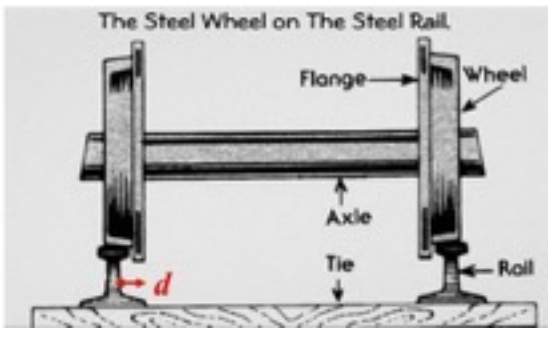
Rails are not a good solution

Many people assume that the wheels would be better running on rails. There are a few advantages, but many disadvantages.

The advantage is the reduced running area for the wheels, compared with running in the tube itself. The running area has to be manufactured very accurately, and then a resilient liner attached. But the savings in the smaller running area are outweighed by the increased complexity.

Railway wheels have a slight taper to make them run centrally on the rails. The flange is not normally in contact as it causes wear. These wheel are unsuitable for the high cornering forces at Hyperloop speeds.

Wheels need to be at least 1m in diameter, to withstand the rotational forces when running at Hyperloop speeds. So the wheels to take the side loads need to be a big as the main ones, even though they have less load.



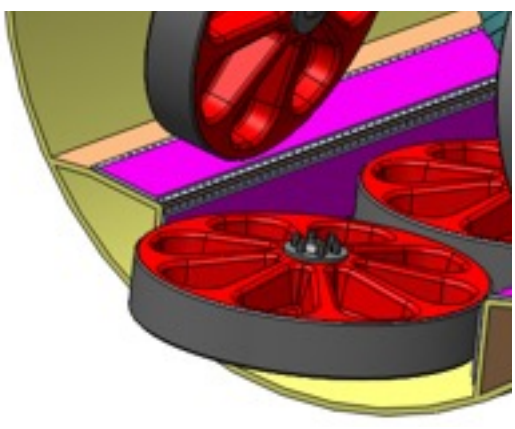
Running on soft rails.

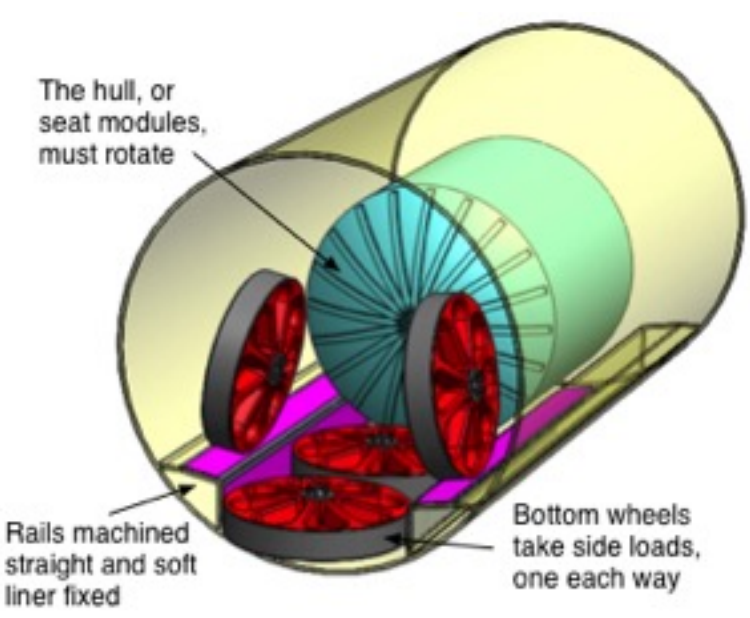
The steel tube is fabricated with wide rails on each side, then machined accurately. The resilient track is attached to the steel. The track can be changed by a machine inside the vacuum tube when necessary.

There are four wheels. A pair of near-vertical wheels take the main vertical forces, the wheels are 1,250mm diameter, 200mm wide. They are made of carbon composite, with a hardened steel rim for wear resistance.

The side loads are taken by the two bottom wheels, one for each side.

Hyperloop needs to have good suspension for passenger comfort at high speed, it is hard to design the suspension so the wheels run true on the tracks, as well as having long-travel for bumps.





Banking in the curves.

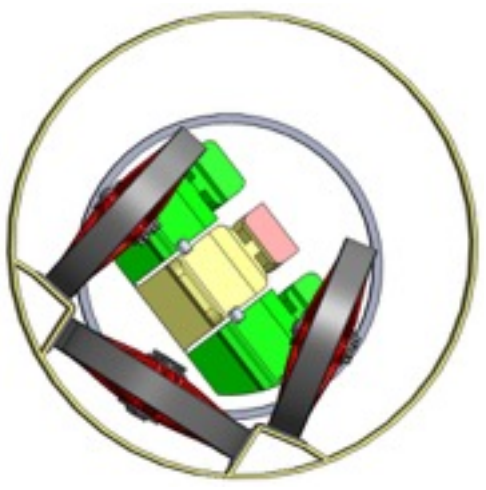
Hyperloop will take curves up to 1g, this requires a 45 degree banking angle.

In a curve, the rails could be pre-banked about 30 degrees.

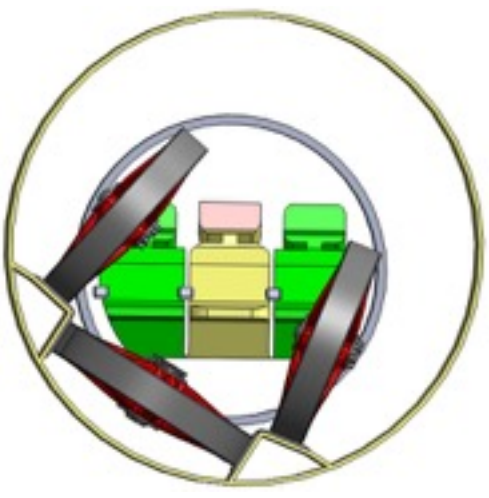
At full speed, the loads on the suspension are angled at 45 degrees, which means there is a 15 degree side-load on the wheel assembly.

For the passengers to be comfortable, their seats need to be angled outwards by an extra15 degrees. The options are:-

- Rotate the whole pressure hull against the wheel assemblies
- Fix the hull, and allow the seating modules to roll inside the hull.

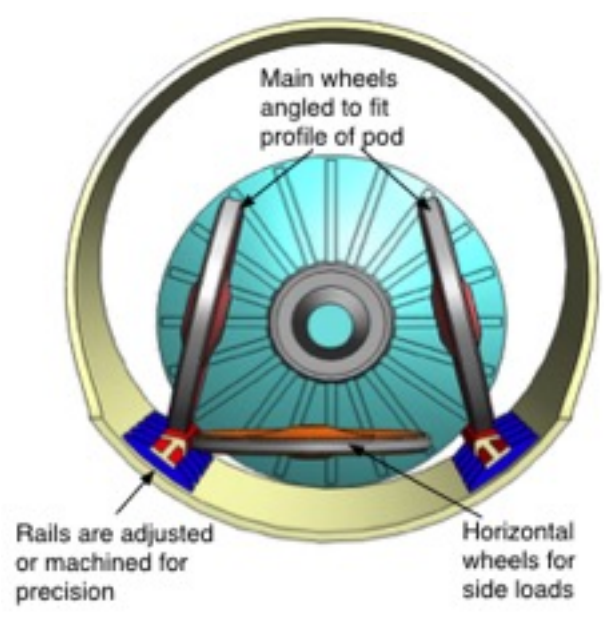


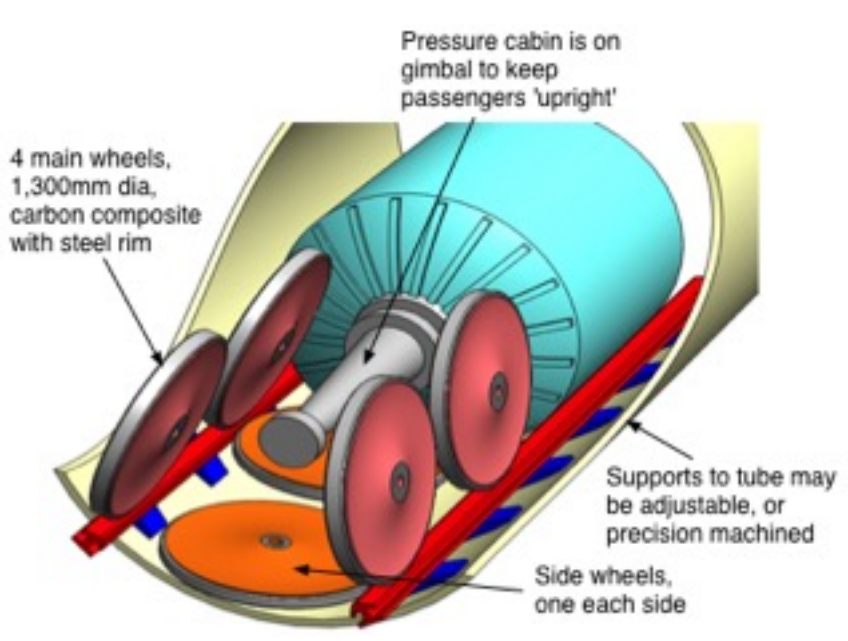
At slow speed in the same curve, due to a station, delays or maintenance, the passengers need little or no bank angle. But the rails are still angled at 30 degrees. So the seats need to angle down by up to 30 degrees.



The banking angle of the rails is a manufacturing problem. It will take about 3 seconds to adopt the banking angle in a fast curve, that is about 1km of distance. The rails need to gently alter their angle for each 25m section of tube, which is a difficult machining operation with the required accuracy.

Steel-on-steel rails





Advantages of steel-on-steel rails

Low rolling friction is possible due to the steel-on-steel contact. But there are many serious problems.

Accuracy can be achieved without moving the whole tube. The rails or their supports could be machined very accurately, or the rails could be adjusted against the supports.

Disadvantages

Limited traction due to the steel-on-steel contact. The maximum grip for steel wheels is about 0.15 g to 0.20 g, which is inadequate for Hyperloop. Expensive linear motors would be required.

Structural problems with the wheels. Steel wheels have very high point loading, due to the hammering effect. This causes extreme stresses throughout the wheels and suspension. But a steel wheel would be unsuitable for Hyperloop speeds, as its strength/weight ratio is low, and the wheels could not take the rotational loads. Carbon composite is ideal, but it would need a steel rim, which would be very difficult to fix with the high loads.

The lack of free-banking means that the passenger cabin needs to be attached using a gimbal, for passengers comfort. This is possible, but adds considerable complications to the whole structure.

Vibration and noise is the result of the steel-on-steel contact. This would require the whole pod construction to be stronger and heavier. Noise in the cabin would be a problem. Like conventional trains, there would be noise from the tube, and vibration transmitted through the ground, which is upsetting to neighbourhoods.

Wear would be a problem. Conventional rail has quite high maintenance cost for the wear in the wheels, and subsequently in the rails. Wear is slow, but very expensive to fix.

Increased complexity. The is the extra cost of the rails and supports, and possibly linear motors or other traction and braking devices. The pod itself becomes much more complex, with the extra side-wheels, noise and vibration control, and the gimbal arrangement for the cabin.