White Paper on Personal Rapid Transit Systems Using Switchless Rails and Hi-Rail Cars

August, 2023

Abstract

This paper discloses two rail technology inventions that work together to enable an energy-efficient personal rapid transit system (PRT) using renewable energy. The first invention enables a vehicle traveling on rails to change tracks at a junction using passive (static or switchless) tracks. A rail vehicle makes the decision which way to turn, not the tracks underneath. A second invention allows the rail vehicle to quickly and safely enter and exit the track system and travel over existing roads. Together they form a basis for a revolutionary transportation system. A model rail system was created to demonstrate this system.

Background on Switches

Conventional rail systems predetermine a route for all vehicles traveling over the rails by moving mechanical switches located in the tracks. Sometimes they are also called a set of points, blades, or turnouts. An example is illustrated in Figure 1. To change routes, the tracks are mechanically moved by an actuator, which is situated on the right in the photograph. Actuators can also be controlled by a train or a train control system.

Rail switches are expensive and must be maintained to be kept free of debris, ice, and snow. Holtzman Inc. has introduced passive switchless tracks where a rail vehicle chooses to go left, right, or straight ahead at a junction by applying lateral (sideways) force. Track components underneath are passive and remain static.

Background Hi-Rail Vehicles

There are vehicles called Hi-Rails or Road-Rail vehicles that can travel on both roads and on rails. An example is illustrated in Figure 2. Often these vehicles are used for track maintenance. They feature 4 road wheels and 4 rail wheels. The rail wheels are elevated for road travel. On the rail, the road wheels usually provide traction while the rail wheels align the vehicle on the tracks. Road wheels not providing traction are lifted to reduce rolling resistance.

Mounting rails with a hybrid vehicle is a difficult and dangerous proposition because it is normally done in a road-rail intersection. The rail wheel flange-to-rail positioning must be exact. Holtzman Inc. has introduced a **transition span** that makes mounting a rail easy, quick, and safe. A transition span has a road on one side and a rail on the other side

Advantages of Rails over Roads

The advantages of standard rails over roads include less real estate used for a rail system relative to a road, lower cost of construction, lower rolling resistance allowing much better fuel economy, greater load carrying capability, and longer service life expectancy. Rails can also be used to carry electrical power. However a huge advantage of roads over a rails is that road vehicles can travel wherever there is a road. Another advantage of roads over conventional rails is an ability to have a tight turning radius.

These two new Holtzman Inc. inventions, used together, preserve the advantages of rails over roads, while retaining the route flexibility of roads. Another advantage of this system is an easy implementation of driverless vehicles. This frees riders for productive work or relaxation.

Figure 1. A switch is moved to cause a conventional train to change tracks. Picture of switch is from Wikipedia®

Figure 2. A Hi-Rail vehicle on tracks. The front rail wheels go behind the front bumper when retracted.

Static Rail Switches

Figure 3 is a top view of a passive rail switch. Vehicles approach a junction from the bottom and take a right track when a right lateral (sideways) force is applied. This is illustrated as an arrow on a red wheel set. If a left force is applied, illustrated as an arrow on a green wheel set, the vehicle takes a left track. Vehicles coming from the top, either left or right, are funneled onto the bottom track without any need for lateral force. The left or right lateral forces are applied only over a "decision distance" near the junction as illustrated in the drawing.

Rail wheels have a wide cylindrical section (tread) that allows the rail wheel to bridge a rail gap when switching.

Lateral force may be applied by numerous "diverter" methods, such as side rollers, magnetic attraction, inertial, skid steering, wheel steering, or even a horse responding to the commands "gee" or "haw" to change direction of pull.

Figure 4 is a mechanical diagram of 4-wheeled vehicle using steering to apply lateral force. Front and rear axles are rotated around a pivot point. Steering a rail vehicle is not obvious, but a non-obvious advantage is gained. A turning radius of the tracks can be made much smaller than is possible with fixed wheel sets, mechanically enabling tight turns.

Figure 5 is a mechanical diagram of a hybrid 8-wheeled vehicle with an addition of rail wheel sets located in the front and back of the vehicle to keep the vehicle aligned over a track. The guide wheels are lowered for rail travel or lifted for road travel. Traction can be provided by either road wheels or rail (guide) wheels.

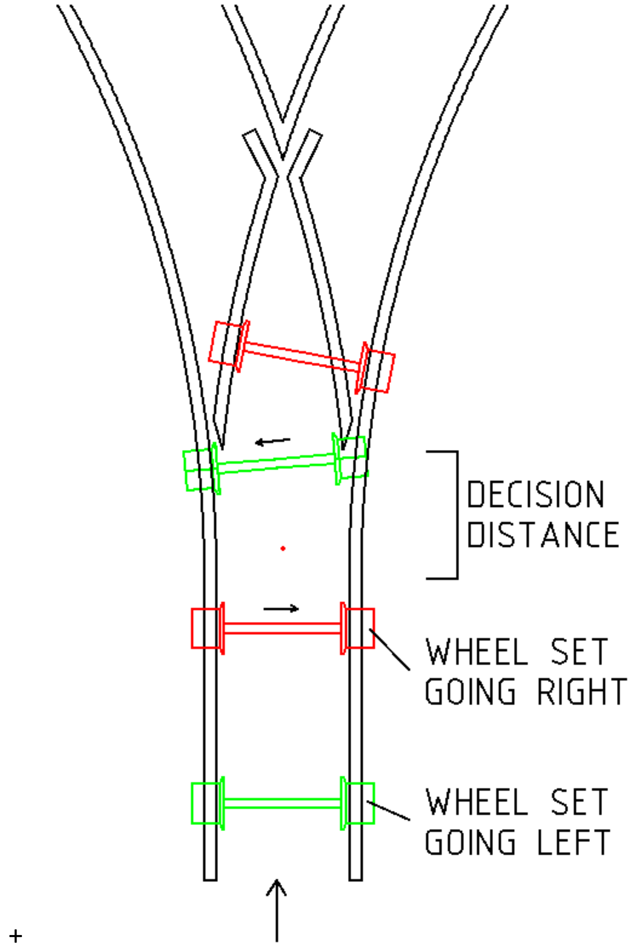

Figure 3. A passive junction illustrating a red rail wheel set going right and a green wheel set going left. Tops of rails are illustrated along with red and green wheel sets. Gaps in the rails allow the passage of rail wheel flanges. Rail wheels have wide tread surfaces. Lateral force, shown as right and left arrows, determine which direction is taken by the wheel set at a junction. Lateral force is applied over decision distance. There are multiple ways to apply lateral force.

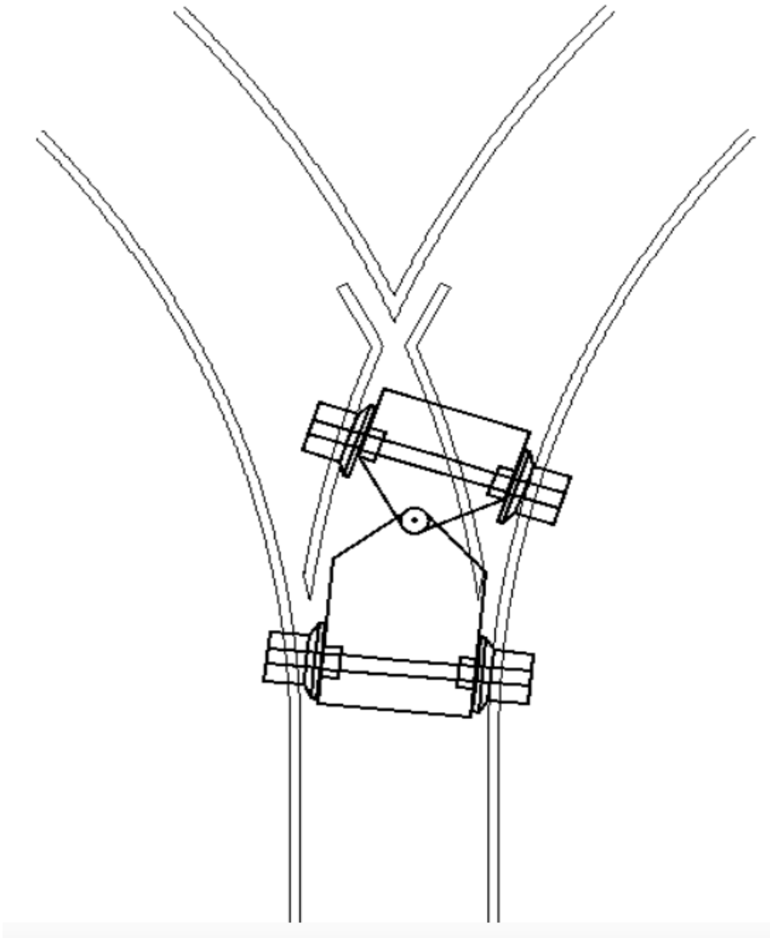

Figure 4. A diagram of a 4-wheeled vehicle using steering to choose a right turn at a passive junction. This geometry is also used for turnouts.

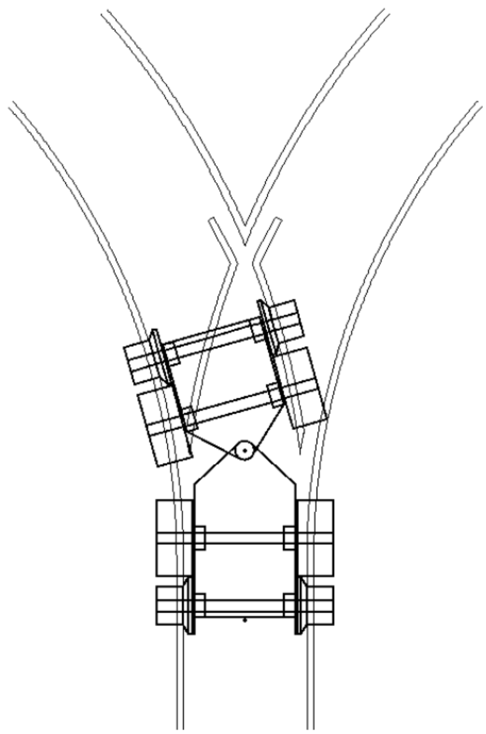

Figure 5 An 8-wheeled rail vehicle with guide rail wheels in the front and back, and road wheels in the middle. This vehicle can travel on rails with the guide rails lowered and can travel on roads with guide wheels raised.

Figure 6 is a picture of a 3-channel Radio Controlled (RC) G-scale (45mm) hybrid vehicle model. One channel is used for steering, one for speed control and one to lift or lower the retractable rail wheels in the front and back. It uses a rechargeable lithium battery and a brushless motor. This hybrid vehicle can run on either roads or rails. While on the rails, it uses steering to apply lateral force to turn at passive junctions.

Passive Switchless Switch

Figure 7 is a picture of a passive switch with the hybrid vehicle approaching a junction. The hybrid vehicle steers in the direction it wants to go. This switch was made by removing the moving blades on a LGB brand switch and replacing them with static blades.

Transition Rail

Figure 8 is a picture of a section of model rail road track with a transition rail. A transition span connects to a road on one end and to a rail on the other. A hybrid model is sitting on an up-ramp, which is part of the road. When a hybrid vehicle pulls from a road onto the transition rail and lowers its rail wheels, wheel flange alignment is made easy because an entry track gauge is wider than an exit track gauge. The exit gauge is the same as the rail road's. As the vehicle pulls forward in the transition span, its rail wheel flanges are forced into alignment with the rail gauge. The wide tread surface (cylindrical portion) of the rail wheels prevent derailment in the wide gauge section of the transition rail. Sloped gutters and a front funnel piece also assist hybrid vehicle alignment.

Figure 9 is a picture of a full rail road track with a transition span in the foreground and the passive track in the background.

Inventions Combined

Figure 9 is a picture of a model G-scale rail road track. It has three passive switches. Two are used on the track and one is used to connect the transition rail. A URL of video of this track in operation is https://www.youtube.com/watch?v=OMPgFyIa2-Y

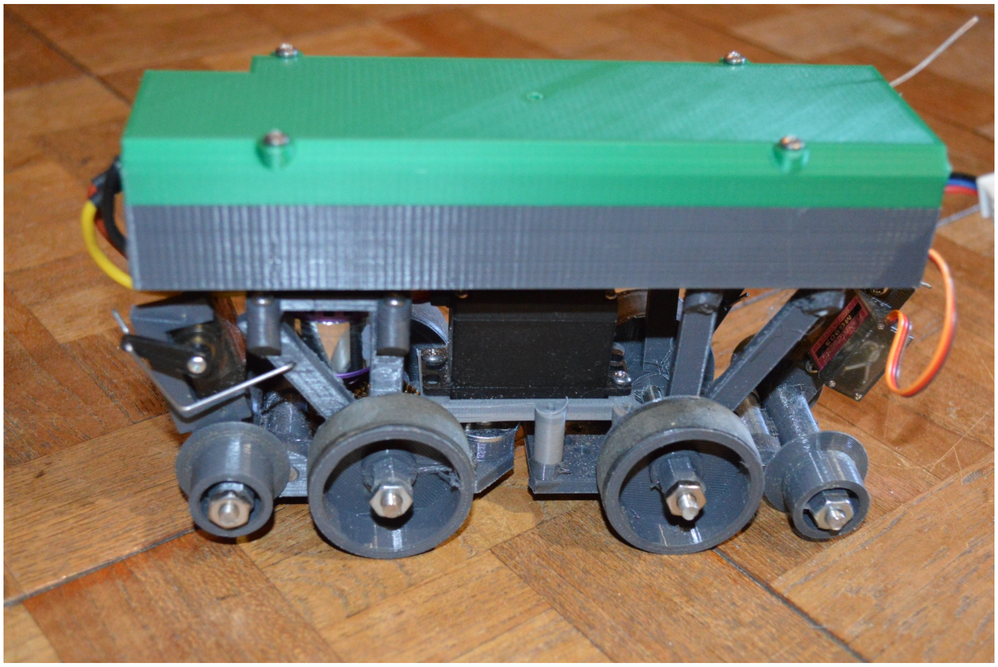

Figure 6 A hybrid G-scale vehicle using 4 road wheels and 4 rail vehicles.

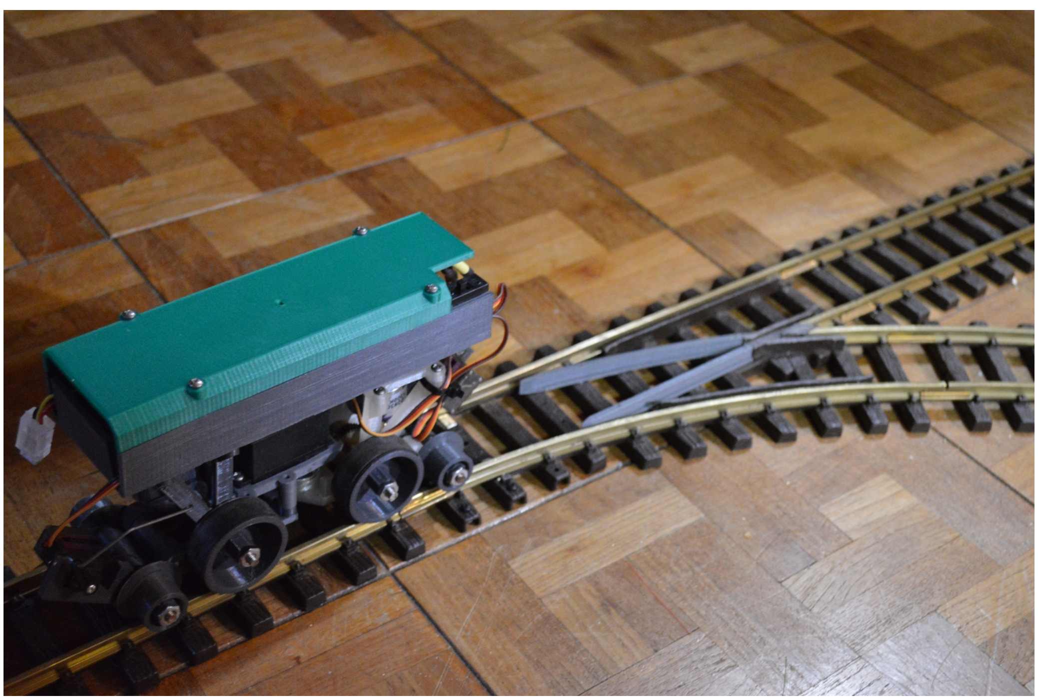

Figure 7. A hybrid vehicle approaching a passive switch.

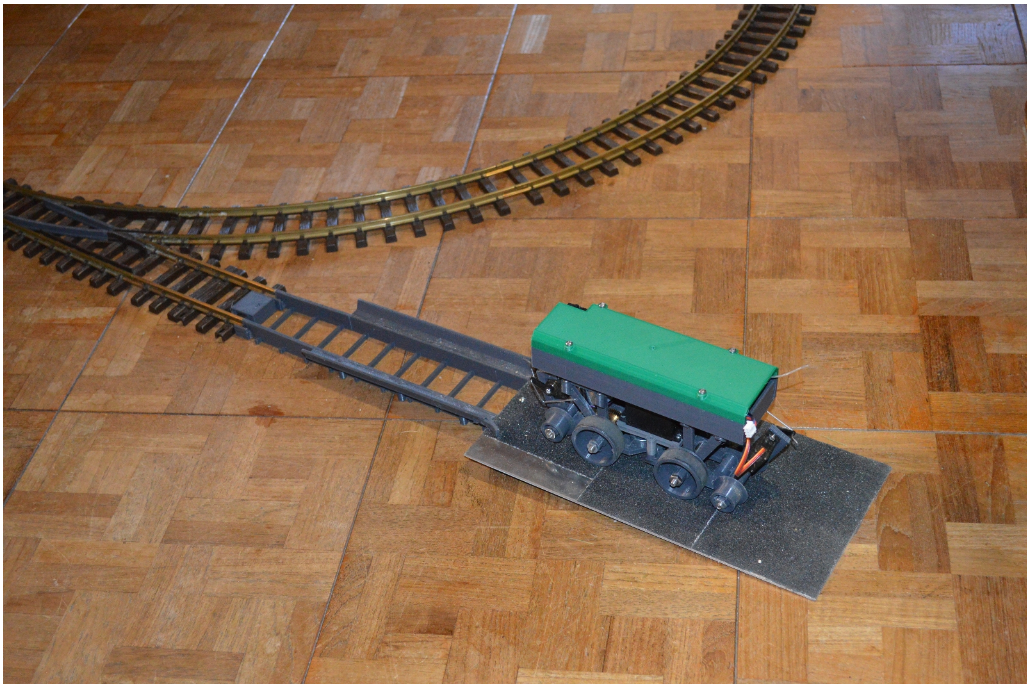

Figure 8. The hybrid model entering a road-side of a transition rail. The left end of the transition rail is connected to a passive junction.

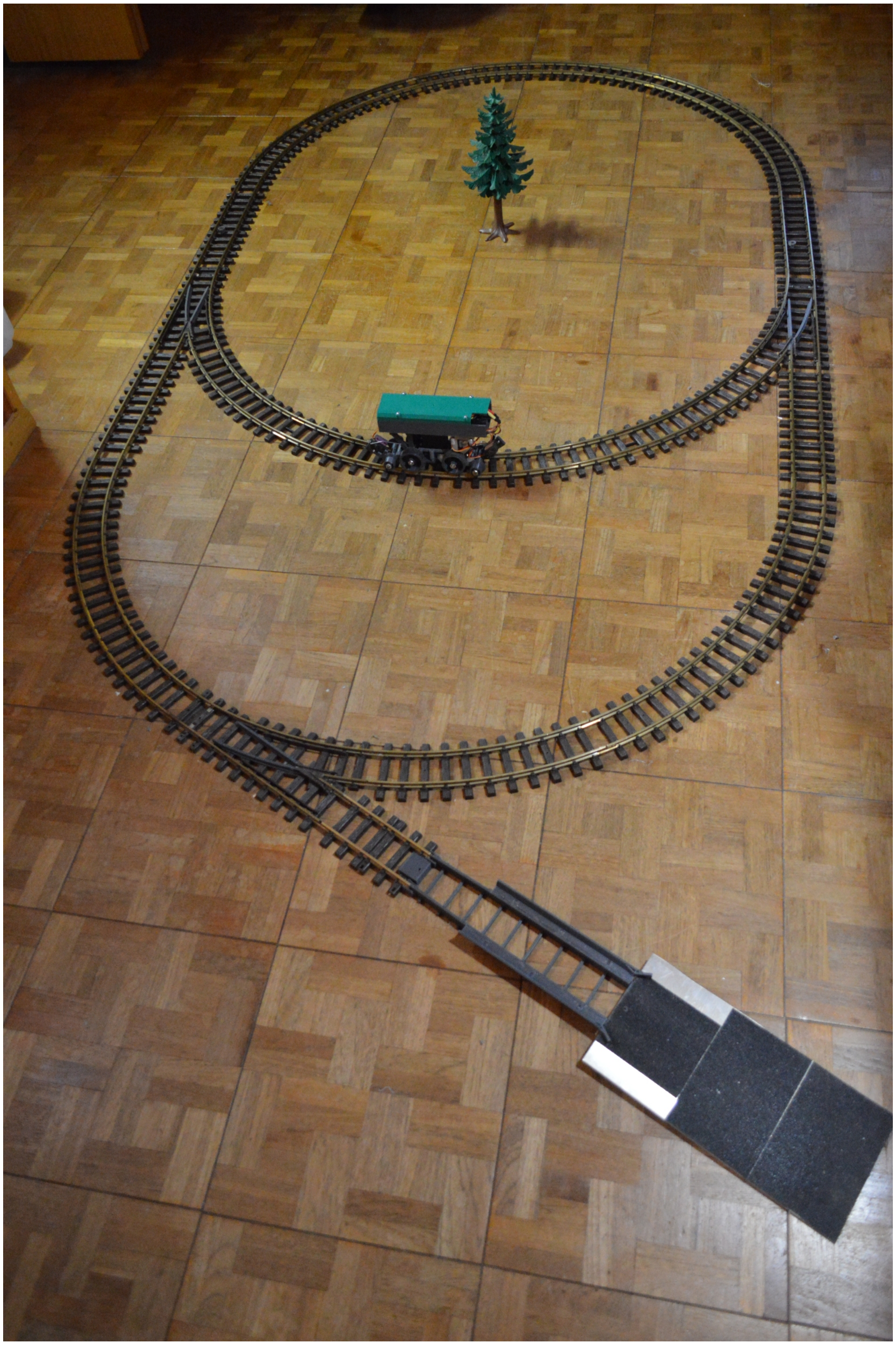

Figure 9. A transition rail in the foreground and a passive switchless rail system in the background. The rail system has three passive junctions, two in the middle for rail switching and one on the near end to connect the transition rail.

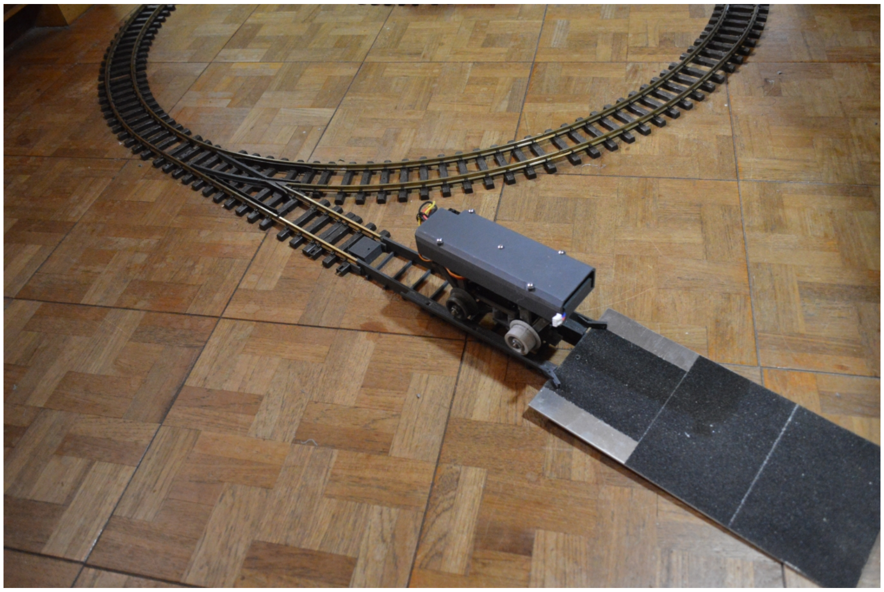

Figure 10 A 4-wheeled hybrid vehicle using combination wheels entering a track from a transition rail. On the rail the tread portion of the rail wheel contacts the rail. On the road, the flange tip of the combination contacts the road's surface.

Traffic Control Systems (TCS)

When a large number of uncoordinated hybrid vehicles want to use a passive rail network, chaos will result. Fortunately, advancements in communications, computing and sensing now enable a safe and efficient traffic control system. For example, individual vehicles can be grouped together to form a train using virtual or "air" connections. This is called "platooning". In a hybrid road-rail operation, control of vehicles should be taken over as a vehicle ramps onto a transition rail and maintained while the vehicle is on the rail. During rail construction, maintenance and emergencies vehicle rerouting can be done by the TCS.

Other Variants

If rail-only operation is desired, (non-hybrid) vehicles can just use 4 rail wheels with steering.

If rail operations are in rugged terrain, high wind or icy conditions, the vehicle's steering diverters can be backed-up by other means, such as side rollers.

The rails and passive switches can be embedded in streets, similar to tracks that trolleys (or street cars) use.

Rails and hybrid vehicles can be public or private, with a fee collected on private rails. For-hire vehicles can be summoned with a cell phone application. A TCS can be consulted for arrival times and fees.

Figure 10 illustrates a hybrid vehicle can be made with just 4 wheels using "combination" wheels. Combination wheels are similar to rail wheels except when a hybrid vehicle gets off of the rail and onto a road, it is supported by the tip of the rail wheel's flange. If the flanges are made of steel and the roads are made of brittle material like concrete, there will likely be road damage. This application can work using steel plates as a road surface or making flange tips from an elastic material like rubber.

Applications

All rail application are potential candidates for this invention. This invention is seen as complimentary to conventional public and private railroads and tracks, not as a replacement. It creates another use for existing tracks, most of which spend most of a day vacant. When the vehicle's steering is locked in a straight position, the vehicle can behave like a normal rail vehicle and be towed by an engine on conventional switched tracks. In this application the rail wheels will be fully lowered. The use of a Traffic Control System (TCS) allows safer, faster, and fuller utilization of a rail system. TCS capabilities include mass transit, rides on demand, traffic management, collision avoidance, forming trains from individual vehicles to reduce air drag, automatic speed control, autonomous operation, and adaptive route selection.

Other applications include warehouses, mines, resorts and theme park transit, toys, switching yards, abandoned section of tracks and cog railroads. Lines on light rail systems can be linked, allowing greater route flexibility and less train switching by passengers

Junctions have been designed that mechanically accommodate both rail-switched trains and steered vehicles.

Conductive tracks can provide powering or a neutral return. A goal is to use renewable energy as a power source. Track power can also be used to charge vehicle batteries. Hybrid battery powered cars will have more range than conventional electric cars if rails are available. A hybrid car traveling on rails uses less electricity than traveling on roads. Rails can be used to extend the range of battery powered cars.

This system also makes an entertaining toy, either when manual or computer control is used.

Patents are granted (US 11,364,940) and pending.

Conclusions

This paper describes new ideas of rail systems using static rails and transition rails. The invention is designed to bring route flexibility to rails, allowing efficient rail transport to gain an advantage over flexible but inefficient highway transport.

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Relevant Links

https://holtzmaninc.com/ Holtzman Web Site https://www.youtube.com/watch?v=OMPgFyIa2-Y //You Tube Video on this invention

https://ariesrail.com.au/light-vehicles/ //Hi-Rail vehicle company

https://en.wikipedia.org/wiki/Road%E2%80%93rail_vehicle //Wiki Road-Rail Vehicle

https://urbanloop.fr/en/ //French personal vehicle project