The SemiMaglev Urbanaut™ – A New Total Monorail Concept

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Abstract

The SemiMaglev Urbanaut™ technology represents a new innovative, unique, energy-efficient high-capacity total monorail passenger transportation and light freight concept, incorporating all aspects of monorail technology, including vehicles, guideways at surface and elevated, stations, and simple switching. The technology applies vertical levitation forces that vary from 0 – 100% depending on economics and application. Load wheels are partially applied to conserve energy when the vehicle is stationary as is in a station, in the maintenance area, etc. The aerodynamic shaped vehicles, powered by LIM or in-wheel electromagnetic motors, ride on top of a narrow 1.0 meter wide runway at surface, in tunnels, on bridge decks, or on prefabricated elevated guideways. The Urbanaut® technology does not envelope a massive beam way like most other monorails in operation today, so has unlimited flexibility. A uniquely shaped magnetic guide rail, ideal for maglev, is installed in the center of the runway and interacts with magnets in the vehicle to provide combined lift, guidance and stability with easy switching of guideways.

1 Introduction

Figure 1

The Urbanaut® is a light weight, independent, innovative medium-to-high speed Semi or Full maglev transportation system applicable in medians of highways and in densely populated areas, communities and recreation areas where space, pollution and other environmental restrictions do not permit conventional wide-guideway transportation systems. It is adaptable to high, medium and low speed depending on a project's route planning, capacity and economics. The Urbanaut® system has boundless flexibility in planning and application in transportation technology [16].

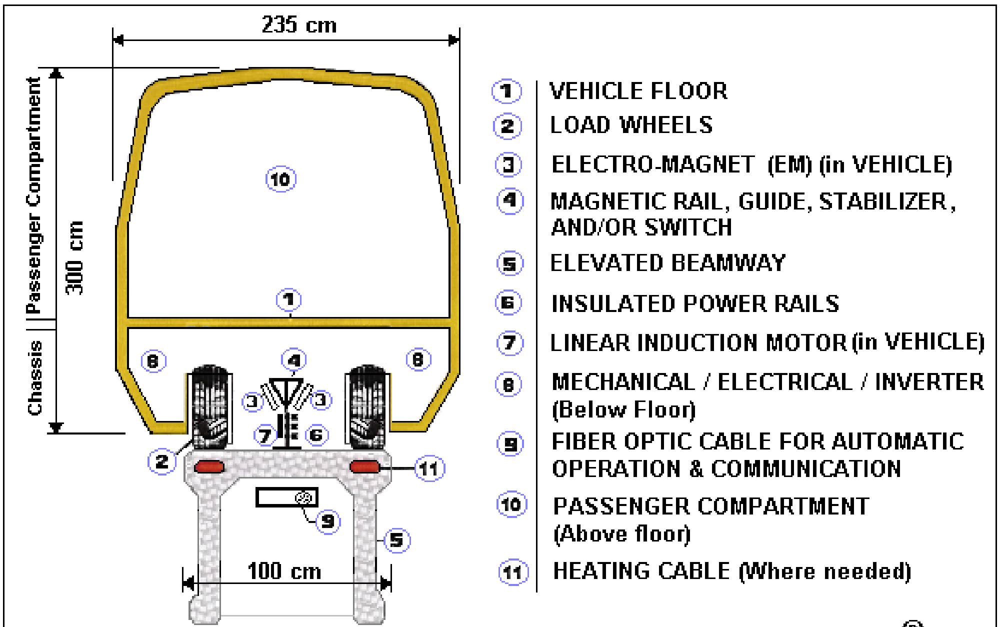
The SemiMaglev Urbanaut™ Monorail is a trade name of The Urbanaut® Company, Inc. There are numerous issued patents and patents pending worldwide on all aspects of the technology, including two issued in China. The concept is unique in several respects and is **the only monorail in which a smaller vehicle operating on a smaller guideway can be seamlessly integrated with and switched onto a larger higher capacity system** [3][18][19].

By applying the simpler new SemiMaglev Urbanaut™ total monorail technology, with its small vehicle and guideway, **the high cost of conventional construction of massive maglev guideways** [2][4][9]

and vehicles can be reduced considerably. The safety and stability of the Urbanaut® system has been determined by extensive engineering studies and large scale model testing of vehicles and guideways.

2 New Technology

2.1 Basic Principle of the SemiMaglev Urbanaut™



BASIC PRINCIPLE OF THE SEMI-MAGLEV URBANAUT®

Figure 2

The SemiMaglev Urbanaut™ system is not dependent on a massive enveloping beam way as other monorails, but utilizes a narrow runway which can be on an elevated beamway, a slab at surface or subsurface. No parts of the vehicle will extend below the top surface. Electric automatic light weight maglev vehicles that ride on top of the runway are guided and held in place by **a single center magnetic rail**, which also serves as a simple switch for guiding vehicles from one guideway to another. The magnetic contacts along the guide rail make the system ideal for maglev at low, medium and high speed applications. The technology is adaptable to semi-maglev or full maglev concepts, depending on application and economics [18].

2.2 Dynamic Stability of the Vehicle

Ideal for maglev, a center magnetic rail with a uniquely shaped head (Fig. 3) dynamically guides and stabilizes the vehicle against excessive wind and centrifugal lateral forces. The guide rail head configuration locks the vehicle to the guideway and derailment is virtually impossible. Unique shapes of the head of the guide rail allow for a magnetic air cushion that provides guidance and lift of the vehicle.

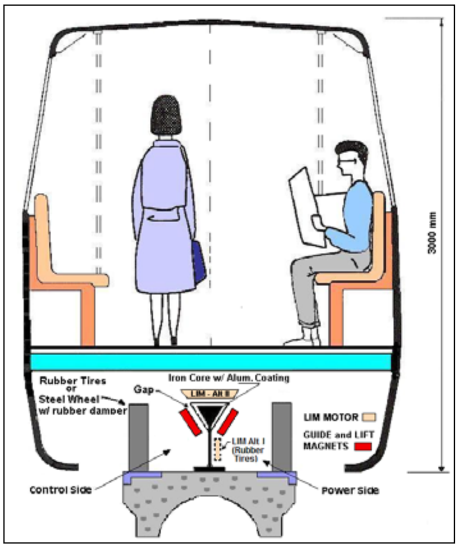


Figure 3

3 SemiMaglev Urbanaut™ Vehicle Bogies

3.1 Comparison of Conventional Rubber Tire and SemiMaglev Urbanaut™ Vehicles

Figure 4

Figure 4 is a photo of a typical Single Urbanaut® vehicle illustrating size and shape of 2 types of compact bogies:

1) A rubber tire wheel bogie in front (at left) and
2) A SemiMaglev Urbanaut™ bogie, in the rear (at right) on an elevated guideway.

The basic difference between the 2 bogies is that for the SemiMaglev bogie the inclined guide wheels are replaced with electromagnets that maintain an air gap with the inclined faces of the guide rail. The photos are of large scale operational test models with in-wheel lightweight EM (electromagnetic) or LIM (linear induction motor) propulsion bogies. The tests show superb stability, exceptional low aerodynamic and frictional resistance.

3.2 SemiMaglev Urbanaut™ Bogie Components (See Figure 5)

A SemiMaglev Urbanaut™ vehicle has 2 confined maglev bogies, located in the front and rear ends of the vehicle. The 2 bogies are the most important components (the "brains") of the vehicle, and also, by far, the most complicated portion of the vehicle. Special pockets in the chassis have been designed and engineered for easy installation, service, and removal of the bogies. The bogies are the link between the concrete runway and vehicle body above it with the primary suspension being air bags in the 4 corners of the bogie. The SemiMaglev Urbanaut™ primary bogie components and functions are as follows;

3.2.1 Service Load Wheels to Preserve Energy – SemiMaglev Technology. The 2 bogie load wheels can be partially loaded for safety, to save energy and to simplify operation. While the vehicle is at stations, in service, during switching, etc., there is no vertical levitation energy used. Weight from the load wheels is transferred from the vehicle bogie frame to the concrete runway below.

3.2.2 Combined Guidance and Magnet Lift. All lateral forces such as centrifugal forces and wind acting on the vehicle are transferred to the center guide rail. The guide rail forces are transferred to the structural guideway below. Air cushioned magnets in the vehicle bogie interact with the magnetic guide rail, and steer the vehicle along the guideway; they are angled approximately 30°, acting against the center guide rail, and create **combined guidance and lift of the vehicle**.

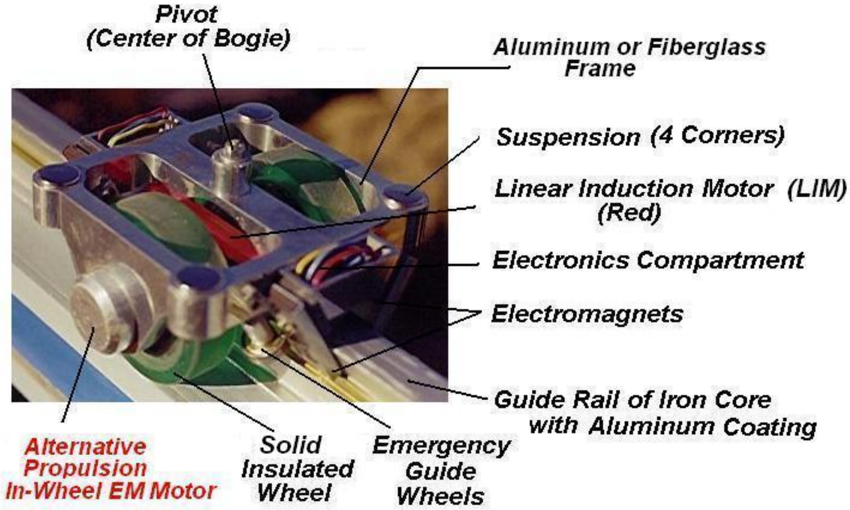


Figure 5 SemiMaglev Urbanaut™ Bogie Components for LIM Propulsion

3.3 Three Alternatives of Propulsion Systems

The SemiMaglev Urbanaut is a highly flexible technology in which a typical bogie has been engineered and designed for 3 alternative types of optional propulsion systems [14][18], which are illustrated in the following. An air cushion guidance is typical for all of these, eliminating numerous guide wheels which are a large annual maintenance cost for other type of monorails;, for example, the Hitachi monorail applies 48 rubber tire guide wheels for a 4-car train that need replacement several times a year.

3.3.1. Alternative I - In-wheel Electromagnetic Propulsion Motor for rubber tire traction, for speeds up to 100 km/hr (Fig. 5)

The In-Wheel Electromagnetic Motor Propulsion alternative is a simplified SemiMaglev Urbanaut™ concept adaptable to vehicle speeds up to 100 km/hr when station stops are 1.5 km apart. It implies traction between the rubber tire and the runway at all times and an EM air-cushion guidance that during operation can partially levitate up to 75% of the vehicle weight to save on cost of energy.

A powerful In-Wheel Electromagnetic Motor provides propulsion with direct traction on the wheel hub for load wheels that have brakes, but no axles and no gears [11][18].

A bogie can have an Electromagnetic Motor for each load wheel depending on vehicle size and power requirements. For example, in a 3-car train the propulsion will be by 4 motors, 2 on each of the bogies within the outer ends of the front and rear cars. (Fig. 9)

3.3.2. Alternative II: (ElectroMagnetic System (EMS) Application of Linear Induction Motor (LIM) Propulsion for speeds up to 300 km/hr. (Fig. 6 -Alternative I))

The SemiMaglev Urbanaut™ EMS is unique to the Urbanaut® Monorail only, and is a considerably simpler and less costly concept than a full maglev system. This alternative utilizes a Linear Induction Motor (LIM) propulsion system, and a pair of electromagnets (EM) that interact with the inclined faces of the guide rail to guide and lift the vehicle.

The Urbanaut® (LIM) version consists of two primary components:

1) The **Primary Coil Stator** (Moving component installed in the vehicle) is the LIM, which is basically an ordinary rotary motor that has been opened, rolled out and flattened in shape. The LIM motor is part of the SemiMaglev Urbanaut™ Bogie.

2) The **Secondary Conductor** (Stationary component) is the magnetic reaction guide rail. The guide rail which is part of the guideway is made of magnetic iron, with the top surface and 2 vertical sides of the rail coated with a 5 mm thick aluminum or copper plating, which serves as an electrical conductant. This is a very simple technical and practical arrangement for a maglev vehicle that is locked to a monorail guideway.

The interaction between the two components (the moving and stationary) takes place across a small air gap less than 10 m/m. There are no mechanical frictional contacts, no axle, and no gear, which are major advantages of an LIM.

Electric power to the primary stator in the vehicle is provided by an outside source, which can be contact power rails along the guide rail or a non-contact source.

The *LIM together with an Inverter* represents a propulsion system that ensures propulsion, acceleration, deceleration, braking, stopping and operational control of the vehicle. While LIMs used in rail transportation apply contact steel wheels for guidance, the SemiMaglev Urbanaut™ utilizes an electrommagnetic air cushion, where a small gap along the inclined faces of the guide rail is maintained by a constant current in the EM by means of an active controller.

Alternative II - ElectroMagnetic System (EMS)
Maglev Interaction between EM and Magnetic Guide Rail

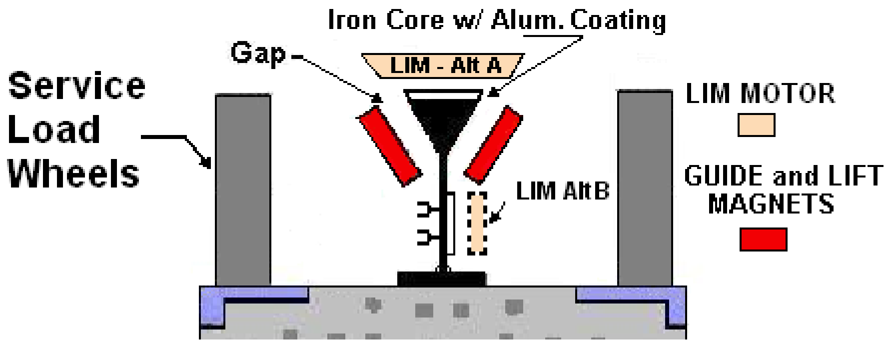


Figure 6 -Alternative II

There are several potential locations of the LIM motor unit in the bogie.

a. LIM Interaction with Top of Guide Rail – Applying Insulated Steel Load Wheels
For high speeds, 2 insulated *partially loaded steel wheels* are applied for variable speeds up to 225 km/hr when station stops are 6.5 km apart. The LIM unit is attached to the underside of the longitudinal cross brace of the bogie, (Fig. 5) interacting magnetically with the top portion of the guide rail. In this alternative location a Maglev Linear Induction Motor (MLIM) is applied. This MLIM has a repulsive force approximately 135% of the propulsion force which will reduce the demand for levitation energy [14] by the EM magnets.

b. LIM Interaction with Vertical Web of Guideway Applying Rubber Tire Load Wheels
This alternative [13] applies *air cushion rubber tires* which, during partial weighting of the load wheels, may slightly deflect. The LIM is located in the vehicle so it faces the vertical web of the magnetic rail. The surface of the web has a 5 m/m aluminum or copper coating for electrical conductance**.**

Advantages of LIM

1. Can be custom made to shape and size
2. Traction is not by adhesion
3. Vehicle can climb steeper grades
4. Needs no wheels, no gear, and no axle.
5. No mechanical links
6. No contact friction

3.3.3. Alternative III - Electrodynamic System (EDS) - Applying Permanent Magnets (PM) in the vehicle and coils (LSM) in the guide way for speeds up to 500 km/hr. (Fig. 6 – Alternative III)

Alternative III - Electrodynamic System (EDS)
Providing Levitation, Guidance and Propulsion

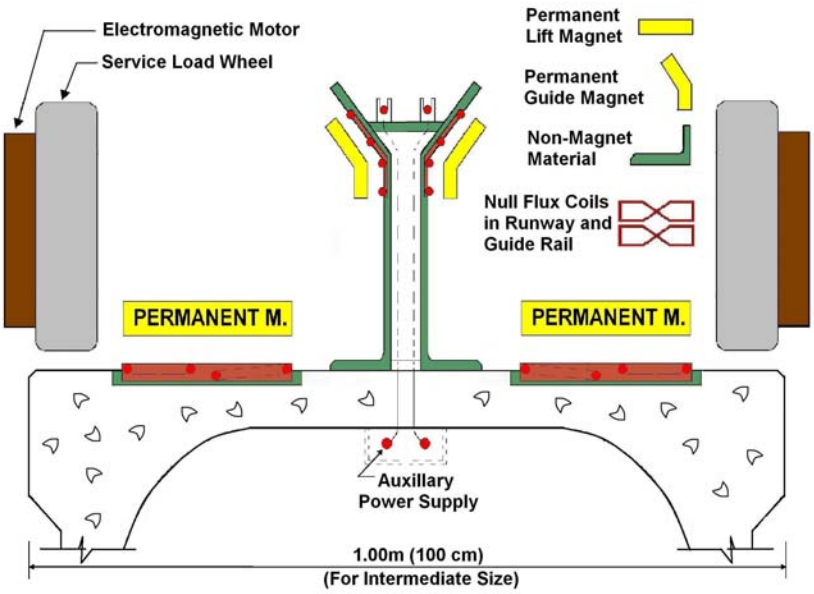


Figure 6 - Alternative III

Permanent magnets (PM), such as the Halbach type, are known to have a larger concentrated magnetic force than regular magnets. They are used as permanent magnets for an Urbanaut® Electro Dynamic (EDS) system. These magnets are arranged in a Halbach Array, where the internal magnetic orientation of each bar is at a right (90°) angle to adjacent bars. They also have the advantage that only one face (side) of the bars (facing the coils) is magnetic.

In the Urbanaut® vehicle's EDS, the PM is mounted to the structural frame of the aluminum bogie and is the ***traveling part*** of the EDS system. The PM interacts with the closed packed parallel coils, the ***stationary part,*** installed in the runway. One row of coils on each side of the central guide rail (which is made of non-magnetic materials like aluminum or fiberglass) is embedded in the prefabricated Urbanaut® guide way. The stationary part commonly is referred to as a **Long Stator Linear Synchronous Motor (LSM)** since it extends the full length of the guideway.

The interaction between the PM and the null-flux coils [22] in the runway creates an electric current in the coils which generate a powerful Repulsive Force (RF) that levitates the Urbanaut® vehicle approx. 2 cm. Such an RF can be maintained without any outside electric power. *It represents Passive Magnetic Levitation (PML)*, for which the cost of power needed for propulsion is considerably less than for an Electromagnetic System (EMS). An NdFeB type magnet can create a repulsive force of 50 times the magnet weight, (or 4 kilograms per square centimeter of the magnet area).

To function with such an EDS as described, a stationary vehicle is dependent on an outside energy source to *initiate a starting movement* of the vehicle, at which time increasing acceleration and speed is activated by magnetic interaction between the PM and the LSM. The Urbanaut® utilizes a patented in-wheel small Electromagnetic Motor (EM) to provide the initial movement. [18]

Outside electric power to the EM is provided by small power rails along the guideway, which also supplies on-board auxiliary power for control, lighting, air conditioning, etc. The Electromagnetic motor also serves as an emergency propulsion power when going through switches and in maintenance facilities where the coils in the runway are eliminated. This makes the operation much simpler with considerable savings in construction and operation costs. Wide guideway Maglev Systems have not yet demonstrated an operational switch, which will become complex and expensive. For example the 22 km Seattle Monorail planned for the rubber tire Hitachi Monorail will have 30 massive switches.

3.34 Urbanaut® Vehicle Guidance and Stability.

For guidance the Urbanaut® EDS applies smaller Permanent Magnets in the vehicle bogie and coils along the inclined faces of the guide rail, a similar arrangement and principle as applied for the runway.

An arrangement of a smaller pair of PMs in front and rear end of the bogie interacts with a row of coils along the 2 faces of guide rail creating Repulsive Forces, of which one force component provide horizontal guidance and a smaller second component creates a downward force which has a preloading effect on stabilizing the vehicle for a smooth ride.

4 Vehicle Sizes and Trains

Three different scales (Full, Intermediate, and Small) of the SemiMaglev Urbanaut™ have been designed, engineered and model tested.

4.1 Urbanaut® PRT Vehicle - Small Size

The low-profile PRT (Personal Rapid Transit) version features vehicles that can seat 10 passengers or 6 passengers plus a wheel chair. The Low Profile vehicle is unique since the vehicle height from floor to ceiling is less than the average passenger's height. A central sliding or overhead doorway on each side of the vehicle covers half the cross section of the vehicle [18].

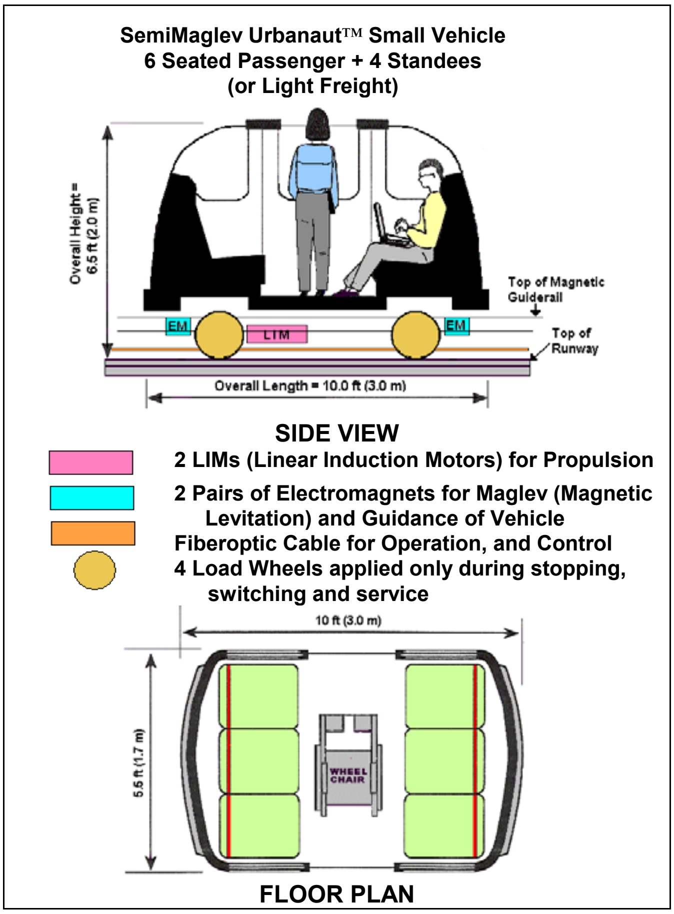


Figure 7

4.2 Single Vehicle – Intermediate Size

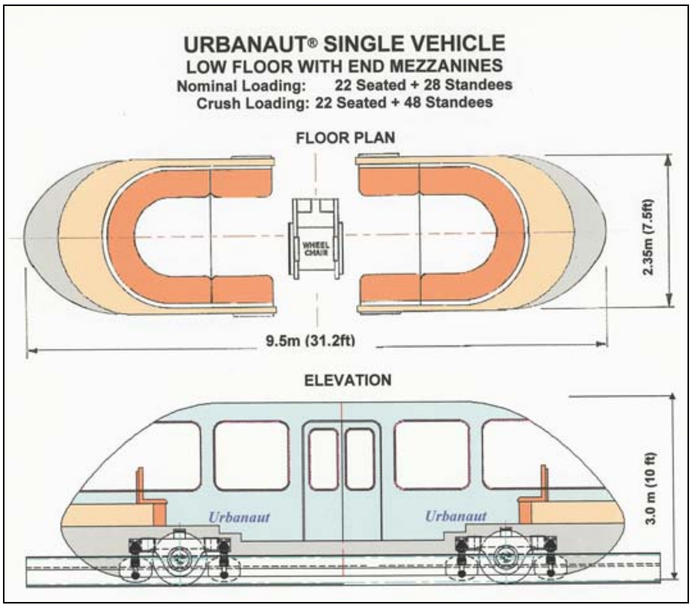


Figure 8

4.3 3-Car Train at Surface – Intermediate to High Speed

SemiMaglev Urbanaut™ 3-Car Bullet Nose Train – Intermediate Size

Max. Nominal Loading: 62 Seated + 72 Standees
Max. Crush Loading: 62 Seated + 102 Standees

Figure 9 **3-Car Train = 80 ft (24.3m)**

4.4 6-Car High Capacity Trains on Dual Elevated Guideway

Figure 10

The SemiMaglev Urbanaut™ " The SemiMaglev Urbanaut™ "Full Scale" System is applicable to trunk lines and as commuter vehicles and for potential large volumes of passenger traffic per hour. It can be made for high speed and slightly longer distances between stops [21].

Full scale Urbanaut® trains of 6 cars with a length of 55 meters (180 ft) has the potential carrying capacity of 40,000 passengers per hour (seated + standees).

5 Guideways and Stations

5.1 Prefabricated Portable Guideway Components

At surface and subsurface only a 1.0 meter wide concrete runway slab is required compared to 2.5 to 3.0 meters for normal non-stabilized maglev vehicles. The elevated guideway is a standardized prefabricated system of basically 2 components, a column-to-beam unit and a drop-in center beam [20].

Several types of elevated, lightweight, pre-manufactured guideways have been engineered by Urbanaut® which can be located off-street, having no interference with existing auto traffic. One type consists of two elements; a curved Y-shaped column-to-beam and a center drop-in beam. These two elements allow for free spans of 45 meters between foundations which can bridge a large, busy street intersection. This system allows for flexibility in a network route design in that it can be easily expanded, removed or relocated if need be.

Figure 11

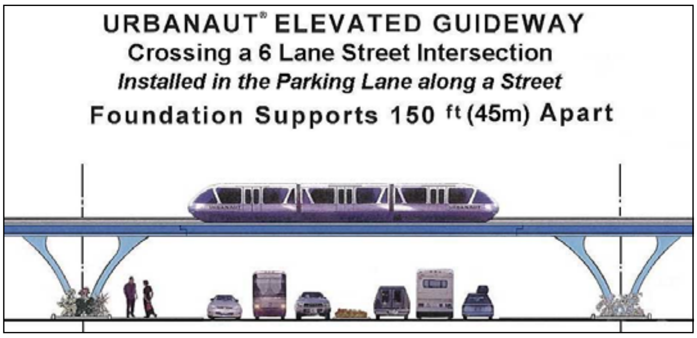


Figure 12

The attractive elevated curved Y-shaped column-to-beam triangular units have a unique structural advantage which makes the elements more slender and lighter, leading to a lower construction cost. Longer beam spans will reduce the number of foundations needed and interference with underground utilities and will have less environmental impact on the community.

An alternative is an inexpensive guideway assembled with portable lightweight components utilizing vertical hollow columns and a beam way of composite or steel materials with a concrete running slab on top. Heating cables are installed in the runway for regions with cold climates to prevent surface icing.

5.2 Switching of Guideways

Urbanaut® has 3 different simple switches, depending on application: **1.** An on-board switch for at slow speed; **2.** A swivel switch for 2 guideways crossing each other; and
3. A flexible high speed switch.
The central magnetic rail can also be made into a lightweight high speed switch [18], which is flexed by automatic operation to route the vehicle from one guide way to another. This allows the Urbanaut to be used in a network configuration so that larger areas in a community can be served and the vehicles can be utilized more efficiently. **It is possible to switch vehicles from a smaller guideway onto a larger one**. This has application where smaller, independent single guideway Urbanaut® "circulators", extending from a trunk line into a high density community, will interact continuously with passenger movement to and from, avoiding large, expensive parking lots at the stations.[15]

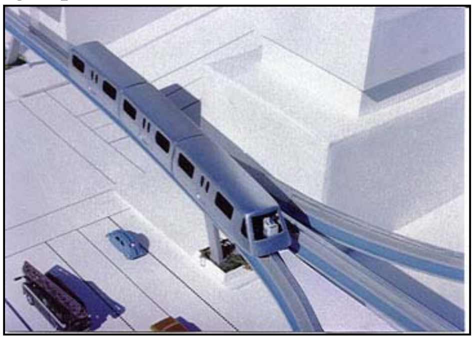
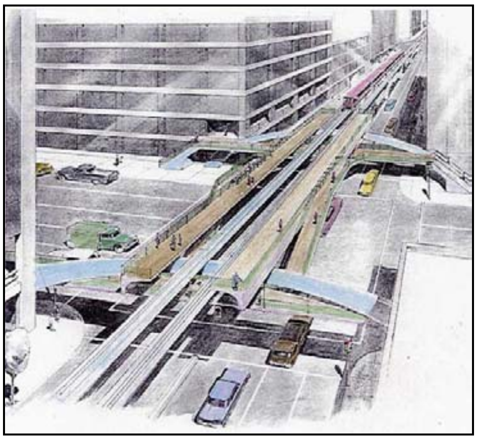


Figure 13

5.3 Stations Adapted to Planned Route Layouts

Monorail stations are a significant part of monorail systems. Efficient stations serve to enhance passenger entry and exit of the monorail vehicles and trains. For a dual guideway, the station must be designed and engineered for maximum capacity for 2 trains simultaneously loading/unloading plus emergency unloading in case escalators and stairs fail to expedite passenger exiting to the surface below. Urbanaut® has several versions of stations depending on application and service of passengers and vehicles [16]. Where practical and economically feasible, an Urbanaut® station can be built into a multistory building

Figure 14



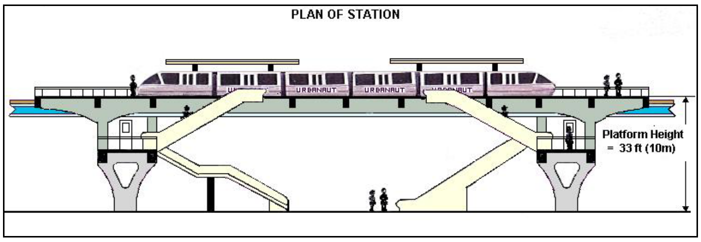


Figure 15

Figures 14 and 15. High Capacity Elevated Urbanaut® Intersection Stations are special stations designed and engineered for unobstructed free flowing surface traffic in both directions below. Such a station has the flexibility for passengers to enter and exit any of the 4 street corners.

An Off-Line Urbanaut® Station shown has dual uses. A) It can load and unload passengers on an Off-Line guideway platform while vehicles are moving by on the On-Line guideway. B) By means of simple Urbanaut® switching provided by the uniquely shaped magnetic rail several parallel off-line guideways can be added to a station for storage and servicing of vehicles [18].

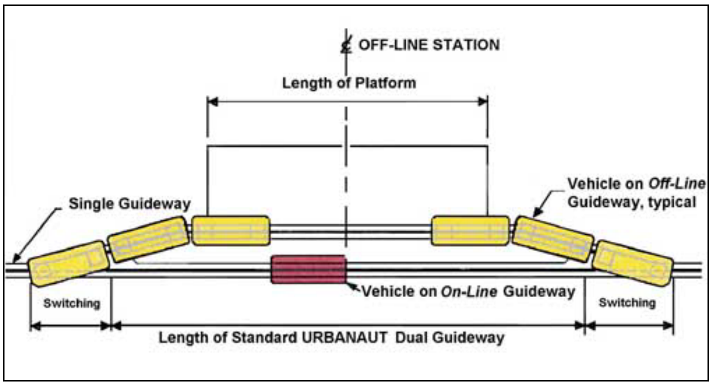


Figure 16

5.4 Passenger Safety and Evacuation

The Urbanaut systems will be fully automated (no drivers) with central control from facilities adjacent to the guideways. Security personnel, by means of audio-visual communication, would view the vehicles inside at all times, during unloading and loading as well as while traveling on the guide way. Laser beams on-board the vehicle will control any irregularities or emergencies on the guide way and bring the vehicle to a stop if needed. *Special vehicle escape devices* are provided in case of emergency evacuation from elevated guideways.

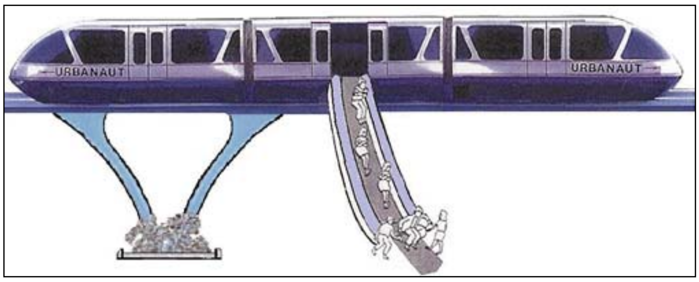


Figure 17

6 Project Sample and Costs of SemiMaglev Urbanaut™ (U.S.A.)

The SemiMaglev Urbanaut™'s central magnetic rail which enables simple and fast switching allows for the versatility of using a single, smaller, environmentally friendly guideway to feed a larger high capacity trunk line, thus creating a versatile transportation network serving larger areas of the community. The SemiMaglev Urbanaut™' is the only monorail system that allows this exchange. Such an example is the 160 km (100 miles) long Puget Sound Regional Master Plan (PSRMM) [15], a large scale monorail layout that has the potential to move up to 500,000 passengers daily in Washington State, USA.

An Urbanaut® elevated, surface or subsurface single or dual line right-of-way loop "Circulator" (See Figure 19) can be applied to the distribution of people within urban communities, industry, shopping centers, ports, parks, university and school campuses, sports activities and recreational areas. Such a guide way concept is expandable and can be connected to other loops or guide ways in the future if needed. Several "circulator" loops can be integrated, with transfer from one to another possible.

During high capacity demand periods, vehicles (trains) will be operated continuously around the loop, programmed for maximum service. When there are few passengers, such as at night, the excess vehicles can be docked and/or serviced away from the guideway in an off-line station area.

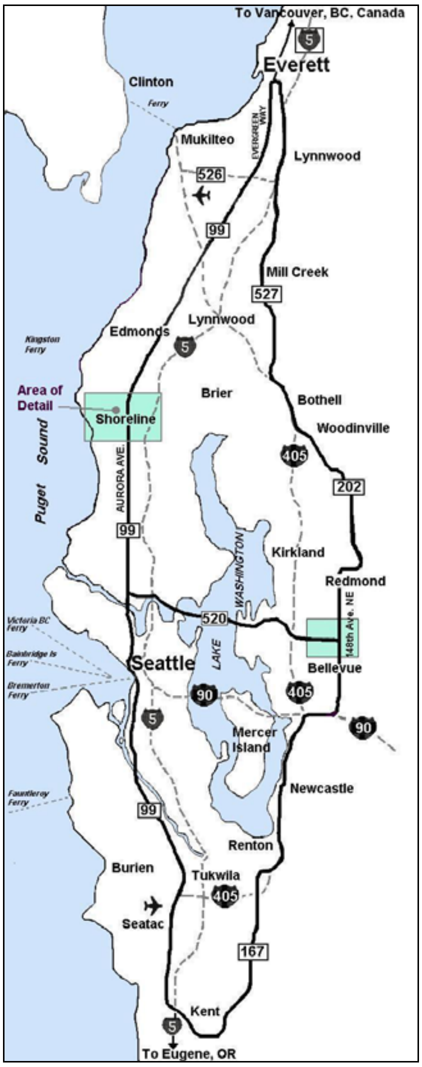


Figure 18

SemiMaglev Urbanaut™ Circulator

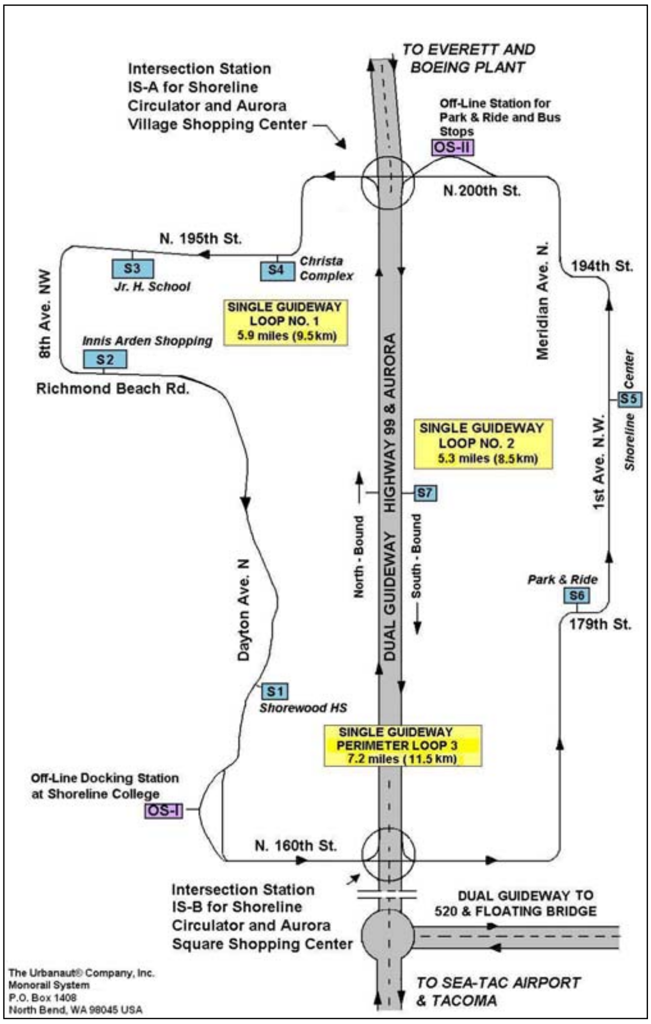


Figure 19 Area of Detail

6.1 Cost of High Capacity Master Plan [21]

Puget Sound Regional SemiMaglev Urbanaut™ Monorail Master Plan

Location: Washington State, U.S.A

TECHNICAL DATA

1) 100 miles (160KM) of Elevated and Surface Urbanaut® Dual Guideway
2) 50 high capacity stations, 2500 passenger design loading, spaced 2 miles apart
3) Trains each capable of carrying up to 1000 passengers
4) Daily potential moving capacity: 500,000 passengers
5) Maximum speed of trains = 128 km/hr (80 mph) for train stops every station
6) Maximum potential speed = 185 km/hr (115 mph) for train stops every second station
7) 2 Maintenance facilities
8) Apply SemiMaglev Urbanaut™ monorail technology

COST ESTIMATE OF 3 STAGES OF CONSTRUCTION

Stage I	West Side:	Everett to Seatac With 20 stations	= 64 km (40 miles)	US$1.3 billion
Stage II	East Side:	Seatac – Kent – Everett With 25 stations	= 80 km (50 miles)	US$1.5 billion
Stage III	Central Connector:	Highway 99 across 520 Bridge With 5 stations	= 16 km (10 miles)	US$0.3 billion
	Total	100 miles of Urbanaut® dual guideway With 50 stations		US$3.1 billion

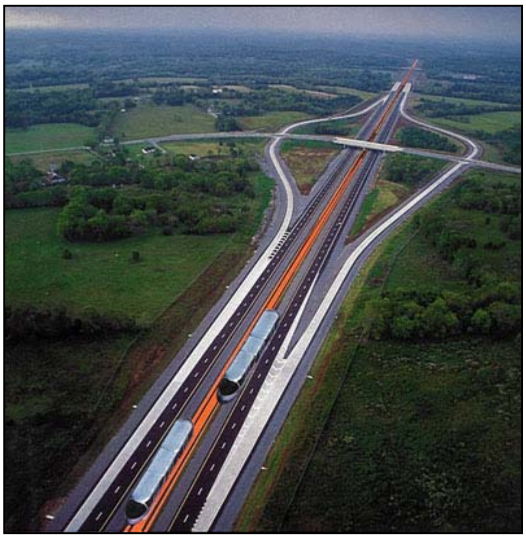
Cost Estimate does not include:

1) Updating the 520 Floating Bridge
2) Any underground (tunneling)
3) Major utility relocation
4) Cost of surface and aerial right of way (to be donated by state and local government)
5) Financing of capital
   (Revenue and other income may pay for operation, part or all of installation over a 15 year period) (Example: existing Seattle Monorail)

Note: The above cost estimate is for a heavily congested area in the United States of American and would be considerably less in Asia.

6.2 SemiMaglev Urbanaut™ in Median of Freeway

Figure 20



An inexpensive high speed SemiMaglev Urbanaut™ constructed on a 1.0 meter wide slab in the median of a freeway can favorably compete with autos, thus reducing the congestion and gridlock on the freeway, and provide a relaxed, stress less ride and a much shorter traveling time at reasonable cost [21].

There are numerous such application sites along freeways in the USA and abroad. Such an inexpensive high speed SemiMaglev Urbanaut™ as a back-bone system can have passenger transfers to slower speed SemiMaglev Urbanaut™ Circulators or distribution networks serving high density communities and cities. As part of a comprehensive regional transportation plan, applying the same technology throughout has numerous practical and economical advantages. It becomes more efficient, has greater capacity and is a less costly alternative than complicated tunnel diversions and expensive, massive, outdated steel wheel-steel rail concepts.

It should be noted that the speed of 225 km/hr (140 mph) is the upper limit on our freeways in the U.S. because of the limited right-of-way curvatures. Ultra high speed maglev systems also require very large radial curves, which would require additional right-of-way along freeways, substantially increasing costs.

6.3 Speed/Time Curve for High Speed SemiMaglev Urbanaut™

For a SemiMaglev Urbanaut™, a potential speed of, for example, 225 km/hr (140 mph) can be reached at relatively low operational cost. However, because of longer acceleration and deceleration distances, the spacing between stops will have to be considerably longer (Figure 21). Such an Urbanaut® could be suitable for application between cities, high density centers and airports. The high speed, inexpensive SemiMaglev Urbanaut™ could, for example, travel from Vancouver BC, Canada to Eugene, Oregon, USA, a distance of 690 km in approximately 4 hours with stops in 10 cities. This is half the time an auto would take driving nonstop with no freeway congestion.

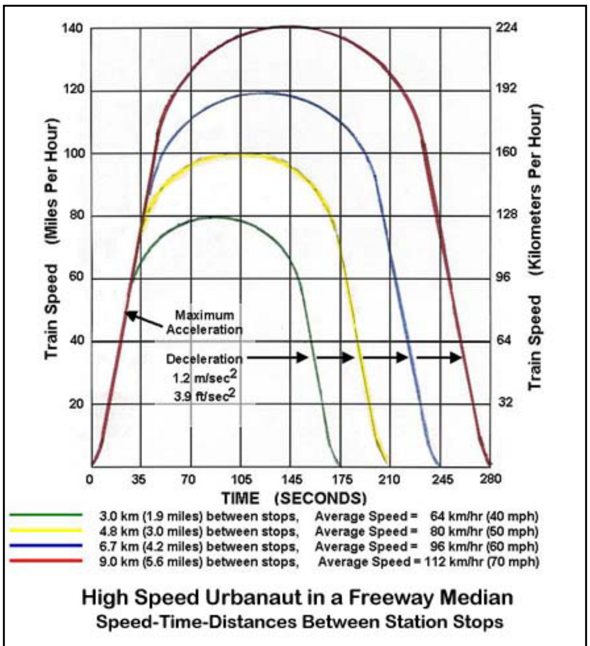


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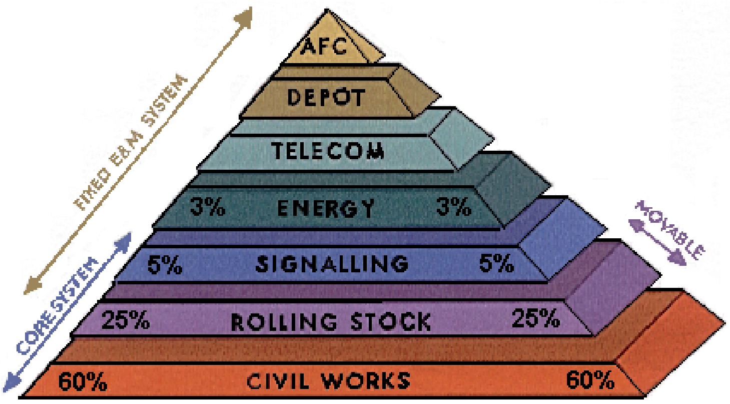
Figure 21

7. Distribution of Cost for the SemiMaglev Urbanaut™



In the SemiMaglev Urbanaut™, the Core System, representing 85% of costs, embraces

1. The Civil Works (Elevated Guideway)
2. The Rolling Stock
3. Signaling (Automatic control)

The Fixed E&M (Electrical & Mechanical) integrates with the Civil Works [12]

Description of Element

- **Civil Works: Guideway, Stations, Switches, Maintenance Buildings**
- **Rolling Stock: Trains and special vehicles**
- **Signaling: Train Control System (TCS) and other controls**
- **Energy: Energy supply**
- **Telecom: Communication**
- **Depot equipment and control center**
- **AFC: Automated fare collection system**

Figure 22

Cost of a monorail project is quite involved and varies with the passenger capacity of the system, the location, the geography and the route layout of the monorail guideway, along with the station location and sizes, service and maintenance facilities, switching and total environmental impact on the community. Urbanaut® has the flexibility to integrate future expansion or deletion, which could reduce planning and construction cost.

The graphical cost illustration [7] shown in Figure 23 is specific to the Urbanaut® technology. While the "Cost of Depot" is a relatively small item for the Urbanaut®, it is very large for the straddle-beam type monorails, which require a very large land area with complicated equipment to move the inseparable massive beam ways with the trains on top.

The height of the Urbanaut® is 40% to 60% less than the straddle-beam type monorails built in the USA and Japan because the Urbanaut® technology is not dependent on a beam way like most other monorails. This means the much lighter vehicle and guideway can be constructed for considerably less cost.

A cost comparison by an independent consultant suggests costs may be only 50% of the Alweg type technology because of Urbanaut®'s many features discussed above [16].

Urbanaut® has the potential capacity of 20 freeway lanes at 10% of the cost.

8. Summary - Economical and Practical Advantages of a SemiMaglev Urbanaut™ Compared with Other Transit

The SemiMaglev Urbanaut™ monorail technology is substantially different from conventional straddle-beam type monorails [1] and steel wheel –light rail systems [8] and proposes to solve many of the problems encountered by them. It has been designed so that it does not have to straddle the beam way, but rides on top of a runway and is guided by a central magnetic rail. It has much more flexibility, is much smaller and lighter in weight and considerably less costly to install and operate.

8.1 Comparison of Relative Energy Demand

The energy cost to propel a vehicle is directly related to the weight and size of the vehicle. A heavier, more massive, vehicle will require more energy. A Comparison of Energy Demand shows the SemiMaglev Urbanaut™ will use only 60% of the energy per passenger as the straddle type rubber tire monorails.

Force = mass (acceleration) or (F=ma)
A more massive vehicle will require more energy.
A straddle-beam type monorail with a large number of contact tires has considerable more mechanical friction. Such a monorail vehicle also has a larger cross section and less aerodynamic shape than the smaller aerodynamic bullet-nose-shaped SemiMaglev Urbanaut™ .

	New York Transit	Alweg / Hitachi/ Bombardier	SemiMaglev Urbanaut™
Aerodynamic Drag	1.3	1.0	0.60
Mechanical Friction	1.5	1.0	0.65
Ac-De-celeration	1.4	1.0	0.60

8.2 Operation and Maintenance (O & M)

The installation and operation of an Urbanaut® maintenance facility may cost only one-tenth of a straddle beam type monorail which needs a very large area and dozens of complicated mechanical switches for arranging and moving vehicles on the bulky beamways. The Urbanaut® center magnetic guide rail is removed within the maintenance area and the vehicles can be stored parallel to each other either by manpower or by using a custom small pallet lift for a three-car or longer train.

8.3 Advantages in Switching

The concept of the **small central magnetic rail** allows for far more flexible and efficient methods of switching and is more versatile for urban network applications as opposed to the current monorails' back and forth (shuttle) or continuous loop applications which have no practical nor economical switching capabilities.

8.4 Advantages of Steeper Climbing Capabilities

The SemiMaglev Urbanaut™ is environmentally friendly and adjusts to the landscape. The SemiMaglev Urbanaut™ powered by a **non-contact LIM** can climb considerably steeper grades than light rail, where adhesion between steel wheels and rails is limited to grades of 3 to 4%. Light rail therefore frequently has to construct deep cuts and tunnels, while the SemiMaglev Urbanaut™ can adapt to steeper grades up to 12%, adjusting more closely to the landscape, avoiding expensive tunnels and deep, damaging expensive cuts for rights-of-way through existing residential communities.

8.5 Advantages in Sharp Turn Radius and Steep Climbs

The SemiMaglev Urbanaut™ has a small turning radius of 38 m (125 feet) allowing for sharp curves at 90° street intersections (Figure 23).
Both the large turning radius required and the inability to climb steep hills are **major problems for the straddle-beam type monorails and steel light rail** in many cities and urban areas.
Shown is a vehicle at a station built into a multistory building.

Figure 23

8.6 Noise Impact

The SemiMaglev Urbanaut™ is virtually noiseless with its aerodynamic shape and no surface friction. The old conventional steel-wheel/steel-rail (light rail) concept is very noisy, and has much greater visual and street disruption impacts, has less flexibility and costs are 3 times greater than the Urbanaut®.

8.7 Advantages in Size

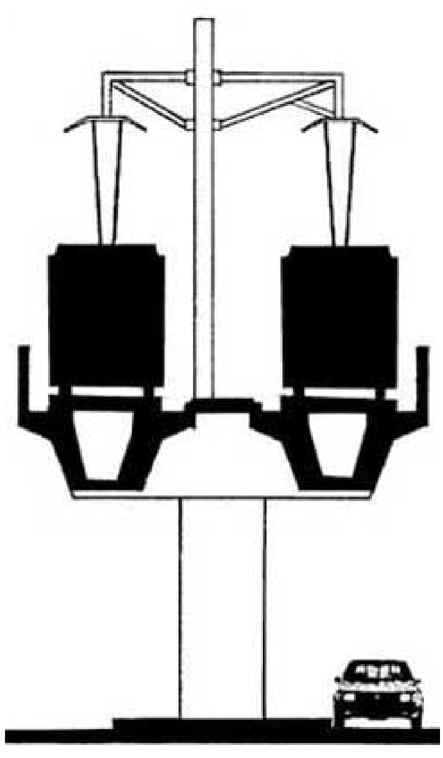
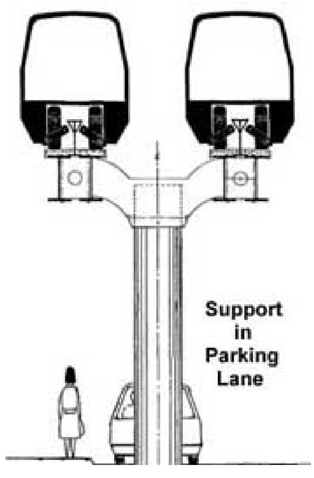
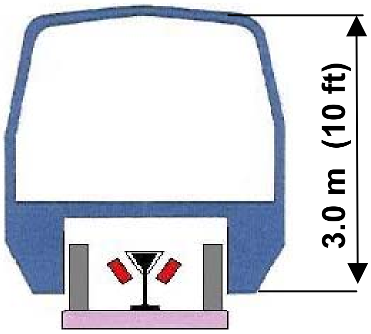
Typical Conventional Steel Wheel Light Rail in Center of Street on Bulky Supports [8]	**SemiMaglev Urbanaut™ Monorail in Parking Lane [18]**
	
This concept has a large environmental impact on a community	**The Urbanaut® has 1/3 the environmental impact of light rail**

Figure 24

8.8 Energy and Cost Advantages

Figure 25

L I G H T



The SemiMaglev Urbanaut®

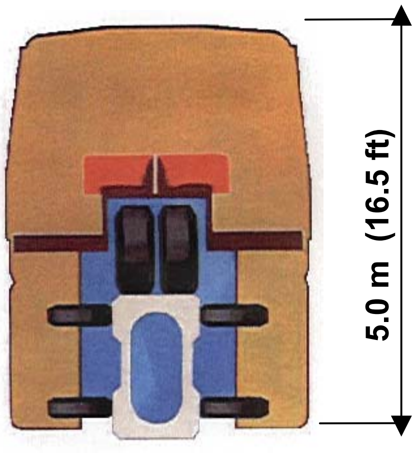
Energy Saving System

Applies inclined electromagnets to create 90% to 100% maglev (lifting) when the vehicle is in motion. When stationary, the weight is all on the load wheels. The "BEAM" is NOT part of the system, which has numerous advantages

Advantages

1. **Only a slab is needed at surface and tunnels**
2. **Easy switching of guideways with crossing of 2 guide ways at same level**
3. **A 3-car train has 12 load wheels**
4. **Automatic operation and control**
5. **Height of vehicle is 60% less**
6. **50% less tunnel excavation**
7. **A lighter vehicle means saving in costs: Construction, Vehicle, Operation**
8. **Greater flexibility in planning and design of guide ways**

H E A V Y



Straddled Type Train

In this type of Monorail (which is antiquated 50-year old technology) the massive "BEAM" is part of the Basic System.
A 3-car Train has 60 tires that need frequent replacement.

Examples are:

Disneyland and Disney World
Seattle Monorail
Las Vegas Monorail
Japanese Monorails

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