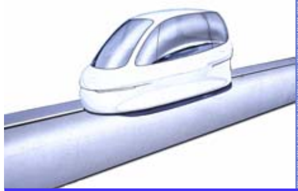

Personal Rapid Transit

Innovative Transportation Technology

Overview
and
State of the Industry

February 14, 2006

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Agenda

- Background and Need
- PRT Technology Overview and Features
- PRT History and Vendor Status
- Cost and Performance Comparisons
- Options For Development
- The Network Business Model

Background

- **Congestion in the U.S. is a significant problem affecting:**
  - Economic viability of urban regions
  - Quality of life
  - Environment

- **National metrics of congestion*:**
  - 2.3 billion annual gallons of fuel wasted
  - $63 billion in financial costs
  - Average annual delay per person
    - 93 hours in Los Angeles
    - 69 hours in Washington DC
    - 49 hours in NY/NJ
    - 47 hours US average

- **Congestion is only getting worse and has increased an average 9% per year since 1982**

*Source TTI 2005 Urban Mobility Study

Background

- **Expansion of current modes is limited by:**
  - High costs
  - Land availability
  - Impact and public acceptance
- **Highways**
  - Expensive in urban areas
  - Limited land availability
- **Metro/Commuter Rail**
  - Expensive in urban areas
- **Light Rail**
  - High service factor but limited by surface traffic unless separated at higher cost
- **Bus**
  - Low cost but limited by surface traffic and slower trip times




Needs and Features – The Genesis of PRT

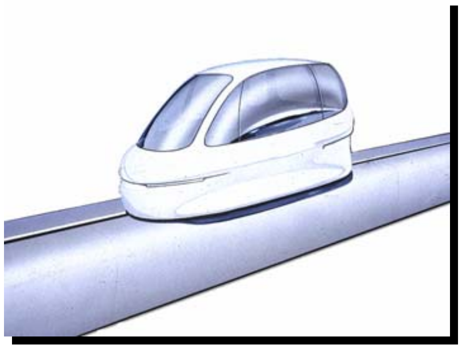
Engineered System

PRT has been engineered as an innovative and new system to address the needs of urban transportation

Need	Design Feature and Goal
Faster service	✓ Non-stop, on-demand service
Lower operating costs	✓ Increased levels of automation ✓ Reduced energy use
Lower capital costs	✓ Reduced size of infrastructure for stations, track and right-of-way
Improve integration	✓ Smaller footprint and tighter turning radius to integrate into dense urban environments
Reduced congestion	✓ Faster and personalized service to attract private automobile users
Reduced pollution	✓ Electric vehicles
Reduced energy use	✓ Small, lightweight vehicles ✓ Non-stop, on demand service to eliminate unnecessary vehicle movements
Increased safety and security	✓ Distributed demand and continuous flow to eliminate crowds ✓ Advanced monitoring and control

Technology Overview – PRT Fundamentals

- **Fundamental elements of PRT technology:**
  - On-demand, origin-to-destination service
  - Small, automated vehicles
  - Small, exclusive use guideways
  - Off-line stations
  - Network of connected guideways



- **Combines elements of automotive, computer, network and transit technologies**
- **Uses current state-of-the-art technologies including:**
  - Advanced propulsion systems
  - On-board switching and guidance
  - High speed controls and communication
  - Lightweight advanced materials

PRT represents a new paradigm for urban transportation

Components of PRT

- **Small, fully automated vehicles**

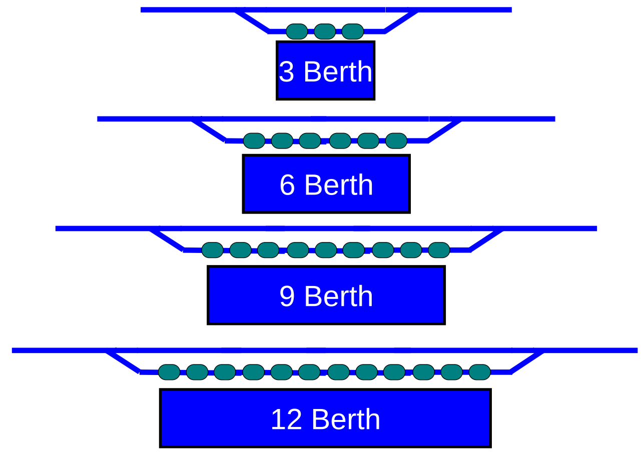
- **Small, exclusive use guideways**

Small PRT Guideway

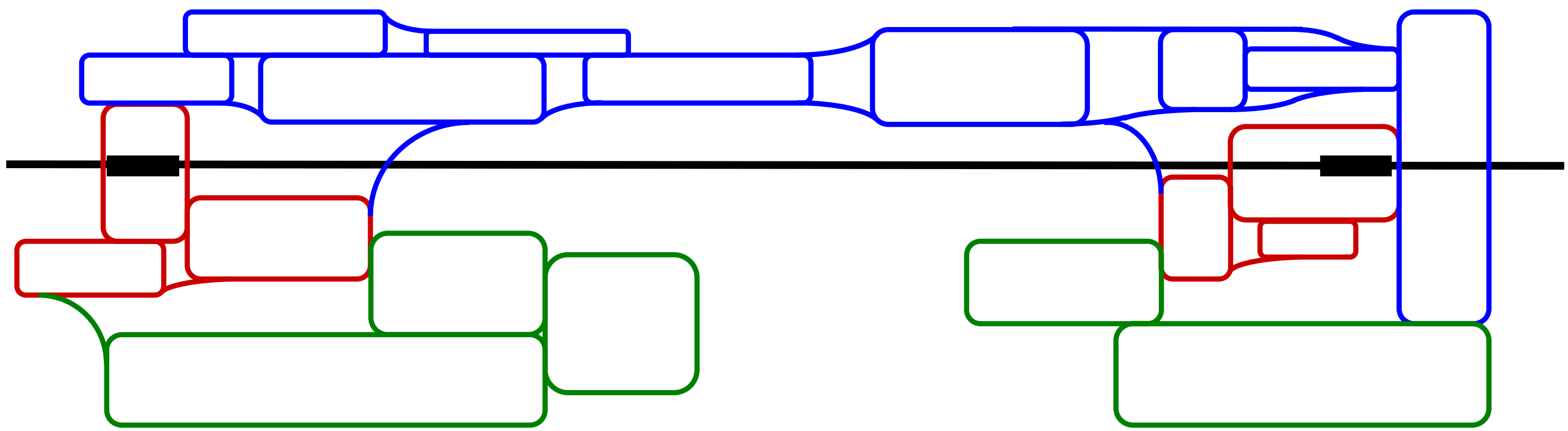
Large Conventional Guideway

Components of PRT

- **Off-line stations**



- **Networks supporting distributed demand and line haul**



PRT Automation and Simulation

- **PRT requires a new level of automation and communication to provide:**
  - Short headway between vehicles for adequate capacity
  - Management of occupied and empty vehicles throughout the network
  - High levels of safety and reliability
  - Scalability from small initial networks to larger expanded networks
- **This level of technology is beyond the current state-of-the-art in transit but within other industries**
- **Development and proof of operation in a safe and reliable manner is critical to the success of a PRT system**
- **A simulation example of an urban network**

Potential PRT Applications

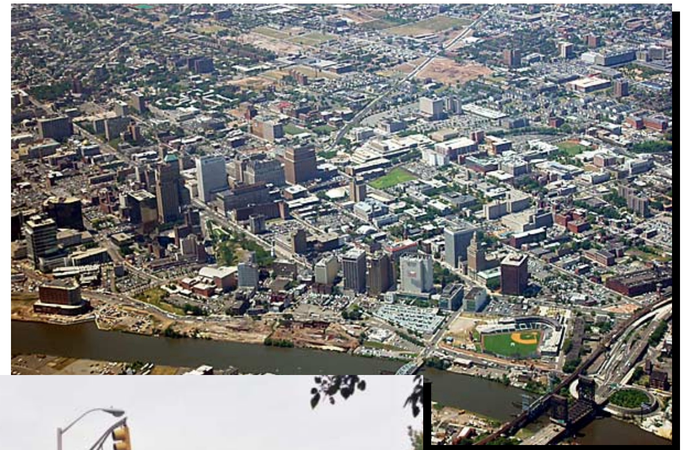
- **Urbanized Area:**
  - Central Business District circulator
  - High density area connector
  - Feeder to existing transit stations/hubs
  - Connector/distributor from satellite parking facilities
  - Potential alternative to LRT, BRT or Monorail development or expansion
  - Urban goods and light freight movement

- **Activity Center/Campus:**
  - Circulator within entertainment/tourism district
  - Circulator within/between college or business campuses
  - Airport landside and airside access
  - Feeder to existing transit stations/hubs
  - Connector/distributor from satellite parking facilities

Examples of Potential PRT Applications in New Jersey

- **Urbanized Area:**
  - Harrison — Hoboken
  - Jersey City — Long Branch
  - Morristown — Newark
  - Trenton

- **Activity Center / Campus:**
  - Meadowlands Sports Complex and Entertainment District
  - Atlantic City
  - New Brunswick – Rutgers University
  - Suburban employment nodes:
    - Bridgewater-Raritan-Somerville
    - Cherry Hill
    - Metropark
    - Parsippany Troy Hills
    - Piscataway
    - Secaucus
    - Woodbridge



Potential PRT Application – Meadowlands

- **Potential Features:**
  - Connect major venues within the complex
  - Circulate and distribute visitors within the complex
  - Provide feeder service to future commuter and light rail stations/stops
  - Provide access to remote areas including satellite parking
  - Accommodate future expansion to adjacent areas
  - Could be a potential alternative to future light-rail extension
- **Potential Benefits:**
  - Improve flow and movement of visitors within the complex
  - Allow increased density of development and replacement of parking
  - Increase transit access and usage to neighboring areas
  - Reduce traffic congestion on roadways adjacent to and within complex
  - Higher level of service with lower capital and operating costs than alternative options

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Potential PRT Application – Atlantic City

- **Potential Features:**
  - Connect major hotels, casinos, convention center, and parking areas
  - Connect to rail line
  - Circulate and distribute visitors within the area
  - Improve access to remote areas including satellite parking
  - Provide potential for goods and baggage distribution
- **Potential Benefits:**
  - Improved flow and movement within the area
  - Increase transit access and usage to neighboring areas
  - Allow increased density of development and replacement of parking
  - Increased attractiveness and prestige to the area
  - Reduce traffic congestion on roadways throughout the area
  - Can accommodate future expansion to adjacent neighborhoods and other areas

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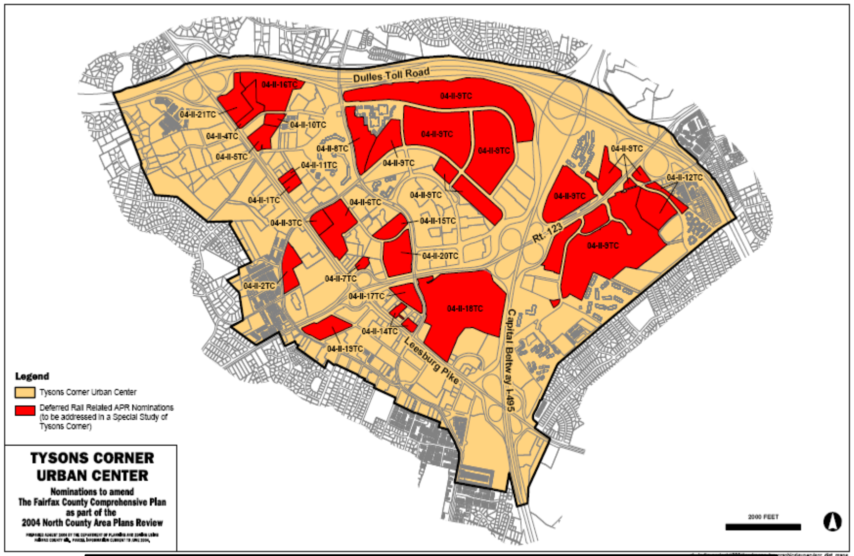
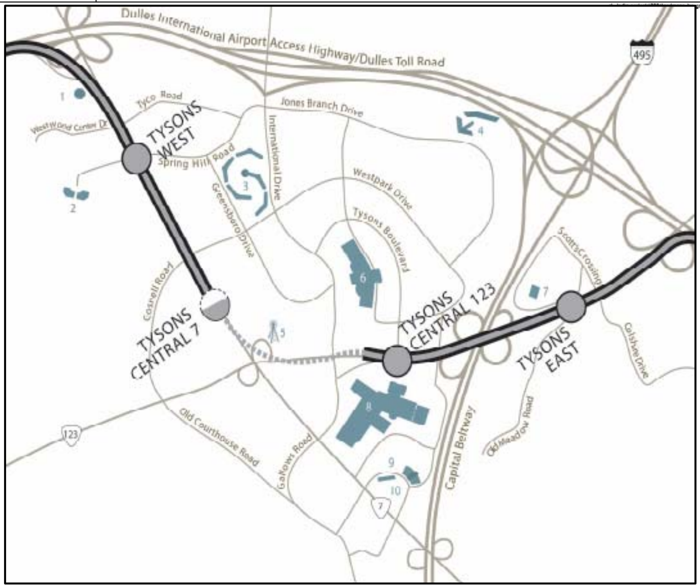
Potential PRT Application – Tysons Corner Virginia

- **Potential Features:**
  - Connect major businesses, hotels, shopping malls, retail and restaurants
  - Circulate and distribute workers and visitors within the area
  - Alternative to Metrorail extension
  - Increased number of stations over Metrorail
  - Connect to Metrorail lines on either side of the area
- **Potential Benefits:**
  - Improved traffic flow and movement within the area
  - Increase transit access and usage to neighboring areas
  - Allow increased density of development and replacement of parking
  - Increased attractiveness and prestige to the area
  - Reduce traffic congestion on roadways throughout the area
  - Allow proposed Metrorail expansion to reduce costs and disruption by avoiding major construction in dense environment





A Brief History of PRT

- **Concept originally developed in the 1950's**
- **World-wide development and multiple prototype systems under Federal government funding in the 1970's**
- **Four major international PRT conferences**
  - 1972, 1973, 1975, 1996
- **Large scale research and development programs conducted**
  - Aerospace Corp, Cabintaxi, CVS, Aramis, Morgantown, RTA/Raytheon
- **Major technology assessments conducted in**
  - 1975, 1980, 1989, 2003
- **One "semi"-PRT system in operation at Morgantown, WV**
- **Numerous major studies conducted around the world supporting research, engineering and application analysis of PRT**
- **Over 120 Automated People Mover (APM) applications currently operating world wide incorporating many PRT components**

Morgantown System (1970 – present)

- **US federally funded program with short schedule and limited R&D effort**
- **System designed and built by Boeing:**
  - Larger group vehicles requiring large guideway with a large physical footprint
  - Expensive to construct and maintain due to custom design and components
- **Continuous operation since 1972**
  - 2 million passengers per year, 63 million total
  - 30,000 passengers per peak day
  - 98% reliability
  - 8.7 lane miles, 74 vehicles
- **Demonstrates the successful use of several PRT concepts, including:**
  - Off-line stations
  - Automatic control systems
  - High level of reliability
  - Low operating costs

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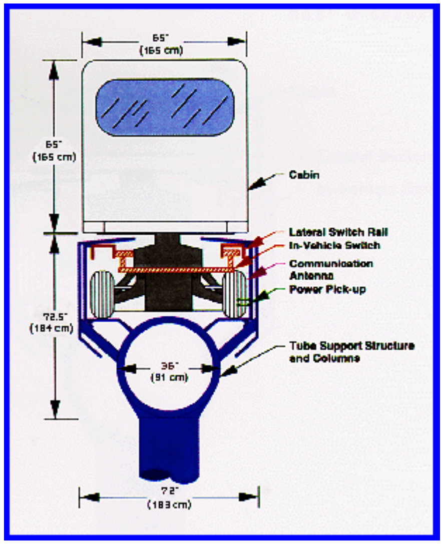
Raytheon/Chicago RTA Program (1990's)

- **Program funded through $50M public/private partnership**
  - Joint development and intellectual capital
  - Shared revenue/royalties
- **Initial designs included small vehicle and guideway but evolved to a larger vehicle and guideway**
- **Test track demonstrated the successful use of full automatic control and off-line stations**
- **Program cancelled in 1999 due to changes in political leadership and non-competitive system features:**
  - Large vehicles and guideways resulted in high capital costs, greater visual impact, with only moderate performance
- **Program failed to learn and adapt critical design and economic lessons from past efforts**



Results from Past Application Studies

- **Seattle SeaTac MIS Study**
  - Activity center circulation and connector to airport and regional rail
  - Significant local support for system and technology
  - 9% reduction in overall surface traffic in study area
  - Study recommended to establish public/private partnership for DBOM when technology is available
- **Cincinnati Central Area Loop**
  - Downtown circulator and cross-river connector
  - 3-5 times increased in ridership of alternative modes
  - Project 17,000-32,000 trips/day
  - Significant support of PRT by business and developer community
  - PRT desired but rejected due to lack of existing prototype
- **Indianapolis Downtown study**
  - 33% projected mode share for area-wide system
  - Project halted due to lack of technology and political support

Results from Past Application Studies

- **EDICT – Sweden Kungens Kurva**
  - Large shopping area seeking to reduce congestion, improve travel time and connect with regional rail
  - PRT network selected with 7.5 miles of guideway and 12 stations
  - 26% reduction in average travel time
  - 300% increase in ridership over bus
  - 17% increase in overall area demand due to improved service
  - 8% reduction in road traffic
  - 35% of capital and 60% of operating cost for comparable fixed guideway alternatives
- **EDICT - Cardiff Wales**
  - Redevelopment of docklands next to city center
  - Considerable economic modeling and traveler acceptance testing
  - 5 mile network project to serve 5.7 million trips per year
  - 100% operating and significant capital cost recovery
  - 348,000 person-hours/year reduction in congestion
  - 8% increase in mode share
  - Preferred deployment of PRT upon funding approval

PRT Industry Expert Survey

- **Leading industry experts with at least 30 years of experience were surveyed through:**
  - Questionnaire
  - Phone and in-person interviews
- **Intent of survey was to gather:**
  - Lessons learned from PRT history
  - Insight and guidance for the future of the technology
  - High level insights from senior level experts
- **Survey focused on five key areas:**
  - Development
  - Applications
  - Costs and Service
  - Performance and Standards
  - Technology

Industry Expert Survey - Results

Development

- PRT is ready to proceed to final engineering and development
- Limited funds are available to support development
- Investors are hesitant to support new technology in a conservative market
- Alternative system configurations are being independently developed
- A full pilot system is needed to demonstrate effectiveness and gain market acceptance

Applications

- PRT can support urban transit needs across the globe
- Initial applications can support circulator and distribution functions
- Systems can expand to support larger networks and connection of initial networks

Costs and Service

- PRT systems can expect to provide lower capital and comparable operating costs than current fixed rail or grade-separated transit systems

Performance and Standards

- Defacto and optimum technology standards will emerge
- Capacity, reliability, safety and security need to be demonstrated before large developments can be supported
- Governments will provide safety and security standards and oversight

Industry Expert Survey – Results: Technology

- PRT technology is not generally understood by the larger transportation planning and engineering community or by the general public
- The development of a PRT system is fully within the state-of-the-art and generally requires the engineering and application of proven technology
- The core technical elements of PRT control, communication, power and propulsion are commercially available
- The system engineering, design, testing and validation of a fully configured PRT system is needed
- Engineering design should include performance targets for system cost, reliability, safety, performance, scalability, and flexibility of implementation and operations
- A development, testing and validation program is needed with adequate capital funding and systems engineering approach that is not constrained to implementation before development is completed
- Larger scale systems will require more advanced engineering efforts but will not require fundamental research or technology development

Vendor Status – Ultra System

- **Developed since 1995 in Wales by Advanced Transport Systems in conjunction with University of Bristol**
- **Strong European government and private partner support**
- **Currently operating a test track**
- **Recently selected for implementation at Heathrow airport with corporate investment from British Airport Authority**
- **Technology Components:**
  - Automotive form factor
  - Battery power, rotary motors
  - Moderate speed and capacity
  - Open guideway
  - Guided steering
  - Synchronous control system
  - Moderate application for cold climate operation

Vendor Status – SkyWeb Express System

- **Developed since 1982 by Taxi 2000, including considerable research and systems engineering**
- **Original funding from the University of Minnesota with limited additional funding and partnerships formed with manufacturing firms**
- **Limited function prototype is currently available, but no test track**
- **Considered in many PRT studies over the past 20 years**
- **Technology Components:**
  - Body on bogie form factor
  - Vehicle LIM propulsion, guideway power
  - High speed and capacity
  - Narrow enclosed guideway
  - On-board switch
  - Distributed asynchronous control
  - Suitable for cold climate operation

Vendor Status – Posco/Vectus System

- **Developed since 2003 primarily funded by Posco Steel of Korea**
- **Initial partner in study for Fornebu in Oslo Norway**
- **Extended development program in cooperation with Korean universities**
- **Partnerships formed with European firms**
- **Currently developing a test track in Upsalla Sweden**
- **Technology Components:**
  - Body on bogie form factor
  - Guideway LIM propulsion
  - High speed and capacity
  - Open guideway
  - On-board switch
  - Distributed asynchronous control
  - Suitable for cold climate operation

Vendor Status – CabinTaxi System

- **Developed in the 1970's with funding from German federal government**
- **System evolved from multiple design iterations involving advanced operating characteristics**
- **A fully operational test track with 24 vehicles was constructed and operated until 1980, demonstrating high reliability**
- **Cabinlift system operating since 1976**
- **Program cancelled in 1980 due to lack of federal funding. System is still actively marketed.**
- **Technology Components:**
  - Body on bogie form factor
  - Vehicle LIM propulsion, guideway power
  - Moderate speed and capacity
  - Enclosed over/under guideway
  - On-board switch
  - Distributed asynchronous control
  - Suitable for cold climate operation

Vendor Status – Other Current PRT Developers

- **EcoTaxi – Finland**
  - Partner with Kone Elevator
  - Developing design
- **Oceaneering – Florida**
  - Responding to Destiny Program
  - Developing prototype
- **Micro Rail – Texas**
  - Privately funded
  - Mix of vehicle configurations
- **Frog / 2getthere / Park Shuttle**
  - Automated guided vehicle
  - Several implementations
- **Austrans**
  - Group Rapid Transit

PRT Lessons Learned

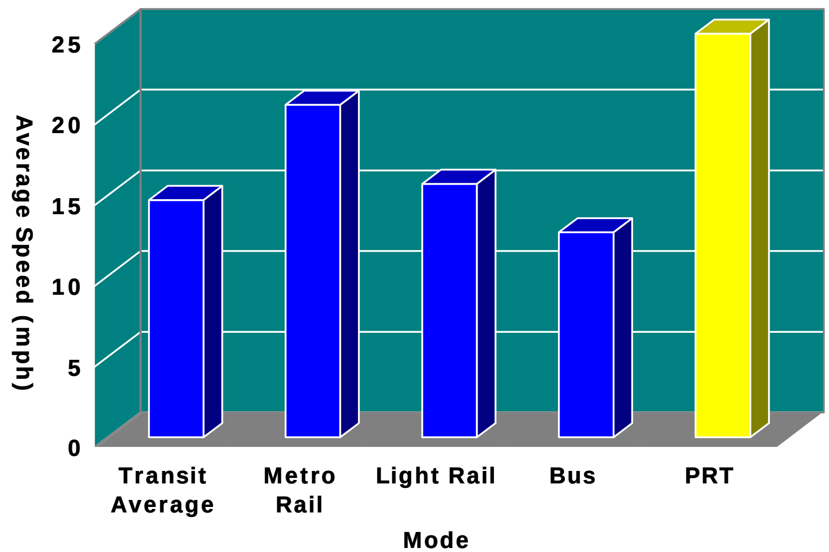
- **Design is critical**
  - Performance requirements should rigorously dictate the design
  - The overall design and integration of features is a critical success factor
  - Picking a design before complete alternatives analysis is potentially fatal
  - Design needs to be safe, reliable, economic, attractive, low impact, high performance and scalable to larger networks
- **Required technology**
  - Advanced control and communication systems are required to deliver safety, reliability, and high levels of performance
  - Short headways and advanced network management systems are needed to provide capacity
  - Consistent levels of propulsion and braking are needed to provide high capacity
  - On-board switching or guidance is critical
- **Careful development is needed**
  - Alternatives analysis requires time, patience and sufficient funding
  - Final design, systems engineering and testing is needed
  - Development should not be constrained by deployment deadlines
  - Adequate funding and consistent political support is critical

PRT State-of-the-Industry

- **Active or past test track operation**
  - **ULTra**, CabinTaxi, Raytheon, CVS, Morgantown, Aramis
- **Current prototype development**
  - **Vectus**, SkyWeb Express, Microrail, Coaster, Ecotaxi/Kone
- **Readiness**
  - Significant research, engineering, development and application studies for over 40 years
  - Past efforts provide a solid foundation for final engineering and development
  - Advanced technology components are proven and ready to support an integrated PRT system design
  - An optimum configuration and viable vendor base has not been established
- **Acceptance**
  - Cities and regions continue to display interest in PRT and select as preferred alternative but disqualify PRT due to lack of proven technology
- **Research and development**
  - Developers are limited due to lack of market acceptance and financial backing
  - Korean, Swedish and British development programs underway
- **Current application interest and procurements**
  - Great Britain; United States; Dubai, UAE; Korea; Europe

PRT Performance Comparison – Average Speed

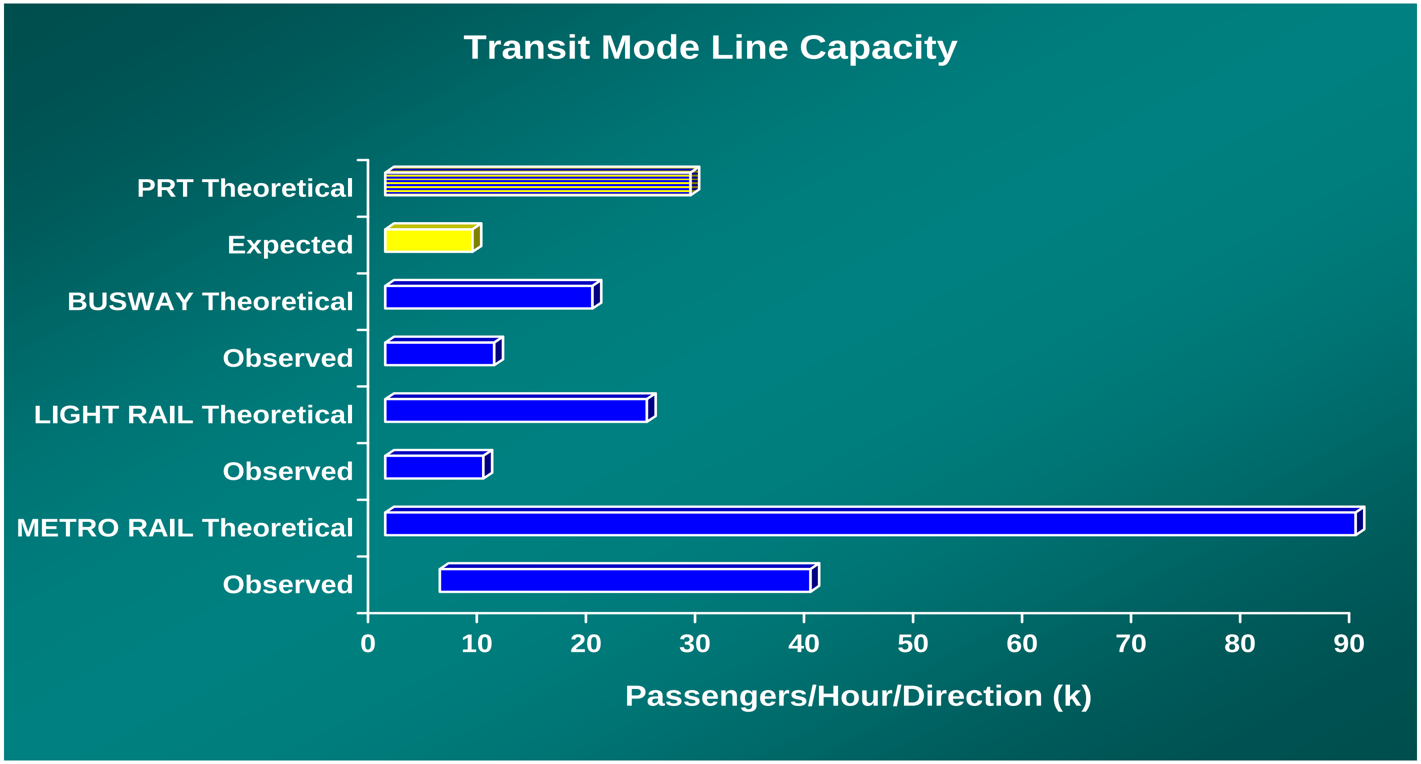
- **Average speed is determined by line speed, number of stops, distance between stops, dwell time at stops, and trip length**
- **PRT systems can achieve an average speed of 20-25 mph with line speed of 25-30 mph due to non-stop trip**
- **PRT trips can be 80-100% faster than a typical bus trip**
- **PRT trips can be 20-30% faster than a typical heavy rail trip**
- **All else being equal, higher average speed can result in higher patronage**



Source: 2005 APTA Fact Book

PRT Performance Comparison – Capacity

- **Line capacity is determined by headway, vehicle capacity and load factor**
- **PRT systems can have comparable line capacity with bus and light rail if safe and reliable short headway operation is achieved**
- **PRT systems can have higher overall system capacity when multiple lines and network layouts are considered with comparable total costs**



Source: TCRP Transit Capacity Manual

PRT Capital Cost Comparison

- **Capital costs are highly specific to location, line layout, number and complexity of stations**
- **The design of PRT systems, with small vehicles and guideways, can support lower capital costs than other exclusive, grade-separated, fixed guideway rail systems**
- **PRT costs can be expected to be comparable with exclusive right-of-way BRT systems**
- **Lower capital costs would be primarily due to:**
  - Smaller guideway and stations
  - Reduced civil work and right-of-way acquisition

	Capital Cost / Mile ($M)		
Mode	**Low**	**Average**	**High**
Metro Rail	$110	$200	$2,000
Light Rail	$25	$50-$70	$195
APM – Urban	$30	$100-$120	$145
APM - Airport	$49	$100-$150	$237
BRT Busway	$7	$14-$25	$50
BRT Tunnel	$200	$250	$300
PRT One Way	$15	$20-$25	$40
PRT Two Way	$20	$25- $30	$50

Sources:Kerr-2005, TCRP –R90, GAO – BRT 2000, Vendor Estimates, Case Studies

Operating and Maintenance Costs

- **Operating and maintenance (O&M) costs per passenger-mile are highly dependent on ridership, system efficiency and system scale**

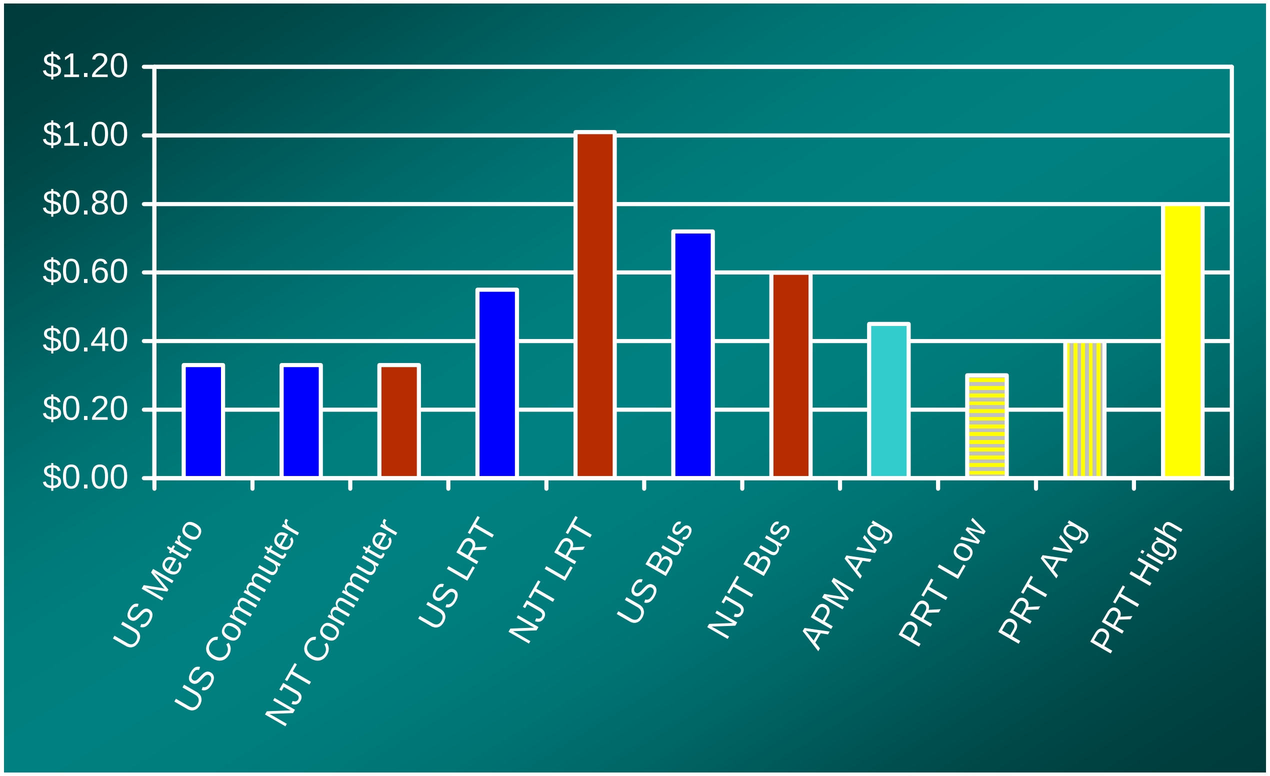
- **PRT systems can be expected to offer comparable O&M costs to heavy and commuter rail if deployed effectively and to moderate scale**

- **PRT systems can be expected to demonstrate lower O&M costs than current automated people mover (APM) systems at airports and the Morgantown PRT (M-PRT) due to:**
  - Higher expected levels of automation
  - Greater use of modern and standardized components
  - Simplified design and mechanical wear reductions
  - Reduced energy use

- **PRT systems could be expected to experience comparatively high O&M costs if deployed in limited service areas with small patronage demand**

O&M Cost Comparison

O&M Cost Per Passenger Mile



Source: 2005 APTA Transit Fact Book, NJT, FTA, Case Studies, PRT Vendors

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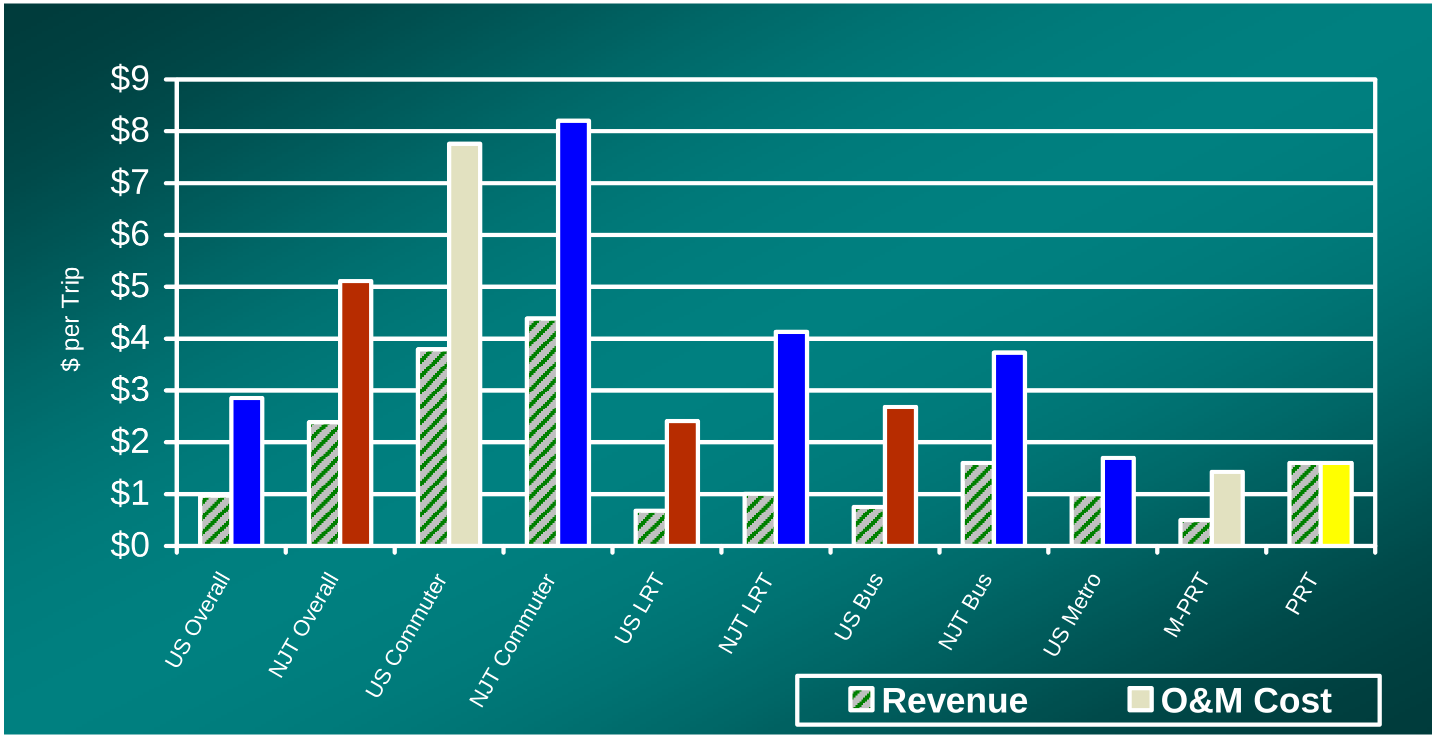
O&M Cost and Revenue Per Trip Comparison

- **Transit O&M cost recovery is 34% nationally**
- **PRT systems can be expected to recover a higher percentage of O&M costs if fares reflect per mile O&M cost**
- **PRT in a moderate scale application can expect to break even on operating costs for an average four mile trip and average fare of $1.60**



Source: 2005 APTA Transit Fact Book, NJT, FTA, Case Studies, PRT Vendors

Challenges to Implementation

- **Engineering and planning expertise**
  - Limited depth of experience in the industry
  - Need to draw upon expertise in related industries such as Aerospace, Automotive, Defense, Computing and Networking
- **Open technology development**
  - Avoid proprietary designs and vendor exclusivity
  - Use of commercially available components
- **Development and application of standards**
  - Safety
  - Security
  - Technical
- **Institutional framework to deal with design, safety and security issues**
- **Consistent and appropriate political, economic and technology support**

Options for Government Support of PRT Development

- **Option 1 – Monitoring and Support**
  - Monitor current private technology developments and consider participation in the future as PRT technology development advances
  - Endorsement of the technology development and consideration for alternatives analysis
- **Option 2 – Research and Analysis**
  - Participate in research and analysis activities that advance development, implementation and operation of PRT systems
  - Quantify economic and transportation benefits
- **Option 3 - Detailed Application Studies**
  - Conduct initial application studies for future implementation of PRT systems
  - Define cost, performance, ridership, layout, impact analysis, and public outreach for one or more potential applications

Options for Government Support of PRT Development

Option 4 - Public/Private Development Program

- Public/private partnership structured to develop and implement PRT technology for the US and world-wide applications
- Shared risk and reward program with potentially multiple public and private partners
- $50-$100 million comprehensive program involving:
  - Public outreach and initial application studies
  - Development of performance requirements; initial operation and safety standards; acceptance, social and economic criteria
  - Analysis, design, development and testing of technology
  - Pilot system demonstration
- Limited risk with program performance requirements
- Establish industrial and research base in host region
- Potential private partners with previous interest:
  - Bombardier, Siemens, Lockheed Martin, General Electric, Oceaneering, Kone, Alcatel, Honeywell, Northrup Grumman

Benefits to Support PRT Development

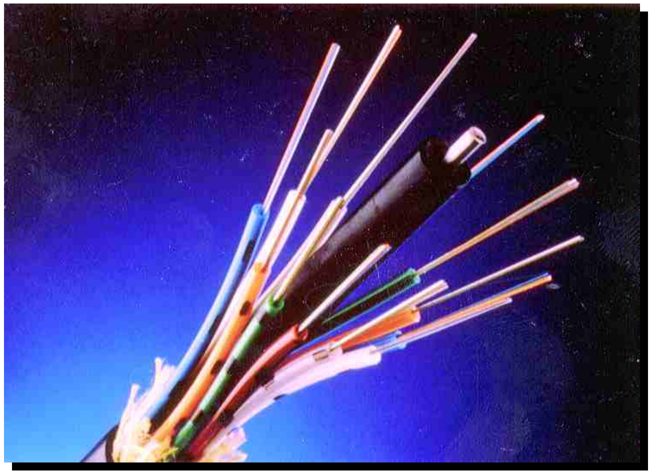
- **PRT has the potential to offer:**
  - High level of service that can potentially attract drivers from their cars and help relieve congestion
  - Lower capital and operating costs than other fixed rail options
  - Lower right-of-way requirements and opportunity to integrate and expand existing transportation systems with potentially reduced urban disruption
  - Reduced energy use and environmental impact
  - Increased safety and security
  - A business model that:
    - Can reduce government transit capital and operating investments through private development
    - Can increase the use of private firms for operations and maintenance
  - An opportunity for economic development:
    - Supporting new implementations
    - A new manufacturing, support and operations industry

Vision for the Future PRT - The Network Model

- **PRT has the opportunity to develop a new business model with the potential to SCALE beyond the limited access of fixed guideway transit**
- **The model is founded on the success of other commercial network businesses such as:**
  - Telephone
  - Internet
  - Cell Phones
  - Cable
- **These network industries are founded on several fundamental principles:**
  - Open standards
  - Mass production and economies of scale
  - Multiple suppliers and providers
  - Government regulation of public access and right of way
  - Market pricing
  - Open competition
  - Private funding
- **Transit can also follow these network successes if the fundamentals are applied to a common technology**

The Internet Example

- **Standards**
  - TCP/IP protocol allowed all manufacturers to build to a common standard that allowed different devices and software products to work on a common network.
- **Mass production, competition and division of providers**
  - Backbone Trunk Lines
  - Devices
  - Software
  - Customer Access
  - Billing
  - Administration
  - Content Providers
- **Limited regulatory government involvement**



The Internet: On Demand Information, Anytime, Anywhere

PRT Standards

- **Performance and technical standards needed for scaleable PRT deployments:**
  - Vehicle Guideway Interface
  - Power
  - Propulsion
  - Control and Communication
  - Ticketing
  - Safety, Security

Standards allow competition and mass production to occur resulting in:

- reduced costs
- increased quality
- market certainty

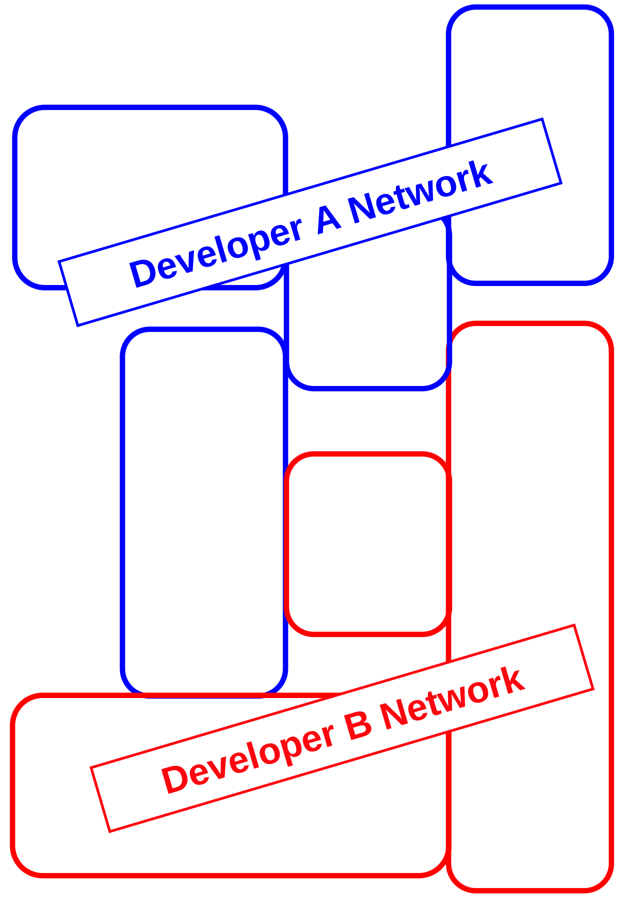
- **Development of standards can occur:**
  - As de facto from the industry leading technology
  - In cooperation with public agencies, federal government, associations, and manufacturers

Public/Private Implementation and Operating Model

- **Structured to be a distributed, self-promulgating model similar to the Internet, Cable or Cellular**
- **Elements of an integrated business model**
  - Regulator Agency
  - Developers
  - Service Operators
  - Vehicle Operators
  - Manufacturers
- **Regulatory agency:**
  - Sells or grants public access/right-of-way
  - Oversee standards compliance
  - Insure safety, security, equal access
  - Manage fare policy and costs of developer/service provider
  - Manage central operations provider

Development Funded Capital Expansion

- **Developers**
  - Granted air-rights to install guideways in specific regions
  - Multiple developers with adjoining regions provide connectivity between networks
  - Contract with manufacturers to build and install guideways
  - Sell station rights to local developers to install stations and off-line guideways as an aid to development
  - Contract with central operations provider for system management and control
  - Value capture from capital appreciation or revenue from increased land value and real estate development



Operators Contract to Provide Services

- **Service Operators**
  - Provide command and control functions
  - Supervise overall control of system
  - Insure vehicles and guideway sections are performing to standards
- **Vehicle Operators**
  - Multiple providers are allowed to operate vehicles
  - Similar to access providers for the internet
  - Contract with manufacturers to build vehicles
  - Contract with service operators for access to systems
- **Manufacturers**
  - Build components such as control, vehicles and guideways to standards
  - Compete on design, cost, efficacy, reliability, performance

Summary - PRT Private Network Business Model

- **PRT can evolve from a public system to a private utility business model**
- **PRT networks can be based on standards similar to internet and cell phone networks**
- **Model based on franchise rights where developers build and operate integrated networks**
- **Government serves in a regulator role**
- **Vehicle operators provide service on franchised networks**
- **Funded from private and public sources:**
  - Fare revenue
  - **Value capture from real estate development**
  - Right of way fees
  - Advertising and entertainment fees
  - Station services
  - Supplemental public support