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Applying Traffic Engineering Tools to Resource Road Safety

FPInnovations Webinar

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Responding to members' needs

BC Forests, Lands, Natural Resource Operations & Rural Development, industrial resource road operators

NEED:
Systematic and objective methodology to assess safety of resource roads

Road: quantification of safety

Vehicles: assess safe traffic capacity

Traffic Engineering

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Traffic engineering components

Vehicle Data

- Collection methods
- Safety analysis
  - Now/future **safe capacity**
  - Traffic mitigation methods

Road Data

- Collection methods
- Analysis methods
- Cost issues
- Refinement of collection, analysis, and reporting

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Overview of presentation

Theory:

- Need for field data collection, traffic microsimulation

Traffic data:

- Tools used, costs, limitations, post-processing

Microsimulation:

- How traffic field data fits, workflow, possible analyses

Conclusions:

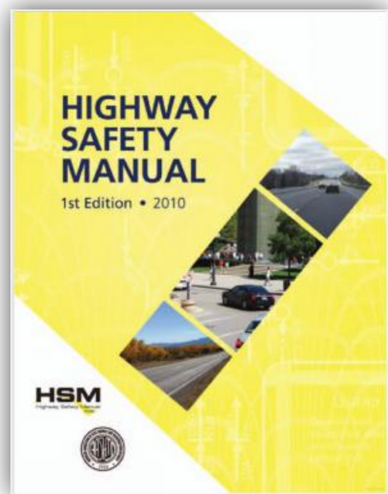
- Benefits , questions, your insights, conversation

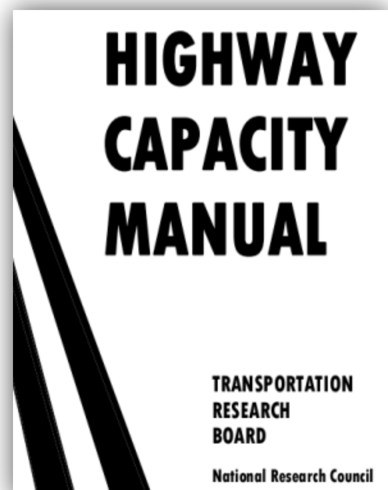
Theory: related fields

Calibrating your crash data to crash data database

“Safe Capacity”

“Level of service” based on measures of effectiveness



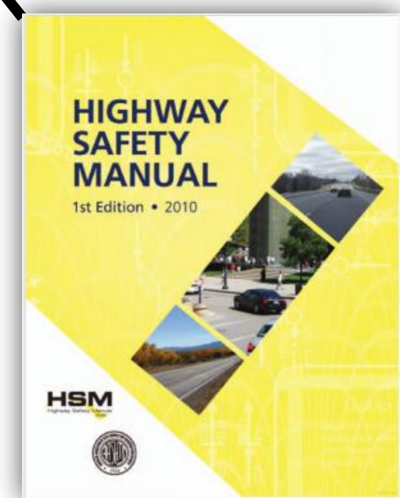


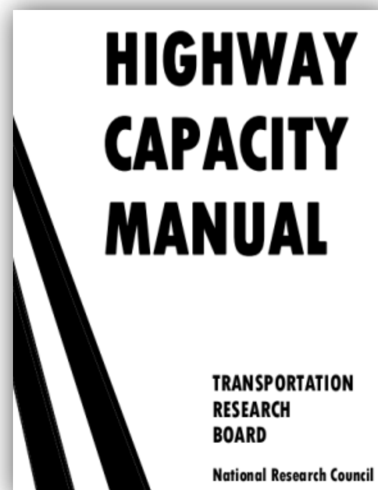
Theory: related fields

Requires crash data for CMFs and SPFs (not available)

"Safe Capacity" of resource roads

Does not have any directly applicable solutions



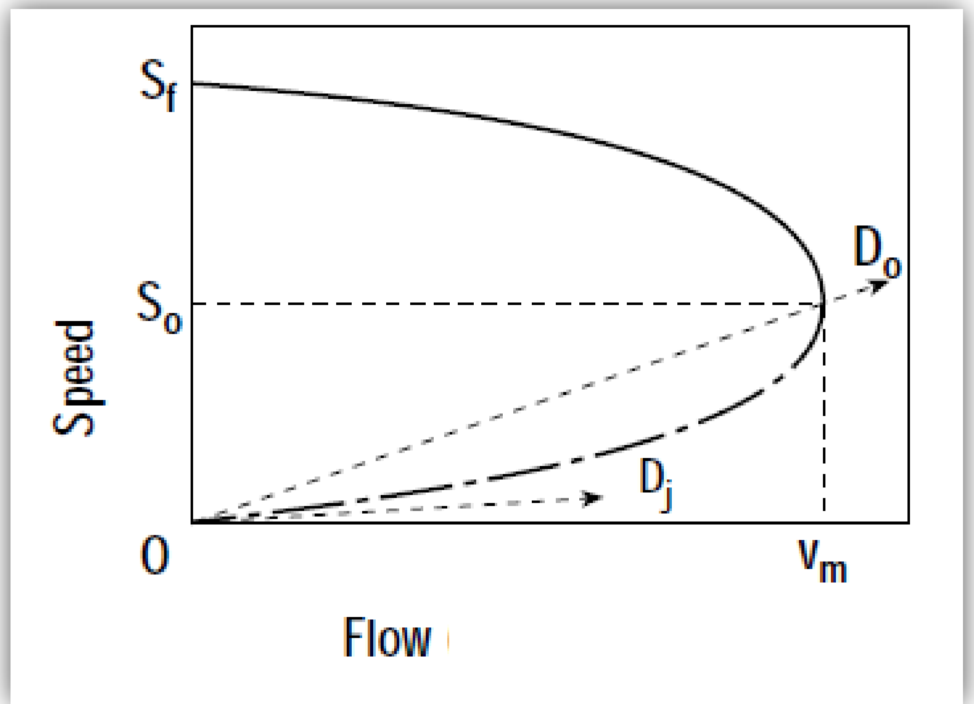


Better safety ≠ Better level of service

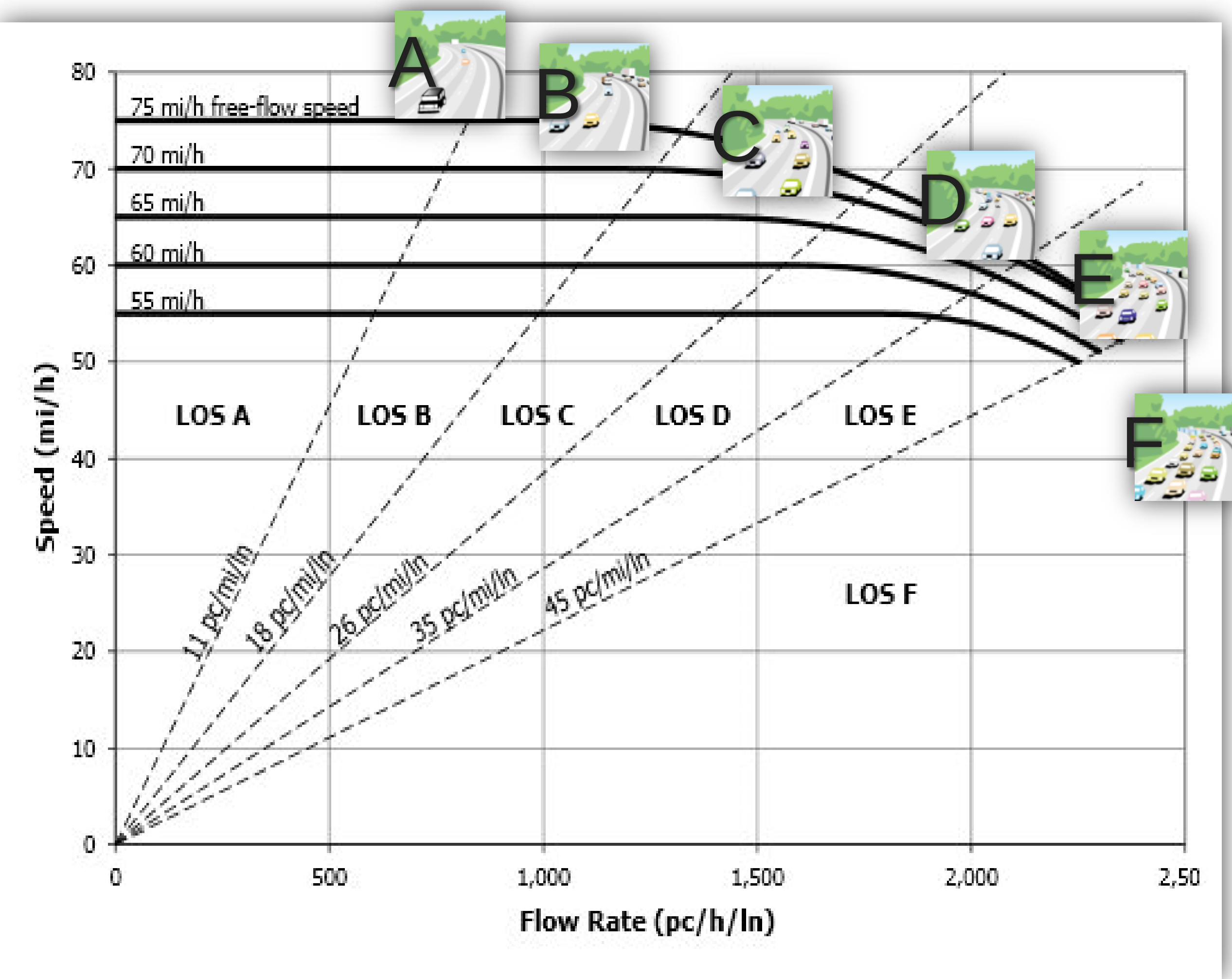
Theory: capacity

Capacity: hard to measure directly

Capacity analysis: considers a "prescribed" level of operation



Theory: level of service – multilane highway



LOS: "[quantitative] quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as:

- speed/travel time
- Freedom to maneuver
- Traffic interruptions
- Comfort and convenience"

- HCM

Theory: LOS – multilane highway

Free flow speed

Always 6 LOS levels

first five are “operational”

sixth is a “fail”

A

Operation at/above posted speed

B

Operation at posted speed,
good maneuverability,
good comfort

C

Operation at/near posted speed,
maneuverability noticeably restricted

D

Operation speed starts to decline,
reduced comfort

E

Operation at capacity, maneuverability
very limited,
poor comfort

F

Operation is in a flow breakdown

Images from:: http://www.mdta.maryland.gov/I95section100DELETE/i95-sect100_los.html

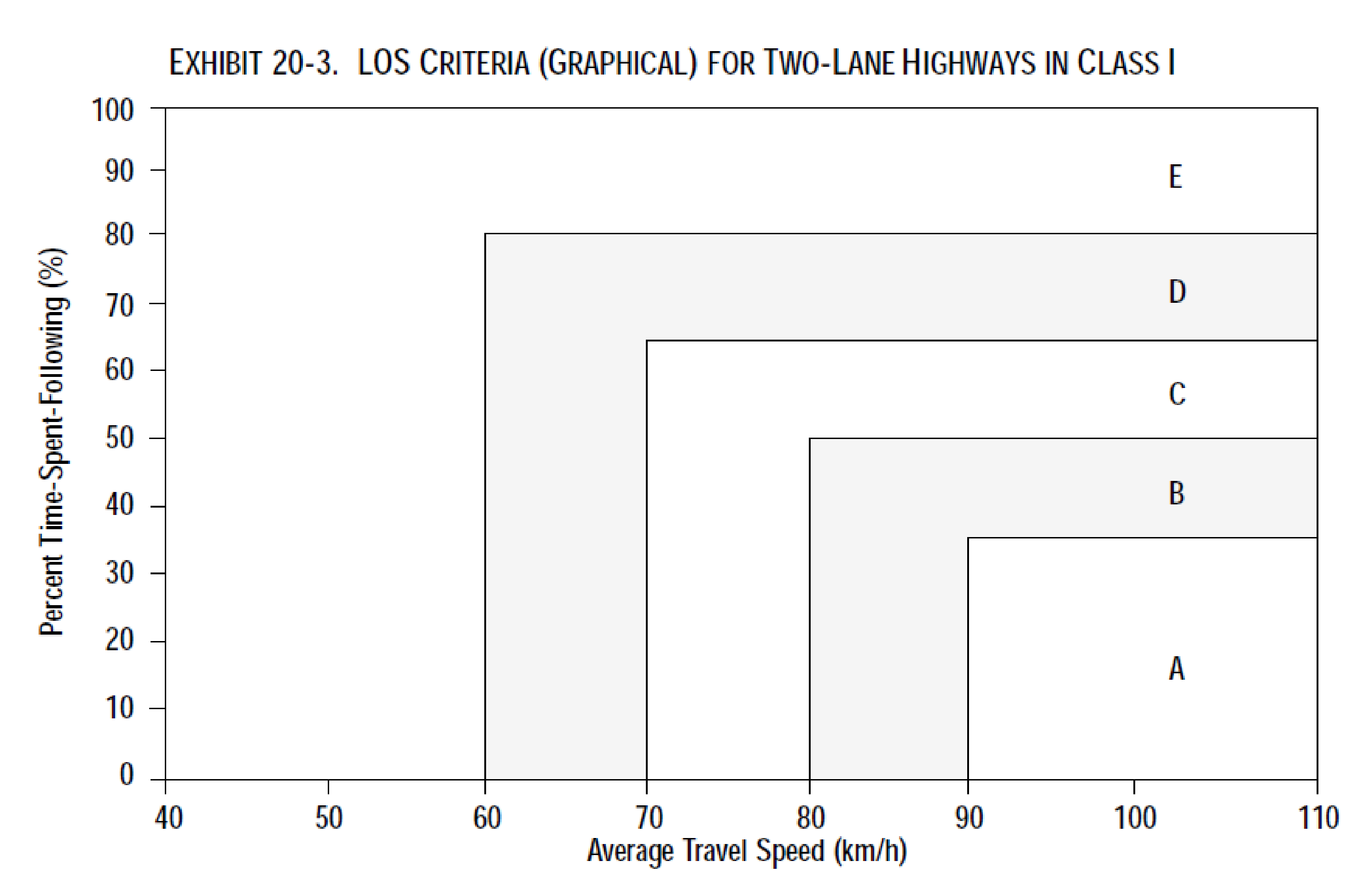
Theory: measures of effectiveness

- MOE metrics used by LOS
- MOE: many kinds
- Different MOE for various infrastructure

	Speed	Density	PTSF	Delay
Multilane Highway	X	X		
Two Lane Highway	X		X	
Urban street	X			
Intersection				X

PTSF = percent time spent following

Theory: LOS – two-lane highway



Theory: LOS – two-lane highway

EXHIBIT 12-5. EXAMPLE SERVICE VOLUMES FOR MULTILANE HIGHWAYS
(SEE FOOTNOTE FOR ASSUMED VALUES)

FFS (km/h)	Number of Lanes	Terrain	Service Volumes (veh/h) A	B	C	D	E
100	2	Level	1200	1880	2700	3450	4060
		Rolling	1140	1800	2570	3290	3870
		Mountainous	1040	1640	2350	3010	3540
	3	Level	1800	2830	4050	5180	6100
		Rolling	1710	2700	3860	4940	5810
		Mountainous	1570	2470	3530	4520	5320
80	2	Level	960	1510	2190	2920	3520
		Rolling	910	1440	2090	2790	3360
		Mountainous	830	1310	1910	2550	3070
	3	Level	1440	2260	3290	4390	5290
		Rolling	1370	2160	3140	4180	5040
		Mountainous	1250	1970	2870	3830	4610

Notes:
Assumptions: highway with 100-km/h FFS has 5 access points/km; highway with 80-km/h FFS has 15 access points/km; lane 0
width = 3.6 m; shoulder width > 1.8 m; divided highway; PHF = 0.88; 5 percent trucks; and regular commuters.

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Theory: LOS – interrupted flow

EXHIBIT 15-2. URBAN STREET LOS BY CLASS

Urban Street Class	I	II	III	IV
Range of free-flow speeds (FFS)	90 to 70 km/h	70 to 55 km/h	55 to 50 km/h	55 to 40 km/h
Typical FFS	80 km/h	65 km/h	55 km/h	45 km/h
LOS	Average Travel Speed (km/h)			
A	> 72	> 59	> 50	> 41
B	> 56–72	[illegible]	[illegible]	> 32–41
C	> 40–56	[illegible]	[illegible]	> 23–32
D	> 32–40	[illegible]	[illegible]	> 18–23
E	> 26–32	[illegible]	[illegible]	> 14–18
F	≤ 26	[illegible]	[illegible]	≤ 14

SIGNAL DENSITY BY URBAN STREET CLASS

Urban Street Class	Default (signals/km)
I	0.5
II	2
III	4
IV	6

Theory: what about a resource road?

- Does not deal with weather, large grades, passing lanes, narrow bridges…
- Points to traffic simulation for more complex situations

Measuring traffic characteristics (MOE) → Simulation

↓ "As is" Analysis

↓ "What if" Analysis

Theory: traffic metrics related to safety

- Roads with radio-controlled one lane sections:
  - Number of pullout occurrences
  - Total time spent stopped at pullouts (delay)
  - Number of pullout overcrowding events
- General metrics for any road:
  - Percent time spent following
  - Number of passing occurrences
  - Average speed and variance
  - Vehicle type classification
  - Average traffic volumes per hour

How to get all this data… economically?

Traffic data: magnetic counters

- Relatively inexpensive ($400)
- TrafX is industry standard
- Not always reliable

- Count

TRAFx

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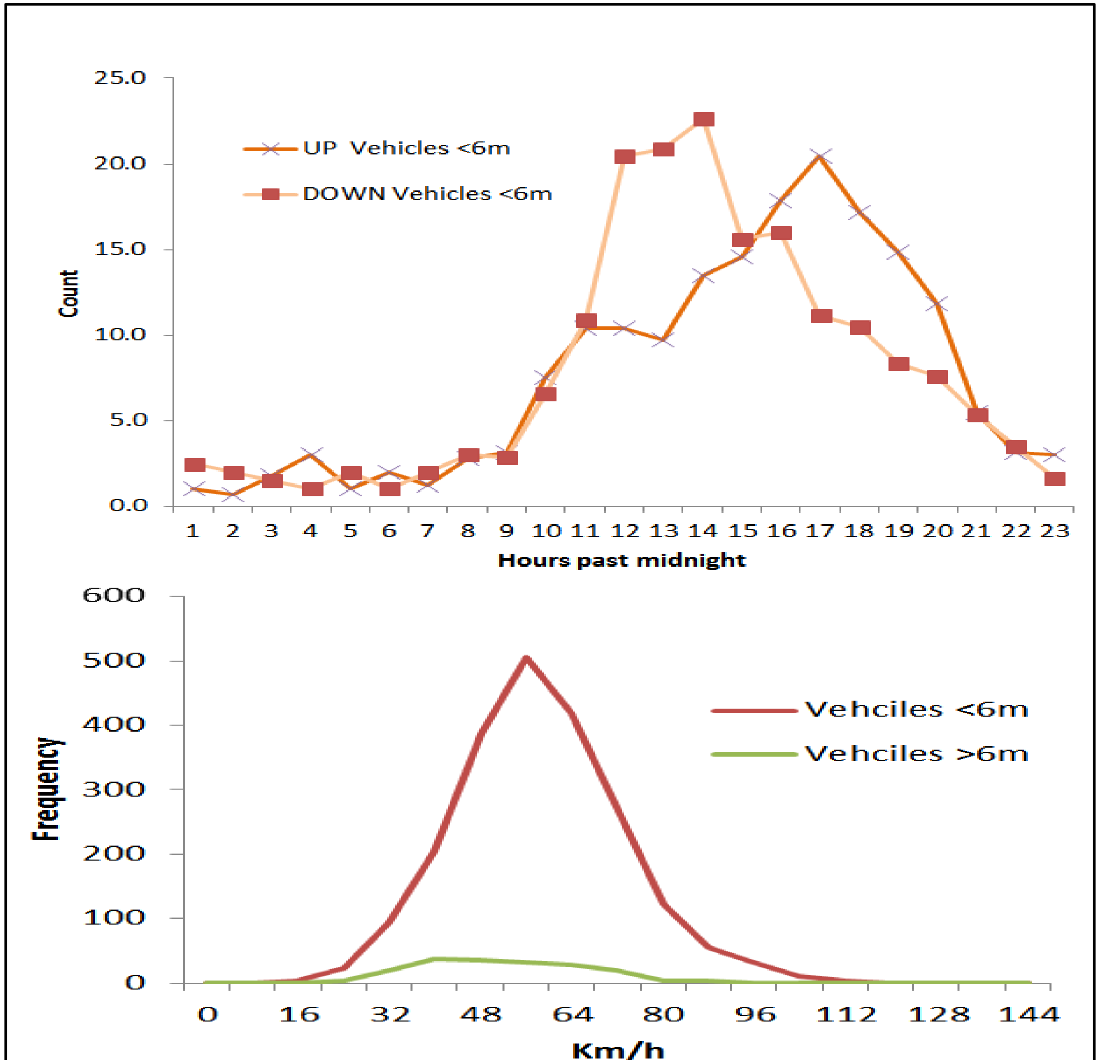
Traffic data: radar

- On straight part of road, facing particular angle, clear shot
- $5000 +

- Spot speed
- Direction
- Vehicle length

Traffic data: radar post-processing



Insights:

- Traffic flow patterns over time of day
- Distribution of spot speed for vehicle length categories
- Headway distribution/ percent vehicle following (1 second time resolution)
- …

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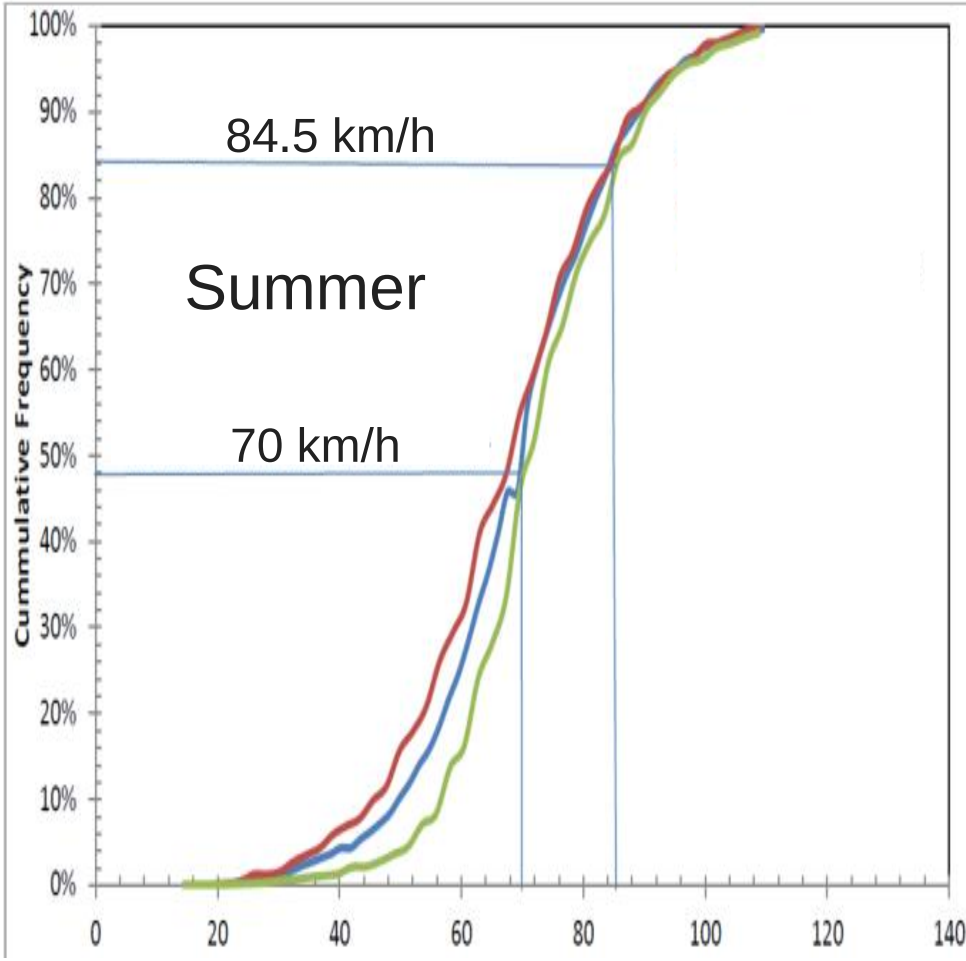
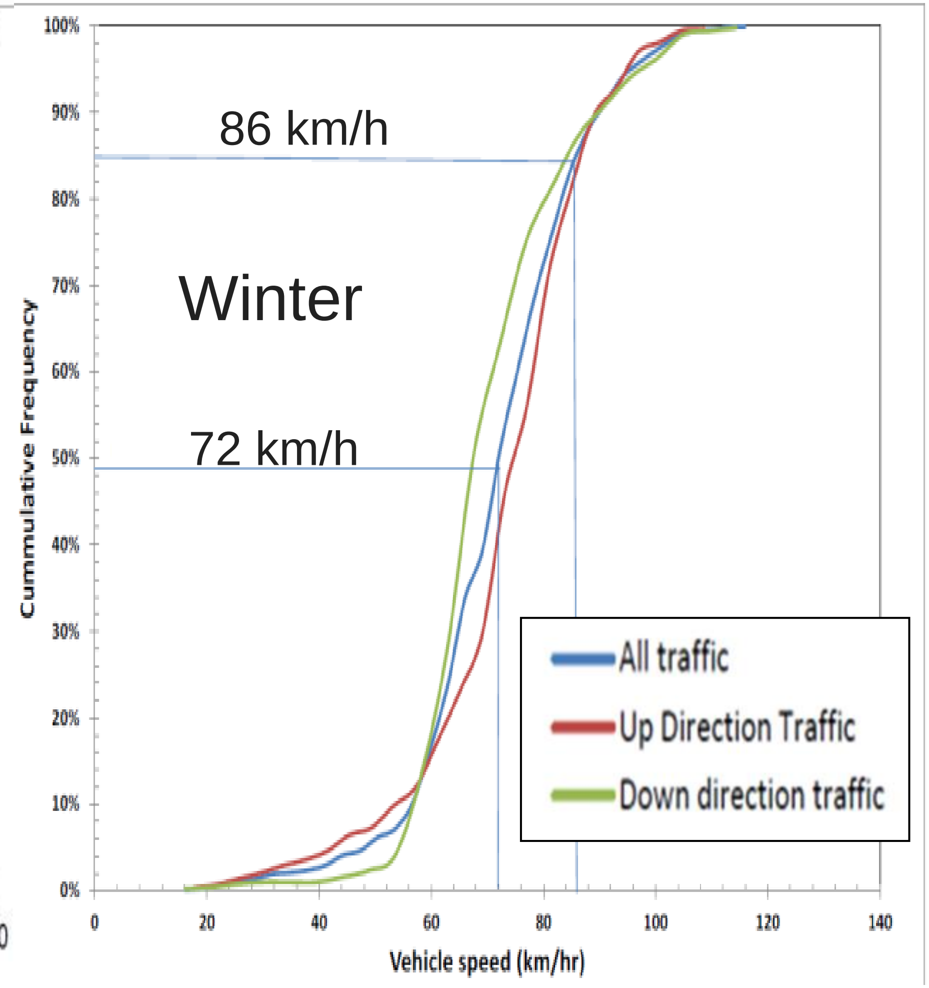
Traffic data: radar post-processing





Traffic data: motion cameras

- Tested four motion cameras ($150 - $700):
  - produced timekeeping
  - unreliable in capturing fast vehicles or vehicles that are following other

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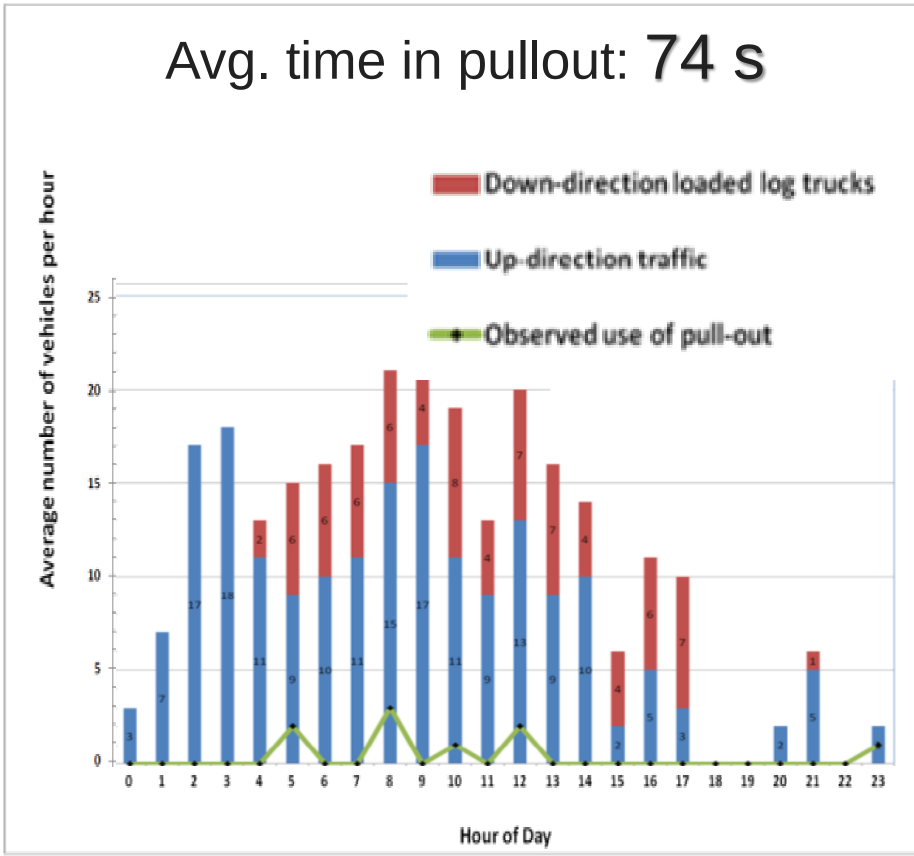
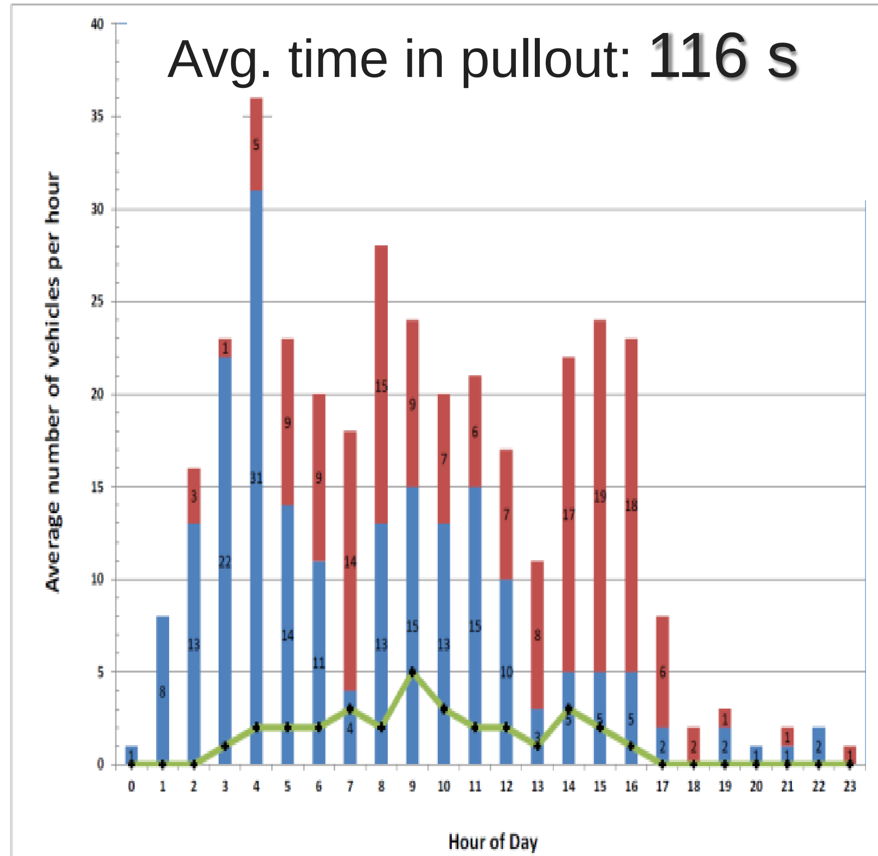
Traffic data: motion cameras post-processing

Summer



Winter



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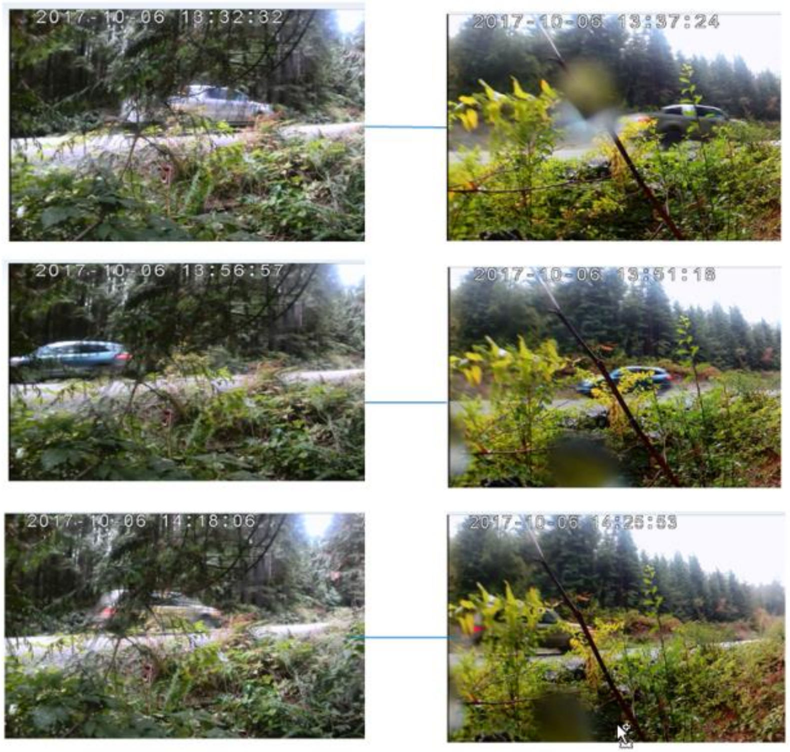
Traffic data: video cameras

- Camera + SD card + waterproofing + battery (as low as $300)

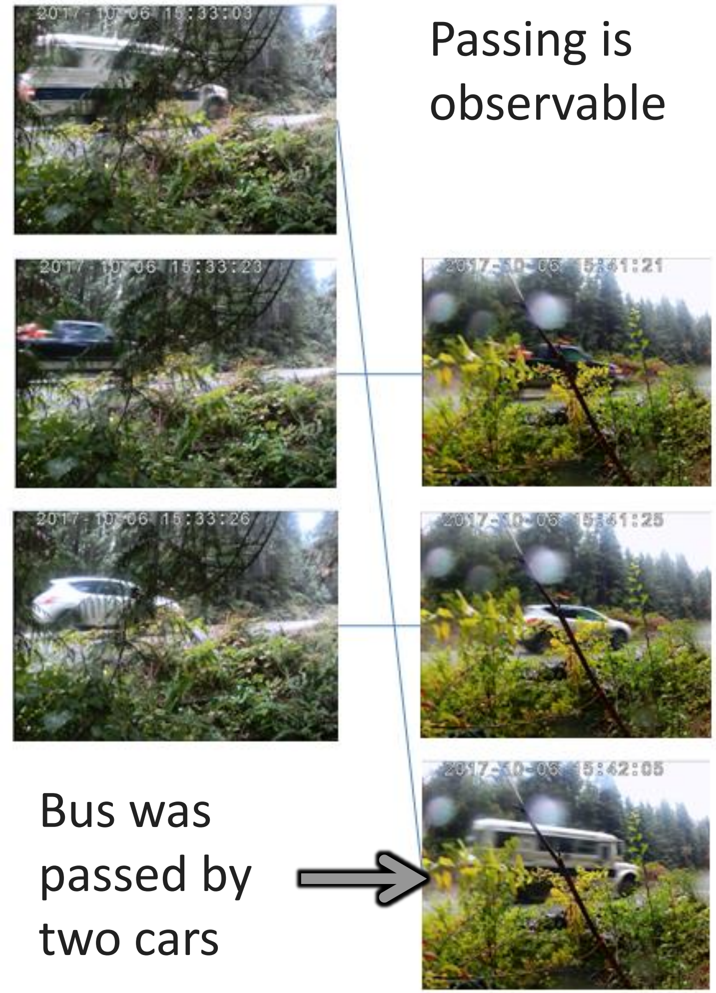
- Capture all traffic reliably with relatively little time drift

Traffic data: video post-processing



Speeds for types of vehicle over a road segment

Passing is observable

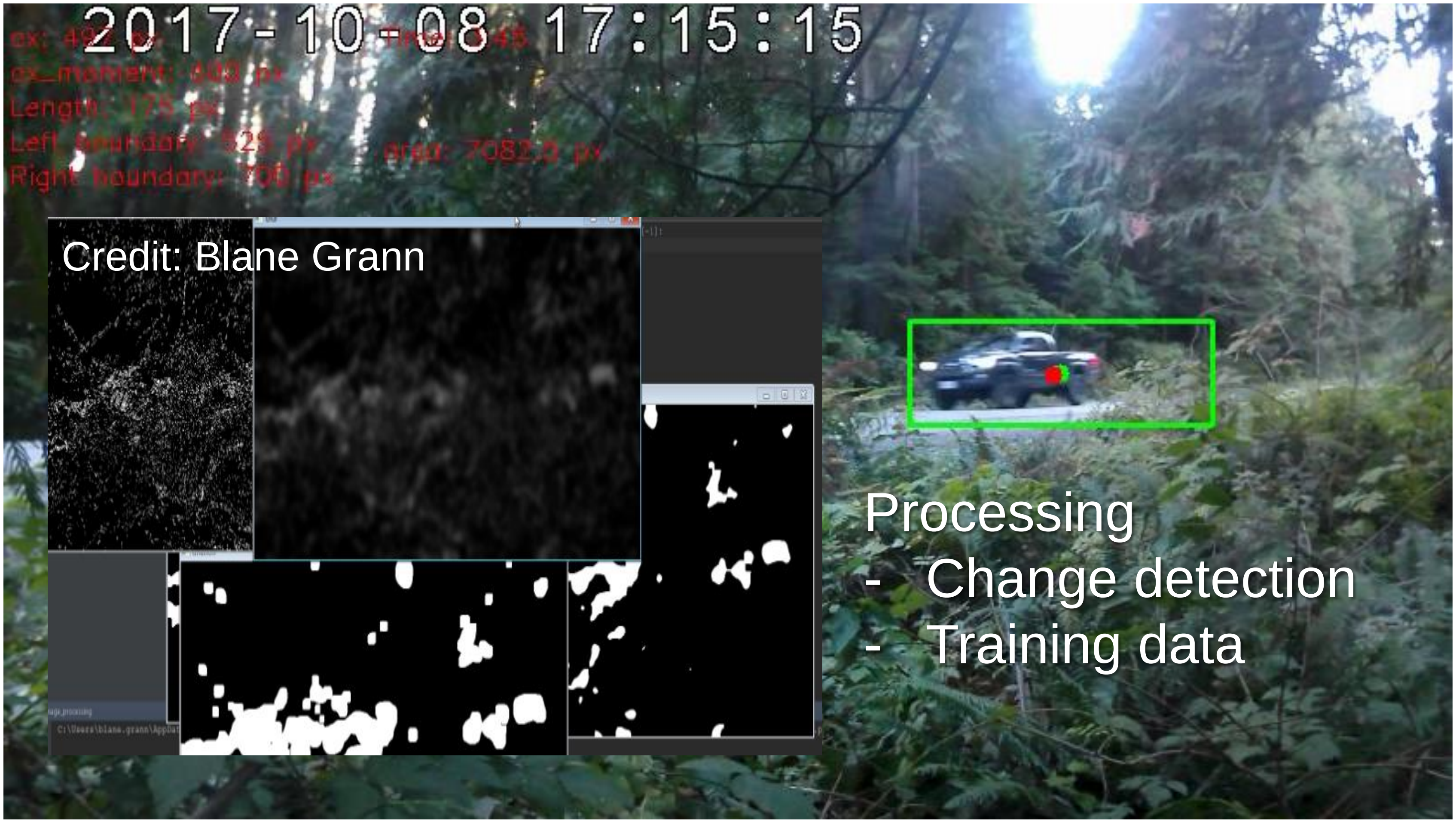


Bus was passed by two cars

Traffic data: video post-processing

Traffic data: video post-processing

Traffic data: video post-processing



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Traffic data: video post-processing

Traffic data: video post-processing

Microsimulation: data collection needs

Finlay FSR (60KM)

Interior BC

Industrial traffic

One lane sections

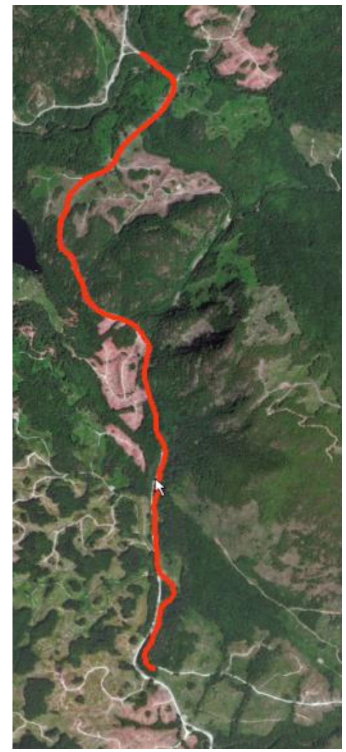
Florence FSR (8KM)

Coastal BC

Recreational traffic

Four one lane bridges

Bamfield Main (7KM)



Coastal BC

Mixed traffic

One lane section

Various tools:

- Roadside sensors
- GPS mapping
- Interviews
- GPS on trucks

Left out ~ 1 week

Need input and validation data

Microsimulation: definition

“[Traffic] Micosimulation models are dynamic, stochastic, discrete time modelling techniques that simulate the movement of individual vehicles based on car-following, lane changing and gap acceptance algorithms that are updated several times every seconds. These vehicle-to-vehicle interactions provide the basis for calculating delays”

– Traffic Modeling Guidelines, Transport Roads & Maritime Services (2013)

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Microsimulation: process

1. **Verification:**
   - Making sure there are no logic errors in the model (using general observation/knowledge)
2. **Calibration:**
   - Iterating model parameters so that output variable matches the *field observations*
3. **Validation:**
   - Use *field data* that was not used during calibration as a final check of road model
4. **Output**:
   - Run many simulations to create average and variance for metrics of interest

Main | Dynamic Models | Microscopic Model | Attributes

Main | Experiment Defaults

	Mean	Deviation	Minimum	Maximum
Speed Acceptance	0.80	0.70	0.50	0.80
Clearance	1.00 m	0.00 m	1.00 m	1.00 m
Maximum Yield Time	4.00 secs	5.00 secs	4.00 secs	30.00 secs
Guidance Acceptance	10.00 %	0.00 %	10.00 %	100.00 %
Value of Time	0.00 $/h	0.00 $/h	0.00 $/h	0.00 $/h

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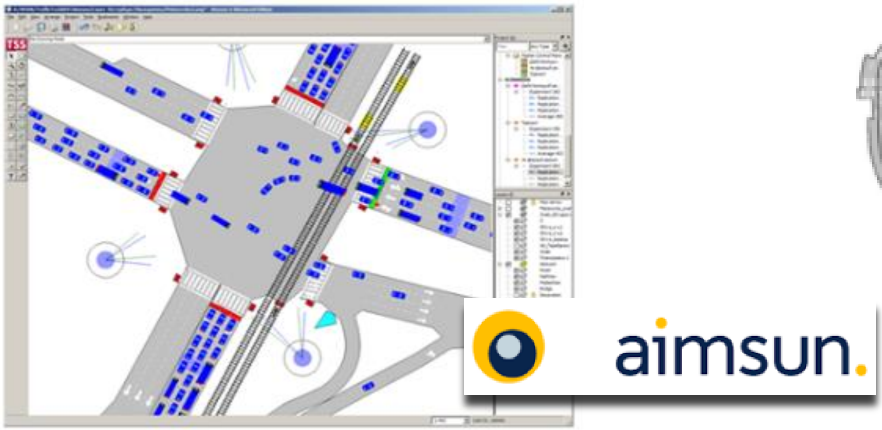
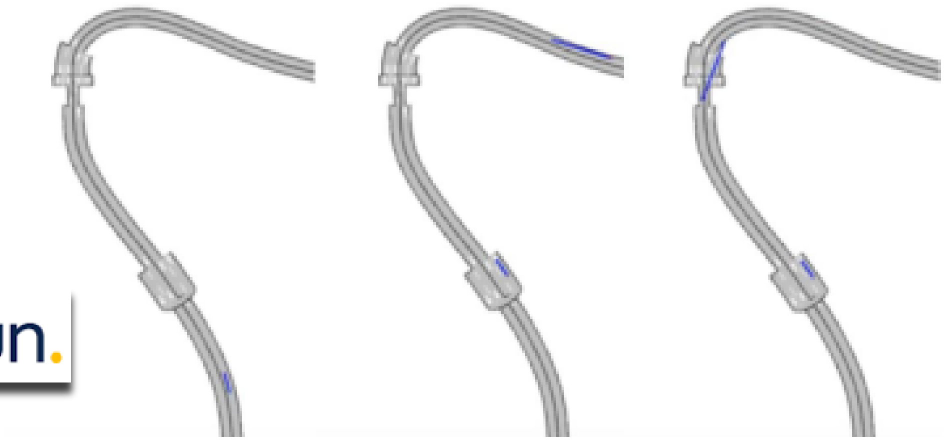
Microsimulation: tool developed





API was developed to accommodate radio pullout use

- pullout rules / conditions
- radio calls – supports % without radios
- slowing down/pulling over for loaded vehicles
- counting statistics unique to resource roads
- defining behaviors of various vehicles
- scripts that automate building Aimsun models

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Microsimulation: entire workflow

Traffic data and Field mapping

↓

Cleaning/preparing all data

↓

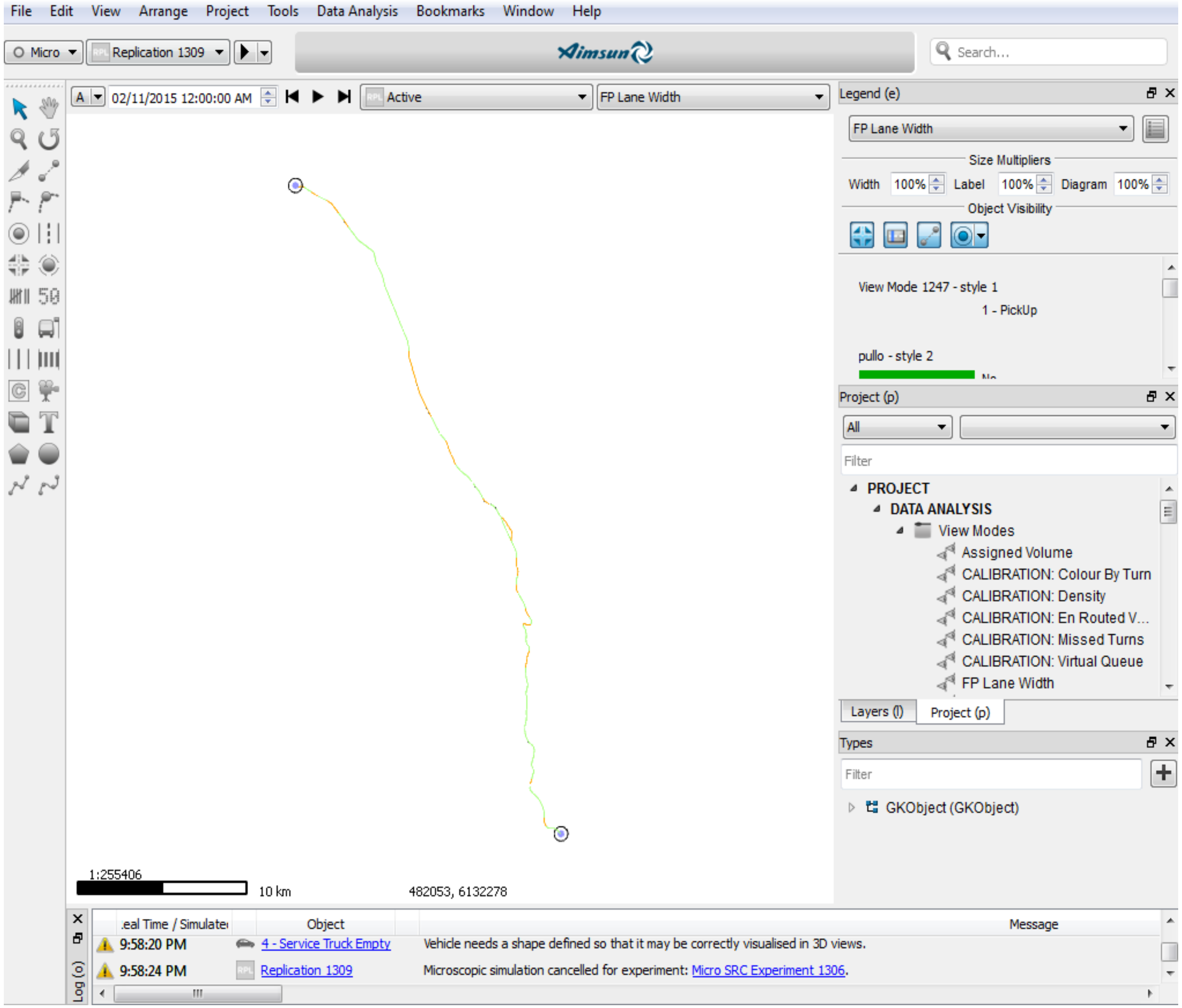
Aimsun scripts to automate building models

↓

Calibrate simulation

↓

Make change and generate output metrics of interest



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Microsimulation: entire workflow

Traffic data and
Field mapping

↓

Cleaning/preparing
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↓

Aimsun scripts to
automate building
models

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Calibrate simulation

↓

Make change and
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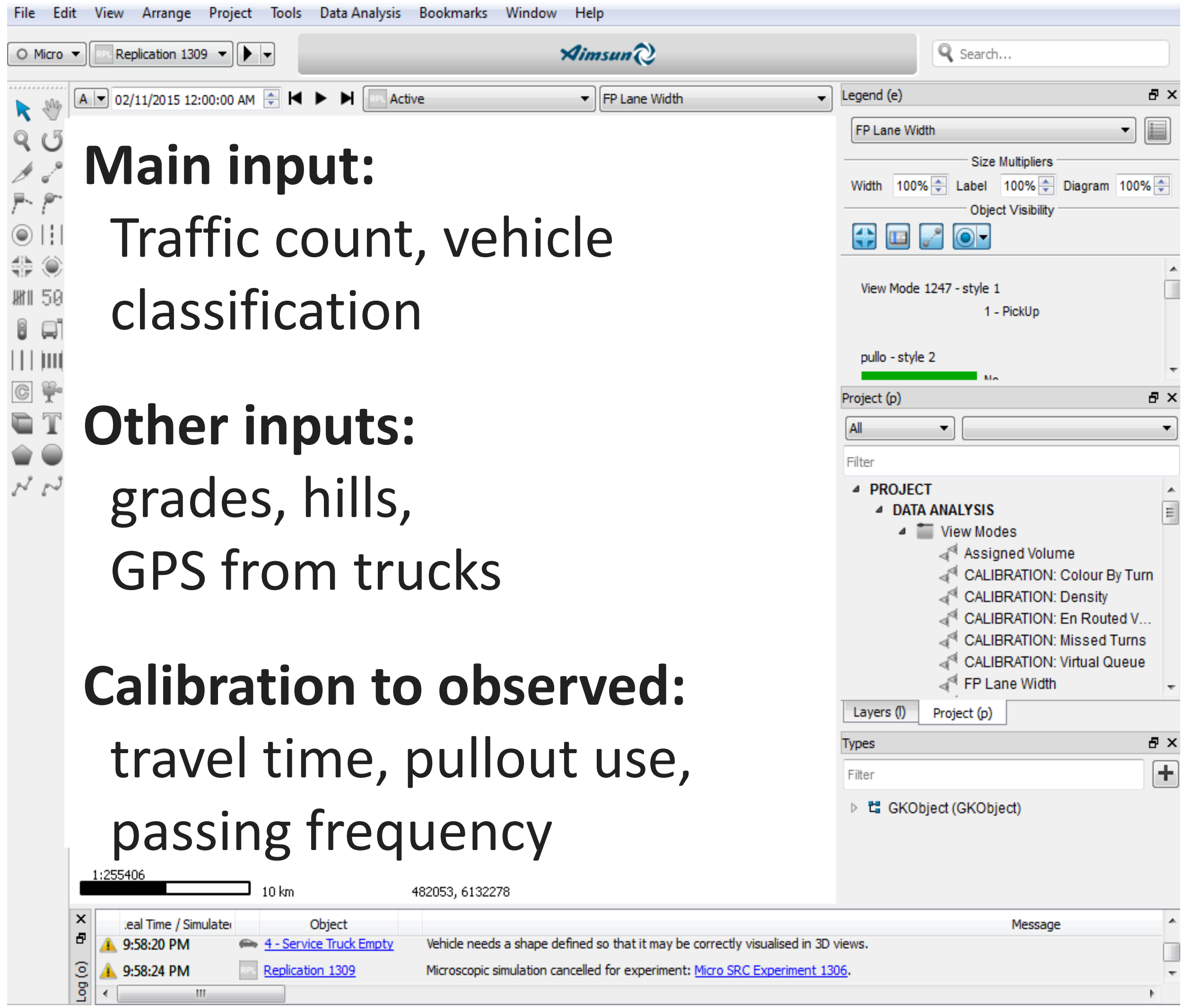

Main input:

Traffic count, vehicle classification

Other inputs:

grades, hills,
GPS from trucks

Calibration to observed:

travel time, pullout use, passing frequency

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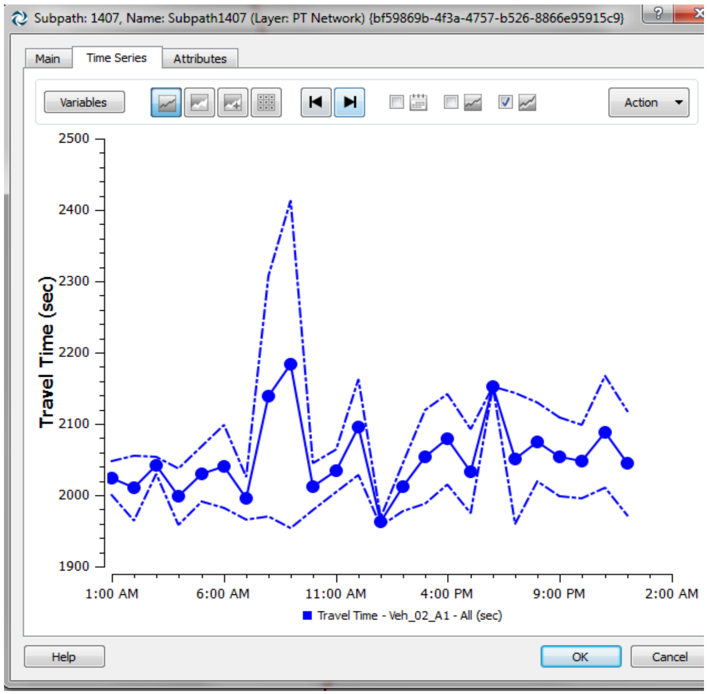
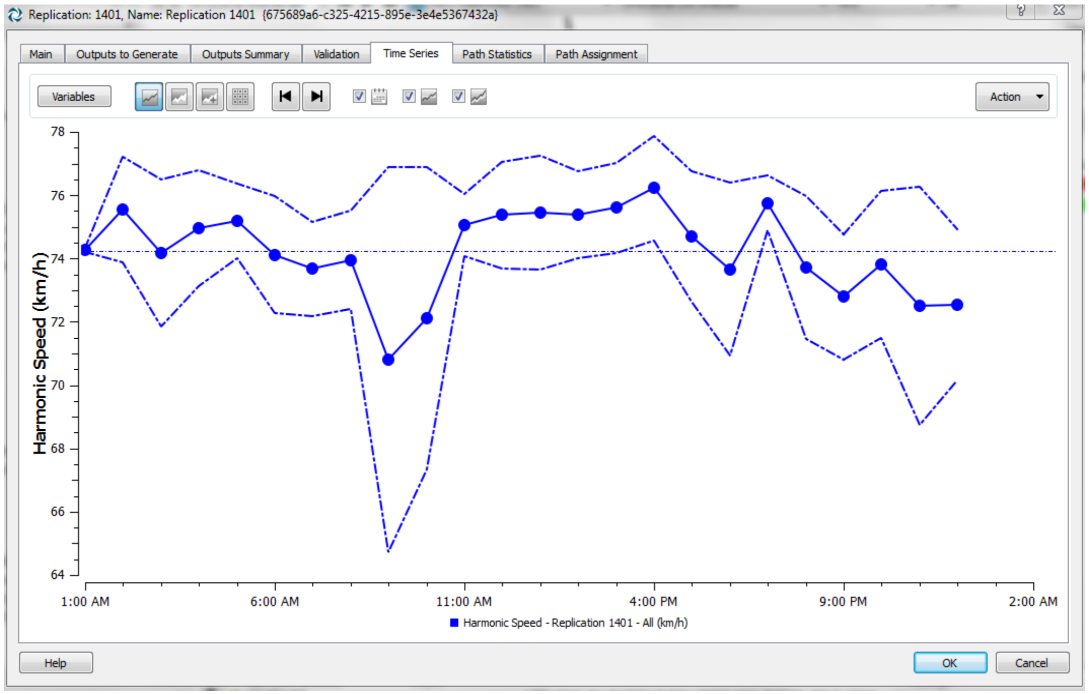
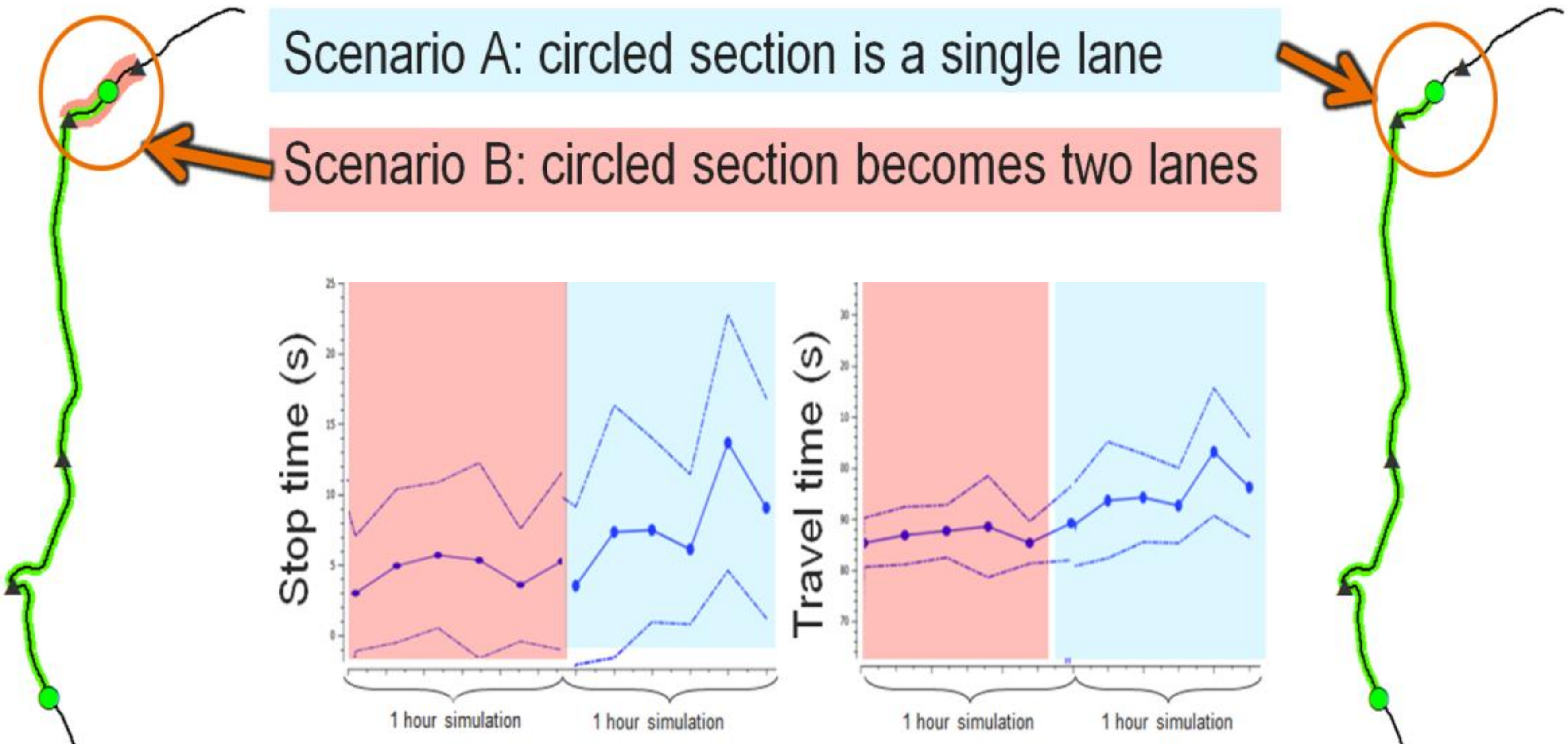
Microsimulation: output examples





Microsimulation: output examples



Microsimulation: qualitative aspects

Workshops: key safety traffic metrics (MOE)

- Percent time spent following
- Average/proportion of time in pullouts
- Number of pullout overcrowding occurrences

LOS: what are the thresholds for

BAD, OK, GOOD for each MOE?

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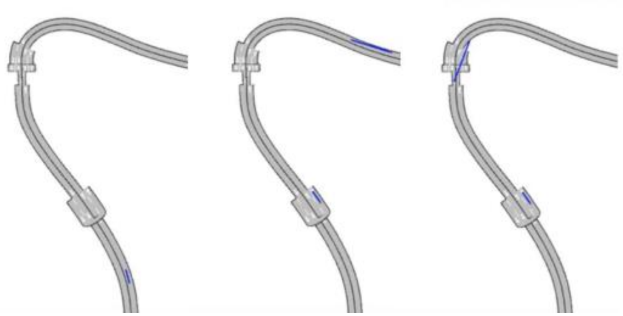
Conclusions: benefits

	Safety	Finance
Analysis of field data only		
▪ Speed profiles of different vehicle types	X	
▪ Improving road asset database (widths, pullouts, etc)	X	X
▪ Confirmation of users (road use agreements)		X
Using field data to drive traffic microsimulation		
▪ Test effects of different scheduling	X	X
▪ Test effect of road improvements	X	X
▪ Test effects of increased traffic volumes	X	X

Conclusions: future

Work this year in BC

- Florence calibration in progress: UBC; methodology being finalized
- Bamfield study now has all field work done
  - Video post-processing will be tested
  - Calibration to follow – with passing
  - Looking at detailed vehicle classification



Further in the future…

- The API tool will work for anyone with an Aimsun license
  - Does not yet support platoons.. future?
- Video post-processing – lots could be done.. future?
- Motion cameras – keep eye on..
- Comparing traffic metrics between study locations may yield interesting results

Cooperators

This year we are working closely with UBC in building simulations on Bamfield road with the help of Island Timberlands

BC FLNRO
NR Canada
Aimsun
UBC – Radio Science Lab
Island Timberlands

FPInnovations:

Al Bradley
Dawson Markle
Mithun Shetty
Glen Legere
Blane Grann

Thank you!
Questions?

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