T_{susp}: Angle of dissymmetry, considered in □or for poor suspension adjustment
- T_{charge}: Angle of dissymmetry, considered in □or for poor load distribution
- T_{osc}: Crosslevel difference selected for calculation of oscillations caused by track irregularities

13.3 Platform offset: ballast, straight, >80 kph, “other tracks”

13.3.1 The value for $\sum 2_{cin}$ was found to be 30 mm (+3%) at 760 mm platform height. The width of the kinematic reference profile at this height is 1620 mm.

13.3.2 Hence b_q for straight track on ballast, running speeds >80kph, "Other tracks" (as opposed to "very good quality tracks") is ~ 1650 mm at 760 mm above the running rail.

13.3.3 This matches with the platform offset recommended by the Infrastructure TSI using the equation below, from statement 4.2.20.5:

$$\frac{\frac{Nominal\ distance\ L\ from\ the\ track}{centre\ parallel\ to\ the\ running\ plane}}{\frac{For\ platform\ edges\ positioned}{at\ the\ nominal\ heights\ (in\ mm)}} = 1650 + \frac{3250}{R} + \frac{g-1435}{2}$$

Where:

- R is the radius of the track, in metres; and
- g is the track gauge, in millimetres.

On a straight track with standard gauge 1435 mm this equation also gives 1650 mm platform offset.

13.3.4 This similarity validates the assumptions, variables and coefficients used and the method was taken forward confidently to assess the platform offset for a 1200 mm platform height. Only the value for height above the running rail was changed in the calculation. This gave an increase of 6 mm on the platform offset, b_q, for 760 mm.

13.3.5 Hence a 1200 mm platform height would need to be offset a further (25 mm + 6mm), i.e. ~30 mm, than a 750 mm or 550 mm platform due to the increase in the kinematic gauge width and the increase in b_q.

13.3.6 If a high platform height was below 1170 mm it would only need to be offset a further 6 mm as the kinematic reference profile is not wider.

13.4 Platform offset: slab track, straight, >80 kph

13.4.1 In comparison to "ballast, straight track, > 80 kph, other tracks", if values for "slab, straight track, >80 kph" (no distinction is made between quality of track for slab track), $\sum_{2_{cin}}$ reduces from 30 mm (+3%) to 6 mm (1 s.f.). This is a reduction of ~25 mm.

13.4.2 Hence HS2 platforms could be closer to the track centreline, as they are using slab track.

13.5 Summary of approximate offsets

13.5.1 Table 12 gives the relevant values to find the platform offset for 2 track types and 2 platform heights, on straight track with a line speed >80 kph:

Table 12 Platform offset with two track types and two platform heights (values in mm) on straight track, with a line speed of >80 kph

	PLATFORM HEIGHT					
TRACK TYPE/CONDITION	**760 mm**			**1200 mm**		
	$\sum_2'$	$b_{CR_{cin}}$	b_q	$\sum_2'$	$b_{CR_{cin}}$	b_q
Ballast, "Other tracks"	31	1620	~1650	37	1645	~1680
Slab	7	1620	~1625	12	1645	~1655

14 Appendix G: PTI related requirements from the PRM TSI

14.1 Platform height

14.1.1 Below are the requirements from the "Persons of Reduced Mobility" TSI regarding platform height:

4.1.2.18. Platform height and offset

4.1.2.18.1. Platform height

For platforms on the Conventional Rail Network, two nominal values are permissible for platform height: 550 mm and 760 mm above the running surface. The tolerances on these dimensions shall be within –35 mm/+ 0 mm.

For platforms on the Conventional Rail Network where tramways (e.g. Stadtbahn or Tram-Train) are intended to stop, a nominal height of platform between 300 mm and 380 mm is permitted. The tolerances on these dimensions shall be within +/–20 mm.

In curves with a radius of less than 500 m, it is permitted for the platform height to be greater or less than those specified provided that the first useable step of the vehicle complies with figure 11 in clause 4.2.2.12.1.

14.2 Boarding aids

14.2.1 Below are the requirements from the "Persons of Reduced Mobility" TSI regarding boarding aids:

4.1.2.21. Boarding aids for passengers using wheelchairs

4.1.2.21.1. Subsystem requirements

When a platform in a station that has obstacle free access routes in accordance with 4.1.2.3.1 is intended to receive trains stopping in normal operation with wheelchair-compatible doorway, a boarding aid shall be provided to be used between that doorway and the platform to allow a passenger in a wheelchair to board or alight,

— unless it is demonstrated that the gap between the edge of the door sill of that doorway and the edge of the platform is not more than 75 mm measured horizontally and not more than 50 mm measured vertically;

and

— unless there is a station stop within 30 km, on the same route, provided with boarding aids.

The responsible Infrastructure Manager (or Station Manager(s) if they are the responsible entities) and Railway Undertaking shall agree the management of the boarding aid in line with Regulation (EC) No 1371/2007 of the European Parliament and Council on Rail Passengers' Rights and Obligations (1) in order to establish which party is responsible for provision of boarding aids. The Infrastructure Manager (or Station Manager(s)) and Railway Undertaking shall ensure that the division of responsibilities they agree is the most viable overall solution.

Such agreements shall define:

— the station platforms where a boarding aid has to be provided by the Infrastructure Manager or the Station Manager and the Rolling Stock for which it will be used,

— the station platforms where a boarding aid has to be provided by the Railway Undertaking and the Rolling Stock for which it will be used,

— the Rolling Stock where a boarding aid has to be provided by the Railway Undertaking and the station platform where it will be used,

— the specific rules for stopping the trains in order to comply with clause 4.1.2.19 (area for boarding aids for wheelchair users).

In its Safety Management System, the Railway Undertaking shall indicate what its obligations are according to such agreements, and how it intends to comply with them.

In its Safety Management System, the Infrastructure Manager shall indicate what its obligations are according to such agreements, and how it intends to comply with them.

In the paragraphs above, the Station Manager operating the platforms is considered as an Infrastructure Manager according to Directive 91/440/EC art 3: definition of Infrastructure and regulation 2598/70/EC.

If the result of the above is that all types of Rolling Stock stopping at the platform are equipped with boarding aids compatible with the platform, it is permissible for aids not to be provided at the platform.

The boarding aid shall fulfil the requirements of clause 4.1.2.21.2.If the wheelchair boarding position is predefined, the platform position(s) of the wheelchair accessible doorway(s) may be marked with the international symbol for the 'provision for the disabled or handicapped persons'. Such signs shall be in accordance with Annex N Clauses N.2 and N.4.

Ramps

An access ramp, whether manual or semi-automatic, to be operated by a member of staff, shall be made available whether stored on the station platform or on board.

The ramp shall fulfil the requirements of clause 4.1.2.21.2.

Platform lifts

If a platform lift is used, it shall comply with the requirements of clause 4.1.2.21.2.

14.3 Access/egress step requirements

14.3.1 The nose of a step shall be located within an envelope related to the platform position as specified by the PRM TSI (4.2.2.12.1):

Table 13 The surface of the envelope which the step should be within for trains stopping at 760 mm platform height only, shown in Figure 21. Note: An identical requirements exists for 550mm platform height.

	δh mm	δv+ mm	δv- mm
on a straight level track	200	230	160
on a track with a curve radius of 300 m	290	230	160

Table 14 The surface of the envelope which the step should be within for trains stopping at both platforms of height 760 mm and of height 550 mm, shown in Figure 21

	δh mm	δv+ mm	δv- mm
on a straight level track	380	230	160
on a track with a curve radius of 300 m	470	230	160

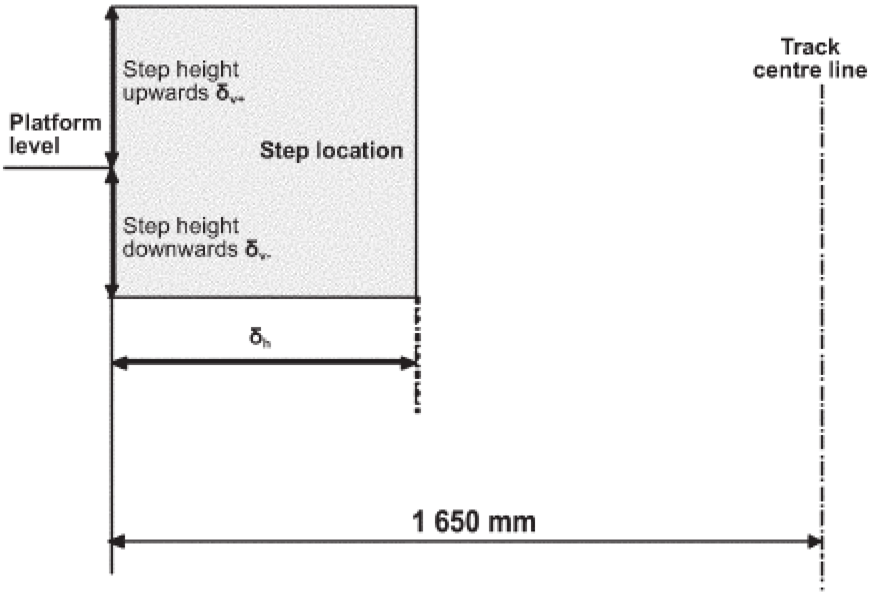

Figure 21 Diagram showing the meaning of the values in Table 13

14.3.2 The height and number of steps are dictated by the following in the PRM TSI:

4.2.2.12.2. Access/egress steps

All steps for access and egress shall be slip resistant and shall have an effective clear width as large as the doorway width.

Internal steps for external access shall have a maximum height of 200 mm and a minimum depth of 240 mm (going) between the vertical edges of the step. The rising height of each step shall be equal. The first and the last step shall be indicated by a contrasting band with a depth of 45 mm to 50 mm extending the full width of the steps on both the front and the top surfaces of the step nosing.

The height of each step may be increased to a maximum of 230 mm if it can be demonstrated that this achieves a reduction of one in the total number of steps required. (For example, if a vertical distance of 460 mm is to be traversed, it can be demonstrated that using steps of up to 230 mm reduces the number of steps required from 3 to 2).

An external access step, fixed or moveable, shall have a maximum height of 230 mm between steps and a minimum depth of 150 mm. If a step board is fitted and it is an extension of a door sill outside the vehicle, and there is no change in level between the step board and the floor of the vehicle, this shall not be considered to be a step for the purposes of this specification. A minimal *drop in level, with a maximum of 60 mm, between the floor surface of the vestibule and that of the exterior of the vehicle, used to guide and seal the door is also permissible and shall not be considered as a step.*

Access to the vestibule of the vehicle shall be achieved with a maximum of 4 steps of which one may be external.

14.3.3 Movable steps must meet the following requirements:

4.2.2.12.3.5. Specific requirements for moveable steps

A moveable step is a device integrated into the vehicle, fully automatic and activated in conjunction with the door opening/closing sequences.

It is permitted to use moveable steps, provided they meet the requirements related to the chosen construction gauge of the Rolling Stock, according to Annex C of the Freight Wagon TSI.

In the case of the moving step extending beyond that permitted by the gauging rules, the train shall be immobilised whilst the step is extended.

The extension of the moveable step shall be completed before the door opening permits the passengers to cross and conversely, removal of the step may only begin when the door opening no longer permits any crossing of PRM passengers.

15 Appendix H: PTI related requirements from the Infrastructure TSI

15.1.1 Below are the requirements from the "Persons of Reduced Mobility" TSI regarding platform height:

4.2.20.4 Platform height

Lines of category I, II and III

The nominal platform height above the running plane shall be either 550 mm or 760 mm, unless otherwise specified in section 7.3.

The tolerances perpendicular to the running surface with reference to the nominal relative positioning between track and platform are −30 mm/+ 0 mm

Note: Section 7.3 provides National Specific Cases. There is a National Specific Case for platform heights on the Great Britain rail network (allowing 915mm platform heights). Further, this GB specific height is applied with a GB specific platform offset of 730mm (from the adjacent rail) which would not be possible to adopt on HS2 due to the use of European "GC" structural gauge.