Volunteer Network of Professionals Working Together to Support, Promote, and Improve Best Practices in the Application of Traffic Simulation and Capacity Analysis

Meeting Agenda

- Welcome and SimCap Updates
- Simulation in the ‘90s – Advancement of the Field
- Integration of Highway Safety Manual Methods into TransModeler
- Open Discussion

ITE SimCap Committee

- Held ITE webinar (May 18)
  - Featured simulation case studies
- Upcoming session at 2021 ITE Annual Meeting (Jul. 28, 12:30–2:00p CST)
  - Traffic Analysis, Modeling, and Simulation Cornucopia
- Upcoming meeting (Aug. 4, 3:00–4:30p CST)
  - Joint meeting with SimSub
  - No registration; use link

TRB Joint Simulation Subcommittee (SimSub)

- Held Summer Liaison Meeting (Jun. 25)
  - Established task groups, discussed activities
  - Vendors provided updates
  - Meeting minutes coming soon
- Upcoming NOCoE webinar (Sept.)
  - Role and benefit of traffic simulation in TSMO
  - Speakers needed!
- Subscribe to e-mail listserv

Local Updates

- FHWA Louisiana Division Office
- LaDOTD
- Louisiana MPOs/Planning Commissions
- Other

Contact Information

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https://simcap.eng.lsu.edu/

David Hale
Leidos

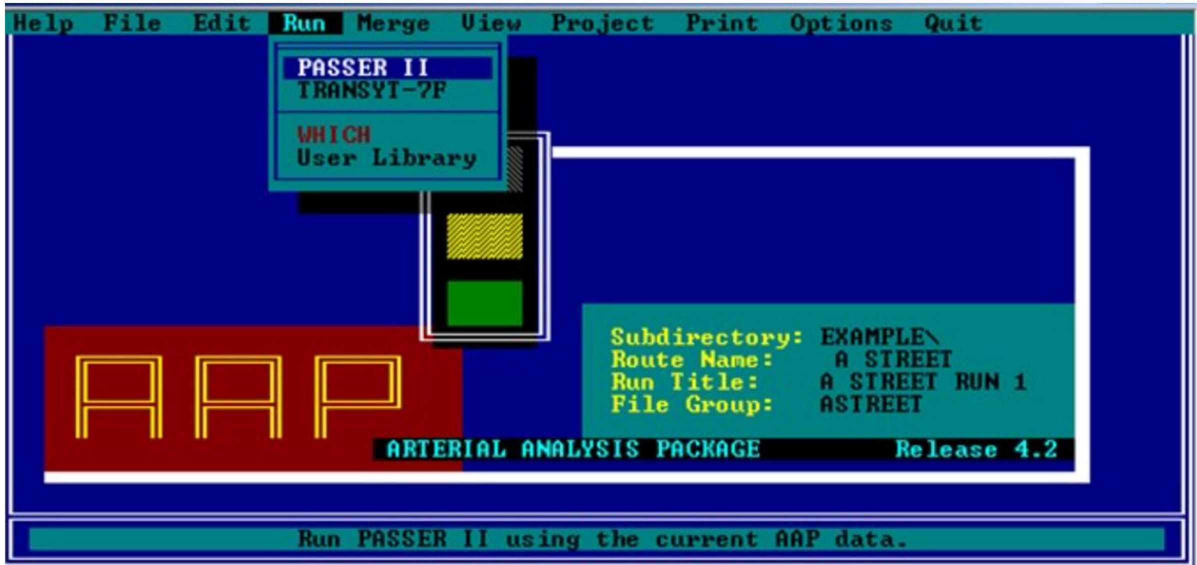
Simulation in the ‘90s

Advancement of the Field

David K. Hale, July 15th 2021

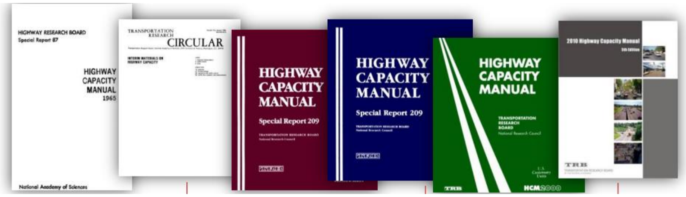
Public and Private Sector Competition

- Expansion of public sector tools:
  - Integration of Netsim and Fresim into Corsim.
  - PASSER II, PASSER III, TRANSYT-7F.
  - Highway Capacity Software (HCS).
  - Arterial Analysis Package (AAP).
- Emergence of private sector tools:
  - Synchro and SimTraffic.
  - TEAPAC.
  - Vissim.



Influence of the Highway Capacity Manual (HCM)

- People began comparing HCM results to simulation results.
- Some simulation tools adopted HCM output measures.
  - Level of service.
  - Control delay.
  - Stop delay.



http://www.texite.org/houston/HCM-HISTORY.pdf

- Researchers updated HCM models using simulation output.
- Comparisons generated new research and development.
  - Microsimulation trajectory analysis (Courage, Dowling).
  - FHWA Traffic Analysis Toolbox (Halkias).

Early Simulation Guidance

McTrans™

Newsletter Volume 11 Number 3 March 1997

How Many NETSIM Runs are Enough?

by David Hale, McTrans

One of the most common oversights in using a simulation tool like NETSIM is using the results from only one run. This can lead to drawing incorrect conclusions from the model results[1]. One common cause is the tight time constraint often placed on engineers who have little training in statistics. Animation is generally not an ideal means of interpreting simulation results. And although the output file provides an overview of the model's response, it is not intended to serve as the primary basis for decision making. One common pitfall involves drawing conclusions based on the results of a single model execution with arbitrary run length. This approach equates to throwing a die once, getting a 6, and concluding that each face of the die is a 6.

Simulation models like NETSIM[2] are non-deterministic in that they generate output which is affected by random processes within the model. Because of these random processes the results of runs with identical parameters will change from run to run. It is as important to report the amount of variation in the results as it is to report an accurate average value of that result. It is impossible to do either with a single run. To account for this variation, an estimated average value and confidence interval for the parameter should be provided. A confidence interval is highly desirable in the evaluation of an average value, an assertion that the true expected result lies inside the interval between x and y with z percent confidence. Without this reliability measure, there is little basis for determining the credibility of the simulation results, regardless of the quality of the underlying model.

A simple technique is taught at a University of Florida graduate course in Digital Simulation Techniques[3]. The technique is used to determine the approximate number of required simulation runs with varying random number seeds. After having performed the appropriate number of runs, the user may estimate that the true expected result lies inside the computed interval with 90% percent confidence.

Example: **Ten initial simulation runs with different random number seeds are performed and the output results are listed in the following table. Between 10 and 20 initial runs are recommended, and the analysis period should be as long as possible, although 60-minute periods are often used in the academic environment. (Ten long runs are preferable to twenty short runs.)**

Replication	Total Delay in Queue (mins)	(avg - obs)	$(avg - obs)^2$
1	1.53	0.50	0.25
2	1.66	0.37	0.14
3	1.24	0.79	0.62
4	2.34	-0.31	0.10
5	2.00	0.03	0.00
6	1.69	0.34	0.12
7	2.69	-0.66	0.44
8	2.86	-0.83	0.69
9	1.70	0.33	0.11
10	2.60	-0.57	0.32
	Avg = 2.03		Sum = 2.79

From the table above, the calculated average value of 2.03 minutes of total delay in queue, and the summation of the (average – observation)^2 terms, 2.79, are used in the upcoming calculations. The objective is to obtain a point estimate and approximate 90% confidence interval for the expected total delay in queue.

First calculate the sample variance, S^2, for n = 10 runs:

$$S^2(10) = 2.79 / (n-1) = 2.79 / 9 = 0.31$$

The 't' factor for 10 runs and 90% confidence, along with the sample average and variance, are now used to obtain the confidence interval estimate. For $t_{9,0.95} = 1.833$, the 10-run, 90% confidence interval is:

$$\bar{X}(10) = 2.03,\ S^2(10) = 0.31$$

$$\bar{X}(10) \pm t_{9,0.95}\sqrt{S^2(10)/10} = 2.03 \pm 0.32$$

After the initial 10 runs, this variation of plus or minus 0.32 appears to unacceptable when compared to the average of 2.03 minutes in queue. This is because it represents plus or minus 16%, or a confidence interval equal to 32% of the average. If the user had performed only the initial replication, the result could have been anywhere within the range 1.71 to 2.35. Note that while we are 90% confident that the true average lies within that region only two of the observed results lie within that bound. This points to the need to be cautious in making conclusions from a few observations, maybe only one. For the network above, suppose that a confidence interval less than or equal to 10% of the average is desired. Determine the total number of simulation runs needed. For this case, the number of initial runs $n_1 = 10$, variation $h_1 = 0.32$, sample average:

$$\bar{X}(10) = 2.03$$

and confidence factor $\beta = 0.1$. The total number of runs (n_2) is:

$$n_2 = (10)\left(\frac{0.32}{0.1 \times 2.03}\right)^2 = 25$$

Therefore, an additional 15 simulation runs are needed to get the desired accuracy of the confidence interval. The previous table containing data for replications 1-10 could be reconstructed with the new data upon completion of the additional 15 runs to verify the new 10% confidence interval, if desired.

Techniques such as this lead to results that are more meaningful than those which are produced by a single model execution with arbitrary run length. By taking advantage of the stochastic nature of models which incorporate a random number seed, as does NETSIM, it is possible to model a system more realistically. For in the real world, vehicle delays and queues may vary significantly from day to day, even when the roadway geometry and signal timing remain constant.

References

[1] Pegden, C.D., R.E. Shannon, and R.P. Sadowski, Introduction to Simulation Using SIMAN, Second Edition, Systems Modeling Corporation, Sewickley, PA., 1995.

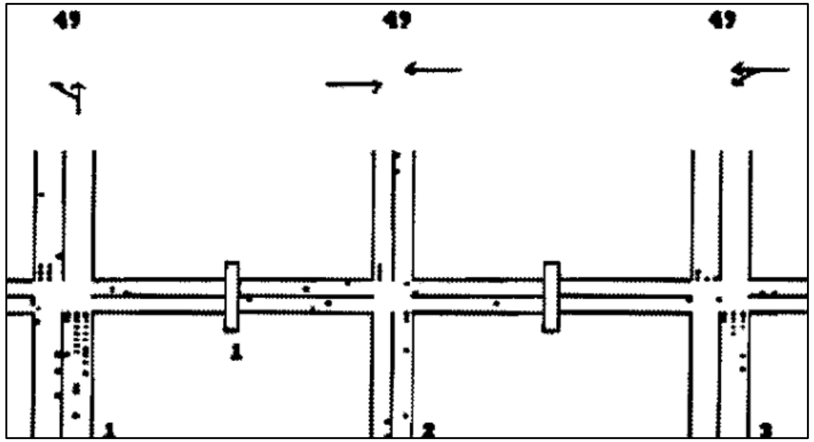
[2] Federal Highway Administration, TRAF User Reference Guide, McLean, Virginia, March 1995. (*Note: NETSIM is currently being integrated with FRESIM into a new corridor model called CORSIM*).

[3] Bai, S.X., ESI 6529: Digital Simulation Techniques, Class Notes, Department of Industrial & Systems Engineering, University of Florida, 1996.

McTrans Newsletter is published four times a year by the Center for Microcomputers in Transportation, a program of the Transportation Research Center, University of Florida, Gainesville, FL, an equal opportunity / affirmative action institution. Graphic design and production provided by Gator Engineering Publication Services, University of Florida.

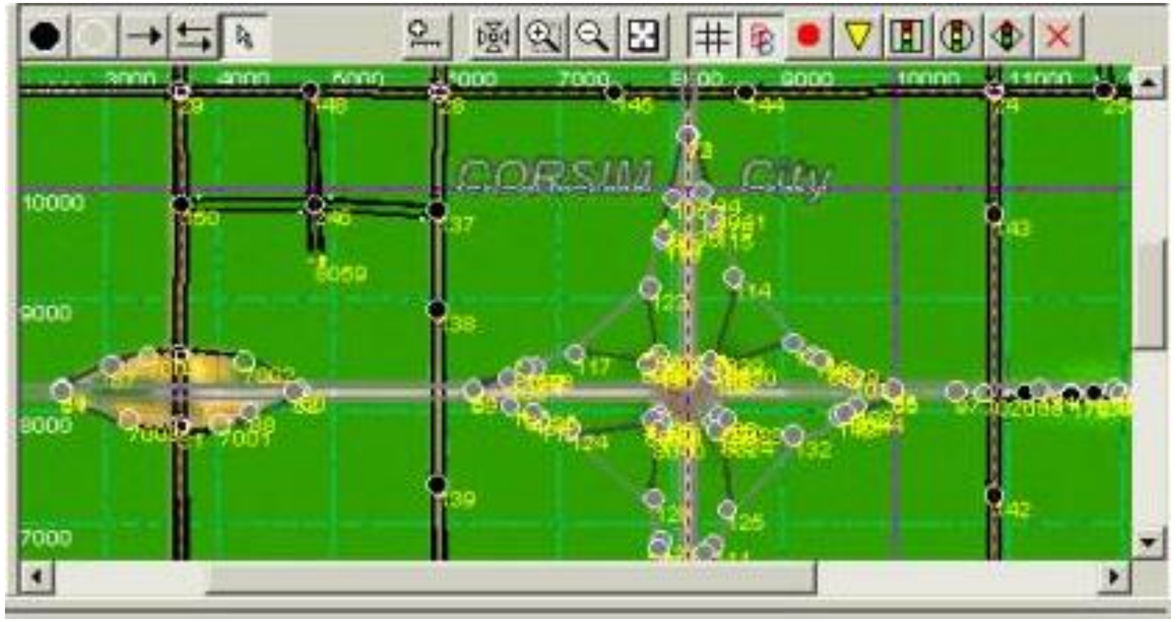
Simulation and Traffic Signal Timing

- SigCinema by KLD Associates.
  - Isolated intersections in Netsim.
  - Animation of optimized timings.
- PASSER by Texas Transportation Institute (TTI).
  - Macroscopic analysis, no platoon dispersion.
  - LEART simulation/animation.
- TRANSYT-7F by University of Florida and McTrans.
  - Macroscopic simulation with platoon dispersion.
  - Step-wise simulation in the late 1990's.
- Synchro by Trafficware.
  - Macroscopic analysis with platoon dispersion.
  - Animation of optimized timings in SimTraffic.



Data Entry via Link-Node Diagram

- Import a bitmap background (aerial photo).
- Drag and drop links and nodes.
- Right-click on links and nodes to edit their properties.
- Moving vehicle animation within the bitmap background.
- Early examples: Synchro and ITRAF.

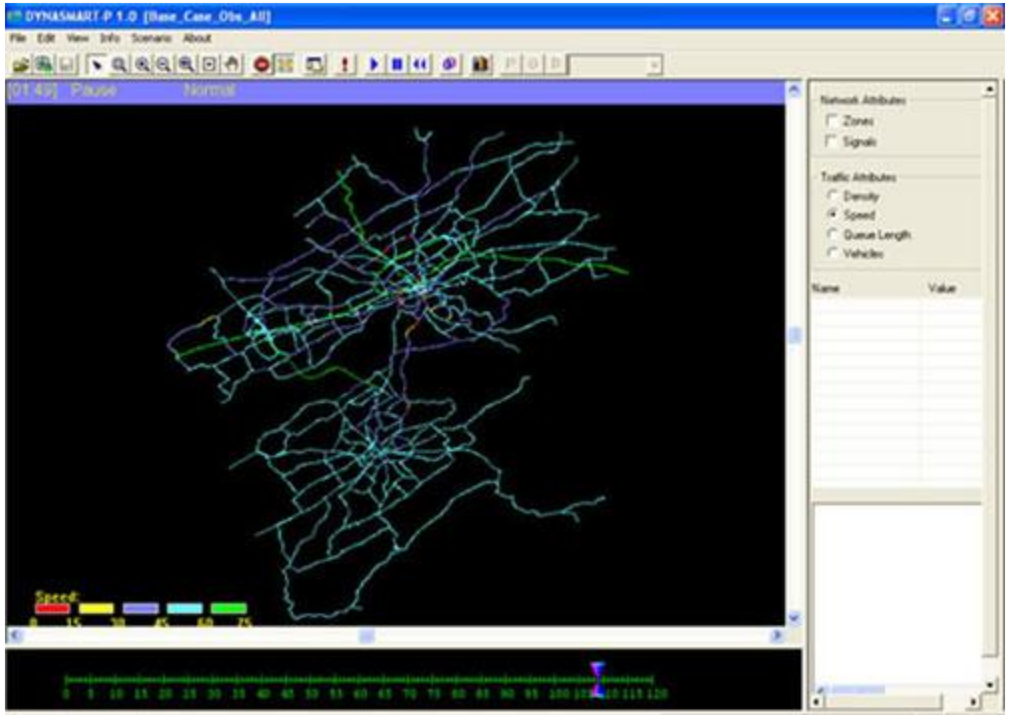


Early Work on Dynamic Traffic Assignment (DTA)

leidos

- Improved computing power made DTA more practical.
- Research and development from Hani Mahmassani.
- 1990’s DTA work mostly confined to academia.
- Moving vehicle animation in DYNASMART-P.
- FHWA support for DYNASMART-P.
- Birth of DTALite and Dynus-T.
- Mesoscopic simulation.

DYNASMART-P
Intelligent Transportation Network Planning Tool



Early Work on Regional Microsimulation

- TRANSIMS: a public sector tool.
- Regional agent-based microsimulation and DTA.
- Hot topic at TRB in the 1990’s, not adopted by industry.
- Set the stage for meso-simulation versus microsimulation.

Tom Creasey

Caliper Corporation

Integration of Safety Analysis Tools into Microsimulation Software

Tom Creasey, PE, PhD
Caliper Corporation

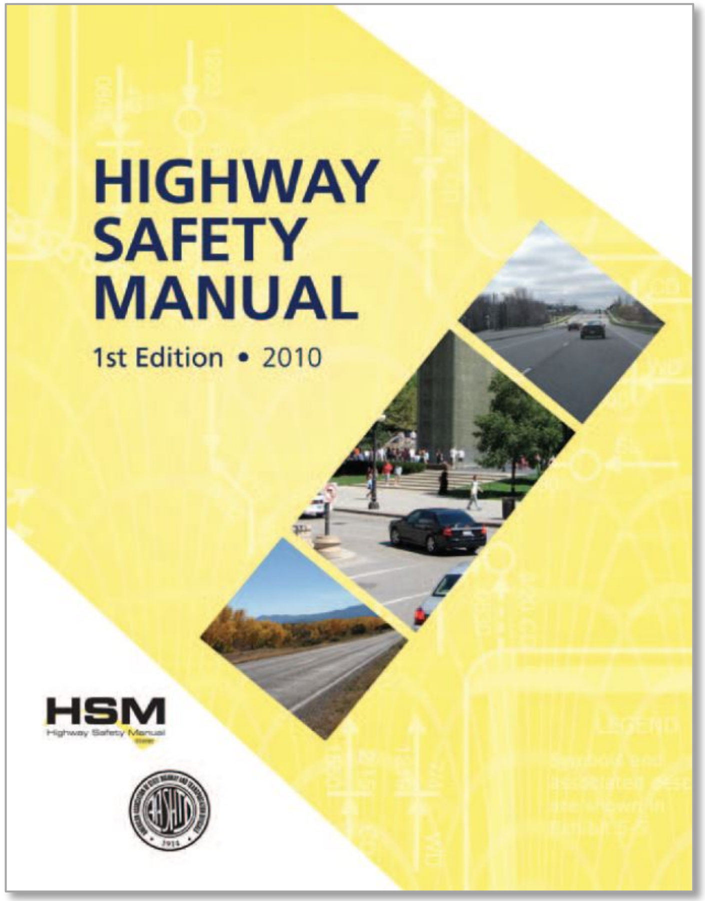
Caliper TransModeler Traffic Simulation Software

“You can’t predict accidents.”

- Former professor, advisor, and mentor of mine
- Circa early 1980’s

Highway Safety Manual

- 1st Edition in 2010
- Part C – Predictive Methods
- 2014 supplement included:
  - *Chapter 18 Freeways*
  - *Chapter 19 Ramps*



HSM Prediction Methods – Basic Structure

$$N = \overset{\text{SPF}}{\overset{\Downarrow}{N_{base}}} * CMF * C$$

N: Predicted average crash frequency for specific site, type, etc.

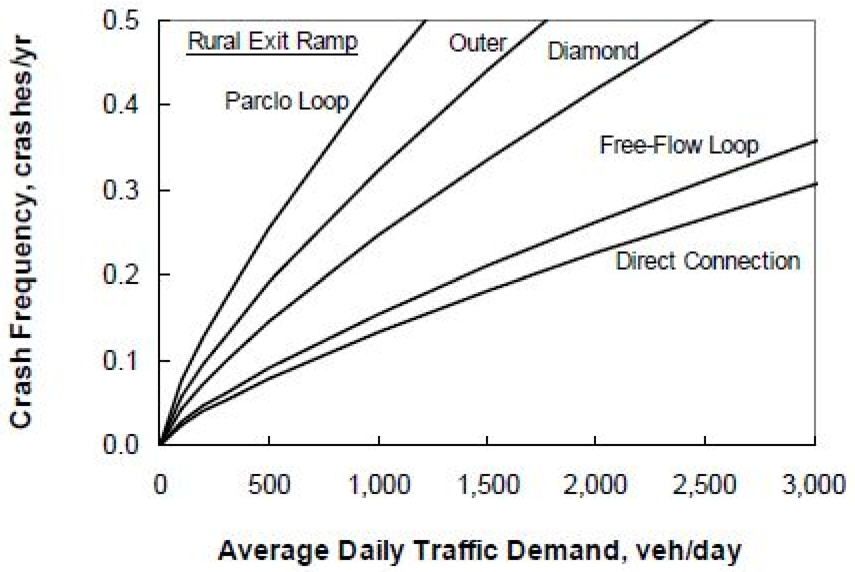
N_{base}: Predicted average crash frequency for base conditions as predicted by Safety Performance Function (SPF)

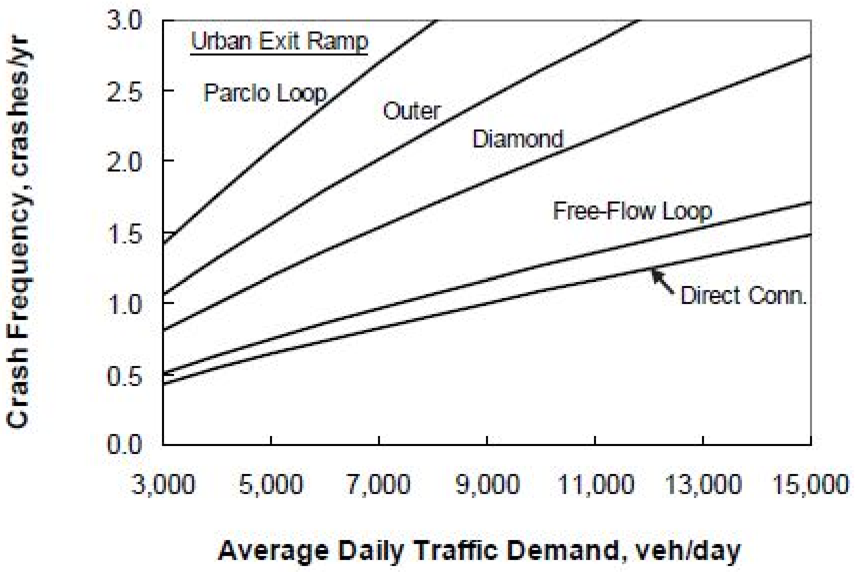
CMF: Crash Modification Factor(s)

C: Calibration Factor

Safety Performance Functions (SPFs)

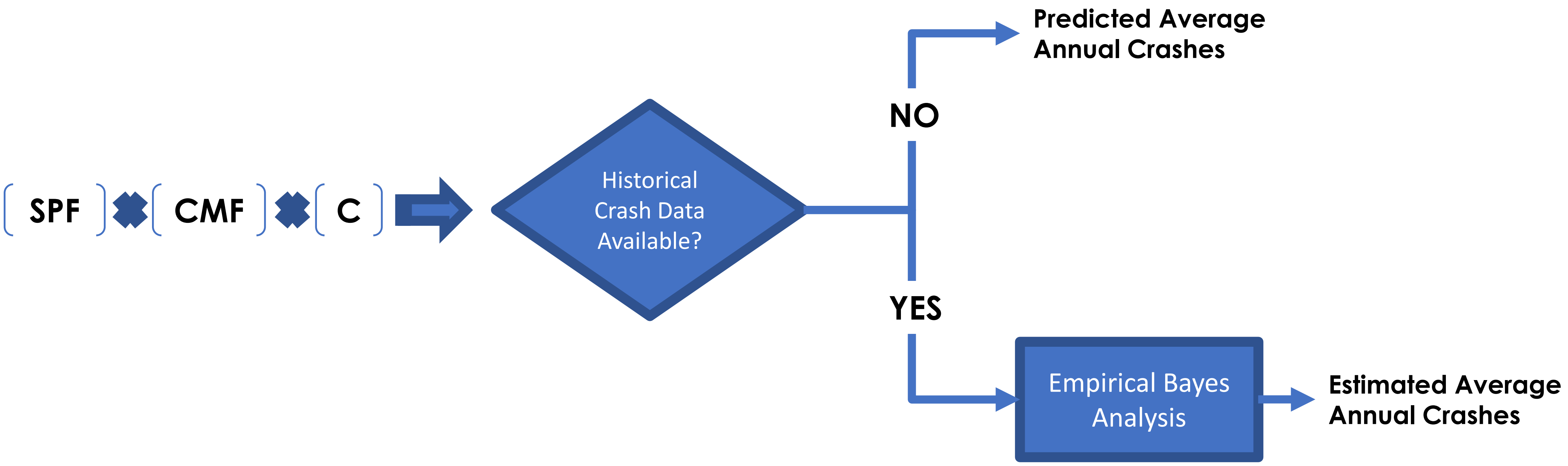
- Regression equations that estimate average crash frequency for specific site type





TransModeler
Traffic Simulation Software

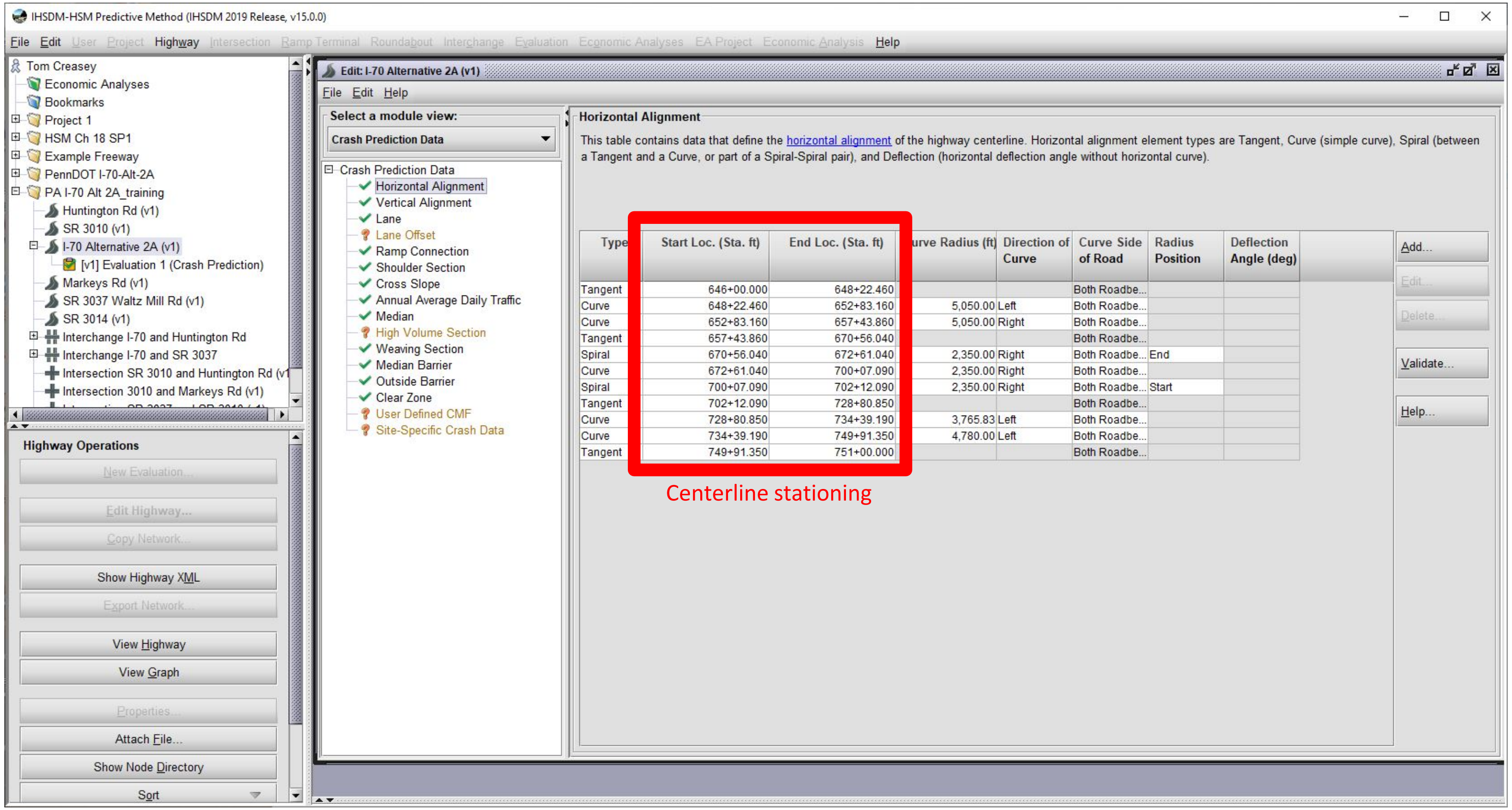
HSM Crash Prediction Methodology



Safety Analysis Tools

- IHSDM
- Highway Safety Software
- Customized Spreadsheets

Interactive Highway Safety Design Model (IHSDM)



Source: FHWA/AASHTO

Interactive Highway Safety Design Model (IHSDM)

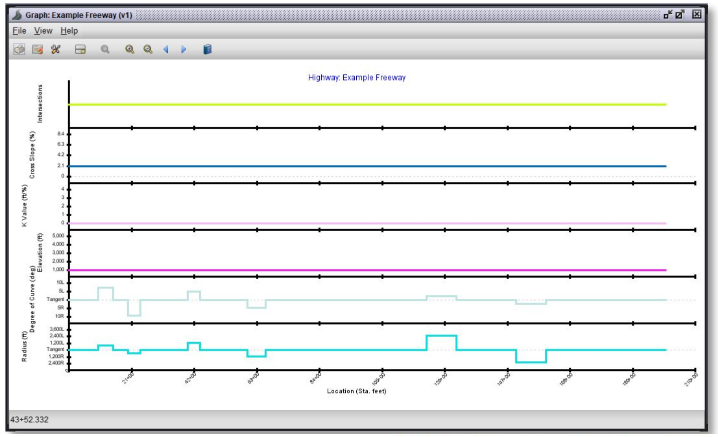


Table 14. Expected Crash Severity by Freeway Segment (Section 1)

Seg. No.	Fatal (K) Crashes (crashes)	Incapacitating Injury (A) Crashes (crashes)	Non-Incapacitating Injury (B) Crashes (crashes)	Possible Injury (C) Crashes (crashes)	No Injury (O) Crashes (crashes)
1	0.0152	0.0377	0.2196	0.3714	0.9416
3	0.3360	0.8462	4.7352	7.6406	16.6265
4	0.1277	0.3197	1.8213	3.0011	8.0517
5	0.0075	0.0186	0.1085	0.1835	0.4943
6	0.0287	0.0730	0.4228	0.9290	2.4672
8	0.0924	0.2197	1.2085	2.4169	5.4525
9	0.0468	0.1090	0.6411	1.3871	3.3651
10	0.0879	0.2232	1.2931	2.8412	6.9090
11	0.0797	0.2088	1.4546	3.4728	7.1447
12	0.1046	0.2550	1.6941	3.6923	6.4784
14	0.0127	0.0303	0.2147	0.5043	0.8901
16	0.1049	0.2513	1.6611	2.7524	6.7732
17	0.1070	0.2426	1.6640	2.6553	6.3124
18	0.0507	0.1151	0.7893	1.2595	3.1568
19	0.0442	0.1003	0.6878	1.0976	3.3897
Total	1.2459	3.0504	18.6157	34.2050	78.4533

Crash Prediction Evaluation Rep
C:/IHSDM2018/users/tom/Projects_V5/p3/h2/e1/evaluation.1.report.htm#_tb...
Apps Caliper Faith FHWA Financial ftc HCQSC ITE Local Governments Other bookmarks

Interactive Highway Safety Design Model

Crash Prediction Evaluation Report

Version v15.0.0 (Oct 31, 2019)

May 19, 2021

Disclaimer

The Interactive Highway Design Model (IHSDM) software is disseminated under the sponsorship of the Department of Transportation in the interest of information

Table of Contents

List of Tables

Highway Safety Software (McTrans)

Highway Safety Software Freeway Segment Report

Project Information

Analyst		Date	12/19/2017
Jurisdiction		Analysis Year	2011
Project Description	HSM Chapter 18: Sample Problem 5	Section Number	1

Input Data

Length of Segment (mi)	0.750	Number of Through Lanes	6
Number of Curves	0	Clear Zone Width (ft)	30
Lane Width (ft)	12.0	Median Width (ft)	40
Outside Shoulder Width (ft)	10	Inside Shoulder Width (ft)	6
Proportion of Rumble Strips (Outside Shoulder)	0.000	Proportion of Rumble Strips (Inside Shoulder)	0.000
Barrier in Median	No	Barrier on Roadside	No
Freeway AADT (veh/day)	120000	Proportion of AADT (High-volume)	0.643

	Travel in Increasing Milepost Direction		Travel in Decreasing Milepost Direction	
	Entrance Ramp	Exit Ramp	Entrance Ramp	Exit Ramp
Distance to Upstream Ramp (mi)	0.500	0.100	0.850	0.100
AADT (veh/day)	8000	7675	6750	7150
Presence of Type B Weave	None		None	
Length of Weave (mi)	-		-	
Length of Weave in Segment (mi)	-		-	

Crash Modification Factors

	Combined CMF		Calibration Factor	
	Fatal and Injury	Property Damage Only	Fatal and Injury	Property Damage Only
Multiple Vehicle	1.354	1.291	1.00	1.00
Single Vehicle	0.939	0.716	1.00	1.00

Predicted Roadway Section Crashes

	Predicted Crash Frequency		
Crash Severity	Multiple Vehicle	Single Vehicle	Total
Fatal and Injury (FI)	4.812	1.988	6.800
Property Damage Only (PDO)	11.329	3.660	14.989
Total	16.141	5.648	21.789

Customized Spreadsheet Tools

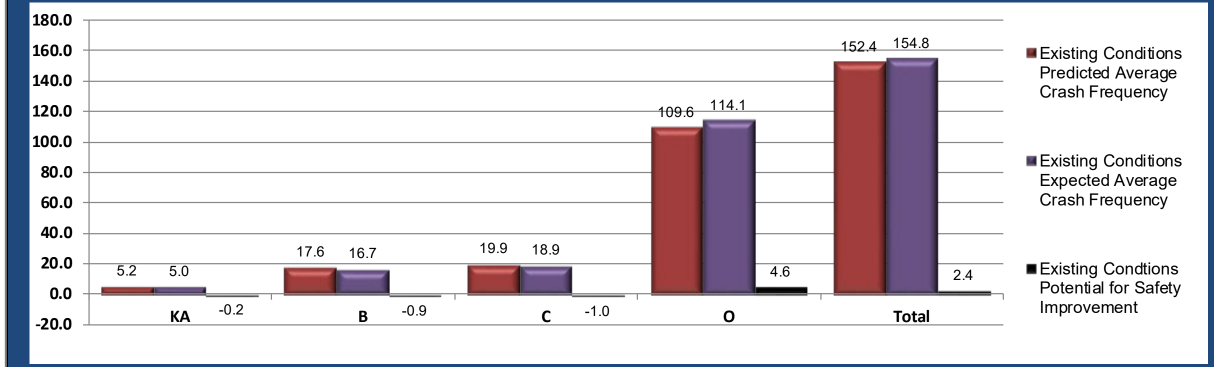
Project Safety Performance Report

ECAT Economic Crash Analysis Tool

General Information

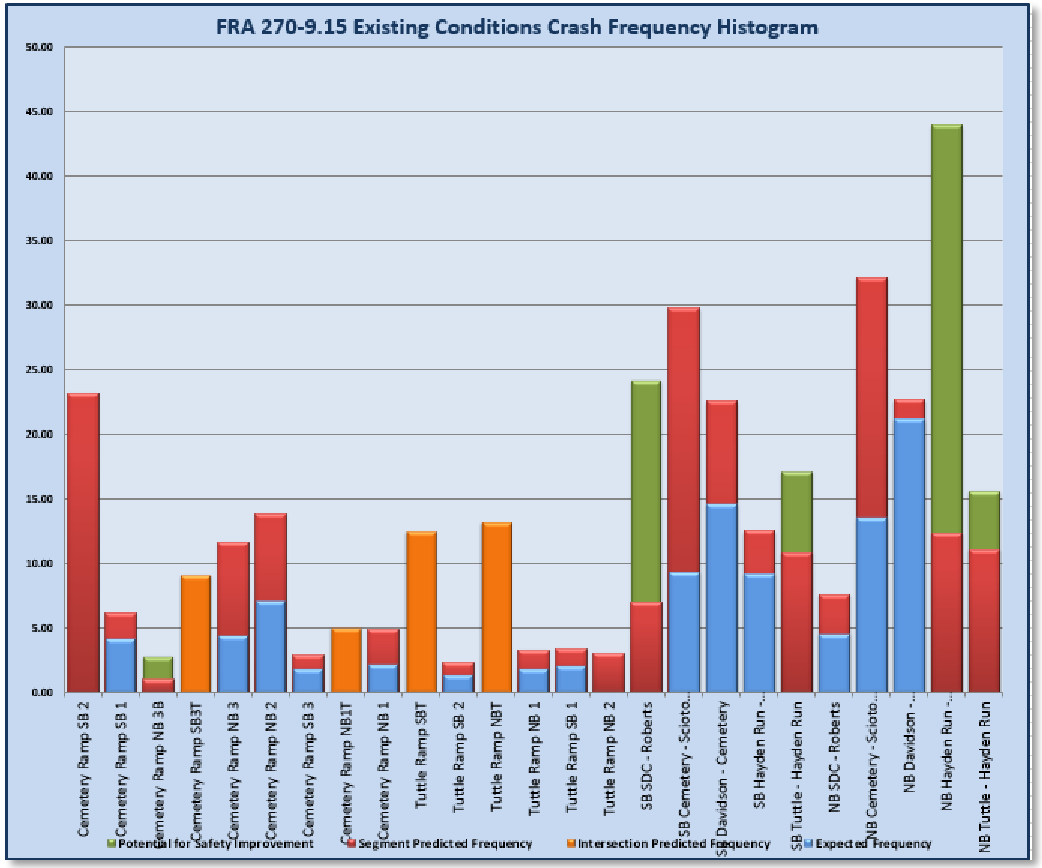
Project Name	SUM 8	Contact Email	
Project Description	Design-Build Project	Contact Phone	
Reference Number	PID 106589	Date Performed	
Analyst		Analysis Year	Existing Conditions
Agency/Company			

Summary of Anticipated Safety Performance of the Project (average crashes/year)



Project Summary Results (Without Animal Crashes)

	KA	B	C	O	Total
$N_{predicted}$ - Existing Conditions	5.2384	17.6227	19.9360	109.5636	152.3607
$N_{expected}$ - Existing Conditions	4.9924	16.7458	18.9137	114.1256	154.7775
$N_{potential\ for\ improvement}$ - Existing Conditions	-0.2460	-0.8769	-1.0223	4.5620	2.4168



Source: Ohio Department of Transportation

TransModeler Traffic Simulation Software

"Can you add this to your existing software?"

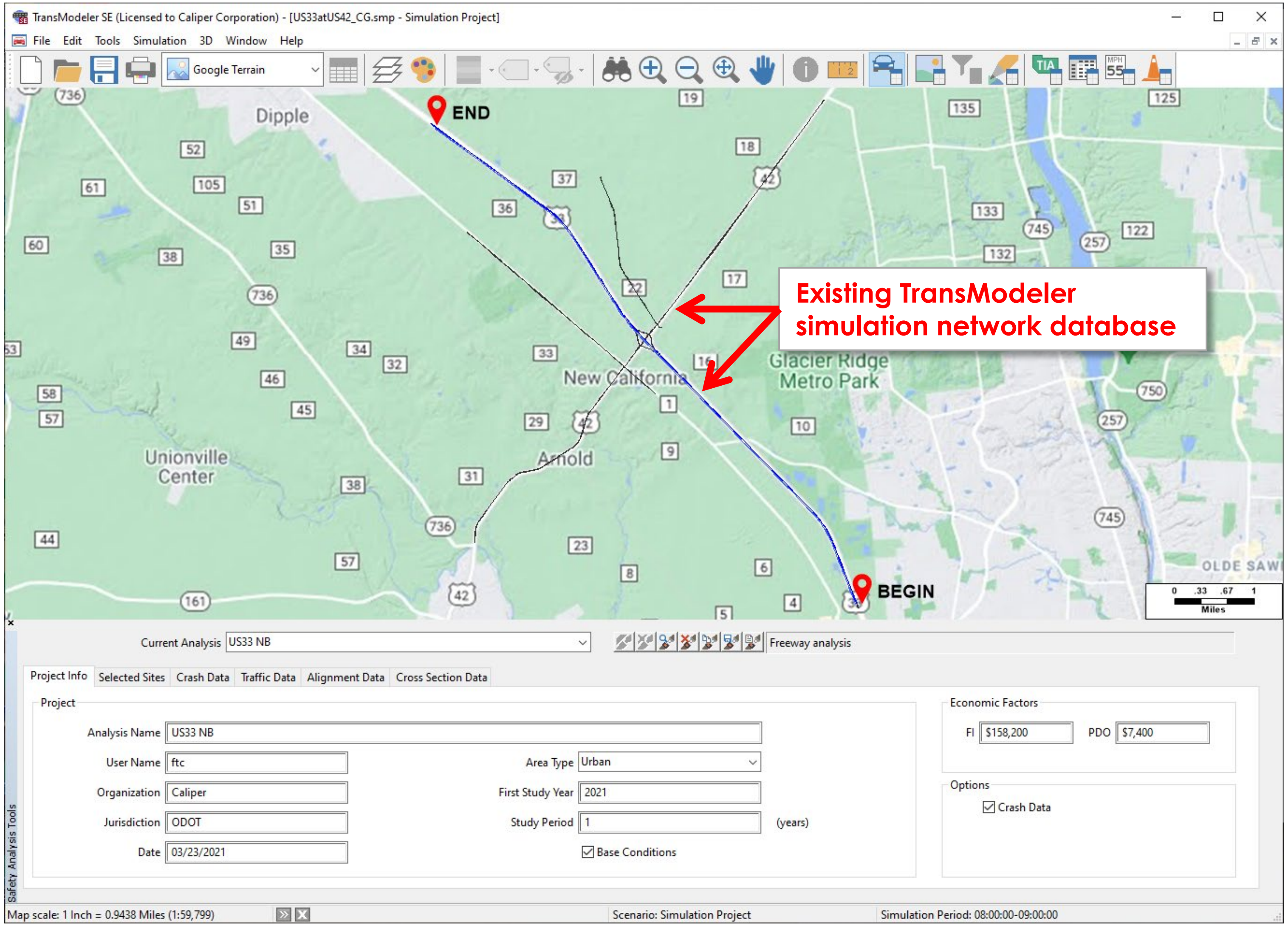
Challenges

- We've never added this type of feature before.
- Microsimulation – What to use and what not to use?
- Auto-identified vs. user input?
- What should the graphical user interface (GUI) look like?
- Agency customization?
  - *Calibration factors*
  - *CMFs*
  - *Severity Distributions*

Benefits

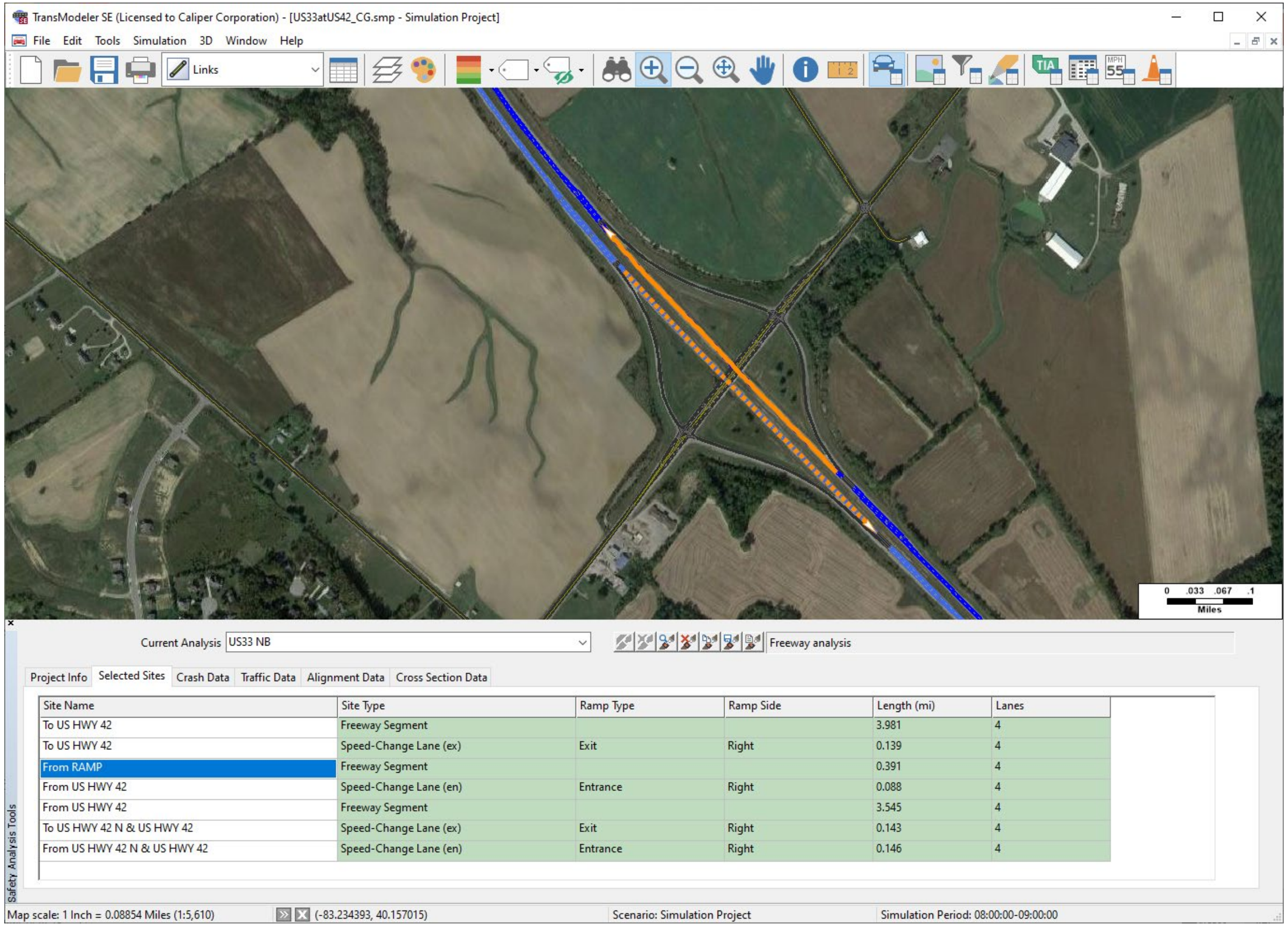
- One tool, multiple purposes
- Take advantage of existing GIS functionality
  - *Roadway geometry*
  - *Automated site classification*
  - *Other spatially referenced data*
- Alternatives analyses → transferability of data

Project Identification



TransModeler
Traffic Simulation Software

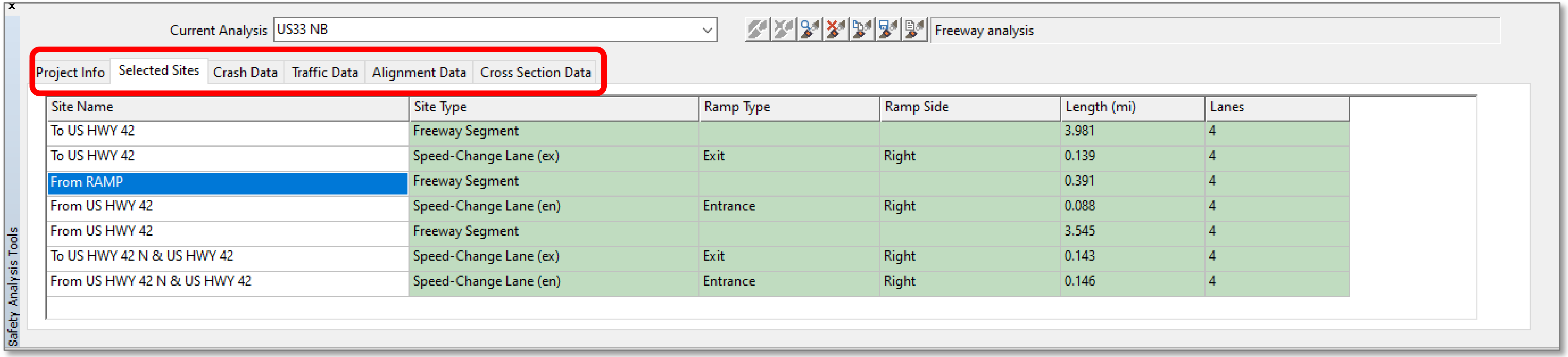
Project Identification



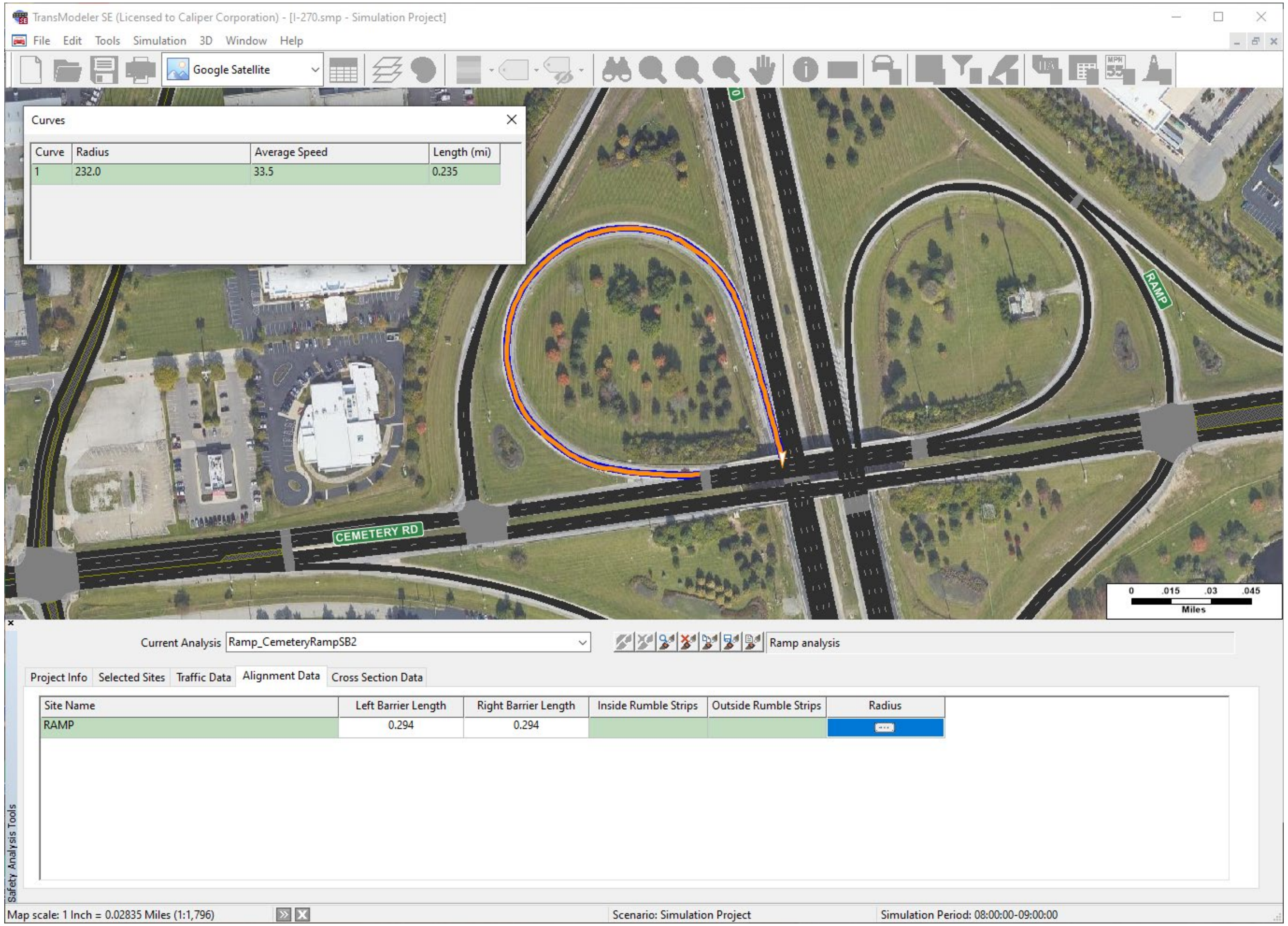
TransModeler
Traffic Simulation Software

Graphical User Interface

- Project Information
- Selected Sites
- Crash Data
- Traffic Data
- Alignment Data (Longitudinal)
- Cross Section Data (Transverse)

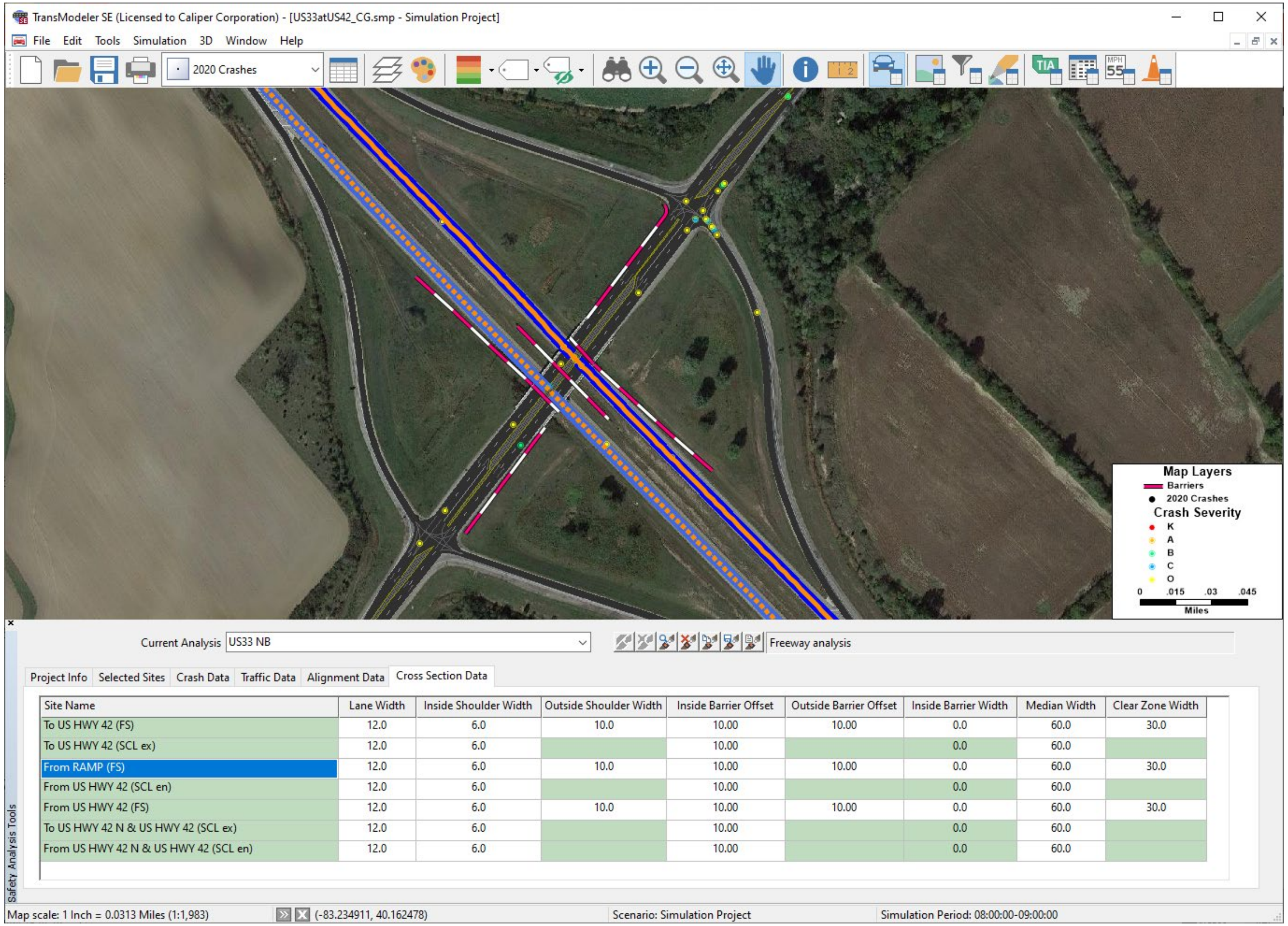


Auto-calculate Curve Radii



TransModeler
Traffic Simulation Software

Geospatial Reference Files



TransModeler
Traffic Simulation Software

How It Works

- Utilize graphical functionality (GIS) of software
- Automatically identify/segment study sections
- User input other analysis variables through GUI
- Perform computations
- Report results

Steps

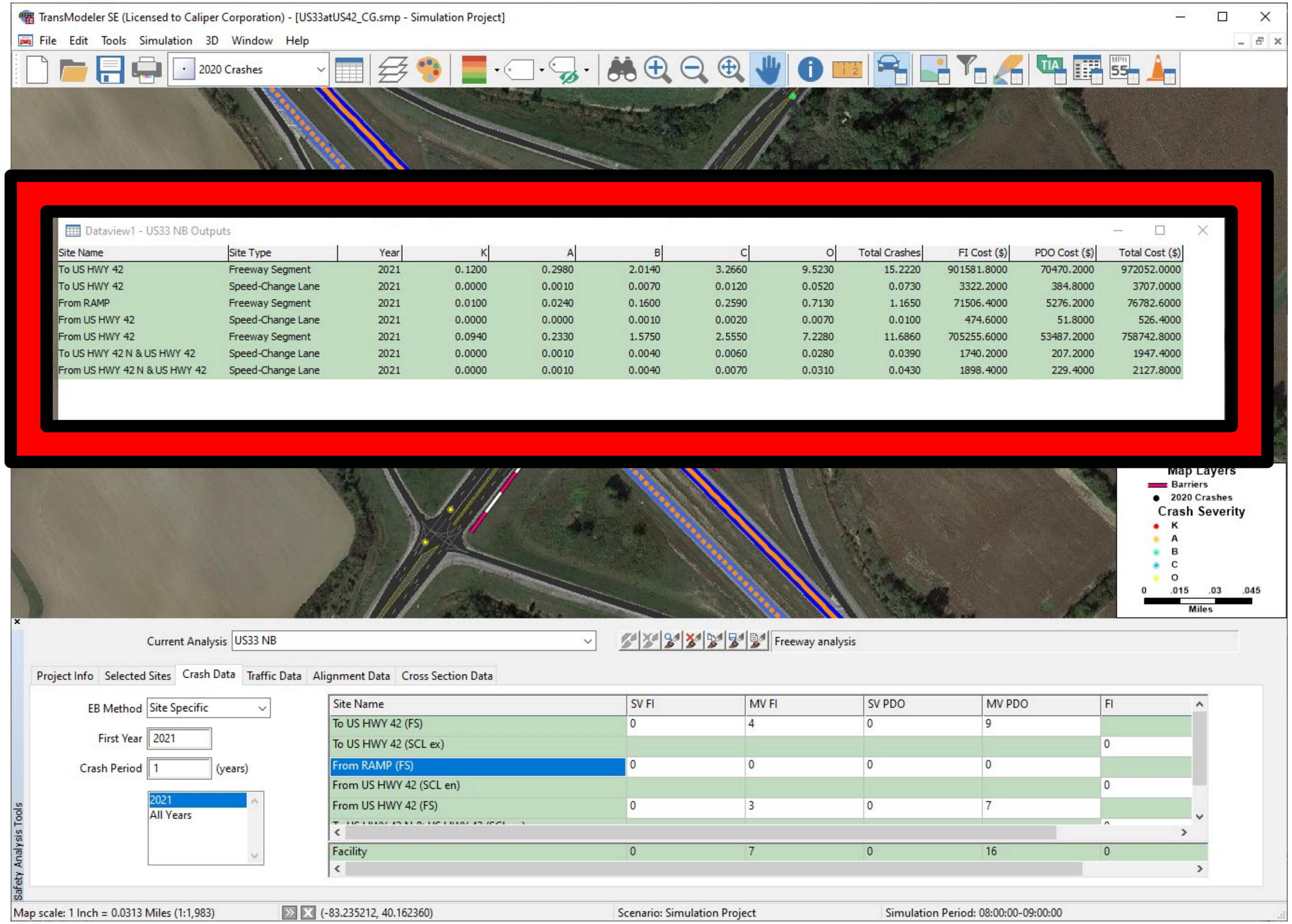
1. Define roadway limits and facility types
2. Determine period of study
3. Determine traffic demand (ADT) and availability of crash data
4. Determine geometric conditions
5. Divide study area into individual sites – freeway segments, ramp or C-D roads, or ramp terminals
6. Assign observed crashes to individual sites (if applicable)

Determined/Applied through GUI

7. Select and apply Safety Performance Functions (SPF)
8. Apply Crash Modification Factors (CMFs)
9. Apply calibration factors
10. Apply site-specific Empirical Bayes method (if applicable) and severity distribution functions (SDFs)
11. Sum predicted/expected crash frequencies for each site

Internal Computations

Tabular Report (TransModeler or CSV)

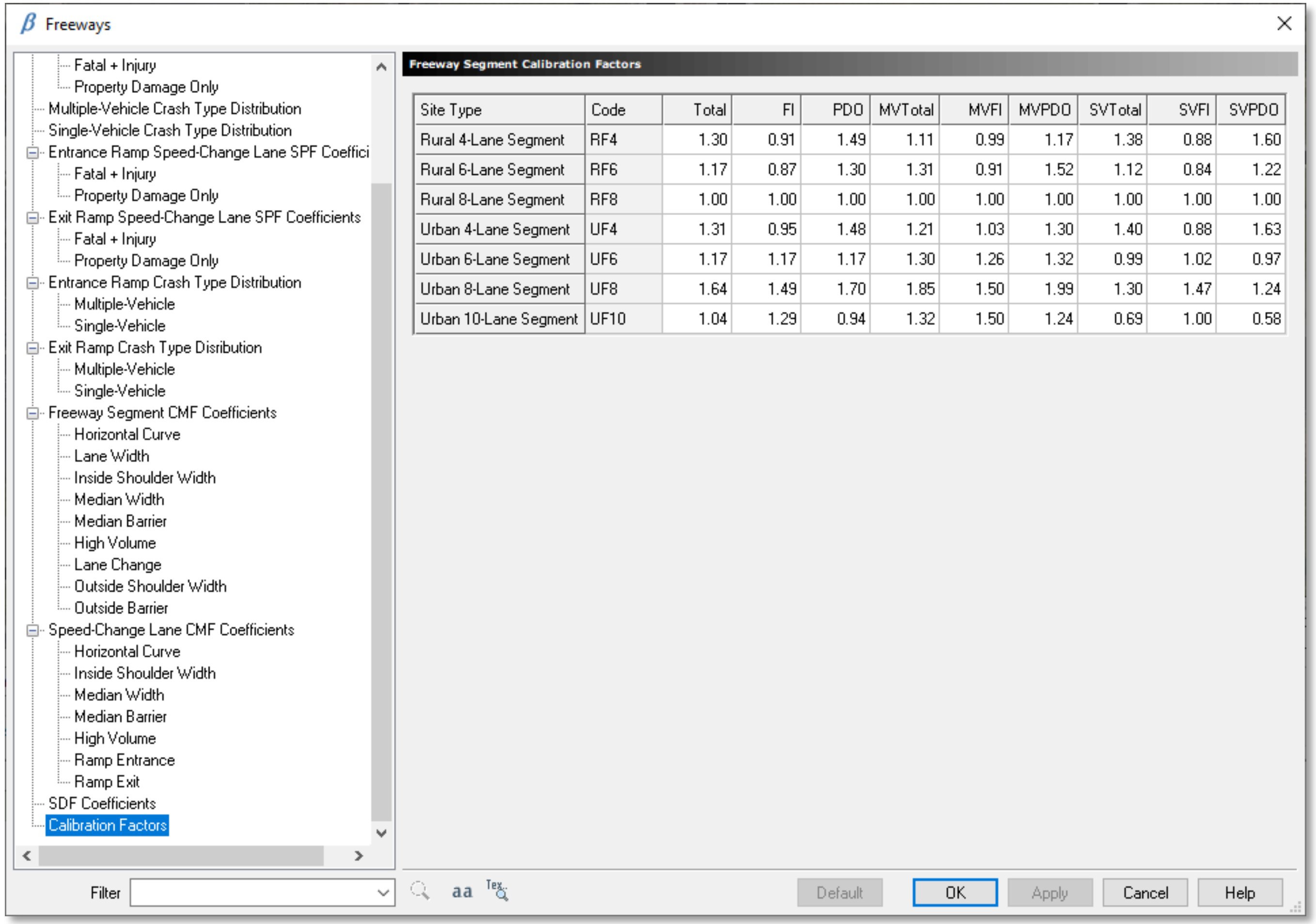


Site Name	Site Type	Year	K	A	B	C	O	Total Crashes	FI Cost ($)	PDO Cost ($)	Total Cost ($)
To US HWY 42	Freeway Segment	2021	0.1200	0.2980	2.0140	3.2660	9.5230	15.2220	901581.8000	70470.2000	972052.0000
To US HWY 42	Speed-Change Lane	2021	0.0000	0.0010	0.0070	0.0120	0.0520	0.0730	3322.2000	384.8000	3707.0000
From RAMP	Freeway Segment	2021	0.0100	0.0240	0.1600	0.2590	0.7130	1.1650	71506.4000	5276.2000	76782.6000
From US HWY 42	Speed-Change Lane	2021	0.0000	0.0000	0.0010	0.0020	0.0070	0.0100	474.6000	51.8000	526.4000
From US HWY 42	Freeway Segment	2021	0.0940	0.2330	1.5750	2.5550	7.2280	11.6860	705255.6000	53487.2000	758742.8000
To US HWY 42 N & US HWY 42	Speed-Change Lane	2021	0.0000	0.0010	0.0040	0.0060	0.0280	0.0390	1740.2000	207.2000	1947.4000
From US HWY 42 N & US HWY 42	Speed-Change Lane	2021	0.0000	0.0010	0.0040	0.0070	0.0310	0.0430	1898.4000	229.4000	2127.8000

Site Name	SV FI	MV FI	SV PDO	MV PDO	FI
To US HWY 42 (FS)	0	4	0	9	
To US HWY 42 (SCL ex)					0
From RAMP (FS)	0	0	0	0	
From US HWY 42 (SCL en)					0
From US HWY 42 (FS)	0	3	0	7	
Facility	0	7	0	16	0

Agency Customization

- Geometric Parameters
- AADT Ranges
- Crash Severity Distribution
- Calibration Factors



Status

- TransModeler/TransModeler SE Version 6.0
- Beta testing
- HSM Part C Predictive Methods
  - *Chapter 18*
    - Freeway Segments
    - Speed-Change Lanes
  - *Chapter 19*
    - Ramps
    - Ramp Terminal Intersections
- Volunteers

THANK YOU!

Tom Creasey
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(617) 775-5759

Open Discussion

Core Competencies of the Traffic Analysis, Modeling, and Simulation Practitioner

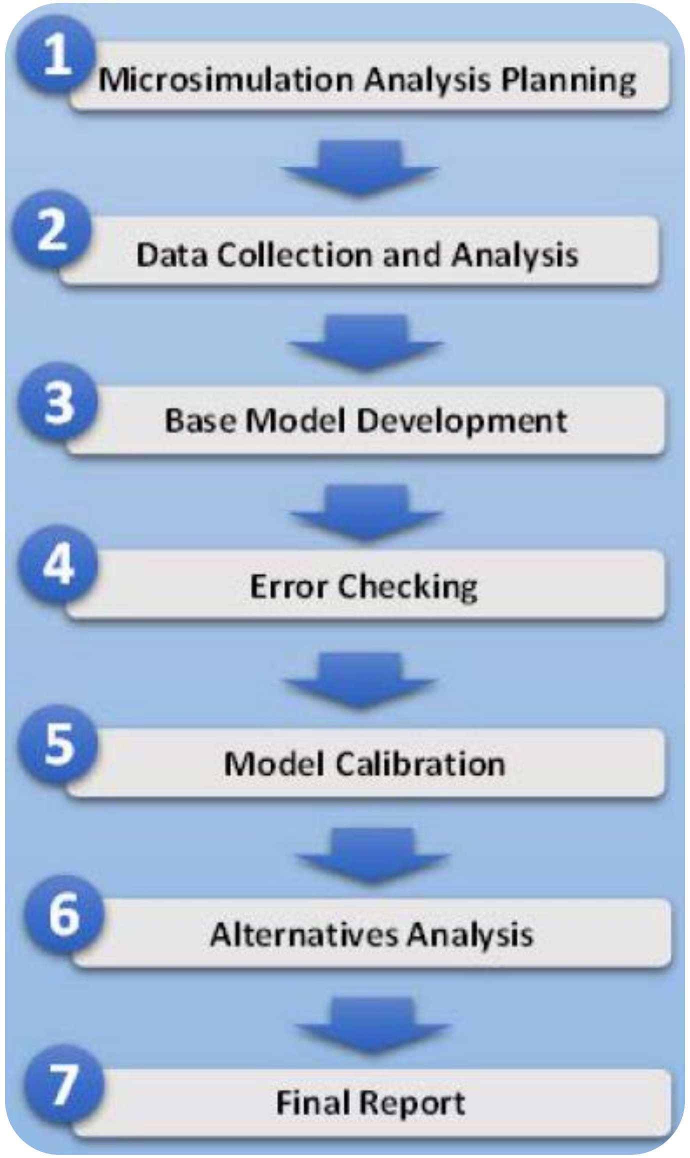
Chris Melson

LTAP Program Manager

LOCAL TECHNICAL ASSISTANCE PROGRAM
LTAP
LOUISIANA TRANSPORTATION RESEARCH CENTER

Overview of Initiative

- **Purpose**
  - Determine core competencies of TAMS practitioner
- **Benefit**
  - Provide foundational structure to:
    - Organize resources
    - Identify user needs
    - Address “gaps”
  - Supplement national guidance
  - Inform educational curriculum
  - Agency-specific use



Core Competency Areas

Data

Modeling Best Practices

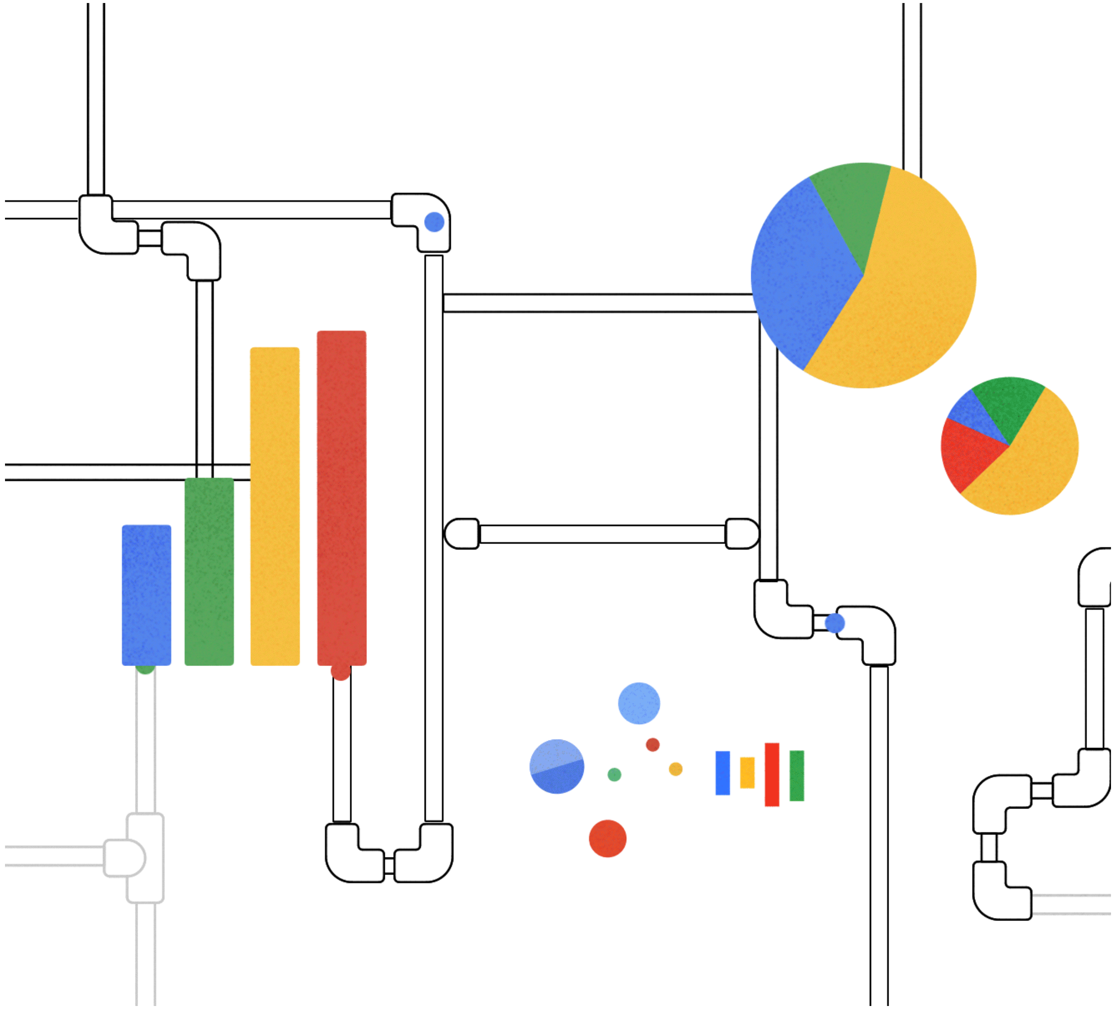
Principles of Traffic Engineering (and Related)

Modeling Software

Applications to Be Modeled

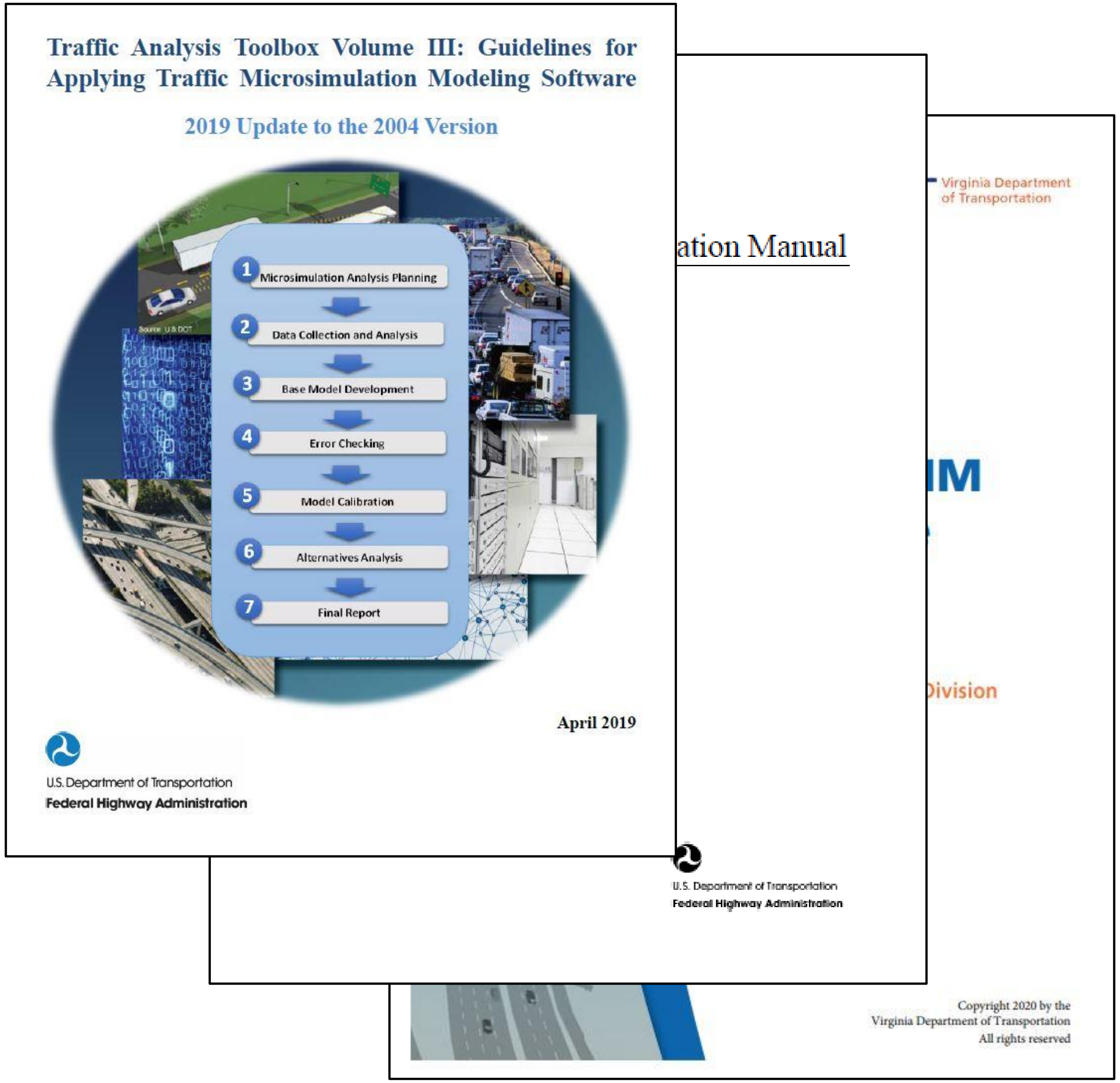
Data

- Data Requirements
- Data Sources
- Data Analysis
- GIS Tools
- Statistical Analysis



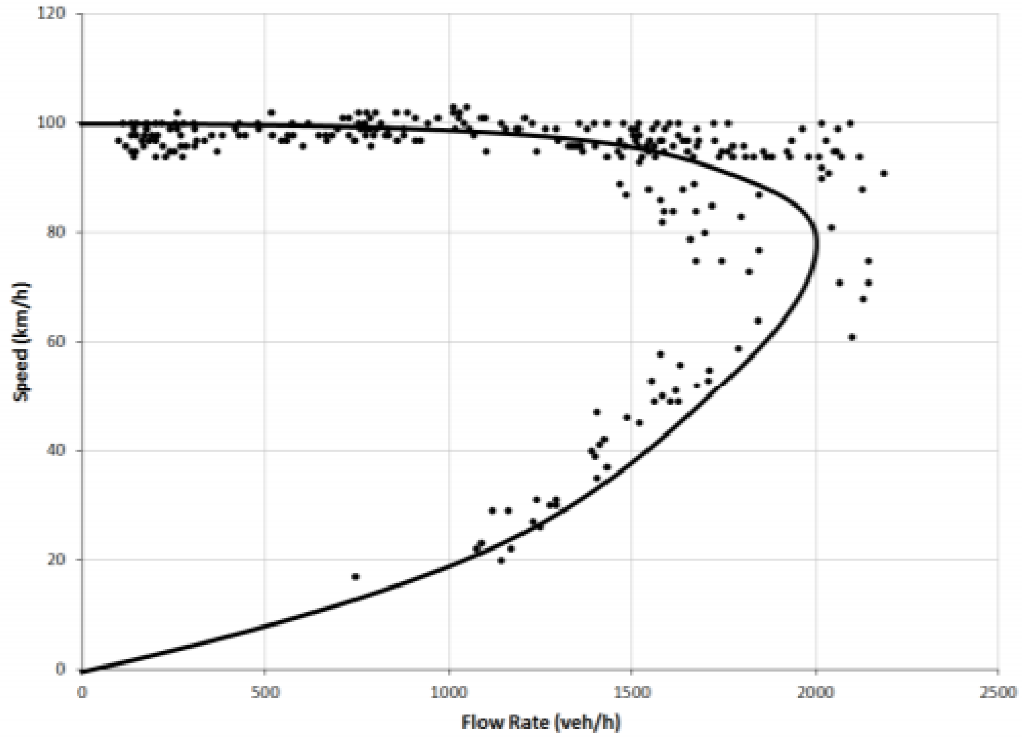
Modeling Best Practices

- Best Practices
- Internal Processes
- Technical Report and Correspondence Writing



Principles of Traffic Engineering (and Related)

- Traffic Flow Theory and Characteristics
- Traffic Engineering Studies
- Transportation Planning
- Traffic Signal Operation
- Geometric Design
- Driver Behavior
- Economic Evaluation



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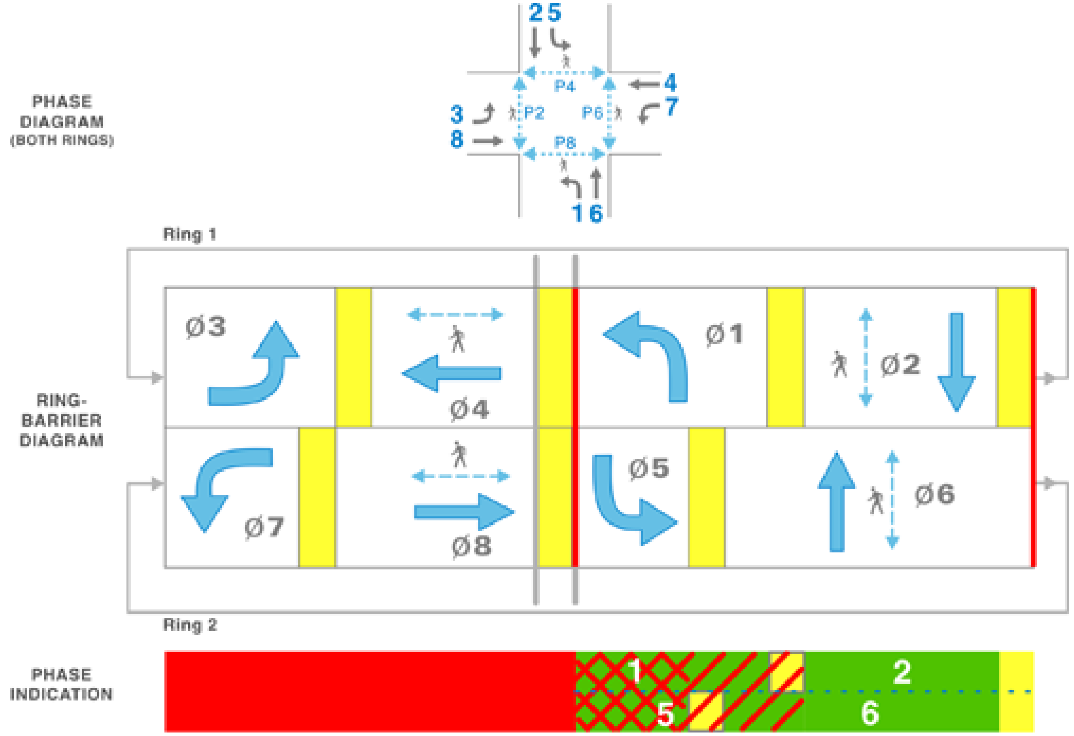

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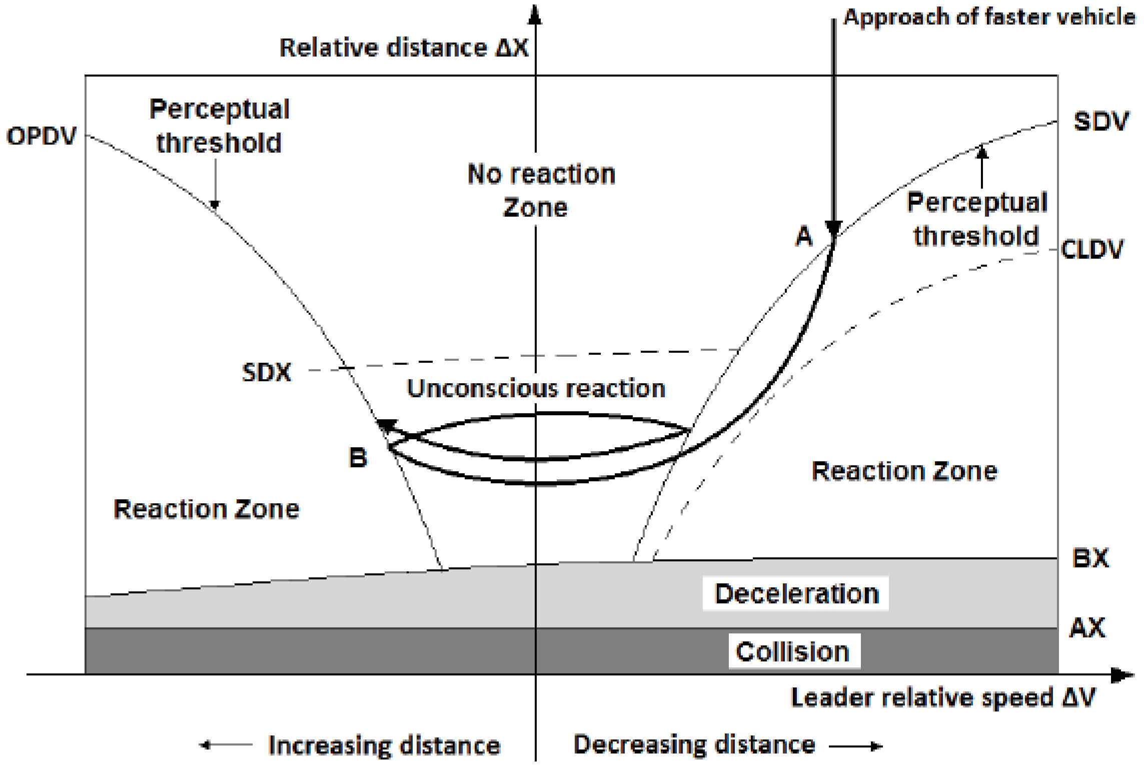

Modeling Software

- Modeling Software

Applications to be Modeled

- Intelligent Transportation Systems
- Traffic Management Strategies
- Mobility as a Service (MaaS)
- Multi-Modal Transportation Systems
- Real-Time Decision Support
- Connected and Automated Vehicles

Survey

- Rate importance of each core competency
  - High Importance
  - Substantial Importance
  - Moderate Importance
  - Low Importance
  - No Importance
- Opportunity to add/modify core competencies

https://bit.ly/2Tw46pC

Questions?

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Thank You!