TBEST: A Transit Service Planning Solution

Demonstration of Modeling Applications in NOVA Region

TRANSPORTATION PLANNING BOARD

TRAVEL FORECASTING SUBCOMMITTEE (TFS)

JULY 17, 2020

MATT CHENG – PROGRAM ANALYST

TBEST Overview

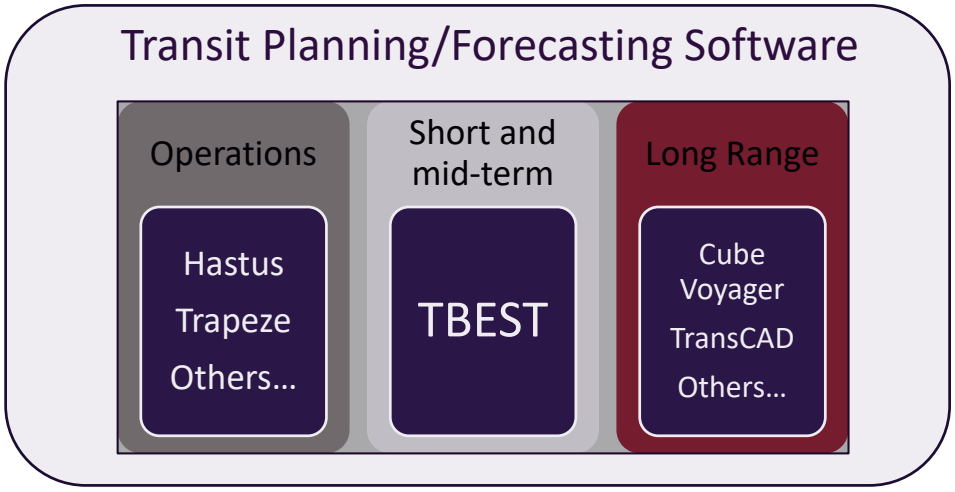
TBEST: Transit Boardings Estimation and Simulation Tool

- FDOT Objective: to provide a "comprehensive transit network modeling, management, and analysis software with a focus on short to mid-term transit planning available to all Florida transit agencies"
- Developed to support agencies' transit development plans (TDPs), via FDOT approved ridership estimation methodology
- A software solution for short-term transit service and strategic planning for local agencies
- Joint development with CUTR at University of South Florida

TBEST Overview

TBEST Planning Analysis Market

- Operational: Hastus, Trapeze, Clever, etc.
- Short- to Mid-Term: TBEST, Remix
- Long Range: Cube Voyager, TransCAD, etc.



TBEST Modeling Framework

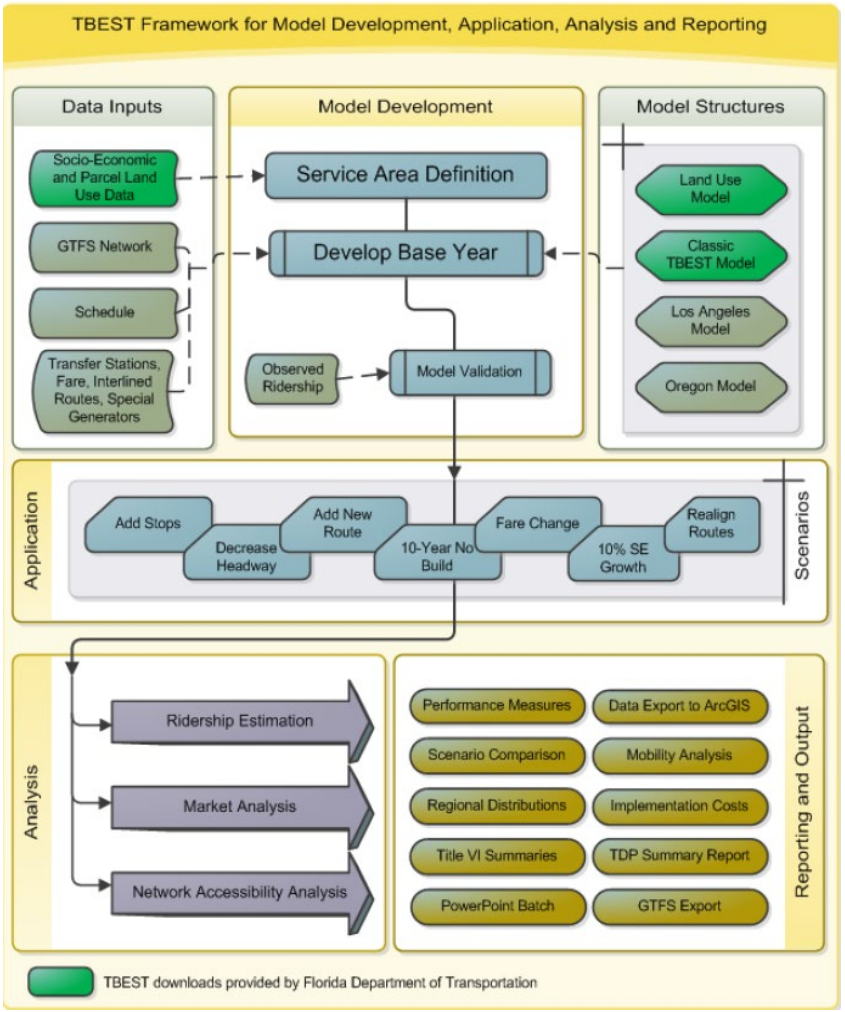
Data Inputs
- Socio-Economic (ACS, Census, TAZ EMP, Parcel Level)
- GTFS, Schedule, Stops, Special Generators

Model Structure
- TBEST Model, LA Model, NYDOT

Model Development
- Validation to Base Year Ridership

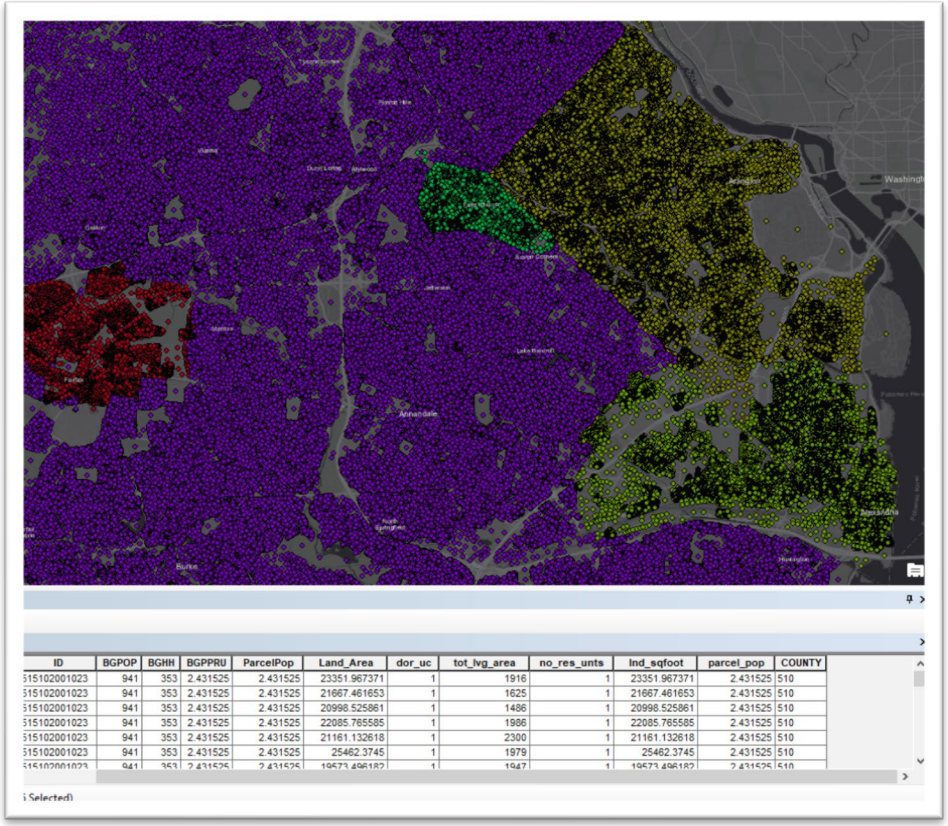
Application
- Service Changes/Network Redesign
- Socioeconomic Adjustments

Analysis
- Ridership Estimate
- Stop Level Demand Projection
- Market Analysis
- Network Accessibility



TBEST Data Requirements

- Socio-demographic: Census 2010 and ACS 2017
- Employment: InfoUSA, LEHD or TAZ
- Land Use: parcel land use data from jurisdictions
- Transit Network (GTFS, shapefiles, or otherwise: routes, stops, schedules, fare)
- Special generators and stop amenities
- Socioeconomic growth rates (system-wide or zonal growth)
- Observed ridership for validation (route level, stop level optional)



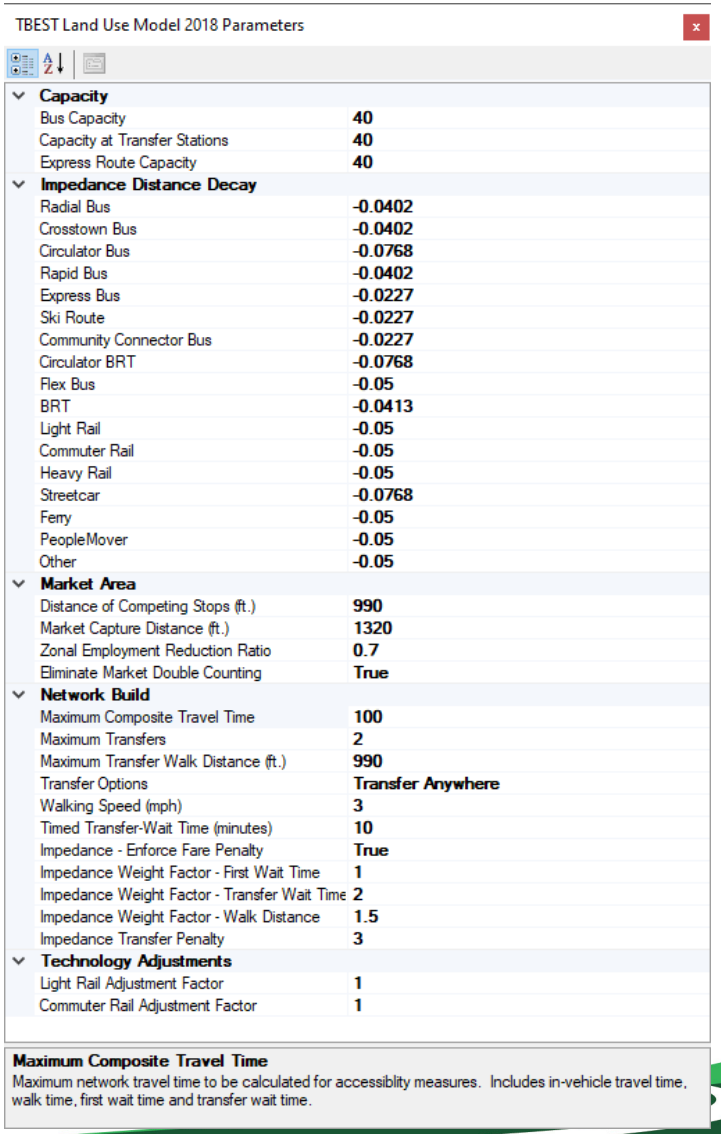
TBEST Modeling Framework

Forecasting Stop-Level Boardings

1. Direct and Transfer Boardings
   a. Discrete Equations for Direct/Transfer
2. Time of Day Based Analysis
   a. Coefficients differ based on temporal, demographic, technology factors and special generators
3. Spatial Accessibility
   a. Demographic buffer access
4. Time-Space Network Connectivity
   a. Activity opportunities measured by POP, EMP or parcel trip gen.
5. Competing and Complementary System Effects

$$D_n^s = g(C^s, A_{1n}^s, A_{2n}^s, A_{3n}^s, A_{4n}^s, X_n^s), n = 1, \dots, N$$

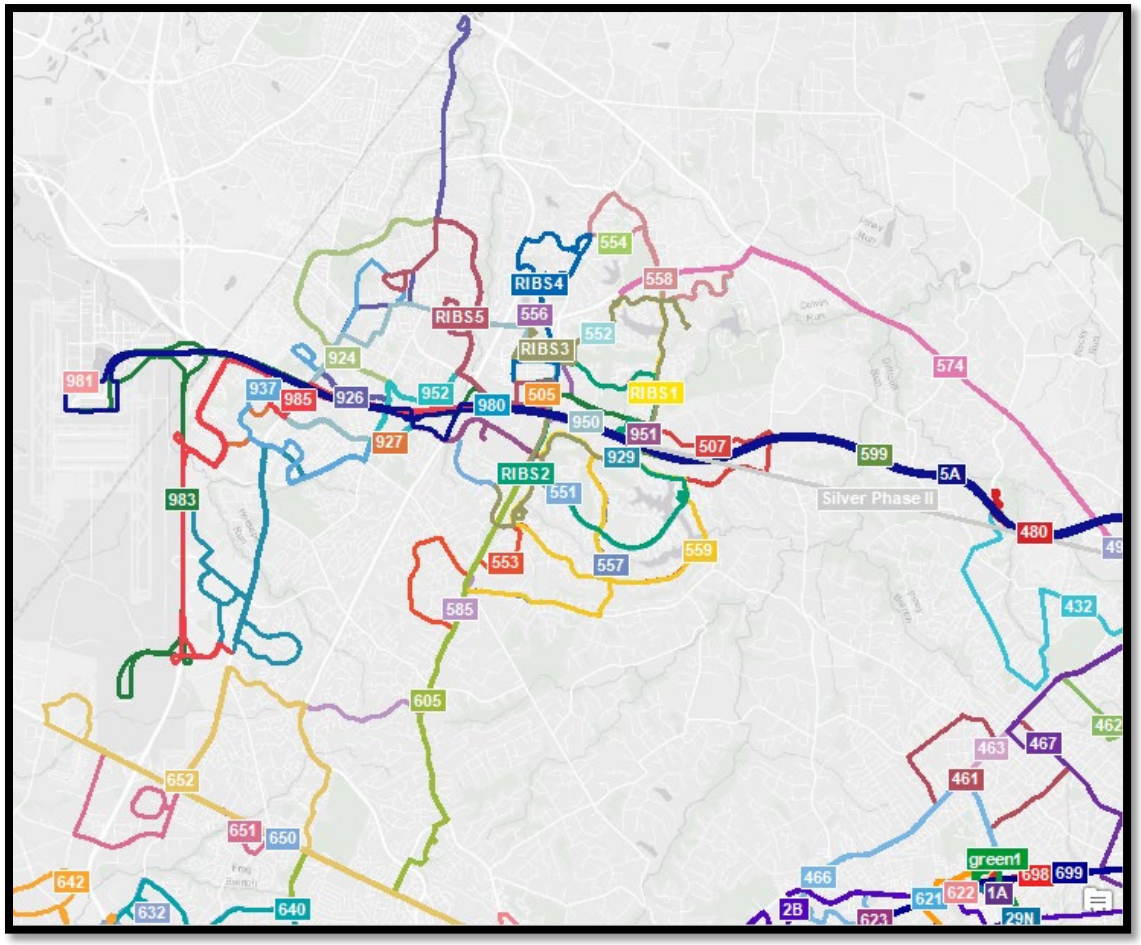
$$T_n^s = t(P_{0n}^s, A_{1n}^s, A_{2n}^s, A_{3n}^s, A_{4n}^s, Y_n^s), n = 1, \dots, N$$



NVTC Parcel Database

	Dept. of Revenue land-use code	PROPERTY TYPE	Property Type (Short)	Property Display Grouping	TRIP RATE FROM ITE TRIP GENERATION MANUAL		Key Parcel File Variable Used to Drive		ITE or Other Source Data						
									Vehicle Trips						
					Unit (Independent Variable)	Remarks	0=not relevant for transit, 1=Dwelling Units, 2=Building	Group Code, 1 = Residential, 2=Visitor-based non-residential, 3=Employee-based non-residential	Weekday Total	Weekday AM Peak Hour	Weekday PM Peak Hour	Calculated AM Peak Period	Calculated PM Peak Period	Saturday Total	Sunday Total
Residential		Vacant Residential	Vacant Residential	Residential	Dwelling Units		0	1	0	0	0	0	0	0	0
	1	Single Family	Single Family	Residential	Dwelling Units	ITE LU - 210	1	1	9.57	0.77	1.02	1.63	2.93	10.08	8.77
	2	Mobile Home	Mobile Home	Residential	Dwelling Units	ITE LU - 240	1	1	4.99	0.44	0.60	0.93	1.73	5.00	4.36
	4	Condominiums	Condominiums	Residential	Dwelling Units	ITE LU - 230	1	1	5.81	0.44	0.52	0.93	1.50	5.67	4.84
	5	Cooperatives	Cooperatives	Residential	Dwelling Units	ITE LU - 220	1	1	6.65	0.55	0.67	1.17	1.93	6.39	5.86
	3	Multi-family - 10 units or more	Multi-family >= 10 units	Residential	Dwelling Units	ITE LU - 221	1	1	6.59	0.51	0.62	1.08	1.78	7.16	6.07
	8	Multi-family - less than 10 units	Multi-family < 10 units	Residential	Dwelling Units	ITE LU - 222	1	1	4.20	0.34	0.40	0.72	1.15	4.98	3.65
	6	Retirement Homes	Retirement Homes	Residential	Dwelling Units	ITE LU - 251	1	1	3.71	0.29	0.34	0.61	0.98	2.77	2.33
	7	Miscellaneous Residential (migrant camps, boarding homes, etc.)	Miscellaneous Residential	Residential	Dwelling Units	average of 260 and 270	1	1	5.33	0.44	0.52	0.93	1.48	4.95	4.01
	10	Vacant Commercial	Vacant Commercial	Commercial	1000 Sq.ft GFA		0	3	0	0	0	0	0	0	0
	11	Stores, one story	Stores, one story	Commercial	1000 Sq.ft GFA		2	2	22.88	2.14	2.81	4.54	8.08	25.40	**28.44**
	12	Mixed use - store and office or store and residential or residential combination	Mixed use	Commercial	1000 Sq.ft GFA		2	2	17.23	1.97	2.27	4.18	6.53	**3.05**	**3.42**
	13	Department Stores	Department Stores	Commercial	1000 Sq.ft GFA		2	2	22.88	2.14	2.81	4.54	8.08	25.40	**28.44**
	14	Supermarkets	Supermarkets	Commercial	1000 Sq.ft GFA		2	2	102.24	10.05	11.85	21.31	34.08	177.59	166.44
	15	Regional Shopping Centers	Regional Shopping Centers	Commercial	1000 Sq.ft GFA		2	2	42.94	1.00	3.73	2.12	10.73	49.97	25.24
	16	Community Shopping Centers	Community Shopping Centers	Commercial	1000 Sq.ft GFA		2	2	42.94	1.00	3.73	2.12	10.73	49.97	25.24
	17	Office buildings, non-professional service buildings, one story	Office buildings one story	Commercial	1000 Sq.ft GFA		2	3	11.57	1.8	1.73	3.82	4.98	**2.05**	**2.30**
	18	Office buildings, non-professional service buildings, multi-story	Office buildings multi-story	Commercial			2	3	23.14	3.60	3.46	7.63	9.95	**4.10**	**4.60**
	19	Professional service buildings	Professional buildings	Commercial	1000 Sq.ft GFA		2	2	11.01	1.55	1.49	3.29	4.29	2.37	0.98
	20	Airports (private or commercial), Marine terminals, piers, marinas	Airports or Marinas	Commercial	1000 sq.ft	Non ITE Source	3	2	1.38	NA	NA	**0.23**	**0.34**	**0.25**	**0.2737**
	21	Restaurants, cafeterias	Restaurants	Commercial	1000 Sq.ft GFA		2	2	127.15	13.53	18.49	28.69	53.17	158.37	131.84
	22	Drive-in Restaurants	Drive-in Restaurants	Commercial	1000 Sq.ft GFA		2	2	496.12	54.81	46.14	116.21	132.69	722.03	542.72
	23	Financial institutions (banks, saving and loan companies, mortgage companies, credit services)	Financial institutions	Commercial	1000 Sq.ft GFA		2	2	148.15	17.31	26.69	36.70	76.76	86.32	31.90
	24	Insurance company offices	Insurance company offices	Commercial	1000 Sq.ft GFA		2	2	11.01	1.55	1.49	3.29	4.29	2.37	0.98
ial	25	Repair service shops (excluding automotive), radio and T.V. repair, refrigeration service, electric repair, laundries, Laundromats	Non-Automotive Repair shops	Commercial	1000 Sq.ft GFA		2	2	44.32	6.84	5.02	14.50	14.44	42.04	26.43

Model Application



Example

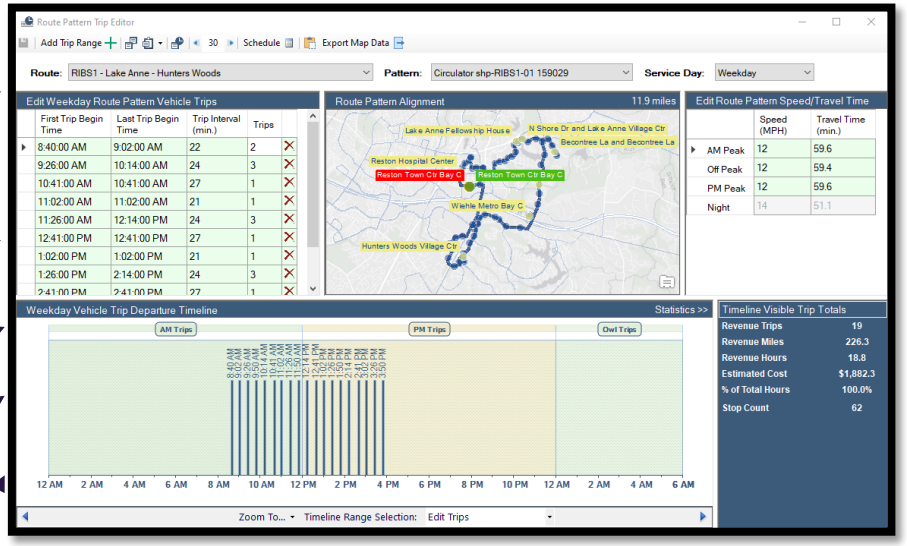
- Fairfax Connector Restructuring-- Silver Line Phase II
- Forecast Year 2020
- 33 Routes
- 87 Buses
- 1,163 Revenue Service Trips (WD)
- 5 Metrorail Stations
- 446,508 Population
- 683,485 Jobs

Model Application

GTFS_Alternative1.zip

		Weekday						
	Full Span	Early AM (4:00AM- Headway	AM Peak (6:00AM- Headway	Offpeak (9:00AM- Headway	PM Peak Headway	Night Headway	Late Night Headway	Total Weekday Trip
RIBS 1	5:08 AM-12:47 AM	60	25	20	25	25	60	41
RIBS 2	8:06 AM-10:04 PM		40	40	40	40	40	21
RIBS 3	5:08 AM-12:47 AM	60	25	20	25	25	60	41
			40	40	40	40	60	24

asmine Tew:
trip=1 way loop



Observed Ridership

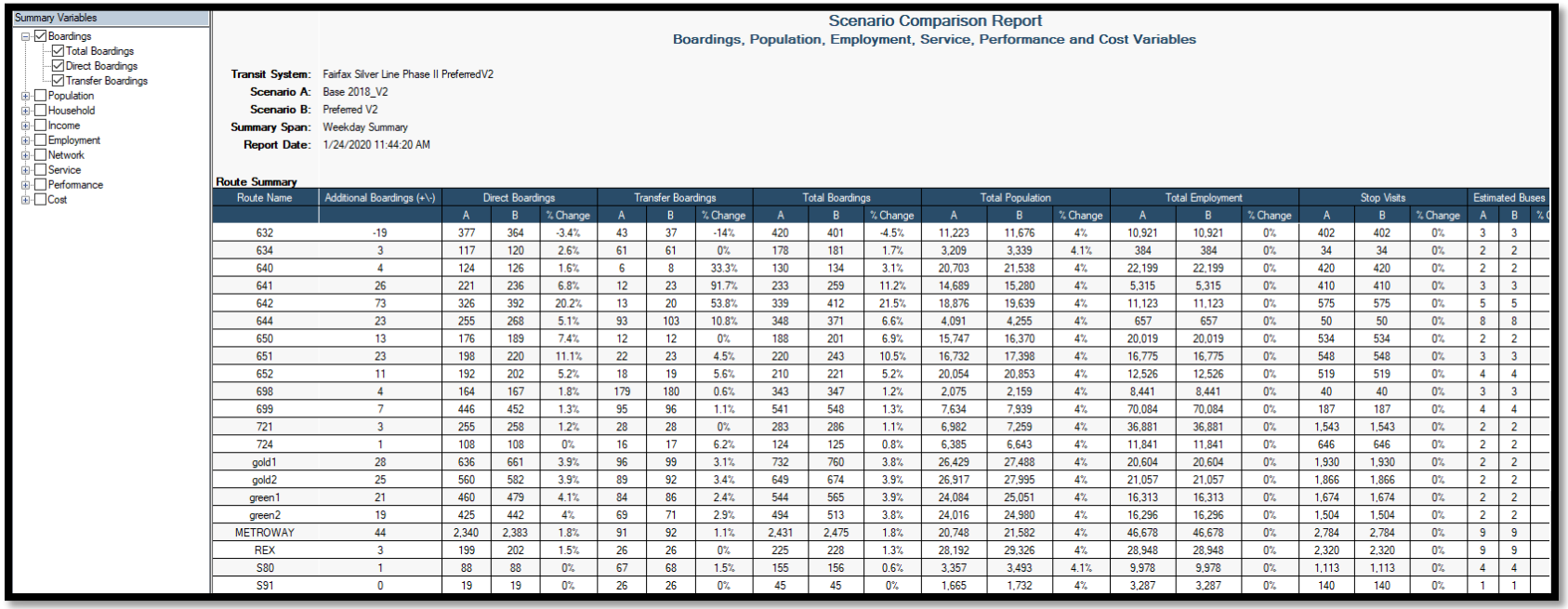
Fare Levels/Operating Costs

Socioeconomic Conditions/ Growth%

Base

1. Alternative Scenario
2. Alternative Scenario
3. Alternative Scenario

TBEST Model Outputs



Summary Variables
- Boardings
  - Total Boardings
  - Direct Boardings
  - Transfer Boardings
- Population
- Household
- Income
- Employment
- Network
- Service
- Performance
- Cost

Scenario Comparison Report
Boardings, Population, Employment, Service, Performance and Cost Variables

Transit System: Fairfax Silver Line Phase II PreferredV2
Scenario A: Base 2018_V2
Scenario B: Preferred V2
Summary Span: Weekday Summary
Report Date: 1/24/2020 11:44:20 AM

Route Summary

Route Name	Additional Boardings (+\-)	Direct Boardings			Transfer Boardings			Total Boardings			Total Population			Total Employment			Stop Visits			Estimated Buses		
		A	B	% Change	A	B	% Change	A	B	% Change	A	B	% Change	A	B	% Change	A	B	% Change	A	B	%
632	-19	377	364	-3.4%	43	37	-14%	420	401	-4.5%	11,223	11,676	4%	10,921	10,921	0%	402	402	0%	3	3	
634	3	117	120	2.6%	61	61	0%	178	181	1.7%	3,209	3,339	4.1%	384	384	0%	34	34	0%	2	2	
640	4	124	126	1.6%	6	8	33.3%	130	134	3.1%	20,703	21,538	4%	22,199	22,199	0%	420	420	0%	2	2	
641	26	221	236	6.8%	12	23	91.7%	233	259	11.2%	14,689	15,280	4%	5,315	5,315	0%	410	410	0%	3	3	
642	73	326	392	20.2%	13	20	53.8%	339	412	21.5%	18,876	19,639	4%	11,123	11,123	0%	575	575	0%	5	5	
644	23	255	268	5.1%	93	103	10.8%	348	371	6.6%	4,091	4,255	4%	657	657	0%	50	50	0%	8	8	
650	13	176	189	7.4%	12	12	0%	188	201	6.9%	15,747	16,370	4%	20,019	20,019	0%	534	534	0%	2	2	
651	23	198	220	11.1%	22	23	4.5%	220	243	10.5%	16,732	17,398	4%	16,775	16,775	0%	548	548	0%	3	3	
652	11	192	202	5.2%	18	19	5.6%	210	221	5.2%	20,054	20,853	4%	12,526	12,526	0%	519	519	0%	4	4	
698	4	164	167	1.8%	179	180	0.6%	343	347	1.2%	2,075	2,159	4%	8,441	8,441	0%	40	40	0%	3	3	
699	7	446	452	1.3%	95	96	1.1%	541	548	1.3%	7,634	7,939	4%	70,084	70,084	0%	187	187	0%	4	4	
721	3	255	258	1.2%	28	28	0%	283	286	1.1%	6,982	7,259	4%	36,881	36,881	0%	1,543	1,543	0%	2	2	
724	1	108	108	0%	16	17	6.2%	124	125	0.8%	6,385	6,643	4%	11,841	11,841	0%	646	646	0%	2	2	
gold1	28	636	661	3.9%	96	99	3.1%	732	760	3.8%	26,429	27,488	4%	20,604	20,604	0%	1,930	1,930	0%	2	2	
gold2	25	560	582	3.9%	89	92	3.4%	649	674	3.9%	26,917	27,995	4%	21,057	21,057	0%	1,866	1,866	0%	2	2	
green1	21	460	479	4.1%	84	86	2.4%	544	565	3.9%	24,084	25,051	4%	16,313	16,313	0%	1,674	1,674	0%	2	2	
green2	19	425	442	4%	69	71	2.9%	494	513	3.8%	24,016	24,980	4%	16,296	16,296	0%	1,504	1,504	0%	2	2	
METROWAY	44	2,340	2,383	1.8%	91	92	1.1%	2,431	2,475	1.8%	20,748	21,582	4%	46,678	46,678	0%	2,784	2,784	0%	9	9	
REX	3	199	202	1.5%	26	26	0%	225	228	1.3%	28,192	29,326	4%	28,948	28,948	0%	2,320	2,320	0%	9	9	
S80	1	88	88	0%	67	68	1.5%	155	156	0.6%	3,357	3,493	4.1%	9,978	9,978	0%	1,113	1,113	0%	4	4	
S91	0	19	19	0%	26	26	0%	45	45	0%	1,665	1,732	4%	3,287	3,287	0%	140	140	0%	1	1	

Summary Report

- Boardings (Direct, Transfer)
- Market Population, Employment, Demographic, Income
- Performance (Boardings per Service Hour, Avg Boardings per Stop Visit etc.)
- Cost (Total Route Cost, Cost per Passenger Trip)

TBEST Model Outputs

Population

Route Summary

Route Name	Total Boardings	Total Population	Black	Female	Foreign Born	Hispanic	Over 65	Under 18	Poverty Population	Working Population	Population in Multi-Family DU
505	616	4,880	238	2,503	1,185	230	911	596	267	3,013	2,233
507	159	2,323	110	1,338	365	238	460	413	79	1,412	316
551	859	16,955	2,979	8,719	5,389	3,470	2,079	3,557	1,507	10,021	2,692
552	129	11,814	1,385	6,087	3,217	1,461	1,787	2,327	1,408	6,703	2,744
553	113	14,045	1,224	7,368	2,743	1,286	2,217	2,843	690	7,970	1,138
554	121	9,446	831	5,061	2,046	931	1,301	1,759	724	5,259	1,652

Household

Route Summary

Route Name	Total Boardings	Median HH Income	Avg Household Income	Per Capita Income
505	616	$143,982	$175,414	$100,991
507	159	$142,019	$160,860	$70,193
551	859	$97,366	$118,297	$49,344
552	129	$107,943	$127,209	$53,557
553	113	$139,563	$158,614	$60,766
554	121	$127,827	$148,121	$62,823

Performance

Route Summary

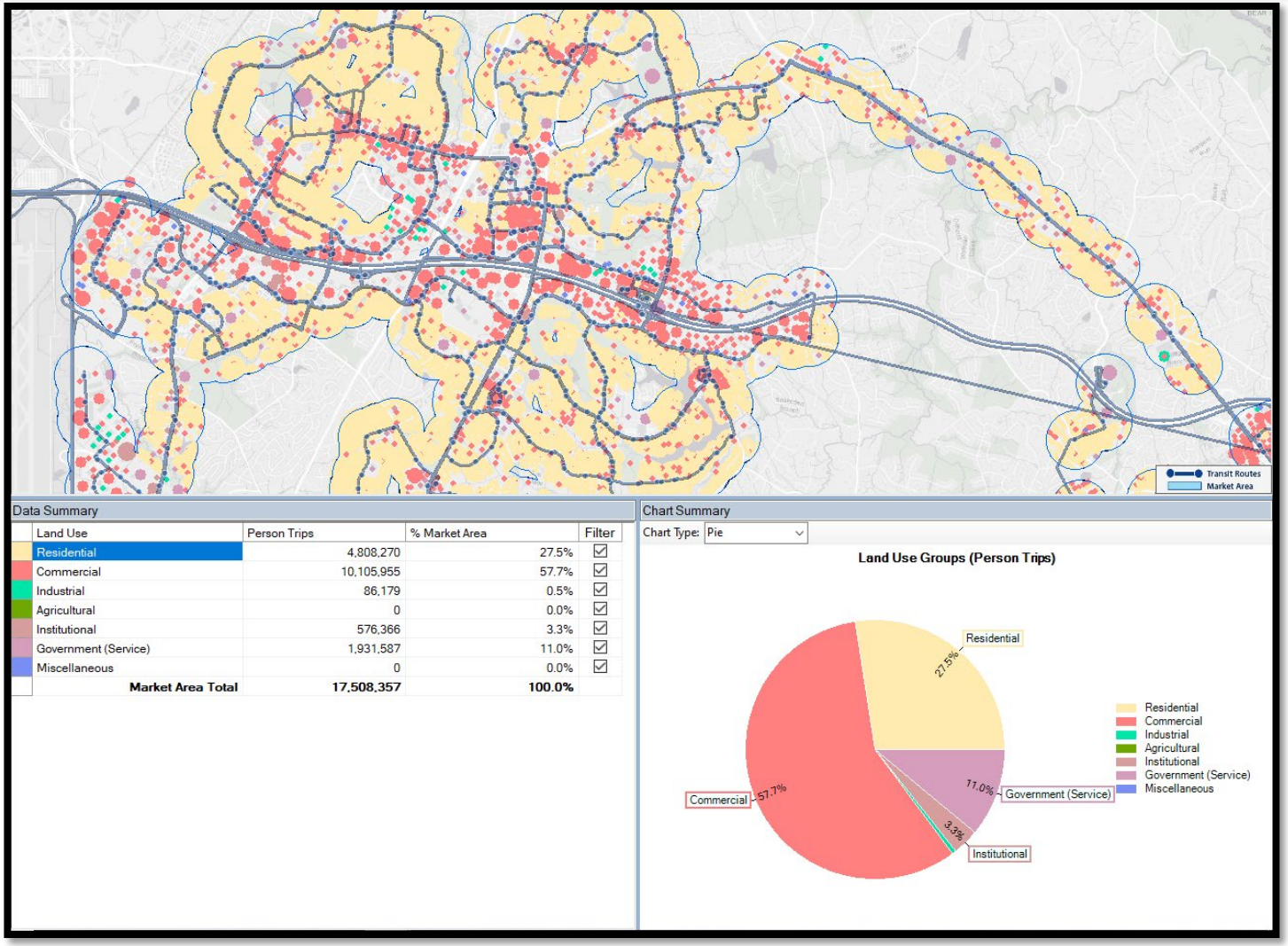
Route Name	Total Boardings	Boardings Per Service Hour	Boardings Per Service Mile	Boardings Per Service Trip	Avg Boardings Per Stop Visit
505	616	40.6	2.7	5.5	0.6
507	159	13.3	0.9	3.8	0.2
551	859	21.4	1.4	9.2	0.3
552	129	16.3	1.1	5.4	0.2
553	113	9.1	0.6	5.4	0.1

Service

Route Summary

Route Name	Total Boardings	Stop Visits	Estimated Buses	Headway	Service Span (Hours)	Speed (MPH)	Round Trip Travel Time (min)	Revenue Service Trips	Revenue Service Miles	Revenue Service Hours
505	616	998	2	21	20	15	16	111	228.1	15.2
507	159	756	1	24	16.8	15	17	42	179.2	12
551	859	3,023	3	25	20.5	15.1	51.5	93	605.5	40.2
552	129	733	3	18	7.3	15	40	24	119	7.9
553	113	823	4	18	7	14.5	71	21	179.7	12.4

TBEST Model Outputs



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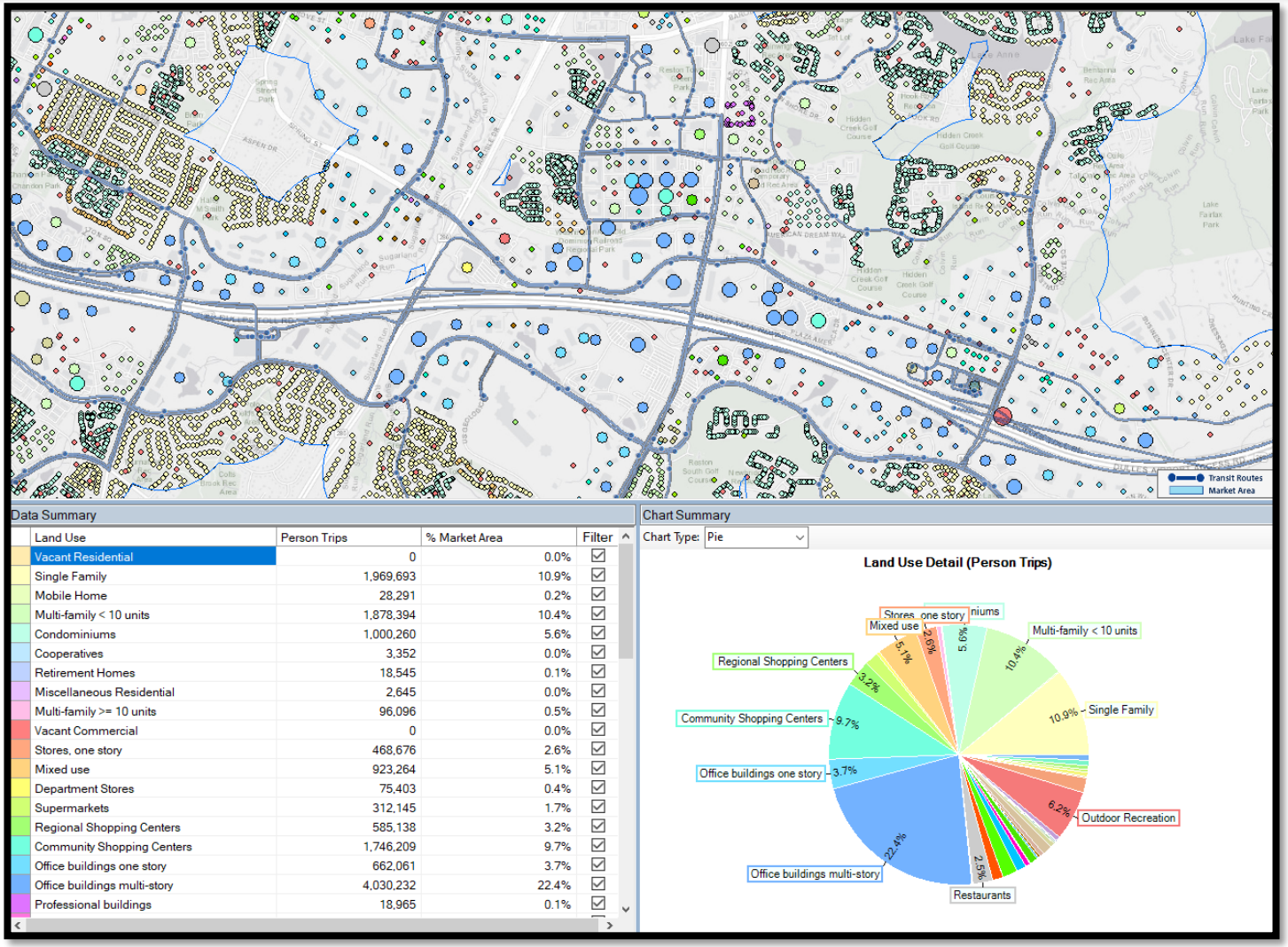

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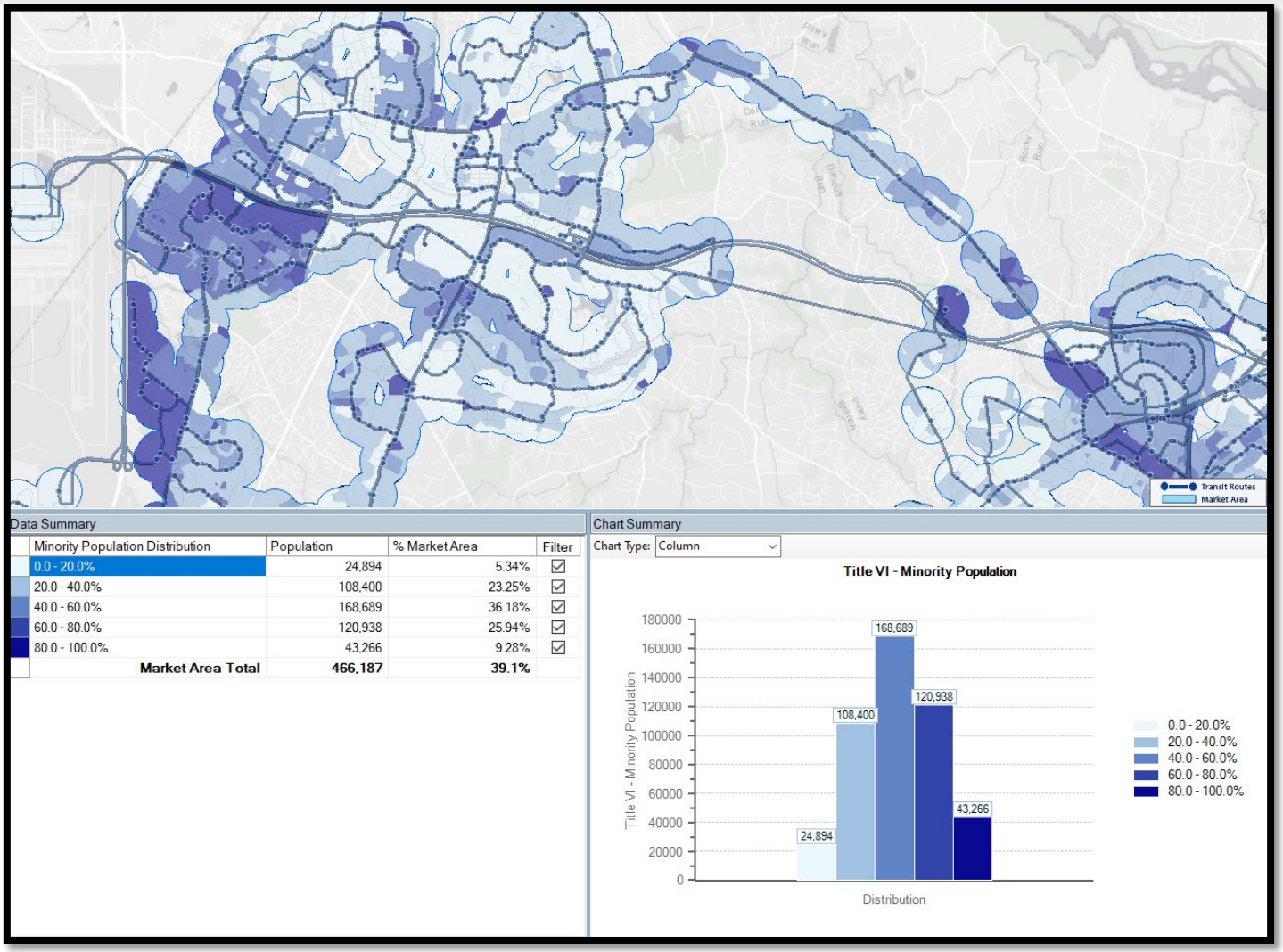


TBEST Analysis Example

Scenarios	Parameters
Base	Current Service
Preferred Alternative	Route Realignment & Service Change

Route Name	Route 951	
Model Run	Base	Preferred
Direct Boardings	99	498
Transfer Boardings	27	66
Total Boardings	126	564
Boardings Per Service Hour	17.2	18
Boardings Per Service Trip	4.7	15.6
Population	3,861	33,717
Employment	20,319	34,861
Estimated Buses	2	6
Average Headway	30	20
Average Speed	15	15

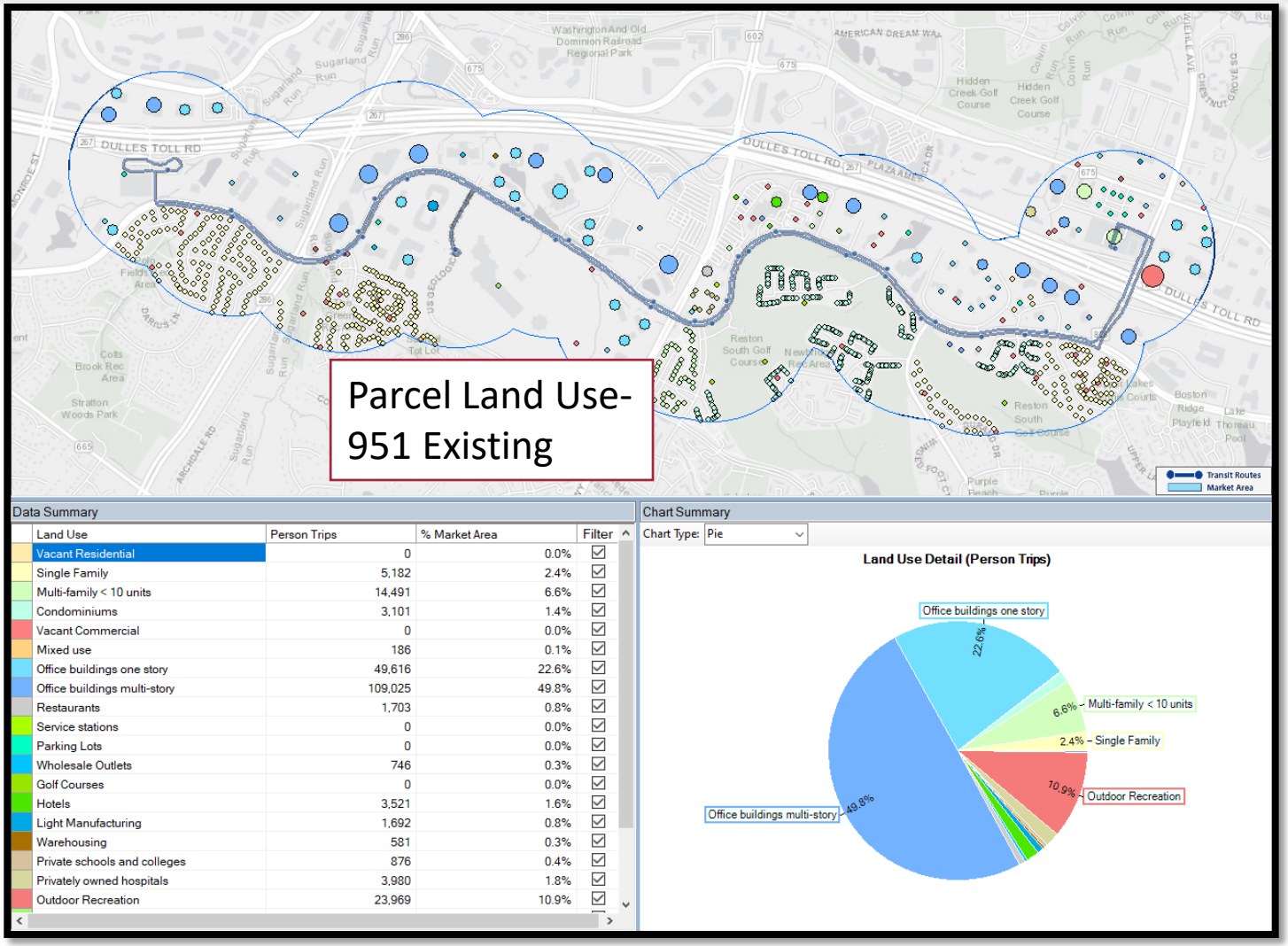
347% Increase in Total Boardings

TBEST Analysis Example

Scenarios	Parameters
Base	Current Service
Preferred Alternative	Route Realignment & Service Change

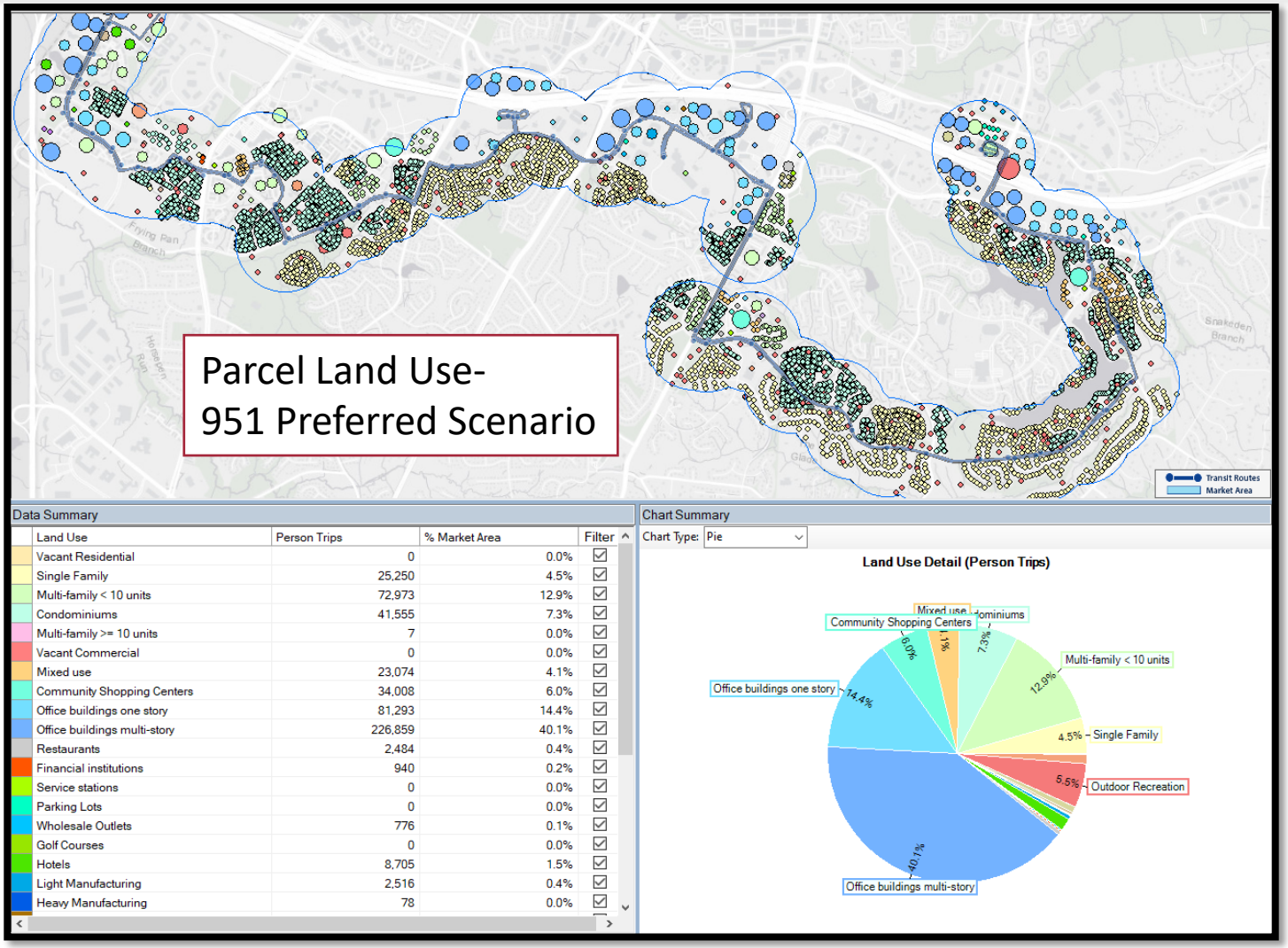
Route Name	Route 951	
Model Run	Base	Preferred
Total Boardings	126	564
Poverty Pop.	240	1,573
Working Pop.	2,358	19,428
Zero Vehicle Households	42	585
Avg Household Income	$134,821	$137,268
Households w/Children/Dependent	378	4,496
Commercial Employment	18,532	30,864
Revenue Hours	7.3	31.2
Route Cost	$730	$3,120
Cost Per Passenger Trip	$5.8	$5.5

TBEST Analysis Example



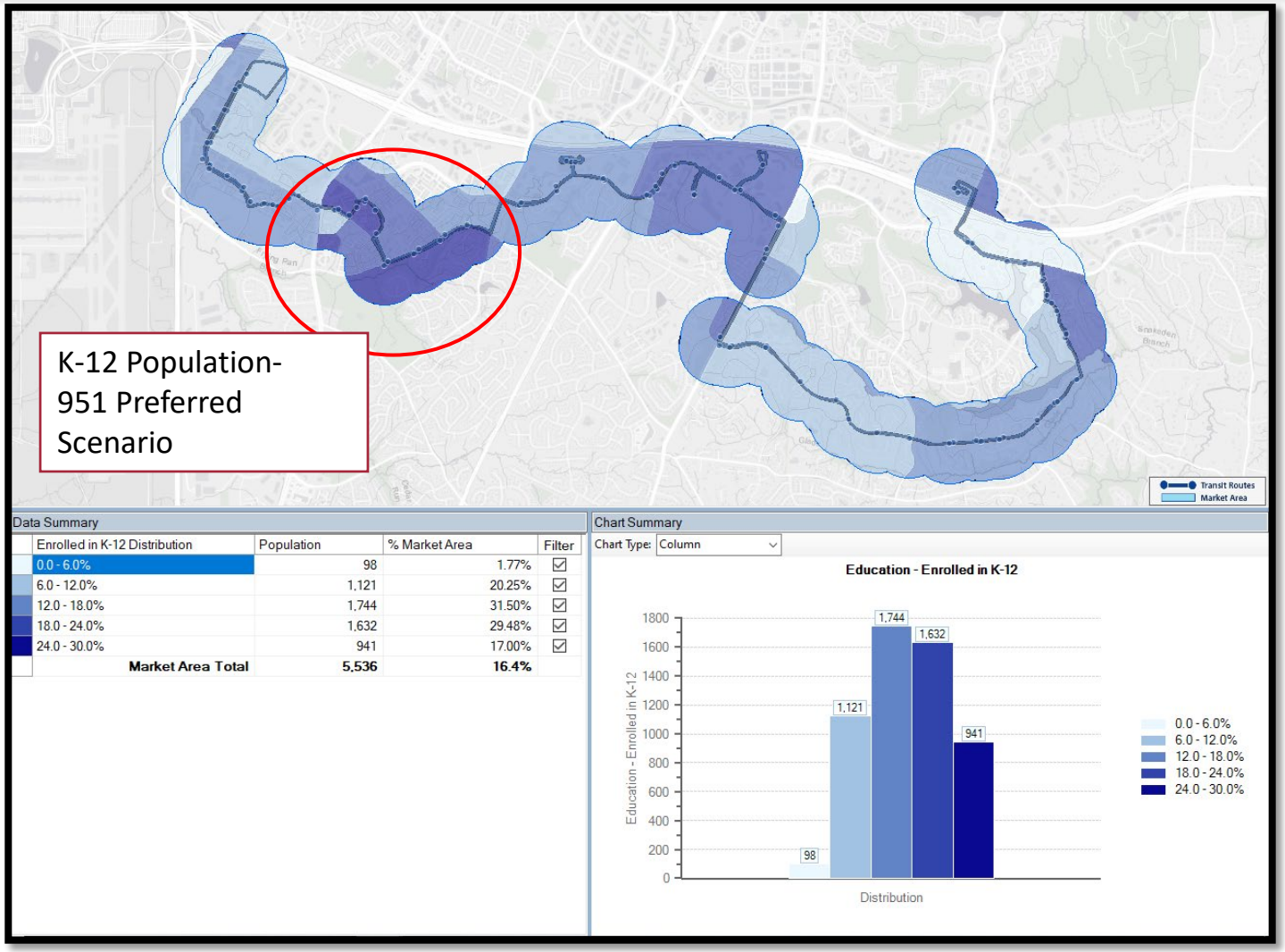
Land Use	Person Trips	% Market Area	Filter
Vacant Residential	0	0.0%	☑
Single Family	5,182	2.4%	☑
Multi-family < 10 units	14,491	6.6%	☑
Condominiums	3,101	1.4%	☑
Vacant Commercial	0	0.0%	☑
Mixed use	186	0.1%	☑
Office buildings one story	49,616	22.6%	☑
Office buildings multi-story	109,025	49.8%	☑
Restaurants	1,703	0.8%	☑
Service stations	0	0.0%	☑
Parking Lots	0	0.0%	☑
Wholesale Outlets	746	0.3%	☑
Golf Courses	0	0.0%	☑
Hotels	3,521	1.6%	☑
Light Manufacturing	1,692	0.8%	☑
Warehousing	581	0.3%	☑
Private schools and colleges	876	0.4%	☑
Privately owned hospitals	3,980	1.8%	☑
Outdoor Recreation	23,969	10.9%	☑

TBEST Analysis Example



Land Use	Person Trips	% Market Area	Filter
Vacant Residential	0	0.0%	☑
Single Family	25,250	4.5%	☑
Multi-family < 10 units	72,973	12.9%	☑
Condominiums	41,555	7.3%	☑
Multi-family >= 10 units	7	0.0%	☑
Vacant Commercial	0	0.0%	☑
Mixed use	23,074	4.1%	☑
Community Shopping Centers	34,008	6.0%	☑
Office buildings one story	81,293	14.4%	☑
Office buildings multi-story	226,859	40.1%	☑
Restaurants	2,484	0.4%	☑
Financial institutions	940	0.2%	☑
Service stations	0	0.0%	☑
Parking Lots	0	0.0%	☑
Wholesale Outlets	776	0.1%	☑
Golf Courses	0	0.0%	☑
Hotels	8,705	1.5%	☑
Light Manufacturing	2,516	0.4%	☑
Heavy Manufacturing	78	0.0%	☑

TBEST Analysis Example



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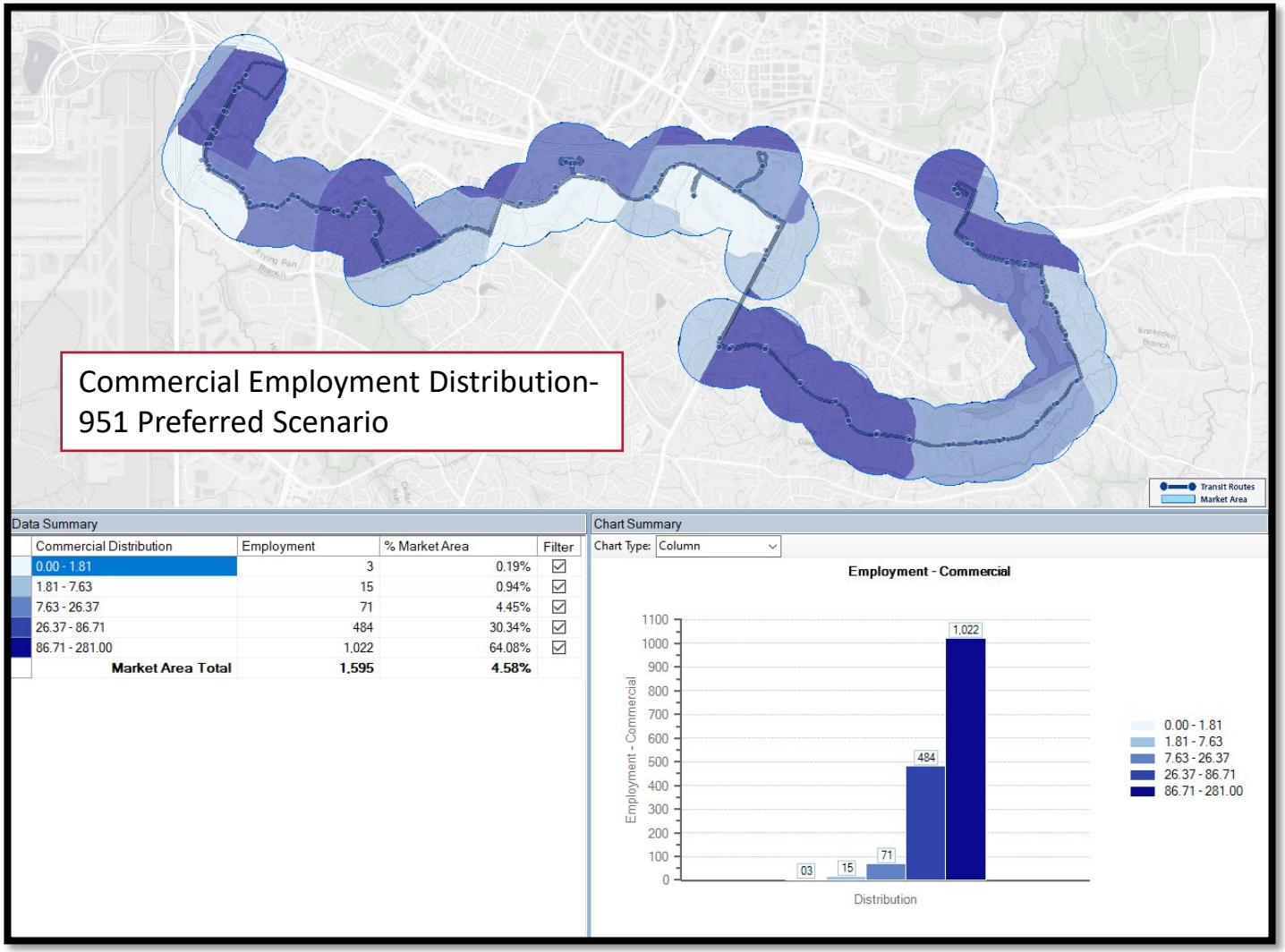

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Base	Current Service
Preferred Alternative	Route Realignment & Service Change
Preferred Plus Alternative	"Wishlist" Network

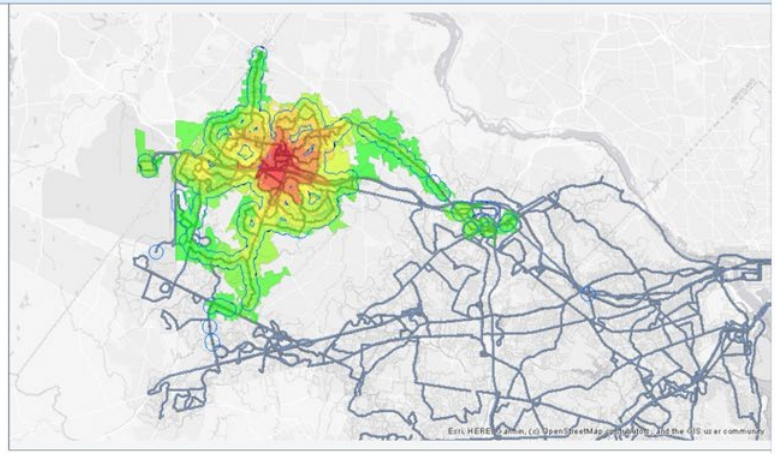
Route Name	Route 951		
Model Run	Base	Preferred	Pref. Plus
Direct Boardings	99	498	963
Transfer Boardings	27	66	112
Total Boardings	126	564	1,075
Boardings Per Service Hour	17.2	18	17.2
Boardings Per Service Trip	4.7	15.6	18.5
Population	3,861	33,717	34,849
Employment	20,319	34,861	37,991
Estimated Buses	2	6	8
Route Cost	$730	$3,120	$6,260
Cost Per Passenger Trip	$5.8	$5.5	$5.9

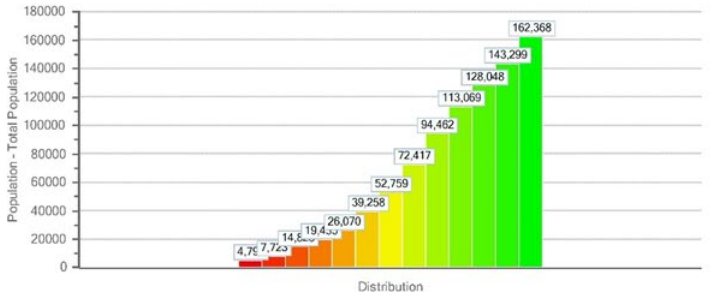
TBEST Network Accessibility

Fairfax Silver Line Phase II PreferredV2 - Base 2018_V2_Acessibility

Market Variable Travel Time Summary for Population - Total Population within the Mobility Area

Travel Time (min)	Total	% Market
0 - 2	4,791	2.95%
3 - 5	7,723	4.76%
6 - 9	14,828	9.13%
10 - 14	19,435	11.97%
15 - 17	26,070	16.06%
18 - 21	39,258	24.18%
22 - 24	52,759	32.49%
25 - 27	72,417	44.60%
28 - 30	94,462	58.18%
31 - 34	113,069	69.64%
35 - 38	128,048	78.86%
39 - 41	143,299	88.26%
42 - 45	162,368	100.00%
Accessible Market Total	**162,368**	**100%**





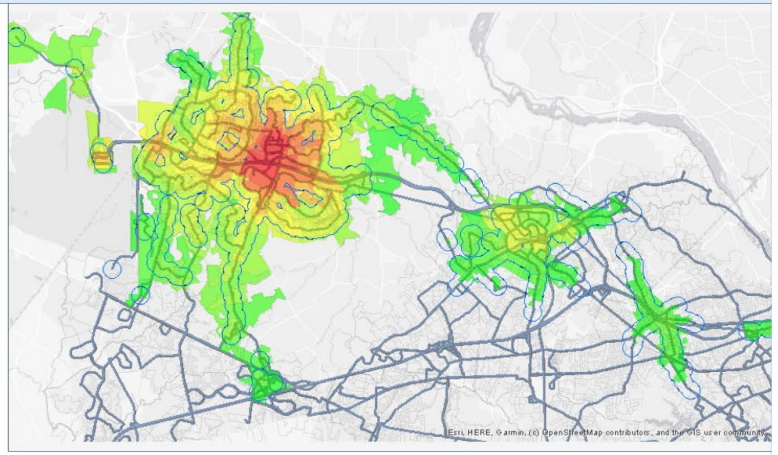
Population Data Source: Census and 5-Year Amercian Community Survey data grown to represent 2018 conditions
Employment Data Source: Local Zonal Data file

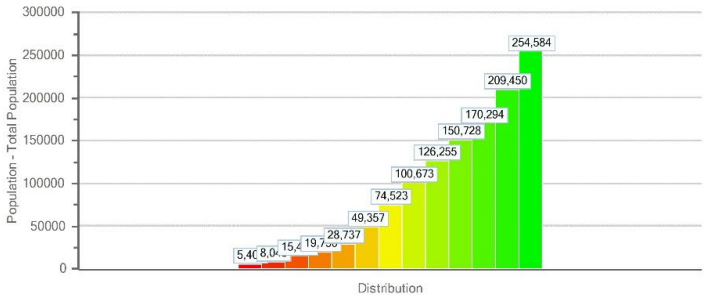
TBEST Network Accessibility

Fairfax Silver Line Phase II PreferredV2 - Preferred V2

Market Variable Travel Time Summary for Population - Total Population within the Mobility Area

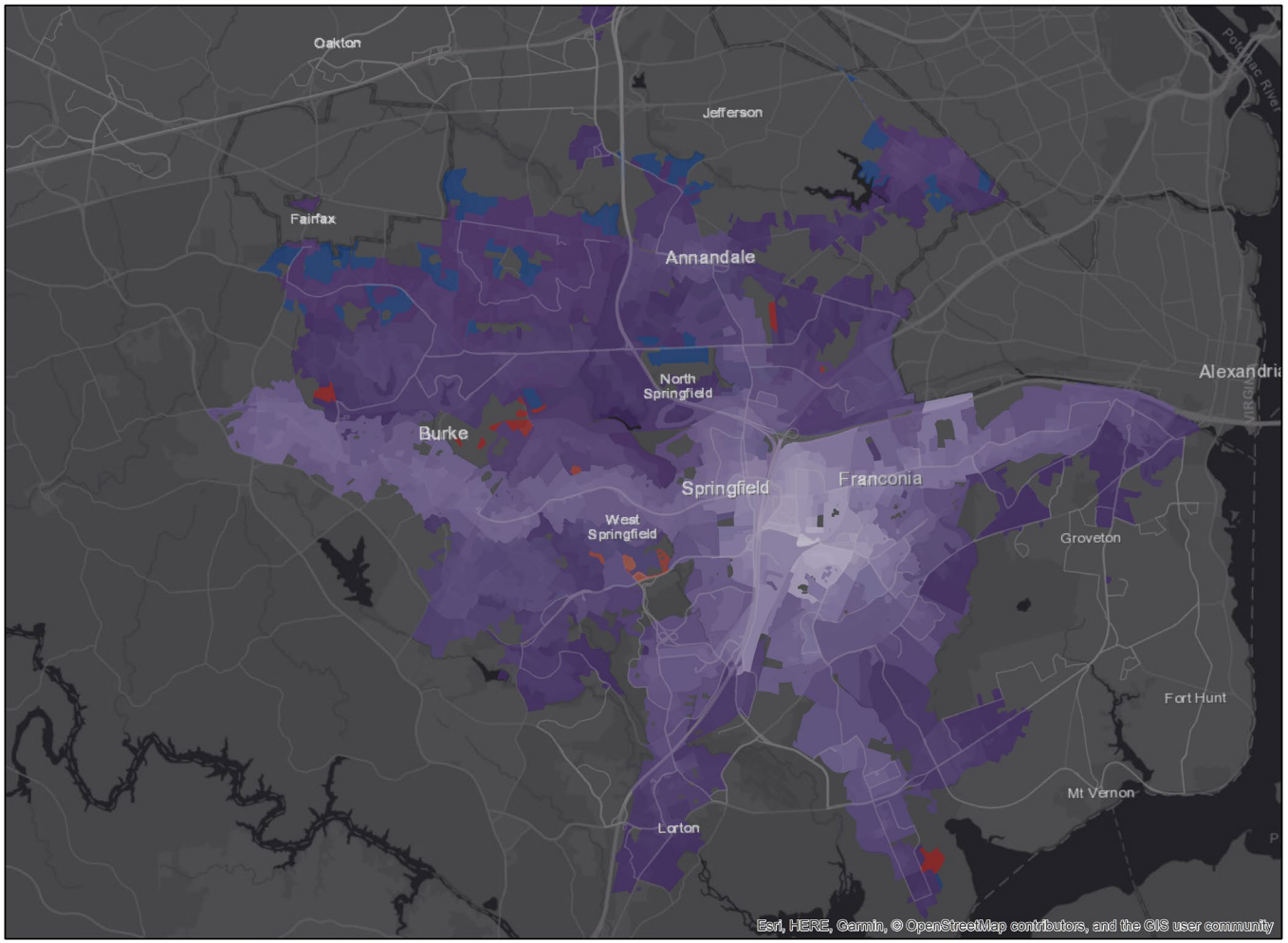
Travel Time (min)	Total	% Market
0 - 2	5,409	2.12%
3 - 5	8,040	3.16%
6 - 9	15,435	6.06%
10 - 13	19,750	7.76%
14 - 17	28,737	11.29%
18 - 20	49,357	19.39%
21 - 23	74,523	29.27%
24 - 27	100,673	39.54%
28 - 30	126,255	49.59%
31 - 34	150,728	59.21%
35 - 38	170,294	66.89%
39 - 42	209,450	82.27%
43 - 45	254,584	100.00%
Accessible Market Total	**254,584**	**100%**





Population Data Source: Census and 5-Year Amercian Community Survey data grown to represent 2020 conditions
Employment Data Source: Local Zonal Data file

TBEST Network Accessibility



TBEST Challenges & Opportunities

Challenges

- Maintaining Socioeconomic Database, controlling for vacancies, version control
- Accounting for Heavy Rail, Light Rail, BRT Modes
- Development of Northern Virginia model set

Opportunities

- Open Software Development, Interoperability, Exportability w/ other planning tools
- Title VI, Comprehensive Operational Analysis, Mobility Area Tools
- Use for Program/Policy/Budget Evaluation
- DRPT exploring TBEST opportunities in Virginia

Thank you

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