Transit Signal Priority and its Effect on Traffic Congestion and Air Quality

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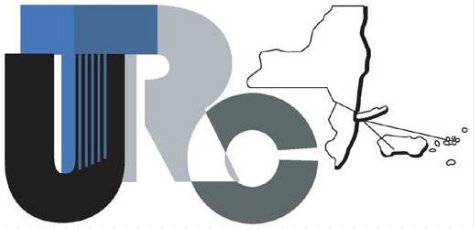
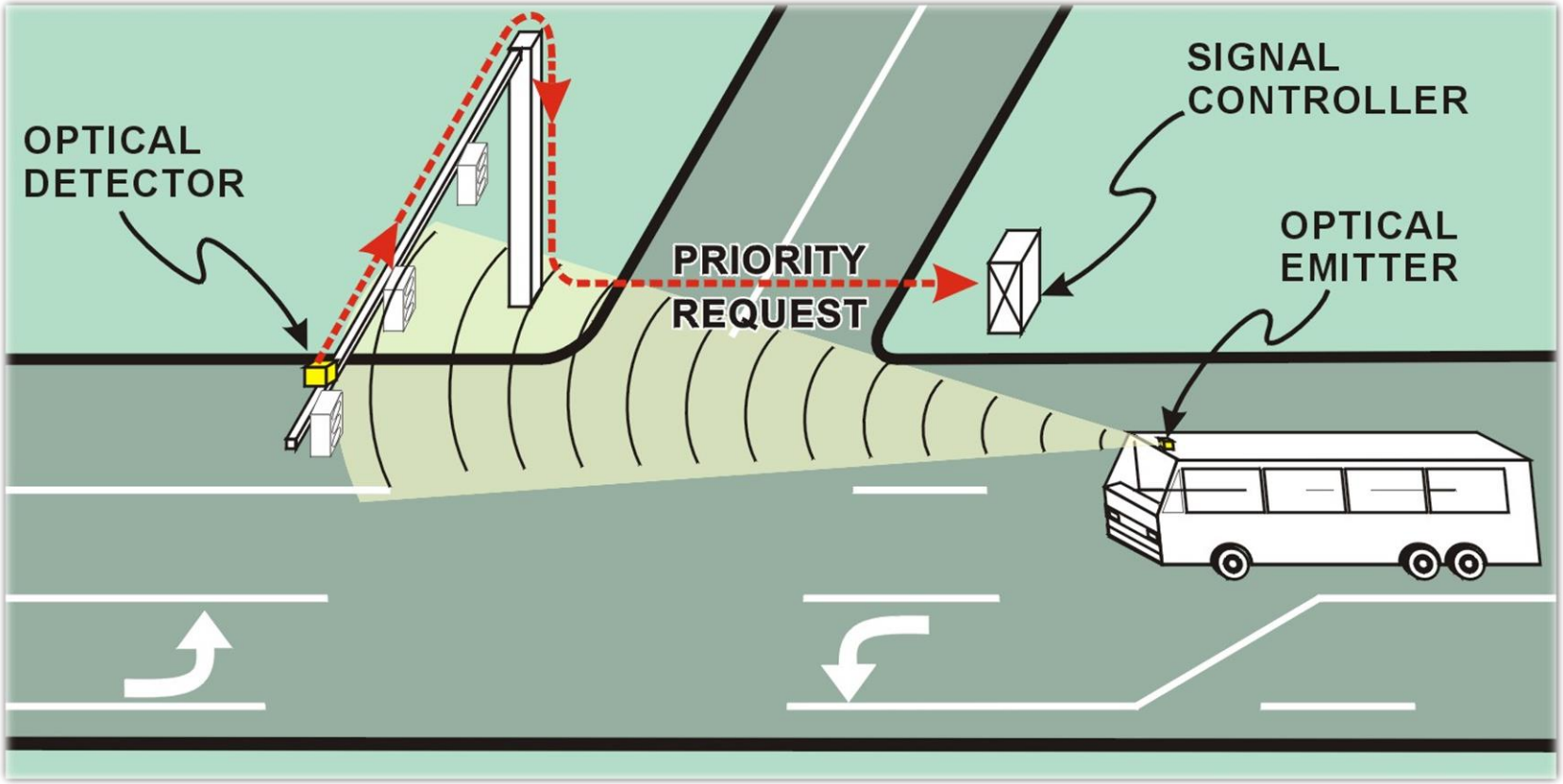


Introduction:

- Public transport is affected by intersection signal which can cause vicious cycle of congestion
- Transit priority as a potential strategy to improve public transport performance
  - ✓ Schedule reliability
  - ✓ Reduce delays at intersections
- Also benefits for:
  - ✓ Public transport operators by reducing operational cost, lower pax delay time
  - ✓ Improve reliability,
  - ✓ society by reducing environmental impacts

Introduction:

What is Transit Signal Priority?



Priority Makes Sense

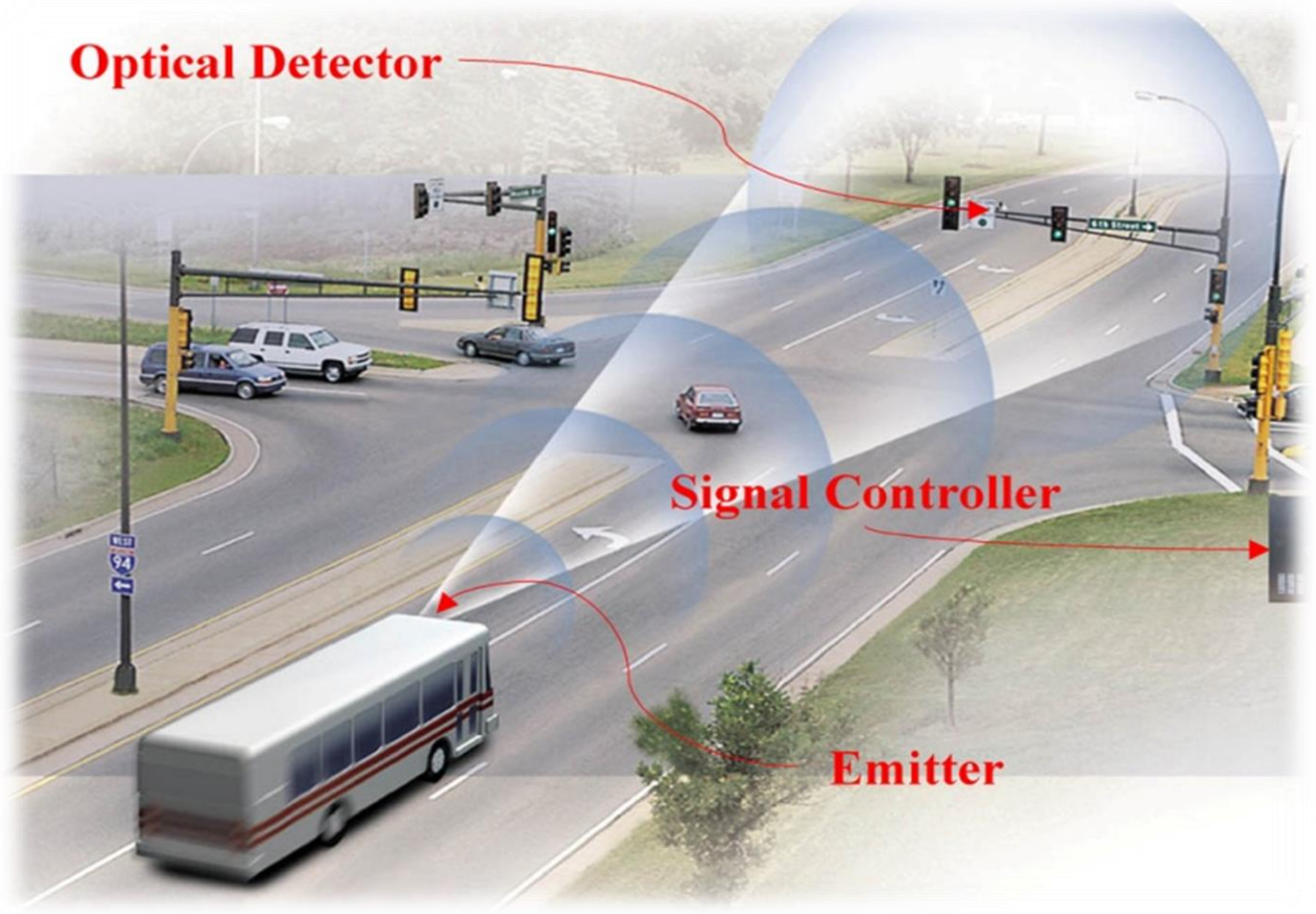
- One extreme ($$$$): build a metro
- Other extreme: do nothing, buses become swamped in congestion
  - Traffic delay can represent up to 30% of a bus route's operating cost
- In between:
  - Priority in space: bus lanes, etc.
  - Priority in time: signal priority

❑ TSP will Reduce mean running time

- Lowers passenger travel time
- Reduces operating cost

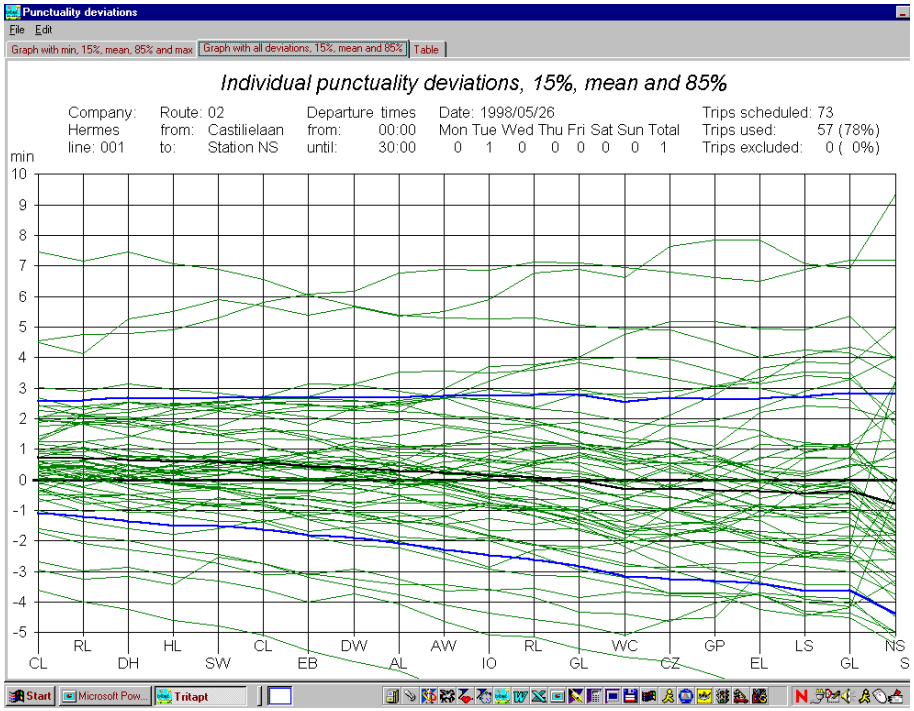
Transit Signal Priority – Help or Hype?

- Tri-Met Line 12 (Portland, OR): priority reduced needed transit cycle length from 104 min to 93 min (11%) – saved a bus

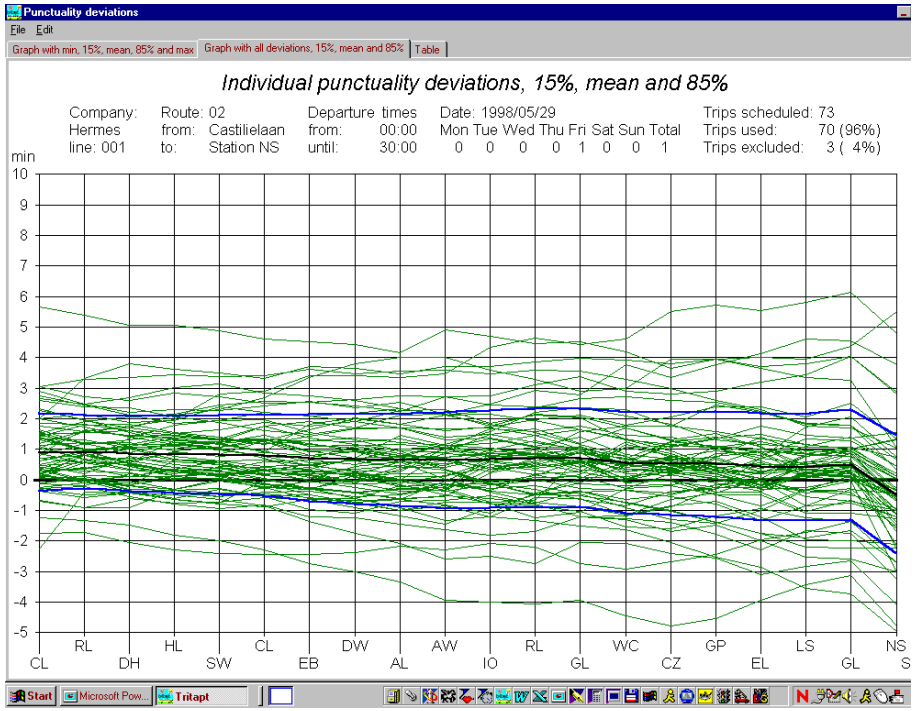


Operational Control: Schedule Adherence

Schedule deviation along the route, without priority, Eindhoven

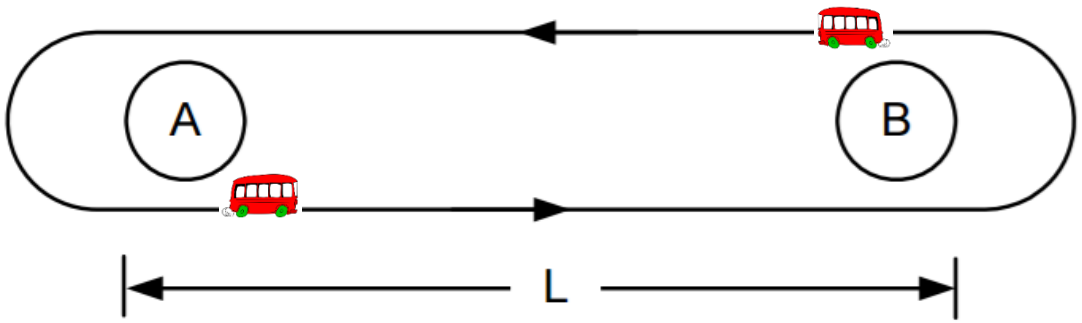


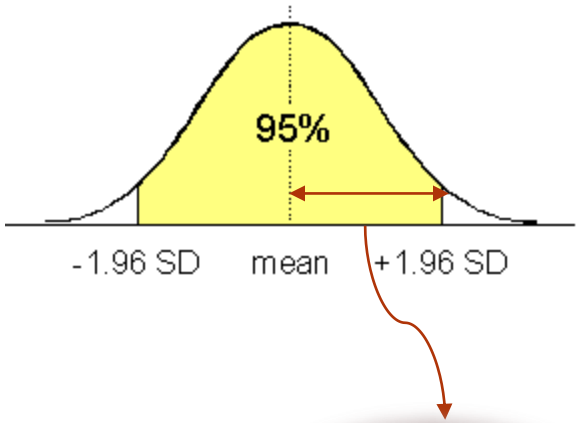
With priority



Basic calculation in transit scheduling:

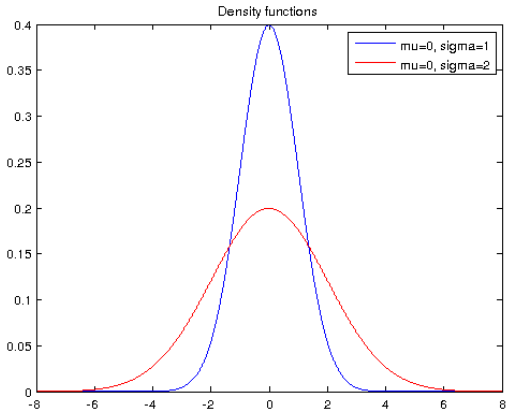
Number of Buses= CycleTime / Headway





L= Transit CycleTime= RunningTime(AB) + RunningTime(BA) + Layover time

- **TSP** makes the RT-distribution be more reliable
  - -less layover time
  - -save # buses and waiting time,…



Transit Signal Priority Tactics

Green Extension

if the current state is green, extend the green for the coming bus.

Large benefit to a **few** buses!

Early Green (Green Truncation)

if the current state of bus phase is red, make the conflicting green phases red (considering min green constraint) in order to the bus phase return to green faster in the next cycle.

Smaller benefit to **large** number of buses!

Phase Rotation

if the bus phase is red and it is at the barrier, make the lagging bus phase leading in order that the bus get green sooner.

Queue Jump, Phase Insertion, Flush-and-Return, Queue Dissipation, …

Passive Priority

Treatments that favor buses, but don't rely on bus detections

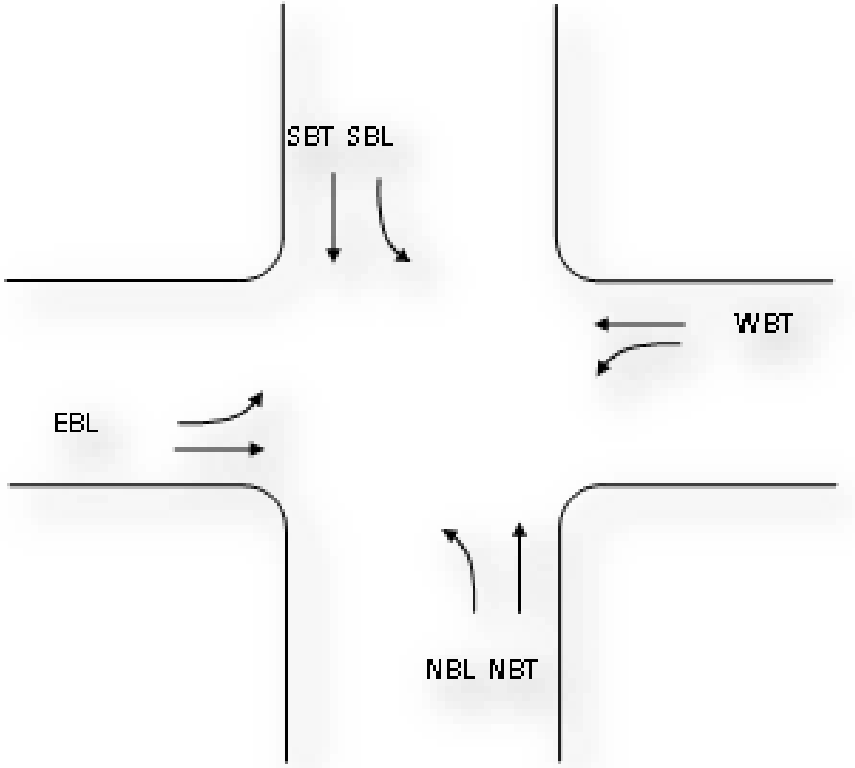
- Favorable splits and offset for bus phase
- Hard to do over more than a few intersections due to uncertain dwell time

Active Priority

Conditional Priority: e.g. *priority to Late Buses*

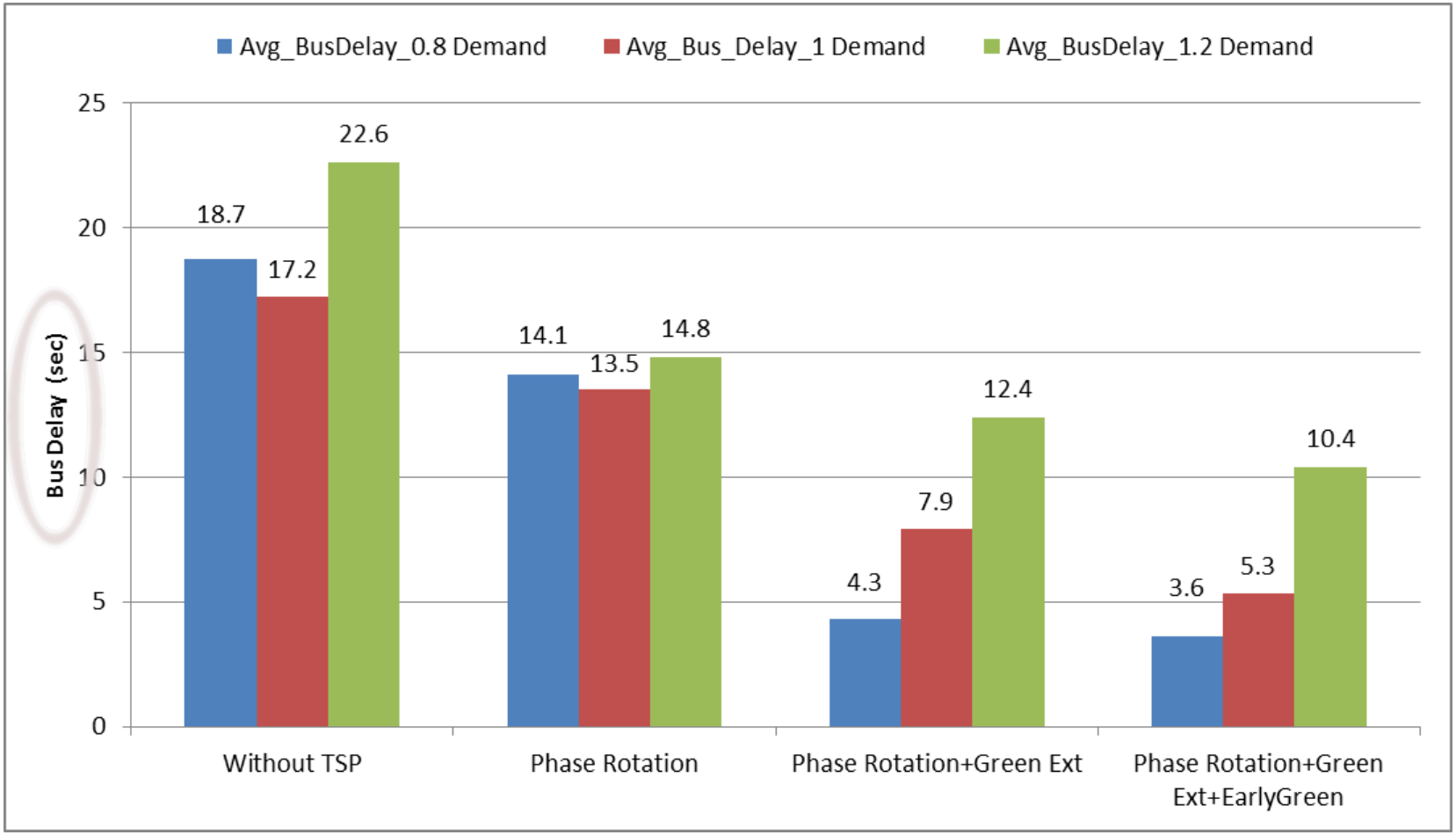
- Passenger occupancy,
- Transit scheduling (late buses),
- Signal saturation level,
- Queue spillback,
- …

TSP comparison over an Isolated Intersection

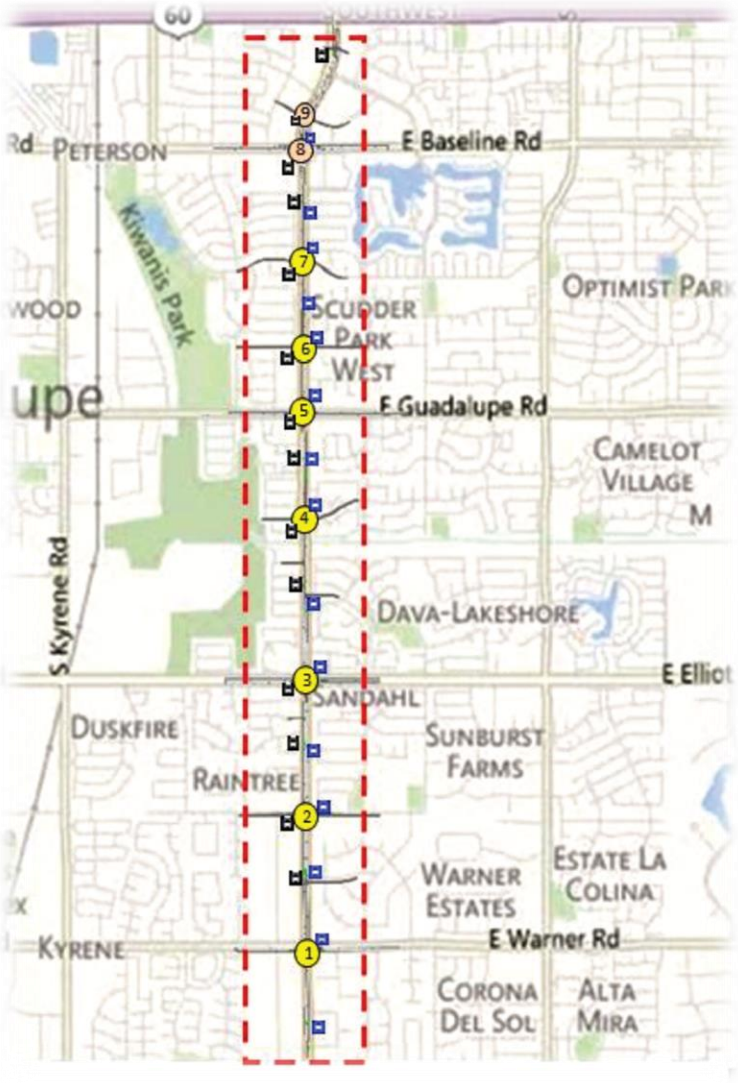


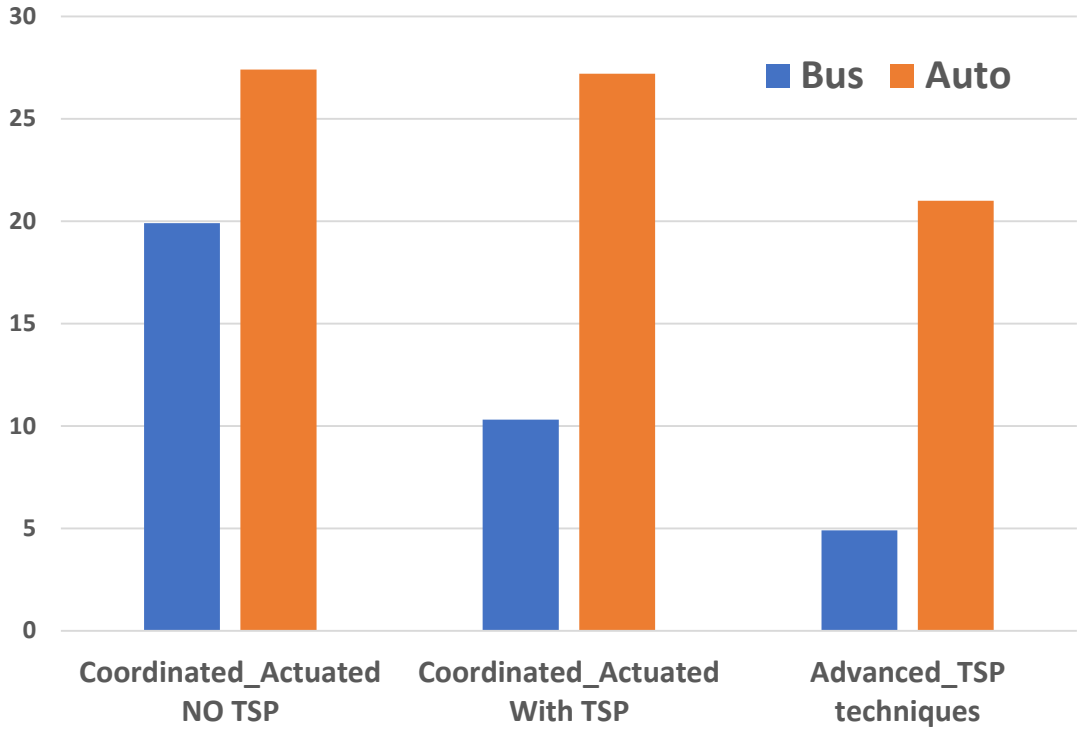
DEMAND			
Approach	Vol * 0.8	Vol * 1	Vol * 1.2
EB	960	1200	1440
WB	800	1000	1200
SB	400	500	600
NB	240	300	360

TSP method	0.8 factor of Demand		1 factor of Demand		1.2 factor of Demand	
	Total Avg. Delay	Bus Avg. Delay	Total Avg. Delay	Bus Avg. Delay	Total Avg. Delay	Bus Avg. Delay
Without TSP	16.6	18.7	20.3	17.2	26.1	22.6
Phase Rotation	16.7	14.1	20.9	13.5	27.3	14.8
Phase Rotation + Green Extension	15.9	4.3	20	7.9	26.6	12.4
Phase Rotation+ Green Ext+ EarlyGreen	15.5	3.6	19.5	5.3	26.2	10.4



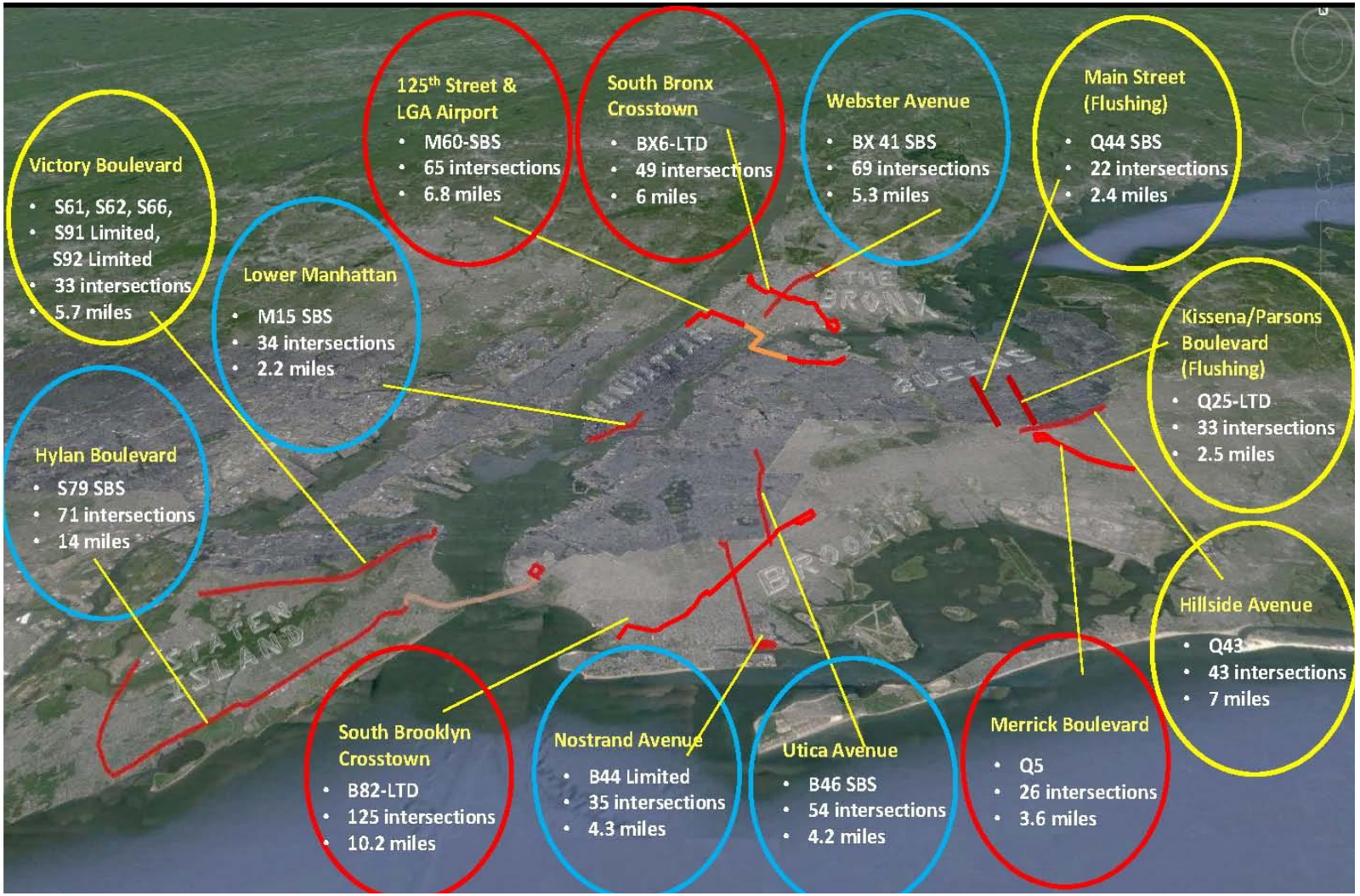
TSP over a Corridor



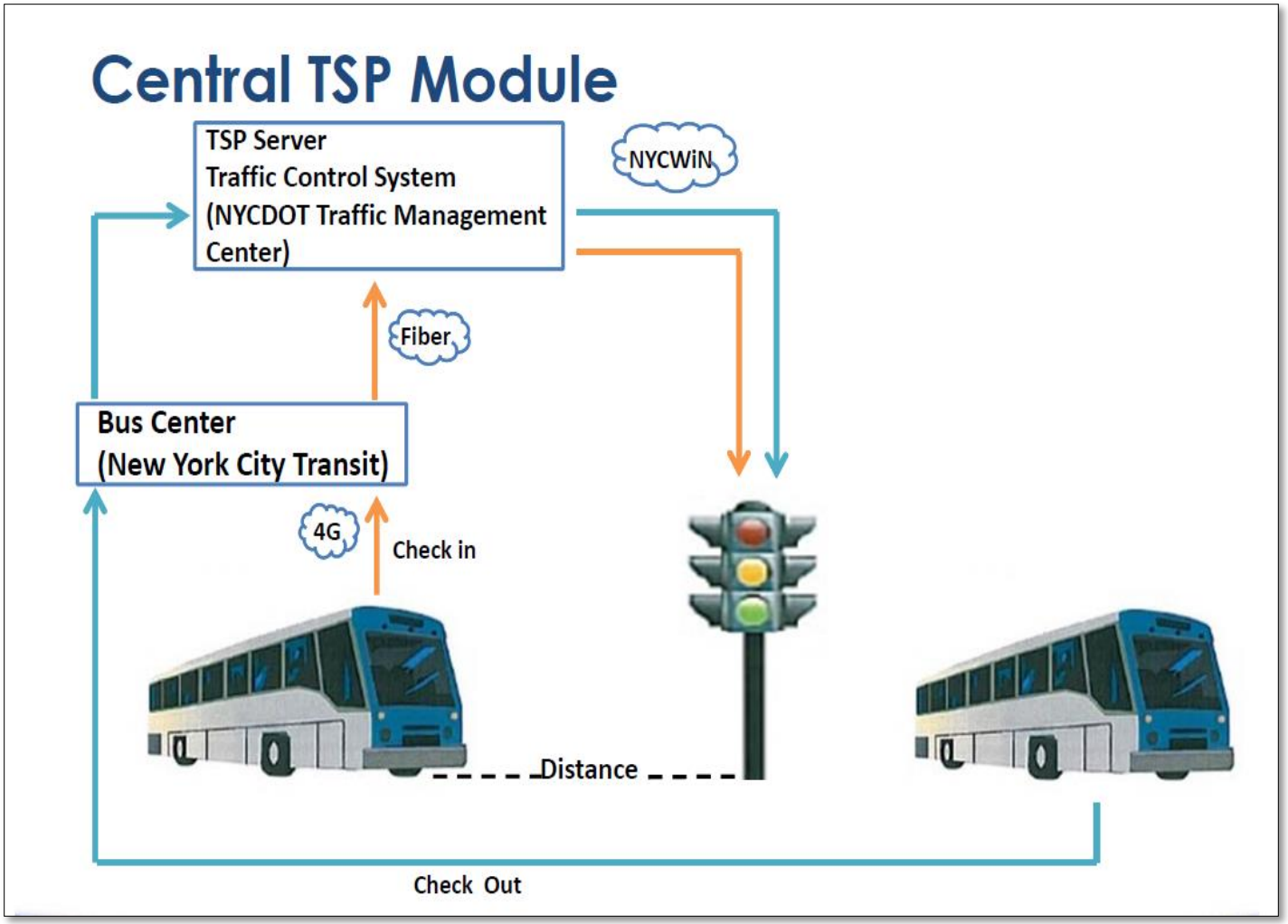


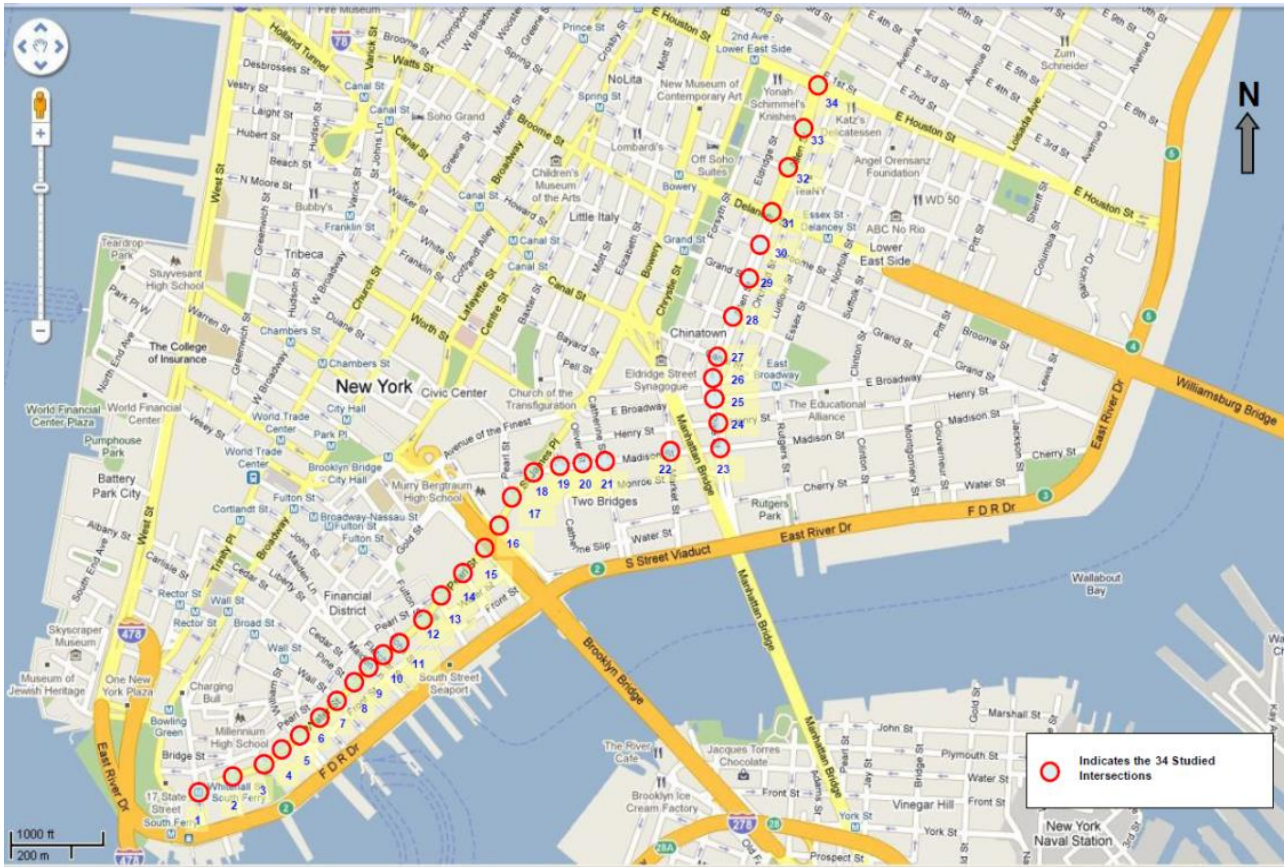
Average Intersection Delay (s), Auto and Bus

List of TSP projects in NYC DOT



TSP by New York City DOT





For the PM peak, Active TSP provides the following improvements in **average travel time** for M15 Select Buses

- Northbound/eastbound direction, a reduction from 22.7 to 20.6 minutes **(9%)**
- Southbound/westbound direction, a reduction from 21.2 to 18.9 minutes **(11%).**

Average speed for these buses similarly improved:

- Northbound/eastbound direction, an increase from 5.8 to 6.4 mph **(10%)**
- Southbound/westbound direction, an increase from 6.2 to 7.0 mph **(13%).**

Webster Avenue

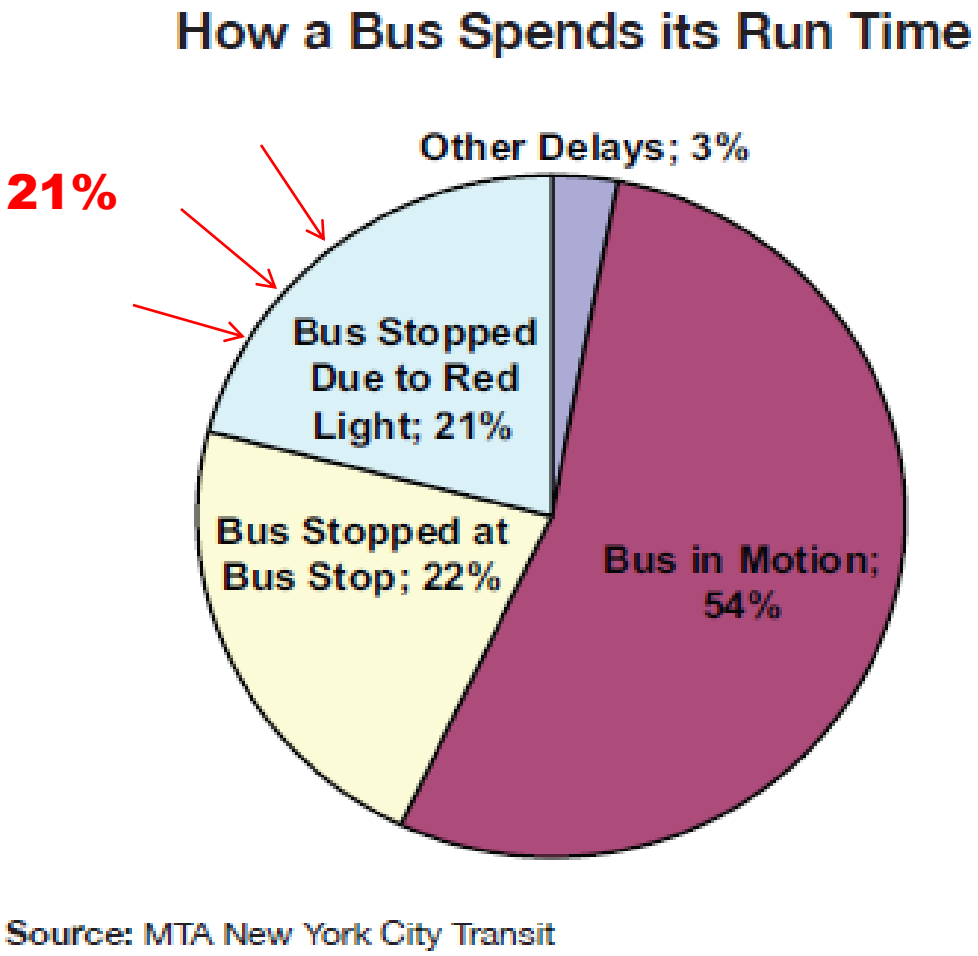
- Saving 5.1 to 8.5 minutes per trip **(12% to 21%)** during the AM peak
- Saving 6.8 to 8.8 minutes per trip **(16% to 20%)** during the PM peak

Nostrand Avenue

- Saving 4.0 to 5.5 minutes per trip **(13% to 18%)** during the PM peak
- Field observations of actual travel times shows 10% to 13% improvement during the PM peak

Hyland Avenue

- Result revealed that TSP improved travel times by **16% for AM** peak and by **11% in the PM** peak period.



In NYC **21%** of running time is due to traffic light; however, up to **30%** is mentioned in the literature review

Introduction to NYBPM

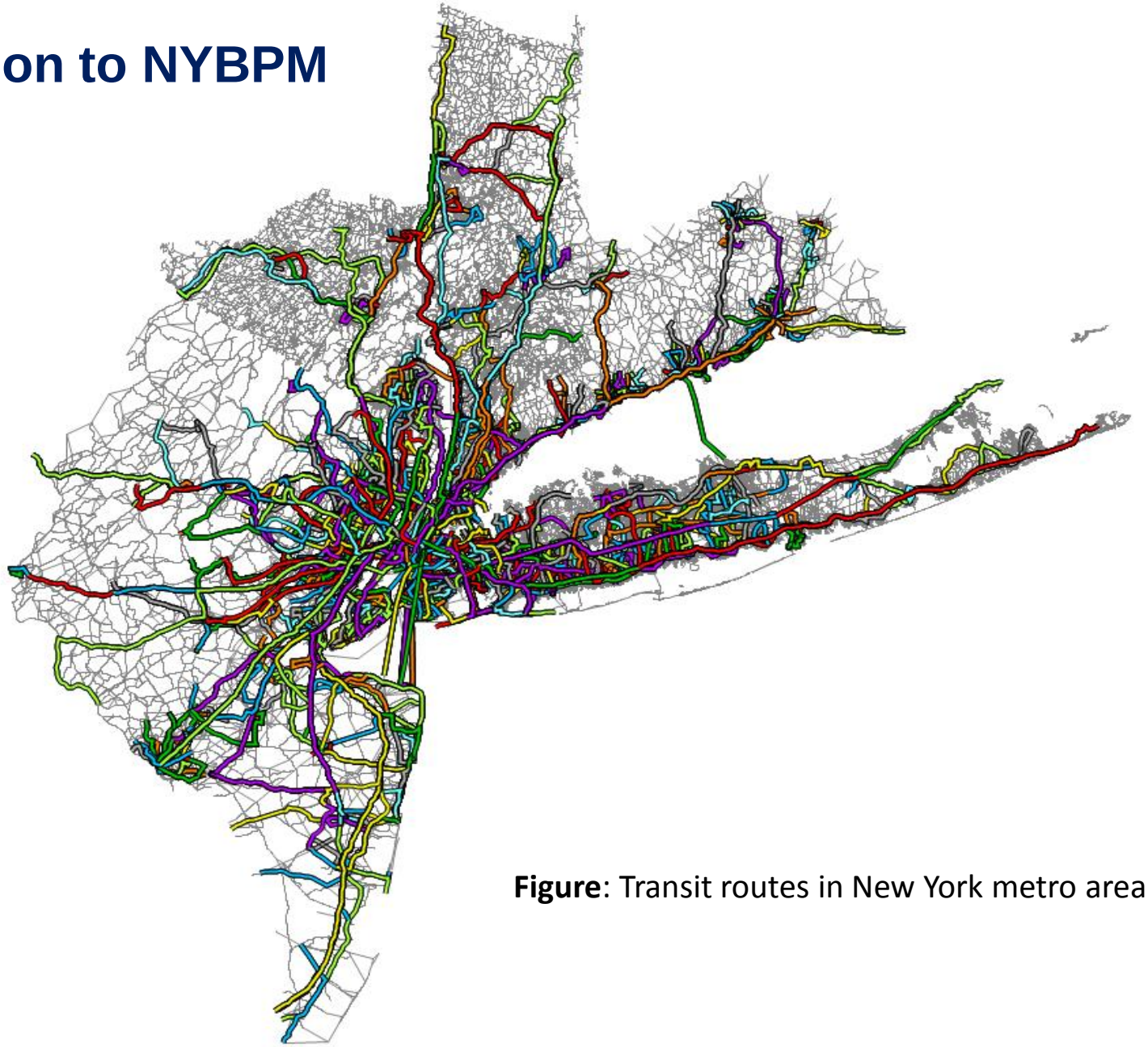
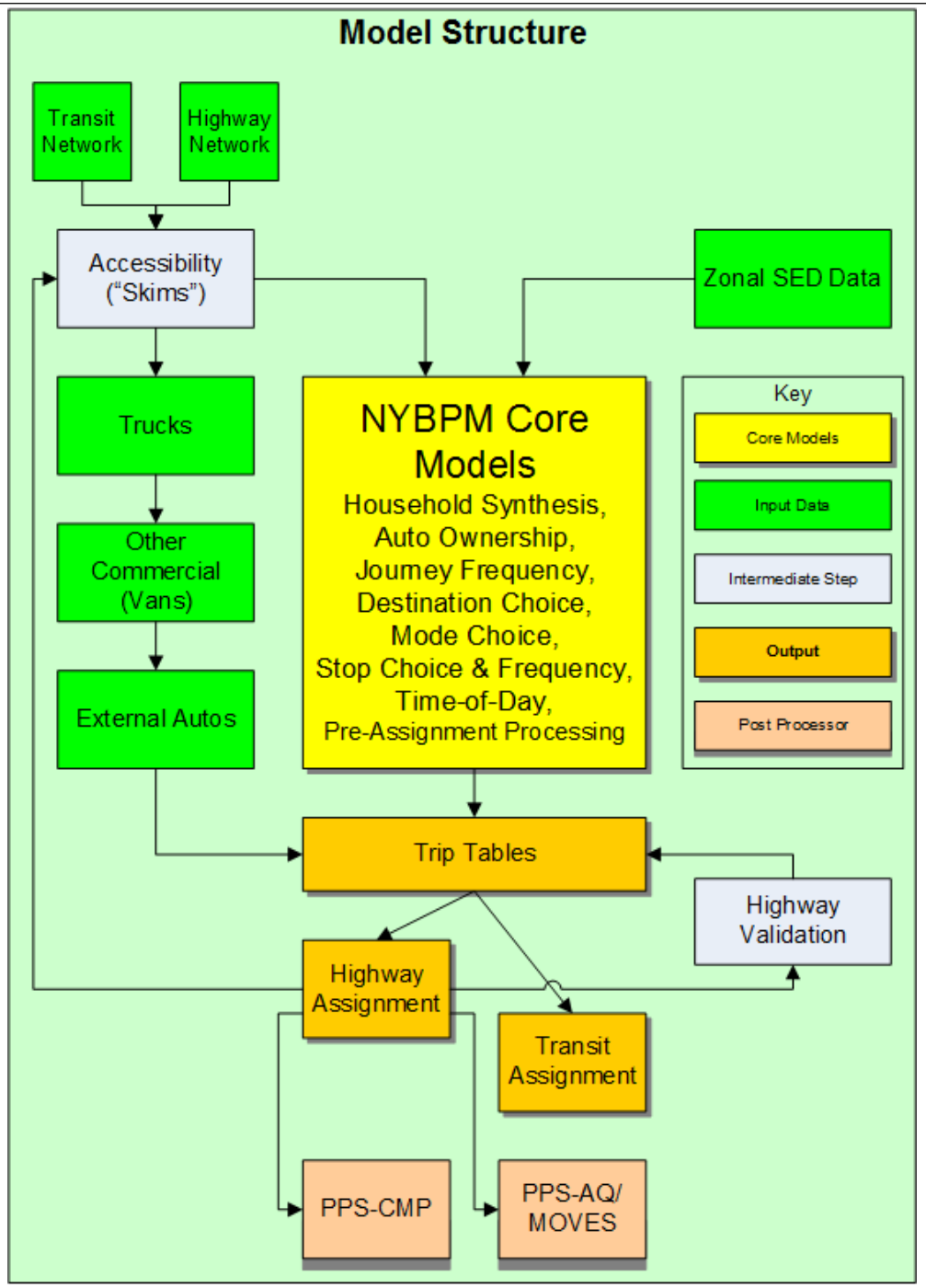


Figure: Transit routes in New York metro area

Introduction to NYBPM



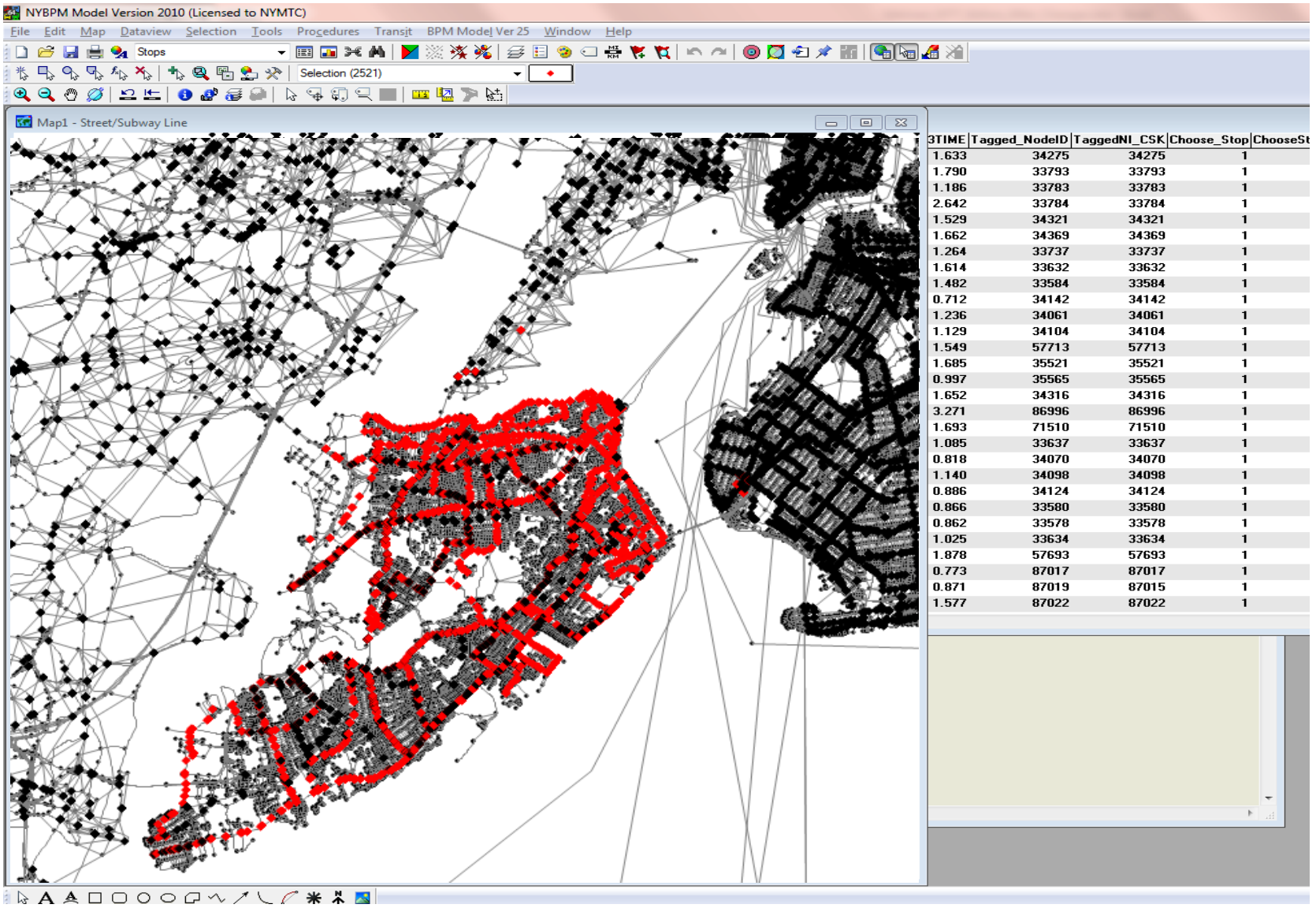
Changing Bus In-Vehicle Travel Time

Running NYBPM

Evaluate Traffic Congestion

and Air Quality (CMP & PPS-AQ)

Staten Island, NY



3TIME	Tagged_NodeID	TaggedNI_CSK	Choose_Stop	ChooseSt
1.633	34275	34275	1	
1.790	33793	33793	1	
1.186	33783	33783	1	
2.642	33784	33784	1	
1.529	34321	34321	1	
1.662	34369	34369	1	
1.264	33737	33737	1	
1.614	33632	33632	1	
1.482	33584	33584	1	
0.712	34142	34142	1	
1.236	34061	34061	1	
1.129	34104	34104	1	
1.549	57713	57713	1	
1.685	35521	35521	1	
0.997	35565	35565	1	
1.652	34316	34316	1	
3.271	86996	86996	1	
1.693	71510	71510	1	
1.085	33637	33637	1	
0.818	34070	34070	1	
1.140	34098	34098	1	
0.886	34124	34124	1	
0.866	33580	33580	1	
0.862	33578	33578	1	
1.025	33634	33634	1	
1.878	57693	57693	1	
0.773	87017	87017	1	
0.871	87019	87015	1	
1.577	87022	87022	1	

2010 scenario

Changing bus in-vehicle travel time of Hyland Boulevard in Staten Island for 20 percent and see how it will impact of Staten Island's **CMP**.

NYBPM Model Version 2010 (Licensed to NYMTC)

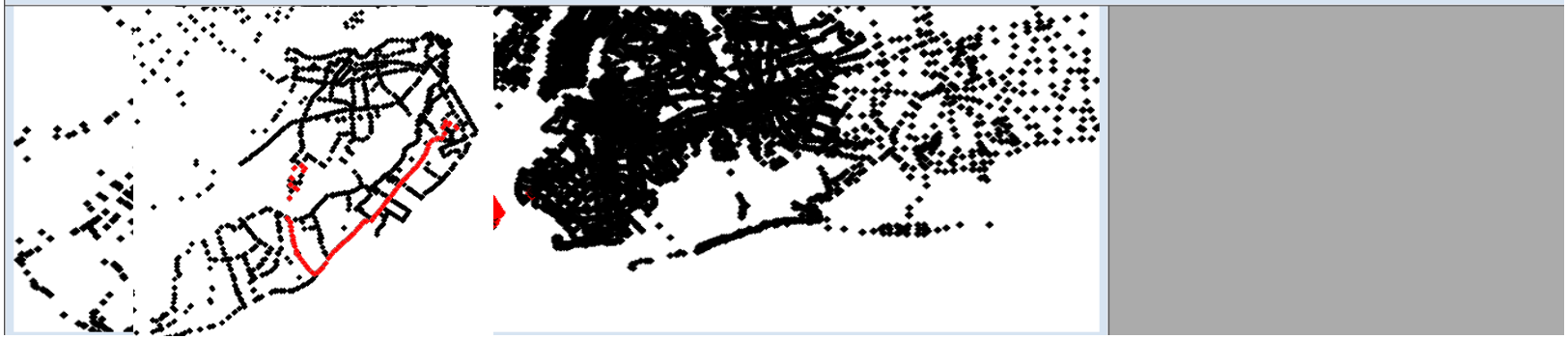
File Edit Dataview Selection Tools Procedures Transit BPM Model Ver 25 Window Help

Selection

Selection (4849)

Dataview1 - Stops

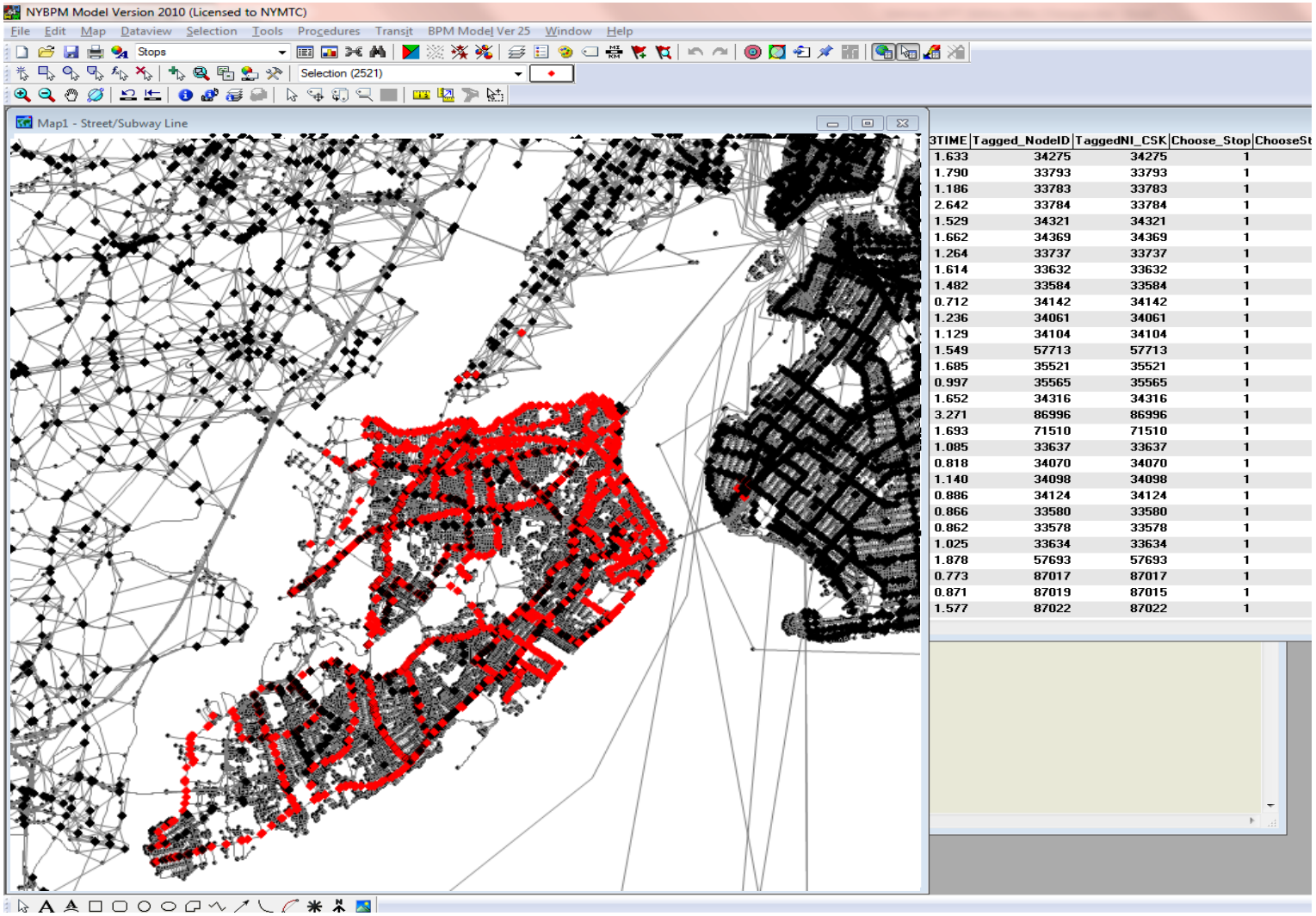
PTZ_ID	PTZ_ID_backup	PTZ_new	ModelID_new	Mode_new	RUNTIME	Runtime_bak	BUSIVTT	XBUSIVTT	RAILIVTT	CRIVTT	FERRYIVTT	PATH1TIME	PATH2TIME	PATH3TIME	Tagged_NodeID	Tagged
--	--	--	2	Local Bus	1.222	1.222	0.978	--	--	--	--	0.978	1.345	1.467	34267	
--	--	--	2	Local Bus	1.415	1.415	1.132	--	--	--	--	1.132	1.557	1.698	34286	
--	--	--	2	Local Bus	1.307	1.307	1.045	--	--	--	--	1.045	1.437	1.568	34316	
--	--	--	2	Local Bus	2.725	2.725	2.180	--	--	--	--	2.180	2.998	3.271	86996	
--	--	--	2	Local Bus	0.000	0.000	0.000	--	--	--	--	0.000	0.000	0.000	32279	
--	--	--	2	Local Bus	1.767	1.767	1.414	--	--	--	--	1.414	1.944	2.120	33003	
--	--	--	2	Local Bus	0.531	0.531	0.424	--	--	--	--	0.424	0.584	0.637	33004	
--	--	--	2	Local Bus	1.656	1.656	1.325	--	--	--	--	1.325	1.822	1.988	33013	
--	--	--	2	Local Bus	1.198	1.198	0.959	--	--	--	--	0.959	1.318	1.438	47255	
--	--	--	2	Local Bus	1.027	1.027	0.821	--	--	--	--	0.821	1.129	1.232	47243	
--	--	--	2	Local Bus	1.083	1.083	0.866	--	--	--	--	0.866	1.191	1.300	33450	
--	--	--	2	Local Bus	1.575	1.575	1.260	--	--	--	--	1.260	1.733	1.890	33565	
--	--	--	2	Local Bus	1.273	1.273	1.018	--	--	--	--	1.018	1.400	1.527	33588	
--	--	--	2	Local Bus	1.915	1.915	1.532	--	--	--	--	1.532	2.106	2.297	33623	
--	--	--	2	Local Bus	1.458	1.458	1.166	--	--	--	--	1.166	1.603	1.749	33705	
--	--	--	2	Local Bus	1.628	1.628	1.303	--	--	--	--	1.303	1.791	1.954	47493	
--	--	--	2	Local Bus	1.494	1.494	1.195	--	--	--	--	1.195	1.644	1.793	33724	
--	--	--	2	Local Bus	1.724	1.724	1.380	--	--	--	--	1.380	1.897	2.069	34259	
--	--	--	2	Local Bus	1.361	1.361	0.708	--	--	--	--	1.089	1.497	1.633	34275	
--	--	--	2	Local Bus	1.492	1.492	0.933	--	--	--	--	1.194	1.641	1.790	33793	
--	--	--	2	Local Bus	0.988	0.988	0.434	--	--	--	--	0.791	1.087	1.186	33783	
--	--	--	2	Local Bus	2.202	2.202	0.608	--	--	--	--	1.762	2.422	2.642	33784	
--	--	--	2	Local Bus	1.274	1.274	1.165	--	--	--	--	1.019	1.402	1.529	34321	
--	--	--	2	Local Bus	1.385	1.385	0.999	--	--	--	--	1.108	1.524	1.662	34369	
--	--	--	2	Local Bus	1.054	1.054	1.005	--	--	--	--	0.843	1.159	1.264	33737	
--	--	--	2	Local Bus	1.345	1.345	0.805	--	--	--	--	1.076	1.480	1.614	33632	
--	--	--	2	Local Bus	1.235	1.235	0.577	--	--	--	--	0.988	1.358	1.482	33584	
--	--	--	2	Local Bus	0.593	0.593	0.588	--	--	--	--	0.475	0.653	0.712	34142	
--	--	--	2	Local Bus	1.030	1.030	0.980	--	--	--	--	0.824	1.133	1.236	34061	



Change in **VMT** and **VHT** from the base 20% reduction for Hyland Blvd bus

Hour	VMT Comp	VHT Comp	Speed Comp
1	-0.14%	0.28%	-0.03%
2	-0.14%	0.30%	-0.04%
3	-0.14%	0.31%	-0.04%
4	-0.14%	0.31%	-0.04%
5	-0.14%	0.31%	-0.04%
6	-0.14%	0.22%	0.00%
7	0.42%	0.71%	-0.07%
8	0.42%	0.70%	-0.07%
9	0.42%	0.71%	-0.07%
10	0.42%	0.69%	-0.06%
11	-0.70%	-0.73%	0.00%
12	-0.70%	-0.71%	0.01%
13	-0.70%	-0.74%	0.00%
14	-0.70%	-0.73%	0.00%
15	-0.70%	-0.69%	0.04%
16	-0.70%	-1.00%	0.15%
17	-0.43%	-0.42%	-0.10%
18	-0.43%	-0.31%	-0.14%
19	-0.43%	-0.62%	-0.06%
20	-0.43%	-0.56%	-0.07%
21	-0.14%	-0.03%	0.07%
22	-0.14%	0.28%	-0.03%
23	-0.14%	0.25%	-0.01%
24	-0.14%	0.27%	-0.02%
Average(hourly):	-0.24%	-0.05%	-0.03%
Average (Daily):	-0.30%	-0.29%	-0.03%

More Bus Routes in Staten Island, NY



Change in **VMT** and **VHT** from the base 20% reduction for all bus routes

Hour	VMT Comp	VHT Comp	Speed Comp
1	0.30%	0.90%	-0.02%
2	0.28%	0.63%	-0.01%
3	0.37%	0.35%	-0.01%
4	0.37%	0.42%	-0.01%
5	0.32%	0.30%	-0.01%
6	0.39%	1.08%	-0.03%
7	0.38%	0.25%	0.00%
8	0.37%	0.77%	0.03%
9	0.38%	0.26%	0.00%
10	0.35%	0.75%	0.00%
11	-1.21%	-1.82%	0.05%
12	-1.21%	-1.81%	0.07%
13	-1.21%	-1.82%	0.05%
14	-1.21%	-1.82%	0.06%
15	-1.21%	-1.69%	0.11%
16	-1.21%	-1.55%	0.39%
17	-1.09%	-1.29%	0.06%
18	-1.09%	-1.22%	0.07%
19	-1.09%	-1.35%	0.02%
20	-1.09%	-1.33%	0.04%
21	0.03%	-0.94%	-0.05%
22	0.30%	0.90%	-0.02%
23	0.44%	1.02%	-0.02%
24	0.19%	0.96%	-0.02%
Average(Hourly)	**-0.30%**	**-0.34%**	**0.03%**
Average (Daily)	**-0.58%**	**-0.86%**	**0.03%**

2017 scenario

Comp-VMT = - 0.61%

Comp-VHT = - 1.6%

Comp-Speed = + 0.1%

NB-Scenario			B-Scenario	
County	Hour-id	VMT	VMT	Comp(B-NB)/NB
Richmond	1	65696	65531	-0.25%
Richmond	2	37599	37505	-0.25%
Richmond	3	15701	15661	-0.25%
Richmond	4	19833	19783	-0.25%
Richmond	5	17354	17310	-0.25%
Richmond	6	124618	124306	-0.25%
Richmond	7	272060	270920	-0.42%
Richmond	8	227772	226817	-0.42%
Richmond	9	272547	271405	-0.42%
Richmond	10	169286	168576	-0.42%
Richmond	11	183559	182210	-0.73%
Richmond	12	208639	207106	-0.73%
Richmond	13	170474	169221	-0.74%
Richmond	14	188284	186901	-0.73%
Richmond	15	279155	277104	-0.73%
Richmond	16	517184	513384	-0.73%
Richmond	17	224052	222019	-0.91%
Richmond	18	263392	261002	-0.91%
Richmond	19	147994	146651	-0.91%
Richmond	20	178703	177082	-0.91%
Richmond	21	199979	199478	-0.25%
Richmond	22	66109	65943	-0.25%
Richmond	23	99163	98914	-0.25%
Richmond	24	78091	77895	-0.25%
Daily:		4027244	4002724	-0.61%

PPS-AQ-2010, Daily CO

Change in **Air Quality** and energy from the base 20% reduction for all Staten Island's bus routes

County	MOVES Road Type	CO B_2010 (Tons/Month)	Total Energy B_2010 (MegaJuels/Month)	CO_NB 2010	CO-Improvement percentage	Total energy NB_2010	Total Energy Improvement percentage
Richmond	Urban restricted access	114.813	2.94E+08	118.277	**0.36%**	3.03E+08	**0.44%**
Richmond	Urban unrestricted access	107.525	3.43E+08	218.921	**-0.39%**	6.92E+08	**-0.36%**
Richmond	Off-Network	635.665	1.16E+08	635.665	**0.00%**	1.16E+08	**0.00%**
Richmond	**County Total**	858.003	7.53E+08	972.863	**-0.04%**	1.11E+09	**-0.11%**

Conclusion:

- *TSP has reduced transit delay in intersection/corridor from microsimulation software like VISSIM*
- *TSP implementation should be encouraged in New York metro area*
- *Using NYBPM, it shows that VMT and VHT are reduced, and air quality has improved, but not substantially*
- *The impact of changing bus attributes in NYBPM should be reconsidered in the new update*
- *It is recommended that distribution of bus travel time is included in order to better capture the simulated model*

Thanks for your attention.