Zeitschrift: Swiss express : the Swiss Railways Society journal

Herausgeber: Swiss Railways Society

Band: 3 (1991-1993)

Heft: 5

Artikel: Pendolinos on Swiss rails?

Autor: Hauser-Gubser, A.E.

DOI: https://doi.org/10.5169/seals-855189

Pendolinos on Swiss Rails?

by A.E.Hauser-Gubser

Drawings courtesy SBB, ABB

The possible use of tilting body technology on passenger trains on Switzerland's standard and metre gauge adhesion worked lines is currently the subject of lively discussion in our press. Opinions are divided and range from a blank rejection of the technology through cautious approval to enthusiastic acceptance. I believe an analysis of both the difficulties and benefits to be expected from this system will be of interest to Members.

1 Technical aspects

Each time a conventional passenger train negotiates a curve, centrifugal forces are generated. To compensate for this, the outer rail is laid higher than the inner one (superelevation). The amount of superelevation is governed by the amount of freight trains passing over the route, since it is vital to maintain the stability of loaded wagons. On the other hand, each railway administration wants to have the highest possible speeds for its passenger trains. In consequence they choose a compromise superelevation to obtain the best possible compensation of the centrifugal forces. It is obvious that, for passenger trains, there remains a reserve of speed which is limited by the design of the locomotive or power car, in particular, of its bogies. We term this speed reserve on curves the "uncompensated elevation".

As, in Switzerland, some 40% of the routes are curved, this uncompensated elevation is of considerable importance. Its calculated limit is 150mm, whereas normal superelevation lies between 100 and 150mm depending on the radius of the curve. Overall, Swiss railways allow at best centrifugal forces compensating 250-280mm superelevation but in France the SNCF allows 330mm for its major express trains. We have therefore, the surprising fact that Swiss trains could run about 10% faster without any modifications to track or rolling stock were we to adopt the French standards.

If the bodies of the passenger coaches are now tilted inwards, it is possible to increase the speed and comfort substantially, as the centrifugal forces on passengers are reduced according to the angle of tilt. On Swiss railways, supposing we permit the same lateral acceleration of 0.70-0.97 m/s squared as before, the formula to calculate the highest possible speed is:

tilting angle factor x square root of curve radius

For a conventional train, the above factor is 4.79. When negotiating a curve of 300m radius, the highest possible speed is therefore:

$$4.79 \times 17.3205 = 82.96 \text{ km/h}$$

As you probably know, the speed on the Gotthard route's 300m curves is limited to 80 km/h for the Re class locomotives. If the passenger coach body is tilted by 8 degrees, we obtain a factor of 6.23. The highest possible speed on the curve is now;

$$6.23 \times 17.3205 = 107.9 \text{ km/h}$$

- a gain of 30%.

It is obvious that such an improvement in speed is most interesting and it has induced the SBB to carry out extensive trials with the tilting body systems available at present, ie, the Pendolino system produced by Fiat of Savigliano in Italy, the X2000, a Swedish ABB product, the Talgo Pendular (a Spanish train travelling daily from Barcelona to Zurich) and the NEIKO system, a product of SIG, Neuhausen. Without going too deeply into technical details let us take a short look at these systems.

We have first to distinguish between active and passive tilting technology.

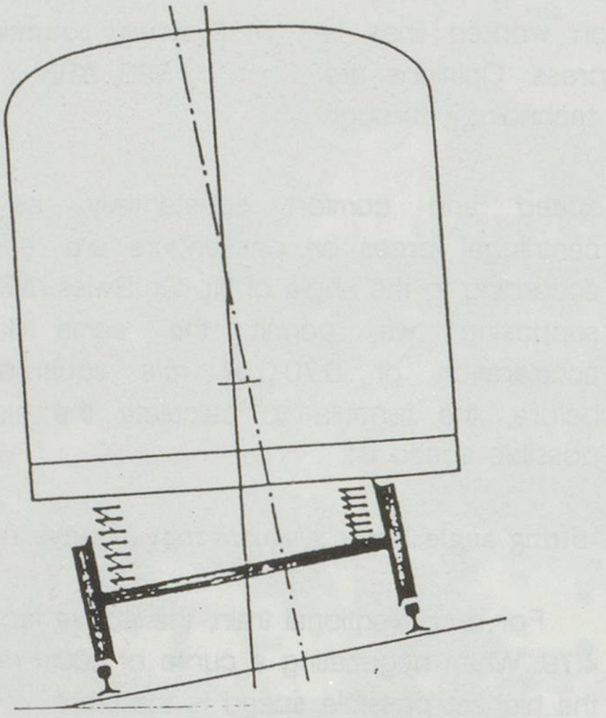


Figure 1 Conventional Coach

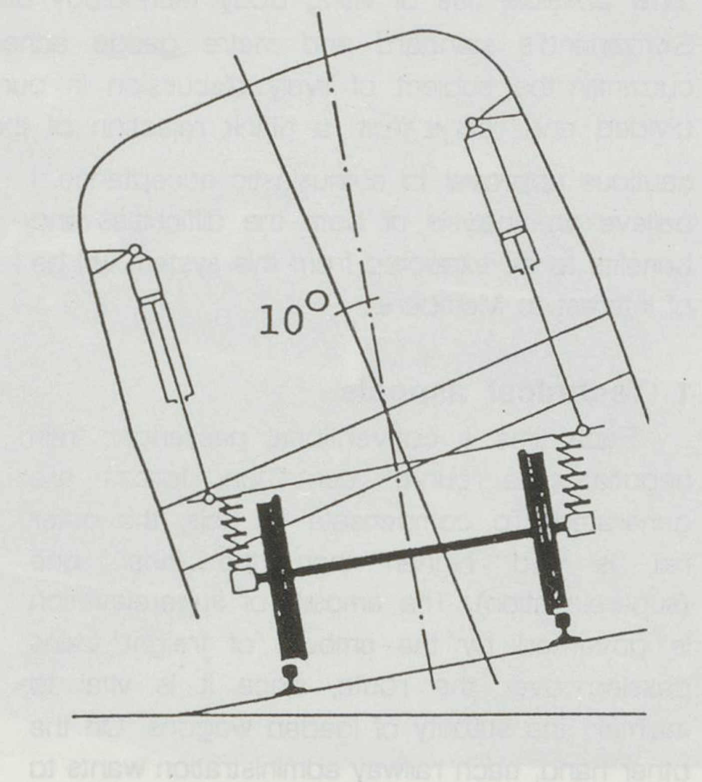


Figure 2 Pendolino Coach

Active Tilting

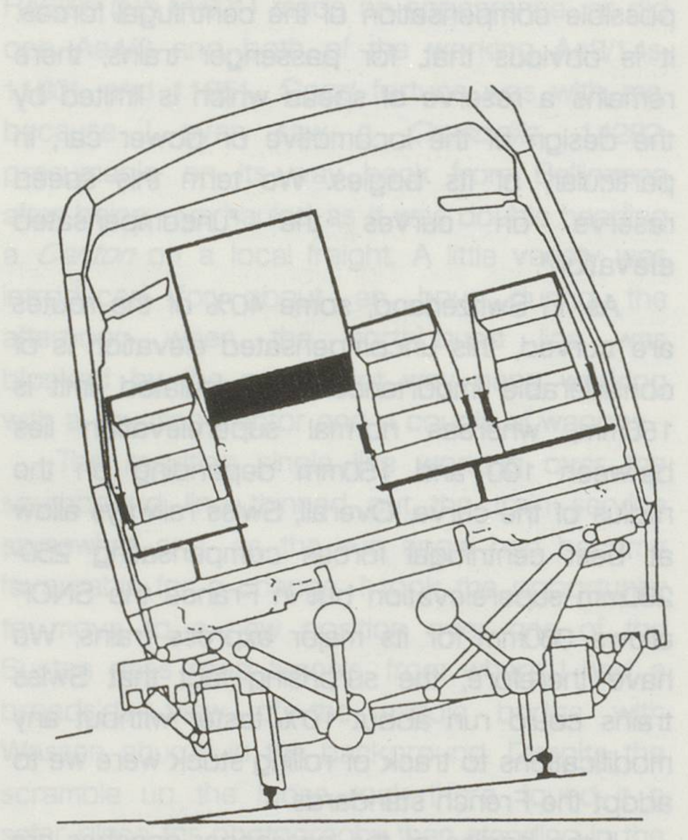
The main characteristics of the active tilting technology is the use of gyroscopes and acceleration measuring devices which feed a continuous stream of data to an on-board computer which calculates the tilting angles depending on speed and curve radius. The results are converted into commands to hydraulic and electro-mechanical mechanisms which tilt the coach body accordingly.

The Pendolino and X2000 belong to this group.

Pendolino

The ETR 450 Pendolino train currently running on various FS routes, such as Milan-Rome-Naples and Genoa-Pisa-Rome can tilt the passenger coaches by up to 8-10 degrees. All coaches (except the bar car) are equipped with one motor to each bogie, suspended below the coach and driving the inner axles of each bogie through a cardan shaft. This results in a very low axle load of only 12.5 to 13 tonnes with an unsprung mass of about 1.5 tonnes. Two

Figure 3 X2000 Coach



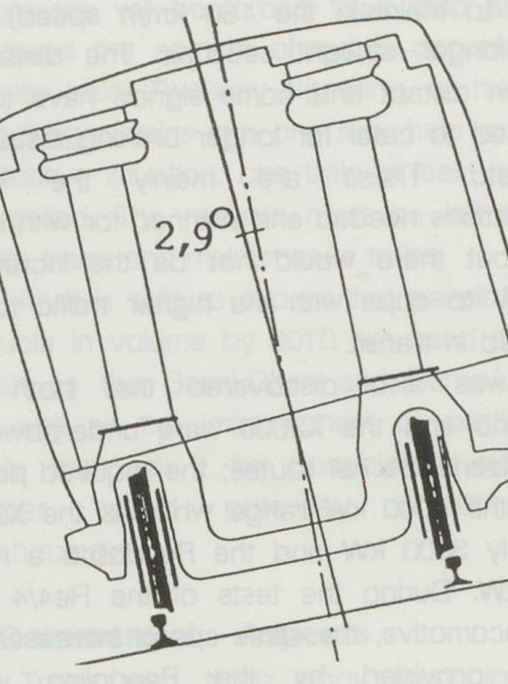


Figure 4 Talgo Coach

coaches form a traction unit and at present 5 and 11 coach trains (including the unpowered bar car) are in use. On the 5 coach sets, 8 out of 20 axles are powered, on the 11 coach set 20 out of 44 are powered. These trains cover the 630 km distance between Milan and Rome in just under 4h 30min, a saving of about an hour over conventional trains. Comfort is excellent and the sight of the leading coach tilting into a curve is quite something for a railfan.

X2000

The X2000 is also a train with an active tilting system and can tilt the coach bodies between 6 and 8 degrees. As opposed to the Pendolino, the entire traction equipment, the measuring devices and the on-board computer are mounted in a so called "light locomotive" which cannot however tilt and is of conventional design. The locomotive axle load is 17.5 tonnes. The bodies are made from stainless steel and the coaches are equipped with self-steering bogies.

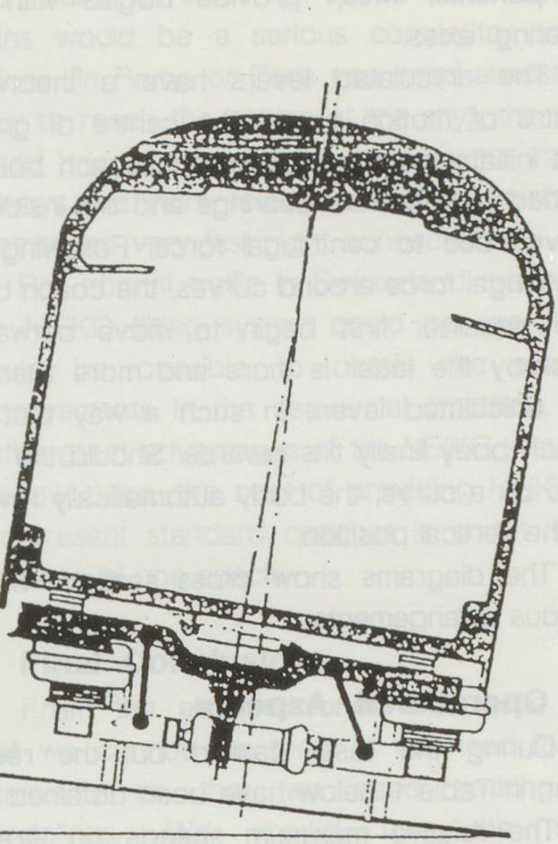


Figure 5 Conventional Coach with Neiko system

The X2000 seats 296 persons in two classes, whereas the first class only Pendolino seats 184 passengers in the 5 coach and 460 in the 11 coach train.

Passive Tilting

Talgo Pendular

The Talgo passive tilting system has the coach bodies suspended on communicating air cushions mounted high above the centre of gravity. These air cushions are supported by columns which rest on a wheel pair, which serves as the support for two coach ends. The car body moves pendulum fashion on bends, with the angle of tilt increase being dependent on speed and track curvature.

NEIKO

The NEIKO passive system consists of a kit of equalisers and articulated levers which can be fitted to existing bogies. This kit can be supplemented by the Navigator system components, which provide bogies with self steering axles.

The articulated levers have a theoretical centre of motion above the centre of gravity and initiate the tilting effect. The coach body is carried in pendulum bearings and tilts inside on curves due to centrifugal force. Following the centrifugal force around curves, the coach body and equaliser first begin to move outwards, whereby the latter is more and more tilted by the articulated levers in such a way that the coach body finally tilts inwards. Should the train stop on a curve, the body automatically reverts to the vertical position.

The diagrams show cross sections of the various arrangements.

2. Operational Aspects

During the tests carried out the results given in Table 1 below have been obtained.

The relative maximum speeds on straight sections are :

Pendolino	250 km/h
X2000	230 km/h
Talgo	200 km/h
NEIKO	230 km/h

Members may be surprised by the relatively small time savings compared to the increase in speeds on curves. We must bear in mind that the overall average speeds also depend on the topography, the length of straight sections between curves, the line capacity, the timetable and also the length of arrival and departure sections in the larger stations where speeds are of necessity lower. Furthermore it is not economical to speed up on short straight sections, only to have to brake at the next curve.

Table 1

System	Tilting Angle	Speed gain on curves	Time saving
Pendolino	10 degrees	30%	8-12%
X2000	7 degrees	27%	8-12%
Talgo	4 degrees	19%	7-10%
Neiko	2.5 degrees	11.5%	4-6%

The first important conclusion is therefore, in order to profit from the higher speed potential with tilting body technology, it will be necessary to make substantial modifications to the lines, such as larger radius curves (for the Pendolino, 1610m to maintain the 160 km/h speed) and much longer straight sections. The distances between distant and home signals have to be increased to cater for longer braking distances etc. etc. These are mainly the same modifications needed and planned for with bahn 2000, but there would not be the increased capacity to cope with the higher traffic to be expected in transit.

It was also discovered that both the Pendolino and the X2000 were underpowered for Switzerland's rail routes; the required power lies in the 5000 kW range whereas the X2000 has only 3300 kW and the Pendolino a mere 3000 kW. During the tests of the Re4/4 460 class locomotive, the same speed increases on curves provided by the Pendolino were achieved. This means that trains of 650 tonnes (13 passenger classes, type 2000) with tilting body of an active system could run at 230 km/h on the new lines and at 150 km/h on the Gotthard line with its 300m radius curves. The operational advantage of this is obvious, since the same locomotive can also be employed on goods trains.

But we have a serious problem regarding the capacity of existing lines. As members probably realise, the Swiss main line capacity is fully extended in carrying the current 400+ trains per day. The introduction of high speed passenger trains such as the Pendolino, X2000 and or the Bahn 2000 train on existing lines does not increase the capacity, but rather reduces it substantially, in some cases by up to 20%.

This appears absurd at first glance, so let me explain the reason. When we look at a given section of line, we may find that within 50 minutes (10 minutes are held in reserve) 2 x IC, 3 x Express trains, 3 x Regional trains and 3 x freight trains travel over the section in the same direction. If we replace the IC and Express trains with , for instance, Pendolinos, then it is quite obvious that due to the high speed differential between the tilting trains and the freight and Regional trains, the expresses will be forced to a stop at signals because the section ahead is occupied by a slower train. Two-way signalling, or marshalling two freight trains into one may help a little, but in such a situation, one train at least has to be cancelled. The reserve must be left open for extra trains and maintenance trains.

As it is safe to expect that transit traffic will double in volume by 2010, we need new lines, such as the Basel-Olten and Berne-Lausanne as well as the improvement of existing lines. Only then will it be possible to exploit the higher speed potential of tilting train technology.

3. Commercial Aspects

Trains with tilting body technology must bring in a good return on investment, the more so because they cost 15-20% more per seat than a train of Bahn 2000 design with tilting body coaches. As we have already seen, the savings in time would be rather small, on the Geneva-Berne-Zurich-St.Gallen run, about 25 minutes. This is by no means sufficient to convince a businessman to use the train, since he can travel the same distance in his own car in about the same time.

Since time saving is the crucial factor in the decision to take the train (look at the TGV, IC and the Pendolino in Italy) then we must look at possible longer runs. There are a number of routes that are of interest:

Bern-Brig-Milan-Venice
Paris-Macon-Geneva-Brig-Milan-Rome
Paris-Belfort-Mulhouse-Basel-Zurich
Stuttgart-Zurich
Zurich-Vienna

On all these connections enormous time savings would be possible, provided that the Swiss trains were built with four-current technology and are able to travel at the same, or better speeds as the TGV. Another question is whether the SNCF would be willing to accept such trains on their high speed lines. As these trains would be a serious competitor to the airlines (in Rome or Paris you need almost one hour to reach the centre of the city), the trains would bring increased revenues to the various railways, the more so as it would be possible to reintroduce very fast night connections.

For normal traffic in Switzerland, trains with the NEIKO tilting system could be used, as it would be possible to obtain the required improvements in the sequential timetable. One of the great advantages of the NEIKO system is the low price, the cost of providing NEIKO on the present standard coaches is about 3% of the price of one coach.

4. Final Conclusions

From the aforementioned it is quite clear that we cannot say there is no need for the Pendolino or that we need nothing but Pendolinos. We should use the spare resources where they bring most in returns. On the other hand we should not neglect the shorter runs in Switzerland, where we may achieve with the NEIKO system lower time savings than at present possible, but at a much lower cost and within the overall Bahn 2000 plan.

In this connection it is interesting to note that both the DB and the OBB are using their Pendolinos on lines with low traffic to improve the net running times. It will be interesting to discover the SBB's decision.

Interlude in Wassen

Continued from page 8

arch, of the church, as in the Marti and Trub Gotthardbahn book.

After this bit of rock scrambling and dodging the road traffic, retired to a field close to the line until the light faded and then met my friend for the last meal of our holiday (and a few more steins with the locals). All in all, a perfect lazy day to end a most enjoyable holiday.