Traffic Monitoring and Incident Management

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Today’s Talk

- Current approaches to monitoring traffic
  - Sensor technologies
  - Role of Traffic Management Centers
- Incident management approach
  - Incident identification
  - Incident response
- Emerging monitoring technologies

Traffic Monitoring

- State and local departments of transportation (DOTs) are primary players
- Federal government requires monitoring of major roads
  - Off-line, archived speed and volume data
- Most large cities also collect real-time data on major facilities

Traffic Monitoring

- Amount of traffic data varies widely depending on facility and area
- Urban freeways
  - Most heavily instrumented (0.5-1 mile sensor spacings)
  - Often have real-time data
  - Often try to provide feedback on congestion back to drivers
  - Data is often archived for future usage

Traffic Monitoring

- Urban arterial roads
  - Data collected at signals and select midblock locations
  - Data often not archived
- Rural roads
  - Data collected at relatively few locations (VDOT has 300 monitoring stations for over 55,000 miles of road)
  - Data not available in real time

Traffic Monitoring

- Most monitoring now done with point sensors
  - Collect detailed data at specific, fixed locations
  - Sometimes creates problems when extrapolated to surrounding areas
- Typical technologies
  - Inductive loops
  - Radar and microwave sensors
  - Video detection
  - Acoustic sensors
  - Piezoelectric sensors

Inductive Loop Detectors

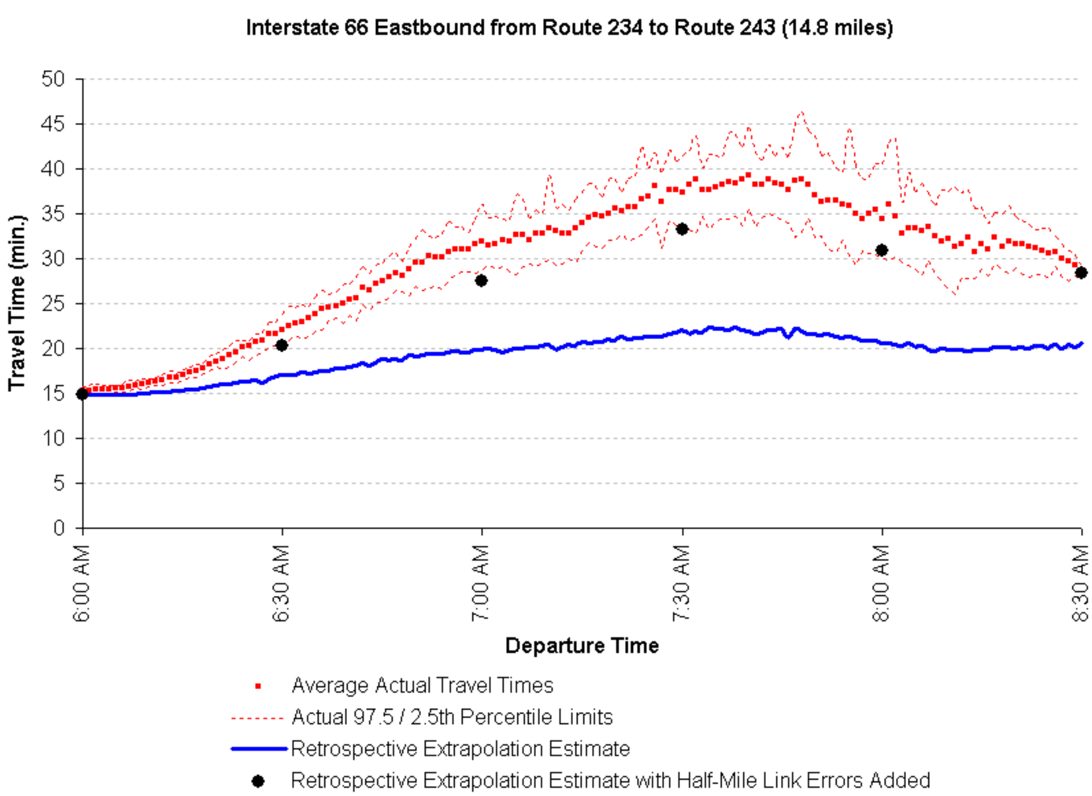
- Most widely used sensor technology
- Detects the presence of metal objects passing over the loop
- One of the oldest detection technologies and still widely used

Inductive Loops

- Advantages:
  – Agencies are familiar with sensors and equipment
  – Lots of "legacy" equipment in place
  – Collects very detailed data where installed
- Disadvantages:
  – Cost: $40,000 to install on multilane freeway + $5,000 annually to maintain
  – Prone to failure due to traffic and weather
  – Maintenance requires closing lanes
  – May weaken pavements due to saw cuts

Inductive Loops

- Placement
  - Traffic signal approaches
  - Between interchanges on freeways
- Paired loops collect:
  - Volume
  - Vehicle class
  - Traffic speed
  - Vehicle occupancy (% of time that detector is on, related to density of traffic)



Inductive Loops

- In Virginia, many loops are not functional
- Recent data from Hampton Roads shows 30-40% of detectors not returning any valid data
- Many more have intermittent outages

Microwave and Radar

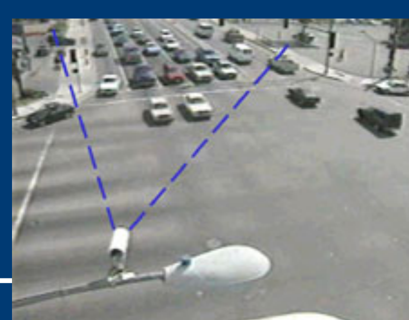
- Non-intrusive detectors
- Collect speed and volume
- Often used as a low-cost was to supplement loops in urban areas

Microwave and Radar

- Occlusion can be a problem with these detectors (trucks blocking other cars)

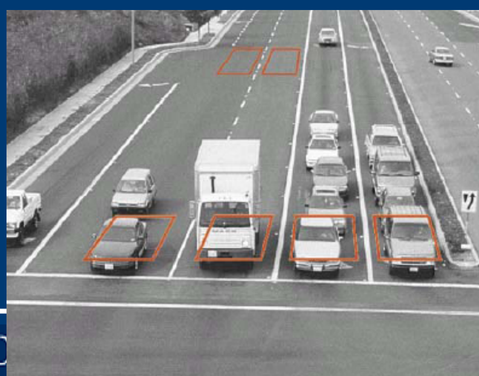
Video Detection

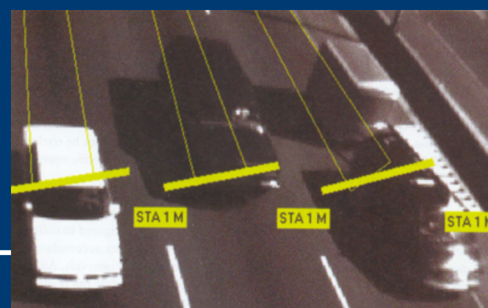
- Uses cameras and video detection software to create "virtual loops"
- Primarily used at intersections, but some freeway applications also



Video Detection

- Collects speeds and counts
- Recent advances to apply technology using existing CCTV cameras on freeways
- Video data stream usually not archived





Video Detection

- Advantages:
  - Not impacted by repaving
  - Relatively reliable and non intrusive
- Disadvantages
  - Set up is critical
  - Prone to occlusion from large vehicles
  - Can have problems at night and in fog

Acoustic

- Passive and active acoustic detectors
- Count and classify vehicles by lane
- Speeds are estimated, but more suspect
- Results generally not very promising so far

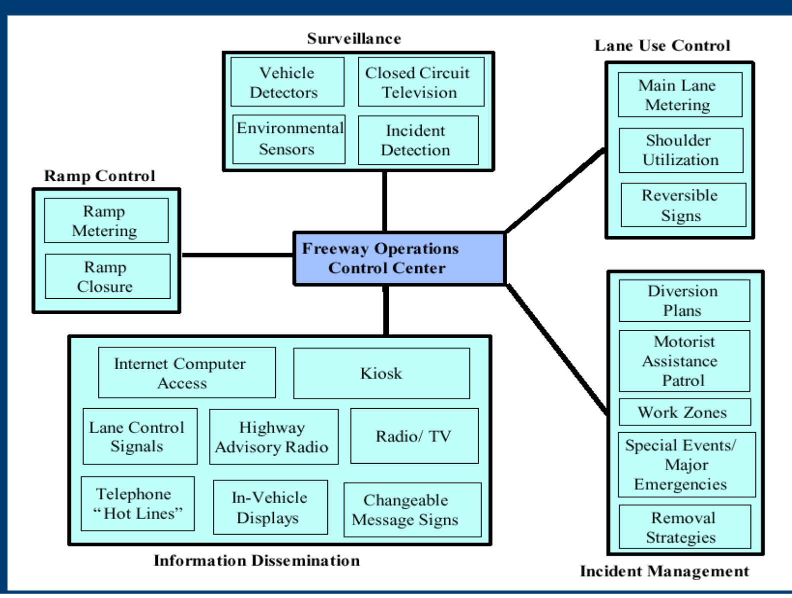
Piezoelectric sensors

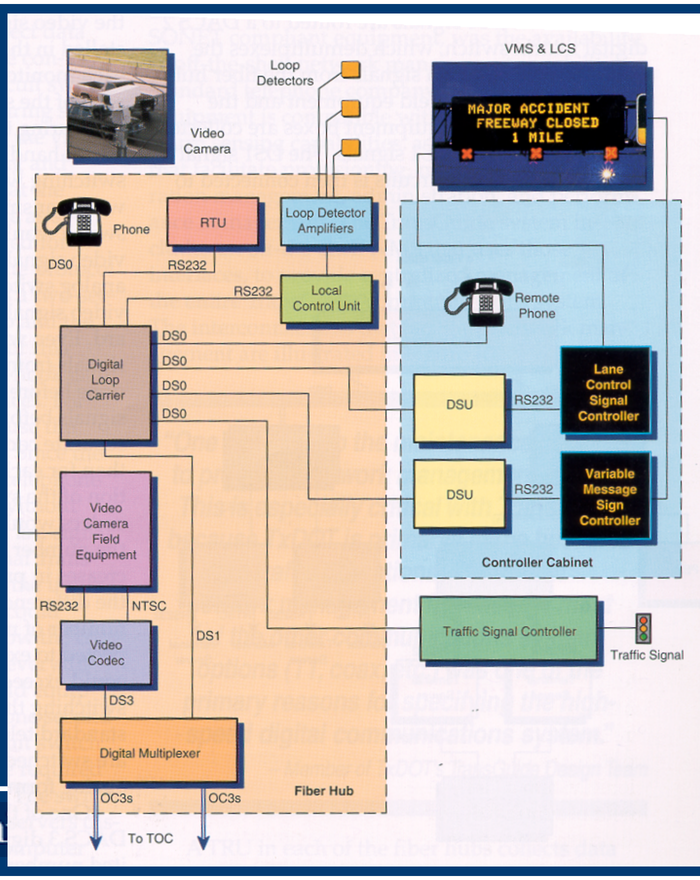
- Primarily used for weigh-in-motion systems
- Limited application for speed sensing
- Not commonly used

Traffic Management Centers

- Gathers, synthesizes, and disseminates information
- Controls various in-field equipment
- Coordination point for stakeholders

Functions of a TMC





Elements of Congestion

- Recurring
  - Created by over capacity operation
  - Predictable, and countermeasures can be developed
- Non-recurring
  - Caused by crashes, breakdowns, special events, construction, and other incidents
  - Sometimes difficult to predict, responses have to be flexible
  - Estimated to account for 50-60% of all urban congestion

Effects of Incidents

- Disabled vehicles on shoulder
  - 26% reduction in capacity
- 3-lane road with one lane blocked
  - 50% reduction in capacity
- 3-lane road with 2 lanes blocked
  - 76% reduction in capacity

Impacts of Incidents

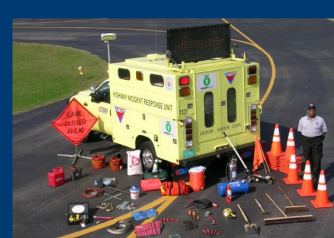
- Congestion
  - Each minute that a lane is blocked created 5 minutes of delay
- Safety
  - Stop-and-go traffic creates the potential for secondary crashes (usually rear ends)
  - Shockwave on Freeway

Incident Management

- Most large urban areas in the U.S. have incident management programs to try to deal with non-recurring congestion
  - Identify when something has occurred
  - Respond and clear the incident as quickly as possible
  - Provide information to drivers on delays

Incident Detection

- Methods
  - Automated methods using sensor data
  - Phone calls from the public
  - CCTV
  - Police or motorist assistance patrols



Automated Incident Detection Algorithms

- A number of incident detection algorithms have been developed and tested
- Rely on data from sensors to identify problems
- Developed for freeways, not transferable to arterial roads
- Measures of effectiveness
  - Detection rate
  - False alarm rate
  - Mean time to detection

Commonly Cited Algorithms

- Approaches:
  - Pattern recognition (California methods)
  - Statistical and times series (ARIMA methods)
  - Macroscopic models (McMaster)
  - Neural networks
- Have to be calibrated to specific conditions at a site (significant effort)

Incident Detection Algorithms

- California algorithms are most popular
  - Compare detector occupancies to predefined threshold values
- False alarm rate is per algorithm application
  - Ex: every 20 sec = 6 false alarms/day for CA #7

Algorithm	Detection Rate	False Alarm Rate	Mean Time to Detect
California #7	67%	0.134%	2.91 min
McMaster	68%	0.0018%	2.2 min

Incident Detection Algorithms

- Used more often before cell phone use was widespread
- Field deployments of automated methods have faired relatively poorly
- Sensor limitations make application difficult
- 2/3 of TMCs surveyed do not use automated methods at all

Common Methods Used to Identify Incidents

- Initial notification
  - Call from the public
  - Call from police or DOT field worker
  - Media reports
- Verification
  - CCTV
  - Incident detection algorithm

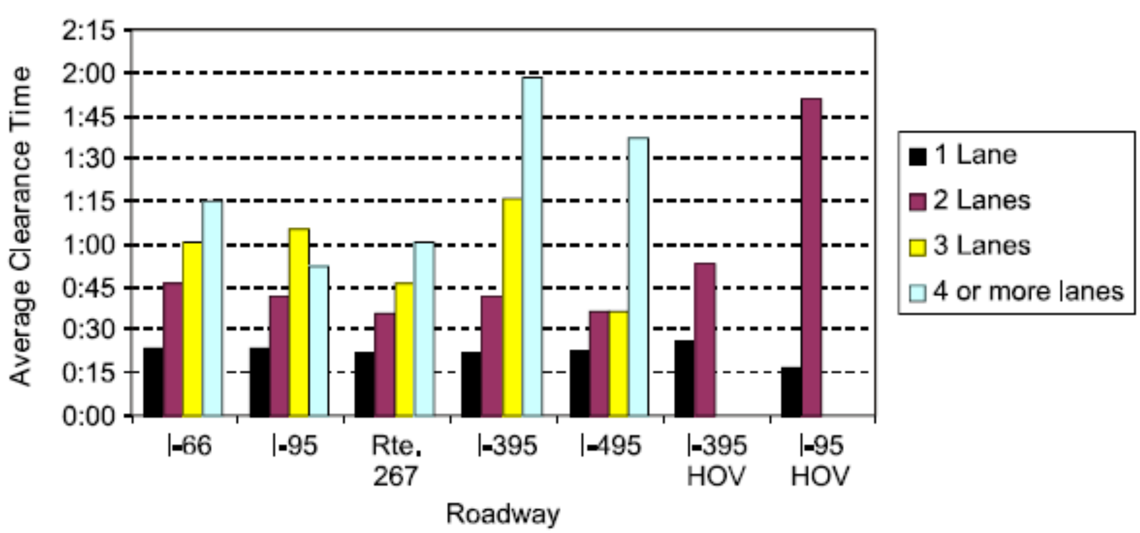
Incident Response

- State DOTs and local governments often fund freeway service patrols (FSPs)
- FSPs travel regular "beats" to enable quick response on major corridors
  - Address minor problems (out of gas, change a tire, clear debris)
  - Call tow trucks or emergency responders
  - Provide traffic control, if needed

Scope of Problem – 1 yr in No. VA

- 44,255 assists by FSP (6/1/04-5/31/05)
- 29% were crashes
- 198 miles of freeway covered
- Averages to 121 assists/day
- About 15% (18/day) block at least 1 lane

Average Time Lane Blocked

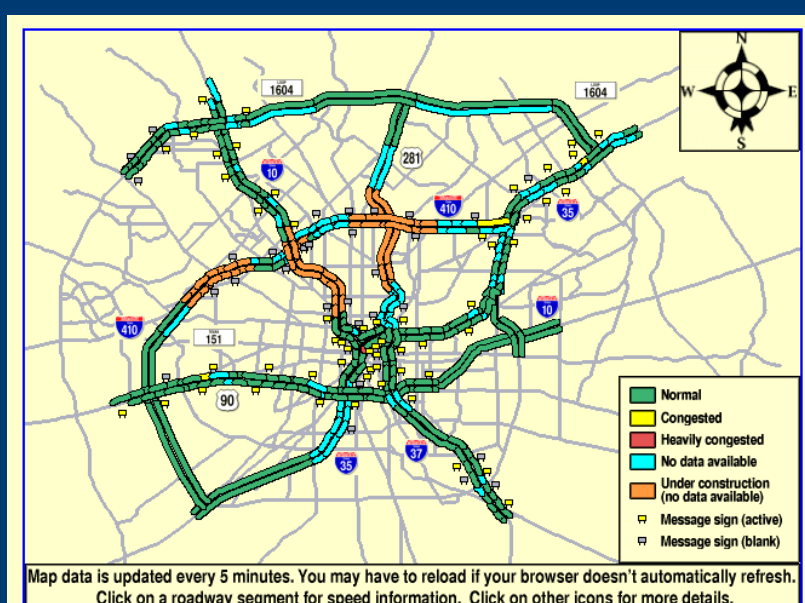


Information Dissemination

- Websites
- Highway advisory radio
- Variable message signs
- Media
- 511 system

511 Travel Info

San Antonio Web Interface



Alerting Drivers to Congestion

- DOTs are often reluctant to provide specific route guidance
- Usually use messages like "Delays Ahead" rather than telling drivers to exit.

Recent Trends in Traffic Monitoring

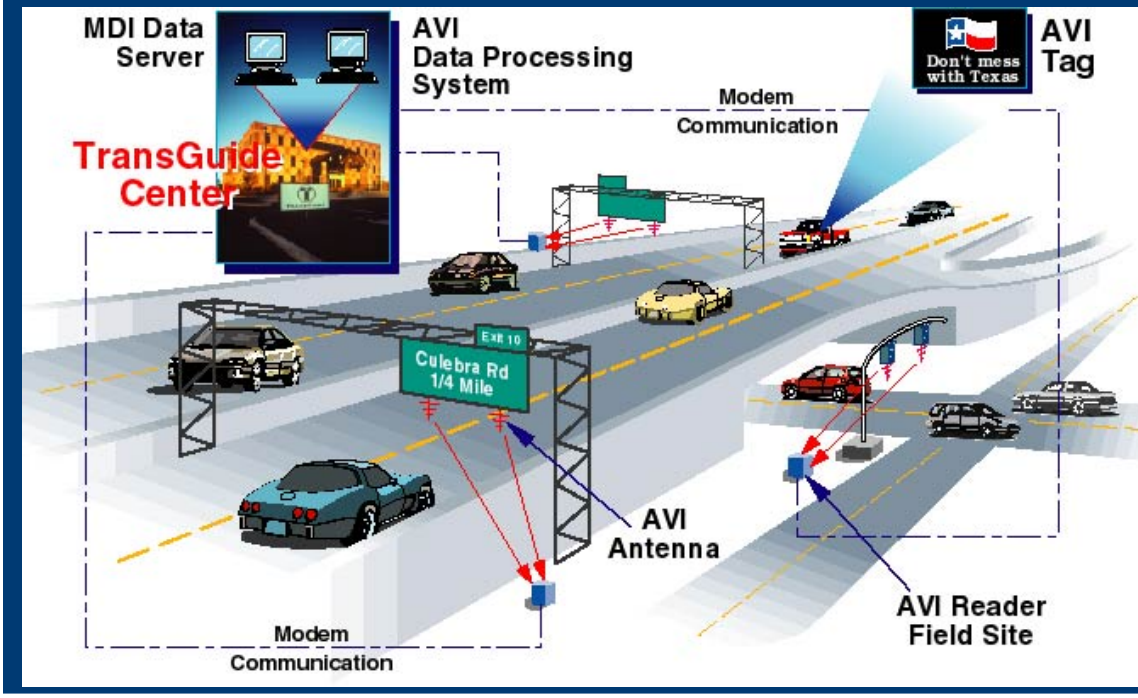
- Private sector is becoming more heavily involved in traffic monitoring
  - Data becomes a commodity which is sold to media, private citizens, DOTs
- Greater interest in learning "true" travel times on routes
- Lots of interest in probe-vehicle based systems

Emerging Monitoring Technologies

- Automatic vehicle identification (AVI) based systems (tracking toll tags)
- Automatic vehicle location (AVL) based systems (tracking transit or fleet vehicles)
- Wireless location technology (anonymous tracking of cell phones)
- Vehicle Infrastructure Integration – communication between vehicle and roadside

AVI

- Builds off of electronic toll collection technology
- Transponders communicate with roadside equipment through DSRC
- Additional antennae installed along corridor
- Transponders register as they pass antennae

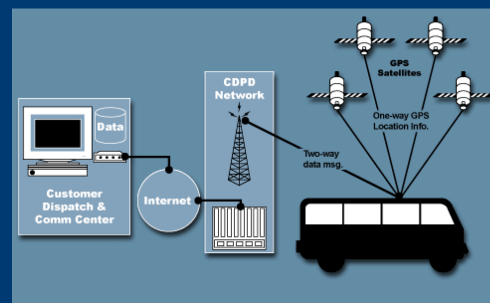


AVI

- Advantages:
  - True point to point data
- Disadvantages
  - Requires a significant proportion of cars to be equipped with transponders to have consistent data flow
  - Can measure speeds, but not volumes

AVL

- GPS-based locations provided for fleet of transit or commercial vehicles
- Location data mined to determine travel times
- Successfully used by some cities
- Private sector getting involved here



AVL

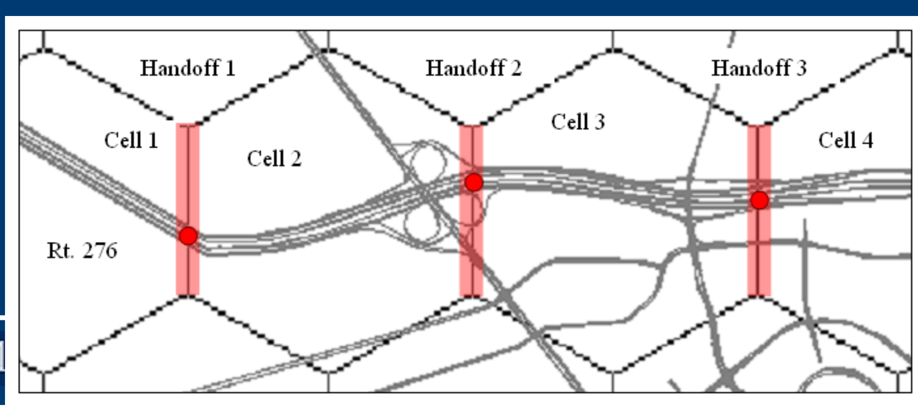
- Advantages
  - True point-to-point data
  - No infrastructure to install (unless you do roadside beacons)
- Disadvantages
  - Smaller number of probes, less reliability for mean speed estimation
  - No volume data can be generated

Wireless Location-Based Technology

- Anonymously tracks cell phone locations, and generates traffic condition data
- 3rd party vendor works with cellular company to gain access to data, which is then sold to DOTs or media outlets
- Technology is still evolving, and business model not well established

WLT-Based Monitoring

- Technology is evolving
- Most rely on mining phone handoffs from cellular companies



WLT-based Monitoring

- Data to data has not been adequate to support traffic monitoring
- Errors > 20 mph common on arterial roads, better results on freeway
- Recent trends have been promising

Vehicle-Infrastructure Integration

- Supported by Federal Highway Administration
- Consortium of universities, auto manufacturers, and state DOTs involved
- Full scope of program still being defined

VII Use Cases

- Vehicle-vehicle (Lane change warnings, road condition warning)
- Vehicle-infrastructure (signal violation warnings)
- Vehicle-Enterprise (electronic payment)
- Vehicle-Internet (media downloads, gas/ food/lodging search)
- Vehicle Probes (aggregate data for traffic purpose)

VII Status

- Laboratory construction and application development underway in Detroit
- Economic feasibility being explored
- Auto industry doing other work in parallel
- In mid-2007, proof-of-concept testing over 20 square mile area near Detroit

Summary

- Right now, agencies rely on point sensors
- Methods to detect incidents are relatively low tech
- Increasing move to probe based methods, with many new techniques in development
- Big potential payoff if we can reduce the impact of non-recurring congestion