



A Breakthrough in Automated Vehicle Occupancy Monitoring Systems for HOV / HOT Facilities

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Problem...or Opportunity?

Being able to count people in vehicles is fundamental to the HOV / HOT program

- *PROBLEM*

- It's very difficult to do

- Accurately, inexpensively, everywhere, all the time

- *OPPORTUNITY*

- It can be done

- Technology is available
- Significant benefits can result



How Many People Are In That Car?

- Only current technique is manual visual observation



What's Wrong with Current Practice?

- Costly
- Inaccurate
- Limited in scope / location
- Weather-dependent
- Vehicle challenges – tinted windows etc.
- Selective – can't support automated enforcement
- Unsuitable to non-barrier-separated or all-electronic HOT lanes
- Need wide shoulders and safe observation areas
- Really difficult for arterial HOV projects



More Police - Is That the Answer?

- Some problems can be overcome with committed enforcement program, but...
 - Requires substantial ongoing budget support
 - HOV violations remain key public flash point
 - Fully automated enforcement plans are impossible
- HOV lane performance data is limited and hard to obtain
- Current practice limits potential support for more HOV / HOT projects



The Baseline

- Police and Transportation Authorities need an effective, cost-efficient, reliable, and targeted technique for observing auto occupancy.
- This cannot be delivered by current practice.



Yes, We've Tried...

- Automated HOV Occupancy Detection has been a research subject:
 - Caltrans (1990): Video
 - TxDot/DART (1995-1999): Video
 - Georgia DoT (1997): Digital Infrared
 - MnDoT (1998): Infrared / Video
 - Leeds, UK (2002): Infrared / Video



The Results?

- Pretty good in some cases, but not good enough
- Inherent problems with “outside the vehicle” monitoring:
 - Darkness
 - Visibility into all seats in all vehicles
 - Single point monitoring vs network wide needs
 - Functionality in non-barrier-separated environment
 - Cost of field installation
 - Need for 100% accuracy if used for automated enforcement



Our View

- Detecting occupancy from *outside* the vehicle is inherently flawed
- Start with systems *inside* the vehicle, and build outwards



Occupancy Detection is Easy!

- Why does the seatbelt warning sign on your dashboard light up?
 - Seat occupancy is being detected, with the warning sign cancelled only by use of the seat belt
 - The auto industry has been detecting seat occupancy since the 1960s!



How Do They Do That?

- Today
 - Mechanical Systems (e.g. seatbelt closure)
 - Weight Sensors
 - strain gauge in seat mount
 - pressure sensor in seat
 - gel bladder under seat
- Other Available Technology
 - Magnetostrictive strain sensors
 - Photography / Video
 - LED imaging
 - Thermal / Infrared imaging
 - Ultrasonic / Radar sensors
 - Capacitive sensor
 - Heartbeat / Breathing monitors
 - Fingerprinting and Biometric recognition
 - Smart Cards and Readers



In Fact...

- US Federal Motor Vehicle Safety Occupant Crash Protection Standard 208 *requires* the use of “smart” air bags (i.e. with occupancy detection system) in the front seats of new vehicles sold in the U.S.:
 - 20% of 2004 model vehicles
 - 65% of 2005 model vehicles
 - 100% of 2006 model vehicles and thereafter
- Occupancy sensing is a \$3.6 B industry (2001-06)



Getting Data to the Roadside

- In-vehicle occupancy detection system creates simple electronic data that can be linked to available transmission systems:
 - Transponder / receiver systems
(e.g. as used in electronic tolling)
 - Satellite-based systems (GPS)
 - Wireless ground-based systems
- Info can then be gathered in monitoring system and used as appropriate



Citation Process

- All HOV lane users must have OMS if the need for police in the field is to be eliminated
- Restrict HOV lane use to vehicles equipped with OMS
 - vehicle in HOV lane with *no* OMS cited for OMS violation
 - vehicle in HOV lane *with* OMS and fewer than required occupants cited for HOV violation
- Police can use OMS
 - In the field, to reliably spot violators and either
 - Stop and issue citation
 - Note vehicle license and issue ticket by mail
 - In a fully automated system
 - Issue ticket by mail



Vehicle-Based Occupancy Detection is...

- Currently available / in use technology
- Relatively low cost
- Capable of being 100% reliable (air bags must work right every time)
- Capable of addressing all the challenges facing out-of-vehicle systems
- Capable of functioning everywhere, continuously



We Could Use That System For...

- High Occupancy Vehicle lanes
- High Occupancy Toll (HOT) lanes
- Managed Lanes, Value Pricing, and Congestion Pricing
- Toll highway rebates for HOVs
- Safety / Seat Belt Use
- Systemwide HOV Tracking (off HOV lanes)
- Data Collection
- Vehicle emissions monitoring / testing
- HOV Traffic Signal Priority
- Vehicle Identification
- Vehicle / Operating Diagnostics
- Vehicle Safety Systems
- Emergency Systems
- Passenger security systems
- Transit Monitoring / Priority
- HOV Preferential Parking
- Carpool Incentives
- Insurance
- Marketing



“Any Concerns?” We Asked ...

- 10 State Transportation Authorities
- 8 Municipalities
- 11 Enforcement Agencies
- 6 Auto Manufacturers / Groups
- 6 other interested parties



“What Are Your Thoughts On...”

- Cost
- Privacy Issues
- Technological Problems / Issues
- Accuracy and Reliability
- Mandatory vs Voluntary Application
- Timeframe for Implementation
- Legal or legislative obstacles
- Ticket by Mail
- Potential other Applications / Benefits / Synergies
- Partnership Opportunities
- Commercial Issues
- Alternative Solutions – Is There a Better Way?
- Other Issues



“Yes, we are concerned about...”

- Lack of public / political acceptance of automated enforcement of any type
 - Triggered by privacy / civil liberty perceptions
 - Ticket-by-mail requires absolute proof and legal support
- Capital cost
 - Competition for funding priority
 - Motorist acceptance of additional in-vehicle cost
- Practicality of rollout
 - Requires government / industry co-ordination, cooperation
 - Needs are immediate; this could take a long time
 - All HOV lane users need the system for it to be effective
- Police presence still desirable
 - Conventional enforcement can be effective when supported by high fines and adequate funding



But Some Positive Thoughts Too

- “Great idea! That’s just what we’ve needed!”
- Concur with technical feasibility
- Could resolve privacy issues by applying to a controlled environment (e.g. HOT lane)
 - An effective pilot project could set the scene for large-scale rollout
- Avoid use of photography, to reduce privacy issues
- Cost could be viewed more positively if fine revenue returned to the system
- Could rationalize expense if additional benefits arise (e.g. automated, effective traffic counting)
- Ticket-by-mail issues can be resolved



Occupancy Monitoring is Not Free

- In-Vehicle Costs
 - Transponder, rear seat monitoring: say \$200 - \$400 (more for retrofit, less for new vehicle)
- Roadside Costs
 - Median antenna system, say \$100,000/mile (covers two buffer- or non-separated HOV lanes)
 - Much less for a barrier-separated environment
 - Total for all U.S. freeway HOV lanes ~\$400M
- Other System Costs
 - Back office, computers, software, administration, customer service, mailing, court costs



Conventional HOV Lane Operation is Also Costly

- Enforcement
 - \$4,500 - \$9,000 per freeway lane-mile per year (\$12M - \$24M per year across the U.S.)
 - Result: 5% - 10% violations
 - Arterial HOV lane violations: 50% - 80%
- Capital cost for enforcement provisions (shoulders, observation areas, etc.)
 - Result: lack of shoulders precludes enforcement
- HOV Lane Performance Monitoring
 - Field work \$2M - \$3M per year across the U.S.
 - Result: spotty, limited data



The Revenue Picture

- Current HOV enforcement revenue
 - In the order of \$35M - \$70M per year (U.S.)
 - If 100% of violators were cited, fines would amount to \$2B - \$4B per year
- With Automated Enforcement
 - Fine revenue drastically reduced, because all violators would be identified and fined
 - For 1% violation rate, annual revenue \$375M
 - Ultimate objective is to eliminate fine revenue
 - Benefits lie in more effective TDM program



Is There a Business Case?

- Implementing automated occupancy monitoring is costly but can be paid back over time by:
 - User-pay for in-vehicle system
 - Reduced HOV policing cost
 - Reduced HOV lane construction cost
 - Increased ability to implement HOT lanes
 - Value of improved performance monitoring data
 - Public / political support for expanded HOV / TDM program, yielding net benefits in congestion, air quality, land use, etc.
- But - a successful system will result in no violations and no fine revenue!
- Automated OMS unleashes many potential synergistic applications



Three-Pronged Action Plan

- Technical
 - Develop prototype
 - implement pilot project
- Social-Political
 - Market research re: public / political views
 - Refine Business Case and financing
- Commercial
 - Consult with auto industry re: implementation



Where To From Here?

- Automated occupancy monitoring
 - Can be done
 - Should be done
 - But will it be done?
- Who will take this forward to the next stage?
 - TRB?
 - FHA?
 - ITS America?
 - State DoTs?
 - HOT proponents?
 - Commercial entity?



Credits

- The study was undertaken in 2004 by McCormick Rankin. It was managed by the Ministry of Transportation of Ontario and funded by ENTERPRISE, a pooled-fund ITS research program
- ENTERPRISE members are :
 - Federal Highway agencies in U.S., Canada, Netherlands
 - DoTs from Arizona, Colorado, Iowa, Kansas, Michigan, Minnesota, Ontario, New Mexico, Virginia, Washington
- Report can be downloaded from:
www.mrc.ca/pdf or
enterprise.prog.org/completed/0304carpool.htm
- e-mail contact: sschijns@mrc.ca

