IntelliDrive℠ Overview

MDOT IntelliDrive Stakeholder Workshop

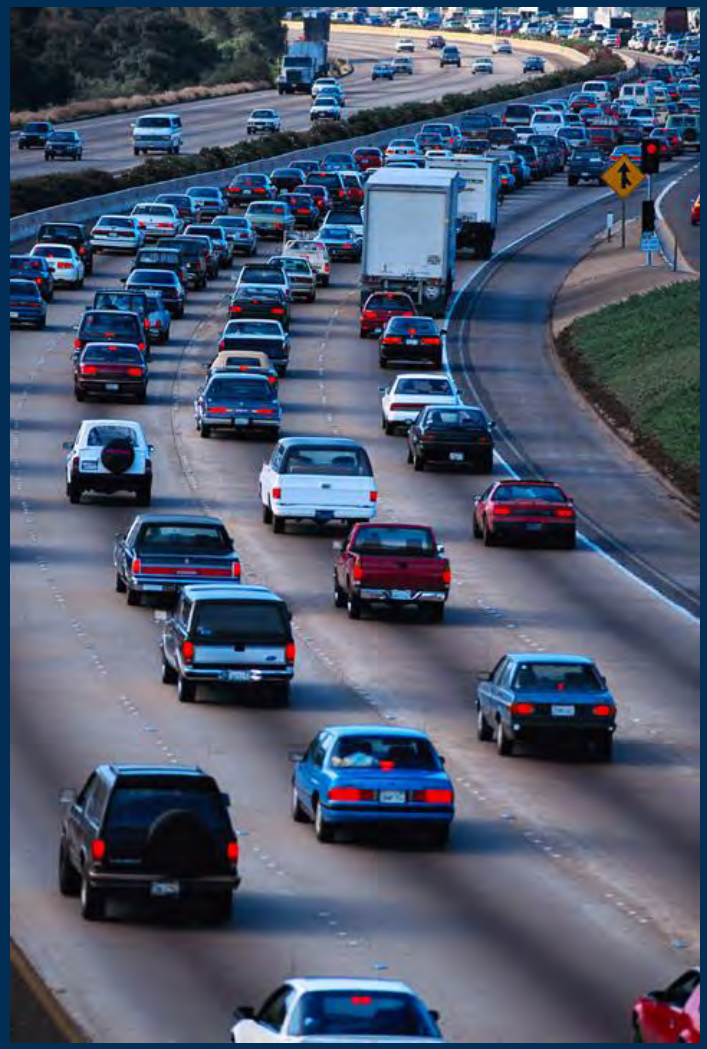
September 27, 2010

Marc Start, PE PTOE

URS

Mn/DOT Mileage Based User Fee Project (2007)

- Researched other MBUF operation tests
- Developed project concept
- Vendor RFI released
- Project put on hold



URS

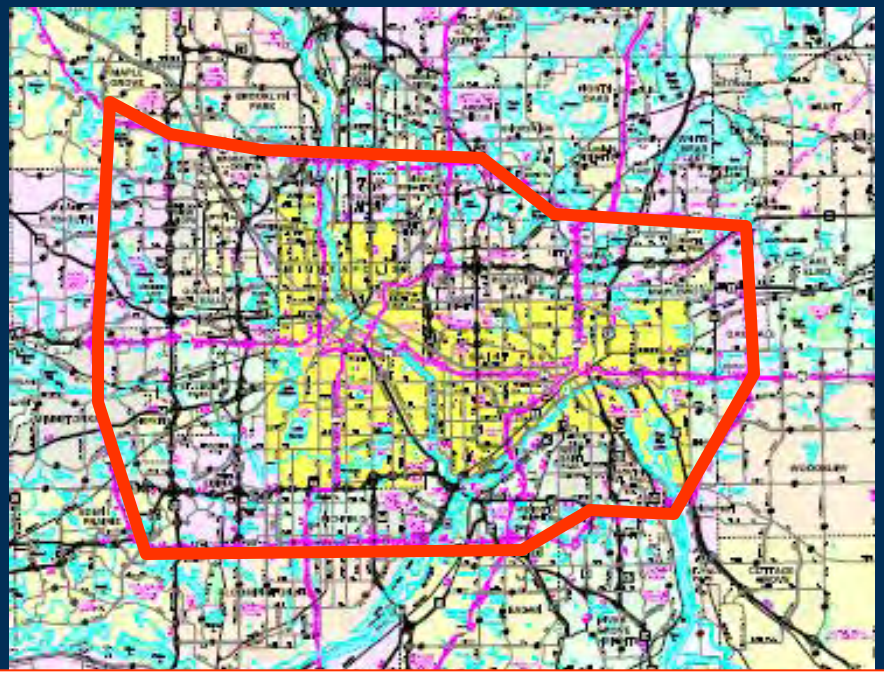
MBUF Project Findings (2007)

- MBUF fees can be made proportional to public costs (wear-and-tear)
- Potential for better transportation system efficiency and environmental outcomes
- Privacy can be protected by encryption
- No significant legal impediments

URS

Mn/DOT Mileage Based User Fee Project (2010)

- Sub to Battelle
- 500 participants / outfitted vehicles
- Test deployment in summer 2011
- 2011 World Congress demonstration
- Revenue-neutral goal

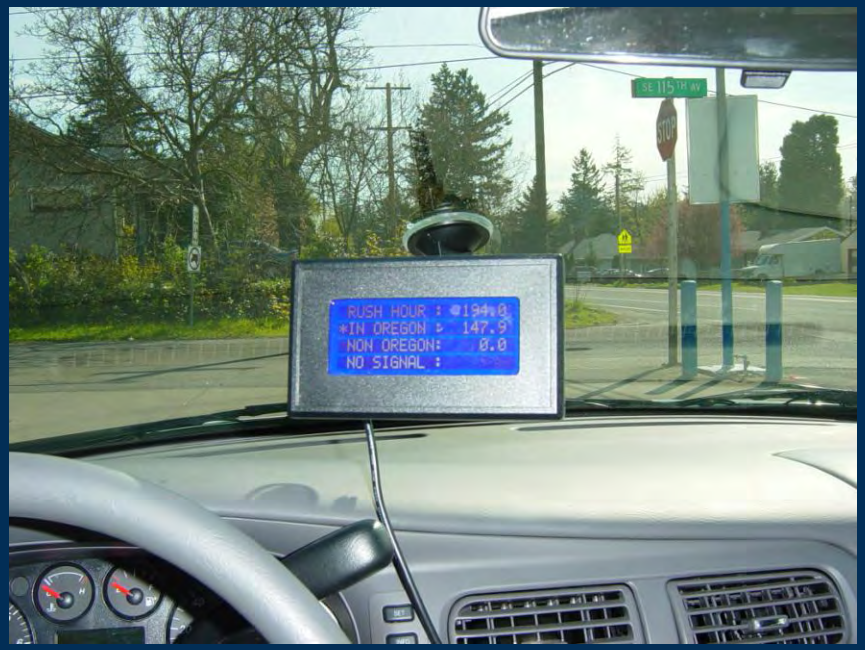


Minneapolis-St. Paul Metro Area

URS

MBUF Rate Factors under Consideration

- Vehicle types (wear-and-tear impact)
- Fuel-efficient vehicles
- Urban and rural
- Roadway jurisdiction
- Time-of-day travel
- With/without GPS technology



URS

MBUF Project Challenges

- MBUF base rate and incremental adjustment factors
- Cost differences between fuel tax and MBUF for users
- Formula for reimbursing jurisdictions
- Public policy choices (fuel efficient vehicles)
- Driving habit changes

URS

UK In-Vehicle Traffic Management System

- Growing partnership with manufacturers
- Feasibility study (phase 1) is nearly complete
- Functional specifications (phase 2) has not yet begun

Dynamic regulatory information

URS

In-Vehicle TMS Considerations

- Accurately replicating information already provided on gantries
- Transition from highway to urban street environment
- Driver distraction in urban environments
- Prioritizing information provided by the TMS

URS

Other Projects / Focus Areas

- Freeway and arterial operations focus in MI
- Weigh-in-motion / virtual weigh station applications
- IntelliDrive Guidance Documents (sub to Mixon-Hill)

URS

Connected Vehicle Proving Center

Steve Underwood
University of Michigan – Dearborn

Leading Causes of Death

Major Cardiovascular Diseases	936,923
Malignant Neoplasms	553,091
Chronic Lower Resperitory Dis.	122,009
Diabetes Mellitus	69,301
Influenza and Pneumonia	65,313
Alzheimers	49,558
Motor Vehicle Crashes	37,354
Renal Failure	36,471
Septicemia	31,224
Firearms	28,663

CVPC

Component Programs

- Connected Vehicle Proving Center (CVPC) will provide the unique testing and evaluation environment for pre-certification of MI.CAR functionality and interoperability.
- Mobile Intelligence: Connected, Autonomous, and Robotic (MI.CAR) Center of Expertise will promote collaboration among the partners and other industry participants on significant research, development, and demonstration projects with a common roadmap for attaining the long-rang vision.
- Alliance Program supporting the industrial community through networking, outreach, conferences, workshops, and other events.
- Developers Program where academic institutions share development property and organize for joint response to RFPs.
- Education and Training Program combines project-based education with professional development and certification in connected, autonomous, and robotic vehicle

IntelliDrive: Cyber-Physical Systems Perspective

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IntelliDrive is a multimodal initiative that aims to enable safe, interoperable networked wireless communications among vehicles, the infrastructure, and passengers' personal communications devices.

IntelliDrive research is being sponsored by the USDOT and others to leverage the potentially transformative capabilities of wireless technology to make surface transportation safer, smarter, and greener.

—— http://www.intellidriveusa.org

IntelliDrive as cyber-physical systems (CPS)

- Computing/networking are tightly coupled with physical processes at multiple spatiotemporal scales
  - Micro scale: intra-vehicular networked sensing and control at short timescales (e.g., from seconds to micro-seconds) for safety, comfort, and minimum environmental pollution
  - Macro scale: real-time sensing of road traffic condition for traffic flow optimization at multiple spatial scales (e.g., from streets to cities)
- Humans are involved in the dynamic process and introduce uncertainties in system optimization

A call for collaborative research between ITS and Computer Science and Engineering (CSE)

- Example synergistic scenarios
  - Vehicle-assisted road weather sensing ↔ participatory sensing
    - Fidelity/accuracy assertion
    - Delay-tolerant networking: cache and carry etc
    - Data differentiation: real-time vs. non-real-time
  - Uncertainty in traffic flow optimization ↔ CPS uncertainty handling
- Multiple roles of IntelliDrive
  - As a program: assist technology transition from labs to real-world settings
    - NSF Cyber-Physical Systems program
  - As an infrastructure
    - Support both near-term and long-term applications
    - Open infrastructure allowing for evolution
    - NSF GENI program
  - As a service: user opt-in
    - NSF GENI program

My interests

- Wireless and sensor networking
  - Real-time, delay-tolerant
  - Single-hop, multi-hop
- In-network processing for optimal bandwidth management and end-to-end quality assurance
- Mobile computing
  - Energy management: rate/energy metric for different wireless links
  - Middleware: communication abstraction to hide heterogeneity
- Experimentation infrastructures for wireless networking and mobile computing

http://www.cs.wayne.edu/~hzhang

Michigan IntelliDrive^{SM} Working Group Meeting – September 27, 2010

The Role of Outreach and Visioning in the IntelliDrive^{SM} Discussion

IntelliDrive^{SM} Demonstrations

- Numerous demonstrations dominated the VII/IntelliDrive^{SM} landscape 2006-2009
- Demonstrations largely successful in:
  - Showing feasibility of basic technologies
  - Illustrating range of potential uses
  - Generating industry movement
- Early demonstrations focused on technology, user experience secondary

Hitting the Demonstration "Wall"

- PB supported early MDOT demonstrations with design of network infrastructure, visioning of applications
- In 2009, PB and MDOT evaluated how to overcome the shortcomings of prior demonstrations:
  - Most effort/cost in technical development
  - Limited ability to demonstrate core applications
  - Passive user experience

Broadening the View

- In late 2009, PB started on development of an IntelliDrive^{SM} simulator, based on MDOT's goals:
  - Broadening understanding of IntelliDrive^{SM} beyond the ITS industry
  - Emphasizing user experience over technology demonstration
  - Showcasing core applications in a way not done in previous on-road demonstrations

IntelliDrive^{SM} Interactive

- Developed by PB using commercial gaming development software
- Off-the-shelf equipment, including chassis, workstations and monitors

IntelliDrive^{SM} Interactive

IntelliDrive^{SM} Interactive

IntelliDrive^{SM} Interactive

Many Uncertainties

- Before unveiling, the effectiveness of the simulator was uncertain:
  - How would different users react to the "video game"-like environment?
  - Is the experience too immersive to be effective in filtering out the message?
  - How can we balance the need to convey the message with "information overload"?

Overwhelming Response

- Survey conducted for each participant
- 98% of respondents indicated that the simulator helped them better understand IntelliDrive℠
- 96% reacted positively to how IntelliDrive℠ would impact them and their industry
- Results almost identical regardless of prior knowledge or industry sector

Visioning as Part of the Strategy

- The simulator and other tools will play an important role in building understanding and acceptance of IntelliDrive^{SM} concepts
- Much like the internet, privacy concerns will only be overcome when they are seen as outweighed by the benefits
- MDOT is actively pursuing expanded use of the simulator, and exposure to other agencies/states

Thank You

- For more information, contact:

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Environmental Application for IntelliDrive

Method for calculating "Destination Carbon Footprints" using IntelliDrive Data

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Somat Engineering, INCORPORATED

The Problem

Transportation is the fastest-growing source of greenhouse gases (GHG) emissions in the U.S.

- 47 percent of the net increase in total U.S. emissions since 1990.
- largest end-use source of CO_2, which is the most prevalent greenhouse gas.
- $2.9 billion gallons of fuel wasted each year.
- 22% of CO2 emissions from vehicles.

Our Approach

Empower transportation users with IntelliDrive information to make informed transportation decisions.

Important questions to answer:

- How do my transportation choices impact the environment?
- How do the transportation choices of my community impact the environment?
- How can I measure my impact?
- How can I measure my progress in addressing the problem?

Carbon Footprint

A carbon footprint is "the total set of GHG emissions caused by an organization, event or product."

Why?

- The term carbon footprint has become tremendously popular over the last few years and is now in widespread use across the media in the United States.
- With climate change high up on the political and corporate agenda, carbon footprint calculations are in strong demand.

Let's review some examples…

Carbon Footprint Example 1

Vancouver 2010 Olympics Carbon Footprint

- Target: Greenest Olympics Ever
- 15% reduction in carbon footprint
- 268k tons of CO_2
- 150k tons of CO_2 from travel
- Promoted participants to calculate their carbon footprint
  - Online calculators
  - Game-time CO_2 tips - alternate modes of transportation

Carbon Footprint Example 2

2010 World Cup Carbon Footprint

Study by the Norwegian Embassy and South African government

- 2.75M tons of CO_2
- 80% transportation related
- New rail network to give participants transportation choices

Example Lessons Learned

1. There is a social element to carbon footprints that should be acknowledged.
2. Carbon footprints can be grouped around destinations.
3. Calculating carbon footprints takes a lot of effort when trying to measure for events.

Destination Carbon Footprint (DCF)

DCF metric and defines it as "the total set of GHG emissions, grouped by geographic locations and allocated at trip destinations, caused by transportation users as they travel to shared destinations."

A destination's DCF is defined for a specific time frame and is calculated by summing all of the GHG emissions for the transportation systems users' trips to that destination for that time period.

DCF bridges the gap between individual transportation decisions and social shared experiences at travel destinations.

DCF – Information You Can Use

Transportation Users

Working in groups transportation users can potentially leverage more resources to reduce their collective GHG emissions.

- Car pool, change venues for events, measure and track progress.

Event Organizers

Destinations informed of their environmental impact, can coordinate their travelers and/or provide additional services to reduce GHG emissions associated with their location.

- Provide alternative modes of transportation, coordinate with public transportation agencies, incentivize participants to influence transportation decisions.

Summary

As our transportation systems become more intelligent, users will have a tremendous amount of information available to help them make more informed transit decisions.

DCF is one method to help transportation users measure and manage their environmental impact on the system.

We're continuing our DCF research and developing DCF software applications both fixed and mobile.

Accelerating Cooperative Safety Using Aftermarket Devices

MDOT *IntelliDrive* Working Group Meeting

September 27, 2010

Scott Shultz

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About Us

Automotive Insight is a strategic consulting firm staffed by industry experts with extensive OEM and supplier experience. We leverage our industry knowledge and relationships to provide our clients with unique insights, competitive solutions and new business.

Areas of Concentration

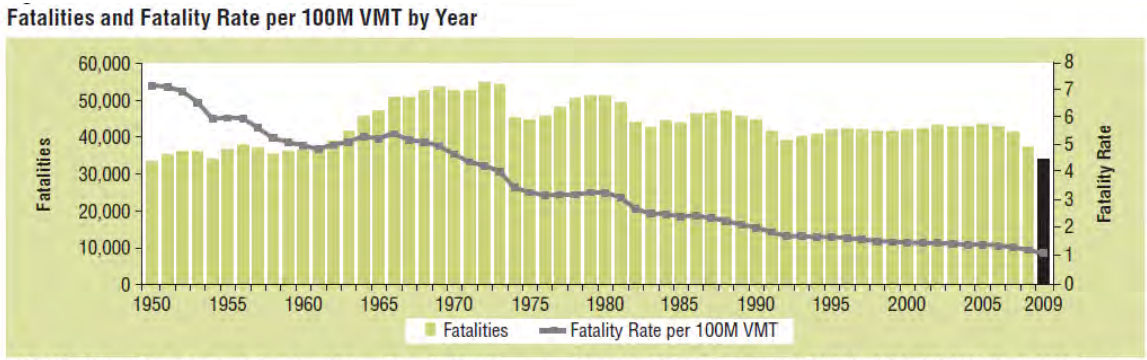
- Telematics and mobile communications for safety, mobility, and convenience
- Vehicle electrification, new powertrain technology, and fuel economy improvement
- Collaborative projects on dual-use automotive and military technologies
- Product innovation, consumer adoption, and marketing studies

Sample engagements

- Mobile Computing Applications Platform project
- Data capture systems with Battelle
- OEM hydraulic hybrid acceptance study
- OEM EV strategy project
- OEM/TARDEC CRADA management for powertrain & hybrid technology
- OEM growth strategy development for Asia
- Milliken Tegris material application study

Vehicle Safety Challenge

- U.S. vehicle safety has improved greatly through changes to driver behavior, infrastructure, and vehicle systems



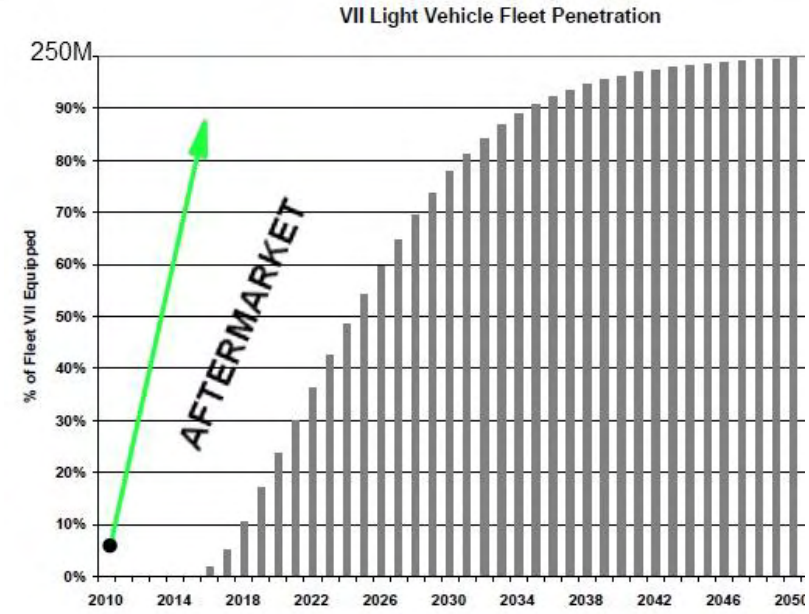
1950-1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2008 (Final), 2009 Annual Report File (ARF); Vehicle Miles Traveled (VMT): Federal Highway Administration.

- Next strategic steps focus on cooperative DSRC systems
  - Enabling interaction with infrastructure
  - Lower cost than adding sensors to each car
  - Dependent on high fleet penetration for effectiveness
- Significant time required for DSRC implementation
  - Rulemaking process
  - OEM development and launch
  - Vehicle fleet penetration / attrition
- Wide system implementation is unlikely until 2025 – 2030 timeframe

➢ **What other measures could augment safety until DSRC is in place?**

Point of View

- Consider the smartphone, offering:
  - Ubiquity -- expect 100M+ Android and Apple OS devices in US market by 2013
  - GPS, computing power, USB, sensors
  - Large display and audible output
  - Field-upgradeability (cost-effective development)
  - Fast communication links – 3G, 4G
  - Short hardware life cycles



- Other possible candidates:
  - Tolling / insurance tracking devices
  - Navigation devices
  - Radar detectors

- DSRC offers very low latency
  - Can it be integrated easily?
  - What could be accomplished with 3G instead? WiMax / LTE?
  - What wireless technology will be in place by 2020?

Automotive Insight

Programming Tutorial

Adoption Issues

- Safety is a hard sell
  - Global Mobile Alert™- Droid map-based safety app
    - Provides warning of schools, train crossings, and signals
    - Fewer than 50 installed at cost of $9.99 per year
- Aftermarket devices face technical challenges
  - Location, location, location!
    - Antenna performance
    - Reported position
    - Driver attention
  - Potential conflict with vehicle Human-Machine Interface (HMI)
    - Likely removal of nuisance alarms
  - More system complexity
    - Additional operating modes – phone calls, multiple devices in vehicle
    - Interoperability with OEM and other aftermarket devices
- Liability / privacy / security issues are no simpler than integrated DSRC's

Proposed Field Trial

- Aftermarket solutions could be available many years earlier than OEM
- With or without DSRC, such devices face technical issues
- An aftermarket field trial may provide important insights into implementation specifics, such as applicability to common scenarios or “softer” safety applications

Stop sign / Curve speed	?
Electronic brake lights	?
Forward collision warning	?
Lane departure	?
Intersection collision warning	?

- Would it be possible to set up a number of units and run them in protocols at MIS?
- Could this be linked with other initiatives?
  - Safety pilot
  - MDOT program for DUAP
  - Dynamic Mobility study (USDOT Request for Information)

Next Steps

- Automotive Insight is promoting use of aftermarket devices to accelerate cooperative vehicle safety
- We intend to engage further with adjacent markets, such as consumer electronics, internet service providers, software developers, insurance providers
- We are considering market studies to better understand consumer perspectives, behavior, and acceptance regarding cooperative safety in aftermarket devices
- We would be interested in talking with others interested in aftermarket cooperative safety devices and / or field trials

University of Michigan Transportation Research Institute

MDOT ITS Leadership Workshop

Michigan International Speedway

September 2010

UMTRI's ITS Involvement

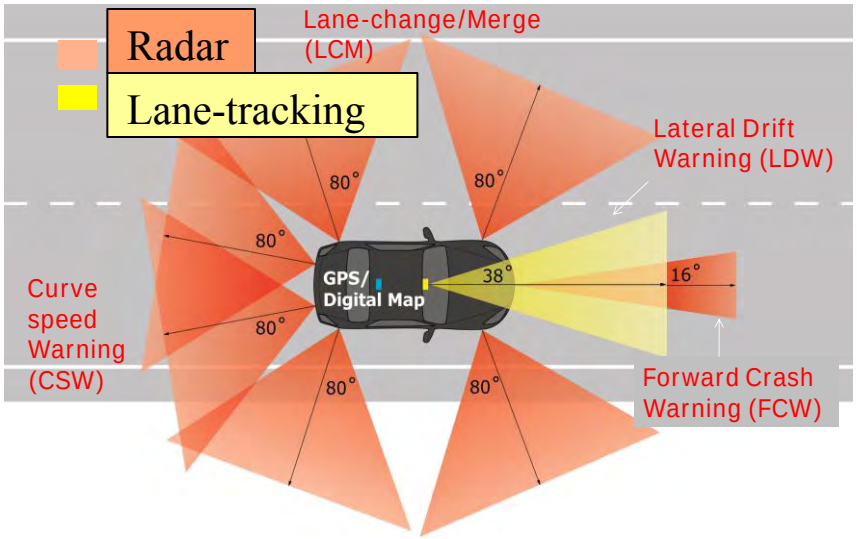
- National Recognition in key ITS programs
  - IVBSS field operational testing
    - Accumulation of a million miles of car and truck Naturalistic Driver Behavior Database
  - IntelliDrive Systems Modeling and Simulation
  - Driver distraction and workload research

Integrated Vehicle-Based Safety Systems (IVBSS)

- Assess the safety potential and driver acceptance of an integrated set of crash warning systems :
  - rear-end,
  - lane change
  - road departure crashes (drift-off and curve-overspeed).
- Passenger vehicles and heavy trucks
- A $25 million Two Phase Program
  - Phase 1: Design, development & objective testing
  - Phase 2: Field operational test in naturalistic driving conditions

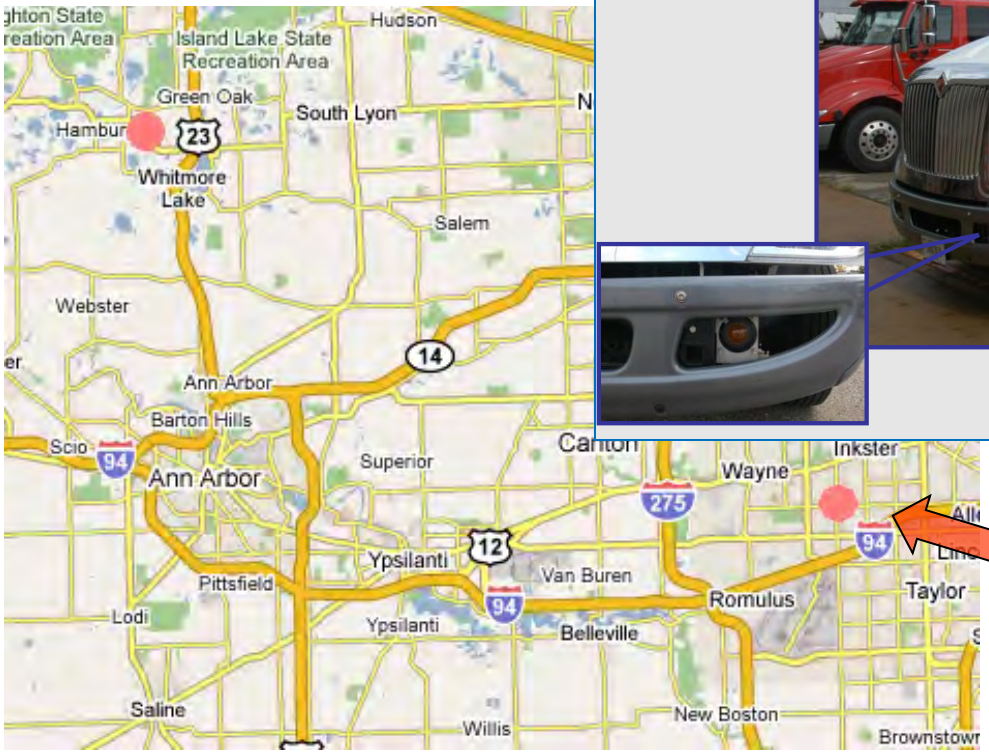
IVBSS Light Vehicle Study

- 108 drivers: 6 weeks each, 220,000 miles
- 16 vehicles each with four prototype crash warning systems
- 7 radars, 5 video streams, GPS, >500 other signals at 10 to 50 Hz



IVBSS: Heavy Truck Platform

- Con-way Freight usage
- 10 tractors
- 600,000 miles of data
- 20 drivers

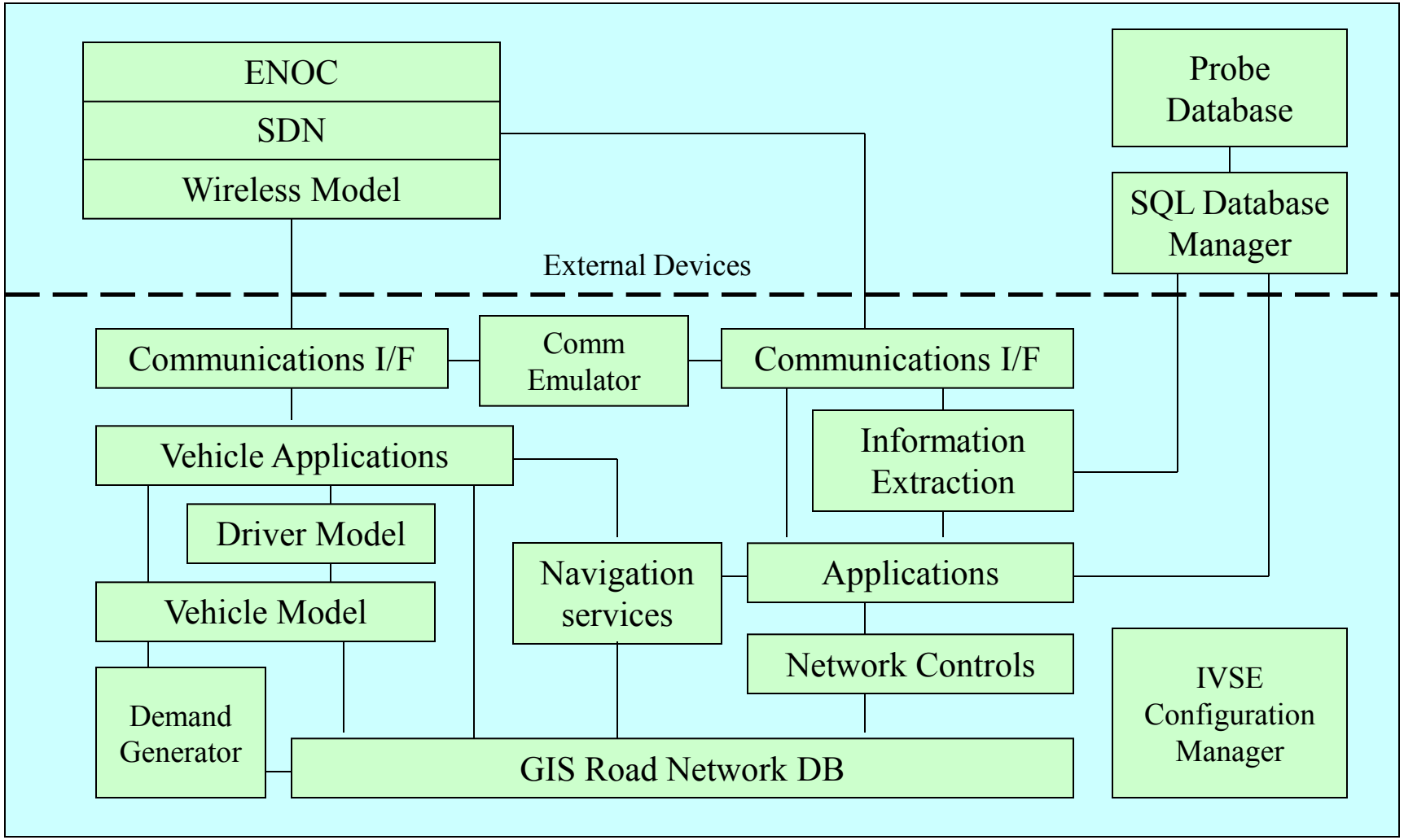


Romulus, MI terminal – 2 shifts for 1 year

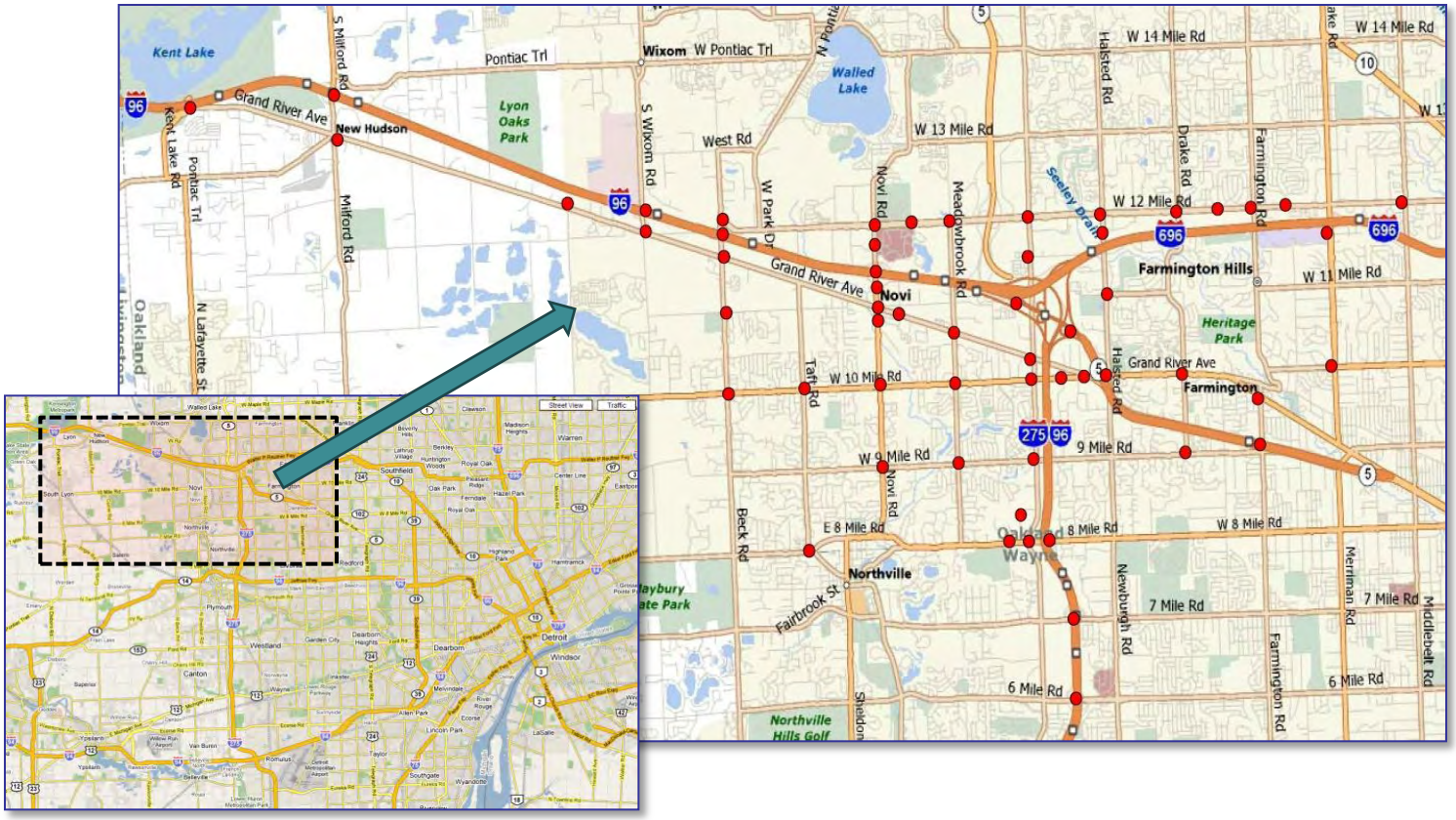
IntelliDrive MicroSimulation

- Advanced systems planning, design and architecture is critically enhanced with early systems simulation analysis
  - NASA simulated the end-to-end air traffic control system for FAA before next generation air traffic system design was started
- IntelliDrive Intelligent Vehicle Simulation Environment (IVSE)
  - used it to confirm POC data collection fidelity
  - used to refine data collection protocol

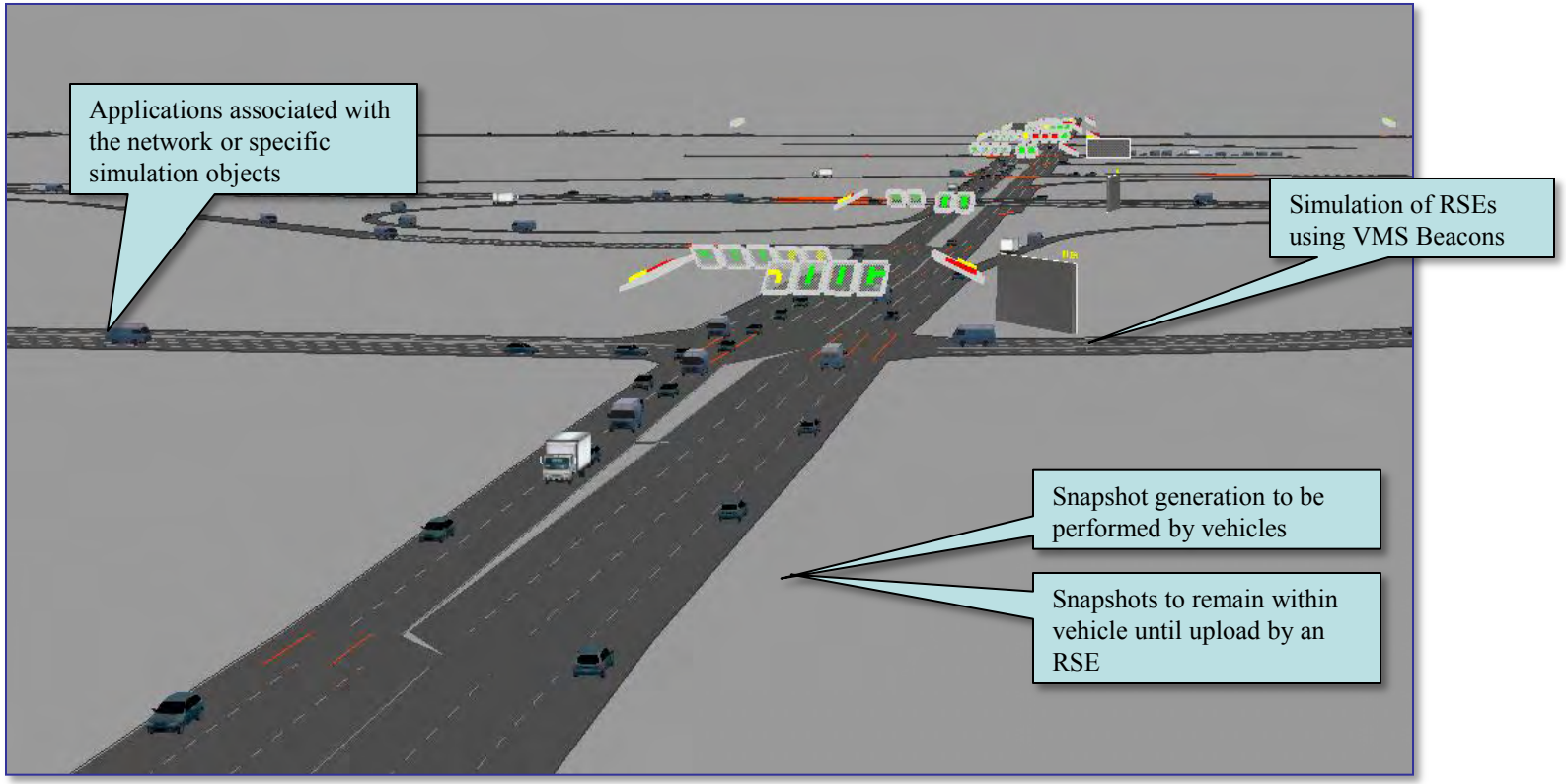
IntelliDrive Vehicle Simulation Environment (IVSE)



U.S. DOT VII Proof-of-Concept Testbed in Novi, Michigan

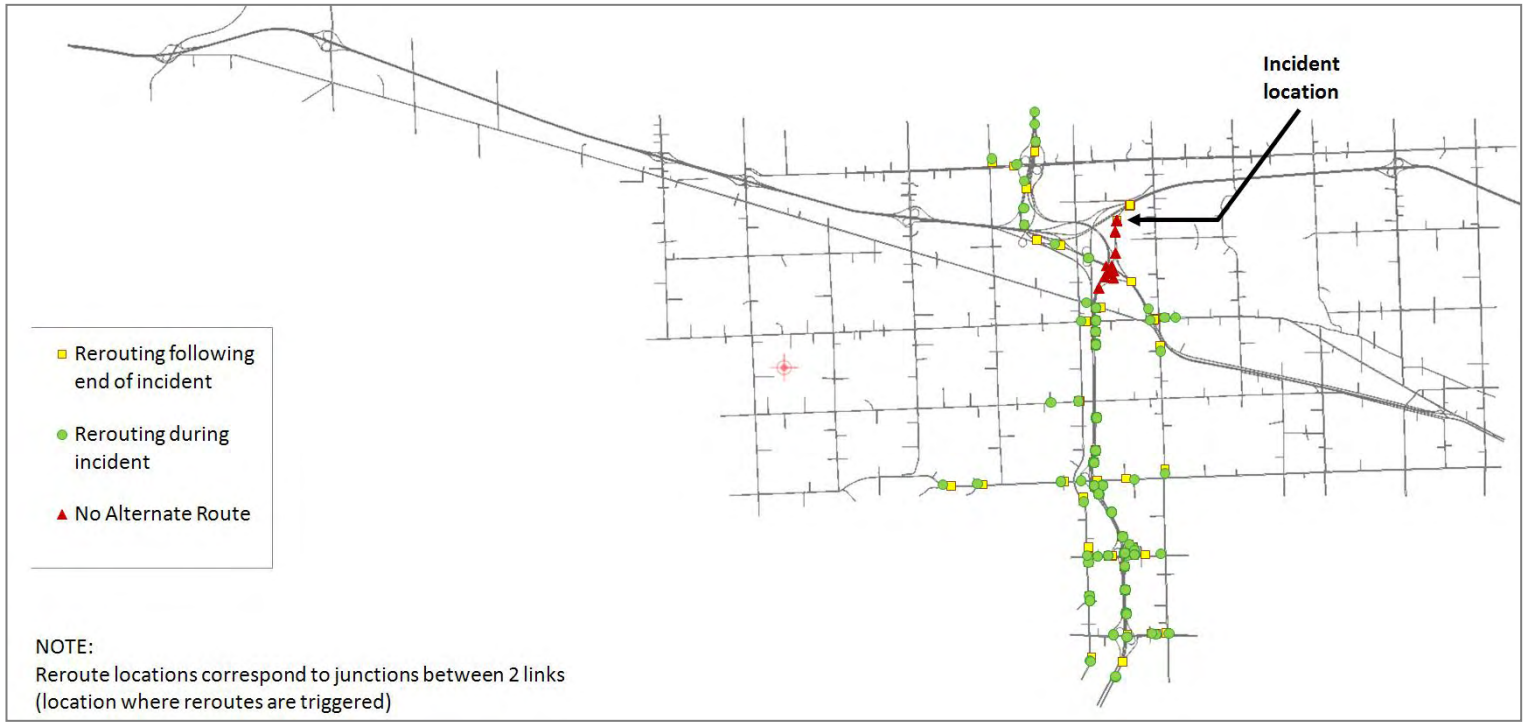


VII System Modeling Concept



Dynamic Vehicle Routing

- Location of vehicles responding to freeway closure incident notification message



Strong Michigan Start

- NOVI POC
- DUAP
- CICAS
- VIIC Joint Partnership
- IVBSS
- IntelliDrive IVSE
- MDOT / Swedish partnership
- MDOT / Taiwanese partnership
- Applications research
  - Slippery Road data monitoring
  - Origin – Destination evaluation
  - Multi-path SPAT broadcast

Michigan Stakeholders and partners include:
USDOT, OEMs, tier 1 suppliers, global companies and transportation operators

Great Michigan Start - Let's Keep It Going!

- Strategic Approach
  - Continue to partner with USDOT to migrate more DSRC test beds in MI while making interoperability mandatory (MDOT)
  - Deploy 2500 vehicle Safety Pilot (UMTRI)
  - Grow DUAP data resources (MDOT)
  - Expand IntelliDrive simulation tool to state-of-the-art research capability (UMTRI)

IntelliDrive Meeting

Michigan International Speedway

September 27, 2010

MICHIGAN INTERNATIONAL SPEEDWAY

It's your speed.

MIS Overview

Michigan International Speedway hosts the state's largest spectator sporting events, generating more than $400 million annually for the state's economy – the equivalent of the Super Bowl coming to Michigan every year.

Beyond NASCAR:

Vision:

- Grow MIS by utilizing our various assets.
- Be more relevant to the automotive industry.
- Help Michigan.

Idea: Utilize the road course for research and development.

Strategic Plan:

- Investigate economic development opportunities specific to automotive OEM, aftermarket and R&D firms that can use the road course and/or our surrounding real estate.

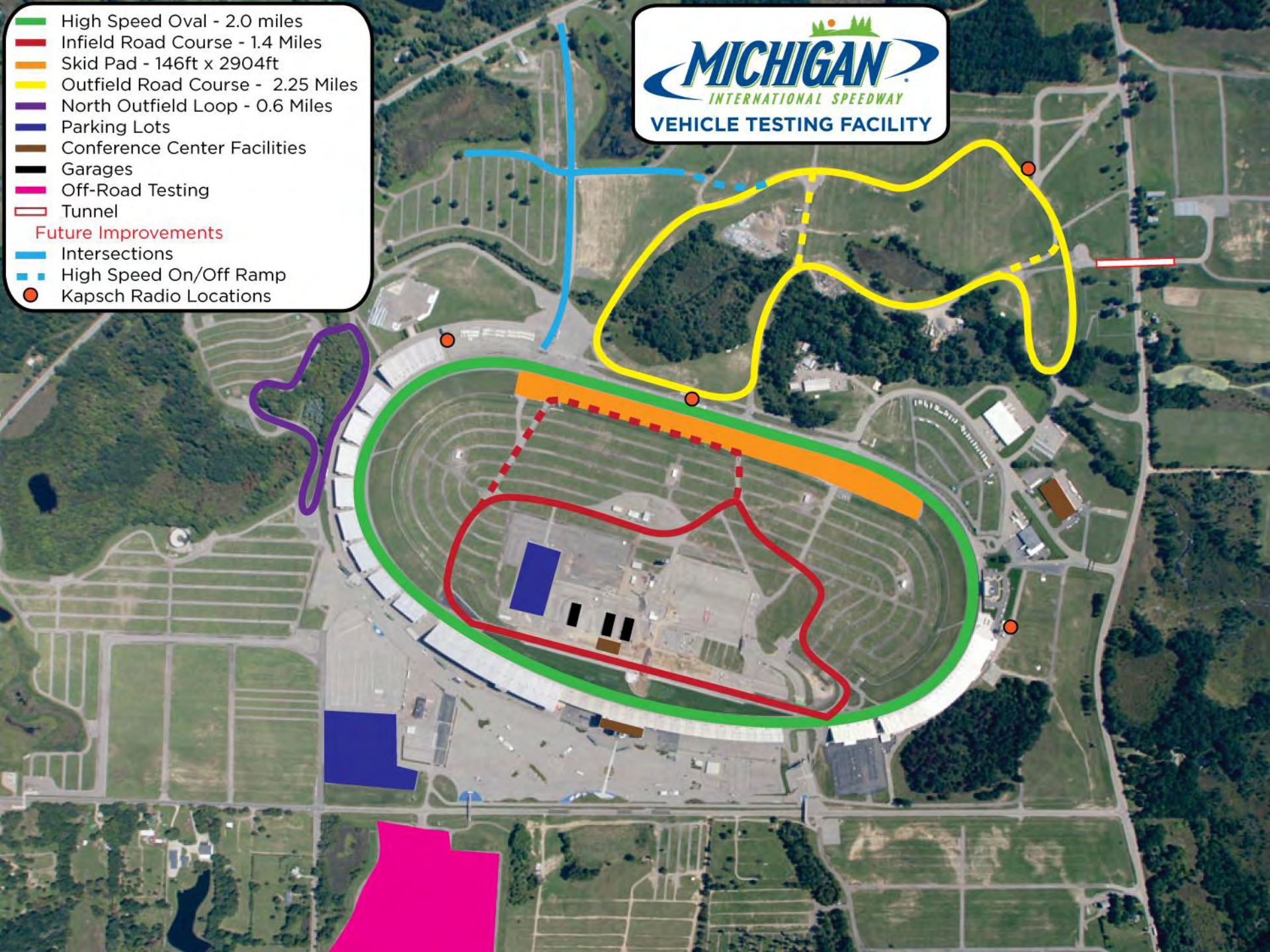
MICHIGAN INTERNATIONAL SPEEDWAY

It's your speed.

Why Michigan International Speedway?

- Test & develop vehicle systems in a neutral, private, closed environment
- Easy access in the heart of the auto industry
- 1,400 acres with various road surfaces, terrains, elevations and barriers
  - Line of sight interferences
  - Multiple pavement types, including gravel and off- road
- 86.5 acres of pavement, 7.8 miles of paved track
- Customization with multiple configurations
- Sprint partnership - 26 miles of fiber optic, WiFi, high-speed internet
- Open 24/7, 365 with on-site security
- FAA-approved helipad

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.


High Speed Oval - 2.0 miles
Infield Road Course - 1.4 Miles
Skid Pad - 146ft x 2904ft
Outfield Road Course - 2.25 Miles
North Outfield Loop - 0.6 Miles
Parking Lots
Conference Center Facilities
Garages
Off-Road Testing
Tunnel
Future Improvements
Intersections
High Speed On/Off Ramp
Kapsch Radio Locations
MICHIGAN
INTERNATIONAL SPEEDWAY
VEHICLE TESTING FACILITY

Western DataCom / TARDEC

Teamlinc Development Goals

- **Voice, Video and Data On-The-Move (OTM)**
- **True Interoperability Bring the Network with you -Don't need the Internet or Radios**
  - Low Cost "COTS" Hardware and Software$60 radio and two inch high antenna
- **Portable solution –from Vehicle to Vehicle**
- **Multiple WAN radio support -Cell, Satellite, etc.**
- **Secure to NIST standards**
- **Upgradeable to stronger security and RF radios/antennas /power amplifiers**

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.

Application Developments

- **Conference and individual voice connections**
- **WAN access by Cellular modems and Wi-Fi**
- **IP video can be controlled (PTZ) and stored**
- **Data services such web, chat, email are available on this network -Windows, Linux and Apple compatible**

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.

Four Days of MIS Drive Testing

Day 1 -Cleveland to Michigan –5 vehicles

- Up to ½ mile apart -web access, voice, data vehicles GPS tracked by network and mapped

Day 2 -MIS –15 vehicles –Off Road Course

- Voice application was intermittent on off-road course –data and video worked

Day 3 -MIS –8 vehicles network

- All applications worked voice, video and data

Day 4 -MIS -Remote Internet access

- JFCOM accessed this mobile network heard voice and viewed video –two JSIC Network Engineers

Development Goals Attained

- Dynamic routing of network traffic “BATMAN”
- Dynamic reconfiguration of the network
- Scalable to large numbers
- 802.11b/g radios in AH demo Mode (non-line of sight)
- IPSec security -NIST FIPS-140-2 standard
- Radio’s -no network broadcasting of beacons
- iPod Touch 802.11g (SIP client) connected by 802.11b/g Access Point

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.

Progressive Insurance Automotive X Prize

MIS chosen as location for all testing stages

- 28 days of track rental

Grand Challenge:

- Goal is to inspire a new generation of viable, safe, affordable and super fuel efficient vehicles that people want to buy.
- $10 million in prizes will be awarded in September 2010 to the teams that win a rigorous stage competition for clean, production-capable vehicles that exceed 100 MPG energy equivalent (MPGe)

Competition Dates: April – August 2010

28 teams, 36 vehicles (April 2010)

PROGRESSIVE AUTOMOTIVE X PRIZE

Testing Breakdown

Shakedown & Qualifying Stages (April – June 2010)

- Teams undergo rigorous safety inspections at Michigan International Speedway and have the opportunity to put their vehicles through a number of challenges simulating final competition conditions

Final Competition Stages (July 2010)

- Finalists compete in actual and simulated real-world driving conditions
- Finalist vehicles undergo tests to determine aerodynamic drag and rolling resistance

PROGRESSIVE AUTOMOTIVE X PRIZE

Progressive Insurance Automotive X Prize

Video

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.

Future Projects and Programs

- **Intersection Light for Vehicle to Infrastructure Testing**
- **IntelliDrive work group testing**
- **SEMA Fuel Economy Task Force Testing**

MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.

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MICHIGAN INTERNATIONAL SPEEDWAY
It's your speed.