Aeromobile-Aeroduct Automated People Movers
AAAPM

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I. Abstract

A new modality for automatic people moving is introduced, the Aeromobile air cushion vehicle (ACV) in elevated Aeroducts. Air cushion support of vehicles offers the benefits of Maglev without the severe limitations of a precision magnetic gap, weather sensitivity, high cost of vehicle and ROW, permanent and superconducting magnets, liquid helium, etc. Air is everywhere and can levitate vehicles frictionlessly, economically, and amphibiously, for all weather, in all climates, in all seasons, with perfect guidance. **AAAPM** offers high-speed personal travel totally automated, eliminating all parking, all parking lots, and gridlock. Automated Aeromobile travel can eliminate highway deaths, injuries, and billions of annual hours lost in gridlock. In the **AAAPM**, Aeromobiles in Aeroducts can economically do what Maglev cannot, inexpensively come from one's home to take people to work, school, shopping and return. Even the venerable but deadly family automobile cannot offer the features of **AAAPM**, and may finally be superseded by Aeromobiles. Air cushion vehicles, ACV's, are simple, both the vehicle and their rights-of-ways are very inexpensive, both are mass producible and the system can be economically elevated, with zero pollution of the air and ground.

II. The Status of Existing APM's

Automated People Movers are now limited to amusement parks, inside cities, industrial parks, and college campuses. But, APM's should be ubiquitous, have much higher speed, have much longer-range installations, and serve wider areas. What is needed is an APM to exceed and supersede the automobile with its many limitations to provide citywide, area-wide, and coast to coast travel for all people all of the time. APM's must start at home and return to home.

The typical, conventional APM has wheels on rails, on a monorail, or on a guideway, and is elevated. They are in pods, cars, or trains often with gorgeous intermodal stations. All APM's except the Maglev types, have wheels. Wheels, whether on roads or rails, have limited top speed and mechanical life, a life that is further reduced as the speed increases.

APM systems must go beyond their limited use if they are to realize their full potential as replacement for a transportation system built around cars and roads. It is clear that neither cars nor the roads on which they run will ever permit sufficient traffic for this world of mobile people. It is, therefore, obvious that another modality must supersede automobiles and paved roads to service the demand for fast, efficient commuting. To provide adequate commuting, there must be a sea change in the modality of personal vehicles, and economical **elevation** of ROW's.

For any new modality to supplant automobiles, the commuting public will demand at least the capabilities of their car. They want to start from home and come back home in their own vehicle. To equal and also exceed the venerable automobile, the new system must provide personal **automated** vehicles to take everyone, anytime, anywhere, to and from home and distant destinations with all of the below attributes:

III. The Automobile as People Mover

The Automobile is the best existing people mover. The automobile is not, however, an APM, is not automated or automatable, and is elitist and very demanding of the driver. The car is available provided the driver:

Has a driver's license,
Can afford to own a car,
Is not disabled, is competent, and stays sober,
Has plenty of time for waiting in gridlock,
Can find the destination,
Can find a parking place there,
Can walk to and from the parking place in all security and weather conditions,
Avoids collision with all other vehicles,
Can abide the annual road repair delays, and
Can stay on the road on ice, sleet, or deep snow, with adequate visibility.

Those who are too young, too old, too poor, or too disabled, are prevented from going where they need to go on demand daily by car. For those who meet the requirements for driving a car, the advent of the automobile and paved roads approximately satisfied transportation needs. But as millions of cars poured onto limited road lanes, traffic slowed and many cities are in gridlock twice daily or more. For all these reasons, the automobile does not and cannot provide everyone with sufficient APM mobility.

Automobiles are over 100 years old and have reached near perfection in reliability, user friendliness, and beauty. Great effort has been made to make cars more comfortable, with improved ride, quietness, plus sound systems, etc. The striving to make cars safer has produced seat belts, air bags, ABS, crash-worthy structures, etc. More attempts are being made to "save" the auto as a people mover by expensive add-ons, and more add-ons, such as:

Anti-collision radar,
Lane following,
Auto-parking,
Back-up cameras,
Front and side air bags,
Hybridization for fuel efficiency,
GPS localization,
Adaptive cruise control,
Spin control,
Anti-rollover electronic stability control ($200),
Computerized traction control, ($800).

All of which raise the cost of these obsolete vehicles. It is all an exercise in futility. The car cannot be rendered an APM by add-ons. Cars-on-roads have reached their zenith of performance and cannot be automated. However comfortable and attractive automobiles are, the record of humanly driven, weather-impacted cars on roads is abysmal. In USA there are annually 42,000 people killed, millions injured, and 2 billion productive hours lost in traffic delays. Protecting passengers from potential deaths and injuries in cars is commendable, but the focus should be on total **elimination** of the crashes that kill and hurt people. Elimination of crashes will never be totally effective with either automated or human driven cars on weather impacted roads. There is no alternative to automation of all traffic. And, since cars need constant traction they can never be automated for operation on icy streets. Notwithstanding all these expensive accessories, the automobile is doomed as a commuter vehicle. This faithful old horse needs to be turned out to pasture.

Automating Cars

Attempts have been made to automate cars on roads. In 1997, the National Automated Highway Consortium, and the SAE Future Transportation Technology Conference and Exposition had a demonstration of automated cars traveling from San Diego to Escodito, CA. There were magnets inserted in the road for the cars to follow with very expensive, ($100,000 per vehicle conversion) with computers, software, and servos to follow the magnetic route. In California, only rain will diminish the critical traction for steering, lane keeping, braking, etc. But, in Illinois, and the North we have rain, sleet, and snow to render traction of wheels-on-roads unguidable. Furthermore, guidance of wheels-on-roads is jeopardized everywhere by debris on the road, potholes, human and animal crossing, etc.

The price of car automation will inevitably come down, but the imperfect automation of cars-on-roads does nothing for increasing the critically needed new traffic lanes, or for upgrading the deteriorating road infrastructure. And, automation of existing roads does nothing for the slow maximum speed of cars at speed limit of 70 m.p.h., far too slow for coast to coast travel.

Summarizing the fatal flaws for the current champion people mover - the car and the roads on which the run are the:

impossibility of reliable automation,
need for constant, reliable traction,
slow top speed of 70 m.p.h.,
high cost of building and maintenance of cars (@ $20,000+, $0.50 per mile),
high cost of the roads on which they run (@ $trillions to bring them up to code),
low fuel efficiency with high rolling friction of tires on pavement,
appalling, intransigent parking problem,
atrocious safety record, killing 42,000 people, and injuring millions annually, plus
2 billion productive hours lost in gridlock,
poor record of polluting the air and the ground,
ecologic destruction of the terrain, paving of roads, driveways, and square miles of parking lots,
prohibitably high cost of elevation of roads.

IV. The Aeromobile Aeroduct System

In many years of flying Aeromobiles on a crowned paved road, the tendency of the frictionless craft is to slide off into the ditch. But, in the ditch, the Aeromobile became a different animal; it would go high speed perfectly guided down the ditch hands-off to the end. This was a serendipitous discovery. For the ACV, to become a transportation system, we believe, it belongs in something like a ditch! To improve the efficiency of the Aeromobile in a curvilinear surface, the base and the skirt were tailored to fit the radius of a cylindrical groove. In our demonstration proof-of-concept ACV, the Aeromobile 17, the base and skirt were made to conform to the 76" diameter thin sheet metal groove Aeroduct. The Aeromobile-Aeroduct System of Automated Transportation came alive.

	Here is the Aeromobile 17, with power off, at rest on the sheet metal Aeroduct groove ROW
	The Aeromobile 17 hovering in the 76 inch diameter sheet metal groove. There is about two inches clearance between the skirt and the groove, making this 800 lb. Craft totally frictionless on any surface condition. The craft is moved forward and backward by tilt of the Gimbal Fan (in the rear) and slipstream over the deck. It can be pushed by one finger.
	The Aeromobile 17 making a high speed turn in the 76 inch diameter sheet metal Aeroduct groove right of way, showing a slight bank angle.

Elevated Aeroducts, and the Aeromobiles both are affordable; each costs less than 50% of that of cars and their roads. The frictionless Aeromobile centers itself in the elevated cylindrical groove Aeroduct for perfect guidance. With that perfect guidance, total automation is possible. The amphibious Aeromobiles are all weather operable, indifferent to rain, sleet, or snow, and need no visibility. Being frictionless Aeromobiles can ultimately travel at all subsonic aircraft speeds.

The Air Cushion Vehicle as Transportation

The air cushion vehicle is one of the simplest of all motor vehicles. It has a chassis, a skirt around the base, and a motor fan for lift and propulsion. The physics of air cushion vehicles, ACV's, is straightforward. A fan pressurizes the entire base area of the Aeromobile ACV. As an example, an Aeromobile base 8 ft. x 20 ft. will have a base area of 160 ft. sq. x 144 in. sq./ ft sq. = 23,040 in. sq. The fan must develop 0.1 p.s.i. to lift the craft. 23,040 x 0.1 p.s.i. fan pressure = 2304 lbs. lift. The Aeromobile can weigh 2304 lbs. and be airborne. To improve ground clearance, reduce lift airflow, allow for surface irregularities of the surface, a skirt is added to the periphery of the craft. For a free roving ACV, on planar surface, the base of the ACV and the skirt will be planar.

	
The twin Gimbal A-2000, with both bow and stern Gimbal Fan units for complete controllability.	The one Gimbal A-14, capable of high speed and significant controllability.

In flying a frictionless air cushion vehicle, ACV, the operator finds that the craft will gravitate down hill, will drift with the wind, and if there is any vertical surface at the stern, it will weathercock into the wind. It has zero yaw stability and will drift around on the yaw axis. This is the conundrum that has limited these otherwise marvelous amphibians from wide acceptance and utility the world over for the 50 years of their existence. Aeromobile Inc. has devoted five decades and has built 19 full scale Aeromobiles to solving the problem of ACV control. Finally, in Aeromobile 2000, we developed the Gimbal Fan that creates lift, propulsion, and steering from both the bow and the stern. The Twin Gimbal Fan A-2000 is powerfully controlled to resist wind, grades, and has high speed forward, reverse, sideways and diagonally. To control it in the field, the operator has the ability to direct 100% of the propulsive force in all 360 degrees from both bow and stern. This singular, fundamental,

and essential ACV performance is achieved only in our amphibious 2000 series Aeromobiles.

Amphibious Aeromobiles have traveled at 60 m.p.h. on land and water, but in Aeroducts they have not yet achieved that speed. It will require aerodynamic modifications to allow speeds in excess of 60 m.p.h. But with modifications, as with Maglev, only aerodynamic drag needs to be overcome for the frictionless Aeromobiles to reach all aircraft speeds.

V. How the AAAPM is the Ideal Automated People Mover

I propose these characteristics for the ideal automated people mover, and I will endeavor to show how the Aeromobile Aeroduct System fulfills these requirements.

Be available to take everyone to and from home and distant destinations,
Be cheaper of personal vehicle purchase and operation than cars,
Be cheaper of ROW construction and maintenance than paved roads,
Be inexpensive of elevation,
Be all weather operable,
Be totally automated eliminating driver error,
Be operable by all ages and abilities,
Be frictionless and as efficient as Maglev without the high cost, super conductivity, liquid helium, etc.,
Be able to attain all subsonic aircraft speeds for cross-country travel,
Have multiply replicable lanes of ROW's,
Have zero pollution of the air and ground,
Have zero collisions with zero crossing and intersections,
Have zero fatalities and injuries,
Have soft, smooth ride,
Have automatic parking and retrieval of vehicles,
Have vehicles that are mechanically simple and extremely reliable,
Never have road repair delays.

The discussion that follows interweaves points about the AAAPM system with points about proposed characteristics of an Ideal Automated People Mover

Elevated Rights of Way (ROW)

Even if we could cheaply mass-produce roads, there is limited space remaining on the ground for their location. There can never be enough roads built on the ground for all the cars, and there can never be enough roads elevated to reach that third dimension of exponential increase in lane capacity. Roads cannot be extensively elevated because of the high cost of elevation that is tantamount to bridge building. But, **elevation** is the only way to get the critically needed **third dimension** opened for ROW location, an **exponential** increase in capacity. It is certain that insufficient new roads can be built to handle the burgeoning car and truck traffic on the ground. Roads cannot be extensively elevated, therefore, the most viable of all modalities of **elevation** will supersede roads on the ground.

Elevated roads have to be designed to carry not only the mass, and absorb the accelerations of the vehicles, but also the tons of the reinforced concrete of the road surfacing. Elevated roads must accept the point pressure of multiple tires on the surface. Cars have 4 points on the road surface @ 30 P.S.I., trucks may have 6, 8, or 18, points pressing on, and pounding the surface @ 90 p.s.i. That road surface also sustains traction forces of acceleration, steering, and braking. To prevent flexion reinforced concrete and steel girders must also stiffen the road laterally and longitudinally. Weather, and the defense against weather, such as snow plowing, salting, cindering, etc. further impact the road surface.

In contrast, Aeroducts are subjected to, at most, 0.25 p.s.i. pressure bearing over the entire base of the air cushion vehicle. An Aeroduct, with zero vehicle surface contact, needs to be structured to carry only the mass and the vertical and lateral accelerations of the air cushion vehicles. The Aeroduct surface can be of very thin, lightweight plastic (even transparent), or sheet metal. Minimal stiffening is needed of the Aeroduct surface. Elevated Aeroducts will therefore be far cheaper to build and maintain than paved roads on the ground.

With a mere 0.1 p.s.i. pressure bearing on them, these elevated, **transparent** groove ROW's will have minimal visual impact, far less than elevated highways or rails. They can be erected over existing roads, rails, or go cross-country, go over water, other ROW's, valleys, etc. AAAPM occupies the third dimension of space economically unavailable to paved roads. Aeroducts can be elevated and erected at a fraction of the cost of paved roads on the ground. Aeroducts can be mass-produced and **multiplexed** as traffic demand grows. They can be placed side-by-side, and over each other in that third dimension to provide virtually unlimited new lanes for the ever growing traffic.

In this third dimension realm, Aeroducts are all elevated at different levels so that there will be no intersections or crossings from origin to destination. There is no conflicting ground traffic of pedestrians, children, animals (wild and domestic), cars, trucks, or trains, no potholes, debris, or precipitation problems. Elevation frees the ground surface from disruption. There will be no bulldozing of the ground to remove hills to fill valleys while disrupting the natural flow of water, human, and animal flow. There will be zero collisions with surface traffic, and with automation, zero collisions with other Aeroduct traffic.

Automation

Programming the Aeromobile in the AAAPM system to go from home to any other place in the system is like dialing the telephone. The automatic elevator is a paradigm for automated travel. The AAAPM will automatically move people horizontally around the surface of the earth by "dialing" the Zip Code of the destination. The central computer then plans the routing of the Aeromobile. When the destination is cleared it comes up on-cushion and is propelled at high-speed non-stop through the Aeroducts to the destination.

The mechanically simple Aeromobile air cushion vehicles can be mass-produced far more economically than cars. Manufacturers could mass-produce, elevated air cushion Aeroduct ROW's, transport them on air to the site and erect them. Why would not all car manufacturers want to mass-produce both Aeromobiles and the Aeroduct "roads" on which

they run? Mass produced Aeromobiles and elevated Aeroducts can accommodate and outpace the worldwide demand for point to point commuting which we call APM's. An Aeromobile-Aeroduct Automated People Mover system could be privately financed.

Aeromobile air cushion vehicles in groove Aeroducts, unlike trains on rails, cannot be "derailed", overturn, or diverge at any speed from the Aeroduct right-of-way. They are amphibious and are indifferent to rain, sleet, or snow. With such perfect guidance, and all-weather operability, Aeromobiles can be totally automated.

In the automated program, Aeromobile speed is only limited by the length of the non-stop programmed trip from origin to destination. There will be comfortable acceleration and deceleration. Long, cross-country trips can ultimately be all subsonic aircraft speeds. Coast-to-coast travel will be in hours not days. Traveling at very high speed in your own vehicle with all its beloved accessories and taking whatever you want along, and stopping anywhere is priceless to car drivers. Traveling at very high speed any distance in all weather will be totally novel to car drivers. In light of the airport "hassle factor", airplane, weather, and other delays, high-speed long distant Aeroduct travel could burgeon. (Reference 2.)

With automation comes the ability to program the routing of the Aeromobile from origin, (home) to destination (work, school, doctor's office, the mall, the ballpark, stadium, etc.) and back. There will be a one-vehicle-one-parking-place rule established from which it automatically goes and comes. The owned, leased, or taxi Aeromobile must have one parking place at home. The Aeromobile takes them to work, discharges them, stopping only momentarily, not parking, but returning home for another family member's trip. The Aeromobile can be recalled to wherever the family members are when it is time to take them home. There will be no search for a parking place in all weather. No ground area anywhere needs be dedicated to parking. Elimination of all parking lots increases the value of that land for more productive use.

When the infrastructure is in place and every home, office, and business has an Aeroduct station, it will be possible for anyone to program the Aeromobile to automatically go to any other station in the system. The stations can be designated by a modified postal Zip Code. By dialing in that Zip Code number the computer selects the fastest route to that station. The family member then enters the Aeromobile in the home station, sits down, and presses the "go" button. When cleared to destination, the Aeromobile comes up on cushion and accelerates down the Aeroduct making the programmed turn offs to arrive at the designated station. The family member walks out of the Aeromobile, which immediately returns to the home, station ready for the next trip.

Versatility

The AAAPM will also compete with two other ground transit modalities, truck freight and rail freight. There is no limit to the to be mass carried on air. As an example, the U.S. Navy has ninety 100 ton LCAC's for carrying M1-A1 Abrams tanks and Marines on water at high speed. Aeroducts can be sized and proportioned for whatever load is to be carried. The higher speed and all-weather operability of large air cushion haulers will compete favorably

with air, road, and rail freight. Whether considering local, in-town commuting, cross-town or cross-country, automated Aeromobiles in Aeroducts will "carry the freight" literally and figuratively. It will be possible to intermix all sizes and types of airborne vehicles on the Aeroducts. Even the atavistic automobiles can be carried as "dual mode" on ACV's in Aeroducts.

Economics

Aeromobiles are intrinsically **more fuel-efficient** than any wheel vehicle. Aeromobiles are as frictionless as Maglev, and as fast as Maglev without the high cost of super cooled magnets, etc. They can be electric powered or even **hydrogen** fuel cell powered for minimal or zero pollution. Hydrogen fueling stations can be built into the Aeroduct System.

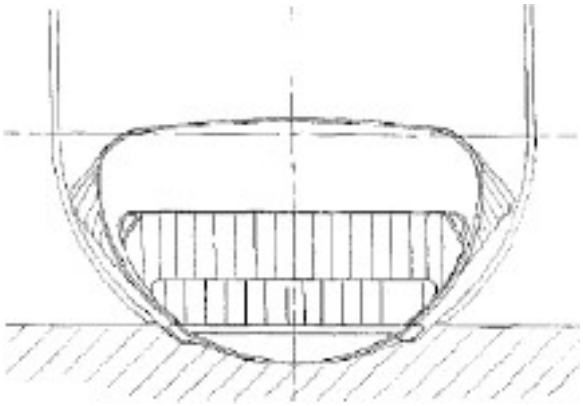
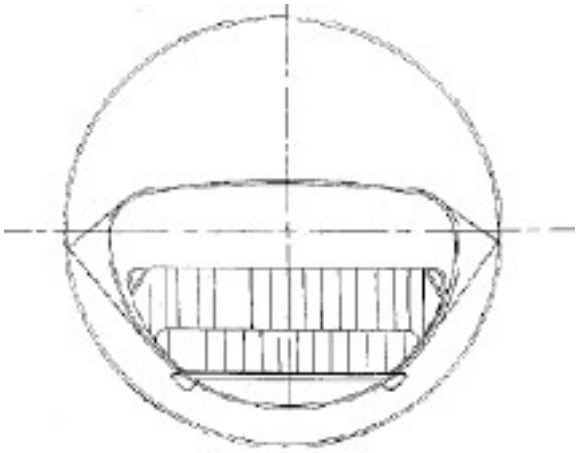
The economics of AAAPM are very favorable. The American Society of Civil Engineers has estimated that the cost of repair of the existing infrastructure of roads and bridges is in the $trillions. It will be less costly to manufacture Aeromobiles and build and install elevated Aeroducts than to repair all existing road infrastructure. The frictionless Aeromobiles in Aeroducts should give both a life of 50 years or more compared to the 10 year average life of road lanes and cars.

Aeroducts are cheaper to build because there is no earth moving, culverts, subsurface preparation, crushed rock, paving with reinforced concrete, drainage ditches, street lighting, signs, striping, or guard rails. Maintenance of Aeroducts will be cheaper because there is no surface wear, salting, cindering, snow plowing, freeze-thaw breakup, or potholes to repair.

The cost of Aeroduct stations and access Aeroduct footage will be comparable to the cost of the conventional driveway and garage. For commercial and public entities, multiple stations will cost no more than the vast parking lot that is displaced.

VI. AAAPM and the Future of Transportation

Aeroducts could be built and erected in an existing city, in an industrial park, on a university campus, etc. that may now have, or consider installing monorail. If planners were to design the whole new city, campus, etc. with the AAAPM, vast saving in concrete, high priced ground space, (including square miles of parking lots), and earth moving can be made. By designating the AAAPM as the prime mover, eliminating all other motor vehicles, all streets, driveways, and parking lots, the new town would be far more compact, more accessible, and far cheaper to build. There would be no motor vehicles on the ground, and people could walk, jog, or bicycle freely without danger of conflict with cars, trucks, or trains. There will be marked improvement in the ambiance, the ecology, the economy, safety, and well being. Residents could then choose to walk to work, to school, to the store, etc. (Reference 11.)

	
Cross Sectional View of Aeromobile in Station, Off Cushion, Doors Closed	Cross Sectional View of Automated Aeromobile Airborne at High Speed, Returning Vacant, in Aeroduct ROW.

Countries with an already substantial automobile and road infrastructure can implement elevated AAAPM's over the top of roadways and over land not yet paved. Developing countries that have not yet devastated their land with roads with obsolete roads and wheel vehicles can install AAAPM's with elevated Aeroducts in lieu of costly and environmentally damaging roads. All countries will gain these benefits:

Low cost vehicles and maintenance,
Low cost Aeroducts and maintenance,
Low cost elevation of Aeroducts,
Economical car size, private vehicle purchase and operation,
Intermixed car size Aeromobiles with bus and truck size ACV's,
Aeroducts ultimately serving private homes, businesses, and all locations.
All weather, all climate operability,
Total automation, automatic parking and retrieval,
Very high speed, ultimately 100 m.p.h.+,
High speed on curves and in switching,
Bilateral handicap accessibility, level vehicle and station floors,
Frictionless fuel efficiency,
Low noise and vibration,
Low visual impact,
Dual mode capability, carrying cars and people,
Massive load carrying capacity,
Perfect guidance without rollovers, derailments, running off the road, etc.
Very smooth ride,
Centrifugal banking on high speed turns,
Zero collisions, fatalities, injuries,
Zero "road" repair delays,
Zero delays in gridlock (Aeroducts replicated according to increasing demand),
Non polluting of the ground and the air,

VIII. Conclusion

Automated People Movers should not be confined to a few limited applications. They should be at the forefront of transportation in the future. The inadequacy of cars-on-roads to provide sufficient new capacity for the ever-growing traffic volume has been well demonstrated. It is a given that a new elevated ROW system must supervene; and we must choose the most viable elevated ROW. The totally adequate Aeromobile-Aeroduct Automated People Mover, AAAPM, can supersede the automobile on roads on the ground, providing all of the specifications of an Ideal APM.

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IX. Addendum

Here are some questions frequently asked about the AAAPM:

1. *How can a Transportation System based on frictionless Air Cushion Technology handle going up and down hills and mountains?*

   A frictionless Aeromobile on a hill will, if unrestricted, "toboggan" downhill very fast. And, the Aeromobile will need powerful thrust to climb steep hills. In the Aeroduct System, to climb or descend hills, there are two ways to "tame" the hill: a) have steps in the Aeroduct, or b) spiral up and down grades with a 3% or so slope.

   The step risers are about half the skirt height, so that, the Aeromobile planes over the step and comes up on full cushion on the tread of the step and approaches the next step. The tread of the step is tilted slightly up hill so that a little power will be needed to go both up or downhill. Climbing hills on steps allows the altitude to be gained by air cushion skirt lift. The low cost of Aeroducts vs. roads makes longer travel in spirals feasible. Either method can be employed for ascending and descending grades.

2. *How much energy is required by an ACV in the AAAPM guideway?*

   The power required for lift of an ACV is about 10 h.p. per ton of mass. This energy is the same amount expended at hover and at very high speed. There will be very little time hovering in and automated AAAPM. The few seconds required for a static Aeromobile to come up on cushion is the limit of hovering in an automated system. The rolling friction of car tires and the internal friction of car drive trains amount to nearly the same energy loss without the benefit of aircraft speeds. (Reference 10.)

3. *How Noisy is an AAAPM?*

   Electric fans for lift and propulsion are quiet and all noise will be focused upward from open groove Aeroducts. In a closed tube fan noise will not propagate outside. Passengers inside insulated Aeromobiles will have quiet ambiance.

4. *How can you anticipate having Aeroduct ROW's built for Aeromobiles when such structures are not yet built?*

   When Columbus came to this continent, there were only footpaths. Soon there were horse paths, then roads for wagons, buggies, and then dirt roads for cars, paved roads, then Interstate highways. It is obvious that the wheels-on-roads paradigm for the 21st Century travel is totally inadequate, and another modality will supersede it. If one modality alone has the attributes of the Ideal People Mover System, it will be built.

X. References

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