Xerox Vehicle Occupancy Detection System

Xerox America's Commercial, State and Government Transportation (ACSGT)

Xerox Innovations Group (XIG)

Xerox Research Center Webster (XRCW)

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Congestion Countermeasure: “Managed” Lanes

Traffic congestion sets US back by $87 billion/year in wasted fuel and time (2010)

Source: http://urban-review.com/atlanta-to-get-traffic-makeover-with-new-high-occupancy-toll-lane/

Enforcement has Proven Difficult:

- **HOV lane violation rate: up to 65%**
- **Manual HOV enforcement rate: <10%**

“Current enforcement practices limit potential support for more HOV/HOT projects.” –McCormick Rankin Corp

Managed Lanes:
High Occupancy Vehicle lanes (HOV)
High Occupancy Tolling lanes (HOT)

HOT Lanes:

- HOV Lanes which Single Occupant Vehicles may use if they pay a toll.
- Toll is assessed with an RFID transponder.
- Use RFID transponders with Self-declaration switches
- <u>Voluntary</u> Compliance

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High Occupancy Vehicle (HOV)
and
High Occupancy Tolling (HOT)
Vehicle Occupancy Enforcement

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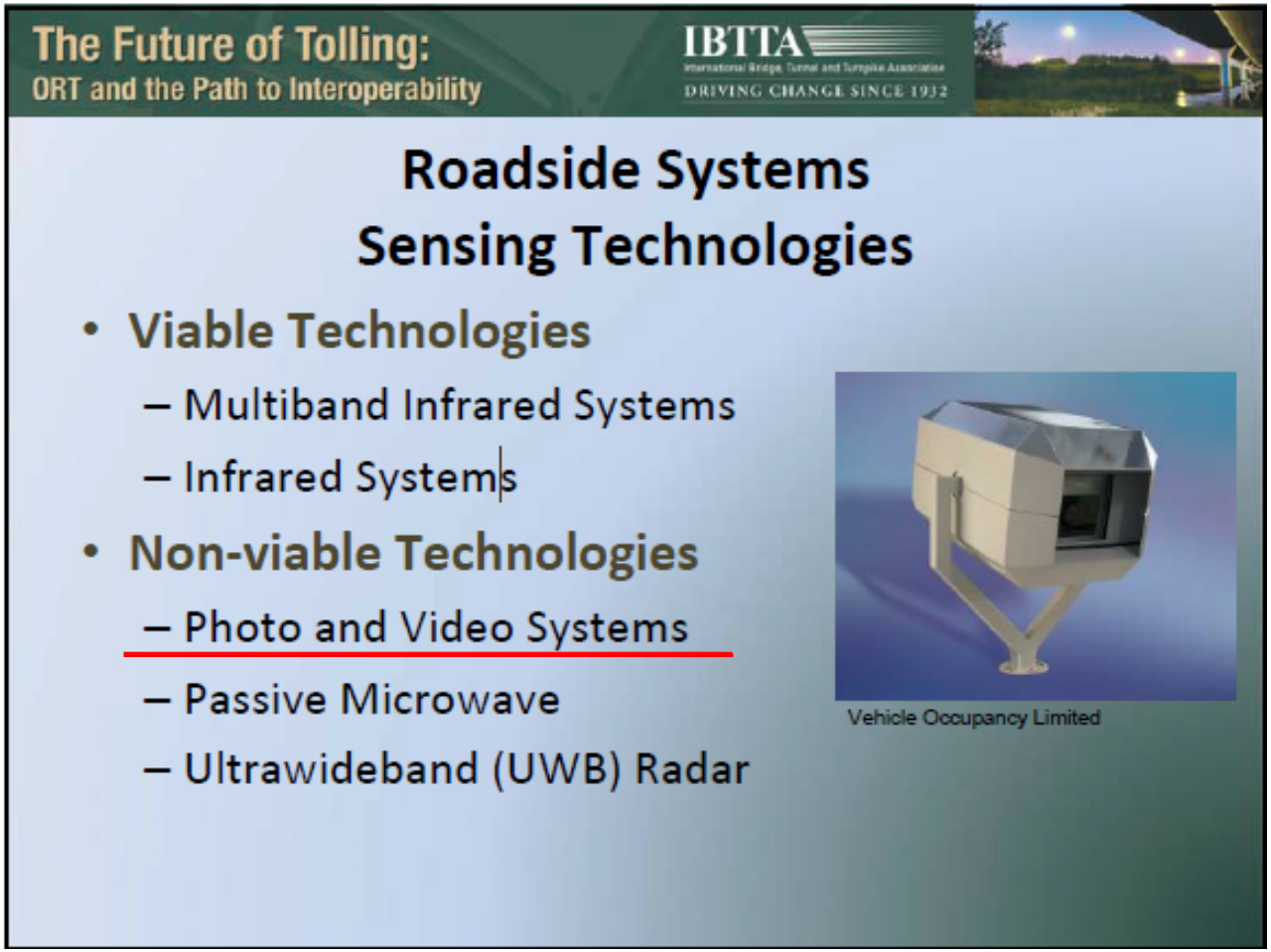
IBTTA History on the Subject



HOV / HOT Enforcement Goals

HOV Enforcement Goals

- Improve current manual enforcement accuracy

Increase from 10% → 60% to 70%

- Improves Safety for Law Enforcement

- Provide automated process for enforcement and notification

- Provide mobile enforcement capabilities

HOT Enforcement Goals

- Need higher accuracy for toll violation enforcement – >90% desired

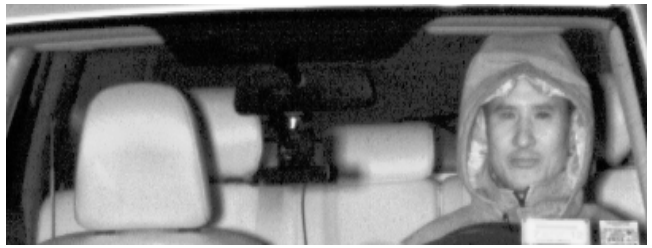
- Automated Process of both Toll Violation and HOV Violation

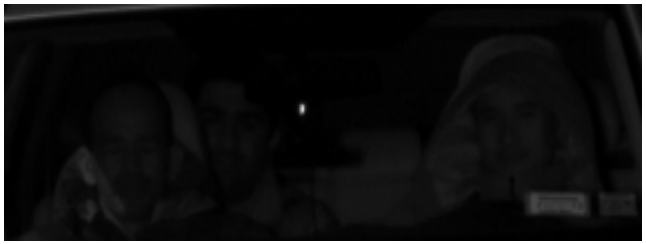
- Provide automated process for enforcement and notification

- Provide mobile enforcement capabilities

Video-Based Detection Challenges

1. Lack of proper illumination
2. Tinted glass
3. Occlusion of Occupants
4. Pose Variation of Occupants
5. Vehicle speed, size, shape
6. Imaging Geometry varies
7. Window Composition
8. Weather condition (snow, fog, atmospheric distortion etc)
9. Use of dummies





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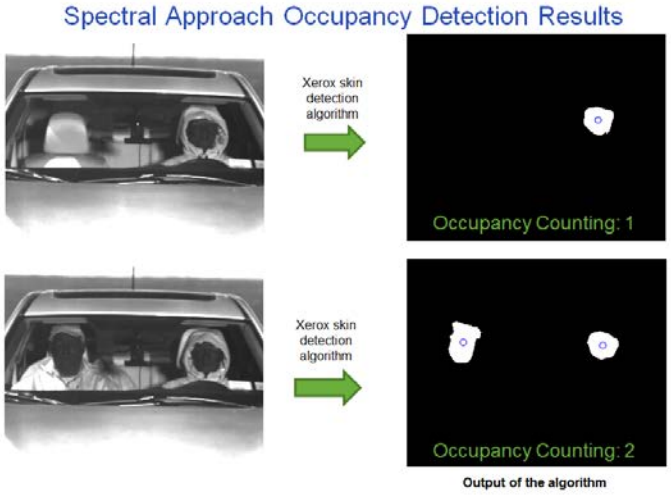
Xerox Occupancy Detection Strategy



Capability/Performance Advances

Time

- Can detect front and rear seat occupancy
- Dummy Detection Possible
- Robust to blurring due to motion
- More robust to weather related noises
- High cost/potential high accuracy

Biometric approach .

- Low cost/Acceptable accuracy
- Rear seat occupancy imageable and automatically detectable
- No distinction in Dummy and Human detection

Geometric approach

Sample Images & Face Detection Algorithm

Passenger Face Detected: Not a Candidate Violator

Passenger Face Not Detected
And Seat Detected: Candidate Violator

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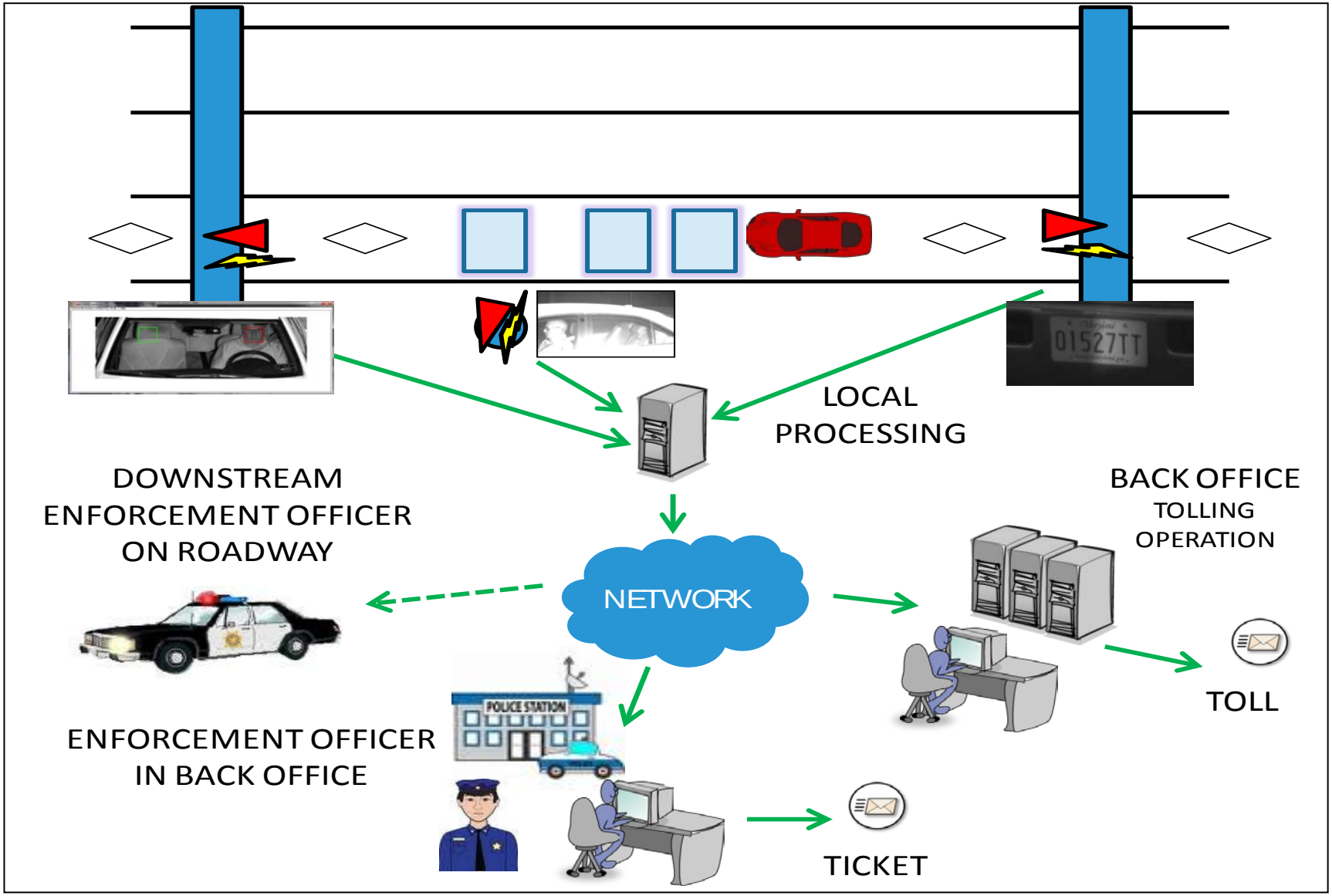
Leveraging Existing Tolling Infrastructure



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Active Roadway Pilot Results: Vehicle Occupancy Testing Baltimore, MD November 2012

Front Seat Detection Processing Steps

•Raw Captured Infrared Image

•Xerox Automatic Windshield Detection

•Xerox Automatic Image Enhancement
•Cropped Windshield Sub-Image

•Front Passenger Side Crop
•Xerox Automatic Passenger Detection

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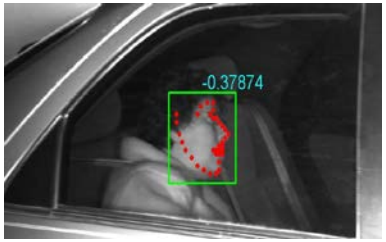
Sample Side View Image

Pilot Side View Detection Performance

Statistics:

- Detection Accuracy: 94.3%

Correctly Detected Occupants :



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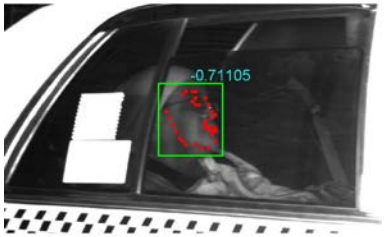

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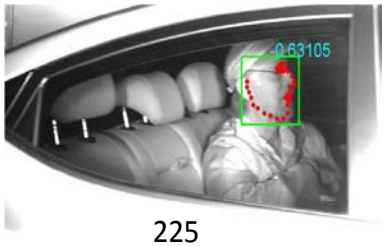

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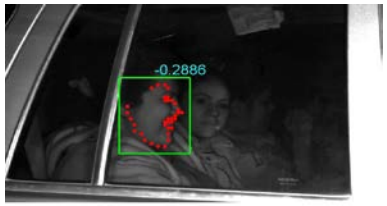
score decreases



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Summary: Vehicle Occupancy Detection
Public Roadway Testing

Baltimore, MD
City Road Intersection
November 12-27, 2012

2 Camera System: (1) Front Seat viewing Camera, (2) Rear Seat viewing Camera

Front Seat:
39,000 Images Captured, 24hrs/day
Image Quality for Human Review on >99% of Images
Automatic Front Seat Passenger Detection Accuracy: 97.6%

Rear Seat:
>3900 Image Captured, daytime only
Acceptable Image Quality for Human Review on >90% of Images
Automatic Rear Seat Passenger Detection Accuracy: 94.3% for >1300 Images

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Driver Cell Phone Usage & Seat Belt Usage can also be Observed in Images

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Next Steps:
Pilot Tests Scheduled for 2013

- **Bay Area Toll Authority**
- **Halifax Dartmouth Bridge Commission**
- **Any Volunteers?**