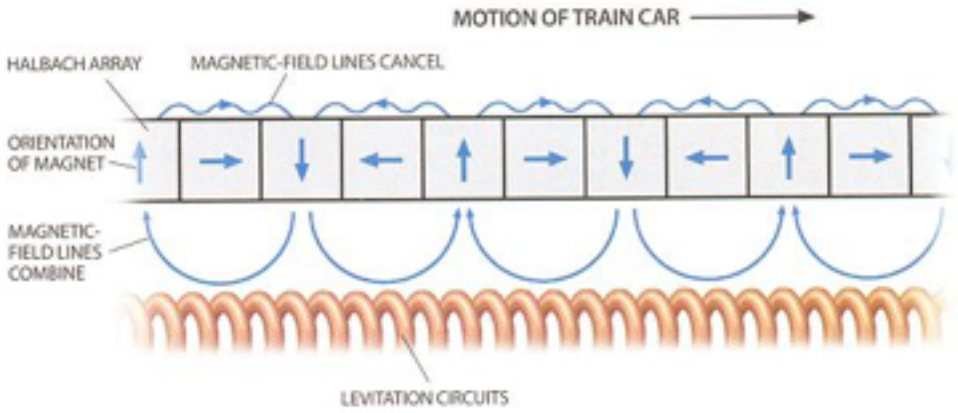
Maglev - passive levitation

Maglev is a very complex subject, with limited published information.
Apologies for any possible inaccuracies.



In the Pod Competition tube, the coils would be replaced by a simple aluminium plate

Passive induced levitation to copper coils
The above image shows the principle of passive induced levitation. A Halbach Array of permanent (or electro-) magnets is moved over a track with with continuous copper coils. The moving magnetic field induces current in the coils, making magnetism in the coils which provides drag against the motion, and lift.

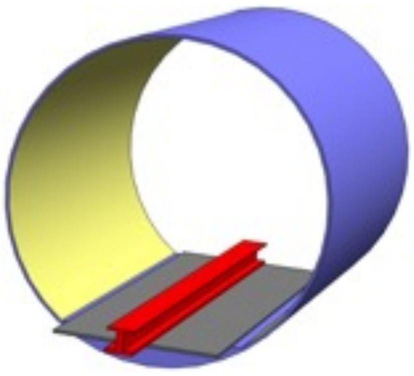
The Inductrack system proposes this levitation for a train system. At low speeds, the force is mainly drag, so that wheels are used until the lift is sufficient. A theoretical lift/drag ratio of up to 200:1 has been claimed at 500 km/h, although high speed operation has never been tested.

Eddy current braking
Eddy current braking is a simple and safe method of braking, used by amusement park cars etc.

Permanent or electro-magnets are placed close to a conducting rail such as aluminium. When the magnets are moved, the magnetism induces currents and opposing magnetism in the rail. The system provides a smooth wear-free braking force, and the eddy currents are converted to heat by the electrical resistance of the aluminium. Typically the magnets are placed each side of the rail, so that any lift is cancelled out.

The magnetic river
The Magnetic River was developed by Eric Laithwaite in 1974 which provided lift, stability, and traction. This seemed to be the perfect solution for maglev, with one side being a simple conductive sheet. But successful experiments in the laboratory have not converted to any suitable passenger-carrying applications.

Passive levitation to a plate,
as proposed by the 2016 Pod Competition.
The proposed tube design for the 2016 Pod Competition has flat aluminium plates for maglev. This is to save the considerable costs of continuous copper coils.



A maglev system for the Pod Competition is forced to use similar principles to eddy-current braking, but utilising the lift that is induced at high speeds. Wheels would be used, which are retracted once sufficient lift to induced. It estimated that lift/drag ratios of between 10:1 to 20:1 are possible at high speed.

The low lift/drag ratio is inherent in the unsuitability of a plain conducting plate compared to copper coils. This type of maglev is impractical for a full-size Hyperloop system.

For a 10,000 kg pod at 1,200 km/h:-
- Modern car tire, L/D 140:1, would have drag of 71.5 kGf, and power of 234 kW
- Maglev to plate, L/D 20:1, would have drag of 500 kGf, and power of 1,633 kW
- Maglev to plate, L/D 10:1, would have drag of 1,000 kGf, and power of 3,267 kW

Arx Pax system
The Arx Pax Hendo Hover-board also uses the same induction levitation, to hover over a copper or aluminium plate. A ring of permanent magnets is rotated over the surface. The eddy currents induce drag on the plate, which is overcome by the rotating motor. But with the drag comes repulsion, which provides levitation. This principle can also be achieved with rotating electromagnetic fields, a combination of which can provide motion and steering.

But the Arx Pax principle relies on the side effects of eddy current drag, which is very energy inefficient. It is useful for providing lift at low speeds, but not suitable at high speed. They have quoted 70 W per kg of lift, which would be 700 kW for a 10,000 kg pod when stationary. At higher speeds, energy is required both for the rotating motor, and for thrust to overcome the linear drag.