Transit Signal Priority (TSP) Application to Miami-Dade Transit

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Overview

PART – A WHAT IS TSP

- INTRODUCTION
- PURPOSE
- TSP – METHODS / BENEFITS
- AGENCIES CURRENTLY USING TSP
- MODELING TSP - MACRO / MICRO SIMULATION
- BENEFITS - A "SUMMARY OF LITERATURE"
- BENEFITS - B "FROM PRACTICE / TRANSIT AGENCIES“

PART-B APPLICATION TO MIAMI-DADE TRANSIT

- MIAMI-DADE TRANSIT TRENDS & CONDITIONS
- TESTING TSP USING MIAMI-DADE MODEL
- LOOK-UP CURVES / SPEED ADJUSTMENTS BY AREA TYPE & FACILITY TYPE
- COMPARISON OF RESULTS - TRIPS & BENEFITS
- FTA – USER BENEFITS & COST EFFECTIVENESS RATIO

Purpose

- TSP to minimize O&M Cost
  - Increase in transit riders (by absolute number)
  - Increase in population and thus transit market share (Socio-demographic factors)
  - Increase in demand for more service (geographic coverage/quality of service)
  - Increase in congestion (effective operational downside)
- Impact on North Corridor project
  - Increase in ridership (both from local bus and metrorail transit)
  - Reduce in passenger hours (travel time)
  - Reduce in revenue hours
  - Improve revenue miles

Introduction

What is TSP?

- *An ITS application to improve transit level of service.*
  - *To improve travel speed, on-time performance and reduce travel time*
  - *Improve flexibility to operate more vehicles during peak periods*
  - *To reduce operating cost incurred due to congestion*

How does it work?

- *At intersections, traffic signal controllers detect transit vehicles via wireless technology.*

TSP in Practice – List of Systems

TSP Transit Agencies		
Transit Agency	City	State
Alameda-Contra-Costa Transit District	Oakland	CA
Ben Franklin Transit	Richland	WA
Calgary Transit	Calgary	CAN
Central Florida Regional Transportation Authy	Orlando	FL
City of Glendale	Glendale	CA
Charlotte Area Transit	Charlotte	NC
Colorado Springs Transit	Colorado Spring	CO
Greater Vancouver Transportation Authority	Vancouver	CAN
Honolulu Transit	Honolulu	HI
Houston Metropolitan Transit Authority	Houston	TX
Illinois DOT (Regional Transit Authority (RTA))	Chicago	IL
Jefferson Transit authority	Port Townsend	WA
King County Metro	Seattle	WA
Kitsap Transit	Bremerton	WA

Source: TSP Handbook, 2005

- Total 24 Transit Agencies with Operational TSP.
- 1 in Florida - Orlando

Methods of Measuring

Field Studies -

- *Automated Vehicle Locators (AVL) and Global Positioning Systems (GPS) on the buses.*
- *Collection and comparison of transit data with and without transit signal priority*
- *Assessing the TSP travel time benefits.*

Computer Model Simulation -

- *Micro Simulation via Synchro and VISSIM*
  - Modifying the signal timing and phasing
- *Regional Model*
  - Typical method to reduce headways to represent travel time savings

Elements to Consider

TSP benefits vary by

- Transit Route – Itinerary
- Area
- Distance
- Type of facility
- Time of day
- Number of stops
- Number of intersections
- Other elements: Special events, passenger demand variation, operator experience, lift operations, bus size and bus bay spacing regularities

TSP Advantages

- Increase transit speed
- Increase ridership
- Improve on-time performance
- Reduce operating costs
- Rules to Success
  - Travel time savings greater than headway
  - Additional trips within scheduled hours

TSP Impact on Travel Time

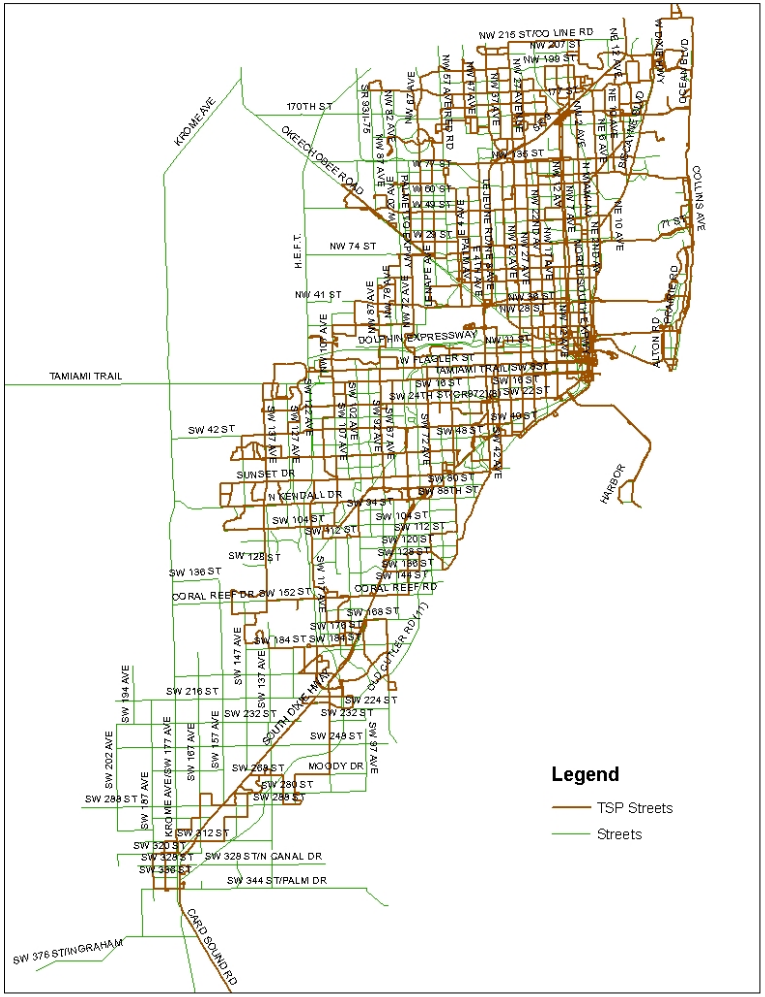
Area	Percentage Reduction in Travel Time					Source
	A.M	M.D	P.M	Hour	Total	
Tri-Met	28.6	28.6	25.3(*)	26.9	27.5	Tri-Met: Based on Line 12 which as 28 percent of route with Signal Priority
Los Angeles	22.0	n/a	16.0	19.0	23.0	LA Data/ schedules from 2003 and TSP Handbook (*)
Minnesota	12.0 to 15.0	n/a	4.0 to 11.0	8.0 to 14.0	8.0 to 10.0	Based on Synchro simulation: Study conducted by Intelligent Transportation Systems Institute, Center for Transportation Studies,
Massachusetts	10.6 to 15.6				17.6 peak direction	Transit Signal Priority Strategies in a Microscopic Simulation Laboratory, Masters Thesis, Massachusetts Institute of Transportation, 2001.
King County, WA				5.5 to 8.0	35.0 to 40.0	TSP Handbook (*)
Chicago, IL				15.0	7.0 to 20.0	TSP Handbook (*)

Research/ Literature Summary

- Lack of information on impact on Non-Transit users benefits
  - Increase delay at intersection
  - Potential travel time savings with shift of commuter to transit.

- No clear relationship between travel time savings and travel speeds
- Los Angles Metro Rapid Development Program shows **TSP the travel speeds** increase by **25 percent** with **28 percent** savings in **travel time**.

Miami-Dade Transit System



2007 Bus Transit Route System

- 84 Metro Bus Routes
- 850 Buses
- 1,900 Route Miles of Service
- Annual Ridership - **100+ Million**
- Ridership Growth Rate **- 4%**
- Population Served – **2.3 Million**
- Population Growth Rate – **1.1%**

Miami- Dade Transit Trends & Conditions

Transit Ridership and Performance trends and conditions							
Year	Revenue Miles	Revenue Hours	Route Miles	VOMS	Revenue Miles per bus	Revenue Hours per bus	Average Speed (RM/RH)
1996	22,921,023	1,814,327	1,534	**650**	35,263	2,791	**12.63**
1997	23,851,395	1,854,770	1,554	**673**	35,440	2,756	**12.86**
1998	24,176,064	1,874,557	1,554	**624**	38,744	3,004	**12.90**
1999	24,367,238	1,882,661	1,582	**626**	38,925	3,007	**12.94**
2000	24,214,832	1,908,766	1,655	**666**	36,359	2,866	**12.69**
2001	25,175,835	1,968,747	1,715	**732**	34,393	2,690	**12.79**
2002	26,294,132	2,091,277	1,720	**969**	27,135	2,158	**12.57**
2003	27,506,309	2,336,218	1,748	**957**	28,742	2,441	**11.77**
2004	31,100,472	2,535,807	1,768	**819**	37,974	3,096	**12.26**
2005	34,222,523	2,731,978	1,917	**981**	34,885	2,785	**12.53**
2006	36,825,387	2,949,999	1,930	**1,108**	33,236	2,662	**12.48**

- Bus service coverage increased by 25%
- Increase in revenue miles
- Increase in revenue hours
- Increased in number of bus to maintain speed/ quality of service

Application in Miami-Dade

Testing TSP in Miami-Dade

- Micro Simulation: Too large to model
  - 84 Metro-Bus Routes (excluding Broward County Transit)
  - 2,468 TSP intersections (3102 Signalized Intersections)
- Regional Model: Dade-Broward Model
  - Lack of additional mode for new system (such as BRT/TSP)
  - Tranplan based version – lack of exclusive queue jumpers
- Application
  - 2030 No Build vs. 2030 TSP No-Build
  - 2030 Baseline vs. 2030 TSP Baseline
  - 2030 Build vs. 2030 TSP Build

Modified Transit Speeds

- Improve transit speed by 25%
- Transit speed improvement by facility type/area type / mode type.
- Transit Speed Curves

	Highway Speed		Transit Speed without TSP		Transit Speeds with TSP	
Curve #	Low	High	Low	High	Low	High
7	22	35	13	22	16	27
8	18	37	10	27	12	33

- TSP applied to - **Arterial/Collector Streets** in CBD and on **Undivided Arterials** and also in **Fringe Areas**
- Applied only to **Peak Period**

TSP Results - Trips

2030 No-Build with and without TSP Alternative

- 3% increase in transit ridership
- 36% are Home Based Work trips

Estimated Daily Person Trips

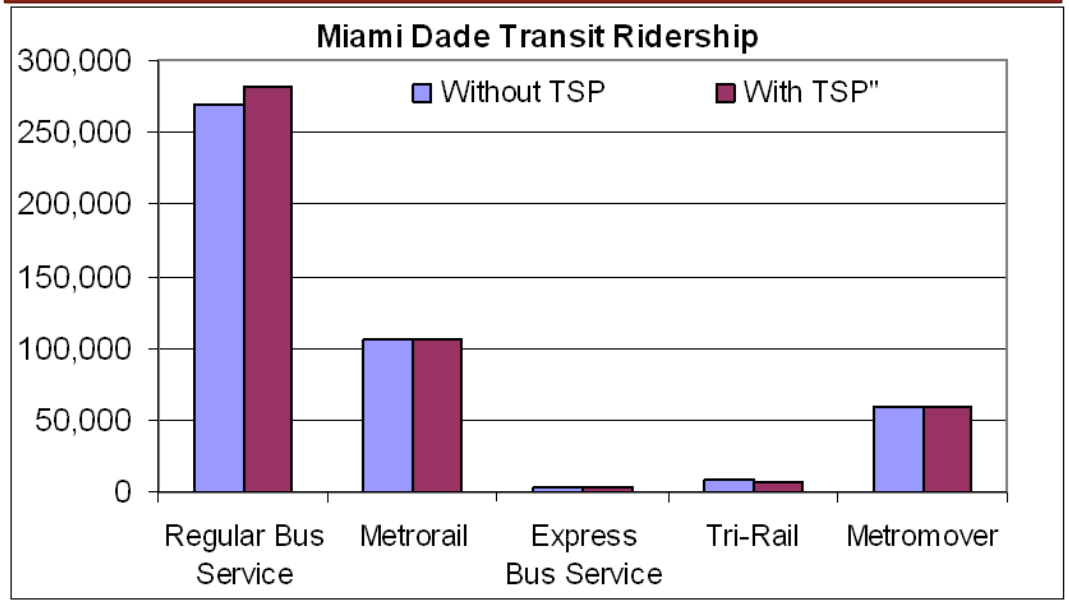
Trip Purpose by Mode	Without TSP	With TSP	Difference
Highway Work Trips	2,225,530	2,223,441	-2,089
Highway Non-work Trips	6,571,890	6,568,172	-3,718
Total Highway Trips	**8,797,420**	**8,791,613**	**-5,807**
Transit Work Trips	92,406	94,495	2,089
Transit Non-work Trips	118,373	122,091	3,718
Total Transit Trips	**210,779**	**216,586**	**5,807**

RESULTS – TRIPS BY MODE

2030 No-Build with and without TSP

- 5% increase in Local Bus ridership
- 1% increase in Metrorail and Metromover
- TSP routes compete with Express Bus & Tri-rail routes

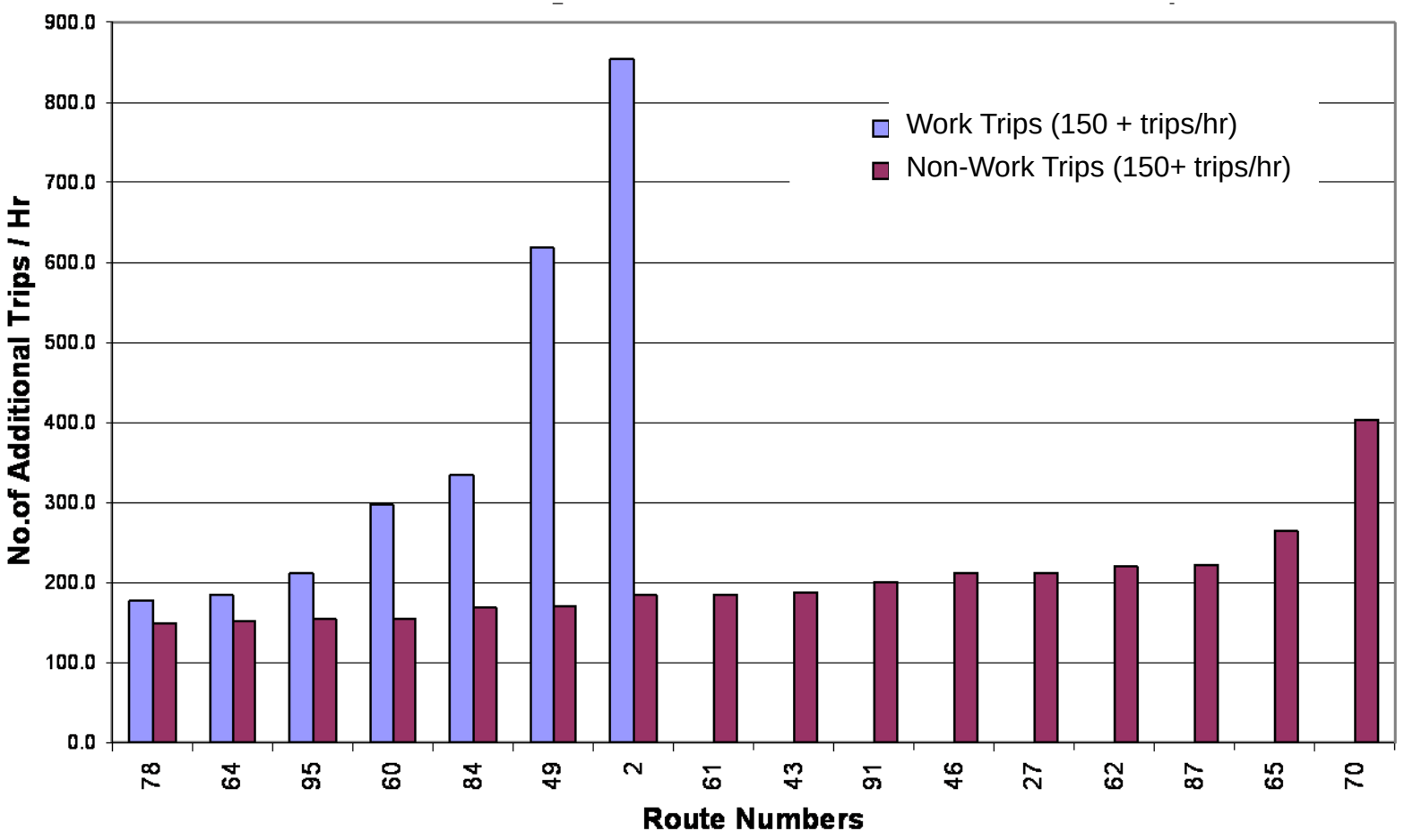
Estimated Daily Ridership by Mode



Route Benefits – Work & Non-work Trips

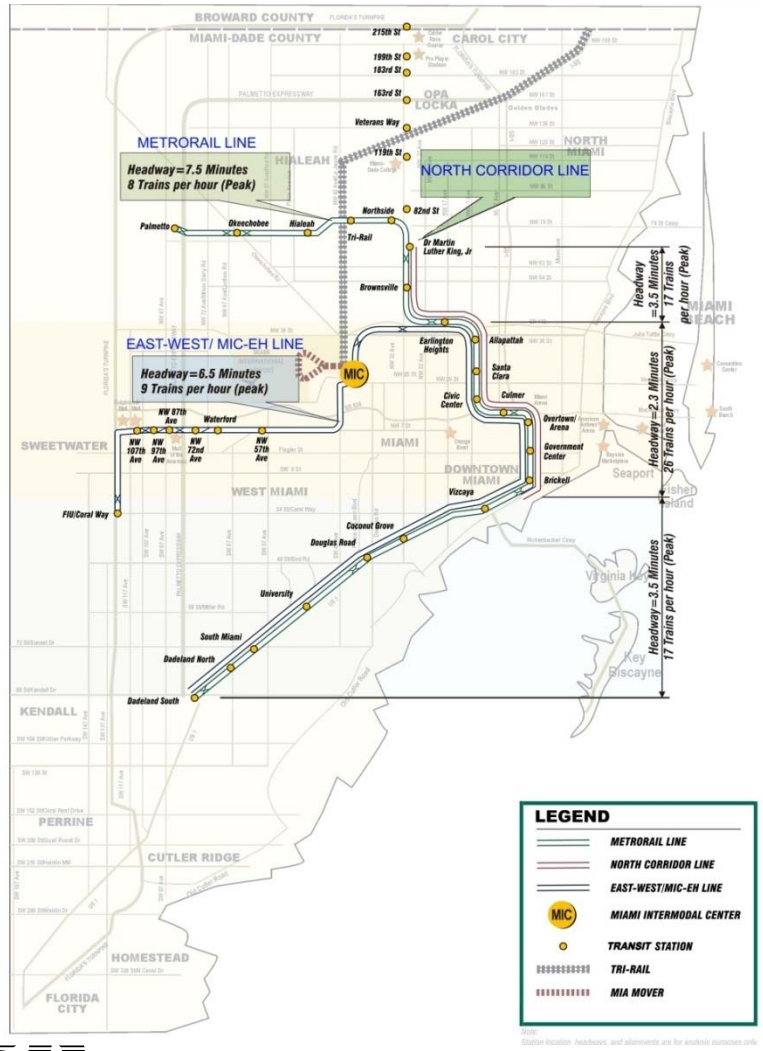
2030 No Build with and without TSP

Routes with 150+ trips per revenue hour gain

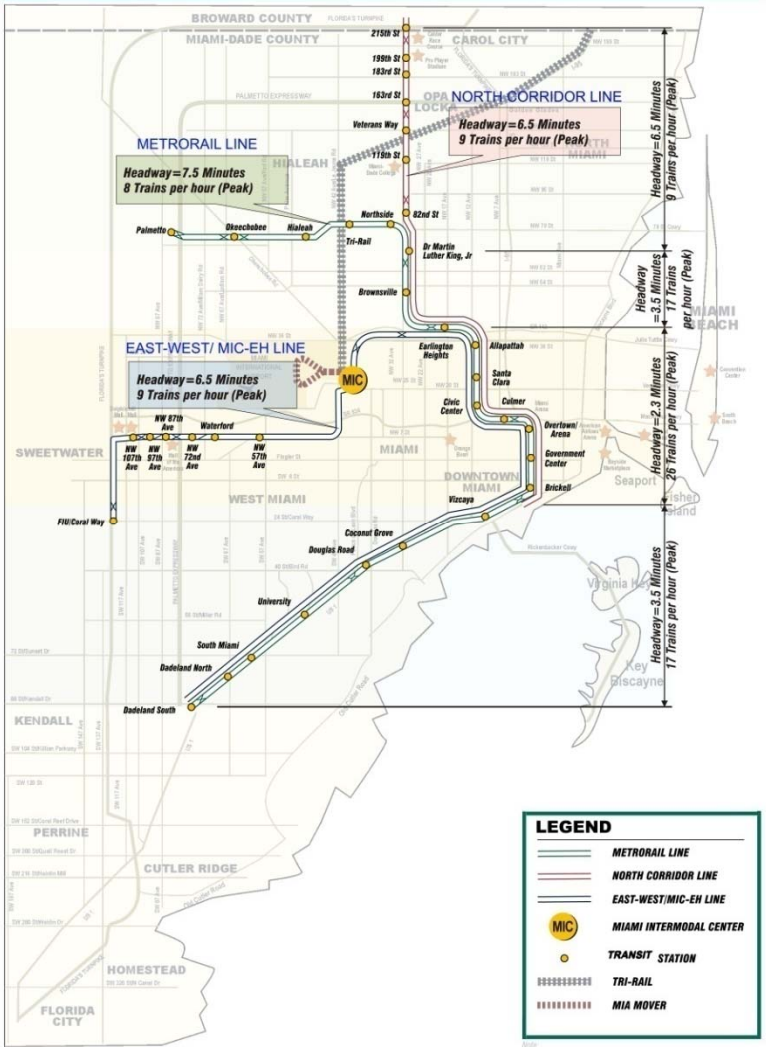


2030 Baseline & Build Alternative

North Corridor Baseline



North Corridor Build



TSP Results- Trips by County

2030 Baseline with and without TSP Alternative

	Baseline Alternative without TSP			Baseline Alternative with TSP		
Total Trips	**Miami-Dade**	**Broward**	**Total**	**Miami-Dade**	**Broward**	**Total**
Miami-Dade	9,008,199	441,123	9,449,322	9,008,199	441,123	9,449,322
Broward	902,365	6,099,079	7,001,444	902,365	6,099,079	7,001,444
Total	**9,910,564**	**6,540,202**	**16,450,766**	**9,910,564**	**6,540,202**	**16,450,766**
Highway Work Trips	**Miami-Dade**	**Broward**	**Total**	**Miami-Dade**	**Broward**	**Total**
Miami-Dade	2,225,530	134,534	2,360,064	2,223,441	134,324	2,357,765
Broward	335,809	1,548,842	1,884,651	335,184	1,547,366	1,882,550
Total	**2,561,339**	**1,683,376**	**4,244,715**	**2,558,625**	**1,681,690**	**4,240,315**
Highway Non-Work Trips	**Miami-Dade**	**Broward**	**Total**	**Miami-Dade**	**Broward**	**Total**
Miami-Dade	6,571,890	300,491	6,872,381	6,568,172	300,189	6,868,361
Broward	547,286	4,419,375	4,966,661	546,573	4,417,023	4,963,596
Total	**7,119,176**	**4,719,866**	**11,839,042**	**7,114,745**	**4,717,212**	**11,831,957**
Transit Work Trips	**Miami-Dade**	**Broward**	**Total**	**Miami-Dade**	**Broward**	**Total**
Miami-Dade	92,406	3,153	95,559	94,495	3,363	97,858
Broward	10,451	59,592	70,043	11,076	61,068	72,144
Total	**102,857**	**62,745**	**165,602**	**105,571**	**64,431**	**170,002**
Transit Non-Work Trips	**Miami-Dade**	**Broward**	**Total**	**Miami-Dade**	**Broward**	**Total**
Miami-Dade	118,373	2,945	121,318	122,091	3,247	125,338
Broward	8,819	71,270	80,089	9,532	73,622	83,154
Total	**127,192**	**74,215**	**201,407**	**131,623**	**76,869**	**208,492**

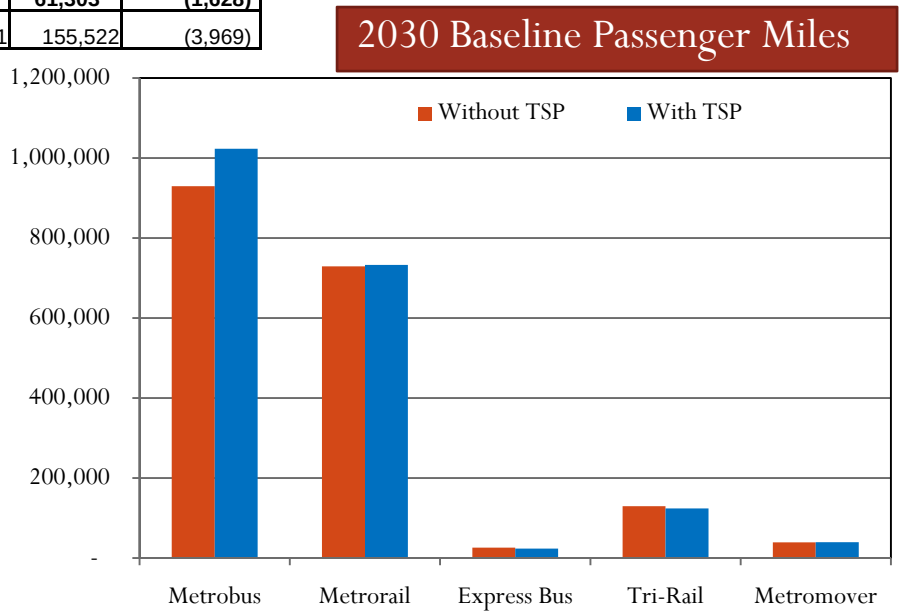
- Decrease in 11,000 Highway trips
- 5, 000 in Miami-Dade
- 61% gain in non-work transit trips region wide.
- 18% work trips increase in Miami-Dade
- 32% non-work trips transit trip increased in Miami-Dade
- Similar differences are observed in between ***Build and TSP Build*** Alternatives

TSP RESULTS- TRIPS/HOURS/MILES

2030 Baseline with and without TSP Alternative

Baseline Alternative with and without TSP							
		Passenger Trips			Passenger Hours		
	Mode	Without TSP	With TSP	Net Change	Without TSP	With TSP	Net Change
Miami	Metrobus	269,185	281,609	12,424	69,791	67,560	(2,231)
	Metrorail	106,169	106,848	679	18,622	18,724	102
	Express Bus	4,210	3,791	(419)	1,368	1,267	(101)
	Tri-Rail	7,688	7,334	(354)	3,316	3,174	(142)
	Metromover	59,187	59,943	756	3,463	3,494	31
MDT Total		**446,439**	**459,525**	**13,086**	**96,560**	**94,219**	**(2,341)**
Broward	Local bus	246,454	255,279	8,825	56,853	55,572	(1,281)
	Express Bus	21,413	19,775	(1,638)	6,078	5,731	(347)
BCT Total		**267,867**	**275,054**	**7,187**	**62,931**	**61,303**	**(1,628)**
Total		714,306	734,579	20,273	159,491	155,522	(3,969)

- TSP baseline increases Metro-Bus ridership by 12,000 and saves over 2,000 passenger hours.
- 3.4% travel time savings in Miami-Dade

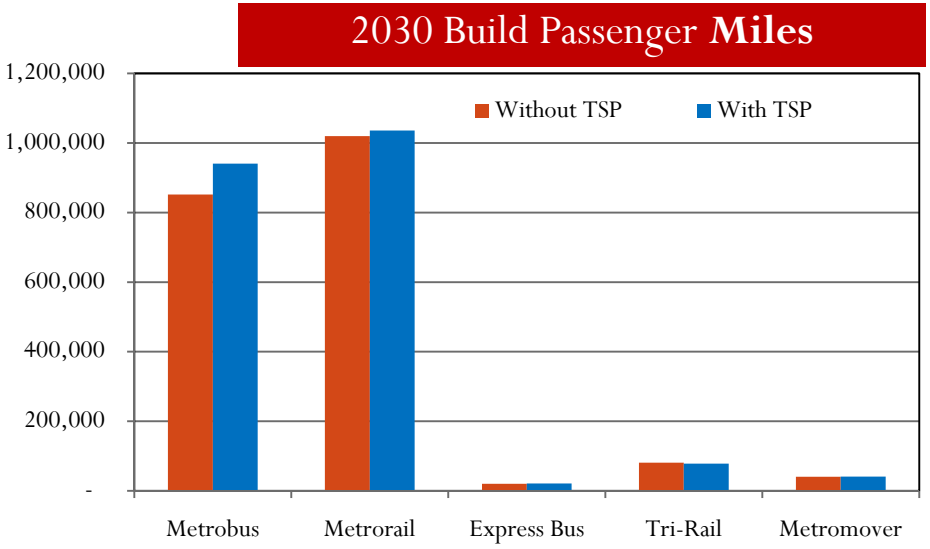


TSP RESULTS- TRIPS/HOURS/MILES

2030 Build with and without TSP

Build Alternative with and without TSP							
		Passenger Trips			Passenger Hours		
	Mode	Without TSP	With TSP	Net Change	Without TSP	With TSP	Net Change
Miami	Metrobus	267,708	279,819	12,111	65,578	61,727	(3,851)
	Metrorail	131,592	133,100	1,508	26,425	26,844	419
	Express Bus	4,083	4,166	83	1,152	1,135	(17)
	Tri-Rail	5,012	4,834	(178)	2,094	2,024	(70)
	Metromover	62,354	62,890	536	3,626	3,643	17
MDT Total		**470,749**	**484,809**	**14,060**	**98,875**	**95,373**	**(3,502)**
Broward	Local bus	237,831	264,484	26,653	54,183	56,790	2,607
	Express Bus	15,890	23,142	7,252	5,561	7,455	1,894
BCT Total		**253,721**	**287,626**	**33,905**	**59,744**	**64,245**	**4,501**
Total		724,470	772,435	47,965	158,619	159,618	999

- Metro-Bus travel time savings similar to baseline benefits, 12,000 trips and 6% travel time savings



TSP IMPACTS – NET BENEFIT

2030 Net difference with and without TSP

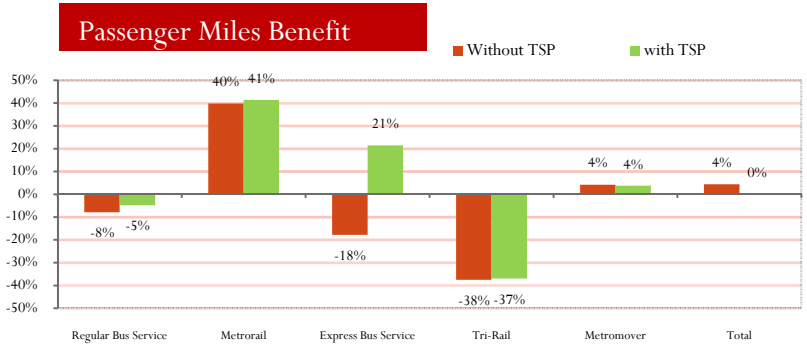
Difference between Build and Baseline Alternatives

		Passenger Trips			Passenger Hours		
	Mode	Without TSP	With TSP	Net Change	Without TSP	With TSP	Net Change
Miami	Metrobus	-1,477	-1,790	-313	-4,213	-5,833	-1,620
	Metrorail	25,423	26,252	829	7,803	8,120	317
	Express Bus	-127	375	502	-216	-132	84
	Tri-Rail	-2,676	-2,500	176	-1,222	-1,150	72
	Metromover	3,167	2,947	-220	163	149	-14
MDT Total		**24,310**	**25,284**	**974**	**2,315**	**1,154**	**-1,161**
Broward	Local bus	-8,623	9,205	17,828	-2,670	1,218	3,888
	Express Bus	-5,523	3,367	8,890	-517	1,724	2,241
BCT Total		-14,146	12,572	26,718	-3,187	2,942	6,129
Total		**10,164**	**37,856**	**27,692**	**-872**	**4,096**	**4,968**

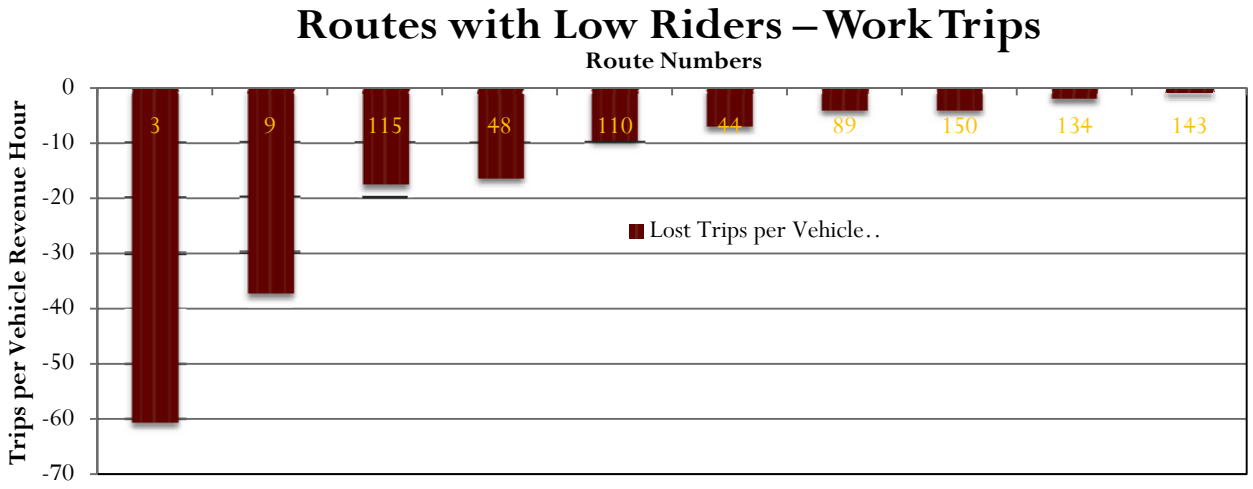
Net Benefit =

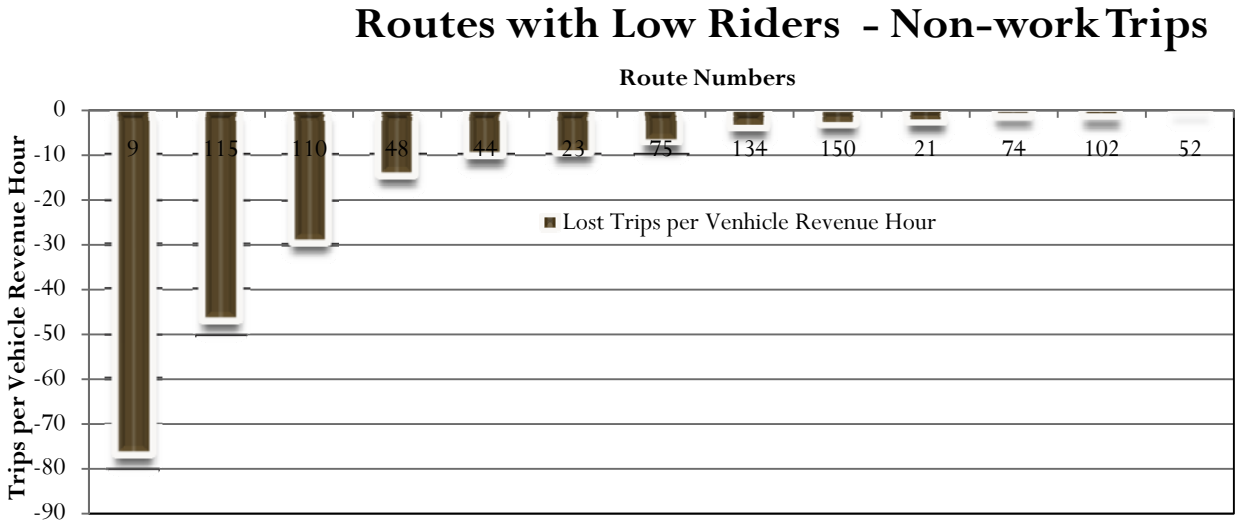
(TSP Build-TSP Baseline) – (Build – Baseline)

- With TSP the *ridership gain is less on Metro-Bus than without TSP* between Baseline and Build alternatives.
- TSP benefits North Corridor ridership.
- TSP has an additional 2.5%benefit on travel time



2030 Route Level Analysis

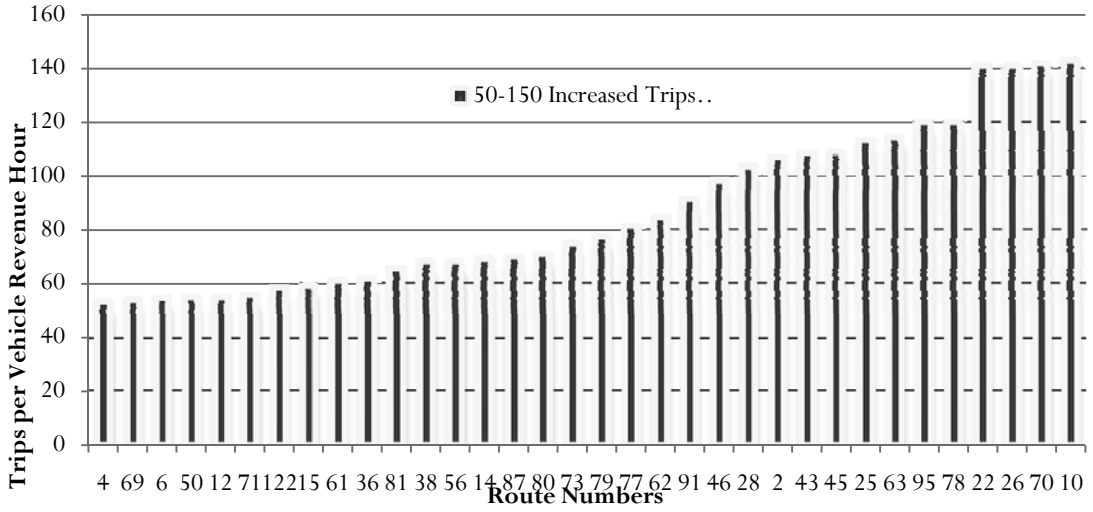


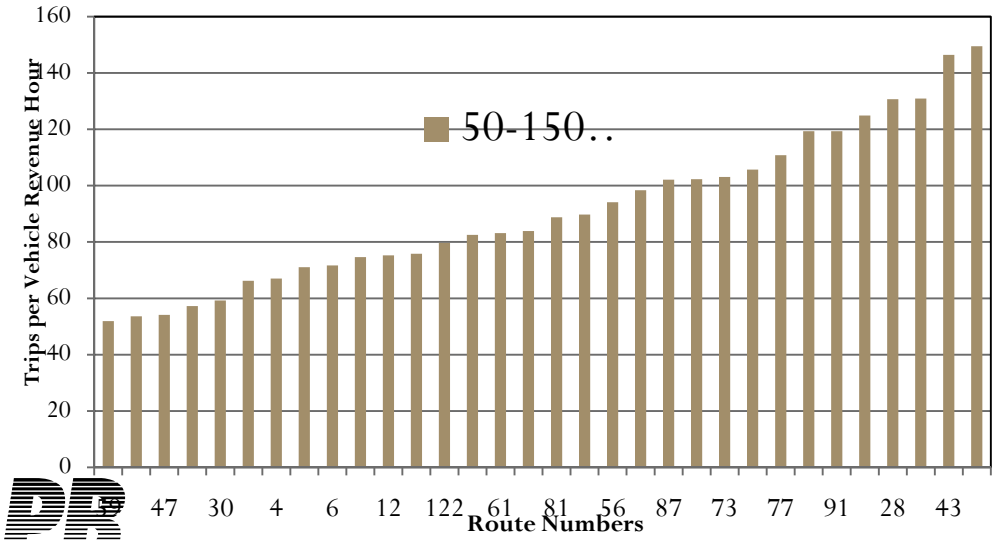


- Competition among similar routes
- Not all routes benefit the same

2030 Route level Analysis

Routes with Moderate Gain in Work Trips

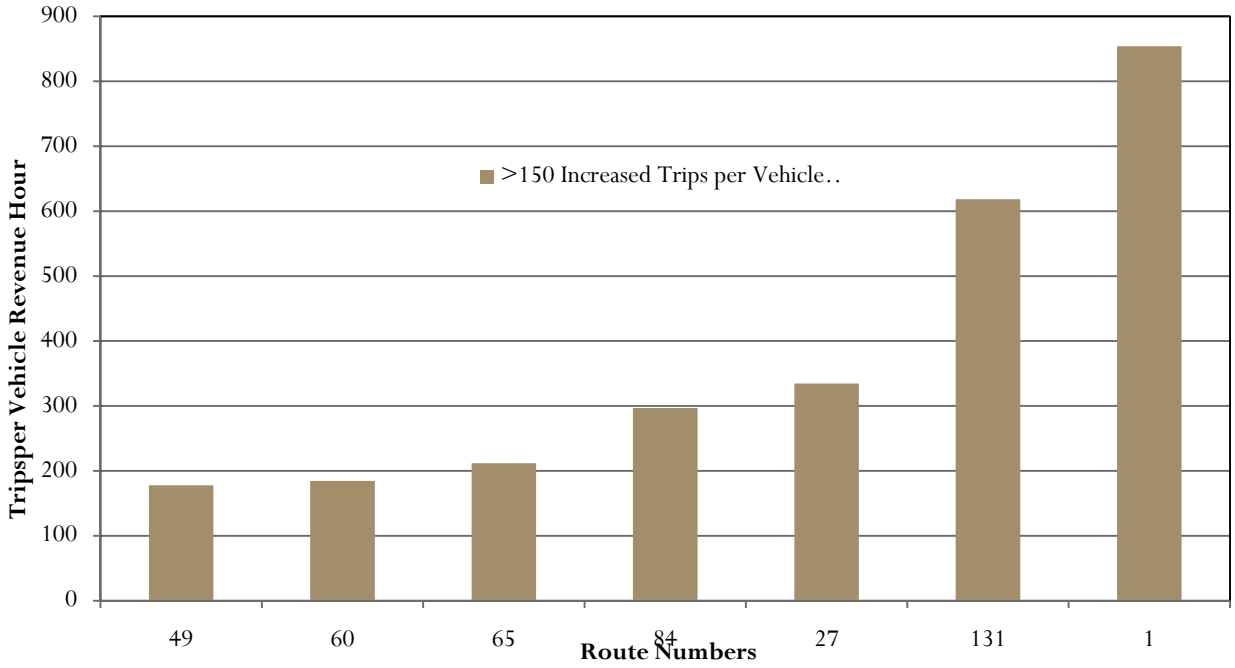




Routes with Moderate Gain in Non-Work Trips

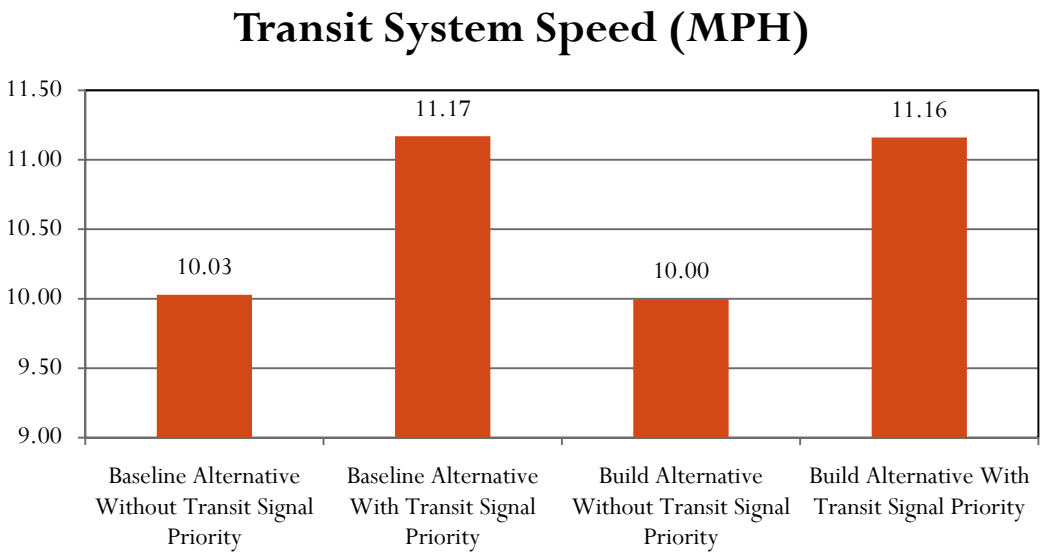
2030 Route Level Analysis – Work Trips

- **Routes with High Ridership Gain in Work Trips**



TSP Impacts - Performance Measures

Summary of Metro-Bus trips						
	1. Peak Period			2. Off Peak Period		
Alternative	Vehicles	Revenue-Vehicle-Hours*	Revenue-Vehicle-Miles	Vehicles	Revenue-Vehicle-Hours*	Revenue-Vehicle-Miles
Baseline Alternative Without Transit Signal Priority	1,024	1,024	9,325	524	524	6,199
Baseline Alternative With Transit Signal Priority	950	950	9,223	428	428	6,168
Build Alternative Without Transit Signal Priority	1,004	1,004	9,114	514	514	6,062
Build Alternative With Transit Signal Priority	930	930	9,013	418	418	6,031



Impact of North Corridor SUMMIT Results

SUMMIT User Benefits

	With TSP	Without TSP	Difference
Home-Based Work	5,847	6,717	**-870**
Home-Based Other	3,073	3,490	**-417**
Non-Home Based	1,292	1,488	**-196**
Total User Benefits (Minutes)	**10,212**	**11,695**	**-1,482**

Cost-Effectiveness Ratio

	With TSP		Without TSP	
	Annual O&M Cost	**Annualized Capital Cost**	**Annual O&M Cost**	**Annualized Capital Cost**
Baseline	$606.92	$10.05	$645.91	$10.05
Build	$621.72	$83.33	$660.04	$83.33
Incremental Annual Cost	$85.40		$84.74	
User Benefit Hours	**10,212**		**11,695**	
Cost Effectiveness Ratio	**$26.55**		**$23.65**	

Conclusions

- Ridership increase on Metrobus by 4% percent
- Decrease service hours by 10%.
- Ridership on Metrorail and Metromover increases by 1.5%
- Net loss in User Benefits -1,400 hours
- The cost effectiveness for the North Corridor line increases from $23.65 to $27.03

Thank You