PRT consulting

Introduction To Personal Rapid Transit

Outline

- Transportation needs transforming
- PRT response
- PRT Description
- Example Systems
- Stations and Guideways
- PRT Characteristics
- Comparison with Other Systems

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Transportation Needs Transforming

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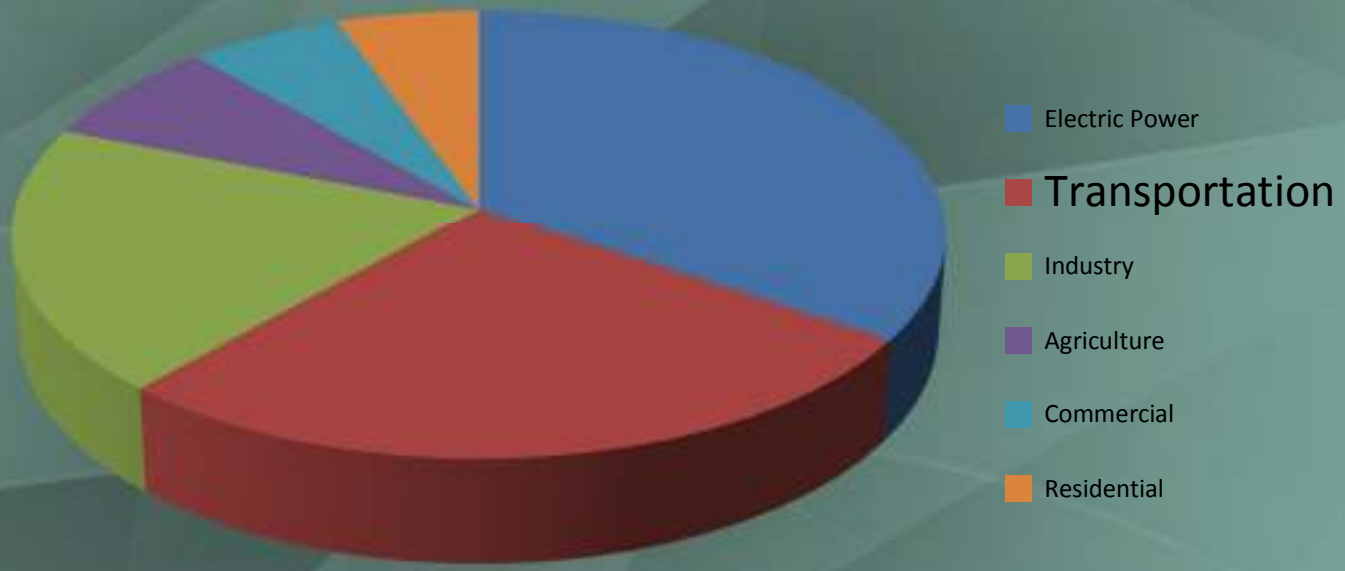
Transportation Needs Transforming

Transportation Needs Transforming



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

2getthere

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

2getthere Masdar PRT Vehicle

2getthere Masdar PRT System

Vectus PRT System

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

Vectus 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

Video/Animation

Stations & Guideways

- PRT stations are typically smaller (even for same capacity)
- Tight radii (15’) and steep (10%) gradients make PRT station flexible
- Sized according to demand

T2K Elevated

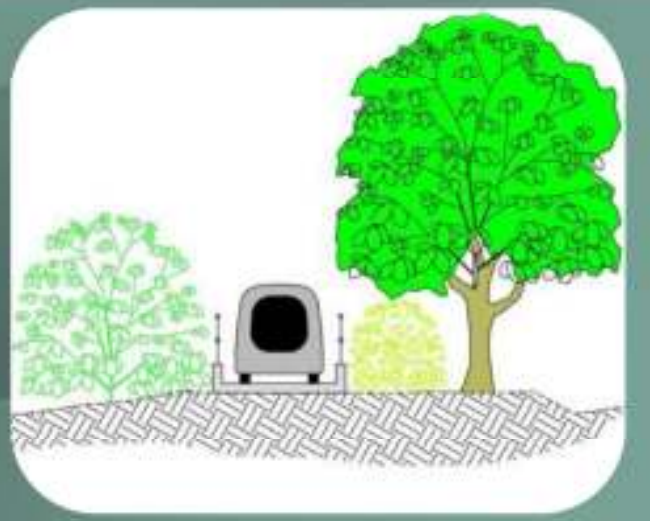
ULTra at Grade

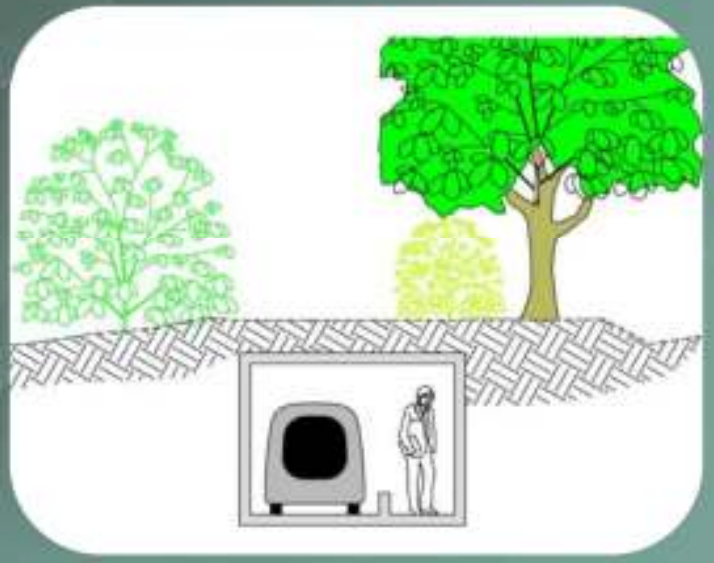
ULTra at Heathrow T5

2getthere at Masdar

Vectus Elevated/At Grade

Guideway Concepts





Vectus Guideway

ULTra Guideway at Heathrow

T2K Guideway Rendering

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

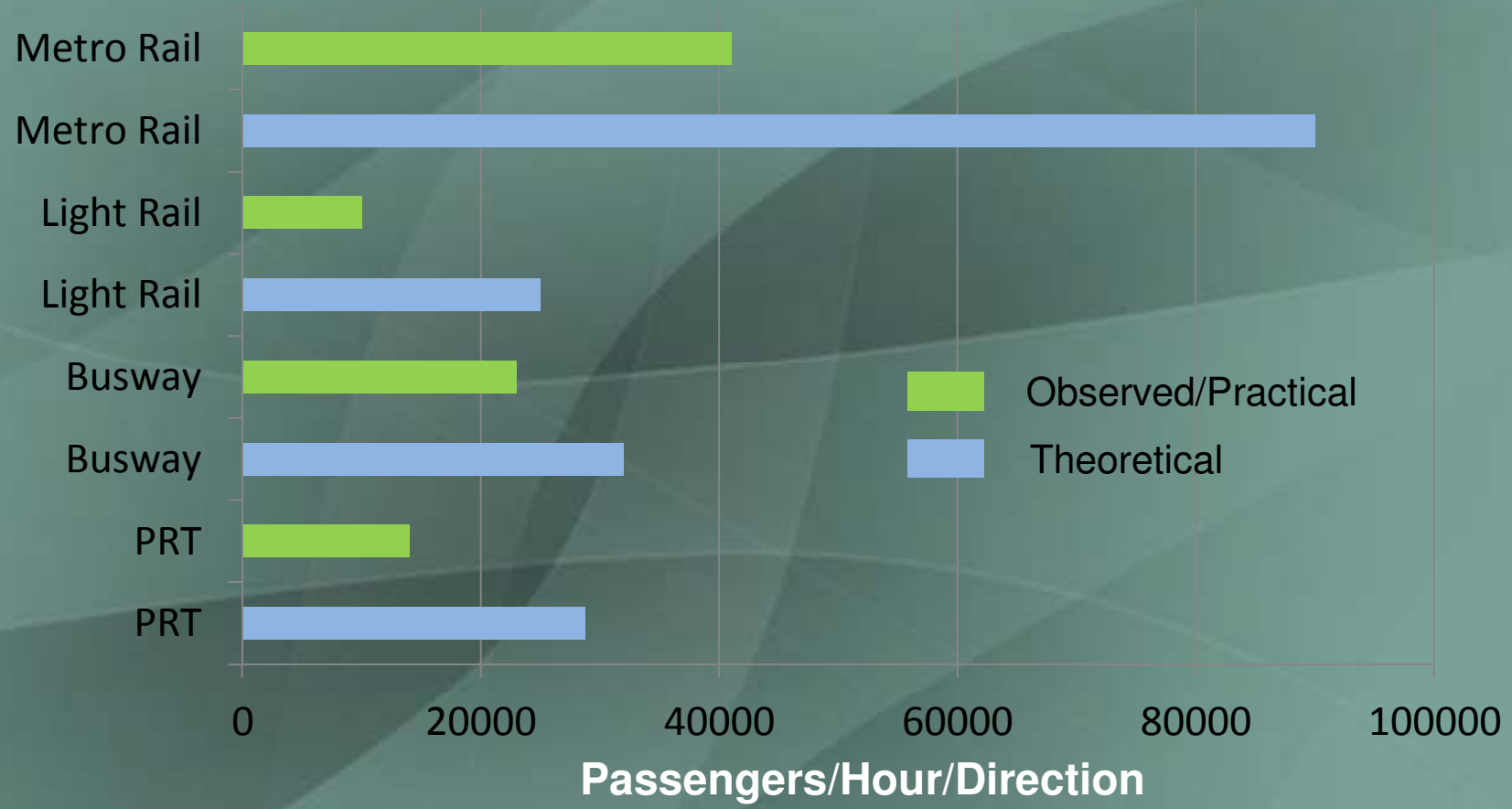
PRT Capacity

Maximum Theoretical Personal Rapid Transit Capacities

	With Brick Wall Stopping (BWS)[1]				Without BWS			
Deceleration (G)[2]	0.25		0.50		0.50	0.50	0.50	0.50
Minimum Headway (sec)	3.0	3.0	2.0	2.0	1.0	1.0	0.5[3]	0.5
Occupancy (passengers)	1	4	1	4	1	4	1	4
Passengers per Hour	1,200[4]	4,500	1,800	7,200	3,600	14,400[5]	7,200	28,800

Note: This is guideway/corridor capacity
PRT's strength is network capacity

Capacity Comparison



Sources: TCRP Transit Capacity Manual
PANYNJ
PRTC Estimates

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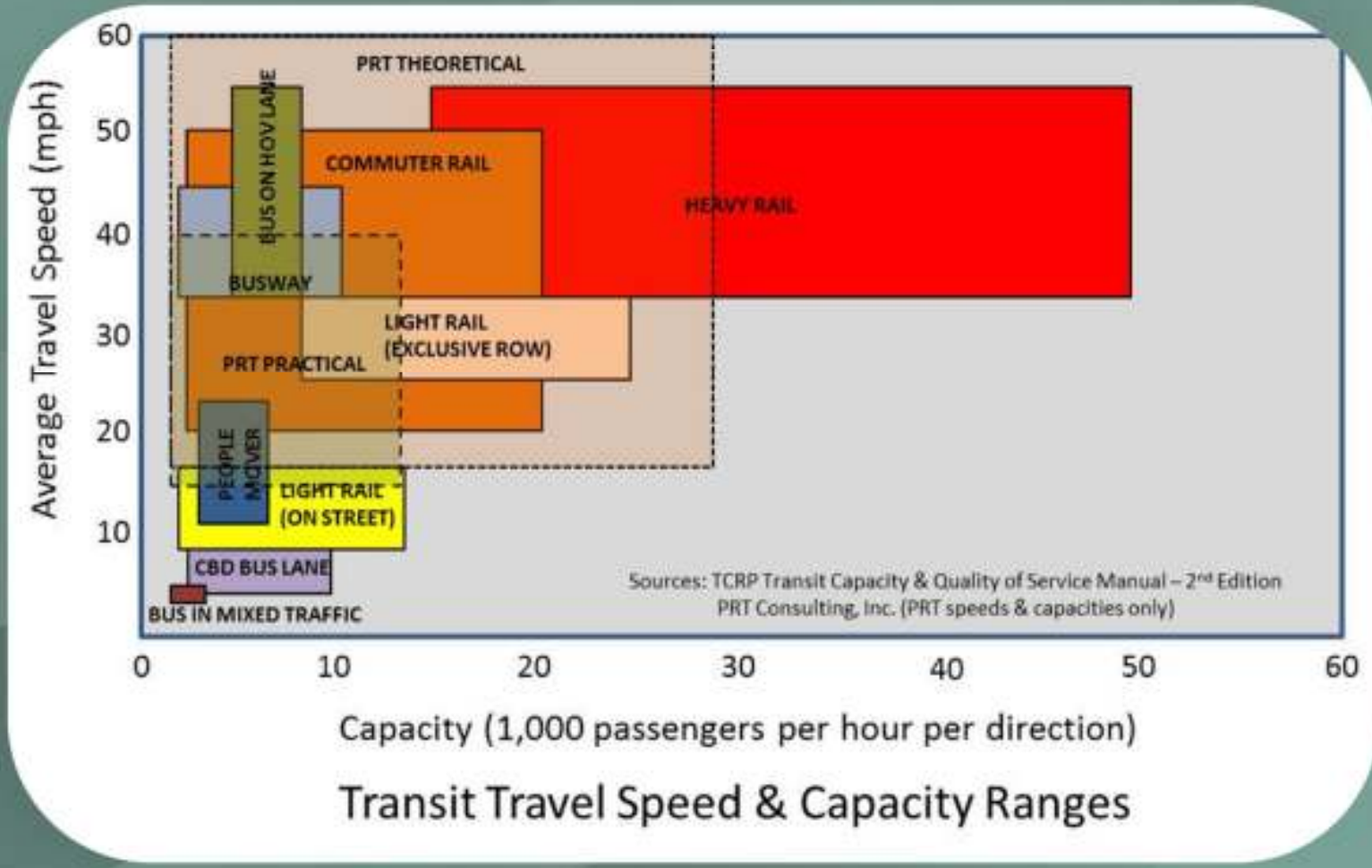
Capacity Comparison



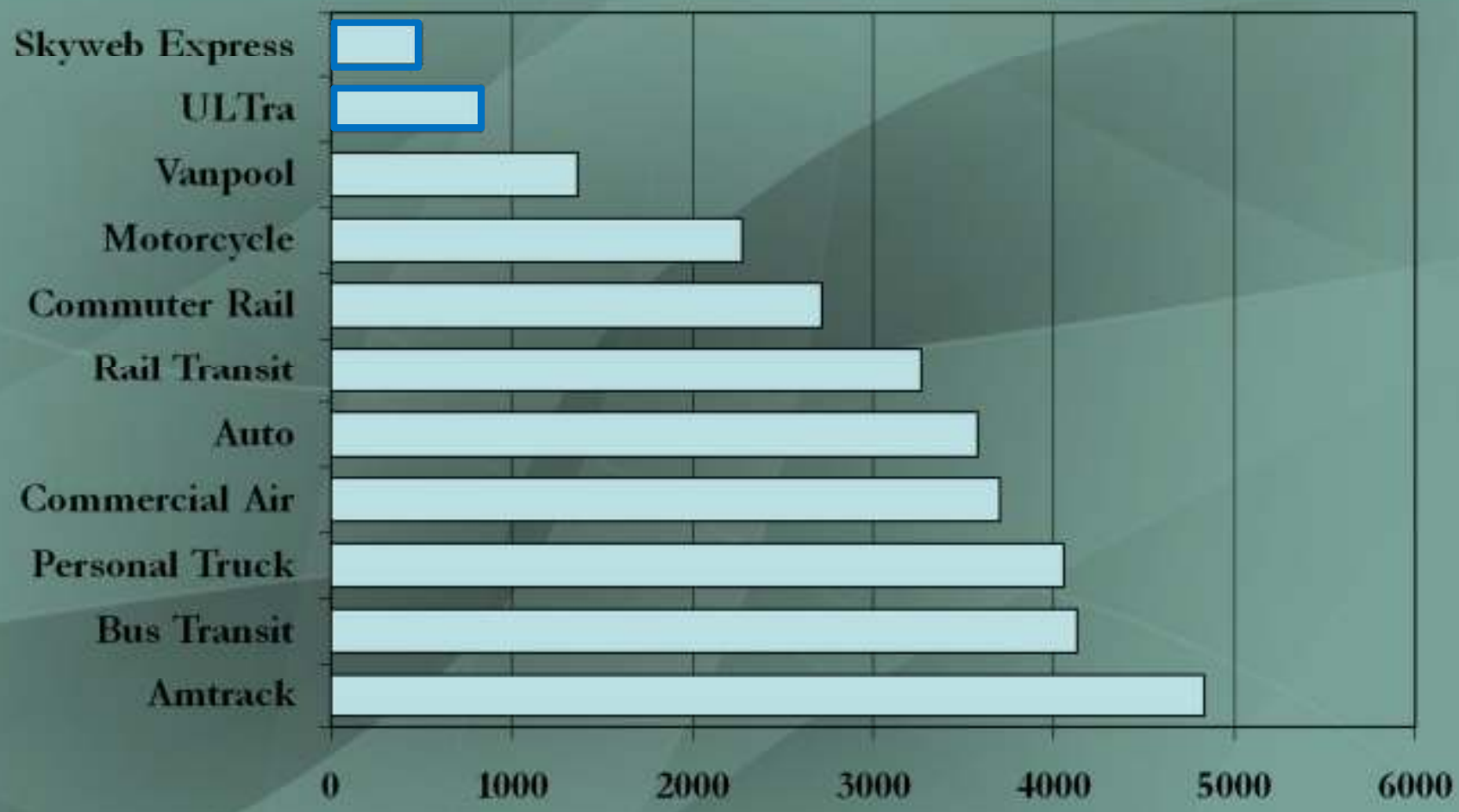
Transit Travel Speed & Capacity Ranges

Note: This is guideway/corridor capacity
PRT's strength is network capacity

Safety & Security

- 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



Sources: PRT Vendors
USDOT

Emissions

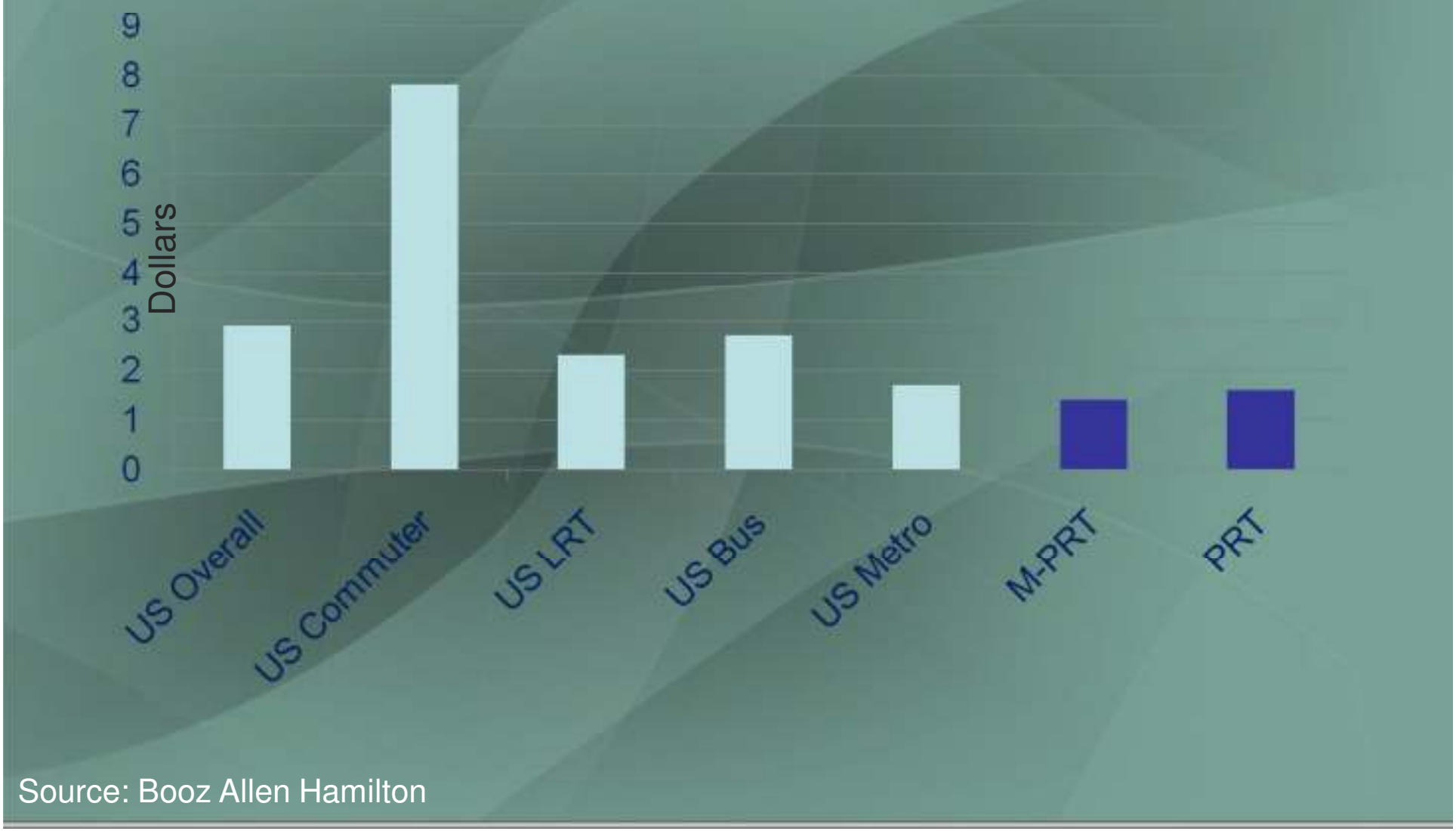
- No point-of-use emissions
- Power from the grid

Capital Cost per 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-$35	$50
PRT Two Way	$25	$30- $50	$75

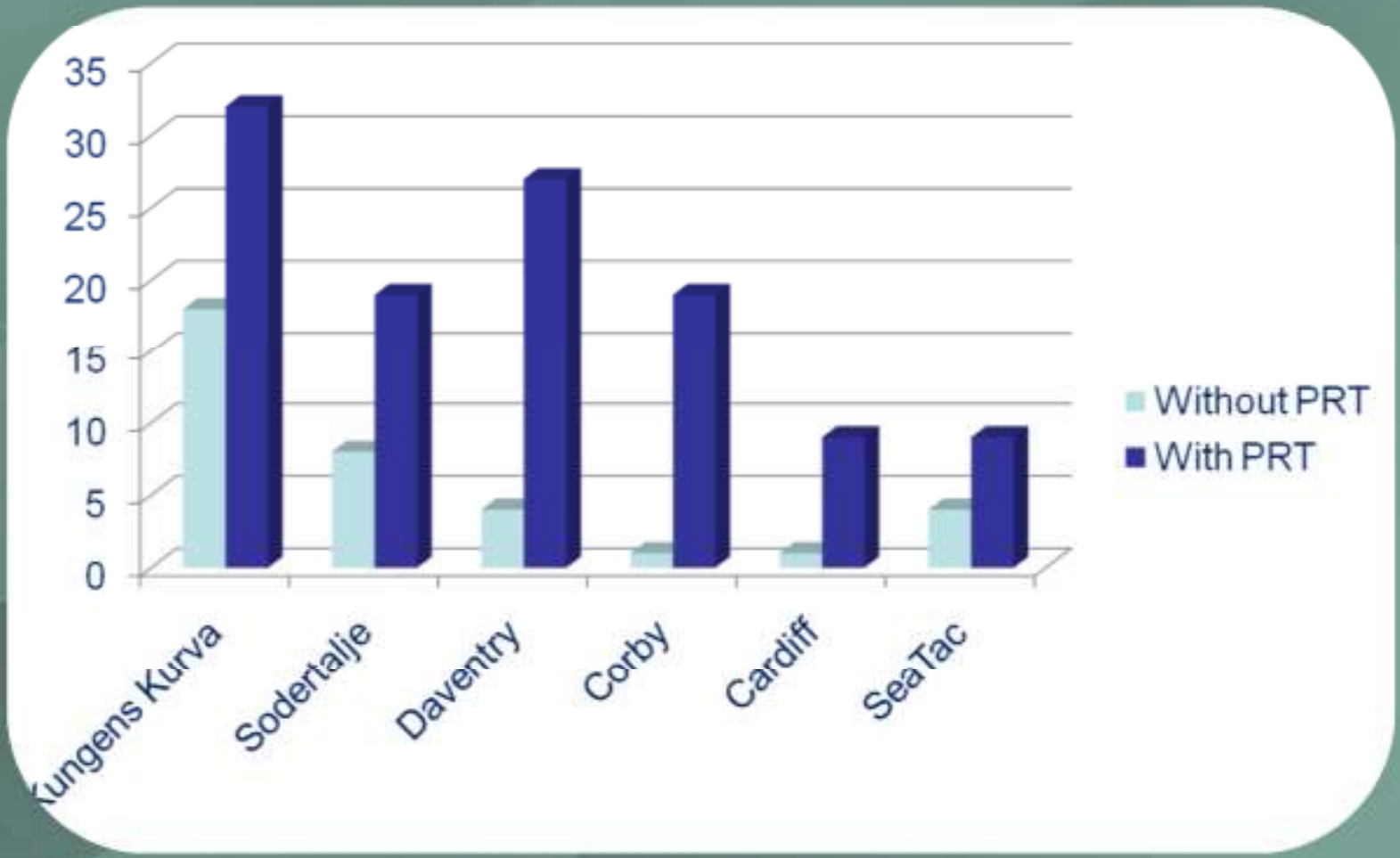
Source: Booz Allen Hamilton

Operating Cost Per Passenger



Source: Booz Allen Hamilton

Transit Mode Share



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

Transit/Car/PRT Comparison

	Transit	Car	PRT
New technology	Good	Good	OK
Trip Time	OK	OK	OK
Cost per passenger	OK	OK	Good
On-demand 24/7	Poor	Good	Good
Transfers	Poor	Good	Good
Seated travel	OK	Good	Good
Private	Poor	Good	Good
Non-stop	Poor	OK	Good
Vehicle waits for passenger	Poor	Good	Good

Good OK Poor

Transit/Car/PRT Comparison

	Transit	Car	PRT
ADA compliant	OK	Poor	Good
Safe and secure	OK	OK	Good
User friendly	OK	OK	Good
Snow & ice	OK	Poor	OK
Minimal walking	Poor	Good	OK
Environmentally friendly	OK	Poor	Good
Energy efficient	OK	OK	Good
Visually appealing	OK	OK	OK
Operate inside buildings	Poor	Poor	OK

Good OK Poor

Comparison with Rail

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

Comparison of positive impacts

	High speed Rail	Light & Commuter Rail	Street Cars	Demand Management	Hybrid cars	Electric cars	Automated Highways	PRT
Accidents	1	1	0	0	0	0	2	2
Congestion	0	1	0	1	0	0	0	2
Energy use	0	0	0	1	1	2	1	2
Cost	0	0	0	0	0	0	0	1
GHG	1	1	1	1	1	2	2	2
Logistics	1	0	0	1	0	0	1	1
Severence	0	0	0	1	0	0	0	2
Real estate	0	1	0	0	0	0	1	2
Walkability	0	1	2	1	0	0	0	2

No positive impact
Some positive impact
Significant positive impact

0
1
2

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