

# Development of Speed Models for Improving Travel Forecasting and Highway Performance Evaluation

*Presented to*

MTF Advanced Traffic Assignment Subcommittee

*Presented by*

Ren Moses, PI

*Project Manager*

Frank Tabatabaee

*Contributors*

Enock Mtoi, Steve Ruegg, Heinrich McBean

June 17, 2013



## Project Goals



- Explore the efficacy of both public and private data for use in travel forecasting
- Update speed and capacity look-up tables based on observed data
- Investigate Volume-Delay Functions (VDFs) and select the best functional form based on observed data
- Improve FSUTMS model performance through the use of more accurate speed-cap tables and VDFs



# Project Execution



- **Phase I** – Develop speed-cap and VDF for uninterrupted flow facilities including freeways, expressways, toll roads, HOV/HOT facilities
- **Phase II** – Develop speed-cap and VDF for interrupted flow facilities



# Free Flow Speeds on Freeways



Area Type	2-LaneS			3-Lanes			4-Lanes			5-Lanes		
	50th	85th	99th	50th	85th	99th	50th	85th	99th	50th	85th	99th
<i>Speed Limit = 55 MPH</i>												
Urban	62	64	66	64	65	67	63	64	65	67	70	72
Residential	61	63	65	63	65	66	66	67	68	66	67	68
Rural	66	67	69	67	68	69	68	68	70	68	69	70
<i>Speed Limit = 60 MPH</i>												
Urban	64	66	68	65, 66	66, 68	68, 71	65	67	68	66	67	69
Residential	66	68	69	67	68	70	67	69	70	68	69	70
Rural	68	69	71	69	70	71	69	70	72	70	71	72
<i>Speed Limit = 65 MPH</i>												
Urban	67	68	70	66	67	67	67, 68	69, 71	71, 73	66	69	70
Residential	68	70	71	69	72	74	69	71	72	68	70	71
Rural	70	71	73	71	72	73	71	72	74	72	73	74
<i>Speed Limit = 70 MPH</i>												
Urban	68	70	72	68	70	72	69	71	73	70	71	73
Residential	71	73	75	72	74	75	71	72	74	72	73	75
Rural	72	74	76	72	74	76	73	74	76	74	75	76


- TTMS
- Model
- STEWARD



## Practical Capacities on Freeways


*in passenger cars per hour per lane*

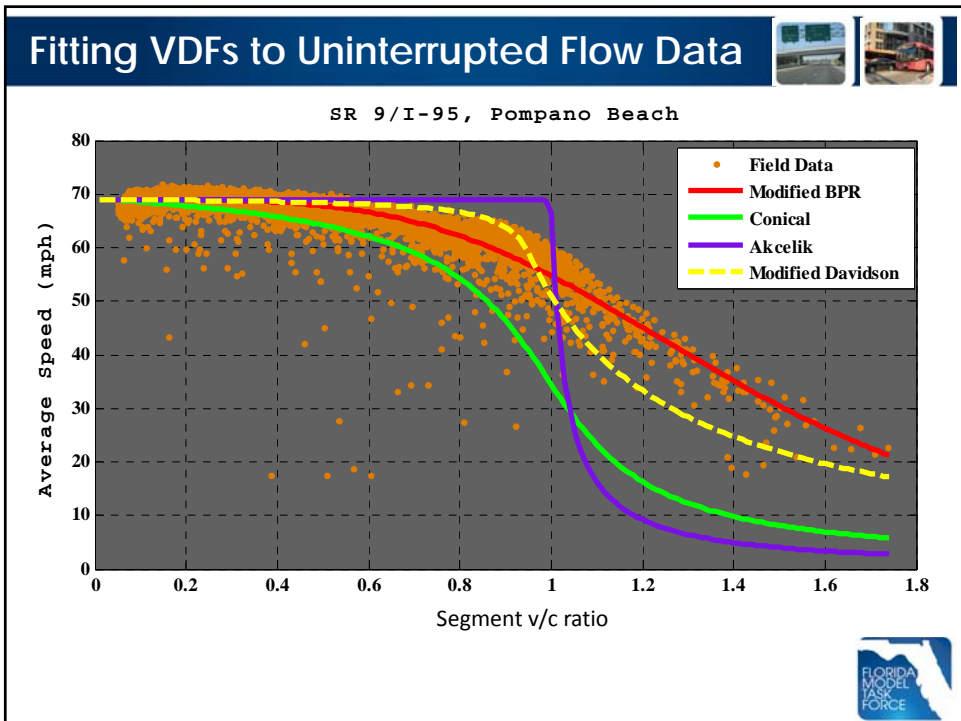
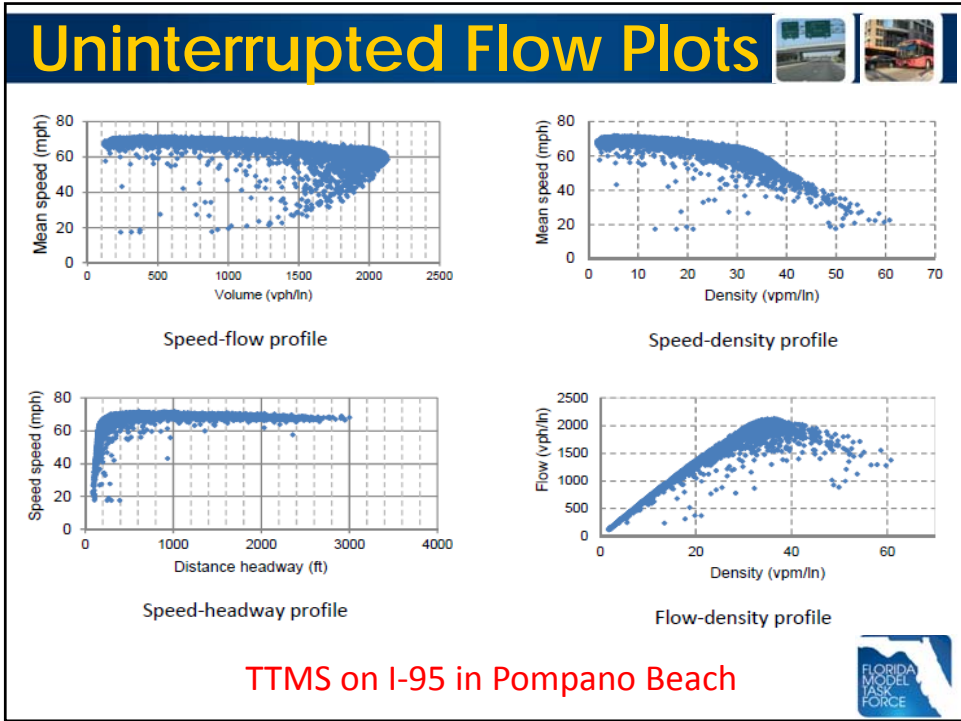
Area Type	Number of Lanes	Maximum Volume	99 <sup>th</sup> Percentile Volume	Default FDOT LOS Handbook Values
Urban	2	1,717	1,516	2,100
Urban	3	2,384	2,073	2,100
Urban	4	1,891	1,564	1,800
Urban	5	1,809	1,537	1,600
Residential	2	1,731	1,274	2,100
Residential	3	2,311	1,771	2,100
Residential	4	2,435	2,223	2,100
Residential	5	1,771	1,652	1,800
Rural	2	1,743	970	1,800
Rural	3	1,761	1,343	1,800

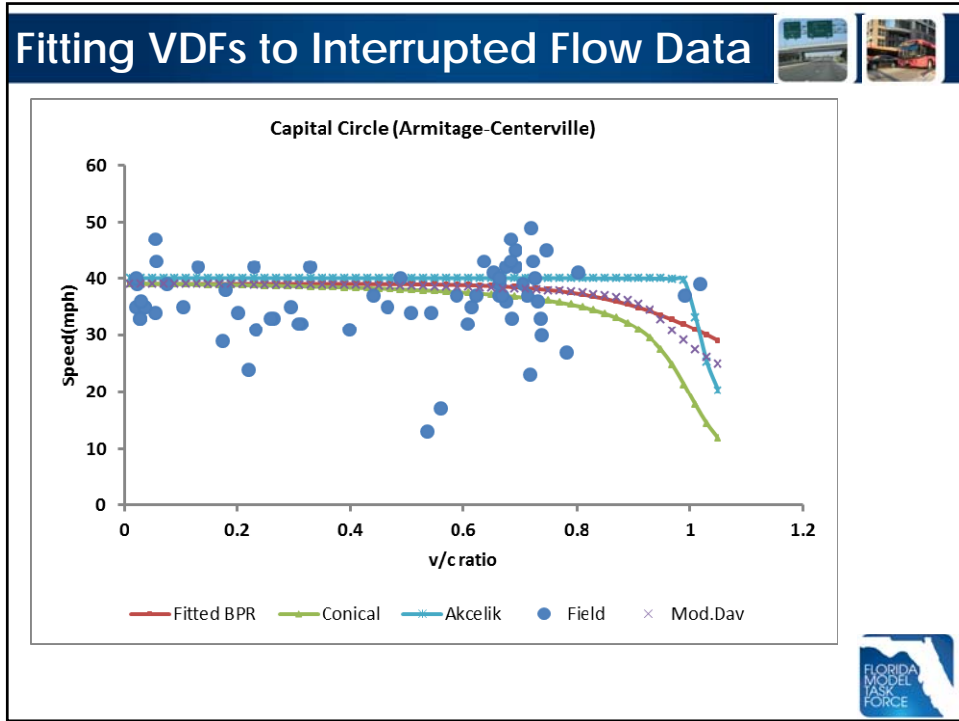


## Volume-Delay Functions

Function	Form	Parameter
Standard BPR	$U(v) = \frac{U_0}{[1.0 + a(v/c)^\beta]}$	$a$ and $\beta$
Fitted BPR	$U(v) = \frac{U_0}{[1.0 + a(v/c)^\beta]}$	$a$ $\beta$
Modified Davidson	$U(v) = \begin{cases} \frac{U_0}{1 + \frac{J(v/c)}{(1-v/c)}}, & \text{for } v/c \leq \mu \\ \frac{U_0}{1 + \frac{J\mu}{(1-\mu)} + \frac{J(v/c - \mu)}{(1-\mu)^2}}, & \text{for } v/c > \mu \end{cases}$	$J$ $\mu$
Conical	$U(v) = \frac{U_0}{\left[2 + \sqrt{\beta^2 \left(1 - \frac{v}{c}\right)^2 + \alpha^2} - \beta \left(1 - \frac{v}{c}\right) - \alpha\right]}$	$a$ $\beta$
Akcelik	$U(v) = \frac{U_0}{\left(1 + 0.25U_0 \left[\left(\frac{v}{c} - 1\right) + \sqrt{\left(\frac{v}{c} - 1\right)^2 + 8J\frac{v}{c}}\right]\right)}$	$J$









## Interrupted Flow Data Collection

ROAD NAME	INTERSECTION 1	INTERSECTION 2	Speed Limit, $S_{pl}$	No. of through lanes $N_{th}$	Field Free-flow Speed, $S_f$
N Macomb St	W Pensacola St	W Tennessee St	30	2	37
Lake Bradford	Jackson Bluff Rd	Gamble St	35	2	42
Thomasville Rd	South Ride	Waverly Rd	35	2	41
Thomasville Rd	E Bradford Rd	South Ride	35	3	41
Tennessee St	Monroe St	Meridian St	35	2	43
Blair Stone Rd	Old St Augustine Rd	Apalachee Pkwy	30	2	36
Blair Stone Rd	Apalachee Pkwy	Park Ave	35	2	42
Orange Ave	Wahnish Way	Adams St	35	2	41
Apalachee Pkwy	Franklin Blvd	Magnolia Dr	45	2	51
Tharpe St	High Rd	Ocala Rd	30	2	37
Tennessee St	N Copeland St	Woodward Ave	30	3	37
W Pensacola St	Ausley Rd	White Dr	40	2	46
S Adams	W Orange Ave	Paul Russell Rd	45	2	52
N Monroe St	Park Ave	Tennessee St	25	2	32
S Monroe St	Oakland Ave	Palmer Ave	35	2	42
Paul Russel Rd	S Adams St	S Monroe St	30	2	36
Capital Circle NE	Centerville	Hermitage Blvd	45	3	54
Capital Circle NE	Hermitage Blvd	Raymond Diehl Rd	45	3	52
Miccosukee Rd	Blair Stone Rd	Capital Circle Ne	35	2	42
Miccosukee Rd	Magnolia Dr	Hillcrest	30	1	37




### Estimation of Capacities for Signalized Facilities

Road Name	Class	Nth	PHF	g/C	Observed Volumes (vphph)						HCM Capacity Values (pcphpl)	Default Capacity Values (pcphpl)		
					Min.	Ave.	StDev	Max	99%-ile	NCHRP 387		FDOT	VDOT	
N Macomb St	Collector	2	0.89	0.45	27	446.41	150.42	616	589	761	625	720	510	
Lake Bradford	Minor Arterial	2	0.91	0.55	45	341.12	222.62	985	858	951	800	800	715	
Thomasville Rd	Principal Arterial	2	0.93	0.50	34	376.32	231.74	936	842	884	825	800	805	
Thomasville Rd	Principal Arterial	3	0.94	0.55	55	296.13	208.66	942	849	982	825	807	845	
Tennessee St	Minor Arterial	2	0.91	0.45	38	376.23	202.62	966	838	778	800	800	715	
Blair Stone Rd	Minor Arterial	2	0.89	0.45	55	426.00	245.87	986	860	761	800	800	715	
Blair Stone Rd	Minor Arterial	2	0.92	0.50	44	452.23	198.46	954	887	874	800	800	715	
Orange Ave	Minor Arterial	2	0.88	0.35	57	522.04	288.97	937	924	585	800	800	715	
Apalachee Pkwy	Principal Arterial	2	0.93	0.40	43	374.54	261.16	990	976	707	800	910	890	
Tharpe St	Minor Arterial	2	0.92	0.45	36	368.74	258.15	892	852	787	800	800	710	
Tennessee St	Minor Arterial	3	0.90	0.41	26	334.32	271.19	890	844	701	800	807	715	
W Pensacola St	Principal Arterial	2	0.89	0.50	48	448.43	263.24	984	923	846	825	910	860	
S Adams	Principal Arterial	2	0.95	0.45	42	446.64	249.37	988	940	812	825	910	890	
N Monroe St	Principal Arterial	2	0.91	0.40	196	631.83	209.99	922	920	692	825	800	780	
S Monroe St	Principal Arterial	2	0.93	0.40	62	526.13	254.22	928	910	707	825	800	805	
Paul Russel Rd	Minor Arterial	2	0.90	0.44	38	376.23	202.62	966	848	752	800	800	710	
Capital Circle NE	Principal Arterial	3	0.94	0.41	34	456.53	253.34	978	950	732	825	914	890	
Capital Circle NE	Principal Arterial	3	0.89	0.41	46	476.24	263.11	969	942	693	825	914	890	
Miccosukee Rd	Minor Arterial	2	0.90	0.45	14	384.74	281.17	880	847	770	800	800	715	
Miccosukee Rd	Minor Arterial	1	0.92	0.48	16	332.61	242.22	852	806	839	800	720	650	



### Level of Service Analysis

Segment	Prediction Method	Speed Limit, mph	Free Flow Speed, mph	Cycle Length, sec	g/C ratio	Control Delay, sec	Intersection Approach LOS	Speed, mph	Segment LOS
Apalachee Pkwy	FDOT	45	50	150	0.40	35.65	D	33.28	B
	HCM	45	44	150	0.40	35.65	D	30.8	C
	Field FFS	45	51	150	0.40	35.65	D	33.28	B
S Adams	FDOT	45	50	150	0.45	36.58	D	24.19	C
	HCM	45	44	150	0.45	36.58	D	22.86	D
	Field FFS	45	52	150	0.45	36.58	D	24.20	C
W. Pensacola	FDOT	40	45	140	0.50	38.42	D	21.03	D
	HCM	40	41	140	0.50	38.42	D	19.73	D
	Field FFS	40	47	140	0.50	38.42	D	21.24	D
N Macomb St	FDOT	30	35	130	0.45	35.75	D	23.15	C
	HCM	30	36	130	0.45	35.75	D	25.85	C
	Field FFS	30	37	130	0.45	35.75	D	26.45	C
Lake Bradford	FDOT	35	40	140	0.55	37.30	D	30.78	C
	HCM	35	40	140	0.55	37.30	D	30.48	C
	Field FFS	35	43	140	0.55	37.30	D	34.78	B
Thomasville Rd	FDOT	35	40	160	0.50	35.50	D	33.42	B
	HCM	35	38	160	0.50	35.50	D	28.72	C
	Field FFS	35	42	160	0.50	35.50	D	35.92	B
Thomasville Rd	FDOT	35	40	160	0.55	36.30	D	28.35	C
	HCM	35	40	160	0.55	36.30	D	28.35	C
	Field FFS	35	40	160	0.55	36.30	D	28.35	C



Segment	Prediction Method	Speed Limit, mph	Free Flow Speed, mph	Cycle Length, sec	g/C ratio	Control Delay, sec	Intersection Approach LOS	Speed, mph	Segment LOS
Tennessee St	FDOT	35	40	160	0.45	34.10	C	28.10	C
	HCM	35	36	160	0.45	34.10	C	24.90	D
	Field FFS	35	43	160	0.45	34.10	C	31.10	C
Blair Stone Rd	FDOT	30	35	148	0.45	36.20	D	18.60	D
	HCM	30	37	148	0.45	36.10	D	19.90	D
	Field FFS	30	37	148	0.45	36.10	D	19.90	D
Blair Stone Rd	FDOT	35	40	148	0.50	36.60	D	30.90	C
	HCM	35	39	148	0.50	36.60	D	29.40	C
	Field FFS	35	44	148	0.50	36.60	D	34.50	B
Orange Rd	FDOT	35	40	130	0.35	37.10	D	30.60	C
	HCM	35	39	130	0.35	37.10	D	30.30	C
	Field FFS	35	43	130	0.35	37.10	D	23.50	C
Tharpe St.	FDOT	30	35	150	0.45	38.50	D	18.00	D
	HCM	30	37	150	0.45	38.50	D	18.90	D
	Field FFS	30	34	150	0.45	38.50	D	17.30	D
Tennessee St.	FDOT	30	35	160	0.41	35.00	C	21.60	B
	HCM	30	37	160	0.41	35.00	C	25.70	C
	Field FFS	30	37	160	0.41	35.00	C	25.70	B
N. Monroe St.	FDOT	25	30	150	0.41	34.20	C	17.80	D
	HCM	25	33	150	0.40	34.20	C	18.70	D
	Field FFS	25	32	150	0.40	34.20	C	18.20	D

Segment	Prediction Method	Speed Limit, mph	Free Flow Speed, mph	Cycle Length, sec	g/C ratio	Control Delay, sec	Intersection Approach LOS	Speed, mph	Segment LOS
S Monroe St	FDOT	35	40	150	0.40	38.30	D	25.20	C
	HCM	35	38	150	0.40	38.30	D	20.50	D
	Field FFS	35	41	150	0.40	38.10	D	25.90	C
Paul Russel Rd	FDOT	30	35	150	0.44	32.10	C	22.10	D
	HCM	30	34	150	0.44	32.10	C	21.30	D
	Field FFS	30	36	150	0.44	32.10	C	22.30	D
Capital Circle NE	FDOT	45	50	160	0.41	33.50	C	37.20	B
	HCM	45	44	160	0.41	33.50	C	32.00	C
	Field FFS	45	52	160	0.41	33.50	C	38.70	B
Capital Circle NE	FDOT	45	50	160	0.41	34.40	C	35.40	C
	HCM	45	43	160	0.41	34.40	C	29.60	D
	Field FFS	45	52	160	0.41	34.40	C	36.50	C
Miccosukee Rd	FDOT	35	40	130	0.45	33.50	C	24.20	C
	HCM	35	39	130	0.45	33.50	C	23.40	C
	Field FFS	35	41	130	0.45	33.50	C	24.60	C
Miccosukee Rd	FDOT	30	35	130	0.48	34.30	C	17.70	D
	HCM	30	36	130	0.48	34.30	C	19.90	D
	Field FFS	30	36	130	0.48	34.30	C	19.90	D

## Tasks Ahead



- Wrap up speed-cap for uninterrupted flow facilities
- Test uninterrupted flow VDFs
- Develop and test VDFs on interrupted flow facilities
- Produce draft final report



## Questions and Comments?





## Speed Modeling



- For area type-speed limit combination with no data source, free flow speed was estimated using a least square regression equation:

$$p^{\text{th}} \text{Pecentile Speed} = \beta_0 + \sum_{i=1}^N \beta_i X_i + \varepsilon_i \quad \text{with } i = 1, 2, 3.$$

where,  $X_1$  = Speed limit,  $X_2$  = Area Type, and  
 $X_3$  = Number of Lanes

