Understanding the Potential for Video Analytics to Support Traffic Management Functions

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Project Summary Slides – November 2014

ENTERPRISE Program

Program Goals

- Facilitate rapid progress in the development and deployment of ITS technologies
- Accelerate the systematic advancement of selected ITS projects

Members carry out ITS projects and activities including fundamental research, technology development, demonstration, standardization, and deployment.

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Members

- Arizona DOT
- Georgia DOT
- Idaho Transportation Department
- Illinois DOT
- Iowa DOT
- Kansas DOT
- Maricopa County, AZ
- Michigan DOT
- Minnesota DOT
- Mississippi DOT
- Oklahoma DOT
- Pennsylvania DOT
- Texas DOT
- Washington State DOT
- Ontario Ministry of Transportation
- Transport Canada
- Dutch Ministry of Transport
- FHWA

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What is Video Analytics?

Video Analytics systems ***process video streams*** from traffic cameras to:

- ***Collect Traffic Data***: Vehicle counts, speeds, vehicle classifications
- ***Detect Incidents and Create Alerts***: Stopped vehicles, slow traffic, wrong-way vehicles, wildlife, pedestrians, debris

DATE	TIME	VOL(NS)	SPEED(NS)
2013/06/13	12:00 AM	161	71
2013/06/13	12:00 AM	130	68
2013/06/13	12:15 AM	121	70
2013/06/13	12:30 AM	112	69
2013/06/13	12:45 AM	83	70
2013/06/13	1:00 AM	54	67
2013/06/13	1:15 AM	59	68
2013/06/13	1:30 AM	84	68
2013/06/13	1:45 AM	48	65
2013/06/13	2:00 AM	74	71
2013/06/13	2:15 AM	60	66
2013/06/13	2:30 AM	65	68
2013/06/13	2:45 AM	56	68

Traffic Data Output (15-min Increments)

Incident Detection

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Why Use Video Analytics?

Challenges
• Difficult to monitor conditions in rural areas • Challenge for TMC operators to monitor multiple camera views simultaneously • Vehicles traveling the wrong way introduce safety hazard

Opportunities
• Utilize existing camera infrastructure • Potential to use Video Analytics for multiple purposes (traffic data collection, incident detection)

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Why Evaluate Video Analytics?

Project Goals
• Investigated potential of Video Analytics as a tool for: – Traffic data collection – Incident detection – Wrong-way vehicle detection • "Proof of Concept" evaluation to understand current state of practice – How accurate? How effective? How useful? – Compared to traditional methods/technologies: Loop detectors, radar, reported incidents, visual observation • Not a comparison of vendors' products

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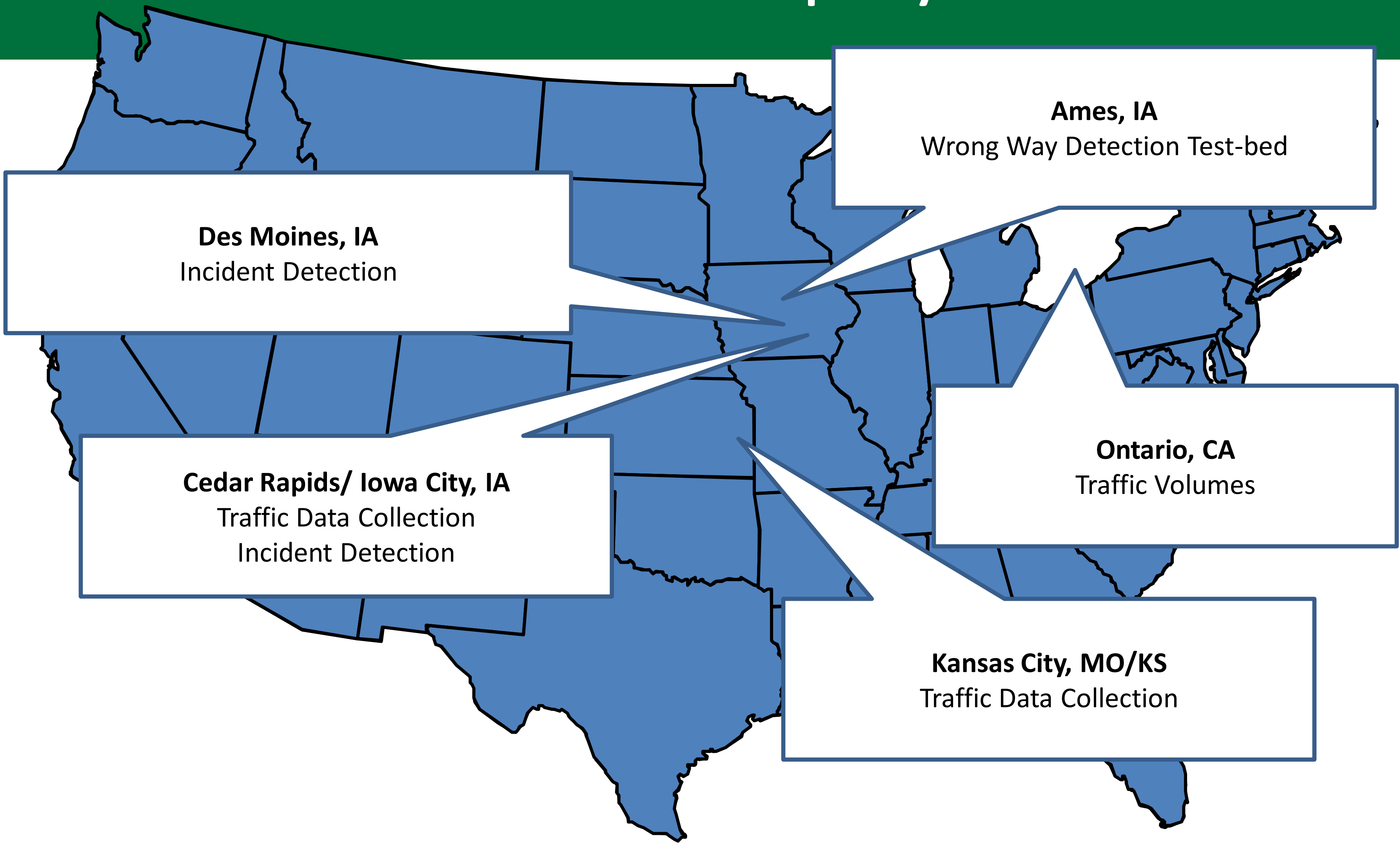
"Virtual Test Bed" Deployment Sites



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Deployment Conditions

Tested in "Real World" Conditions

- Existing camera infrastructure
- Typical TMC practices and workflow

Conditions Not Controlled to Ensure Optimum Performance

- Camera settings & system configurations not always ideal for video processing (doing this could affect viewing ability)
- Normal panning/zooming of cameras
- TMC operations did not allow for constant monitoring and re-configuring of Video Analytics. Efforts made to adjust systems as much as practical.

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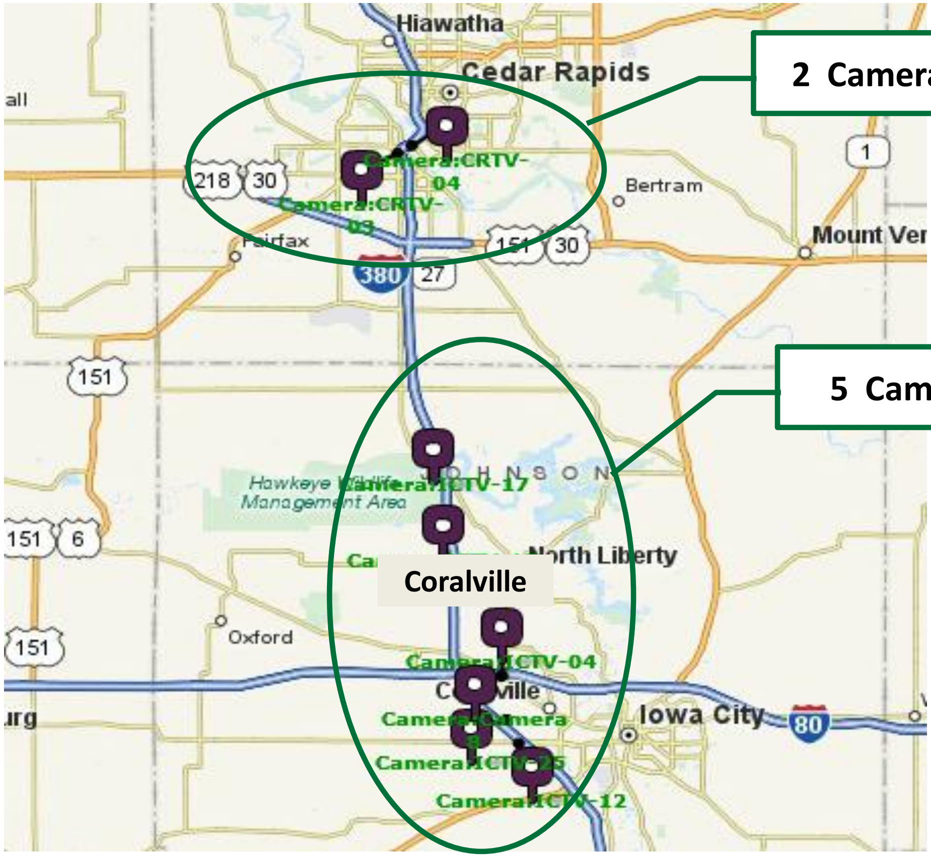
INCIDENT DETECTION

Incident Detection

Cedar Rapids - Rural Deployment

7 cameras instrumented - 2 vendors



2 Cameras – Cedar Rapids

5 Cameras – Rural Interstate

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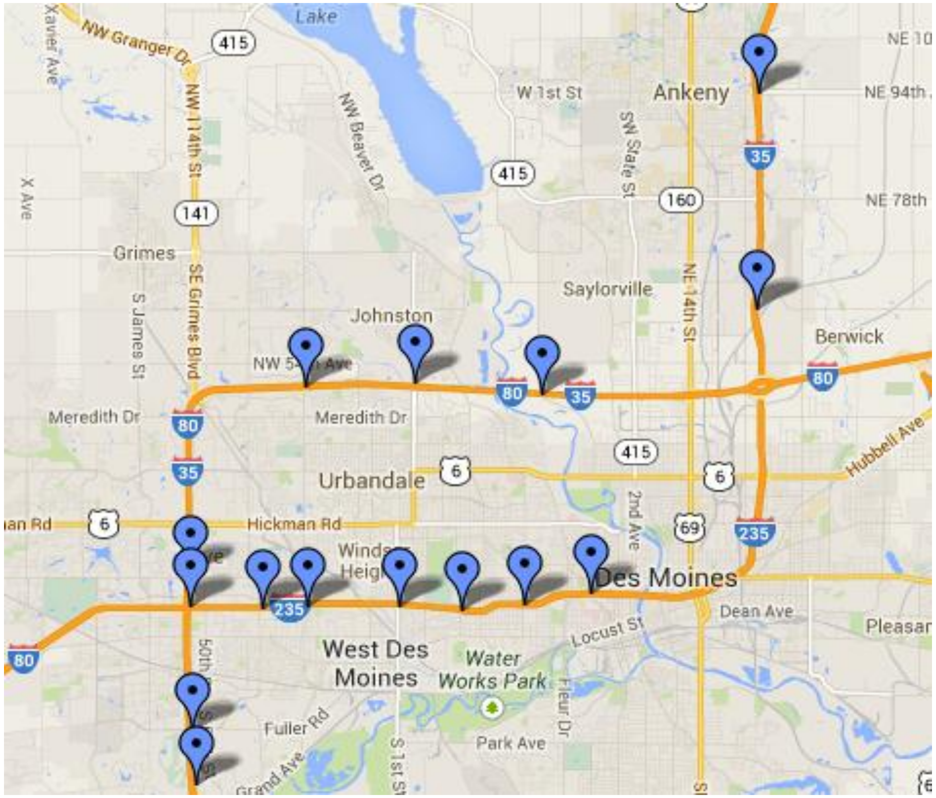
Incident Detection

Des Moines Deployment – Urban / Suburban

15 cameras instrumented – 1 vendor

(Approx. 12% of Des Moines freeway network "coverage" with Video Analytics)



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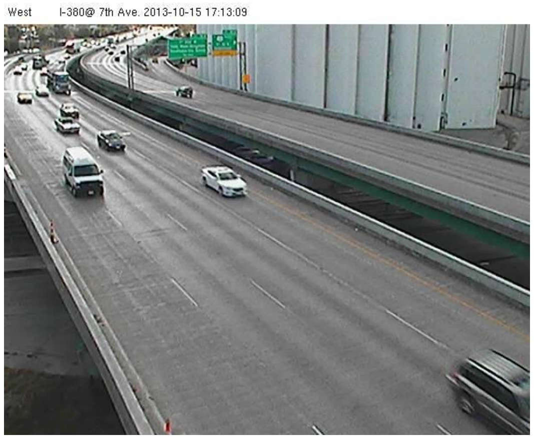
Incident Detection

Variation in Camera Views (examples)



Incident Types Detected by Video Analytics

- Stopped Vehicle / Debris in Road
- Slow Traffic / Congestion
- Pedestrian
- Wrong-Way Vehicle

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Incident Detection

Analysis Approach:

1) Reviewed Detection Alerts: Still Images / Video Clips
2) Classified Alerts:
   - Likely Detection (validated)
   - Detection Not Likely (not validated)
   - Unable to Determine
3) Calculated % validated, % not validated , % unable to determine (as a function of total number of alerts)
4) Highest level of performance reported

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Incident Detection

Examples - Incident detection validated

Stopped Vehicle

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Incident Detection

Examples - Incident detection validated

Stopped Vehicle

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Incident Detection

Examples - Incident detection validated

Slow Traffic / Congestion

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Incident Detection

Example - Incident detection validated

Pedestrian detected as “Stopped Vehicle”

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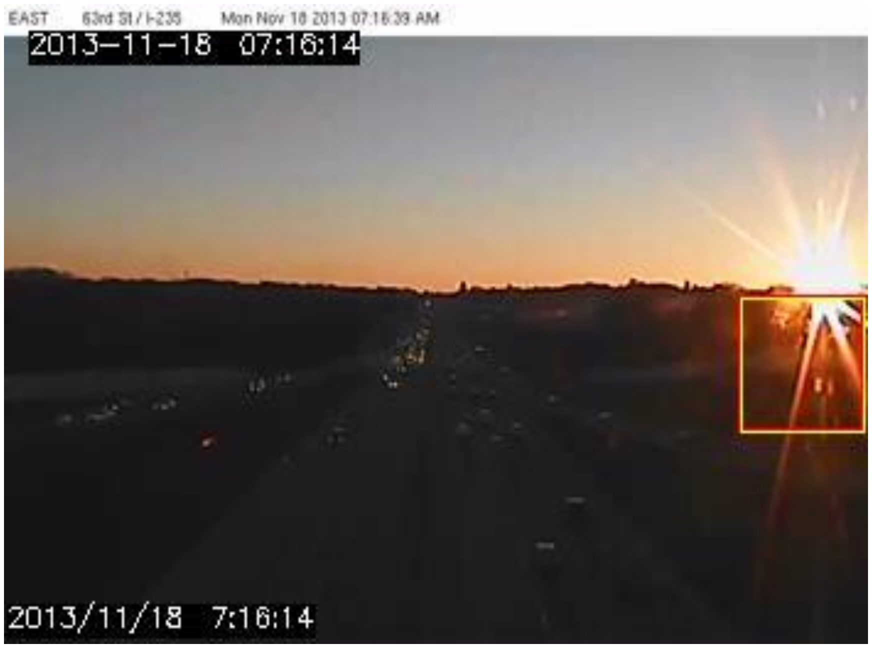
Incident Detection

Examples - Incidents not validated (false alarms)



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Incident Detection

Examples – Incidents not validated

(False Alarms caused by Obstructions in View)

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Incident Detection

Examples - Unable to determine

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Incident Detection

Results:

Highest Level of Performance
Stopped Vehicle / Debris: 72% alerts validated, 23% not validated, 5% unable to determine (81 alerts during a 44-day period) **Stopped Vehicle / Debris – Remove False alarms from Object in View:** 0% “false alarms” (26 alerts during a 21-day period) **Slow Vehicle/Congestion:** 30% alerts validated, 33% not validated, 37% unable to determine (1111 alerts during a 44-day period) **Pedestrian in Road:** None observed **Wrong-Way Vehicle Movements:** None observed

Incident Detection

Results

Factors that Impacted Performance

- Objects in the field of view
- Weather events / moisture on camera lens
- Headlight glare on roadway during nighttime lighting conditions

Factors that Did Not Appear to Impact Performance

- Camera position (zoom level, angle to roadway)
- Inaccurate configuration of Video Analytics to roadway lanes (e.g. camera panning)

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Incident Detection

Comparison of Detection Alerts to Agency Reported Incidents

- It is likely that Video Analytics detected a number of incidents that were not observed by agency staff, indicating that Video Analytics can be an effective tool for supplementing existing mechanisms to alert operators
- Strategic selection of camera locations along a coverage area will optimize usefulness of Video Analytics

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TRAFFIC DATA COLLECTION:
Iowa/Kansas City Deployments

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Traffic Data Collection

<u>Traffic Data Types:</u>

- Volumes (Vehicle Counts)
- Average Speeds
- Vehicle Classifications

Classification Categories from Video Analytics	Corresponding FHWA Classifications
Motorcycles	Classifications 1
Cars	Classifications 2-3
Small Trucks	Classifications 4-7
Large Trucks	Classifications 8-13

Traffic Data Collection

Analysis Approach

- Data collected in 15-minute increments
- Video analytics outputs compared to outputs from DOT detectors (loops and radar)
- Absolute Percent Difference (Abs % Diff) Calculation:
  - Calculate 15 min. period difference from DOT data
  - Convert it to absolute difference (remove any '-')
  - Compute Percent Difference
  - Result is Abs % Diff.
- Caveat: Night-time traffic is often very low volumes. Abs % Diff. is not as meaningful

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Traffic Data Collection

Results : Highest Level of Performance

(All results shown are average % Diff for one week)

Traffic Volumes:

- Day: 9% Avg. % Diff. *(carries reasonable expectation of repeatability)*
- Night: 17% Avg. % Diff. (***Does not*** carry reasonable expectation of repeatability)

Vehicle Speeds:

- Day: 2% Avg. % Diff *(carries reasonable expectation of repeatability)*
- Night: 6% Avg. % Diff *(carries reasonable expectation of repeatability)*

Vehicle Classifications:

- "Motorcycles" (FHWA Classification 1): Avg. % Diff of 24% at night
- "Cars" (FHWA Classifications 2-3): Avg. % Diff of 13% daytime
- "Small Trucks" (FHWA Classifications 4-7): Avg. % Diff of 44% daytime
- "Large Trucks" (FHWA Classifications 8-13): Avg. % Diff. of 23% daytime

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Traffic Data Collection

Results

Factors that Impacted Performance
• Low light / dark conditions • Camera position (proximity to traffic, zoomed out, angled to roadway) • Weather events that reduce image quality • Inaccurate configuration of video analytics to roadway lanes • Camera settings (e.g. shutter speed, max gain)
Factors that Did Not Appear to Impact Performance
• Position of camera relative to direction of traffic (e.g. counting headlights vs. tail lights at night)

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TRAFFIC DATA COLLECTION:

Ontario Ministry of Transportation (MTO) Deployment

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Traffic Data: MTO Deployment

MTO Deployment – Focus on Volumes

- 13 cameras instrumented at 4 Locations
- Data collected in 15-minute periods
- Video recorded for 1 week at each camera, sent to video analytics vendor for processing
- Manual counts conducted for comparison
- Manual counts compared to video analytics data outputs to compute percent error

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Traffic Data: MTO Deployment

Results:

Type of Comparison	Configuration/ Setting	% Error
Time of Day	Day[1]	9.1%
	Night	7.9%
Camera Angle	Side	9.4%
	Overhead	6.5%
Camera Type	Axis	7.5%
	Cohu	9.6%

[1] 'Day' analysis was PM peak (16:30-17:30)

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Traffic Data: MTO Deployment

Results:

1. Camera based counting system is appropriate if:
   - Overall Accuracy within 10% is acceptable
   - Vehicle Classification is not critical

2. Camera based counting system may not be suitable if:
   - Counts are to be conducted in work zones or areas with high stop-and-go traffic
   - Accuracy within 5% is required
   - Vehicle Classification is needed
   - Night-time accuracy is important

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Traffic Data: MTO Deployment

Lessons Learned:

1. Engage in discussions early with camera vendors
2. Standard definition cameras are actually better
3. Ambient light surrounding cameras should be taken into consideration for camera locations

Next Steps:

MTO will be undertaking additional data collection assignments utilizing video analytics beginning this fall and continuing through next summer

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WRONG-WAY VEHICLE DETECTION

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Wrong-Way Vehicle Detection

Controlled Test: Nov. 2013 in Ames, IA

- 3 vendors/technologies at 3 separate freeway ramps
- Ramp closures to test various conditions
- Detections conveyed via email, web interface, or on-site computer interface
- Recorded "detection" or "non-detection"

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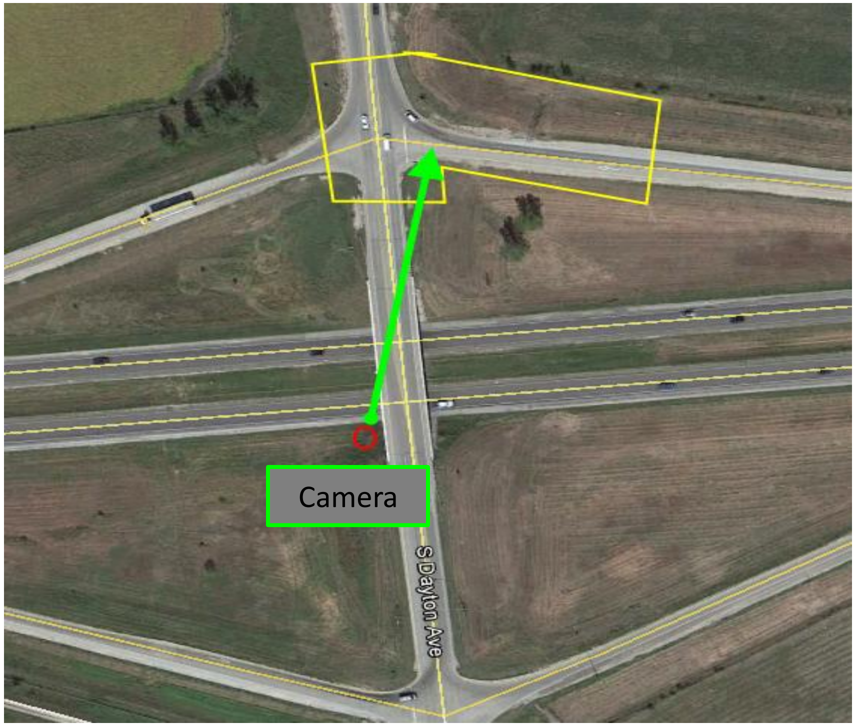
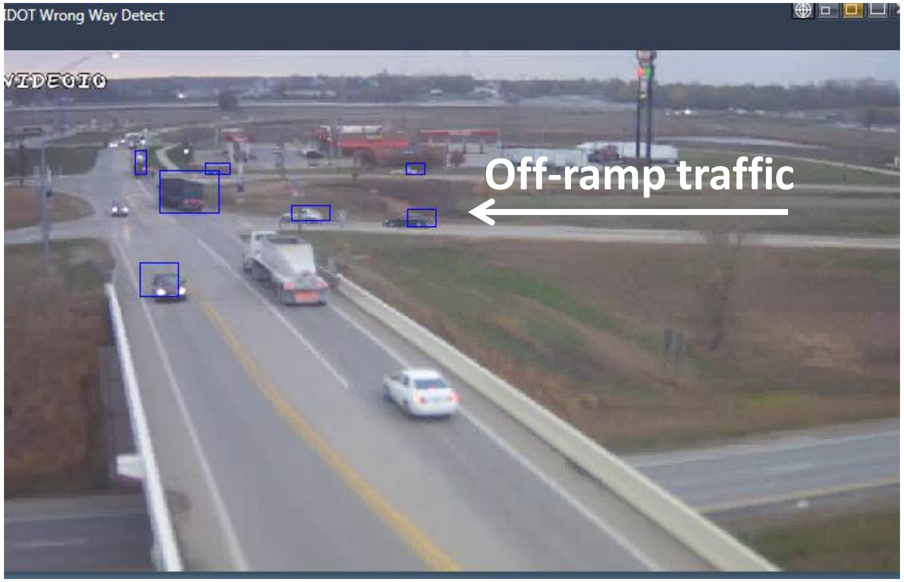
Wrong-Way Vehicle Detection

Deployment Site #1
US 30 at Dayton Ave.





90 degree detection

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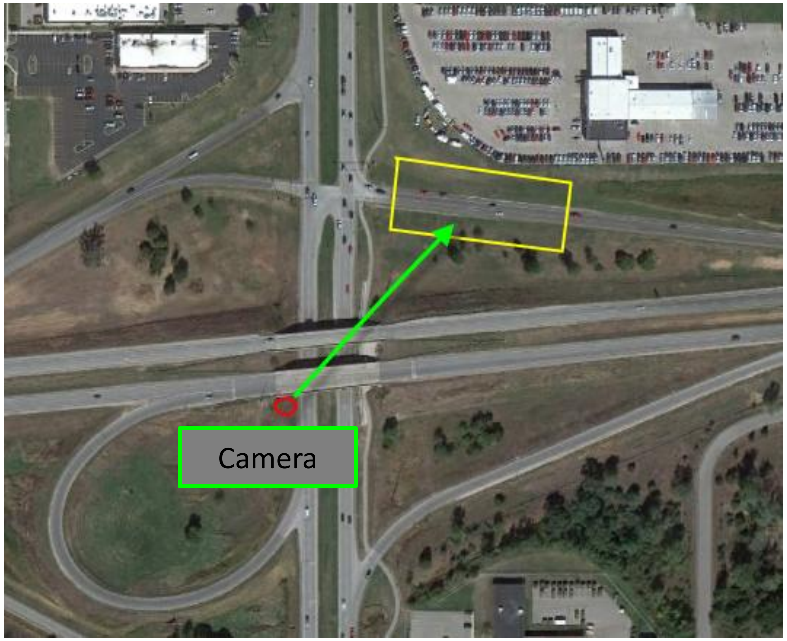
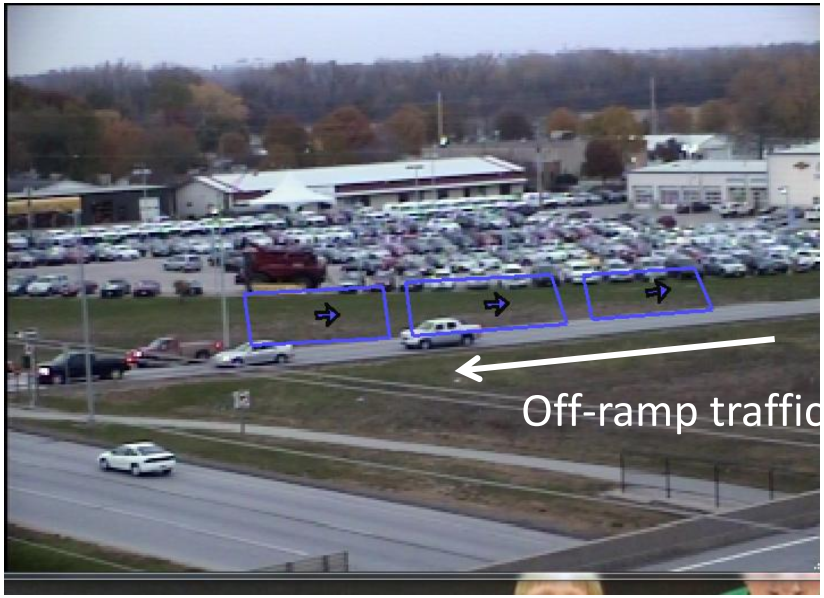
Wrong-Way Vehicle Detection

Deployment Site #2
US 30 at Duff Ave.





90 degree detection

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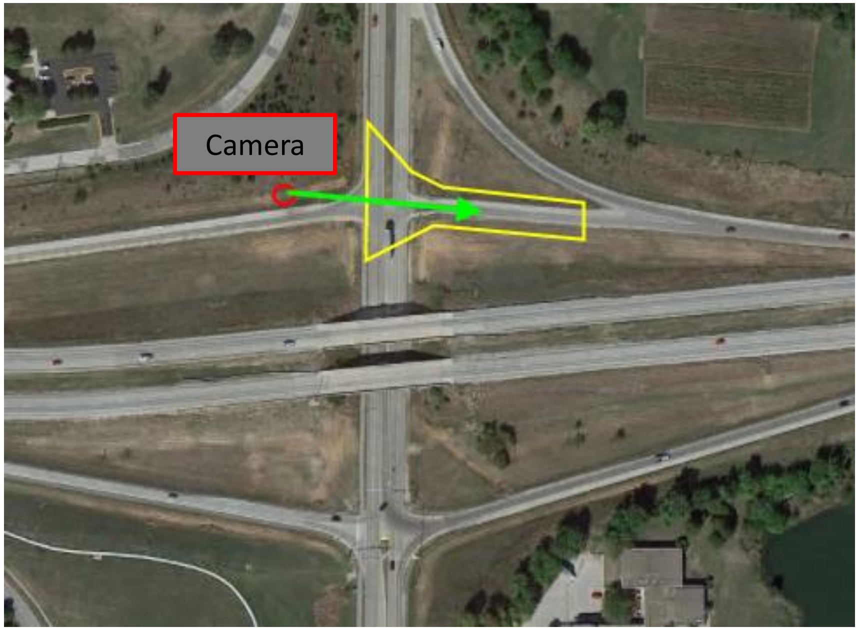
Wrong-Way Vehicle Detection

Deployment Site #3
US 30 at University Blvd.



"head-on" detection

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Wrong-Way Vehicle Detection

Highest Level of Performance Achieved
Daytime Test: 100% detection for 12 test drives **Nighttime Test:** 83% detection for 12 test drives
Factors that Impacted Detection Rate
Nighttime / Low Light Conditions Slow Speeds
Factors that Did Not Appear to Impact Detection Rate
Color/Size of Vehicle Lane Position (consistent position, shoulder, and/or weaving)

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LESSONS LEARNED

Lessons Learned

Planning and Procurement

1. **Determine Uses and Needs**
   - What will the system be used for?
   - What are the most important uses (e.g. traffic data collection, incident detection, etc.)?
2. **Understand Limitations of Multi-Purpose Capabilities**
   - Camera positions / settings may serve one application better than others
   - Multiple uses may be difficult or impractical

Lessons Learned

Planning and Procurement, cont'd

3. **Recognize Investment Tradeoffs**
   - Potentially lower up-front investment with Video Analytics
   - Consider continuing costs: Staff training, setup, and ongoing monitoring/configuration
4. **Utilize Fixed Cameras and/or Dedicated Cameras for Traffic Data**
   - Traffic data tends to be more accurate with cameras that remain stationary (fixed, dedicated)
   - Consider installing temporary dedicated cameras where infrastructure does not allow optimized positioning

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Lessons Learned

Planning and Procurement, cont'd

5. **Optimize Video Feed Quality and Communications**
   - Video feeds with minimal interruption are desired. "Choppy" feeds/communications will not be accurately processed.
   - Ask vendors to provide feedback on feed quality
   - Test video feeds in advance of procurement
6. **Include Design & Testing Provisions in Procurement**
   - Add tasks for additional testing and tuning 6 months to 1 year after initial deployment

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Lessons Learned

Planning and Procurement, cont'd

7. **Make 'Go/No-Go' Decisions When Selecting Cameras**
   - Work with vendors to determine if camera positions are suitable
8. **Consider Future Potential for Video Analytics when Installing New Cameras**
   - Even if Video Analytics deployments are not planned, consider potential for future use when installing new camera infrastructure

Lessons Learned

Deployment

1. **Dedicate Agency Resources to Deployment Activities**
    - Agency resources needed during installation and trouble-shooting during set-up
    - Schedule check-in visits with vendors
2. **Commit to Learning & Understanding System Procedures**
    - Dedicate resources to learning system configurations, procedures, and performance impacts
    - Operators should fully understand capabilities to ensure that the system is as useful and accurate as possible

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Lessons Learned

System Operation

1. **Use Camera Presets and Auto-Return to Preset Positions**
   - Cameras should reset to optimal Video Analytics positions after being manually moved
2. **Monitor Calibrations and Adjust as Needed**
   - Operators should ensure that cameras are returned to their optimal view settings (use presets, if possible)
3. **Recognize Strong Link Between Human Interaction & System Performance**
   - Success is dependent on agency's level of commitment
   - Resources needed to monitor performance, adjust and re-configure when cameras pan/zoom, etc.

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Lessons Learned

Evaluation

1. **Establish Performance Parameters**
   – Develop subjective “success” parameters to determine if a system performs to pre-determined standards
2. **Compare/Contrast Video Analytics to Other Detection Mechanisms**
   – Compare performance outcomes of various technologies for specific uses
3. **Extend Incident Detection Testing to “Missed Incidents”**
   – Determine extent to which Video Analytics fails to detect actual incidents
   – Utilize closed test track or other controlled environment

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EVALUATION FINDINGS

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Evaluation Findings

State of Practice for Video Analytics is ready to meet many agency needs.

- Dedicated and/or fixed cameras may be warranted, especially for traffic data collection
- Video Analytics may not serve all purposes simultaneously (e.g. a camera used for incident detection may not be optimal for traffic data collection)
- Important to follow vendor guidelines for camera selection, position, zoom level, etc.
- Recognize significant human component involved. Operator resources are required to monitor system settings and re-configure as needed.

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Acknowledgements & Project Contact

Final Report:

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Participating Agencies

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- Peek Traffic Corporation
- TrafficVision
- VideoIQ

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