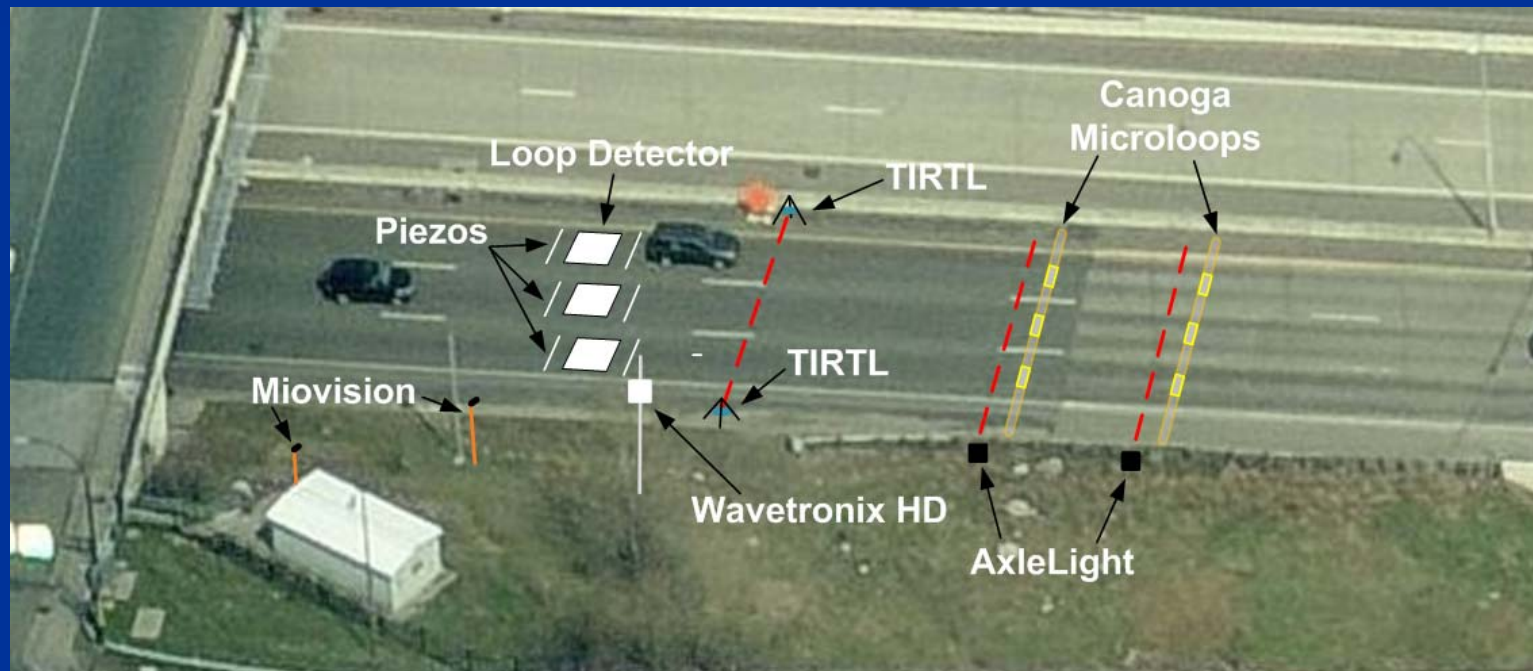


TPF-5(171)

Evaluation of Non-intrusive Traffic Detection Technologies – Phase III



NATMEC Conference - June 24, 2010





Project Management Team

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Participating Agencies

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- Georgia, Scott Knight
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- Idaho, Jack Helton
- Illinois, Rob Robinson
- Iowa, Troy Jerman
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- Mississippi, Mike Stokes
- Montana, Tedd Little
- New York, Kurt Matias
- Ohio, Lindsey Pflum/Anthony Manch
- Texas, Robert Wheeler
- Wisconsin, Susie Ford



Technical Advisory Committee

- Emphasis on heavy congestion in urban areas.
- Strong interest in examining volume, speed and class (axle and length-based). Some interest in travel times, turning movements, and bike/pedestrian.
- Examine various weather conditions and different mounting configurations.
- Evaluate specific sensors of interest.
- Do not: evaluate prototype sensors, emerging travel time technologies (i.e. Bluetooth), solar.

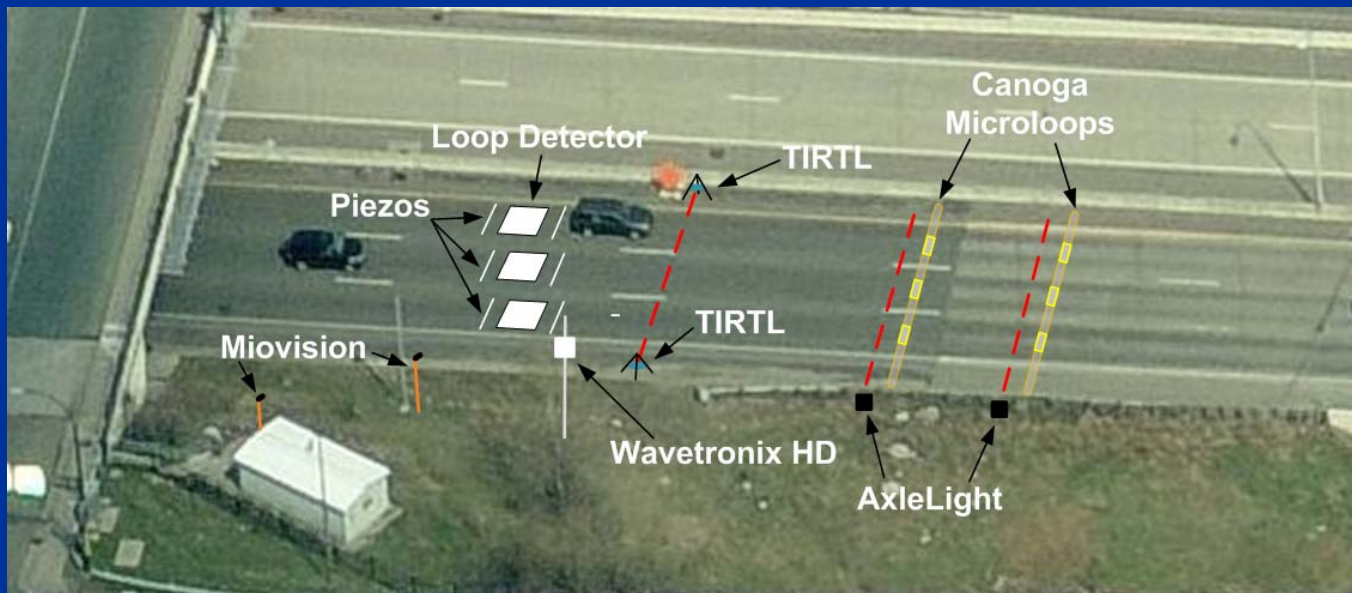
Non-Intrusive Detectors

- Wavetronix Smartsensor HD (Radar)
- GTT Canoga Microloops (Magnetometer)
- Peek AxleLight (Laser)
- TIRTL (Laser)
- Miovision (Video)



Baseline

- Piezo-Loop-Piezo (PLP)
 - Installed six 11-foot piezos
 - Provide volume, speed and axle-based classification
- Manual observation to verify axle-based classification
- Manual frame-by-frame video observation



NIT Phase 3 – Video Length Ground Truthing



Classification

Table 7. FHWA 13 Class Axle-Based Classification Scheme

Class Bin	No. of Axles	Vehicle Description
1	2	Motorcycles
2	2	Passenger Vehicles
3	2	Other 2-axle, four tire single unit vehicles
4	2 or more	Buses
5	2	2-Axle, 6-Tire, Single Unit Trucks
6	3	3-Axle Single Unit Trucks
7	4 or more	4-Axle Single Unit Trucks
8	3,4	4 or fewer Axle Single-Trailer Trucks
9	5	5-Axle Single-Trailer Trucks
10	6 or more	6 or more Axle Single-Trailer Trucks
11	4,5	5 or fewer Axle Multi-Trailer Trucks
12	6	6-Axle Multi-Trailer Trucks
13	7 or more	7 or more Axle Twin Trailer Semi Trucks

Table 8. Vehicle Length-Based Classifications

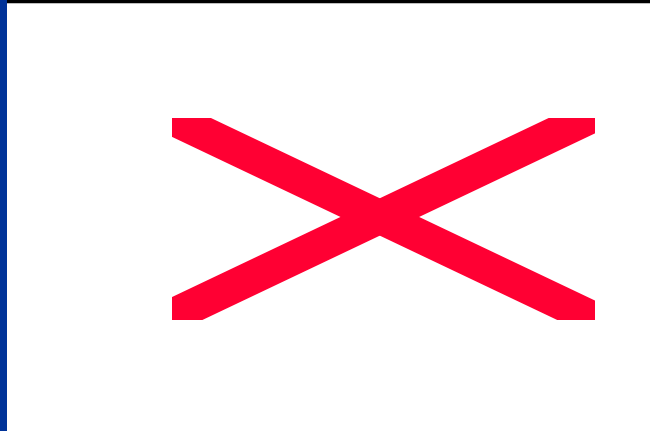
Vehicle Class	Vehicle Length	Vehicle Class
Motorcycle	0 to 7ft	1
Passenger Vehicles (PV)	7 to 22 ft	2, 3
Single Unit Truck (SU)	22 to 37 ft	4-7
Combination Trucks (MU)	Over 37 ft	8-13

Detector Placement Options

Pole



Guardrail



Stand-Alone/Flexible





Research Findings

- Wavetronix SmartSensor HD
- GTT Canoga Microloops
- PEEK AxleLight
- TIRTL
- Miovision

Wavetronix SmartSensor HD

- Installed 30' offset, 28' high
- Volume error 1.6 percent
- Speed error less than 1 mph
- Vehicle length absolute average error 1.6 feet for passenger vehicles and 2.8 feet for large trucks



Wavetronix SmartSensor HD

- Slow moving trucks caused 20 percent undercounting in occluded lanes





Wavetronix SmartSensor HD

Volume

	LOS A-D (>50 mph)	LOS E-F (20-50 mph)	LOS F (<10 mph)
Non-occluded lane	-1.3%	-1.8%	-10%
Occluded Lane	-3%	-11%	-21%

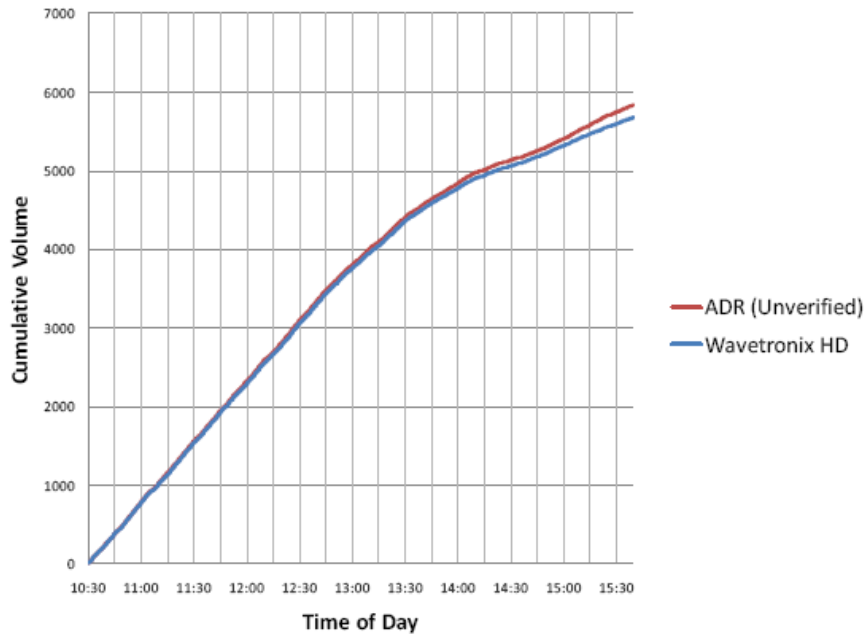
Speed

Speed	Error
60 mph	-0.3
50 mph	0.5
40 mph	0.8
30 mph	-0.8
20 mph	-1.1
10 mph	0.2

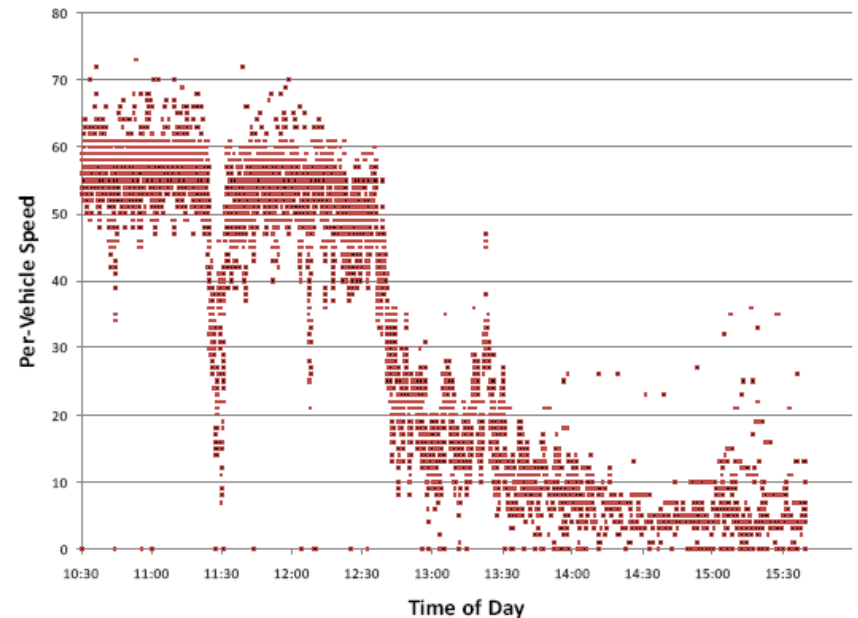
Wavetronix SmartSensor HD

Wavetronix HD sample data

Cumulative Volume - Lane 1

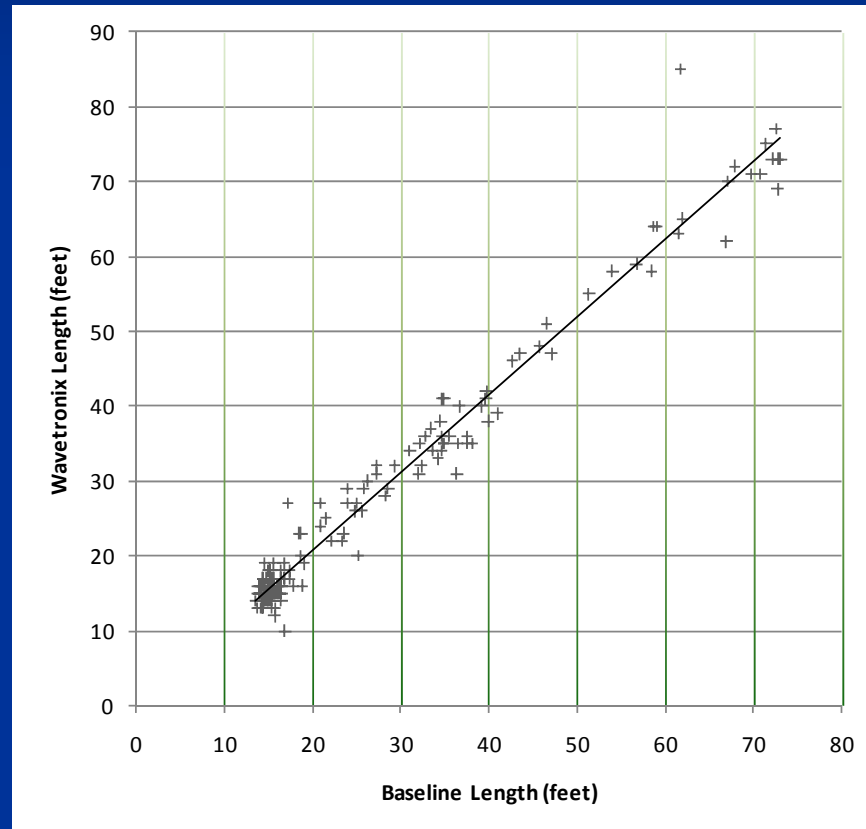


Per-Vehicle Speed - Lane 1



Wavetronix SmartSensor HD

Baseline (video) vs. Sensor Vehicle Length





GTT Canoga Microloops

- Installed in two conduits beneath roadway
- Volume accuracy typically within 2.5 percent
- Aggregate speed less than 1 mph error
- Reported vehicle length with an absolute average error of 3.7 feet for passenger vehicles and 4.0 feet for large trucks
- Permanent installation required



GTT Canoga Microloops

Volume

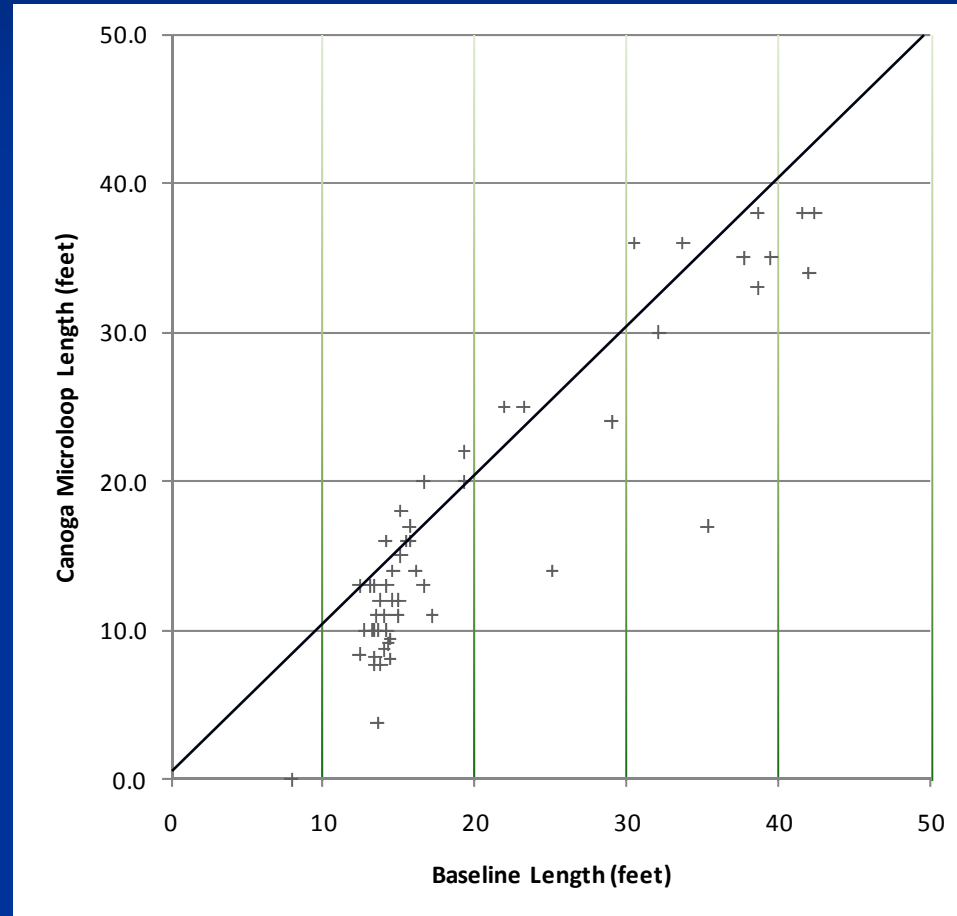
	Baseline	GTT Microloops	Percent Error	Absolute Percent Error
Lane 1	663	680	2.6%	2.6%
Lane 2	530	510	-3.7%	3.7%
Lane 3	470	475	1.1%	1.1%
Total	1663	1665	0.1%	2.5%

Speed

	Baseline	GTT Microloops	Error	Absolute Error
Lane 1	57.8 mph	57.5 mph	-0.3 mph	0.3 mph
Lane 2	60.9 mph	60.9 mph	-0.0 mph	0.0 mph
Lane 3	64.0 mph	63.2 mph	-0.8 mph	0.8 mph
Average	60.9 mph	60.5 mph	-0.4 mph	0.4 mph

GTT Canoga Microloops

Baseline (Video) vs. Sensor Vehicle Length





7.9-foot motorcycle measured at 0 feet long by Canoga Microloops.



35.3-foot SUV pulling trailer measured at 17 feet long by Canoga Microloops.



42-foot bus measured at 34 feet long by Canoga Microloops.

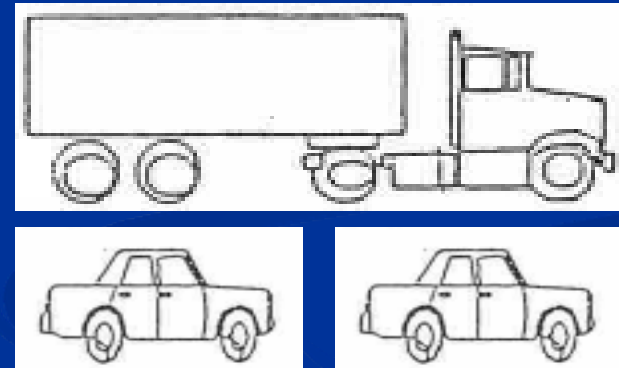


25.1 foot truck measured at 14 feet long by Canoga Microloops

Figure 14. Selected Vehicles That Canoga Microloops Measured Length Less Than Actual Length

Axle-Based Detectors

- Issue with grouping vehicles (less than 45' gap) due to lack of presence detector
- Example: Semi 2S2
 - Axle Spacing 1: 6-26'
 - Axle Spacing 2: 8-45'
 - Axle Spacing 3: 2.5-20'
- Recommend change third axle spacing from 2.5 to 6 feet
 - Vehicles would be put in a default class



PEEK AxleLight



PEEK AxleLight





PEEK AxleLight

- Install on guard rail or similar infrastructure
- Bidirectional setup possible, but requires significant iterative setup process
- Many steps required to deploy and calibrate the sensor
- Axle-based detection with sensors on one side of the roadway
- Permanent deployment possible with specially-designed cabinet



PEEK AxleLight

- Axle-spacing accuracy within 5 percent
- Speed values were consistently 2 mph lower than baseline.
- The raw sensor data typically undercounted by 5.4 percent
- Data prone to classification errors due to grouped tailgating vehicles
- Vendor recommends 20 mph minimum speed

TIRTL

Portable Application



TIRTL

Portable Application Traffic Control



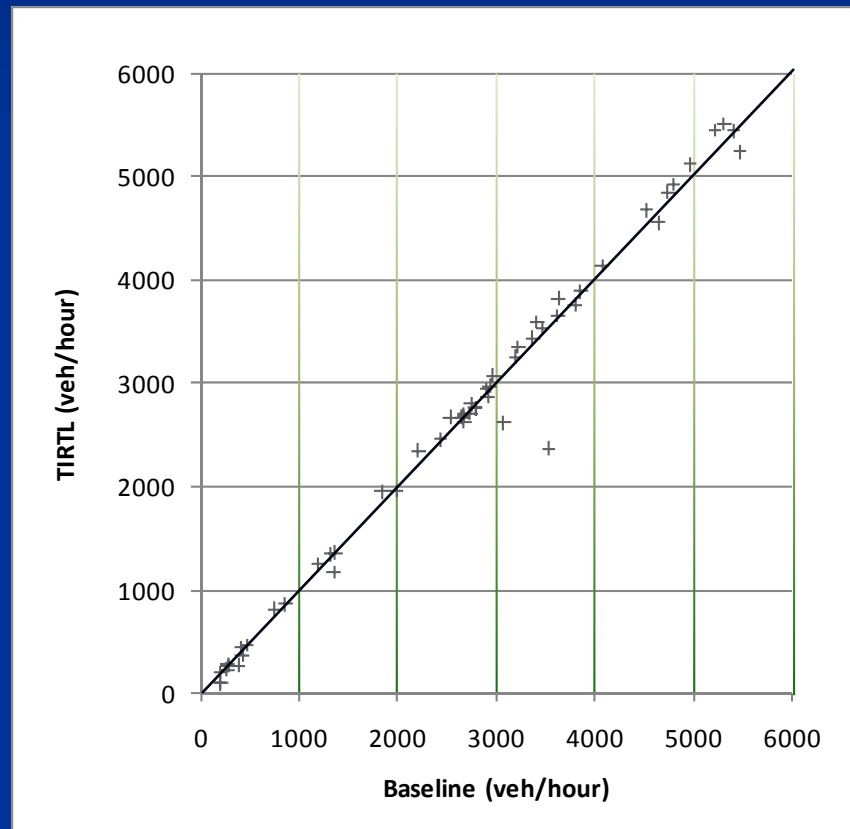


TIRTL

- One set of sensors covered four lanes of bidirectional traffic on a divided roadway
- Portable deployment requires significant traffic control on both sides of the roadway
- Permanent deployment possible by placing the sensors in a specially-designed cabinet
- Volume accuracy was 3.8 percent
- Speed and axle-spacing data was typically within 2 percent

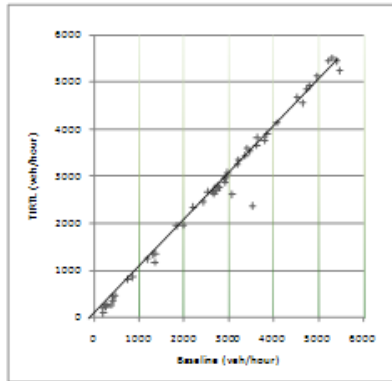
TIRTL

Volume

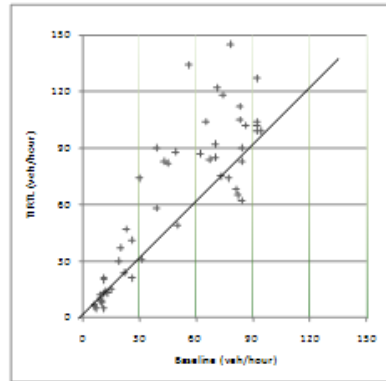


TIRTL

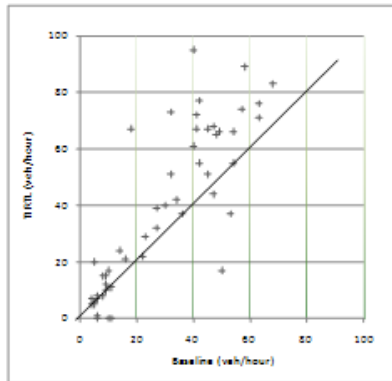
Classification



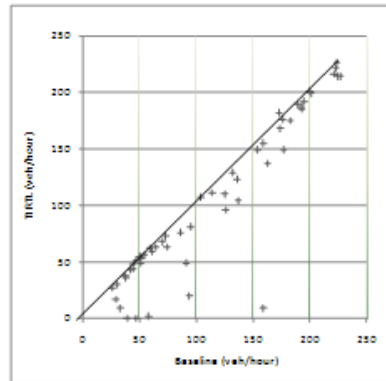
2-axle vehicles. $r^2=0.985$.



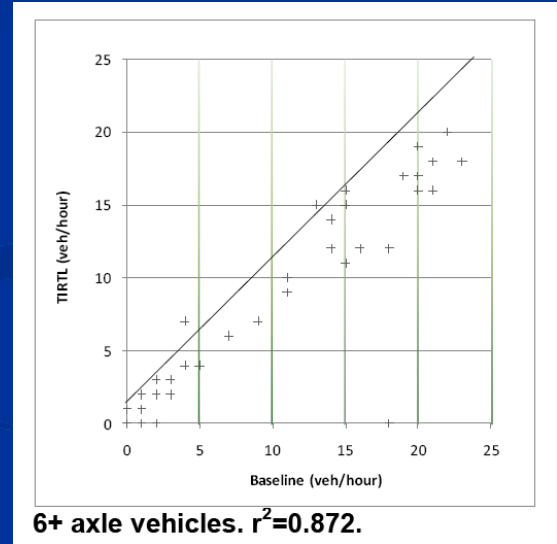
3-axle vehicles. $r^2=0.767$.



4-axle vehicles. $r^2=0.734$.



5-axle vehicles. $r^2=0.871$.



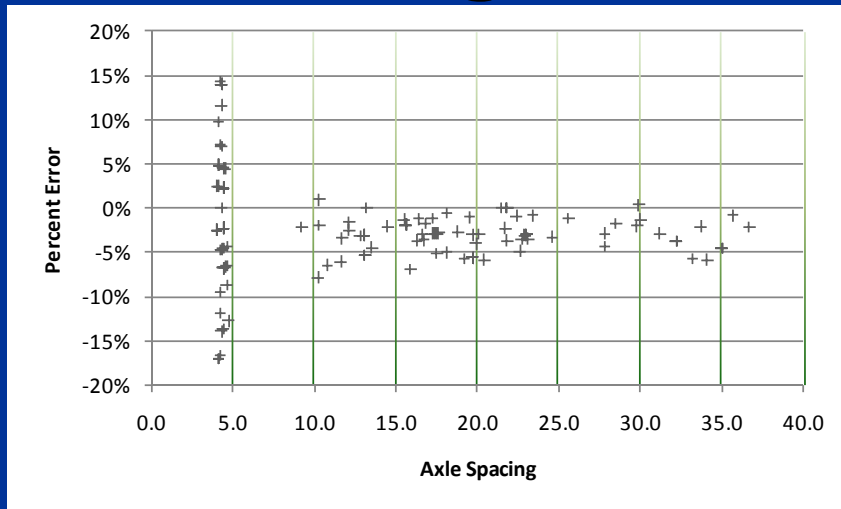
6+ axle vehicles. $r^2=0.872$.

Axle-Based Sensor Comparison

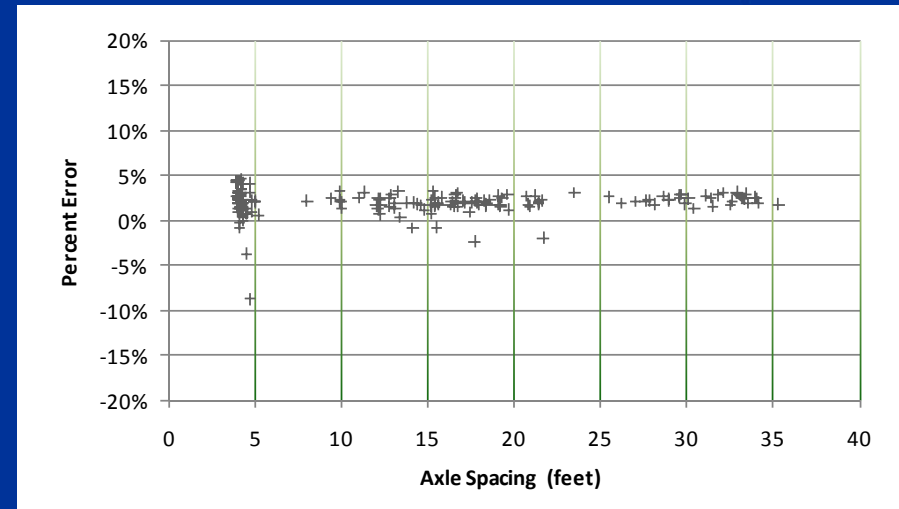
Axle-Spacing Accuracy



AxleLight



TIRTL





Miovision

- Intersection turning movement counts
- Volume accuracy matched ability to manually verify
- Classification by car, medium truck, heavy truck, bus and RV
- No speed data or per-vehicle records
- Video files are submitted to the vendor for remote processing on a per-hour basis
- Quick setup

Miovision

- I-394 volume test
 - Error less than 2 percent



Miovision

- Intersection turning movement counts
 - Error less than 0.5% for each movement
 - 2 hour test, 4-6 pm





Project Findings

- Weather had minimal effect on Wavetronix and Microloops
- Axle-based sensors not recommended during heavy rain
- Axle-based sensors not effective in congested conditions (<20 mph)
- Occlusion an issue for most sensors
 - Error increases with congestion
- Sensor setup and calibration time is important



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