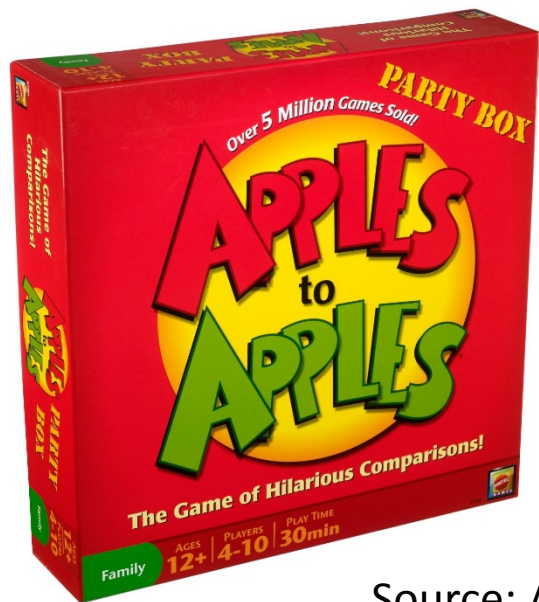


Apples to Apples: Measuring the Performance of Transit and Roadways Equivalently

Reuben Juster

Faculty Research Assistant

CATT Works



Source: Amazon



The Tale of Two Modes



The Four Oh Five
SFVmedia

WMATA Rail
ARLnow

Performance Measurement

1. Goal (Qualitative)
2. Objective (Quantitative)
3. Performance Measures (Unit)
4. Performance Target (Range)



Why Measure Performance?



Regulation
(*Love Canal, Buffalo News*)



Problem Identification
(*I-35W Collapse, Wikimedia*)



Transparency
(*Enron, Wikipedia*)



Prioritization
(*Momofuku Milkbar, NY Daily News*)



Justification
(*Intercounty Connector, FHWA*)

The Problem



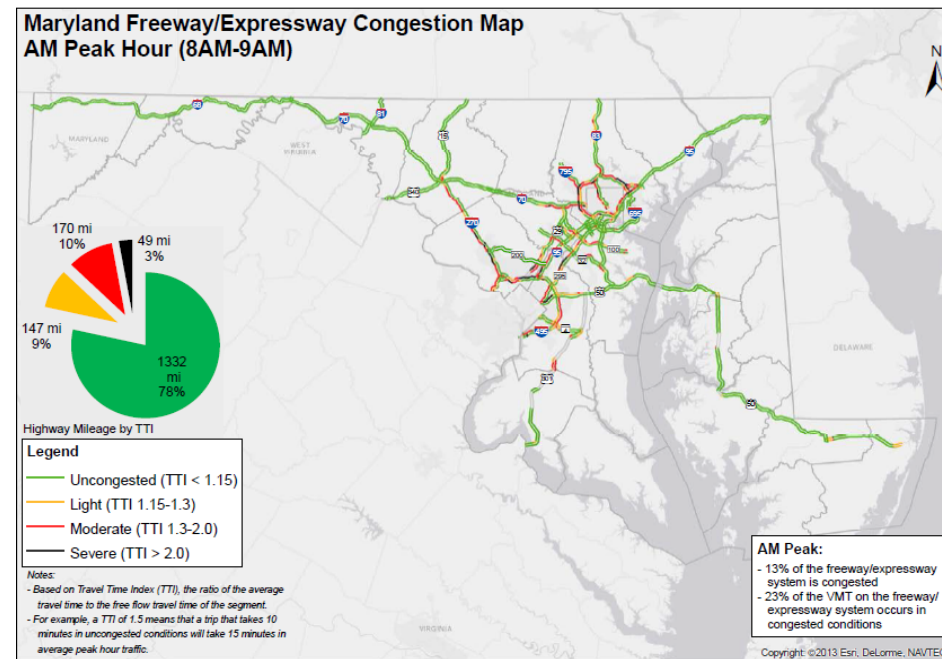
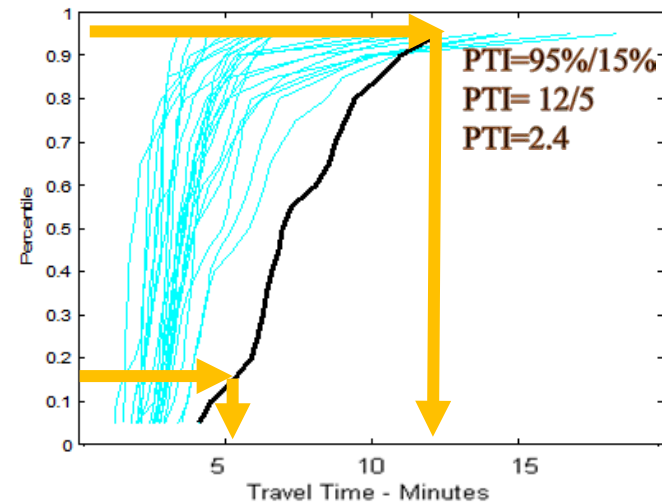
The Ideal



The Dan Ryan Branch and Expressway, Wikipedia

Apples (Highway Performance Measures)

- Percentile-based
- Travel Time Index
- Planning Time Index
- Cumulative Distribution Function
- Enabled by Probe Data
- Required by MAP-21



Oranges (National Transit Database)

ID Number: 3030
 www.WMATA.com
 600 Fifth Street, N.W.
 Washington, DC 20001

Washington Metropolitan Area Transit Authority (WMATA)

General Manager: Mr. Richard Saries
 (202) 962-1000

General Information

Urbanized Area (UZA) Statistics - 2010 Census
 Washington, DC-VA-MD

Square Miles	1,322
Population	4,586,770
Population Ranking out of 465 UZAs	8
Other UZAs Served	19, 263

Service Area Statistics

Square Miles	950
Population	3,719,567

Service Consumption

Annual Passenger Miles	1,989,443,559
Annual Unlinked Trips	413,640,060
Average Weekday Unlinked Trips	2 1,406,544
Average Saturday Unlinked Trips	2 677,311
Average Sunday Unlinked Trips	2 445,781

Service Supplied

Annual Vehicle Revenue Miles	135,061,271
Annual Vehicle Revenue Hours	8,814,709
Vehicles Operated in Maximum Service	3,062
Vehicles Available for Maximum Service	3,527
Base Period Requirement	949

Financial Information

Fare Revenues Earned	\$756,295,649
Sources of Operating Funds Expended	
Fare Revenues (46%)	\$756,295,649
Local Funds (27%)	\$433,764,496
State Funds (17%)	\$277,337,629
Federal Assistance (2%)	\$30,700,000
Other Funds (8%)	\$136,004,854
Total Operating Funds Expended	\$1,634,122,628
Sources of Capital Funds Expended	
Local Funds (21%)	\$110,402,400
State Funds (13%)	\$69,489,600
Federal Assistance (66%)	\$348,212,936
Other Funds (0%)	\$0
Total Capital Funds Expended	\$528,104,936

Summary Operating Expenses

Salary, Wages, Benefits	\$1,098,458,474
Materials and Supplies	\$145,154,856
Purchased Transportation	\$107,913,370
Other Operating Expenses	\$229,576,925
Total Operating Expenses	\$1,581,103,625

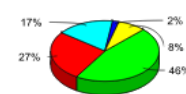
Reconciling Cash Expenditures

\$53,019,003

Vehicles Operated in Maximum Service and Uses of Capital Funds

Mode	Directly Operated	Purchased Transportation	Revenue Vehicles	Systems and Guideways	Facilities and Stations	Other	Total
Bus	1,293	45	\$75,472,882	\$27,813,330	\$19,535,687	\$234,299	\$123,056,198
Heavy Rail	678	0	\$30,735,530	\$110,182,892	\$240,314,694	\$16,396,610	\$397,629,726
Demand Response	0	552	\$7,344,505	\$0	\$0	\$74,507	\$7,419,012
Demand Response - Taxi	0	294	\$0	\$0	\$0	\$0	\$0
Total	2,171	891	\$113,552,917	\$137,996,222	\$259,850,381	\$16,705,416	\$528,104,936

Sources of Operating Funds Expended



Sources of Capital Funds Expended

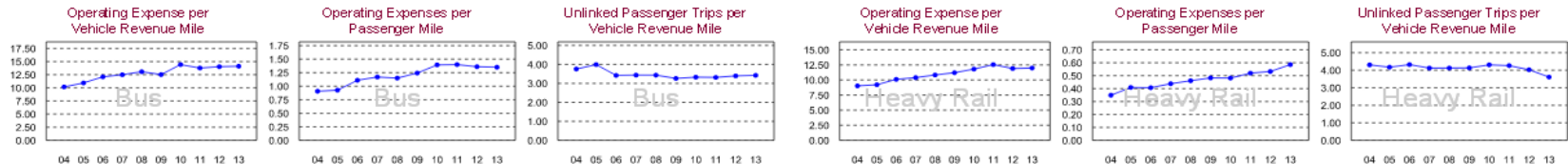


Modal Characteristics

Mode	Operating Expenses ¹	Fare Revenues ¹	Uses of Capital Funds	Annual Passenger Miles	Annual Vehicle Revenue Miles	Annual Unlinked Trips	Annual Vehicle Revenue Hours	Fixed Guideway Directional Route Miles	Vehicles Available for Maximum Service	Average Fleet Age in Years	Vehicles Operated in Maximum Service	Peak to Base Ratio	Percent Spares
Bus	\$568,414,665	\$142,477,455	\$123,056,198	420,648,188	40,263,965	137,778,320	3,935,946	67.0	1,541	6.8	1,338	2.32	15%
Heavy Rail	\$909,456,911	\$605,538,195	\$397,629,726	1,552,619,378	75,884,600	273,828,461	3,094,597	211.8	1,092	22.9	878	2.17	24%
Demand Response	\$95,059,545	\$8,014,194	\$7,419,012	14,627,679	17,364,392	1,930,671	1,718,129	N/A	600	1.5	552	N/A	9%
Demand Response - Taxi	\$8,172,504	\$265,805	\$0	1,548,314	1,548,314	102,628	66,037	N/A	294	N/A	294	N/A	0%

Performance Measures

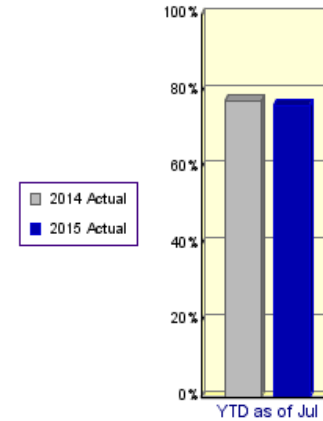
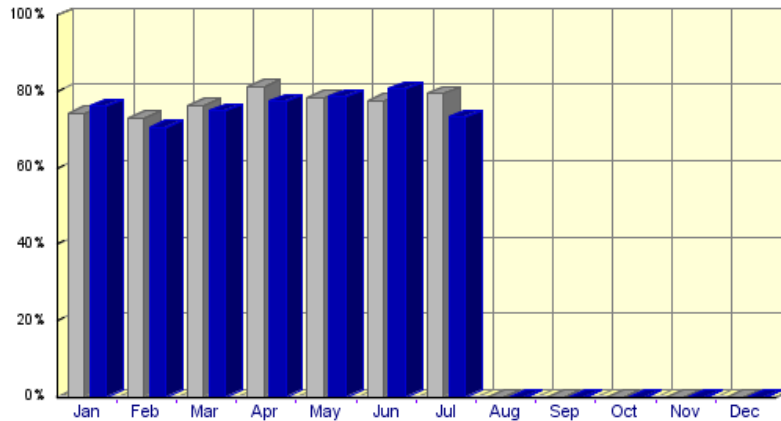
Mode	Service Efficiency		Service Effectiveness		Service Effectiveness	
	Operating Expense per Vehicle Revenue Mile	Operating Expense per Vehicle Revenue Hour	Operating Expense per Passenger Mile	Operating Expense per Unlinked Passenger Trip	Unlinked Passenger Trips per Vehicle Revenue Mile	Unlinked Passenger Trips per Vehicle Revenue Hour
Bus	\$14.12	\$144.42	\$1.35	\$4.13	3.42	35.01
Heavy Rail	\$11.98	\$293.89	\$0.59	\$3.32	3.61	88.49
Demand Response	\$5.47	\$55.33	\$6.50	\$49.24	0.11	1.12
Demand Response - Taxi	\$5.28	\$123.76	\$5.28	\$79.63	0.07	1.55



Oranges (New York)



Monthly Comparison
NYC Transit
OTP (Terminal) - 1 Line



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YTD
2014 Actual	74.3%	73.2%	76.4%	81.4%	78.5%	77.7%	79.5%						77.4%
2015 Actual	76.2%	70.7%	74.9%	77.4%	78.7%	80.7%	73.4%						76.1%
2015 Target													

Subways weekday Terminal OTP evaluates performance based on schedule/service plan in effect, includes all delays.

NYMTA

Percentage of trains that start their journey at their first station within 5 minutes of the schedule and have not skipped any scheduled stations.

Blood Orange (Boston, MBTA)

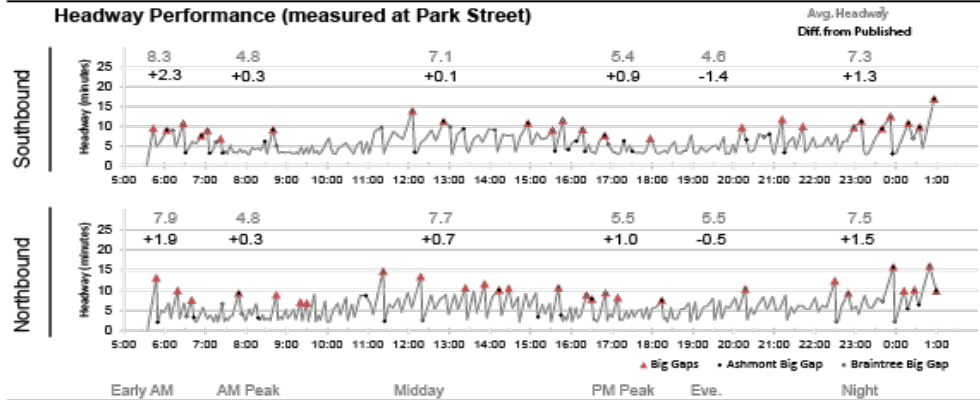
Daily Performance **Red Line** Wednesday, 03/26/14

Passengers Waits			Passenger Travel Time²	
87%	97%	100%	96%	100%
< Headway Goal: 90%*	< Big Gap Goal: 98%*	< 2X Headway Goal: 100%*	delayed < 3 min. Goal: TBD	delayed < 6 min. Goal: TBD

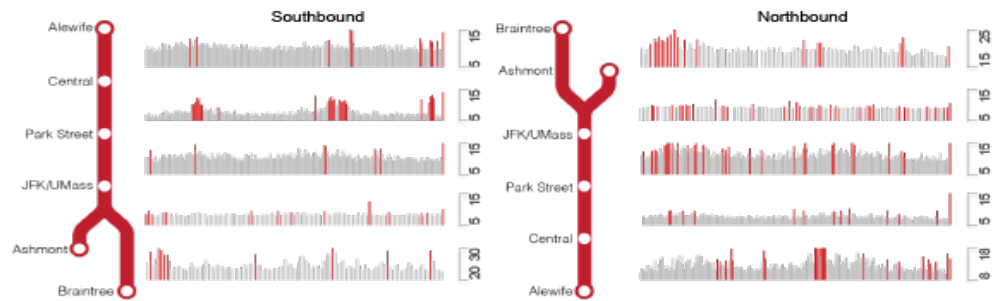
Comparison to range for each metric over prior 6 months (red bar is today, dark grey is worse than median, light grey is better)

* Goals are tentative, may be changed

Headway Performance (measured at Park Street)



Running Time Performance by Segment



Highlighted times are 15% higher than the median for the period

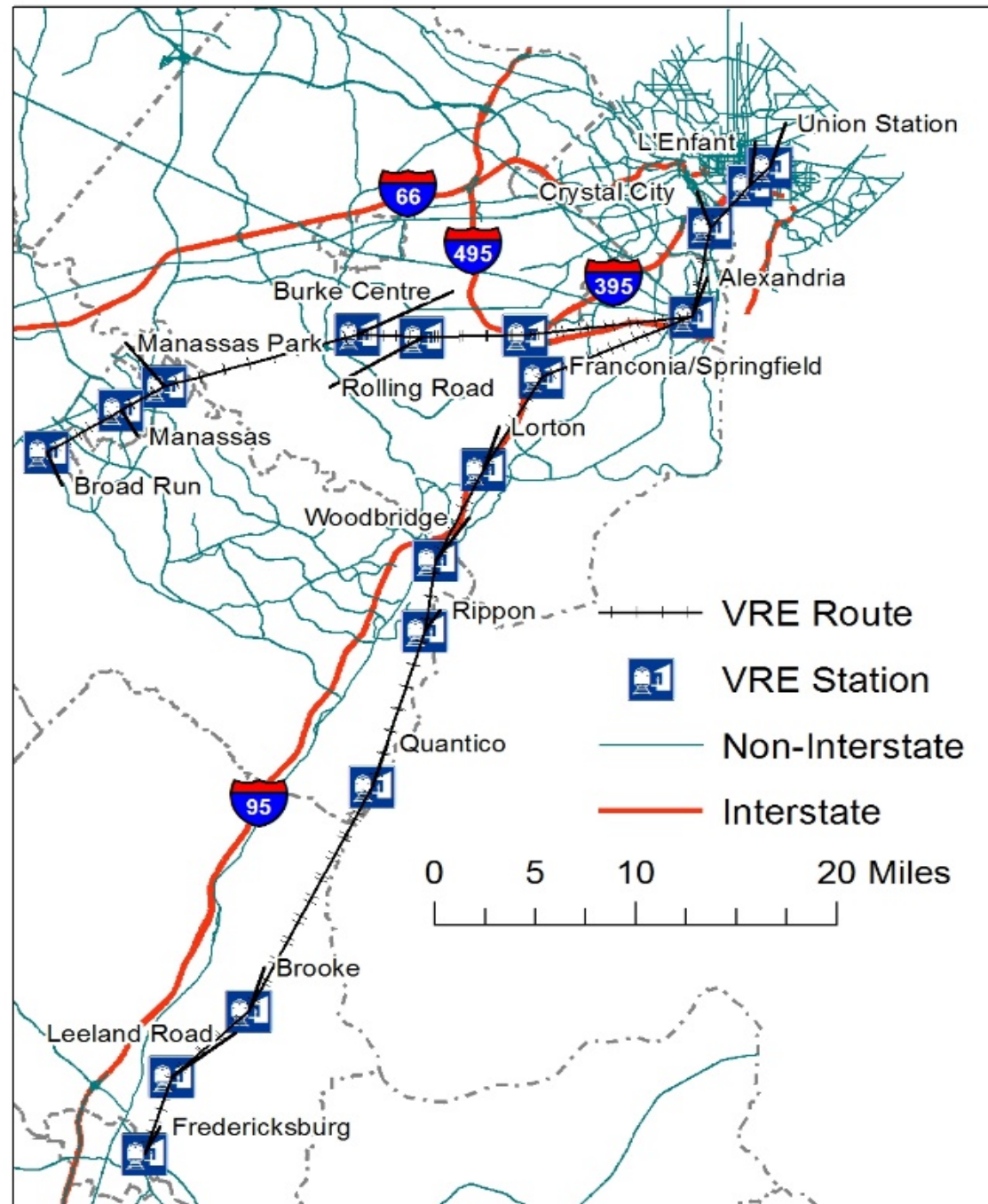
- The standard for a big gap is either 1.5 times or 3 minutes greater than the scheduled headway, whichever is lower.
- Passenger travel time is based on average passenger demand rates per period. I.e. 18000 people entering a station during the peak is a demand rate of 6000/hr or 100/min, which are further divided by destination. The rate is multiplied by the headway of a train to get the number of people boarding that train. If a train takes more than 3 minutes more than normal between any two points, the passengers on that train are considered delayed. It does not account for people not being able to board a train due to crowding.
- Weighted average headway accounts for the fact that fewer people end up experiencing a short headway than a long headway, since fewer passengers arrive between trains.



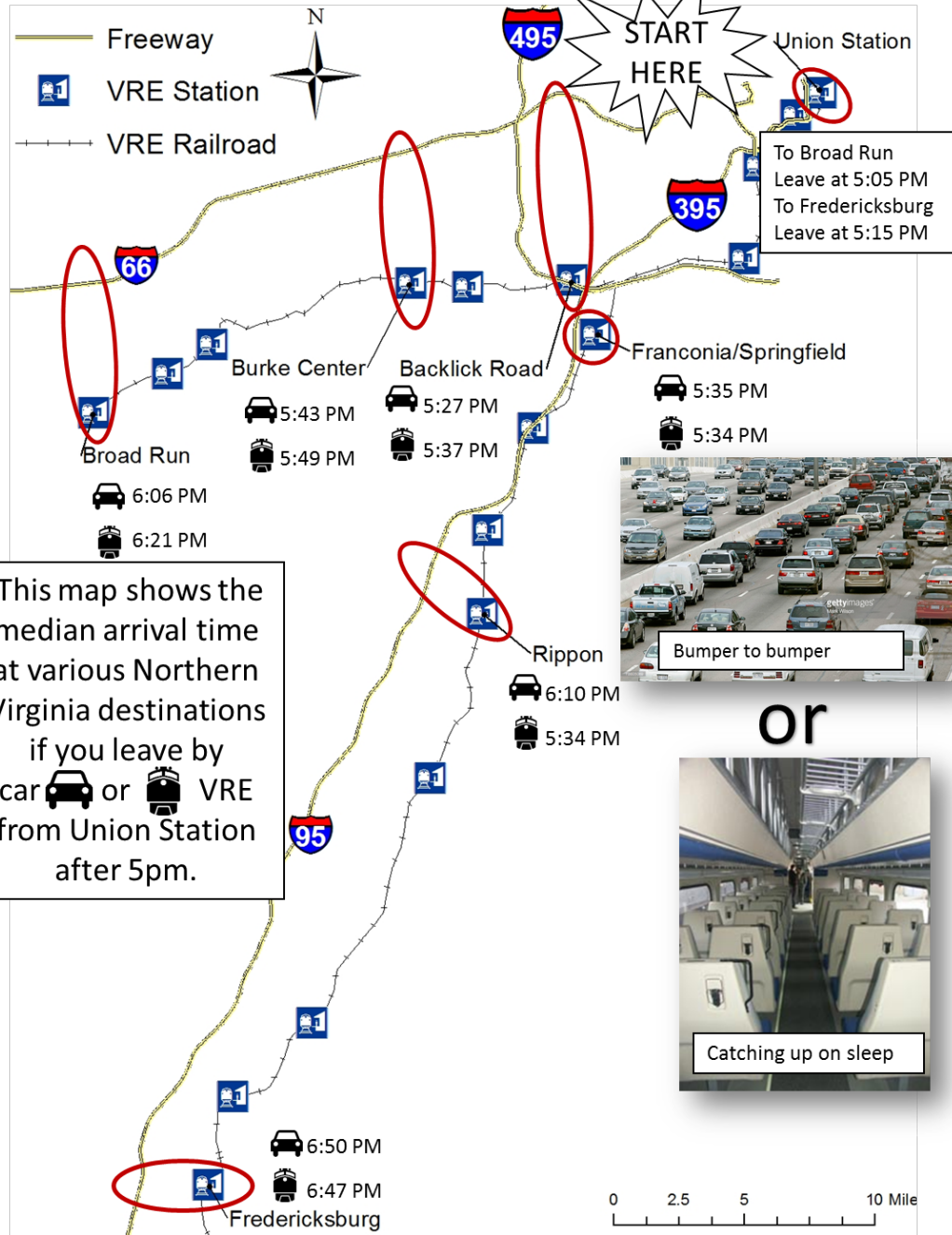
Wikipedia

How about comparing the modes apples to apples?

Study Location



Choose Your Commute



Study Data

- VPP for highways
- In House Virginia Railway Express (VRE) Data

DETECTED DELAYS DETAILED REPORT

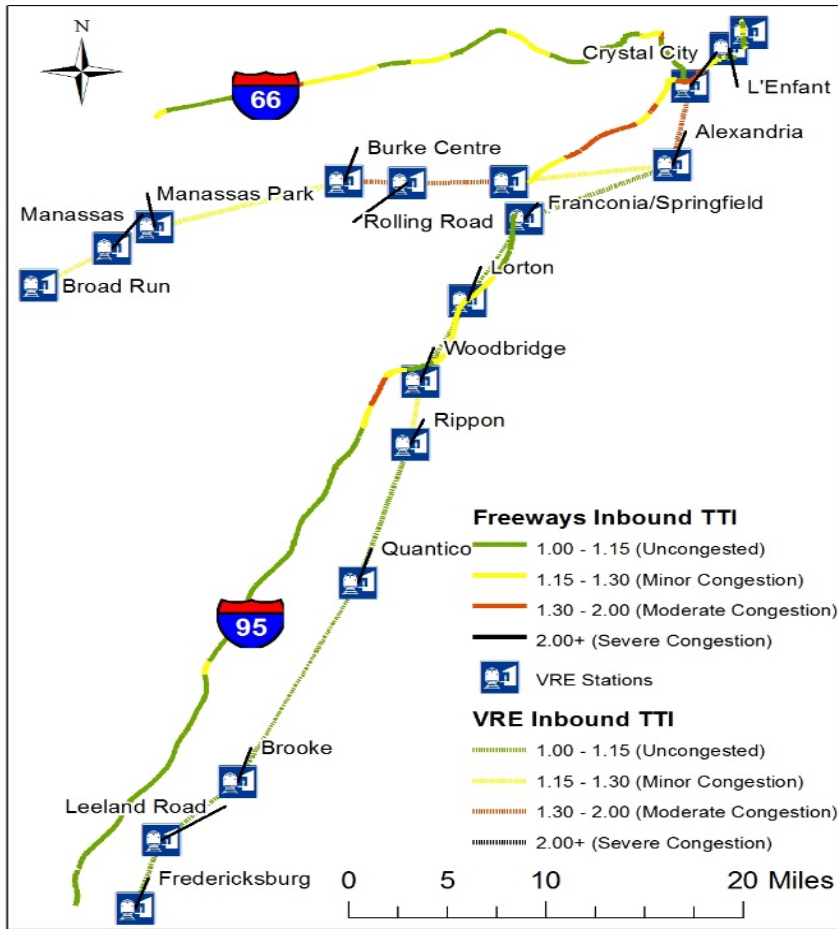
07/01/2014 12:00 AM through 06/30/2015 11:59 PM

WHERE Train Numbers in (300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 321, 322, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 335, 336, 337, 338)

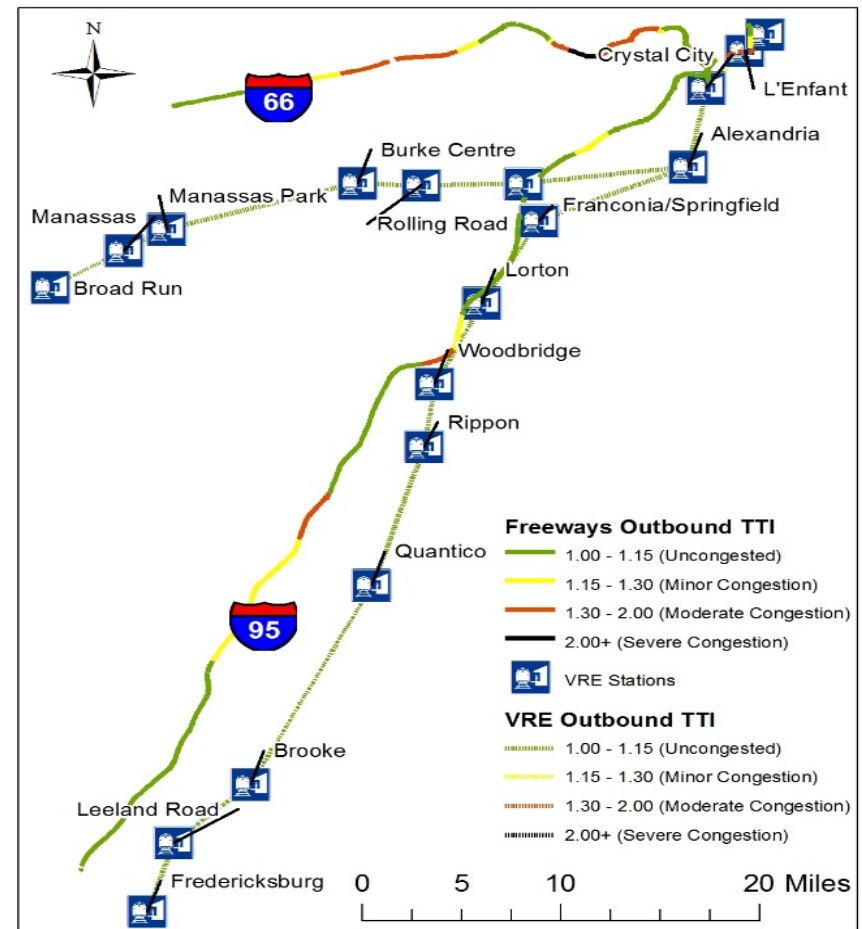
Fredericksburg Line												
NORTH												
Days of Operation	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F	M-F
	300	302	304	306	308	310	312	*AMT	*AMT	*AMT	*AMT	*AMT
		S		S		S	S	86	174	84	94	66
Fredericksburg	5:05a	5:15a	5:40a	6:05a	6:30a	7:15a	7:40a	6:56a	8:00a	9:19a	12:08p	7:57p
Leeland Road	5:12	5:22	5:47	6:12	6:37	7:22	7:47	--	--	--	--	--
Brooke	5:18	5:28	5:53	6:18	6:43	7:28	7:53	--	--	--	--	--
Quantico	--	5:40	6:05	6:30	6:55	7:40	8:05	7:16	8:22	9:41	12:28	8:22
Rippon	--	5:49	6:14	6:39	7:04	7:49	8:14	--	--	--	--	--
Woodbridge	5:40	5:56	6:21	6:46	7:11	7:56	8:20	7:28	8:36	--	--	--
Lorton	--	6:03	6:28	6:53	7:18	8:03	8:27	--	--	--	--	--
Franconia/Spfld (L)	--	6:11	6:36	7:00	7:26	8:11	8:35	--	--	--	--	--
Alexandria (L)	6:07	6:24	6:49	7:12	7:38	8:23	8:47	7:52	9:05	10:15	1:07	8:55
Crystal City (L)	6:15	6:34	6:58	7:21	7:48	8:32	8:55	--	--	--	--	--
L'Enfant (L)	6:23	6:44	7:06	7:29	7:56	8:40	9:02	8:03	9:14	--	--	--
Union Station	6:29a	6:52a	7:14a	7:37a	8:04a	8:47a	9:09a	8:15a	9:34a	10:39	1:35p	9:20p

Train Number	Station	Delay (hh:mm:ss)	Date
322	Broad Run / Airport	00:00:59	07/01/2014
322	Manassas Park	00:01:03	07/01/2014
302	Brooke	00:00:47	07/01/2014
322	Burke Centre	00:02:25	07/01/2014
322	Rolling Road	00:04:23	07/01/2014
302	Quantico	00:01:22	07/01/2014
300	Woodbridge	00:01:21	07/01/2014
	Backlick Road	00:02:40	07/01/2014
	Broad Run / Airport	00:01:01	07/01/2014
	Rippon	00:03:08	07/01/2014
	Manassas	00:00:06	07/01/2014
	Alexandria	00:02:58	07/01/2014
	Woodbridge	00:01:08	07/01/2014
	Manassas Park	00:02:16	07/01/2014
	Crystal City	00:02:39	07/01/2014
	Lorton	00:00:10	07/01/2014
	Quantico	00:00:13	07/01/2014
	Burke Centre	00:03:33	07/01/2014
	Rolling Road	00:05:18	07/01/2014
	Rippon	00:02:22	07/01/2014
	Broad Run / Airport	00:01:49	07/01/2014
	Brooke	00:00:06	07/01/2014
	Backlick Road	00:03:23	07/01/2014
	Manassas	00:01:09	07/01/2014
304	Woodbridge	00:00:29	07/01/2014
326	Manassas Park	00:03:09	07/01/2014
304	Lorton	00:00:11	07/01/2014

Study Results (Congestion)

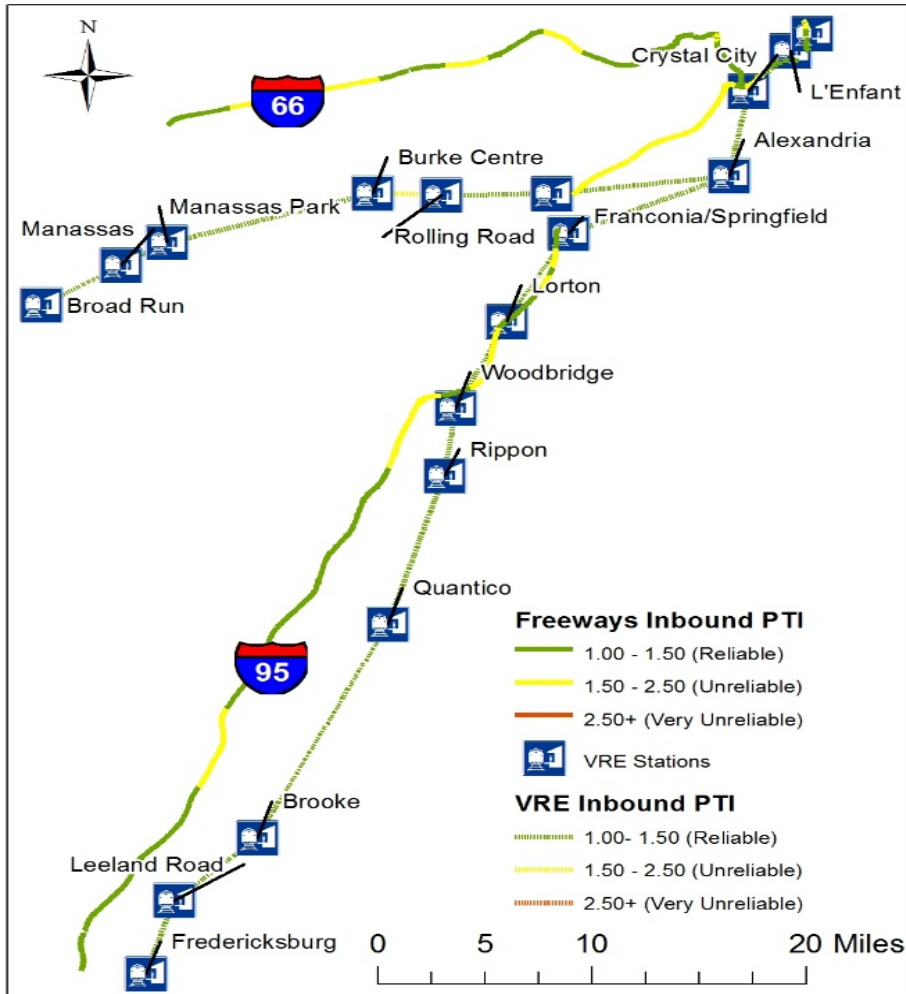


AM (5:00 AM to 9:00 AM)

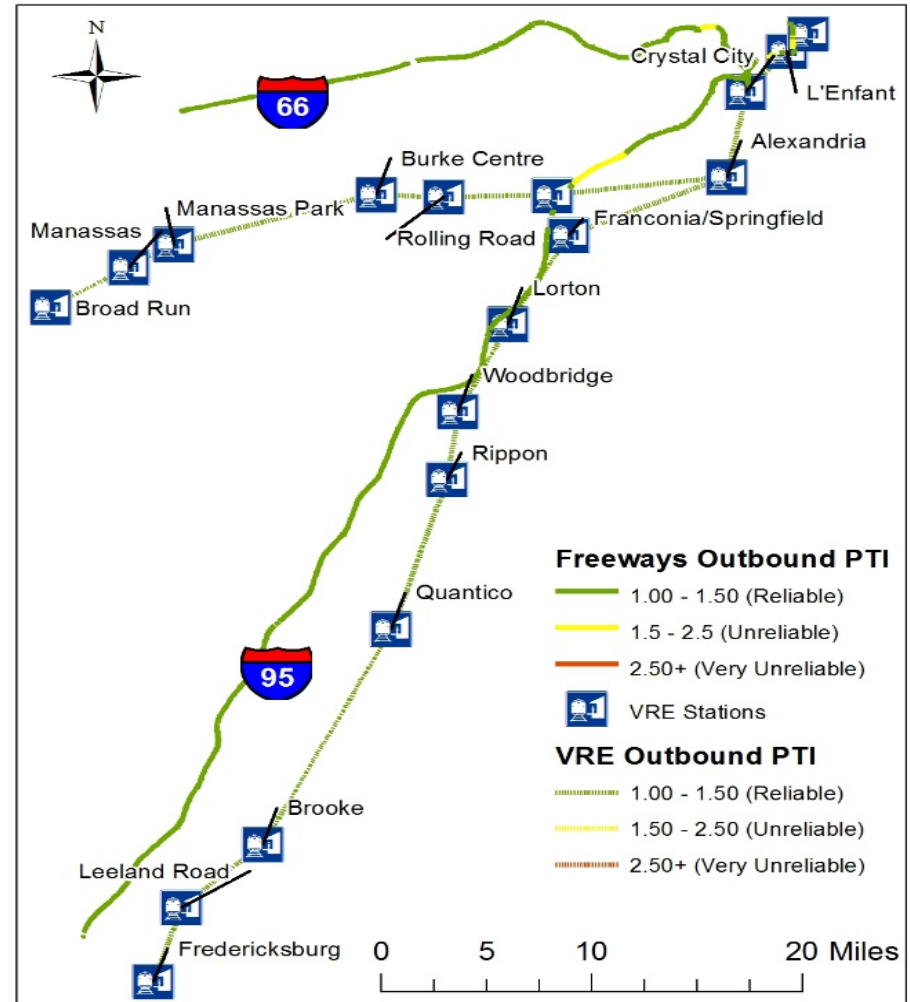


PM(3:00 PM to 8:00 PM)

Study Results (Reliability)



AM (5:00 AM to 9:00 AM)



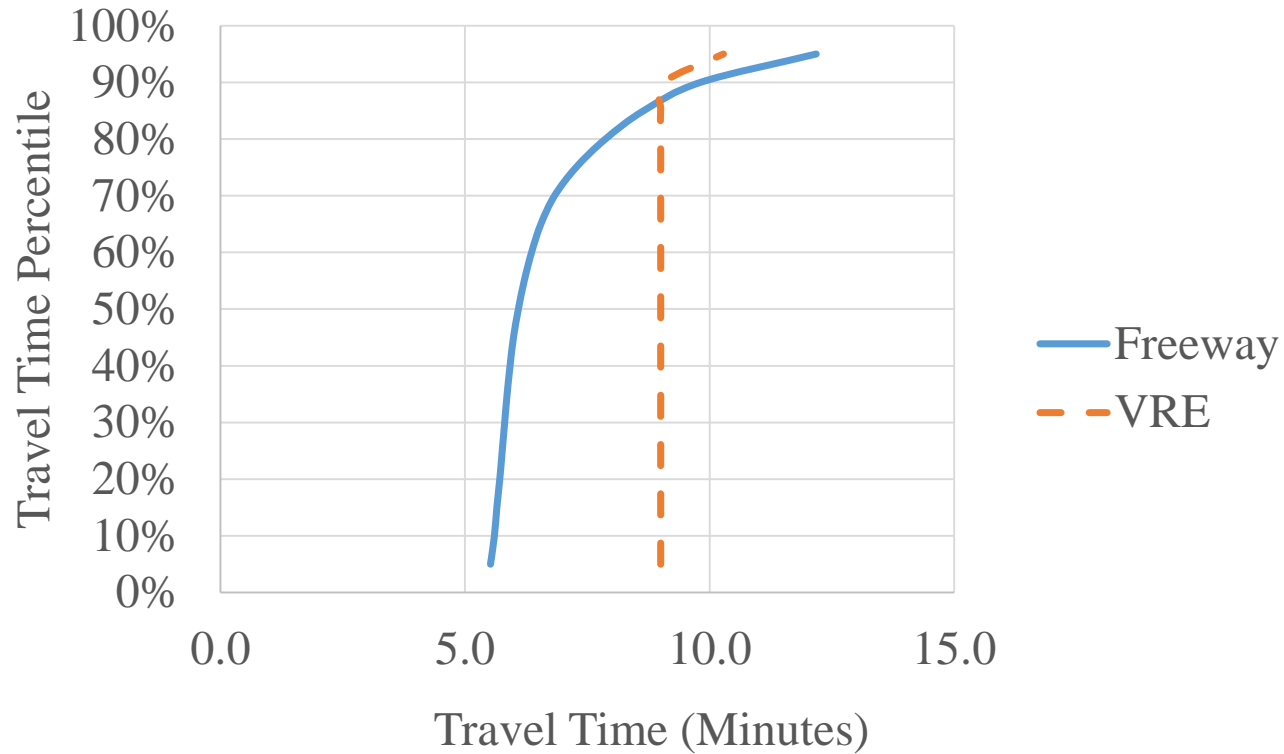
PM(3:00 PM to 8:00 PM)

Study Results

Performance Measure (Time Period)	Traditional Peak Periods		VRE Service	
	(7-9AM, 4-6 PM)		(5-9 AM, 3-8 PM)	
	I-95/ I-395	I-66	I-95/ I-395	I-66
TTI (AM)	1.39	1.64	1.15	1.16
TTI (PM)	1.13	1.23	1.14	1.29
PTI (AM)	2.11	2.69	1.48	1.39
PTI (PM)	1.69	2.07	1.85	1.87

Average Results of Freeway Corridors During Traditional Peak Periods and VRE Service

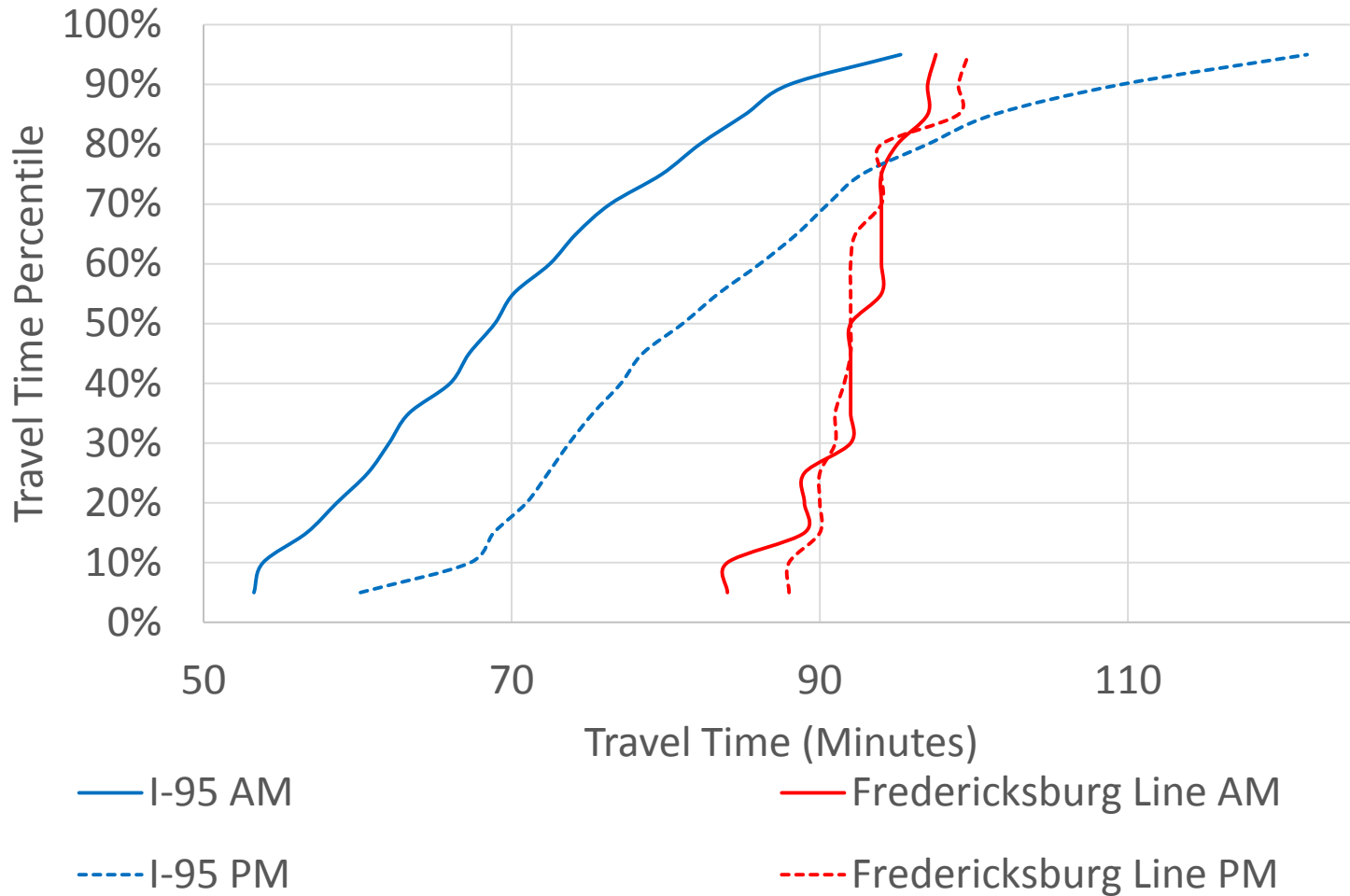
The Ultimate Goal



Cumulative Distribution Function

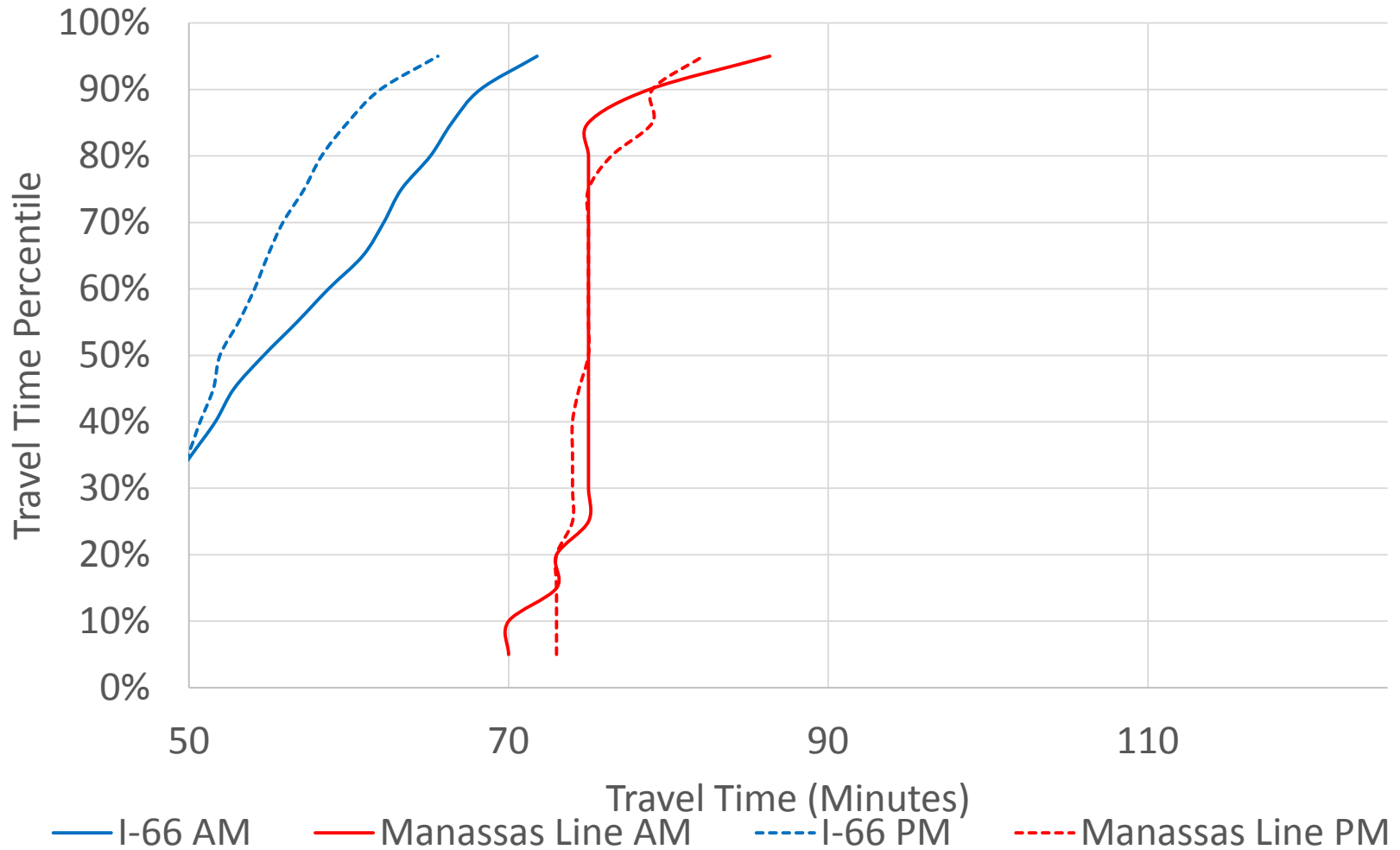


Goal Reached



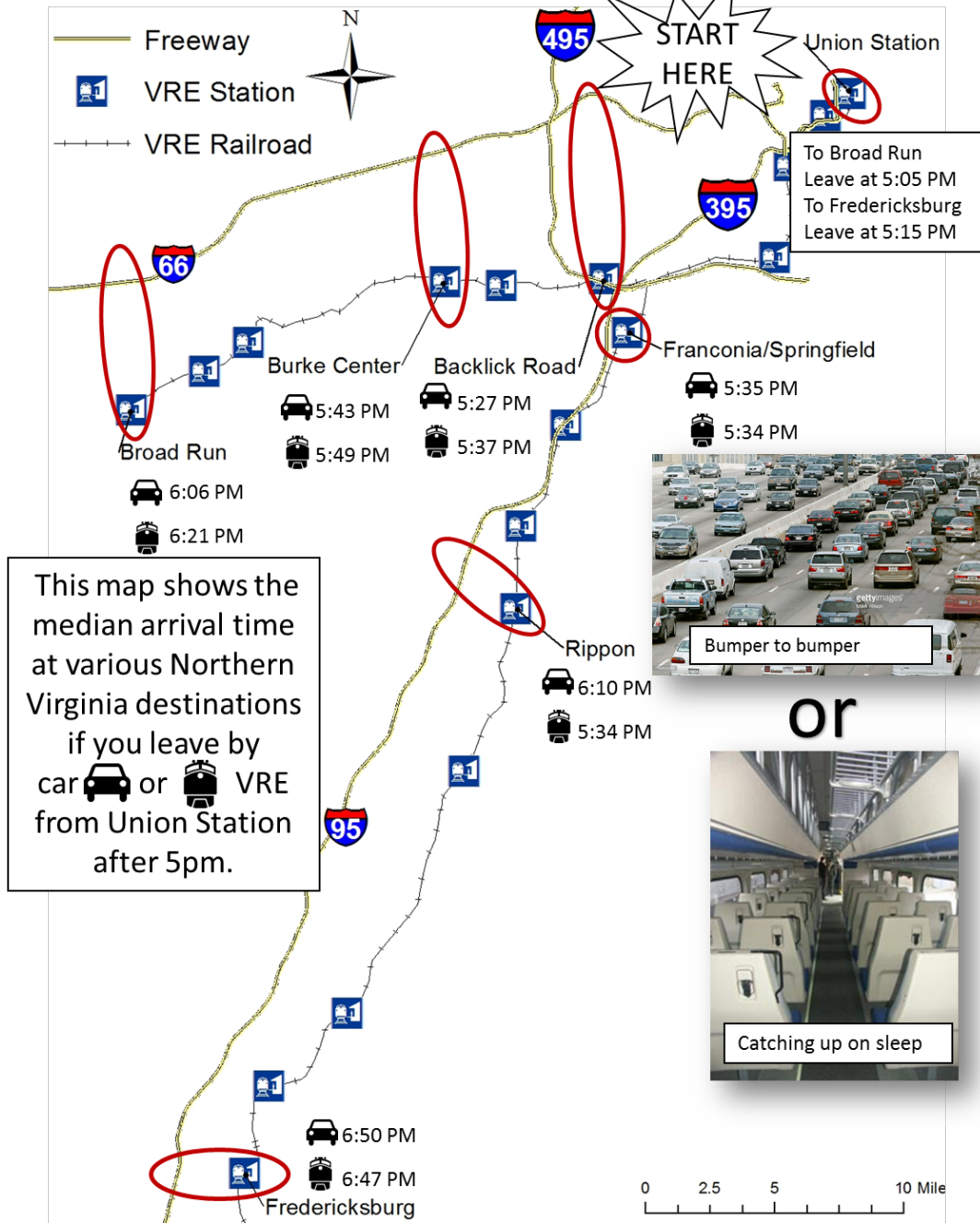
Path-Based Travel Time Percentiles Between Fredericksburg and Union Station

Goal Reached



Path-Based Travel Time Percentiles Between Broad Run/Manassas and Union Station

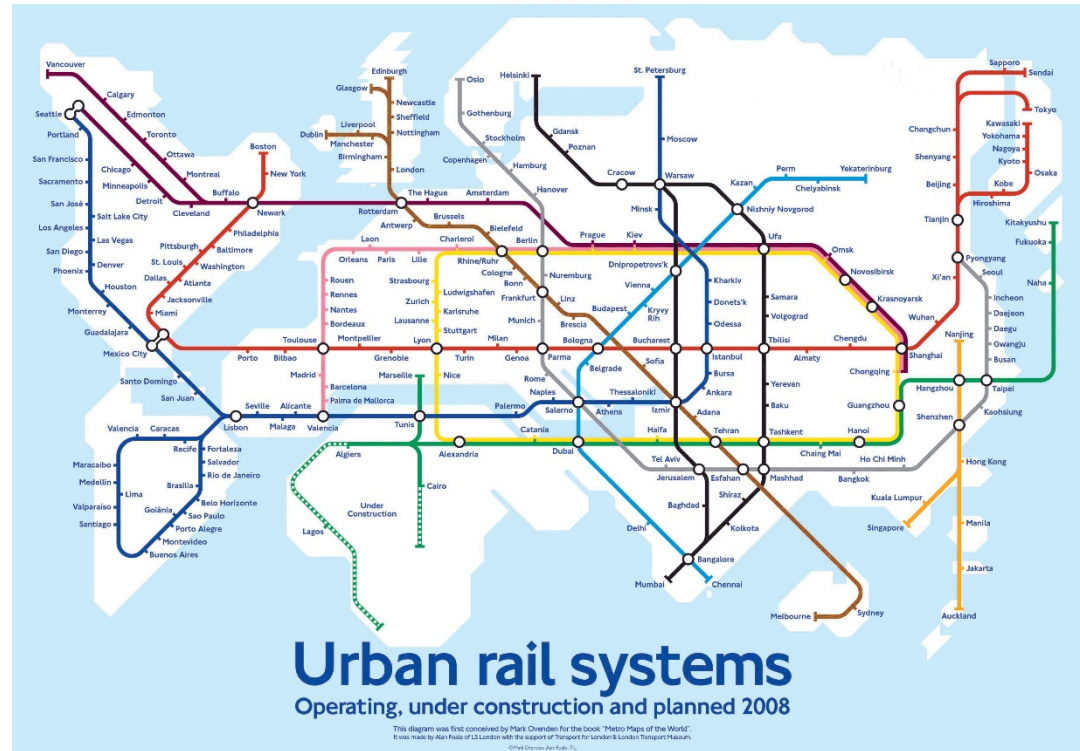
Choose Your Commute



This map shows the median arrival time at various Northern Virginia destinations if you leave by car or VRE from Union Station after 5pm.

Closing Remarks

- Open data?
- Transparency
- Multimodal View
- Need Tools
- MAP-21
- LinkedIn Report



Questions



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