Title: AirTrac Transportation vs. Vacuum Tube Transportation Systems
White Paper

Date: 02 Feb 2020

Author: Sherman Couch, AirTrac Transportation LLC
sherman.couch@airtractransport.com

Executive Summary:

This document compares two next-generation transportation systems; AirTrac and Vacuum Tube Transportation (VTT). There are a variety of VTT concepts that have captured the popular interest in recent years. Some of those systems are variously called in the popular press: “Hyperloop” systems.

While both AirTrac and VTT are high speed transportation systems, they are not equivalent systems. This document allows rapid comparison between the two systems. Where each system has an attribute which is favorable toward that system, a green check mark (✓) is placed. Each green check mark is a positive attribute or “feature of merit”. Here is an unweighted breakdown of the relative features of merit of the two systems:

System	Number of features of merit
AirTrac Transportation	50
Vacuum Tube Transportation	6

Note: The author recalls the tragic fire taking the lives of Apollo I astronauts White, Grissom, and Chaffee on Feb 21, 1967. Had they been able to rapidly egress their capsule, they would have survived. Considering that the base concept of VTT systems is a manned capsule being hurled through a vacuum enclosed in a steel tube, the author suggests that there are fundamental hazards with VTT systems which may never be reduced to adequately low risk.

THIS PAGE INTENTIONALLY LEFT BLANK

AirTrac System vs. Vacuum Tube Transportation Concept

SYSTEM CONSIDERATIONS

	AirTrac System		Vacuum Tube Concept	
Feature	**Attribute**	**Impact**	**Attribute**	**Impact**
Primary transit environment	✔ Elevated above ground level	Open view	✘ Inside a steel tube	Claustrophobic environment
Vehicle type	✔ Vehicle suspended from Guideway	Coordinated turns, comfortable ride	✘ Enclosed pod	Turns banked for specific speed is TBD
System Type	✔ Regional true mass transit system	Can remove 30% cars trucks from highway	✘ Regional, possibly a mass transit system	Arguably limited ability to move large numbers of folks.
System complexity	✔ Low	Economical to Build & Maintain	✘ High	At least 4-8 times the complexity of AirTrac – e.g. valves, pumps, ingress stations, egress stations ...
Years to deploy	✔ 3 – 5 Years	AirTrac does not require new technologies, rather it re-purposes existing aerospace technologies	✘ 10 – 50 Years	System requires solving many new “break-through” technologies; e.g. capsule, life-support, egress, solving tube thermal expansion/contraction (0.2 miles / 250 mi track), fire suppression. etc.
Cost/Mile	✔ 15-30 million	Affordable to Build and Use	✘ Forbes estimates 121 Million/mile	Likely to be similar to expensive HSR. California HSR pushing $100M+ per mile
Vehicle Power	✔ Self contained	Green fuels or battery electric; not grid dependent	✘ Magnetic/electric suspension, linear electric propulsion and vacuum pumps	Green fuels or electric, grid needed along the entire track
Lift Noise	✔ Air cushions	Muted in guideway away from passenger vehicle	✘ Mag lev	Shanghai's mag lev train produces noise; 80% of HSR.
Propulsion Noise	✔ Low fan noise	Aft of Passenger compartment	✘ Mag lev	Increasing roar as speed increases past approximately 150 mph (Shanghai's mag lev evidences the fallacy of silent mag

AirTrac System vs. Vacuum Tube Transportation Concept ***SYSTEM CONSIDERATIONS***				
	AirTrac System		**Vacuum Tube Concept**	
Feature	**Attribute**	**Impact**	**Attribute**	**Impact**
				lev)
Air Noise	✓ Moderate	Boundary layer removal lowers moderate speed air noise.	✓ Low	Vehicle rides in an evacuated tube.
Power Transmission	✓ Unnecessary, power is self contained	No transmission infrastructure	✗ Electrically powered guideway & pump system	Transmission infrastructure required

AirTrac vs. Vacuum Tube Transportation Systems

CABIN CONSIDERATIONS

	AirTrac			Vacuum Tube Transportation Systems		
Feature		**Attribute**	**Impact**		**Attribute**	**Impact**
Vehicle diameter	✓	159 inches	Seat width standard	✗	84 inches	Seat width pod seating - narrow
Passenger Compartment	✓	Aircraft style	Improved human factors; real visibility, comfortable	✗	Canister style	No real visibility. Claustrophobic?
Seating	✓	3 + 3 + Center aisle, or 3 + 2 + Center aisle.	Comfortable	✗	2 + 1 + aisle	Rather close.
Passengers per vehicle	✓	100	Great capacity	✗	40?	Limited capacity
Cabin entry	✓	IN on one side	Fast ingress	✗	Spacecraft capsule style entry, 1 or 2 entry doors	Slower ingress
Cabin exit	✓	OUT on opposite side	Fast egress	✗	Spacecraft capsule style exit, 1 or 2 entry doors	Slower egress
Passenger guidance	✓	Single file each seat row	Fast ingress	✗	Single file, everyone	Slower ingress
Loading time	✓	1 minute (like subway)	Folks don't stand around long	✗	Similar to 40 passenger aircraft	Slower loading time
Departures sequence	✓	Load, close doors, leave	Smaller simplistic station.	✗	Load, Pod enters magazine, indexes, enters tube, tube valves close & open, launch	Larger complex stations. Excess costs.
Departure frequency	✓	every 60 sec on dense route	More than a mile separation between vehicles	✗	Unknown.	Multiple sequences in loading, TBD separation between vehicles

AirTrac vs. Vacuum Tube Transportation System

CORRIDOR CONSIDERATIONS

Feature		AirTrac Attribute	AirTrac Impact		Vacuum Tube Transportation System Attribute	Vacuum Tube Transportation System Impact
Corridor Capacity	✓	Up to 6,000 passengers per hour per direction	More like a conveyor. True mass transit	✗	Unknown	Transit for the folks or transit for the elite?
Corridor Placement	✓	** Reuse of existing freeway right of way. ** Cross country, overhead of agriculture. ** Other modes can be contemplated.	Creation of regional networks with high speed switching	✗	Nearly straight line from point A to B to achieve speed	Difficult to construct a true mass transit network. Switch complexity.
Corridor Termination	✓	Loop	Minimum turn radius (143 yards) enables two way traffic	✓	Loop	Minimum turn radius not known. Two way traffic enabled
Corridor Layout	✓	Layout can be similar to expressway, or follow the nap of the earth, or avoid homes and other improvements, all the while not preventing a 200 mph max speed	Facilitates corridor construction almost anywhere	✗	Corridor must have high radii of turns. Almost a straight line between point A and B.	Tube placement makes it difficult to avoid forced removal of improvements (e.g. homes, parks, cemeteries) or attractive features of the natural environment. Additionally tubes must be very slow change in elevation or direction at max projected speed
Land Usage	✓	One acre per mile is the total footprint for tower bases.	Buy or lease from land owner. Land owner will love the income.	TBD	Right of way must be continuous, without breaks.	May cut landscape in two. May not be economically feasible.
Ground Clearance	✓	Environment dependent: Min. 20 Ft.	AirTrac towers are vertical structures carrying light loads, resulting in minimal overhead structure limits land usage slightly.	✗	Steel vacuum tubes and power lines are heavy structures.	Unknown, but its a heavy structure and slanted piers are contemplated. Piers and support structures are consequentially large.

AirTrac vs. Vacuum Tube Transportation System ***SPEED CONSIDERATIONS***							
		AirTrac			**Vacuum Tube Transportation System**		
Feature		**Attribute**	**Impact**		**Attribute**	**Impact**
Between Cities Speed	✓	200 mph max. Optimum ridership versus speed (MWHSR study)	Minimum time in stations. Total time in transit minimized.	✗	up to 750 mph	Sonic speeds are only advantageous for very long distances.
Interstate Speeds	✗	200 mph max. Optimum ridership versus speed (MWHSR study)	Minimum time in stations. Total time in transit minimized.	✓	up to 750 mph	Assumes a very straight path (both horizontally and vertically), Vacuum tube systems do not turn well at high speeds.
Metropolitan Speed	✓	90 mph	AirTrac is a true metro express system.	**TBD**	Unknown	High speed not possible in metropolitan mode due to acceleration and deceleration distances / times.
Departures/Hour	✓	60 max	6000 people per hour one way.	**TBD**	Unknown	Unknown

AirTrac vs. Vacuum Tube Transportation System ***GUIDEWAY CONSIDERATIONS***				
	AirTrac		**Vacuum Tube Transportation System**	
Feature	**Attribute**	**Impact**	**Attribute**	**Impact**
Guideway Diameter	✓ 84 inches	Minimum profile	✗ 132 inches	High profile
Guideway Type	✓ Trough	Contains lift system	✗ Tube	Contains passengers, life support, lift & power
Guideway Cover	✓ Yes	Weather protection, Solar collector	✓ Above ground Yes. When below ground N/A	Above ground, Solar collector
Support Structure	✓ Vertical/Composite Towers	Easy to place, easy to remove, reasonable costs.	✗ When above ground, heavy concrete piers.	Difficult to place & remove, and expensive to construct.
Appearance of support structure.	✓ Slender and vertical	Good aesthetic threshold	✗ Massive, stubby, costly.	Reduced ascetic threshold
Support spacing	✓ 125 feet	Good aesthetic threshold	✗ Approx. 41 Ft.	Reduced ascetic threshold
Below ground	✗ Only where absolutely necessary	Mountain tunnels	✗ Generally anticipated	More $$$
High Speed Switch	✓ Yes	Forms regional networks	✗ Not yet solved	Technical readiness advancement in jeopardy
Fail safe switch	✓ Gravity assist	Increased safety	✗ Not yet solved	Technical readiness advancement in jeopardy
Switch Velocity	✓ 70 mph minimum	Facilitates route change	✗ Not yet solved	Technical readiness advancement in jeopardy
Guideway Weight	✓ Composites	1/5 the weight of steel & 10 times stronger	✗ Stainless Steel	Heavy and expensive.
Bridge Structure	✓ Light weight composites	Single cable suspension	✗ Steel Pressure Tube	Unknown. Will be significant $$
Soil Compression Loads	✓ Low soil loading	As easily used in swamp as it is deserts and in between.	✗ High soil compression loads	Difficult and costly to use in soft soil environments.
Debris removal	✓ 1/4” Drain hole every TBD feet.	Simple moisture removal, and anti ice features of the vehicle and guideway move the moisture out.	✗ Air pump stations every TBD distance, water naturally pulled into the tubes through fittings, cracks & aging seals.	System naturally pulls water into the system because the tubes are evacuated

AirTrac, Vacuum Tube Transportation System Comparison ***DISASTER MITIGATION***							
		AirTrac				**Vacuum Tube System**	
Feature		**Attribute**	**Impact**		**Attribute**		**Impact**
Emergency Egress	✓	Mode 1: Airline style inflatable escape slides. Mode 2: Vehicle lowers to ground level e.g. lifeboat style davits.	Rapid egress in emergency	✗	Coast or travel to exit portal?		May not get there if pod is damaged or derailed, possibly resulting in large loss of life.
Cabin Fire/Smoke	✓	Use emergency egress	Easy cabin ventilation.	✗	Passengers stuck in a tube without air.		No recourse, no air in tube to ventilate the cabin.
Windstorm consequence	✗	Tornadic winds	Departure delay	✓	Tornadic wind resistant.		NA
Post Hurricane capable	✓	Rides above the flooded terrain	Minimum disruption	✗	Flooding into tubes which are subterranean		Disruption.
Wind driven debris damage (e.g. leaves, pine needles).	✓	Wind blown dibris is carried by air, ergo can be removed by air cushion.	Minimum disruption	✓	Remote		No disruption
Earthquake tolerance	✓	Low: Somewhat flexible guideway and slip joint mitigation	Reasonable repair cycle	✗	Low: Possible slip joint mitigation, tubes are intolerant to bending.		At High speed a bent tube could be disastrous. Protracted repair cycle.
Flood tolerance	✓	Yes	Elevated above max flood.	✗	Flooding into tubes which are subterranean.		Disruption only in subterranean tubes. Elevated lines largely not not affected in a fashion similar to AirTrac.
Moisture in guideway	✓	Gravity moves moisture out of guideway through simple drain holes.	Air cushion also blows water out, snow blown out of guideway by air cushion.	✗	Leaks naturally pull water into tube (because of the evacuation of air / suction)		Pools in tube when impacted by high speed craft, damage is probably more likely.