Hwy 6/10 Interchange Annualized Performance Evaluation

See "Red Triangles" for comments on specific items cd-RIDOT

Tab Colors	
Orange Tabs	Part of the process of deriving inputs for TREDIS
Pink Tabs	Outputs from TREDIS

Performance values obtained from 2035 AM and PM peak Vissim model sponsored by RI DOT

	2035 NB AM	2035 Build AM	2035 NB PM	2035 Build PM
Ave Delay (sec/veh)	72	61	102	85
Ave Spd (mph)	34	37	31	34
Pk hr VMT in system	40,518	40,518	45,020	45,020
Total Time (seconds)	4,244,277	3,901,888	4,656,634	4,280,979
Total Vehicles	16,230	16,236	18,008	18,015
Sytem Miles	2.50	2.50	2.50	2.50

Key Assumptions used in calculations below

167	NB 10 to WB 6 is a new movement that will save at least 2-min/trip for at least 5000 trips/day after traffic readjusts
77%	Ramp Metering delay reduction factor . See "Ramp Meter Performance" tab for details
0.37	Share of 3-hr traffic in single heaviest hour
0.50%	Assumed annual growth rate (half a percent), for extending 2035 to 2040 and backcasting to 2020
0.925	2035 to 2020 Factor
1.025	2035 to 2040 Factor
0.085	AM factor
251	Weekdays/yr
114	Other days/yr
0.9	Weekend factor
5%	Pct Freight-based vehicles

Convert the aggregate time above from seconds into hours, and add in the estimated effect of ramp metering

Total AM Time in Hours	2035 NB	2035 Build	Dif	
Vissim time in hours	1,179	1,083.86	95	8.1%
After ramp metering	1,179	907	272	23.1%
			368	31.2%

Total PM Time in Hours	2035 NB	2035 Build		
Vissim time in hours	1,294	1,189.16	104	8.1%
After ramp metering	1,294	914.35	379	29.3%

Convert Peak hour 2035 hours into 3-hour periods, then estimate 2020 as 92.5% of 2035

Then determine the rest of the hours of the day, but do not give congestion relief credit to other hours

	2020 NB	2020 Build	2035 Replace	2035 Redesign	
AM 3-hr trips	40,575	40,575	43,865	43,865	-
PM 3-hr trips	45,020	45,020	48,670	48,670	-
Remaining trips	91,026	91,026	98,406	98,406	-
Total Daily Trips	176,621	176,621	190,941	190,941	-
AM 3-hr VMT	101,295	101,295	109,508	109,508	-
PM 3-hr VMT	112,550	112,550	121,676	121,676	-
18 hr VMT	227,086	227,086	245,499	245,499	-
Daily VMT	440,931	440,931	476,682	476,682	-
AM 3-hr VHT	2,947	2,266	3,186	2,450	736
PM 3-hr VHT	3,234	2,286	3,496	2,471	1,025
18 hr VHT	4,542	4,542	4,910	4,910	-
Daily VHT	10,723	9,094	11,592	9,831	1,761
Adjust for NB-6 to WB-10		167		180	
Adjusted Daily VHT	10,723	8,927	11,592	9,651	

0.982 VHT Adjustment factor to account for NB-6 to WB-10 improved path

Using weekday values, multiply by 251 as the accumulated effect of all weekdays in the year.

Also estimate accumulated effect of remaining non-weekdays, ensuring no congestion relief is given to non-weekdays

Convert to annual	Sum of weekdays				Sum of Weekends				Full Annual			
	2020 NB	2020 Build	2035 Replace	2035 Redesign	2020 NB	2020 Build	2035 Replace	2035 Redesign	2020 NB	2020 Build	2035 Replace	2035 Redesign
AM 3-hr trips	10,172,732	10,172,732	10,997,548	10,997,548	4,173,429	4,173,429	4,511,815	4,511,815	14,346,161	14,346,161	15,509,363	15,509,363
PM 3-hr trips	11,287,157	11,287,157	12,202,332	12,202,332	4,630,629	4,630,629	5,006,085	5,006,085	15,917,786	15,917,786	17,208,417	17,208,417
Remaining trips	22,821,415	22,821,415	24,671,800	24,671,800	9,362,632	9,362,632	10,121,764	10,121,764	32,184,047	32,184,047	34,793,565	34,793,565
Total Trips	44,281,305	44,281,305	47,871,681	47,871,681	18,166,689	18,166,689	19,639,664	19,639,664	62,447,994	62,447,994	67,511,345	67,511,345
AM 3-hr VMT, annual	25,396,104	25,396,104	27,455,247	27,455,247	10,418,914	10,418,914	11,263,691	11,263,691	35,815,018	35,815,018	38,718,938	38,718,938
PM 3-hr VMT	28,217,893	28,217,893	30,505,830	30,505,830	11,576,571	11,576,571	12,515,212	12,515,212	39,794,464	39,794,464	43,021,042	43,021,042
Remaining VMT	56,933,749	56,933,749	61,549,998	61,549,998	23,357,435	23,357,435	25,251,281	25,251,281	80,291,184	80,291,184	86,801,280	86,801,280
Total VMT	110,547,745	110,547,745	119,511,076	119,511,076	45,352,921	45,352,921	49,030,185	49,030,185	155,900,666	155,900,666	168,541,261	168,541,261
AM 3-hr VHT, annual	738,959	557,778	798,875	603,003	303,163	267,846	280,005	252,004	1,042,122	825,624	1,078,879	855,007
PM 3-hr VHT, annual	810,753	562,601	876,490	608,217	332,617	293,869	282,426	254,184	1,143,370	856,470	1,158,916	862,401
Remaining VHT, annual	1,138,675	1,117,806	1,231,000	1,208,439	467,149	412,728	561,140	505,026	1,605,824	1,530,535	1,792,140	1,713,465
Total VHT, annual	2,688,387	2,238,185	2,906,364	2,419,659	1,102,928	974,443	1,123,571	1,011,214	3,791,315	3,212,628	4,029,935	3,430,873

Summarize key TREDIS inputs, and convert 2035 to 2040 using 0.5% annual growth rate.

Grand Summary, extended to 2040	2020 NB	2020 Build	2040 Replace	2040 Redesign	Diff
Total Annual Trips	62,450,000	62,450,000	69,200,000	69,200,000	-
Total Annual VMT	155,900,000	155,900,000	172,750,000	172,750,000	-
Total Annual VHT	3,790,000	3,210,000	4,130,000	3,520,000	(610,000)
Implied changes in speed	41	49	42	49	

Divide above values into Freight vs. Auto, and upload results directly to TREDIS for analysis

Freight vs. Auto

	2020 NB	2020 Build	2040 Replace	2040 Redesign
Freight Trips	3,122,500	3,122,500	3,460,000	3,460,000
Auto Trips	59,327,500	59,327,500	65,740,000	65,740,000
Freight VMT	7,795,000	7,795,000	8,637,500	8,637,500
Auto VMT	148,105,000	148,105,000	164,112,500	164,112,500
Freight VHT	189,500	160,500	206,500	176,000
Auto VHT	3,600,500	3,049,500	3,923,500	3,344,000
Improvement in annual VHT		15.3%		14.8%

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Determine the percentage of annual VMT that is congested for build and base, and upload to TREDIS

Percent Congested

Previously concluded that for NB conditions, 3-hrs in both AM and PM will be congested by 2040.

Assume 2 in AM for 2020, and 3 in PM for 2020.

For Build, design improvements and metering will reduce congestion as estimated below. Use that as factor

Congestion reduction factor: 68.8%

	2020 NB	2020 Build	2040 Replace	2040 Redesign
VMT congested AM 3hr	67,530	46,477	109,508	75,368
VMT congested PM 3hr	112,550	77,461	121,676	83,742
VMT Congested during 24hr	180,080	123,938	231,184	159,109
VMT total 24 hr	440,931	440,931	476,682	476,682
Pct Congested	41%	28%	48%	33%

Determine conservative Crash Modifcation Factor

CMF as for ramp metering as per FHWA case studies averaged about .58 (42% reduction)

Apply this factor to only 6-peak hours of volume (i.e., apply 20% to entire day, which is similar to applying 42% to just peak hours)

Design also improves a bad weave, includes wrong-way warnings, and general modernization

of a 50+ year old system. Should conservatively result in at least another 5% improvement.

Composite CMF = 0.75

	Fatal/100M	Injury/100M	PDO/100M	
Base Freight	0.02	6.9	96	Original accident rates
Base Auto	1.15	75	186	Original accident rates
Proj Freight	0.015	5.2	72	After adjustment
Proj Auto	0.863	56	140	After adjustment

Upload these rates directly to TREDIS for analysis

Methodology to determine a conservative estimate for benefits of ramp metering to the project

	Reduced Collision Rate	Speed Before	Speed After	Pct Change	Peak Throughput
Minneapolis	38%	40	43	8%	25%
Seattle	34%	20	40	100%	74%
Denver	50%	43	50	16%	18%
Detroit	50%				
Portland	43%	16	41	156%	
Average	43%	30	44	46%	39%
Conservative	20%			23%	20%
Delay reduction factor				**77%**	
Crash Modification Factor				**80%**	

Source: FHWA Ramp Management and Control Handbook, Chapter 5
http://ops.fhwa.dot.gov/publications/ramp_mgmt_handbook/manual/manual/5_1.htm

	Reduced Collision Rate	Speed Increase	Emmissions
Minneapolis	25%	10%	50%
Seattle	33%	10%	
Denver	50%	55%	20%
Detroit			
Portland	40%	170%	
Average	37%	61%	35%
Half	19%	31%	18%

Source: Ramp Metering: A Proven, Cost-Effective Operational Strategy—A Primer, Section 1.5
http://www.ops.fhwa.dot.gov/publications/fhwahop14020/sec1.htm

This documents some of the national experience with the benefits of ramp metering, as reported by a 2014 FHWA in a publication titled: Ramp Metering: A Proven, Cost-Effective Operational Strategy—A Primer, Section 1.5
Long Island was one of the locations with data, but this was excluded here because it is too different from the others.

This also draws upon FHWA's publication "FHWA Ramp Management and Control Handbook, Chapter 5"

Table 5-2 : Ramp Metering Benefits by Performance Measure [2],[3]

Measure	Location	Benefits
Safety	Minneapolis, MN	26% reduction in peak period collisions and 38% decrease in peak period collision rate.
	Seattle, WA	34% decrease in collision rate.
	Denver, CO	50% reduction in rear-end and side swipe collisions.
	Detroit, MI	50% reduction in total collisions, 71% reduction in injury collisions.
	Portland, OR	43% reduction in peak collisions.
	Long Island, NY	15% reduction in collision rate.
Travel Time and Speed	Long Island, NY	9% increase in average vehicle speed.
	Portland, OR	26 to 66 km/h increase in average vehicle speeds (16 to 41 mi/h).
	Denver, CO	69 to 80 km/h improvement in average vehicle speeds (43 to 50 mi/h).
	Seattle, WA	Decrease in average travel time from 22 to 11.5 minutes.
	Minneapolis, MN	64 to 69 km/h improvement in average peak hour speeds (40 to 43 mi/h).
Throughput	Minneapolis, MN	25% increase in peak volume.
	Seattle, WA	74% increase in peak volume.
	Denver, CO	18% increase in peak volume.
	Long Island, NY	2% increase in throughput.
Environmental	Minneapolis, MN	2 to 55% reduction in fuel consumption.
		Savings of 1,160 tons of emissions.

Below are the cost estimates provided by RIDOT, in millions

Costs		Year					
		2017	2018	2019	2020	2021	Sum
Base*	Cost Category						$ 500
	Structures	$ -	$ 70	$ 110	$ 110	$ 30	$ 320
	Roadway Construction	$ -	$ 20	$ 30	$ 40	$ 40	$ 130
	Property Acquisition	$ -	$ -	$ -	$ -	$ -	$ -
	Design & Engineering Services	$ 20	$ 15	$ 8	$ 5	$ 2	$ 50
Build	Cost Category						$ 595
	Structures	$0	$80	$130	$130	$60	$ 400
	Roadway Construction	$0	$20	$30	$45	$45	$ 140
	Property Acquisition	$0	$0	$0	$0	$0	$ -
	Design & Engineering Services	$20	$15	$10	$5	$5	$ 55
	Constant Dollar Year of Cost Estimate						

Reformat above table into the format TREDIS requires as input

500		50	0	450	0	0	0	0

Base

	Property Acquisition	Engineering And Design	Right Of Way	Transport Structures	Terminal	Vehicles	Ongoing Operations	Maintenance And Rehabilitation
2017	0	20	0	0	0	0	0	0
2018	0	15	0	90	0	0	0	0
2019	0	8	0	140	0	0	0	0
2020	0	5	0	150	0	0	0	0
2021	0	2	0	70	0	0	0	0

595		55	0	540	0	0	0	0

Build

	Property Acquisition	Engineering And Design	Right Of Way	Transport Structures	Terminal	Vehicles	Ongoing Operations	Maintenance And Rehabilitation
2017	0	20	0	0	0	0	0	0
2018	0	15	0	100	0	0	0	0
2019	0	10	0	160	0	0	0	0
2020	0	5	0	175	0	0	0	0
2021	0	5	0	105	0	0	0	0

Copy and Paste values above into correct cells in the "cost by year" tab, and then copy/paste that tab into TREDIS.

	A	E	G	I	J	K	L	M	N	O	P	Q	R	S
1		Alternative	Region	Facility Name	Year	Property Acquisition	Engineering And Design	Right Of Way	Transport Structures	Terminal	Vehicles	Ongoing Operations	Maintenance And Rehabilitation	
2	**Undiscounted costs: Copy and paste this entire sheet directly in to Cost portion of TREDIS**													
3		Base	RI Statewide	Road	2017	0	20.00	0	0.0	0	0	0	0	cd-RIDOT
4		Base	RI Statewide	Road	2018	0	15.00	0	90.0	0	0	0	0	
5		Base	RI Statewide	Road	2019	0	8.00	0	140.0	0	0	0	0	
6		Base	RI Statewide	Road	2020	0	5.00	0	150.0	0	0	0	0	
7		Base	RI Statewide	Road	2021	0	2.00	0	70.0	0	0	0.00	0.00	
8		Base	RI Statewide	Road	2022	0	0.00	0	0.0	0	0	0.10	0.25	
9		Base	RI Statewide	Road	2023	0	0.00	0	0.0	0	0	0.10	0.25	
10		Base	RI Statewide	Road	2024	0	0.00	0	0.0	0	0	0.10	0.25	
11		Base	RI Statewide	Road	2025	0	0.00	0	0.0	0	0	0.10	0.25	
12		Base	RI Statewide	Road	2026	0	0.00	0	0.0	0	0	0.10	0.25	
13		Base	RI Statewide	Road	2027	0	0.00	0	0.0	0	0	0.10	0.25	
14		Base	RI Statewide	Road	2028	0	0.00	0	0.0	0	0	0.10	0.25	
15		Base	RI Statewide	Road	2029	0	0.00	0	0.0	0	0	0.10	0.25	
16		Base	RI Statewide	Road	2030	0	0.00	0	0.0	0	0	0.10	0.25	
17		Base	RI Statewide	Road	2031	0	0.00	0	0.0	0	0	0.10	0.25	
18		Base	RI Statewide	Road	2032	0	0.00	0	0.0	0	0	0.10	0.25	
19		Base	RI Statewide	Road	2033	0	0.00	0	0.0	0	0	0.10	0.25	
20		Base	RI Statewide	Road	2034	0	0.00	0	0.0	0	0	0.10	0.25	
21		Base	RI Statewide	Road	2035	0	0.00	0	0.0	0	0	0.10	0.25	
22		Base	RI Statewide	Road	2036	0	0.00	0	0.0	0	0	0.10	0.25	
23		Base	RI Statewide	Road	2037	0	0.00	0	0.0	0	0	0.10	0.25	
24		Base	RI Statewide	Road	2038	0	0.00	0	0.0	0	0	0.10	0.25	
25		Base	RI Statewide	Road	2039	0	0.00	0	0.0	0	0	0.10	0.25	
26		Base	RI Statewide	Road	2040	0	0.00	0	0.0	0	0	0.10	0.25	
27		Project	RI Statewide	Road	2017	0	20.00	0.00	0.00	0.00	0.00	0.00	0.00	
28		Project	RI Statewide	Road	2018	0	15.00	0.00	100.00	0.00	0.00	0.00	0.00	
29		Project	RI Statewide	Road	2019	0	10.00	0.00	160.00	0.00	0.00	0.00	0.00	
30		Project	RI Statewide	Road	2020	0	5	0.00	175.00	0.00	0.00	0.00	0.00	
31		Project	RI Statewide	Road	2021	0	5	0	105	0	0	0.00	0.00	
32		Project	RI Statewide	Road	2022	0	0	0	0	0	0	0.10	0.25	
33		Project	RI Statewide	Road	2023	0	0	0	0	0	0	0.10	0.25	
34		Project	RI Statewide	Road	2024	0	0	0	0	0	0	0.10	0.25	
35		Project	RI Statewide	Road	2025	0	0	0	0	0	0	0.10	0.25	
36		Project	RI Statewide	Road	2026	0	0	0	0	0	0	0.10	0.25	
37		Project	RI Statewide	Road	2027	0	0	0	0	0	0	0.10	0.25	
38		Project	RI Statewide	Road	2028	0	0	0	0	0	0	0.10	0.25	
39		Project	RI Statewide	Road	2029	0	0	0	0	0	0	0.10	0.25	
40		Project	RI Statewide	Road	2030	0	0	0	0	0	0	0.10	0.25	
41		Project	RI Statewide	Road	2031	0	0	0	0	0	0	0.10	0.25	
42		Project	RI Statewide	Road	2032	0	0	0	0	0	0	0.10	0.25	
43		Project	RI Statewide	Road	2033	0	0	0	0	0	0	0.10	0.25	
44		Project	RI Statewide	Road	2034	0	0	0	0	0	0	0.10	0.25	
45		Project	RI Statewide	Road	2035	0	0	0	0	0	0	0.10	0.25	
46		Project	RI Statewide	Road	2036	0	0	0	0	0	0	0.10	0.25	
47		Project	RI Statewide	Road	2037	0	0	0	0	0	0	0.10	0.25	
48		Project	RI Statewide	Road	2038	0	0	0	0	0	0	0.10	0.25	
49		Project	RI Statewide	Road	2039	0	0	0	0	0	0	0.10	0.25	
50		Project	RI Statewide	Road	2040	0	0	0	0	0	0	0.10	0.25	

Project Net Costs (Build minus Base) and Net Benefits

7% Discount Rate

	Project Costs Startup Costs	O&M Costs	Residual Value	Total Costs	Project Benefits Total Benefits	Net Total Benefits
Total	72.9	0	-5.9	67	332.5	259.7
2017	0	0	0	0	0	0
2018	8.7	0	0	8.7	0	-8.7
2019	18	0	0	18	0	-18
2020	19.1	0	0	19.1	27.2	8.2
2021	27.1	0	0	27.1	25.6	-1.5
2022	0	0	0	0	24.1	24.1
2023	0	0	0	0	22.7	22.7
2024	0	0	0	0	21.3	21.3
2025	0	0	0	0	20.1	20.1
2026	0	0	0	0	18.9	18.9
2027	0	0	0	0	17.8	17.8
2028	0	0	0	0	16.7	16.7
2029	0	0	0	0	15.7	15.7
2030	0	0	0	0	14.8	14.8
2031	0	0	0	0	13.9	13.9
2032	0	0	0	0	13.1	13.1
2033	0	0	0	0	12.3	12.3
2034	0	0	0	0	11.6	11.6
2035	0	0	0	0	10.9	10.9
2036	0	0	0	0	10.3	10.3
2037	0	0	0	0	9.7	9.7
2038	0	0	0	0	9.1	9.1
2039	0	0	0	0	8.6	8.6
2040	0	0	-5.9	-5.9	8.1	8.1

3% Discount Rate

	Project Costs				Project Benefits	Net Total Benefits
	Startup Costs	O&M Costs	Residual Value	Total Costs	Total Benefits	
Total	84.5	0	-14.8	69.7	535.7	451.2
2017	0	0	0	0	0	0
2018	9.4	0	0	9.4	0	-9.4
2019	20.1	0	0	20.1	0	-20.1
2020	22.2	0	0	22.2	31.7	9.5
2021	32.8	0	0	32.8	31	-1.8
2022	0	0	0	0	30.3	30.3
2023	0	0	0	0	29.6	29.6
2024	0	0	0	0	29	29
2025	0	0	0	0	28.3	28.3
2026	0	0	0	0	27.7	27.7
2027	0	0	0	0	27	27
2028	0	0	0	0	26.4	26.4
2029	0	0	0	0	25.8	25.8
2030	0	0	0	0	25.2	25.2
2031	0	0	0	0	24.7	24.7
2032	0	0	0	0	24.1	24.1
2033	0	0	0	0	23.6	23.6
2034	0	0	0	0	23.1	23.1
2035	0	0	0	0	22.6	22.6
2036	0	0	0	0	22.1	22.1
2037	0	0	0	0	21.6	21.6
2038	0	0	0	0	21.1	21.1
2039	0	0	0	0	20.6	20.6
2040	0	0	-14.8	-14.8	20.2	20.2

Undiscounted

	Project Costs				Project Benefits	Net Total Benefits
	Startup Costs	O&M Costs	Residual Value	Total Costs	Total Benefits	
Total	95	0	-30	65	803.6	708.6
2017	0	0	0	0	0	0
2018	10	0	0	10	0	-10
2019	22	0	0	22	0	-22
2020	25	0	0	25	35.7	10.7
2021	38	0	0	38	35.9	-2.1
2022	0	0	0	0	36.2	36.2
2023	0	0	0	0	36.4	36.4
2024	0	0	0	0	36.7	36.7
2025	0	0	0	0	36.9	36.9
2026	0	0	0	0	37.2	37.2
2027	0	0	0	0	37.4	37.4
2028	0	0	0	0	37.7	37.7
2029	0	0	0	0	37.9	37.9
2030	0	0	0	0	38.2	38.2
2031	0	0	0	0	38.5	38.5
2032	0	0	0	0	38.7	38.7
2033	0	0	0	0	39	39
2034	0	0	0	0	39.3	39.3
2035	0	0	0	0	39.6	39.6
2036	0	0	0	0	39.9	39.9
2037	0	0	0	0	40.2	40.2
2038	0	0	0	0	40.4	40.4
2039	0	0	0	0	40.8	40.8
2040	0	0	-30	-30	41	41

Benefits at 7% Discount Rate	(A) Traveler Benefits ($M)		(B) Traveler Benefits (non-$M)			(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits
	Vehicle Operating Costs	Business Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus				
2020	6.3	6.2	6.4	7.1	0	0.8	0	0.5	27.2
2021	5.9	5.9	6	6.7	0	0.7	0	0.5	25.6
2022	5.5	5.5	5.7	6.3	0	0.7	0	0.5	24.1
2023	5.2	5.2	5.3	5.9	0	0.6	0	0.5	22.7
2024	4.8	4.9	5	5.5	0	0.6	0	0.4	21.3
2025	4.5	4.6	4.7	5.2	0	0.6	0	0.4	20.1
2026	4.2	4.4	4.5	4.9	0	0.5	0	0.4	18.9
2027	4	4.1	4.2	4.6	0	0.5	0	0.4	17.8
2028	3.7	3.9	4	4.3	0	0.5	0	0.4	16.7
2029	3.5	3.7	3.7	4	0	0.4	0	0.4	15.7
2030	3.3	3.5	3.5	3.8	0	0.4	0	0.4	14.8
2031	3.1	3.3	3.3	3.6	0	0.4	0	0.3	13.9
2032	2.9	3.1	3.1	3.4	0	0.4	0	0.3	13.1
2033	2.7	2.9	2.9	3.1	0	0.3	0	0.3	12.3
2034	2.5	2.8	2.8	3	0	0.3	0	0.3	11.6
2035	2.4	2.6	2.6	2.8	0	0.3	0	0.3	10.9
2036	2.2	2.5	2.5	2.6	0	0.3	0	0.3	10.3
2037	2.1	2.3	2.3	2.5	0	0.3	0	0.3	9.7
2038	1.9	2.2	2.2	2.3	0	0.2	0	0.3	9.1
2039	1.8	2.1	2.1	2.2	0	0.2	0	0.3	8.6
2040	1.7	2	1.9	2	0	0.2	0	0.2	8.1
Total	**74.2**	**77.7**	**78.7**	**85.8**	**0**	**9.2**	**0**	**7.7**	**332.5**

Benefits at 3% Discount Rate	(A) Traveler Benefits ($M)		(B) Traveler Benefits (non-$M)			(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits
	Vehicle Operating Costs	Business Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus				
2020	7.3	7.3	7.4	8.3	0	0.9	0	0.6	31.7
2021	7.1	7.1	7.3	8.1	0	0.9	0	0.6	31
2022	6.9	7	7.1	7.9	0	0.9	0	0.6	30.3
2023	6.7	6.8	7	7.7	0	0.8	0	0.6	29.6
2024	6.6	6.7	6.8	7.5	0	0.8	0	0.6	29
2025	6.4	6.5	6.7	7.3	0	0.8	0	0.6	28.3
2026	6.2	6.4	6.5	7.1	0	0.8	0	0.6	27.7
2027	6	6.3	6.4	7	0	0.7	0	0.6	27
2028	5.9	6.2	6.2	6.8	0	0.7	0	0.6	26.4
2029	5.7	6	6.1	6.6	0	0.7	0	0.6	25.8
2030	5.6	5.9	6	6.5	0	0.7	0	0.6	25.2
2031	5.4	5.8	5.9	6.3	0	0.7	0	0.6	24.7
2032	5.3	5.7	5.7	6.2	0	0.6	0	0.6	24.1
2033	5.1	5.6	5.6	6	0	0.6	0	0.6	23.6
2034	5	5.5	5.5	5.9	0	0.6	0	0.6	23.1
2035	4.9	5.4	5.4	5.7	0	0.6	0	0.6	22.6
2036	4.7	5.3	5.3	5.6	0	0.6	0	0.6	22.1
2037	4.6	5.2	5.2	5.5	0	0.6	0	0.6	21.6
2038	4.5	5.1	5.1	5.3	0	0.6	0	0.6	21.1
2039	4.4	5	5	5.2	0	0.5	0	0.6	20.6
2040	4.2	4.9	4.9	5.1	0	0.5	0	0.6	20.2
Total	**118.5**	**125.7**	**127.1**	**137.6**	**0**	**14.6**	**0**	**12.6**	**535.7**

Summary of BCA, by category

Benefit	3% discount rate ($M)	7% discount rate ($M)
Vehicle Operating Costs	118.49	74.04
Business Time and Reliability Costs	125.5	77.68
Value of Personal Time and Reliability	126.88	78.67
Safety	137.41	85.57
Logistics/Freight Costs	14.59	9.12
Productivity from Access/Connectivity	0	0
Environmental Factors	12.77	7.68
Consumer Surplus and other Social Welfare	0	0

Costs	3% discount rate ($M)	7% discount rate ($M)
Capital Investment Costs	84.55	72.86
Operation and Maintenance Costs	0	0

	3% discount rate ($M)	7% discount rate ($M)
Benefit/Cost Ratio	**7.67**	**4.97**

	3% discount rate ($M)	7% discount rate ($M)
Present Value of Benefit Stream	**535.56**	**332.70**
Travel Benefits	508.27	315.95
Value of Vehicle Operating Cost (VOC)	118.48	74.04
Value of In-Vehicle Travel Time (IVTT)	163.13	101.94
Value of Out-of-Vehicle Travel Time (OVTT)	0.00	0.00
Value of Improved Travel Time Reliability	89.27	54.42
Value of Safety Improvement	137.39	85.55
Value of Consumer Surplus From Induced New Activity	0.00	0.00
Environmental and Social Benefits	12.70	7.63
Value of Emission Reduction For Mobile Source Pollutants	0.42	0.27
Value of Emission Reduction For Carbon Dioxide	12.28	7.37
Wider Economic (Productivity) Benefits	14.59	9.12
Value of Logistics & Supply Chain Cost Savings	14.59	9.12
Value of Business Productivity	0.00	0.00
Value of Enhanced Labor Market Participation Rate	0.00	0.00
Transfer Benefit Effects (net benefit adjustment)	0.00	0.00
Added Fees: Collected By Operators	0.00	0.00
Added Fees: Loss to Users	0.00	0.00
Change in Tax Revenues Collected By Government	0.00	0.00
Present Value of Cost Stream	**69.79**	**66.94**
Project Costs	84.55	72.86
Capital Investment Costs	84.55	72.86
Operation and Maintenance Costs	0.00	0.00
Cost Adjustments	-14.76	-5.91
Residual Value of Maintenance Costs	-14.76	-5.91
Reduction in Effective Capital Cost Due to Value of Added Fees Collected by Govt.	0.00	0.00
Net Benefit (Benefits - Costs)		
Transportation System Efficiency – Traveler Benefits Only	438.48	249.01
Traditional BCA – Traveler Benefits + Environmental Benefits	451.18	256.64
Full Societal BCA – All Benefit Categories	465.77	265.76
Benefit Cost Ratio (Benefits / Costs)		
Transportation System Efficiency – Traveler Benefits Only	7.28	4.72
Traditional BCA – Traveler Benefits + Environmental Benefits	7.47	4.83
Full Societal BCA – All Benefit Categories	**7.67**	**4.97**

Benefit	3% discount rate ($M)	7% discount rate ($M)
Vehicle Operating Costs	118.49	74.04
Business Time and Reliability Costs	125.5	77.68
Value of Personal Time and Reliability	126.88	78.67
Safety	137.41	85.57
Logistics/Freight Costs	14.59	9.12
Productivity from Access/Connectivity	0	0
Environmental Factors	12.77	7.68
Consumer Surplus and other Social Welfare	0	0

Costs	3% discount rate ($M)	7% discount rate ($M)
Capital Investment Costs	84.55	72.86
Operation and Maintenance Costs	0	0

	3% discount rate ($M)	7% discount rate ($M)
Benefit/Cost Ratio	**7.67**	**4.97**

Providence, Rhode Island: FASTLANES application for the 6-10 Interchange Project

This summarizes many of the key assumptions of the economic analysis for this project. The project includes the redesign of a system to system freeway interchange. Existing bridges are structurally deficient. This would improve a southbound weave, connect NB 6 10 to WB 6, and generally modernize the design to include new safety features and ramp metering to improve operations.

In 2016 dollars, the baseline (rebuild what is already there to current design standards) would cost $500M. The project they want to build would cost $650M. This report is the output of a TREDIS Benefit Cost Analysis for the project. See also accompanying tabs that include the methodology for estimating total Trips, VMT, VHT, Pct Congested, Safety improvements, and other key inputs to the analysis.

BENEFIT-COST RESULTS - BY YEAR (STUDY AREA PERSPECTIVE); DISCOUNT RATE: 3%
Project's Impact on Travel Characteristics (Project - Base)

Data Year	Vehicle Trips	Vehicle Miles(VMT)	Vehicle Hours(VHT)	PassengerTrips	PassengerMiles	PassengerHours	Freight USTons Trips	Freight USTon Miles	Freight USTon Hours
2020	0	0	580,000	0	0	881,600	0	0	697,450
2021	0	0	581,484	0	0	883,856	0	0	699,235
2022	0	0	582,971	0	0	886,116	0	0	701,023
2023	0	0	584,459	0	0	888,377	0	0	702,812
2024	0	0	585,948	0	0	890,642	0	0	704,603
2025	0	0	587,440	0	0	892,909	0	0	706,397
2026	0	0	588,933	0	0	895,178	0	0	708,192
2027	0	0	590,427	0	0	897,450	0	0	709,989
2028	0	0	591,924	0	0	899,724	0	0	711,788
2029	0	0	593,422	0	0	902,001	0	0	713,589
2030	0	0	594,921	0	0	904,280	0	0	715,393
2031	0	0	596,422	0	0	906,562	0	0	717,198
2032	0	0	597,925	0	0	908,846	0	0	719,004
2033	0	0	599,429	0	0	911,132	0	0	720,813
2034	0	0	600,934	0	0	913,420	0	0	722,624
2035	0	0	602,442	0	0	915,712	0	0	724,436
2036	0	0	603,951	0	0	918,005	0	0	726,251
2037	0	0	605,461	0	0	920,300	0	0	728,066
2038	0	0	606,972	0	0	922,598	0	0	729,884
2039	0	0	608,486	0	0	924,898	0	0	731,704
2040	0	0	610,000	0	0	927,200	0	0	733,525

Value of Benefit Stream ($M 2016 Const Dollars) – Undiscounted and Discounted

Data Year	Vehicle Operating Costs	Business Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus	(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits (Undiscounted)	Total Benefits (3% Discount)
2020	8.21	8.17	8.35	9.29	0	1.01	0	0.68	35.71	31.73
2021	8.23	8.23	8.42	9.34	0	1.01	0	0.69	35.92	30.98
2022	8.26	8.31	8.48	9.4	0	1.02	0	0.72	36.19	30.31
2023	8.27	8.38	8.55	9.45	0	1.02	0	0.74	36.41	29.6
2024	8.3	8.47	8.62	9.5	0	1.02	0	0.77	36.68	28.96
2025	8.31	8.54	8.69	9.54	0	1.02	0	0.79	36.89	28.27
2026	8.34	8.63	8.76	9.59	0	1.03	0	0.81	37.16	27.65
2027	8.36	8.7	8.83	9.64	0	1.03	0	0.83	37.39	27.01
2028	8.38	8.8	8.9	9.69	0	1.03	0	0.87	37.67	26.42
2029	8.4	8.88	8.98	9.74	0	1.03	0	0.89	37.92	25.82
2030	8.42	8.96	9.06	9.79	0	1.04	0	0.92	38.19	25.25
2031	8.44	9.05	9.13	9.84	0	1.04	0	0.95	38.45	24.68
2032	8.46	9.13	9.21	9.89	0	1.04	0	0.97	38.7	24.12
2033	8.49	9.23	9.29	9.94	0	1.05	0	1.01	39.01	23.6
2034	8.5	9.32	9.37	9.99	0	1.05	0	1.04	39.27	23.07
2035	8.53	9.42	9.45	10.05	0	1.05	0	1.07	39.57	22.57
2036	8.55	9.52	9.53	10.1	0	1.05	0	1.11	39.86	22.07
2037	8.57	9.62	9.62	10.15	0	1.06	0	1.14	40.16	21.59
2038	8.59	9.71	9.7	10.2	0	1.06	0	1.18	40.44	21.11
2039	8.62	9.81	9.79	10.25	0	1.06	0	1.22	40.75	20.65
2040	8.63	9.91	9.88	10.31	0	1.06	0	1.25	41.04	20.19

Project's Net Benefits ($M 2016 Const Dollars) – Undiscounted and Discounted

Data Year	Startup Costs	O&M Costs	Residual Value	Total Costs (Undiscounted)	Total Costs (3% Discount)	Total Benefits (Undiscounted)	Total Benefits (3% Discount)	Net Total Benefits (Undiscounted)	Net Total Benefits (3% Discount)
2017	0	0	0	0	0	0	0	0	0
2018	10	0	0	10	9.43	0	0	-10	-9.43
2019	22	0	0	22	20.13	0	0	-22	-20.13
2020	25	0	0	25	22.21	35.71	31.73	10.71	9.52
2021	38	0	0	38	32.78	35.92	30.98	-2.08	-1.79
2022	0	0	0	0	0	36.19	30.31	36.19	30.31
2023	0	0	0	0	0	36.41	29.6	36.41	29.6
2024	0	0	0	0	0	36.68	28.96	36.68	28.96
2025	0	0	0	0	0	36.89	28.27	36.89	28.27
2026	0	0	0	0	0	37.16	27.65	37.16	27.65
2027	0	0	0	0	0	37.39	27.01	37.39	27.01
2028	0	0	0	0	0	37.67	26.42	37.67	26.42
2029	0	0	0	0	0	37.92	25.82	37.92	25.82
2030	0	0	0	0	0	38.19	25.25	38.19	25.25
2031	0	0	0	0	0	38.45	24.68	38.45	24.68
2032	0	0	0	0	0	38.7	24.12	38.7	24.12
2033	0	0	0	0	0	39.01	23.6	39.01	23.6
2034	0	0	0	0	0	39.27	23.07	39.27	23.07
2035	0	0	0	0	0	39.57	22.57	39.57	22.57
2036	0	0	0	0	0	39.86	22.07	39.86	22.07
2037	0	0	0	0	0	40.16	21.59	40.16	21.59
2038	0	0	0	0	0	40.44	21.11	40.44	21.11
2039	0	0	0	0	0	40.75	20.65	40.75	20.65
2040	0	0	-30	-30	-14.76	41.04	20.19	41.04	20.19

BENEFIT-COST RESULTS - BY YEAR (STUDY AREA PERSPECTIVE); DISCOUNT RATE: 7%
Value of Benefit Stream ($M 2016 Const Dollars) – Undiscounted and Discounted

Data Year	Vehicle Operating Costs	Business Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus	(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)	Total Benefits (Undiscounted)	Total Benefits (7% Discount)
2020	8.21	8.17	8.35	9.29	0	1.01	0	0.68	35.71	27.24
2021	8.23	8.23	8.42	9.34	0	1.01	0	0.69	35.92	25.61
2022	8.26	8.31	8.48	9.4	0	1.02	0	0.72	36.19	24.11
2023	8.27	8.38	8.55	9.45	0	1.02	0	0.74	36.41	22.67
2024	8.3	8.47	8.62	9.5	0	1.02	0	0.77	36.68	21.35
2025	8.31	8.54	8.69	9.54	0	1.02	0	0.79	36.89	20.07
2026	8.34	8.63	8.76	9.59	0	1.03	0	0.81	37.16	18.89
2027	8.36	8.7	8.83	9.64	0	1.03	0	0.83	37.39	17.76
2028	8.38	8.8	8.9	9.69	0	1.03	0	0.87	37.67	16.73
2029	8.4	8.88	8.98	9.74	0	1.03	0	0.89	37.92	15.74
2030	8.42	8.96	9.06	9.79	0	1.04	0	0.92	38.19	14.81
2031	8.44	9.05	9.13	9.84	0	1.04	0	0.95	38.45	13.94
2032	8.46	9.13	9.21	9.89	0	1.04	0	0.97	38.7	13.11
2033	8.49	9.23	9.29	9.94	0	1.05	0	1.01	39.01	12.35
2034	8.5	9.32	9.37	9.99	0	1.05	0	1.04	39.27	11.62
2035	8.53	9.42	9.45	10.05	0	1.05	0	1.07	39.57	10.94
2036	8.55	9.52	9.53	10.1	0	1.05	0	1.11	39.86	10.3
2037	8.57	9.62	9.62	10.15	0	1.06	0	1.14	40.16	9.7
2038	8.59	9.71	9.7	10.2	0	1.06	0	1.18	40.44	9.13
2039	8.62	9.81	9.79	10.25	0	1.06	0	1.22	40.75	8.6
2040	8.63	9.91	9.88	10.31	0	1.06	0	1.25	41.04	8.09

Project's Net Benefits ($M 2016 Const Dollars) – Undiscounted and Discounted

Data Year	Startup Costs	O&M Costs	Residual Value	Total Costs (Undiscounted)	Total Costs (7% Discount)	Total Benefits (Undiscounted)	Total Benefits (7% Discount)	Net Total Benefits (Undiscounted)	Net Total Benefits (7% Discount)
2017	0	0	0	0	0	0	0	0	0
2018	10	0	0	10	8.73	0	0	-10	-8.73
2019	22	0	0	22	17.96	0	0	-22	-17.96
2020	25	0	0	25	19.07	35.71	27.24	10.71	8.17
2021	38	0	0	38	27.09	35.92	25.61	-2.08	-1.48
2022	0	0	0	0	0	36.19	24.11	36.19	24.11
2023	0	0	0	0	0	36.41	22.67	36.41	22.67
2024	0	0	0	0	0	36.68	21.35	36.68	21.35
2025	0	0	0	0	0	36.89	20.07	36.89	20.07
2026	0	0	0	0	0	37.16	18.89	37.16	18.89
2027	0	0	0	0	0	37.39	17.76	37.39	17.76
2028	0	0	0	0	0	37.67	16.73	37.67	16.73
2029	0	0	0	0	0	37.92	15.74	37.92	15.74
2030	0	0	0	0	0	38.19	14.81	38.19	14.81
2031	0	0	0	0	0	38.45	13.94	38.45	13.94
2032	0	0	0	0	0	38.7	13.11	38.7	13.11
2033	0	0	0	0	0	39.01	12.35	39.01	12.35
2034	0	0	0	0	0	39.27	11.62	39.27	11.62
2035	0	0	0	0	0	39.57	10.94	39.57	10.94
2036	0	0	0	0	0	39.86	10.3	39.86	10.3
2037	0	0	0	0	0	40.16	9.7	40.16	9.7
2038	0	0	0	0	0	40.44	9.13	40.44	9.13
2039	0	0	0	0	0	40.75	8.6	40.75	8.6
2040	0	0	-30	-30	-5.91	41.04	8.09	41.04	8.09

BCA ASSUMPTIONS

Value of Time		Base	Project
Cost Per Passenger ($/hour)	All Trucks: Freight	0	0
	Passenger Car: All	11.85	11.85
Buffer Time Cost ($/hour)	All Trucks: Freight	62.34	62.34
	Passenger Car: All	11.85	11.85
Cost Per Crew ($/hour)	All Trucks: Freight	26.89	26.89
	Passenger Car: All	0	0

Per Vehicle Cost Factors		Base	Project
Free Flow Conditions ($/mile)	All Trucks: Freight	1.08	1.08
	Passenger Car: All	0.31	0.31
Congested Conditions ($/mile)	All Trucks: Freight	1.33	1.33
	Passenger Car: All	0.33	0.33
Congested/Idle Conditions ($/hour)	All Trucks: Freight	62.01	62.01
	Passenger Car: All	11.64	11.64
Fatality ($/incident)	All Trucks: Freight	9,600,000	9,600,000
	Passenger Car: All	9,600,000	9,600,000
Personal Injury ($/incident)	All Trucks: Freight	174,030	174,030
	Passenger Car: All	174,030	174,030
Property Damage ($/incident)	All Trucks: Freight	4,198	4,198
	Passenger Car: All	4,198	4,198

Environmental Cost		Base	Project
Free Flow Conditions ($/mile)	All Trucks: Freight	0.15	0.15
	Passenger Car: All	0.01	0.01
Congested Conditions ($/mile)	All Trucks: Freight	0.21	0.21
	Passenger Car: All	0.01	0.01
Congested/Idle Conditions ($/hour)	All Trucks: Freight	0.62	0.62
	Passenger Car: All	0.03	0.03

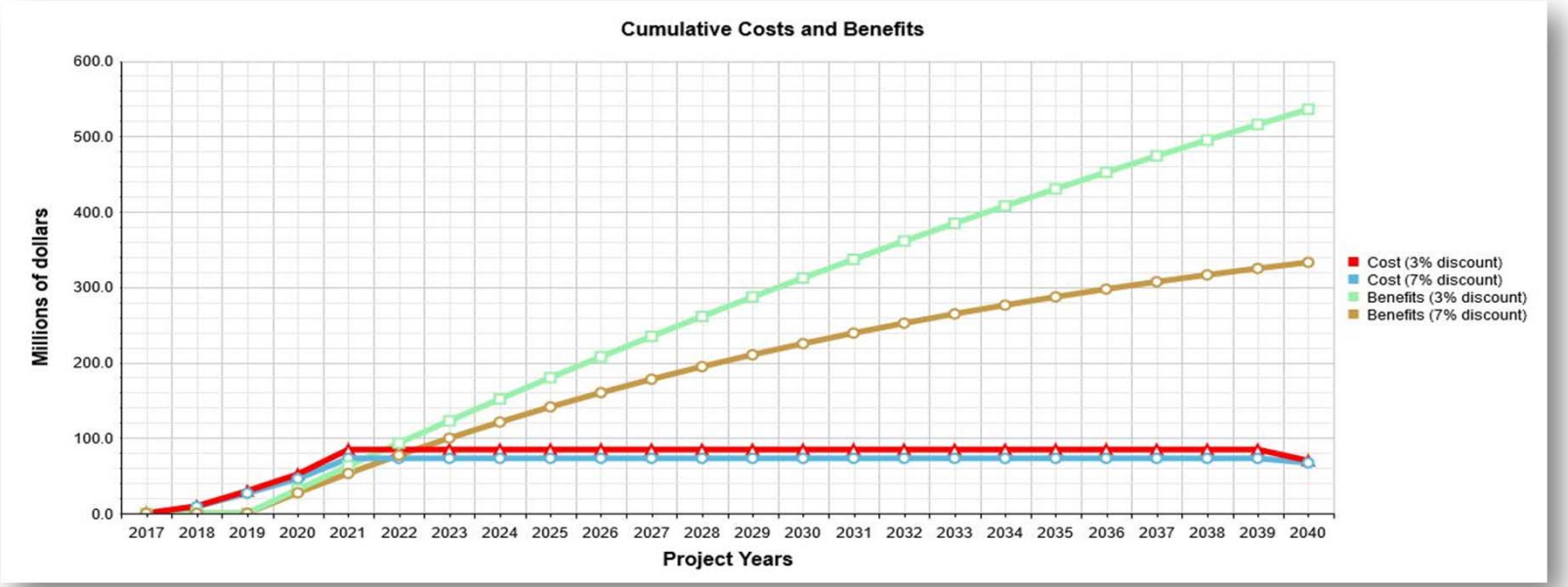
Travel Demand		Base	Project
Period Vehicle Trips	All Trucks: Freight	13,165,000	13,165,000
	Passenger Car: All	250,135,000	250,135,000
Period Vehicle Miles Traveled	All Trucks: Freight	32,865,000	32,865,000
	Passenger Car: All	624,435,000	624,435,000
Period Vehicle Hours Traveled	All Trucks: Freight	792,000	673,000
	Passenger Car: All	15,048,000	12,787,000
Fraction Congested	All Trucks: Freight	1.78	1.22
	Passenger Car: All	1.78	1.22
Buffer Time (hours/trip)	All Trucks: Freight	0.05	0.02
	Passenger Car: All	0.05	0.02
Avg Crew Members per Vehicle	All Trucks: Freight	1.1	1.1
	Passenger Car: All	0	0
Avg Vehicle Occupancy	All Trucks: Freight	0	0
	Passenger Car: All	1.6	1.6
Freight US Tons per Vehicle	All Trucks: Freight	24.05	24.05
	Passenger Car: All	0	0
Toll Charges per Trip	All Trucks: Freight	0	0
	Passenger Car: All	0	0
Fraction of Trips Internal	All Trucks: Freight	4	4
	Passenger Car: All	4	4
Fraction of Trips Incoming	All Trucks: Freight	0	0
	Passenger Car: All	0	0
Fraction of Trips Outgoing	All Trucks: Freight	0	0
	Passenger Car: All	0	0
Fraction of Trips Through	All Trucks: Freight	0	0
	Passenger Car: All	0	0

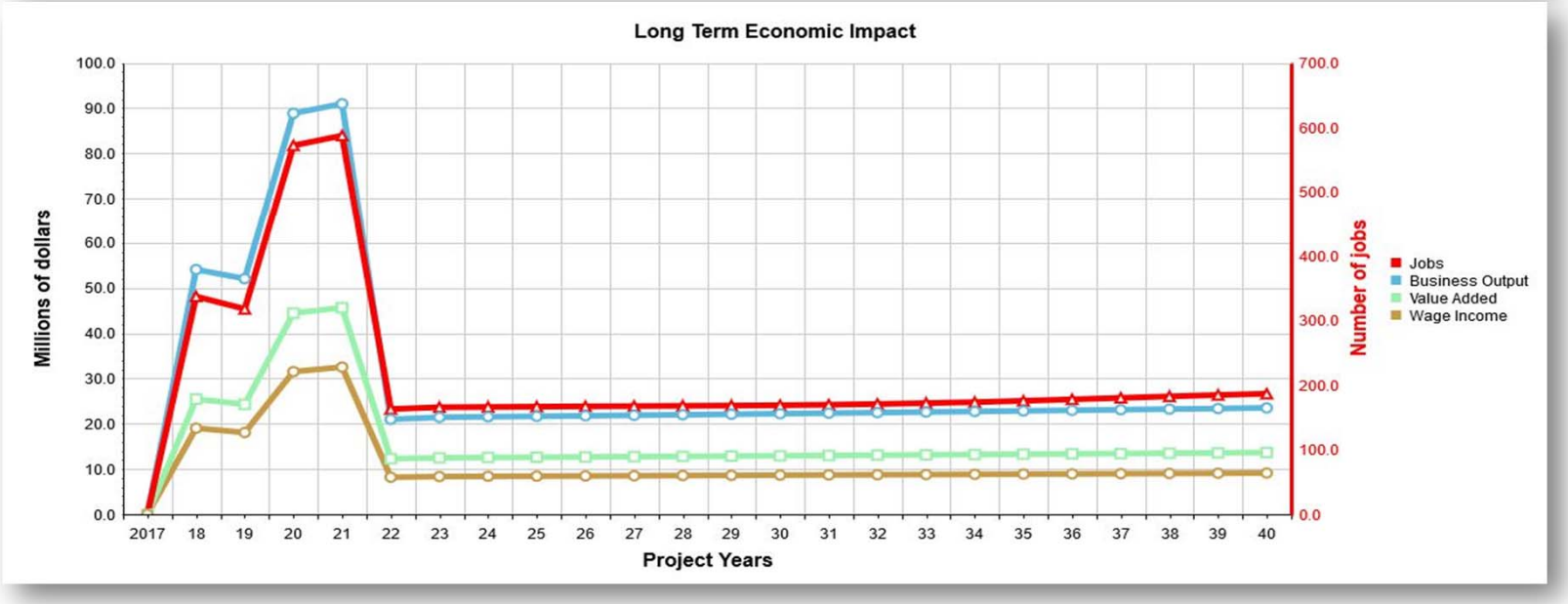
Startup Costs		Base	Project
Road ($m)	Property Acquisition	0	0
	Engineering and Design	50	55
	Right-of-Way (paving, rails)	0	0
	Transport Structures (bridges)	450	540
	Terminal Bldgs & Equipment	0	0
	Vehicles	0	0
Rail ($m)	Property Acquisition	0	0
	Engineering and Design	0	0
	Right-of-Way (paving, rails)	0	0
	Transport Structures (bridges)	0	0
	Terminal Bldgs & Equipment	0	0
	Vehicles	0	0
Air ($m)	Property Acquisition	0	0
	Engineering and Design	0	0
	Right-of-Way (paving, rails)	0	0
	Transport Structures (bridges)	0	0
	Terminal Bldgs & Equipment	0	0
	Vehicles	0	0
Marine ($m)	Property Acquisition	0	0
	Engineering and Design	0	0
	Right-of-Way (paving, rails)	0	0
	Transport Structures (bridges)	0	0
	Terminal Bldgs & Equipment	0	0
	Vehicles	0	0

Annual O & M Costs		Base	Project
Road ($m)	Ongoing Operations	1.9	1.9
	Maintenance & Rehabilitation	4.75	4.75
Rail ($m)	Ongoing Operations	0	0
	Maintenance & Rehabilitation	0	0
Air ($m)	Ongoing Operations	0	0
	Maintenance & Rehabilitation	0	0
Marine ($m)	Ongoing Operations	0	0
	Maintenance & Rehabilitation	0	0

Providence, Rhode Island: FASTLANES application for the 6-10 Interchange Project

This documents key inputs such as:
value of time,
operating costs per mile and per hour,
value of accident types,
environmental cost factors,
travel demand statistics (from other tabs herein)


Cumulative Costs and Benefits
Millions of dollars
600.0
500.0
400.0
300.0
200.0
100.0
0.0
2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Project Years
Cost (3% discount)
Cost (7% discount)
Benefits (3% discount)
Benefits (7% discount)


Long Term Economic Impact
Millions of dollars
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Number of jobs
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
2017 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Project Years
Jobs
Business Output
Value Added
Wage Income