A Novel Railway Carriage Design

by John Kinghorn

As is well known, Britain pioneered railway technology in the nineteenth century. Being a pioneer can have disadvantages, though, as others learn from your experience and find ways of improving things. In particular it was discovered that railway rolling stock can be significantly bigger than was initially allowed for in Britain, even if it runs on exactly the same gauge of track. Since many British bridges and tunnels are the same as they were built a century and more ago, this remains a restricting legacy and the spaciousness of rolling stock on the national rail network usually compares unfavourably with vehicles in service in other countries.

Britain's need for 'special small trains' raises costs because the modest potential market restricts competition. I thought it might be an interesting exercise to see whether passenger rolling stock could be improved, using a concept that would cover a sufficiently wide range of applications to be worth the effort of designing a better product specifically for the British market. Here's what I came up with.

First the range of applications needs to be considered. Short distance trains with frequent stops need fewer facilities and should be lightweight: at the other end of the scale very high speed trains need more robust construction. Between those extremes, however, there is a wide range of services including commuter trains, long distance cross country, rural and inter city services which could use the same carriage structure if it were fitted out in different ways to meet specific requirements. This 'middle' range is the focus of my design, which is for non-tilting trains only. It is assumed that the extra costs of tilting would not be justified for the majority of these applications.

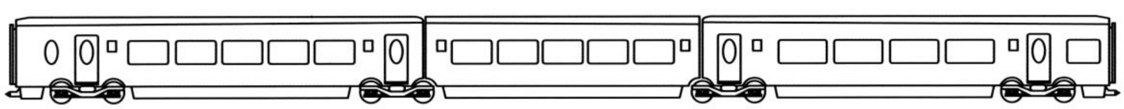
With a few exceptions most passenger coaches built in the last half century use the same kind of design, with a four wheel bogie near each end supporting a long carriage body. The tendency has been for coaches to get longer in an effort to reduce the cost per seat, typically from about 18m to 20, 23 and recently 26m. Unfortunately on a sharp curve the longer the coach the greater the overhang in the middle compared to the position of the track, so the narrower it may have to be to avoid hitting obstacles such as bridge piers. The alternative is to restrict long coaches to routes which have been specially cleared for them, which might cause difficulties preventing trains being diverted to other routes.

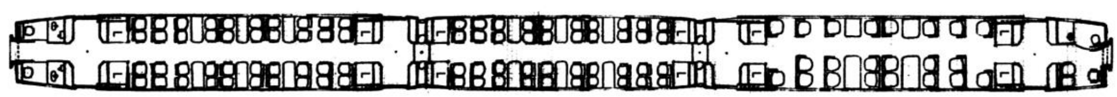
My solution to this problem is to consider a group of coaches 50m long, but instead of two conventional 25m vehicles have instead three shorter vehicle bodies in a partially articulated design. Since the three bodies are joined together and there are only couplers at the outer ends of the group, train lengths can only be altered in 50m steps; but this should be adequate in most cases. The three-unit 'triplet' still rides on four bogies, just the same as two conventional coaches, but the bogies are more evenly spaced. This means the unit can go round curves as well as a short coach body, so it can be wider and contribute to greater spaciousness inside. The outer two vehicles have the bogies, and the centre vehicle has none but is supported by the other two on ball-and-socket articulation joints just below floor level. There are other articulation joints near roof level to keep the centre vehicle upright.

The second fundamental change is to lower the floor to be the same level as the standard platform height (about 0.9m above rail level). This gives step-free access, not only avoiding the need for ramps to load wheelchairs and catering trolleys but also eliminating lifting and climbing hassles for everyone. Since the floor is lower than usual this creates additional headroom too, and entrance doors can be 2.0m high instead of the usual 1.8m, so there is no need for tall people to duck entering the train. Of course the floor has to be a little narrower than before, as it now needs to give sufficient clearance between platform edges, including the worst case of a convex platform on a sharp curve. This is fine in practice, though, as the critical area needing maximum width is between seating level and shoulder level higher up; bodies need the best achievable space but legs can make do with less.

Although there are advocates of smaller wheels for carriages, for this range of applications a top speed of 125 mph is essential and maybe up to 150 mph is desirable. It is considered that a rather conventional wheel diameter of about 0.9 m is probably most appropriate and this means the top of the wheel would be around floor level. Obviously, then, the wheels need to be recessed into the body somewhat, using the same kind of technique as found on a bus. Using an outside frame bogie means there is only the axle to be cleared in the centre of the vehicle, which allows a gangway at least 0.8 m wide in these positions allowing for movement due to curvature and dynamic clearances.

Since it is desirable to minimise the gap between the platform edge and train entrances, even on sharply curved platforms, all doors are immediately above bogies. The boarding area can extend outwards from the usual floor width here as the position of the track relative to the platform edge is tightly controlled and there is no need to allow for overhangs. There will be a small gap to give sufficient clearance allowing for movement tolerances, but the flat access is a great improvement over the current arrangement of two steps up. The vehicle structure looks like this:

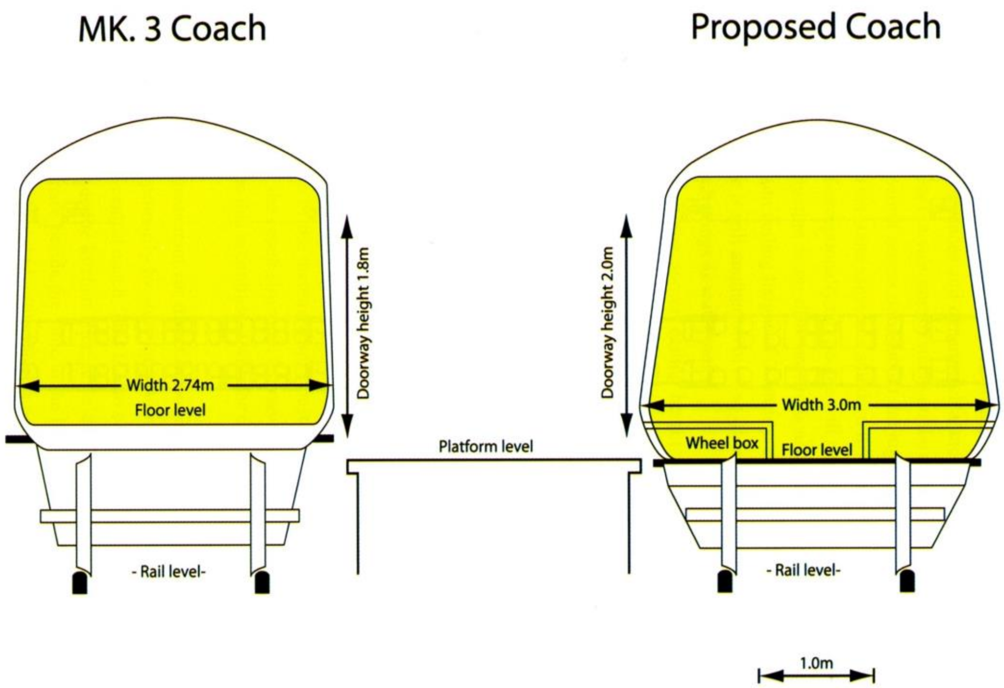




This example is a long distance cross country or inter city version with low density seating in a ‘composite’ arrangement with standard class in the left hand and centre vehicles and first class in the right hand one. It has 82 standard class seats, 22 first class seats, one wheelchair space, and three toilets. There is ample luggage space, including 12 multi-level luggage racks marked as ‘L’ in the plan above. This is just one example of how the vehicle might be fitted out: within the same vehicle structure all sorts of layouts are possible according to requirements.

My book 'Beyond the HST' gives some further suggested examples of arrangements with low and high density seating, powered and unpowered, with and without driving cabs, sleepers, buffet and restaurant cars etc.

The diagram below gives an idea of the vehicle cross section, with the yellow shaded area illustrating the greater spaciousness achievable for seating areas compared with a conventional 23m coach as used, for example, in the InterCity 125 High Speed Train (HST).



The vehicle height is the same as usual, and it conforms to the existing tolerances for 'almost anywhere' route availability below platform level and a short distance above it, allowing for variations in platform height and dynamic suspension movements. Also at or near roof level the profile is more or less the same as usual. Between those areas, however, there is a 'bulge' in the critical position between seat and shoulder level to get additional width. Just how much extra width can you get?

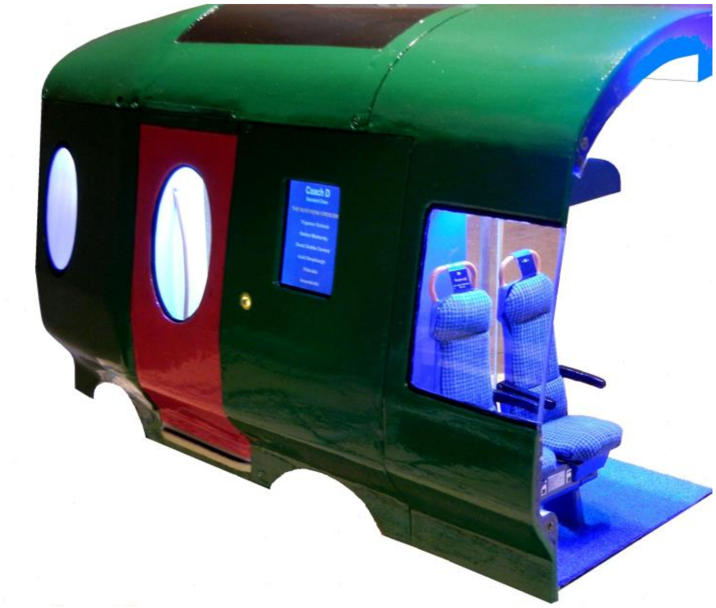
That is an easy question to ask but a difficult one to answer. The many original railway companies all had their own standards for infrastructure dimensions and much of this diversity remains today. Although it would be nice to clear all routes to the wider European standards this would be very expensive and realistically it will not happen. On the other hand, it may be worth spending some money to clear the worst of the infrastructure bottlenecks. There will be little problem on single track routes, as most bridges have ample clearances and tunnels tend to have a rather circular cross section anyway which can accommodate the 'bulge'. The real issue comes with older tunnels on double track lines where clearances in the 'six foot' between the tracks are severely limited. On the other hand, the tapered vehicle profile helps as any rolling on the suspension does not produce very much sideways movement in the most critical areas.

I have guessed that with some moderate expenditure on infrastructure a maximum width of 3.0m would be possible with ‘go anywhere’ route availability. If no infrastructure enhancements are implemented, I expect a maximum width of 2.85m should be OK when the experts on gauging and dynamic envelopes have examined the details; still better than a conventional coach.

Since the lower edges of the doors are at platform level or even below it sometimes, conventional outward opening plug doors cannot be used. Traditional sliding doors are not ideal either, as they do not close to give a smooth surface relative to the coach body. The resulting discontinuities create air turbulence and drag at high speeds and waste energy: not much per door perhaps, but there are many doors in a train. I have devised a new door design intermediate between these two ideas, which mostly operates like a pocketed sliding door but in the final stages of closure moves outwards and downwards to give a smooth surface and robust seal. These pictures of a working model show the closing sequence:

The door opens behind a large static non-scrolling destination display to give clear quick information about where you can travel to if you enter that door: especially important if trains divide en route.

This view of the model, which is a small section of the coach body near a door, gives a better impression of what the vehicle might look like. No wheels or bogie built yet!



Within the train, this picture of the model shows the vestibule area.

The door is 1.0m wide: enough for someone carrying a suitcase in each hand to enter or leave easily. Circulation space near the door and step-free access should speed up loading and unloading significantly, especially as the remotest seats are nearer a door than in a conventional design.

The following view of the model gives a better idea of the vehicle cross section, and how seating might fit the narrower floor and wider body of this design.

Each seat has its own mains socket, USB charging socket and electronic reservation display. Instead of the flat ceiling in the earlier diagram, I decided to have a higher curved ceiling in the seating area to give a more spacious feeling like the railway carriages of my youth.

More information about the design can be found in my book 'Beyond the HST' (Melrose Books, £16.99) and on the Wessex Round Table of Inventors website www.wrti.org.uk under Membership Area – Members Ideas in Development.

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