Reimagining Transportation - Base Case Calculations on Flying Aerial Tram System

It is possible to have a transportation infrastructure capable of much more:

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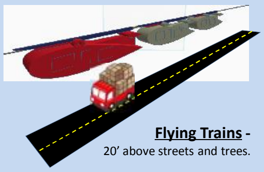
1/5th the Cost 1/5th the Time 1/5th the Energy

Faster Than Hyperloop (total travel time)



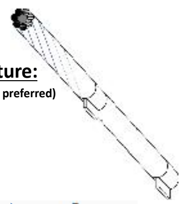
How do we make it happen faster and better?

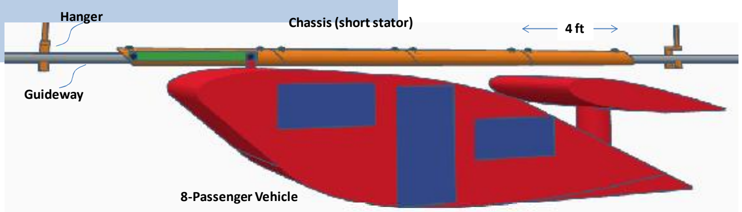
Base Case Design and Moving Forward

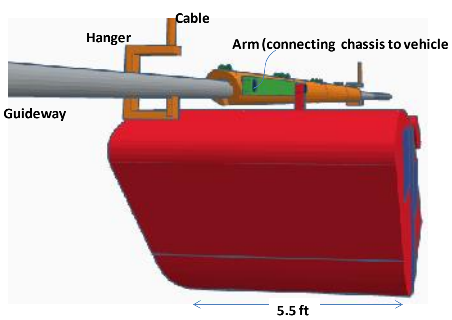
A suspend 2.25" OD wire rope guideway/armature with tower spacing of 0.4 (normal) to 3 miles (between high spots). The cable is polymer-center wire rope of 2.25 inch diameter and copper reactive armature surfaces. A single support cable of 3.5 inch diameter supports up to 6 guideways. Cable connectors attach to hangers on bottom side of cable (right).

Guideway Armature:

(bottom connection preferred)

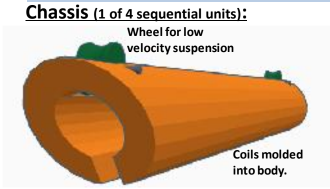


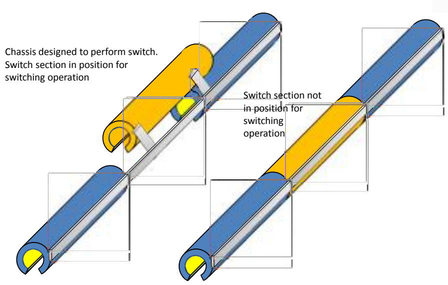




A 6" OD Open-sided coil short stator (chassis) has wheel backup for takeoff, landing, and stall-vehicles. Unibody thermoset molding process around coils and coil core skeleton forms body and coils of the stator in a single process producing high strength and ultra-light weight unibody construction.

Chassis (1 of 4 sequential units):





A vehicle controlled switch occurs when a chassis section is specifically designed to engage a switch guideway at switch locations. Here, the middle section may be positioned to perform the switch or to avoid the switch. A number of design parameters allow this to be implemented with minimal weight or cost associated with this capability.

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FASTER ... FASTEST

TERREPLANE is FASTER than HYPERLOOP-ETC

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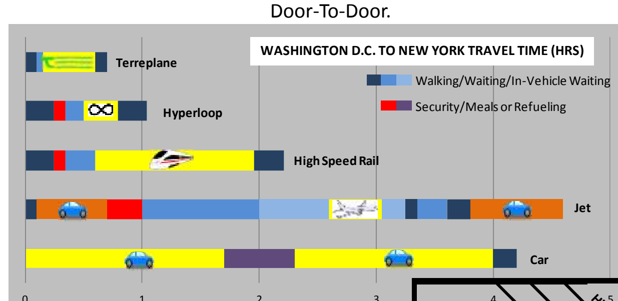
How is it possible? ... Terreplane is faster because:

- Service with vehicles ranging from 2-passenger to 96 passenger trains allows Terreplane to operate like Uber... use a cell phone App to select an option ranging from personal vehicle, ride-share vehicle, or scheduled train.
- Stations are everywhere, because Terreplane is both a commuter and trans-continental service network.
- Terreplane is a technology package providing superior service for travel at a range of conditions including corridors with low-pressure tubes as part of the larger network and access chambers to connect.

FASTEST – To be the fastest, three things are needed: 1) low cost guideways, 2) high-speed vehicle-controlled switching, and 3) open access (no security gates). Hyperloop-type low pressure tunnel transit systems bring none of these; Tererplane brings all three.

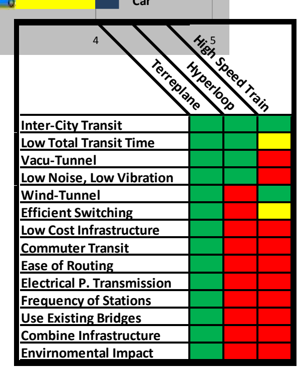
New York City is ***SABET*** Washington DC (43 minutes, door-to-door)
(***SABET*** -- **S**ame **A**s **BE**ing **T**here)

Door-To-Door.



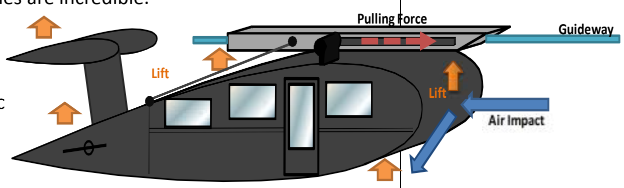
Transportation Evolution:

0-90 mph – Uses ancillary wheels on chassis.
90-200 mph – No problem for initial systems.
200-400 mph – Incremental improve of initial ...
(designed for easy guideway upgrades)
400-600 mph –Tunnels with 50-200 mph tail wind.
(vehicles pump air, ducts route air)
550-730 mph – Low pressure tunnels/tubes.



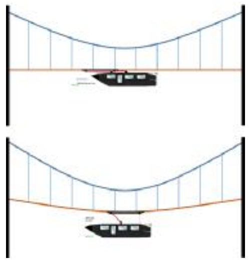
TECHNOLOGY & SCIENCE OF TERREPLANE

Terreplane is a breakthrough transportation system based on wingless glider vehicles propelling themselves along zipline-type guideways. Zipline-type guideways are inexpensive, and yet performance possibilities are incredible.



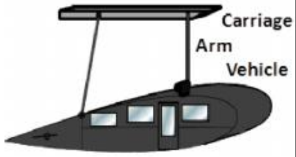
Key Details:

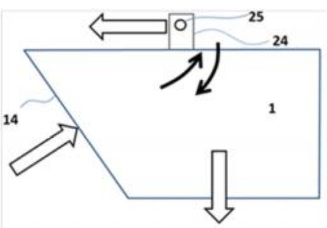
1) **Flying vehicle depiction of Terreplane** – Vehicle weight is supported by aerodynamic lift. The only force on the guideway cable is a pulling force (figure to right).



2) Cable Guideway illustration of suspended zipline-type guideway (left) –
The top/left image is with vehicle in flight with only longitudinal force exerted on guideway. The bottom image is of a stalled vehicle... both the upper support cable and lower propulsion line combine tensile forces to support stalled vehicle weight.

3) Aerial Tram – (right) To the right is a depiction of Terreplane vehicle at rest. The Vehicle is connected to the Carriage/Chassis with a Connection Arm.





A further simplified (left) illustration shows the primary forces and torques on a vehicle representation during flight. The pulling force (from carriage) is at the top of the vehicle and is purely longitudinal since it is a point of rotation in line with the propulsion line. Drag and lift produce a counter-clockwise torque that is balanced by a clockwise torque generated by gravity acting on center of gravity. Drag is converted to lift...an advantage over aircraft.

These Result in:

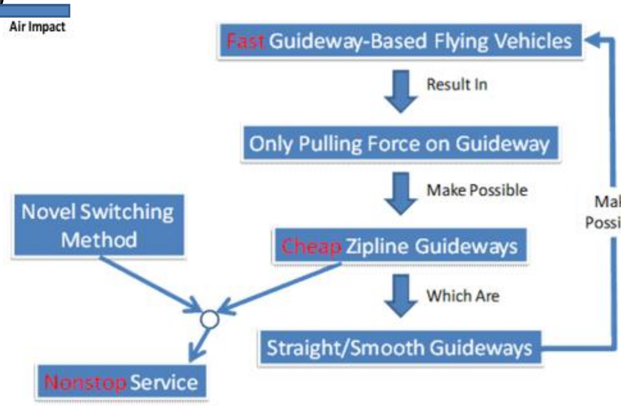
- A zipline type guideway that is less than 20% the cost of alternatives.
- A >95% reduction is forces (wheel or maglev) needed for suspension/propulsion.
- Ease of routing…

1/5th the Cost 1/5th the Time 1/5th the Energy
Setting New Levels for Sustainability!

THE INNOVATIONS

The innovation is not a single advance; rather, it is over a dozen advances in technology resulting from a fundamentally different approach to an age-old problem.

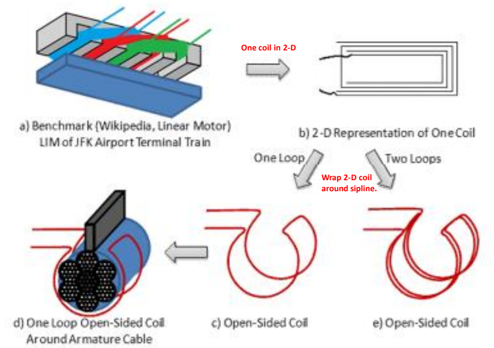
STARTING POINT: It started with guideway-based wingless glider vehicles and a zipline-type guideway, where ...



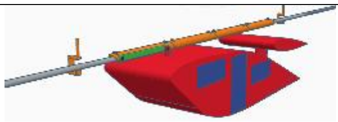
*Technology includes new/novel zipline connectors/supports.

SUPPORTING TECHNOLOGY: Open-sided linear motors are an advance to reduce wear on cables, and have widespread implications.

Wheels can work, but open-sided linear motor are non-contact, having low to zero wear/tear. These linear motors could be shells less than 1 inch thick.



FUNDAMENTAL ADVANCES: Some advances in electromagnets and motor manufacturing have widespread implications. Other advances on torque-suppressing suspended posts and switching methods are more specific to Terreplane.



R&D – Advancing the Technology

(initial calculations/results in red)

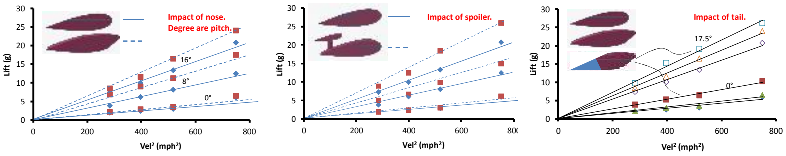
How well will Terreplane work? Initial design/research validate a base case Terreplane system, that works well. Key R&D topics (in question format) to maximize benefit are:

1. What are attainable **Lift:Drag ratios** for wingless vehicles? (Vehicle)
2. What is the base case **Open-Sided Coil** design? (Chassis/Carriage)
3. What is the base case **Cable Technology** to enable open-sided coil stators? (Cable)

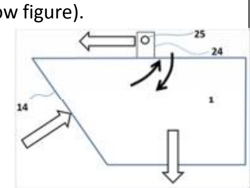
1. Lift:Drag Ratios:

The momentum theory of lift puts a science behind the manner impacting air (due to vehicle velocity) can sustain flight of a wingless vehicle. At 90, 180, and 360 mph, the magnitudes of those impacting momentums for a 3 m^2 cross section are sufficient to support 600, 2400, and 9600 kg; spoilers (etc…) can further increase lift.

The following data/graphs summarize how vehicle shape and pitch angle impact lift:



Conclusion – Data are fully consistent with the momentum theory of lift. A high vehicle nose and a low vehicle tail provide maximum lift. Jet aircraft do not have these features because they make controlled flight more difficult. Conclusion: Terreplane can attain Lift:Drag (L:D) ratios higher than commercial jets. Also, L:D ratios are further increased by Terreplane's ability to convert drag force to lift force (see below figure).



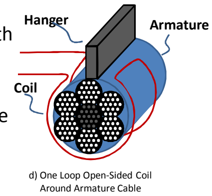
Lift:Drag Ratios – Jet aircraft Lift:Drag (L:D) ratios vary from about 4 (takeoff) to 18 (cruising). The L:D ratio relates propulsion force (drag) to the vehicle weight. For example, a 600 kg vehicle operating at constant velocity and a L:D ratio of 10 would require 60 kg X 9.81 m/s^2 for propulsion force. This is 15 kg per passenger…a number considerably lower than other forms of transit.

Research Objective – Measure lift and drag forces on a series of Terreplane vehicle options to understand both what impacts the L:D ratio and how to optimize L:D ratios as a function of vehicle constraints (e.g. height to weight ratio, no wings, spoilers). (**Expectation –** 20:1 ratios are possible.)

Also - L:D>20 probable for parcel transit since height of vehicle may be less.

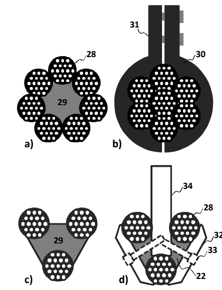
2. Open-Sided Coil:

An open-sided **coil** wraps around the cable (or other) **armature** with a slot open along one side to allow **hangers** to attach to the cable.



In the limit of a very large diameter pipe (or cable) the performance becomes that of commonly used linear motors as used for light rail (e.g. JFK airport terminal train). By method of analogy, it is verified that the open-sided coil will work. A further analogy (with the JFK airport system) identifies that an aluminum shell around a 1.5 inch diameter cable is sufficient for travel velocities up to 200 mph.

Also, the tubular geometry converts levitation forces (as present with flat horizontal armatures) to magnetic bearing forces. This self-centering aspect of the armature in the coil allows for closer proximity of the stator to the armature and greater forces. At low velocities, wheels can be used to support vehicle weight.

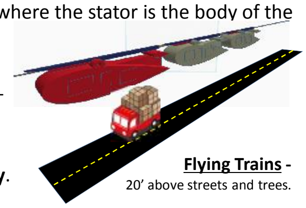


Hanger Design and Factory Installation – At least two approaches (right) will provide reliable and robust cable connections that leave most of the cable circumference unobstructed. Both use sacrificial polymer cores that are at least partially removed at connector locations to make space for the connector hardware. The figure to right illustrates the two approaches, a->b for a wire rope and c->d for three cables held parallel with retainers.

Research Objectives - There is reason to believe that breakthrough higher levels of linear motor performance are possible than exhibited with current/available motors, especially due to the inherent "magnetic bearing" and "tensile-straightening" capabilities as well as the efficiency cooling of 90, 180, and 360 mph air passing the short stator during transit.

Exciting possibilities emerge due to the need for complex electromagnet core needs and heat exchange opportunities. These topics including manufacturing methods for self-assembling cores, coil designs for ultra-fast steady-state heat transfer, and unibody casting/molding methods where the short stator cores and bodies are formed around coils.

It is possible to make short stators less than 1 inch thick where the stator is the body of the linear motor running along the cable. That stator/body is the chassis of the vehicle, and that chassis could realized unprecedented performance in the form of low-profile and low weight.



Flying Trains -
20' above streets and trees.

Cable/hanger topics are covered under **Cable Technology**.

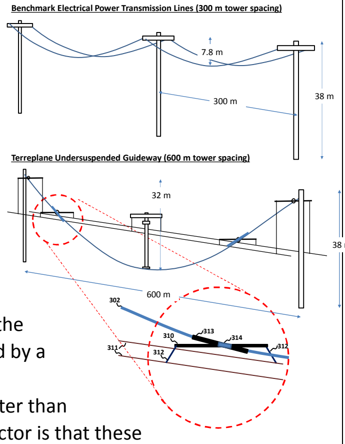
(R&D Continued)

3. Cable Technology

a) Cable Drop (Sagging) - A force balance and Newton method calculations led to the following conclusions relative to cable drop/sag:

- for steel wire rope, a tension of 10% of the steel cable's nominal maximum tension is sufficient to set spacing at 6 meters between guideway hangers,
- a 7.8 m drop at 300 m spacing is consistent with electrical transmission lines, and
- for a support cable supporting the weight of both itself and an equal diameter guideway cable, a 32 m drop (20%) occurs for 600 m spacing between towers.

These calculations lead to a base case guideway infrastructure with towers spaced at 600 m (about 0.4 miles, see figure). This spacing can increase if the towers are at high points in the route.



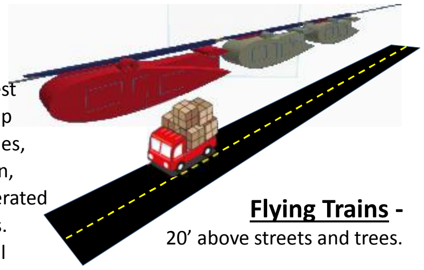
b) Cable Tensile Strength Requirements – an analysis of drag forces, stalled vehicle weights, and acceleration needs was performed to identify tensile strength requirements of the wire rope guideway and support cables. The conclusions were as follows:

- Spacing of vehicles/trains should be no less than 2 lengths where 200 lb/ft load on the guideway of stalled weight can be supported by a 1.5" diameter cable,
- Acceleration demands (0.2 g-force) are greater than drag demands where the most important factor is that these forces are additive for sequential vehicles and so a guideway tension-transfer (see insert) method is needed.

Research Objectives – Wire rope has established itself as a prominent approach to provide the requirements of this type of guideway infrastructure. For electrical power transmission lines, wire rope (cables) infrastructure has costs established at about $2M per mile, based on decades of experience. Research objectives target answering the following questions:

- What is the optimal wire rope (or flexible tube around a wire rope) configuration for effective armature performance to engage the open-sided short stator?
- Can electrical grid power (to power the chassis/vehicle) be transmitted via the guideway cable?
- What is the most effective manufacturing method for attaching hanger connectors to the wire rope guideways that allow free travel of open-sided stators?
- Can interior cable structures support cable weight over moderate distances?

4. A Transformative Technology … worthy of world-scale collaboration



Flying Trains -
20' above streets and trees.

The Terreplane approach to one of the oldest engineering topics (transportation) opens up immense possibilities on reduced travel times, reduced costs, reduced energy consumption, easy routing, sustainability, and even accelerated development of under-developed countries. Possibilities are wide open with incremental advances toward great ends.

Switching Optimization – At 90, 180, and 360 mph, a vehicle-controlled switching process can occur in a fraction of a second by a switch-chassis that can move at high g-forces. This is a critical aspect of non-stop service for door-to-door travel times (typically) less than 20% of today's best alternatives.

Self-Assembling Cores, Molded Unibody Cores/Stators … – Approaches have been identified to build short-stators that are less than an inch thick that exceed the power of today's best linear motors. Such linear motors have a wide range of commercial and transportation applications ranging from horizontal elevators to manufacturing conveyer belts.

Autonomous Vehicles – Advances are being made in autonomous vehicles and respective low-cost and reliable taxi service for short hauls (a few miles). Commuter mass transit systems have not kept pace with these systems, and the opportunity exists for advances in commuter transit (1.5 to 200 miles) to better interface with autonomous vehicles. It would be reasonable and productive to commute 200 miles (and more) on daily basis if the transit occurred at more 180 mph (and faster) in a mobile office environment.

Hyperloop and Beyond – It has been known for nearly a century that travel velocities of 700 mph were possible in low-pressure tubes. The issue has not been whether it is possible, the issue is identifying an economically viable path to establish such systems. Terreplane vehicles capable of >400 mph travel in the open-environment systems with tensile-straightening guideways certainly can establish corridors where tunnel transit, tail-wind tunnel-transit enhancement, and low-pressure tunnels are incremental and self-financed improvements. Terreplane is a path to Hyperloop-type systems (eventually).

Integrated Infrastructure – It is possible to have transportation, electrical power transmission, fiber optic communications, wireless communication towers, and even electrical power generation (wind turbines) combined in a single [guideway] infrastructure. Service could be resilient to hurricanes, earthquakes, snow, wind, and ice. The cost and environmental impact would be a small fraction of the systems built independently.

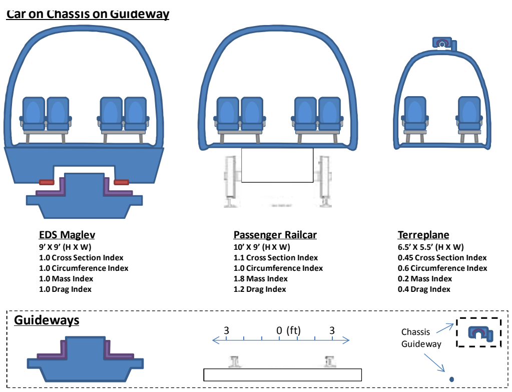
Summary & Path to Commercialization

Summary – A [zipline-type] cable guideway costs less, a lot less than alternatives, but this is only a part of the bigger picture that includes:

- Wingless flying vehicles which generate a tensile force on the guideway that keep it straighter and smoother than what is possible with other guideways.
- Open-sided short stators that that provide contact -free propulsion and guidance with near-zero wear/tear
- A vehicle-controlled switching method that allows non-stop service in a vast network made possible for an ultra-low-cost system, consider:

Cost (/mile)	Rail System
$30 M	High Speed Rail
$40 M	Maglev
>$40 M	Hyperloop
$4 M	**Terreplane**

Cost (/mile)	Large Bridges
$400 M	4-Lane HW Bridge
$4 M	**Terreplane Bridge**



Path to Commercialization – The following have a major impact on the path to commercialization of Terreplane:

- Short (1.5 miles and less) and isolated routes are viable with the guideway.
- Wheels can be used until open-sided stators are ready.
- Flight and switching are not necessary for lower-capacity isolated applications.
- Guideways can be upgraded by rolling out new guideway for large spools/reels.

These observations translate to the ability to commercialize initial applications at considerably lower cost and risk than alternatives. The next page (right) provides example applications that demonstrate key aspects of Terreplane with total [incremental] costs between $10 and $100 M..

Strategic Demonstrations

The ultra-low cost of Terreplane guideways combined with the low-cost of upgrading guideways allows for direct commercialization of Terreplane without typical R&D steps, and allows for incremental improvement/evolution directly on commercial systems. The following are examples of isolated applications that could be designed and implemented today… then upgraded and extended to become part of an international transportation network.

1) Bridge Capacity (Savings of $350 million) – The weight of the terreplane guideway is a small fraction of a percent (e.g. 0.01%) of the weight of a 4-lane highway bridge. Even the stalled weight of ultra-light vehicles with passengers a similar small fraction (e.g. 0.1%) of weight. **Result -** a Terreplane commuter line can "piggybacked" on existing bridges. This eliminates the environmental impact of a new bridge and can same a city hundreds of millions of dollars on an initial application. Ideally, the system would terminate at downtown locations served with autonomous vehicles.

2) SABET (Same As BEing There) Applications (Free) – On-demand service similar to Uber (different prices for ride-share versus dedicated vehicles) with reliable transit times of less than 5 minutes, distances up to 7 miles, and service into 3rd floors of buildings offers something no other transit system has been able to offer to date. It offers SABET.

- (Superports) Airports and Train Stations of a city could offer guaranteed interconnection times of less than 15 minutes allowing them to function as a single superport.
- (Horizontal Elevators) Low-cost real estate located miles from downtown/harbor/ Riverwalk locations with Terreplane horizontal elevators would lead to real estate values approaching the most prime of locations.
- (Commuting) Commuting times of more than 15 minutes would be a historical artifact, unless the commuter lives hundreds of miles away and values the controlled Terreplane cabin as a work environment.
- (Redefined City) Neighboring cities would fu… concept a city would eventually be redefined.

Common Airport Train	SABET Terreplane
> 20 minute transit	< 8 minute transit
Departs Every 20-45 min.	Departs on demand
Arrive early (19-44 min.)	Arrive just In time

Travel Times*

Downtown is **SABET** the airport (5 minutes travel time).
Urban areas are **SABET** downtown (5 minutes).
Philadelphia is **SABET** New York City (18 minutes).
Los Angeles is **SABET** Las Vegas (40 minutes).
Miami, Ft. Lauderdale, and Ft. Myers are **SABET** (18 minutes).
JFK, Newark, Penn Station, and LaGuardia are **SABET** (10 minutes)
…**NEW YORK -TO- DC IN 35 MIN.**

* Does not include up to 5 minutes walking time, each end.

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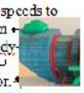
DISPLAY MODELS

Linear Motor

This half-scale model is of the open-sided coil linear motor which provides propulsion and guidance. Power is increased by adding more units in series. For example, four units would work for an 8-passenger vehicle at speeds to 200 mph. Wheels are for suspension when velocities are too low for full vehicle aerodynamic lift. A cut-away shows one of the several open-sided coils in the linear motor.



The technologies advanced by this system have many applications (including railway linear motors). An **Arm** connects to a hinge joint and pulls the vehicle.

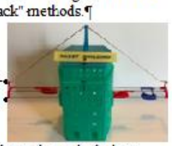
Guideway

The guideway display illustrates how a connector is smooth with the guideway. The plastic representation of wire rope passes through the linear motor display.

Bridge Piggyback

Compared to the structures and slabs of today's bridges the weight of the Terreplane system is negligible. For a 1 mile bridge, this approach could save a city about $400 million by avoiding the construction of a new bridge. This is one of several possible "piggyback" methods.

SABET Building (Horizontal Elevator)



Same As **BE**ing There technology will change cities as we know them. Lack of contacting/moving parts (lack of noise/vibration) and aerodynamic design allows vehicles to go directly into lower floors of buildings. Distances 5 miles distant are less than 4 minutes away. This provides easy access to downtowns, harbors, and airports for real estate located miles away. Airport systems can go directly to gates.

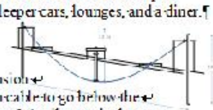
Flying Car

This configuration illustrates an 8-passenger car (and chassis/carriage in a full aerodynamic lift where the hinges of rotation are aligned with the guideway. The vehicle swings downward (relative to chassis and guideway) to a stable position when not in flight.

Train Car

The length of a vehicle can be extended by adding features that direct air downward during travel (momentum theory of lift). This display illustrates how train car luxury is not necessarily lost with Terreplane. A 10-hour Pan-American trip to Chile could include sleeper cars, lounges, and a diner.

Underspanned Suspension



Underspanned suspension allows the suspension cable to go below the guideway, allowing for 0.4 mile standard tower spacing with spacings in excess of 2 miles between high points. Crossing rivers and mountains is relatively easy and inexpensive.

Car Interior

Widths as low as 5 ft will allow easy access for 8-passenger vehicles. As with the history of setting railway track gauges, different criteria lead to different corridor/vehicle widths. The best way to address this and the expected improved technologies is to allow easy replacement of the wire rope guideway (e.g. reels/spools of mile-long sections of guideway with quick-connect connections to permanent suspension cables).

Aerodynamic Models

Wind tunnel experiments were performed on these models to measure lift as a function of air velocity and vehicle pitch. The conclusions were that higher noses and lower tails lead to greater lift. A spoiler increases lift. Wings may extend off sides of vehicles, but that is to be avoided.

FREEDOM TO OPERATE

The PCT (Patent Cooperation Treaty) application of December 2015 (with 12/30/14 priority) has undergone initial examination by the patent office and provided an initial assessment of patentability from which freedom to operate (FTO) has been established.

FTO Summary

Patents dating as far back as 1966 connect with the concept of winged flying vehicles on a guideway system. The expired patents provide FTO for the basic concept of flying vehicles on guideway systems. None of these earlier systems identified important aspects of: a) wingless vehicle flight, b) ultra cheap guideways, or c) low-maintenance linear motor propulsion.

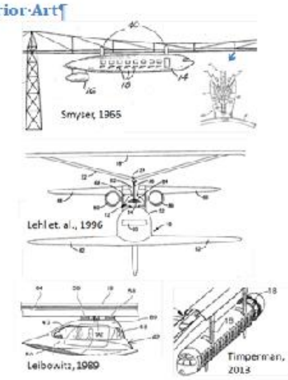
Claims to Patent

Terreplane's claims to patent enable the following relative to prior art: a) inexpensive cable guideways where only longitudinal pulling forces are applied to the guideway during normal transit, b) easy routing due to low noise, tower spacing starting at 0.4 miles, & no wings, c) breakthrough light-weight linear motor propulsion, and d) efficient vehicle-controlled guideway switching.

Our claims to patent include the following.

1. Wingless guideway-based flying vehicles where at least a third of the lift is from the front third of the vehicle (high nose, critical for reasonable Lift/Drag ratios).
2. Open-sided coil linear motor stators capable of operating on wire rope guideways (self-centering cable armature in short stator, critical for low noise and low maintenance).
3. Novel cable connectors that preserve cable strength while leaving 90% of the circumference unobstructed.
4. Novel self-assembling magnet core technology that reduces cost and weight of linear motors.
5. Novel high-speed vehicle-controlled guideway switching method (critical for non-stop service needed for high speeds of flight).

Prior Art



Prior art has had problems that limit their attractiveness for commercialization. Those that claimed flight used wings which widen the needed guideway corridor. Several used jet engines which are unacceptably noisy. In general, the guideway structures of these systems are just as expensive as for monorail trains (quite expensive).

Patent Position

We have over a dozen patent applications have been combined into two PCT patent applications (PCT/US/67799 & PCT/US17/61003) with several awaiting conversion to a third PCT application. Terreplane Technologies, LLC (in collaboration with Homeland Technologies, LLC) is advancing the research and development and pursuing commercialization. Technologies are assigned to The Suppes Family Trust and are available for license. Licensing is available based on market sector and country.

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