Vehicles for a maximum speed of about 250 km/h, development trends and characteristics

1 Significant obstacles to and problems with S250 and high-speed vehicles in general

This study highlights significant issues that should be considered in a discussion of future high-speed trains in Sweden. In particular it deals with issues surrounding high-speed trains with car body tilting (category S). The problems and obstacles currently facing high-speed trains with car body tilting are listed below. However, most of them also apply to high-speed trains in general.

1. Braking distances and signalling systems

   High-speed trains need significantly longer braking distances, especially with vehicles built to European standards. This applies not only to 250-lines, but to the entire track network where a “250” train is to run, since the lower retardation applies to the entire speed range (unless a braking system solution unique to Sweden is developed).

   According to the European standard, the introduction of high-speed trains (not specifically S250) requires substantial changes to the signalling systems, and this also affects track capacity.

2. Track capacity and traffic management

   The use of the same tracks by high-speed trains and in particular goods trains is already a problem with the present differences in train speeds. This problem area affects all traffic with significantly different train speeds, not just S250. The problems increase as speed differences become greater.

   On shared lines, traffic management and track capacity are likely to pose difficult problems with speeds above 200 km/h. Our opinion, which is supported by others, is that speeds above about 200 km/h require separation of traffic[1]. In this case it, the most appropriate solution would probably be to design new lines exclusively for high-speed traffic and for speeds of about 300 km/h rather than 250 km/h. The horizontal and vertical profiles of the track can be built for this and to suit vehicles built to the European standards for high-speed trains.

3. Track position tolerances/track faults

   Track position tolerances/track faults (particular problems when sharing tracks with goods trains and even worse with goods trains with maximum allowable axle load 25/30).

4. Availability of category S250 vehicles

   See Chapter **Fel! Hittar inte referenskälla.** for a table of existing vehicles in Europe with a maximum speed of 200 km/h.

   There a today few, if any, international applications in which car tilting is fully exploited even at high speeds (>200 km/h). And there does not appear to be any particular interest in such vehicles, even though there ought not to be any decisive technical obstacles to building “S250” trains. Such a train is likely to be unique.

   Car body tilting is seen as a way of increasing train speed on existing tracks and is used primarily at speeds below 200 km/h. Stated top speeds for a major part of the existing vehicles are not used in commercial traffic, or only on certain new stretches of line where tilting is not needed anyway. It would seem that all new lines and vehicles for maximum speed > 250 km/h are built for

[1] In practical terms, and with the present Swedish mix of trains, the threshold may be at an even lower speed on many lines.

trains without car body tilting. It seems that the future market for high-speed trains can be divided broadly into the following groups:

- High-speed trains (TSI): Speeds of 300 km/h or higher.
- High-speed trains (not TSI track): with or without car body tilting (used mainly at lower speeds). Typical top speed about 200-230 km/h.

5. The economy of the operators

From the point of view of the operators, category S250 vehicles are likely to be less attractive than category B200-250 vehicles. B-vehicles can be made more spacious. It is easier to provide a certain amount of low floor. The passengers have a more comfortable ride. S-vehicles are slightly more expensive than B-vehicles, and the S-vehicles currently on the market have a significantly lower cost-efficiency per seat compared with the X40 and X50, for example. The technology of the B-vehicles is somewhat simpler, so that maintenance costs are lower. In many traffic patterns, a slightly lower speed can be compensated for by better acceleration and braking performance and more efficient station stops. In these cases, which are probably the majority, a “B220” train may, from a purely financial standpoint, be significantly more attractive to an operator than an “S250” train.

6. Cross-wind

The risk of tipping over due to cross-wind is a problem that becomes more severe as speed increases. It is no trivial matter to satisfy cross-wind requirements at 250 km/h and above with full overspeed in curves, although it is probably technically possible, according to studies done at Royal Institute of Technology in Stockholm, in collaboration with the NRA and Bombardier, among others. In all probability, the ability of the trains that are internationally available today to handle full car tilting at full speed in combination with cross-wind is poor (and as mentioned above, it would does not appear that they are used in such applications).

7. Low-floor design

There is greater scope for providing low floors in a non-tilting train tilting than in a tilting train, although multiple-unit trains for high speeds (> 200 km/h) are always difficult to make with a high proportion of low floor. The main reasons for this are the need to provide space in the chassis for driving gear etc, and the unsuitability of small wheels and brake disks on such trains.

8. Winter traffic

Snow packing problems will probably be greater on a train with car body tilting. However, we wish to point out that there has been no investigation at all of winter problems for higher speeds. There is hardly any experience of operating trains in a winter climate at speeds above 200 km/h.

9. Safety

Safety (collisions, platform passing, etc), is a general problem at high speeds .

10. Noise

This is a general problem at high speeds, not only for trains with car body tilting. The problem of noise can probably be overcome to a certain extent by means of technical measures on the vehicles. Supplementary measures may also be needed on the track. In general, the problem with goods trains is at least as great.

The decisive drawbacks of choosing S250 (with car body tilting) are those of items 4 and 5, which deal with the availability of cost-effective standardised vehicles. With the direction followed up to now in Europe, train category S250 is not standard and is therefore expected become unique and so more costly for the operators, both in terms of one-off cost and in running costs per seat-kilometre.

Items 1, 2, 3 and 8 are decisive for high-speed trains in general.

Items 6, 7 and 8 are areas where car body tilting causes major problems. Items 9 and 10 are not affected by car body tilting.

2 Options for a future Swedish infrastructure standard

We see the following options for a future Swedish infrastructure for high-speed traffic:

1. Continued upgrading and new building with the present track standard:

   Traffic on these tracks will probably include vehicles corresponding to category B 220. It is uncertain to what extent they can be used by interoperable (TSI) vehicles.

2. New building to TSI with maximum speed 250 for trains with car body tilting.
   Upgrading to TSI for S250 (for example) (in terms of curves, approximately equivalent to B220 - 230).

3. New building to TSI with maximum speed 250 for trains without car body tilting.
   Upgrading to TSI for B250, for example.

   This allows more widespread operation with a TSI standardised vehicle fleet, but excludes heavy goods traffic (which should in any case be separated as far as possible).

4. New building of tracks dedicated for passenger traffic to TSI with maximum speed >>250. Upgrading to TSI for B 250, for example.
   This is probably the best option for the long term. It is a standard solution that has been chosen and will, within the foreseeable future, be chosen in European countries with a large area (and Japan). Several other problem in the Swedish railway system would be solved and other capital expenditure could be avoided. Compatibility with the rest of Europe and its vehicles would be achieved. A higher cant (180 or 200 mm) to TSI could be used for high-speed lines, to avoid excessively large curve radii. Separating traffic in this way would allow significantly steeper gradients (up to 35 ‰ according to TSI) than is common on lines that carry heavy goods traffic.

3 Conclusion

The extra cost of trains with car body tilting must of course be set against the possible savings in terms of infrastructure investment. This has not been investigated. However, we wish to point out the possibility of using a higher cant (up to 200 mm) on tracks without heavy goods traffic and operating trains as category B (or possibly slightly lower than category B for reasons of comfort), as well as having steeper gradients. This could give horizontal curve radii of up to 3000 metres for speeds of about 280 to 300 km/h and gradients up to 35 ‰. For maximum speed 250, curve radii of 2200 to 2300 metres are sufficient.

Taking as a starting point the work we did on this study, we see a clear need for a more far-reaching "fast train study 250-320" to be undertaken. It is essential for all parties to work out a coherent and cohesive strategy for the development of the future fast train system in Sweden. The study needs to consider all significant factors: regional policy, the travel market, traffic patterns, technology and standardisation, economy, effect on other transport systems, etc. Such a work of strategy and the possible realisation of the future fast train system is likely to have a significant effect on the transport market (for both passengers and goods) and on other investments in the Swedish railway system.