Outline

- Transportation needs transforming
- PRT response
- PRT Description
- Example Systems
- Stations and Guideways
- PRT Characteristics
- Comparison with Other Systems
Greenhouse Gas Emissions by Sector

Source: USEPA, USDOT
National Transportation Statistics 2009
Air Travel is no Pleasure

Security hassles
Air Travel is no Pleasure

Long walking distances
Air Travel is no Pleasure

Unpleasant waiting conditions
What is Needed

- A public transit system that
  - Attracts drivers from their cars
  - Is 100 times safer than cars
  - Uses much less energy than all other systems
  - Has low infrastructure needs
  - Can also carry freight
  - Is economical to operate
Personal Rapid Transit Response

- High level of service attracts drivers from cars
- Sustainable
  - No emissions, low energy use
  - Low capital and operating costs
- Grade separated
  - Extremely safe
  - Reduces congestion
Airport Response

- Can enhance air travel
  - Replace shuttle buses
  - Reduce curbside congestion
  - Improve security
  - Reduce waiting
  - Reduce walking
  - Cut costs
  - Put joy back in air travel
Personal Rapid Transit (PRT)

- Driverless vehicles on a guideway
- One to four seated passengers plus luggage
- Direct origin to destination service
  - No need to transfer or stop
- Service on demand – not scheduled
- Very short headways (seconds)
Personal Rapid Transit Benefits

- Can attract drivers from their cars
  - Has little or no waiting
  - Provides non-stop service
- Is 100 times safer than cars
- Uses much less energy than other systems
- Has no on-site emissions
- Has low infrastructure needs
- Can also carry freight
- Is economical to operate
PRT Systems

Open Guideway (ULTra)
Vehicle steers itself

Captive Bogey (Vectus)
Guideway steers vehicle

Suspended (Mister)
Vehicle hangs from, and is steered by guideway
Example Systems

- 2getthere
- Vectus
- ULTra
- Morgantown
- Vehicles carry 4 – 20 passengers
- Max. speed = 25mph
- Capacity up to 2,500 pphpd
- Automated operations since 1997
- Masdar PRT Project operating since 2010
2getthere Masdar PRT Vehicle
Vectus PRT System

- Subsidiary of POSCO
- Test track in Sweden
- Meets Swedish safety specs
- Suncheon Project (2013)
Vector PRT System

- Linear induction motors
- Good all-weather capability
- Can accommodate 6
ULTra PRT System

- 2,650 lb gross weight
- 25 mph
- 2KW continuous battery power
- Heathrow public operation since April 2011
ULTra System Features

- Footbridge-like elevated guideway
- 4 passengers
Morgantown, West Virginia

- In operation since 1975
- 15 second headways
- 5,000 pphpd
- Intermediate stations are bypassed
- 98.5% availability (Transit LOS A)
- 140 million injury-free passenger miles
Morgantown, West Virginia

- Speeds up to 30mph
- 10% maximum gradient
- Capital cost ($126M) overran budget
- Operating cost $3.3M/year ($1.50/passenger, $0.94/passenger mile)
- 6 additional stations being planned
• PRT stations are typically smaller (even for same capacity)
• Tight radii (15’) and steep (10%) gradients make PRT station flexible
• Sized according to demand
Guideway Concepts
ULTra Guideway at Heathrow
PRT Characteristics

- Level of service
- Trip time
- Capacity
- Safety and security
- Energy use
- Emissions
- Capital costs per mile
- Operating cost per passenger
- Transit mode share
- Viability
Level of Service

- Little or no waiting (<1 minute at LHR)
- Non-stop
- Seated travel
- Private
- Short trip times
- Matches APM 99.5% availability
Trip Time

- 40% of shuttle bus at Heathrow
- 67% of shuttle bus at DIA
- 45% of APM at DIA
- 15min. time savings at Morgantown
- 2.5 mins longer than car at Fort Carson
- Results from no waiting and non-stop travel, not speed
### Maximum Theoretical Personal Rapid Transit Capacities

<table>
<thead>
<tr>
<th></th>
<th>With Brick Wall Stopping (BWS)¹</th>
<th>Without BWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deceleration (G)²</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Minimum Headway (sec)</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Occupancy (passengers)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Passengers per Hour</td>
<td>1,200⁴</td>
<td>4,500</td>
</tr>
<tr>
<td></td>
<td>1,800</td>
<td>7,200</td>
</tr>
<tr>
<td></td>
<td>3,600</td>
<td>14,400⁵</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7,200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28,800</td>
</tr>
</tbody>
</table>

Note:  
This is guideway/corridor capacity  
PRT’s strength is network capacity
Observed/Practical

Theoretical

Passengers/Hour/Direction

Sources: TCRP Transit Capacity Manual
PANYNJ
PRTC Estimates

Note: This is guideway/corridor capacity
PRT’s strength is network capacity
Capacity Comparison

Note: This is guideway/corridor capacity
PRT’s strength is network capacity
- Lower maximum speeds
- One way traffic
- Separated from other traffic and pedestrians
- Crowding is avoided
- 140 million injury-free passenger miles at Morgantown
Energy Use

Skyweb Express
ULTra
Vanpool
Motorcycle
Commuter Rail
Rail Transit
Auto
Commercial Air
Personal Truck
Bus Transit
Amtrack

Sources: PRT Vendors
USDOT
• No point-of-use emissions
• Power from the grid
## Capital Cost per Mile ($M)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Low</th>
<th>Average</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>Metro Rail</td>
<td>$110</td>
<td>$200</td>
<td>$2,000</td>
</tr>
<tr>
<td>Light Rail</td>
<td>$25</td>
<td>$50-$70</td>
<td>$195</td>
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<tr>
<td>APM – Urban</td>
<td>$30</td>
<td>$100-$120</td>
<td>$145</td>
</tr>
<tr>
<td>APM - Airport</td>
<td>$49</td>
<td>$100-$150</td>
<td>$237</td>
</tr>
<tr>
<td>BRT Busway</td>
<td>$7</td>
<td>$14-$25</td>
<td>$50</td>
</tr>
<tr>
<td>BRT Tunnel</td>
<td>$200</td>
<td>$250</td>
<td>$300</td>
</tr>
<tr>
<td>PRT One Way</td>
<td>$15</td>
<td>$20-$35</td>
<td>$50</td>
</tr>
<tr>
<td>PRT Two Way</td>
<td>$25</td>
<td>$30-$50</td>
<td>$75</td>
</tr>
</tbody>
</table>

Source: Booz Allen Hamilton
Operating Cost Per Passenger

Source: Booz Allen Hamilton
Transit Mode Share

- Without PRT
- With PRT

Kungens Kurva, Sodertalje, Daventry, Corby, Cardiff, SeaTac
Viability

- Morgantown has proven the concept
- Currently no vendors with long history of viability
- ULTra
  - Public service at Heathrow Airport since early 2011
  - BAA is buying stock
- 2getthere
  - Ten-year track record with similar systems in Holland
  - Public service in Masdar in 2010
- Vectus
  - Subsidiary of Posco
  - Public service in S. Korea 2013
<table>
<thead>
<tr>
<th></th>
<th>Transit</th>
<th>Car</th>
<th>PRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>New technology</td>
<td>green</td>
<td>green</td>
<td>yellow</td>
</tr>
<tr>
<td>Trip Time</td>
<td>yellow</td>
<td>yellow</td>
<td>yellow</td>
</tr>
<tr>
<td>Cost per passenger</td>
<td>yellow</td>
<td>yellow</td>
<td>green</td>
</tr>
<tr>
<td>On-demand 24/7</td>
<td>red</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Transfers</td>
<td>red</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Seated travel</td>
<td>yellow</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Private</td>
<td>red</td>
<td>green</td>
<td>green</td>
</tr>
<tr>
<td>Non-stop</td>
<td>red</td>
<td>yellow</td>
<td>green</td>
</tr>
<tr>
<td>Vehicle waits for passenger</td>
<td>red</td>
<td>green</td>
<td>green</td>
</tr>
</tbody>
</table>
## Transit/Car/PRT Comparison

<table>
<thead>
<tr>
<th></th>
<th>Transit</th>
<th>Car</th>
<th>PRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA compliant</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/poor.png" alt="Poor" /></td>
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<tr>
<td>Safe and secure</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
<td><img src="images/good.png" alt="Good" /></td>
</tr>
<tr>
<td>User friendly</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
<td><img src="images/good.png" alt="Good" /></td>
</tr>
<tr>
<td>Snow &amp; ice</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
</tr>
<tr>
<td>Minimal walking</td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/green.png" alt="Green" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
</tr>
<tr>
<td>Environmentally friendly</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/good.png" alt="Good" /></td>
</tr>
<tr>
<td>Energy efficient</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
<td><img src="images/good.png" alt="Good" /></td>
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<tr>
<td>Visually appealing</td>
<td><img src="images/good.png" alt="Good" /></td>
<td><img src="images/ok.png" alt="OK" /></td>
<td><img src="images/good.png" alt="Good" /></td>
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<tr>
<td>Operate inside buildings</td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/poor.png" alt="Poor" /></td>
<td><img src="images/good.png" alt="Good" /></td>
</tr>
</tbody>
</table>

- **Good**: Green
- **OK**: Orange
- **Poor**: Red
## Comparison with Rail

<table>
<thead>
<tr>
<th></th>
<th>Dulles Rail Project</th>
<th>Vancouver Automated</th>
<th>Mid-Jordan LRT Extension</th>
<th>Fort Carson PRT Project</th>
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</thead>
<tbody>
<tr>
<td>Miles of track</td>
<td>23 (2-way)</td>
<td>12 (2-way)</td>
<td>11 (2-way)</td>
<td>23 (1-way)</td>
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<tr>
<td>Stations</td>
<td>11</td>
<td>16</td>
<td>9</td>
<td>35</td>
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<tr>
<td>Daily pax</td>
<td>60,000</td>
<td>100,000</td>
<td>9,500</td>
<td>53,500</td>
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<tr>
<td>Capital cost</td>
<td>$5,200M</td>
<td>$1,870</td>
<td>$428M</td>
<td>$529M</td>
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<tr>
<td>Cost per mile</td>
<td>$113M</td>
<td>$78M</td>
<td>$19M</td>
<td>$23M</td>
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<tr>
<td>Cost per stn</td>
<td>$473M</td>
<td>$117M</td>
<td>$48M</td>
<td>$15M</td>
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<tr>
<td>Cost per annual pax</td>
<td>$290</td>
<td>$62</td>
<td>$150</td>
<td>$33</td>
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<tr>
<td>Type</td>
<td>Corridor</td>
<td>Corridor</td>
<td>Corridor</td>
<td>Network</td>
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## Comparison of positive impacts

<table>
<thead>
<tr>
<th></th>
<th>High speed Rail</th>
<th>Light &amp; Commuter Rail</th>
<th>Street Cars</th>
<th>Demand Management</th>
<th>Hybrid cars</th>
<th>Electric cars</th>
<th>Automated Highways</th>
<th>PRT</th>
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</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Congestion</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Energy use</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Cost</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>GHG</td>
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<td>1</td>
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<tr>
<td>Logistics</td>
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<td>Severance</td>
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<td>1</td>
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<td>0</td>
<td>0</td>
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<td>Real estate</td>
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<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

- **No positive impact**
- **Some positive impact**
- **Significant positive impact**
Contact Information

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