# People Movers:
# Systems and case studies

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## Terminology:

**APM**- Automated People Movers
**PAT**- Personal Automated Transport/MicroRail
**PRT**- Personal Rapid Transit; **GRT**- Group Rapid Transit
**RRTS**- Rapid Rail Transit System
**LRTS**- Light Rail Transit system

## Introduction:

Contemporary society heavily depends on transportation. Congestion, parking deficit, pollution and time loss are problems that effect cities all over the world. Automated People Movers (APMs) are beginning to address many transportation issues providing, at the same time, efficient, fluid and comfortable solutions.

Over the past 30 years APMs have been developed and used primarily for airports and amusement parks. The first commercial APM was constructed in 1971 for Tampa International Airport. Today there are almost 100 transportation systems around the world supplied with electronic mechanisms that allow them to be fully automated. Half of those systems are in airports and leisure areas. One quarter are providing mass transit. Institutions such as hospitals, retail malls, special districts and others use the rest.

APM's can be installed much faster than rail transit. Small APM's can be built in less than a year. People Movers can also be supplied for a limited time and then moved or dismantled after a couple of years of use. The costs per dual-track mile range from $15 million for small, simple shuttle to $110 million for a larger system. Operating and maintenance costs can reach $500,000 a year. That amount would only cover a maintenance person, control operator employee and the supervisory staff. Off-site on-call maintenance usually reduces maintenance costs.

A smaller version of APM is the PRT (Personal Rapid Transit). PRT is offered to an individual or a small group of people wishing to travel together. The vehicle travels without intermediate stops delivering the passengers to their final destination. In that sense PRT is often compared with a taxi. A PRT for larger groups of people who do not travel together by choice is called a GRT –Group Rapid Transit. GRT is not at as private as PRT and it stops at multiple requested destinations. GRT can be compared with an airport shuttle.

## Examples of APM systems

| System type | Funding/ Cost (2001 million US) | Developer | Technology/Capacity | Status |
|---|---|---|---|---|
| **FROG** (FreeRanging OnGrid) park shuttle<br><br>PRT | Funding: 5.3<br><br>Installation cost: 3 | Netherlands<br><br>Established Engineering Firm | Battery powered vehicles with sensors detecting obstacles travels on simple ground level asphalt tracks; Built Cars in Rotterdam fit **6** seated and **4** standing passengers; capacity 200- | 1997- 4 driverless minibuses at Schiphol airport Amsterdam<br>1999- 3 vehicles operate in Rivium Business Park, |

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|  | | | 800 passengers/ h | Rotterdam speed 15 mph (can reach up to 60mph) |
| **Taxi 2000**<br><br>PRT<br>  | Funding: 30-50<br><br>Investment cost: 3.5 per km single guideway, vehicles, and control system. | USA<br>Multi-disciplinary research team, U of Minnesota<br>Prof. J.E.Anderson | Cars fit **3**adult passengers (side by side) or 4-5 children or 1 wheelchair or 1 baby carriage with attendant. Mechanic switching. Electric vehicles run on rubber tires. | 2003- Built prototype<br><br>Taxi 2000 is selected by the SkyLoop Committee, Cincinnati OH as a suitable PRT Speed limit 20-50mph |
| **ULTra** (UrbanLight Traffic)<br><br>PRT<br>  | Funding: 10<br><br>Investment cost: 5-7 per km (includes vehicles, guideway, stations and control system) | UK<br>Univ. of Bristol<br><br>Prof. M.M. Lowson | The car seats **4** people. Battery powered vehicles, run on rubber tires in trough-shaped concrete guideways. Vehicles use on-board maps, wheel angles, FROG system to navigate. Batteries are charged at stations and during standstill. Average speed is 40mph. Max waiting time 1-6 min. | 2001- Built prototype<br>2003- Planned passenger transport February 2003. Passenger trials were conducted in Cardiff.<br><br>City of Cardiff, Wales finances studies and would like to establish the 1st commercial installation. |
| **Austrans**<br><br>GRT<br>  | Funding: 15<br><br>Investment cost: 12-15 per km | Australia<br><br>Bishop Austrans engineering company | Seats **9** passengers. The wheels are sliding on special Z-shaped rails permitting steep routes and safe braking. Flexible rails allow fast switching. The system allows lateral movement of rail parts at stations. Thus, additional vehicles can be loaded independently. | 1998- test track built<br>2000-Built prototype<br><br>The system operates as a PRT during non-peak hours and as a GRT during peak hours.<br><br>Max speed that can be reached is 70km/h |
| **SkyCab**<br><br>PRT<br>  | Funding: 7<br><br>Investment cost: 4 per km | Sweden<br><br>Swedish NCC construction company | Seats **4** passengers. Electrical (battery powered) vehicles with rubber wheels running on a covered guideway (steel or concrete). Batteries are charged at stations and during standstill. | Currently under development.<br><br>Speed: 20 mph |

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| **RUF** (Rapid Urban Flexible)<br><br>dual-mode vehicles<br><br>  <br><br>**Maxi-RUF** PRT | Funding: 1.5<br><br>Investment cost: 3 per km for the guideway construction | Denmark<br><br>Inventor: Palle Jensen Danish Institute of Technology, Danish Ministry of Energy and the Environment. | Maxi-RUF seats **10** people.<br><br>RUF is an electrical car (seats **4-5** people) with a v-shaped channel down its centerline. The vehicle has 8 wheels. Four conventional wheels and four track wheels hidden underneath the car. Vehicles running in the same direction will automatically form a small "train" for efficiency purposes. RUF's can also transport goods and deliver cargo. | Speed: 60 mph and 30 mph when switching.<br><br>2000 -Danish Institute of Technology has build a prototype and a test track.<br><br>Los Angeles is one of the cities interested in RUF technology. (CalMode consortium) |
| **MAGLEV** (magnetically levitated and propelled vehicles)<br><br>  | Funding: 225-300<br><br>Investment cost: 13-19 per mile | USA<br><br>AMT (American Maglev Technology)<br><br>(technology originates in Germany) | Maglev is a magnetic levitation system based on super conducting magnets.<br><br>There are no moving parts and as a result, no friction. Maglevs can reach a speed up to 300 mph.<br>The train can carry up to **100** people. | 2001- test track built in Edgewater, FL<br><br>2003-The train, single vehicle 45' long, will run at 40mph in Old Dominion University, Norfolk, VA |

## Case studies- Existing Campus and University Medical Center APM systems:

| Morgantown, West Virginia<br>**Personal Rapid Transit (PRT)** |
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| Undergraduate | 15,463 |
| Graduate | 6,524 |
| Total | 21,987 |

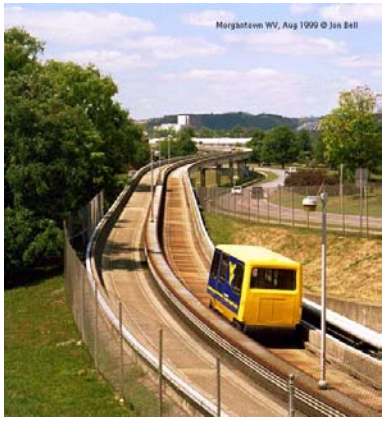
The Morgantown Personal Rapid Transit (PRT) system is one of five people movers built in the United States since late 1970' and the only PRT built on a University campus. The other four people mover systems, GRT's such as Detroit, MI Downtown people mover, Miami, FL Metromover, Jacksonville, FL Skyway, are commercial high volume APMs.

West Virginia University operates the Morgantown PRT. It connects the university's Evansdale and Downtown Campuses with downtown Morgantown. The PRT is a single line, 3.6 miles long, with five stations. The first section of the system opened in 1975. The rest of the line opened in 1979.

Each car seats eight people and also has room for standees. The cars run on rubber tires in a U-shaped concrete guideway that has power and signal rails along the inner walls. The system is fully automated and does not require human staff. There are three intermediate stations. Each station has several platforms and "express tracks" that bypass the stations completely.

"During low-traffic periods, all cars stop at every station. During high-traffic periods, cars bypass stations, using the "express tracks", so that any station can be reached non-stop from any other station. When entering a station, passengers press a button on the entry turnstile that signals where they want to go, then proceed to a specific platform to wait for the next car to that station. Different platforms serve different destinations; some platforms "share" destinations, and use an overhead electric sign to indicate the destination of the next car."[1]

West Virginia University students, faculty and staff ride by paying a per-semester fee. The University's magnetically encoded ID card is swiped though the turnstiles when entering the stations. Passengers who do not possess University ID card pay cash fare of $0.50.




## Duke University
## Future plans for redesigning Central Campus include a monorail system

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|---|---|
| Undergraduate | 6, 240 |
| Graduate | 5, 571 |
| Total | 11, 821 |

Duke University is planning to redesign Central Campus and add a monorail or electric train connecting East, Central and West campuses. The University hopes the new transportation system will revitalize the area creating a new "University Village" and a "Main Street with retail space, additional apartments for 800 undergraduate students and at least 200 graduate and professional school students, faculty and staff housing, a hotel, an amphitheater and an expansion of the Sarah P. Duke Gardens..."[1] The changes would also improve the integration of the city with the campus. The Triangle Transit Authority will start construction works in 2003. The new rail system will provide a hassle-free commute for passengers in the future. TTA would have to show commuters that the rail is convenient, fast and more reliable than the modes of transportation used so far.

"Trains will start running from downtown Raleigh through Cary and Research Triangle Park to downtown Durham in late 2007. The line will extend to North Raleigh and Duke Medical Center three years later, and by 2014, the trains will run every 10 minutes during rush hour. By then, the TTA will have spent $813 million in state, local and federal funds on the rail line." [2]

This is not the first rail transportation system built in this area. In 1982 TTI's Hovair+LIM system started operating a small monorail, floating on air, in **Duke University Medical Center**.

Each vehicle in the system holds about ten standing passengers and makes three stops. The TTI system had, however, a couple major problems:
1. Visual impact.
2. The cost of the U-shaped guideway that supports an air-cushioned vehicle.
3.The system isn't suitable for northern climates and catches snow.

[1] http://www.owdna.org/OWD_in_news.htm
[2] http://news-observer.com/traffic/story/2416097p-2247988c.html 04/06/2003

## Old Dominion University

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|---|---|
| Undergraduate | 13,578 |
| Graduate | 6,527 |
| Total | 20,105 |


PHOTO BY CHUCK THOMAS

**LEVITATING!**

**The long-awaited maglev vehicle is hoisted onto the guideway Thursday morning at Old Dominion University after traveling two days from its test site in Florida. Following adjustments, reattachments and the placing of additional track, test runs should begin in mid-July. The grand opening is scheduled for late September.**

A wheelless 45' long train will start servicing Old Dominion University in September 2003. The train' capacity is 100-140 people and it shuttles 3 stops gliding on magnetic fields. The car runs every 4 minutes. Electricity propels the 23, 000 pound car at 40 mph (max 60mph). The elevated guideway, supported by concrete columns 4 feet in diameter and spaced 140 feet, is 4400 feet long.

The project is just the beginning of a bigger network that will connect Norfolk with Washington DC. By 2007 the train will be able to cover the 200 miles separating Norfolk and Washington in less than one hour.

American Maglev Technology sponsored the $16 million project. The funds came from private and public sources. Private companies, such as Virginia Power and Lockheed Martin services, donated $7 million dollars. The Federal government supplied $2 million dollars. The last portion was fulfilled by a $7 million dollar loan from the Virginia Department of Transportation.

Since there is no friction, the maintenance and operating costs will be nominal. The new rail will be free for all riders.

## Huntsville Hospital Automated People Mover

Brasfield & Gorrie, L.L.C. received an excellence award from the Associate builders and Contractors, Birmingham AL for the Huntsville Hospital People Mover. The system is manufactured by Poma-Otis. The line connects 4 buildings in the Huntsville Medical complex providing an express route and a local route. The APM includes two trains running on pneumatic tires, each with two 50-seater carriages, providing a total capacity of 1500 passengers per hour.

## Case studies- Planned Campus and University Medical Center APM systems:

## NC State University
## N.C. State's Centennial Campus

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|---|---|
| Undergraduate | 22,780 |
| Graduate | 6,857 |
| Total | 29,637 |

In 1984 and 1985, NCSU's Centennial Campus, a multidisciplinary, multi-institutional community for academic, corporate and governmental research, development and work force training, began to develop on land allocated by the state. The new development represented a community, which includes 12 clusters of research and teaching buildings, a hotel and conference center, a town center with restaurants and stores, residential neighborhoods and a golf course. Individual transport and the Wolfline bus service have been a sufficient transport though the years. As the campus continues to grow, considerations for a monorail system running through Centennial Campus and to and from NCSU's main campus have arisen. The proposed monorail for NCSU will use Maglev technology. The projected 2-mile system would cost $30-40 million. Officials speculate that the system will be used daily by 15,000 riders. Phase I of the projected construction would concentrate on establishing a 1-mile link between the 2 campuses.

## Columbia University

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|---|---|
| Undergraduate | 6,950 |
| Graduate | 5,491 |
| Professional | 5,802 |
| Other (Health Sciences; Special) | 4, 649 |
| Total | 22,892 |

Columbia University has been considering a couple of campus improvements for its 250-year anniversary. One of them is the Circum-Campus Monorail. The monorail would take advantage of the tight campus organization and will provide another comfortable mode of circulation. The system will make stops on the 6$^{th}$ floor of every building on its way.

# Case studies-Commercial High-Volume People Movers:

## Detroit, Michigan: Downtown People Mover (DPM)

Detroit's people mover is one of five urban people mover systems built in US since 1970. The system has been in operation since July 1987. The cost of the people mover was $200 million. The APM needs $10 million a year to operate. Only 15 % of that amount is supplied by the 0.50 cent ride cost. The city supplies the rest of the funds ($8.5 million a year). The APM uses two-car trains running on an elevated 2.9-mile one-way loop that includes 13 passenger stations. Two of these stations are integrated into buildings (Millender Center and Cobo Hall). The technology is steel wheels on standard-gauge steel-rails with linear induction motors instead of normal traction motors. A complete circuit takes about fifteen minutes, and trains run every three to five minutes. The fare is 50 cents for the general public, 25 cents for the disabled and free for the elderly. A special feature of the APM is the art installations on each station.
Data from the first year of operation showed a reliability of 98 percent with an average patronage of 11,000 per day (Aiken and Barker, 1989). The system was originally intended to be the downtown distributor for a rapid-transit system, which was not built.

The People Mover carries an average of 8,000 riders a day, but can handle more than 40,000.


## Irving, Texas: Las Colinas Peoplemover (APT)

Las Colinas People mover is another urban people mover built in the early 1970'. The cost of Phase I is reported to be $45 million, which included 5 years of operation and maintenance by the vendor (Lynch, 1989). The APM is maintained and operated by the Dallas County Utility and Reclamation District, a governmental body, which is responsible for much of the Las Colinas infrastructure. Beginning in 1986, the people mover was equipped with four cars and power and control infrastructure by AEG-Westinghouse. Ridership was low and financial problems became so severe that the system shut down completely from July 1993 to December 1996. Since its re-opening, the APT has operated only from 10:30 am to 2:00 pm on weekdays, with two cars, one for each route. Operation is completely manual, with cars running on demand. Only one of the stations (Bell Tower) is generally accessible to the public. The other three are inside private office buildings. Most of the traffic consists of employees traveling to and from the Bell Tower for lunch.


## Jacksonville, Florida: The Skyway

The Skyway was built in the early 1970'. It is an automated system, 2.5 miles long, which uses two-car trains running on an elevated monorail guideway. The system cost was $184 million. The route is in the shape of an inverted "Y". The Skyway has used two different car and control technologies during its lifetime: VAL technologies system and Bombardier system. The cash fare is $0.35, collected at turnstiles at the station entrances.

## Miami, Florida: The Metromover

Miami-Dade Transit operates the Metromover, a 4.4-mile automated "people mover" system that serves downtown Miami with a loop route (1.9 miles, opened 1986) and branches (opened 1994) north to the Omni shopping center and south to the financial district. Construction began in June 1983, and the system opened in May 1986 as the first APM in a downtown setting, with 1.9 miles of double track and 10 stations. The total system cost in 1986 was $159 million, or $83.2 million per mile.

Small driverless rubber-tired cars run on an elevated concrete guideway, using the same technology (from Adtranz, formerly Westinghouse) as in several airport people-mover systems. The car runs at every 90 seconds during rush hour and every three minutes during off-peak hours.

In May 1994, a new extension of the Metromover was opened. It added additional 12stations and 2.5 miles of track to the existing system. The completed system consists of 4.4 miles of track and 22 stations connected to the rapid rail at two locations. The extension costs were $228 million (or 91.2 million per mile). 35% of the costs paid for the guideway and station construction and another 27% covered the vehicles, controls and designs of AEG Westinghouse. Since the opening of the extension, daily ridership has increased to 12,500, close to the predicted 13,000.


## Conclusion

Contemporary cities and dense compilations, such as campuses or research institutions, require environmentally friendly, fast and convenient commuting systems in order to function successfully. Conventional public transportation does not yet provide the comfort level of a private vehicle. Recent advances in electronically smart transit technologies in United States and abroad offer small-scale efficient circulation. Automated People Movers can be used as an integral part of expanding communities, while providing efficient, cost-effective circulation, building links and parking control. APM's are safe automated transit systems that are becoming widely used and applied to campuses and downtowns. The expanding campus of the University of Florida could integrate an Automated People Mover to achieve more attractive and efficient circulation and air-conditioned comfort for faculty, students, alumni, and visitors.

# References

| # | APM system | Examples of APM systems |
|---|---|---|
| 1 | *FROG* | http://faculty.washington.edu/jbs/itrans/parkshut.htm |
| 2 | *Taxi2000* | http://www.taxi2000.com/ |
| 3 | *ULTra* | http://www.atsltd.co.uk |
| 4 | *Austrans* | http://faculty.washington.edu/jbs/itrans/aust.htm |
| 5 | *SkyCab* | http://www.skycab.com<br>http://faculty.washington.edu/~jbs/itrans/gavle.htm |
| 6 | *RUF* | http://faculty.washington.edu/~jbs/itrans/ruf1.htm |
| 7 | *Maglev* | http://mail.american-maglev.com/index2.html |

| # | Campus | Case studies- Existing campus and University Medical Center APM Systems |
|---|---|---|
| 8 | *West Virginia University; Morgantown, VA* | http://web.presby.edu/~jtbell/transit/Morgantown/ |
| 9 | *Duke University Medical Center; Durham, NC* | http://www.owdna.org/OWD_in_news.htm<br>http://news-observer.com/traffic/story/2416097p-2247988c.html 04/06/2003<br>http://faculty.washington.edu/jbs/itrans/history.htm |
| 10 | *Old Dominion University Maglev; Norfolk, VA* | http://www.odu.edu/af/maglev/about.html<br>info@american-maglev.com |
| 11 | *Huntsville Hospital; Huntsville, AL* | www.chapmansisson.com/ body_huntsville_hospital_automated_.html |

| # | Campus | Case studies- Planed Campus and University Medical Center APM Systems |
|---|---|---|
| 12 | *NC Centennial Campus; Raleigh, NC* | http://www.nal.usda.gov/bic/Newsletters/BT_Catalyst/BT_Catalyst_Jan_96.html<br>http://www2.ncsu.edu/ncsu/univ_relations/news_services/ebulletin/97_05/523/523mono.htm<br>Information: 919-515-1390 |

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| 13 | *Columbia University; NYC* | http://www.columbia.edu/cu/bw/may02/to.html |

| # | **Description** | **Case studies-Commercial High-Volume People Movers** |
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| 14 | *Detroit, MI Downtown PeopleMover* | http://web.presby.edu/~jtbell/transit/Detroit/DPM/<br>http://faculty.washington.edu/~jbs/itrans/detroit.htm<br>http://www.freep.com/news/locway/qmover4.htm |
| 15 | *Irving, TX Las Colinas PeopleMover* | http://web.presby.edu/~jtbell/transit/Irving/<br>http://faculty.washington.edu/jbs/itrans/lascol.htm |
| 16 | *Jacksonville, FL The Skyway* | http://web.presby.edu/~jtbell/transit/Jacksonville/<br>http://www.nycsubway.org/us/jacksonville/ |
| 17 | *Miami, FL The Metromover* | http://web.presby.edu/~jtbell/transit/Miami/Metromover/<br>http://www.fta.dot.gov/library/technology/apm/apmrev.html |