Maglev vs. Wheeled PRT

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Magnetic levitation or maglev is an alternative approach to vehicle suspension. Instead of wheels, magnetic force is employed to counteract gravity. Maglev is particularly useful at high speeds when wheels must resist very high centrifugal forces. Ride quality, durability, and safety then require high precision in wheel and track manufacture, installation, and maintenance. At issue is the need for this more complex, energy consuming, and expensive approach in lower speed applications.

There are two basic types of magnetic levitation or maglev: **magnetic attraction and magnetic repulsion**. Attraction can be accomplished with room-temperature magnets but is unstable so that it requires high-gain electronic servo mechanisms to maintain the gap between the guideway and the vehicle. Repulsion has required much higher magnetic fields that can be attained using super-cooled coils, which require use of liquid helium, which is not practical in a small vehicle, but it is stable. Some very powerful room-temperature magnets may change this situation at some point.

Use of magnetic attraction has in several designs led to the configuration shown below in the left-hand sketch, in which vehicle elements wrap around and underneath a guideway element so that the vehicle can be lifted by an attractive force, but this means that the vehicle can't switch without moving the whole guideway, which is not practical for short-headway systems. With the short headways needed for PRT the configuration must be turned around to that shown below in the right-hand sketch. But in a diverge or merge section, if the vehicle is, for example, to switch to the right, the left hand levitation surface disappears and must be replaced by some other means of levitation. By whatever means used, the left side of the vehicle must be supported from below. This could be by repulsive maglev limited to only switch sections, with the superconducting means at wayside, or it could be by wheels. Similar sketches for hanging systems will show similar problems.

Even if the maglev developers create a workable, switchable configuration, either attractive or repulsive, what is its advantage over wheels? The critical advantage of maglev occurs at very high speeds, typically over 200 mph where the friction of steel wheels on steel rails becomes inadequate. This is not a problem at urban speeds.

The maglev configurations I have seen use linear synchronous motors (LSM) for propulsion. The advantage of the LSM is that the propulsive power is at wayside so that sliding contacts are not needed. Sliding contacts cause excessive arcing at very high speeds, which then quickly wears out the power rail. This is not a problem at urban speeds.

The LSM requires windings in the guideway, which must be partitioned so that each separate winding controls one vehicle. Thus the number of these windings required per mile is inversely proportional to the minimum headway. Each of these windings must be controlled by its own electronic package. One LSM expert admitted that that means for PRT one winding about every 20 feet or 264 per mile or 2640 in ten miles, etc., which means that the minimum headway is fixed once and for all – once built there can be no experimentation with smaller headways. Imagine then that because these electronic packages occasionally fail, they must be replaced by a maintenance person who would need to run out to some section of guideway in any kind of weather at any time of day or night. With Linear Induction Motors (LIM) all such repairs or replacements occur in a maintenance shop. The LSM experts say that the mean time to failure of each electronic package is long, but how long? If you have thousands of them, the failure frequency in a system will be high and thus the maintenance cost for replacement will be high.

I have yet to see a practical maglev-LSM PRT configuration, and even if a practical configuration is discovered and developed, it will have high costs for wayside windings and electronic devices. So what is wrong with wheels, other than that they have been used for thousands of years? If LIMs are used for propulsion the main support tires need be used only for suspension. They can be smooth and the running surface can be smooth. The 80-psi tires I use result in very low road resistance. In my configuration no thrust is applied through the wheels either for acceleration or for braking, so wear is minimum. Emergency braking is applied via separate shoes that on extremely rare occasions[1] would press down on the guideway, and they are tested every time the vehicle stops because they are used also as a parking brake. Wheel bearings may fail, but how often? Today, we rarely hear of a bearing failure in an automobile even though their environment is much rougher. With very light-weight vehicles, bearings can be over-designed for long life with little penalty.

In my configuration the wheels operate in the most benign environment possible – smooth running surfaces always away from the sun, with no chuck holes or curbs to run over, and no acceleration or braking through the wheels. What about blowouts or flats? The lifetime of tires in our benign environment will be very long compared with automobile tires, which now typically survive for at least 60,000 mi. Moreover, it is likely that we can use the new Michelin airless tire that provides the cushioning and sound-deadening effect of pneumatic tires without any chance

[1] "Failure Modes and Effects," www.prtnz.com

of going flat. One imagined advantage of maglev is a smoother ride. But in practical experience, maglev follows every perturbation in the guideway as closely as rubber-tired wheels. A final very important point is that we can design a much more compact, lower-cost guideway with wheels than with maglev. And, unlike maglev, wheels require no energy input to support the load.

My opinion about the tradeoff between maglev and wheels is based on these facts. Moreover, with wheeled support, I am ready to go into production immediately and can get into operation in much less time than would be possible with maglev. Maglev was designed for very high speed, on-line-station systems, which require long headways. Scaling such systems down to urban speeds is a solution looking for a problem.

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