U.S. Department of Transportation

Center for Integrated Transportation Systems Management (CITSM)
University of Maryland at College Park

# First Annual University Research Technology Transfer Day
# Poster Compendium

**April 6, 2011**

www.URTTD.umd.edu

RITA *Office of Research Development & Technology*

# University Research Technology Transfer Day

Exhibits and Presentations of university research to U.S. Department of Transportation (DOT) leadership hosted by the Research and Innovative Technology Administration (RITA)

## Wednesday, April 6, 2011 | 9:30 a.m. - 2:00 p.m.
## West Building Atrium

RITA invites you to join Transportation Deputy Secretary John Porcari and DOT leadership to welcome university partners at the University Research Technology Transfer Day. The event will take place April 6 in the West Atrium at DOT headquarters.

Each year the DOT funds university research that supports the department's strategic goals, technology transfer efforts ensure that these investments make positive impacts in society. This event will highlight research products that have been or are in the process of being deployed into the marketplace or impacting policy.

At the event, you will be able to engage in discussions with university colleagues to learn more about their cross-cutting transportation research. Please come and learn more about technology transfer and university-based DOT funded research by meeting the researchers, viewing the displays, and participating in the panel discussions.

Sponsored by: Office of Research, Development, and Technology at RITA

**Displays and discussions will address DOT strategic goals:**

Safety
Livable Communities
State of Good Repair
Economic Competitiveness
Environmental Sustainability

**Schedule of activities**

| | | | |
|---|---|---|---|
| 9:30 a.m. | – | 2:00 p.m. | Interactive poster sessions in the West Atrium |
| 10:00 a.m. | – | 10:30 a.m. | Opening remarks by Deputy Secretary John Porcari and DOT leadership |
| 11:00 a.m. | – | 12:00 p.m. | Panel discussions in Conference rooms 2 and 4 |
| 1:00 p.m. | – | 2:00 p.m. | Panel discussions in Conference rooms 2 and 4 |

Displays brought to you by the University Transportation Centers (UTCs), Remote Sensing Program, Federal Highway Administration (FHWA), and Federal Aviation Administration (FAA).

For more information contact Santiago Navarro at santiago.navarro@dot.gov or 202-366-0849.
Sign language interpreters will be available upon request. If you need a reasonable accommodation, please contact Mr. Navarro no later than April 1, 2011.

U.S. Department of Transportation
**Research and Innovative Technology Administration**

RITA *Office of Research Development & Technology*

# University Research Technology Transfer Day

## at U.S.Department of Transportation (DOT) Headquarters in collaboration with DOT's university partners

*The Research and Innovative Technology Administration (RITA) invites you to join Transportation Deputy Secretary John Porcari and DOT leadership to learn more about technology transfer and university-based DOT funded research by meeting the researchers, viewing the displays, and participating in the panel discussions.*

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10:00 a.m. – Opening remarks by Deputy Secretary John Porcari and DOT leadership

11:00 a.m. and 1:00 p.m. – Panel discussions in conference rooms 2 and 4

### Panel Discussions – Conference Rooms

**11:00 a.m. – Room 2**
Advanced Techniques for Retrofit Performance and Reliability Monitoring on Bridges
(Panel: FHWA/FRA)
Infrastructure Technology Institute, Northwestern University

**11:00 a.m. – Room 4**
OneBusAway
(Panel: RITA/FTA/OST)
Transportation Northwest (TransNow), University of Washington

**11:30 a.m. – Room 2**
Non-Contact Strain Sensor for Pre-Stressed Concrete Inspection in Bridge Structures and High Speed Rail Cross-Ties
(Panel: FHWA/FRA)
Kansas State University's Center for Transportation Research, Kansas State University

**11:30 a.m. – Room 4**
Integration of Variable Speed Control and Travel Time Information to Minimize Recurrent Highway Congestion: System Development and Demonstration
(Panel: RITA/FTA/OST)
Center for Integrated Transportation Management Systems, University of Maryland

**1:00 p.m. – Room 2**
Marketing and Outreach for The Safety Edge
(Panel: FHWA/FTA/FMCSA/NHTSA)
Midwest Transportation Consortium, Iowa State University

**1:00 p.m. – Room 4**
Smartphone-Based Novice Teenage Driver Support System (TDSS)
(Panel: NHTSA/RITA/OST)
Intelligent Transportation Systems Institute, University of Minnesota

U.S. Department of Transportation

**Research and Innovative Technology Administration**

## Table 1 University Exhibits in the West Atrium

| University | Project Title |
|---|---|
| Iowa State University | *Marketing and Outreach for The Safety Edge |
| Kansas State University | *Non-Contact Strain Sensor for Prestressed Concrete Inspection in Bridge Structures and High-Speed Rail Cross-Ties |
| Kansas State University | Innovative FRP Bridge Deck Panels for Accelerated Deck Replacement |
| Marshall University | Electronic Commercial Drivers License (ECDL) |
| Morgan State University | Estimation of Traffic Recovery Time for Different Flow Regimes on Freeways |
| North Carolina State University | Context Sensitive Solutions : Equipping Transportation Professionals for The Challenge of Meeting Livability and Sustainability Goals |
| Northwestern University | *Advanced Techniques for Retrofit Performance and Reliability Monitoring on the John F. Kennedy Memorial Bridge in Louisville, Kentucky |
| Oklahoma State University | Investigation and Implementation of a Precast Bridge Deck System |
| Portland State University, the University of Oregon, Oregon State University and the Oregon Institute of Technology | Developing a Mobile Platform to Assist Agencies and Communities in Identifying Transportation Infrastructure Problem Spots |
| Purdue University | Enriching the Quality of Travel Experience: Innovative Partnerships |
| City College of New York | Smart Travel Station (STS) Pilot Project |
| Rutgers, The State University of New Jersey | Plan 4 Safety |
| Tennessee | FMCSA Wireless Roadside Inspection Pilot Test and Evaluation |
| The University of Tennessee | Electric Bike Sharing Research and Education Project |
| University of Alaska Fairbanks | Instrumentation and Methodology for Evaluating the Performance of Dust Control Palliatives |
| University of California, Berkeley | Bay Bridge Congestion Pricing Evaluation |
| University of Delaware | Moving Freight Faster and Greener - Current Research in Modeling Freight Corridors and Freight Emissions |
| University of Denver/Mississippi State University | Development of an Integrated GPS, GSM and RFID Container and Package Tracking Devices in Intermodal Global Supply Chain Transportation |
| University of Florida | Statewide Transportation Engineering Warehouse for Archived Regional Data (STEWARD) |
| University of Maryland | Roadsmart: A Low Cost Green Wireless Traffic Sensor |
| University of Maryland | *Integration of Variable Speed Control and Travel Time Information to Minimize Recurrent Highway Congestion: System Development and Demonstration |
| University of Massachusetts/Amherst | Regional Traveler Information Center (RTIC) |
| University of Minnesota | *Smartphone-Based Novice Teenage Driver Support System (TDSS) |
| University of Minnesota | Traffic Signal Performance Measurement Using High-Resolution Data: The Smart-Signal System |
| University of Nebraska-Lincoln | Midwest Roadside Safety Facility |
| University of North Carolina at Charlotte | Commercial Remote Sensing for Bridge Monitoring |
| University of Utah | Distracted Driving – It's Not Only Dangerous, But It Adds to Congestion |
| University of Washington | *OneBusAway |

* To be presented in the Conference Center

# Advanced Techniques for Retrofit Performance and Reliability Monitoring on the I-65 JFK Bridge Louisville, Kentucky

Northwestern University
Infrastructure Technology Institute

NORTHWESTERN UNIVERSITY

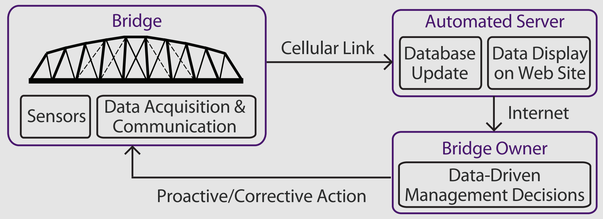
NORTHWESTERN UNIVERSITY
iti Infrastructure Technology Institute

## Safety and State of Good Repair Through Structural Health Monitoring

The John F. Kennedy Memorial Bridge carries seven lanes of Interstate 65 over the Ohio River at Louisville, Kentucky. The ends of the continuous cantilever span are secured by uplift bearings. Since 2007, Northwestern University ITI's advanced computer-controlled sensing systems for real-time measurement of critical engineering quantities have provided important insight for detection and repair of corrosion-related failures of uplift bearing components, helping keep this bridge of both regional and national importance in good repair and safe for the 120,000 vehicles that cross it daily.

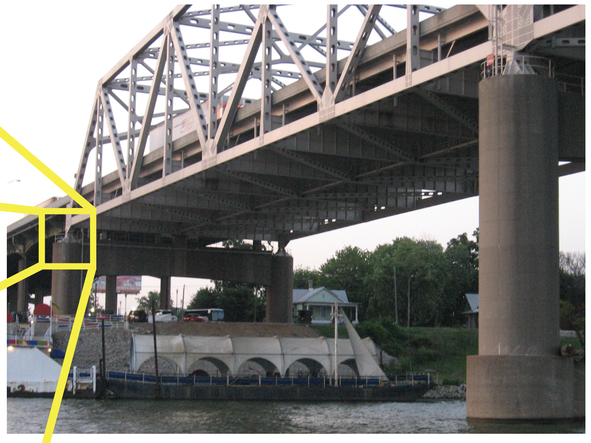
### What is Structural Health Monitoring?

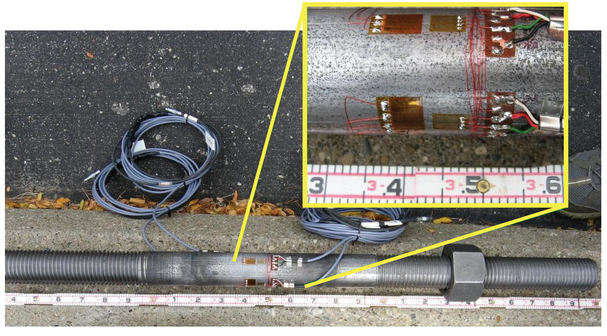
Structural health monitoring (SHM) of transportation infrastructure is the deployment of advanced sensors and data acquisition equipment on in-service transportation facilities - bridges, tunnels, roads, ferries, and railroads, to name a few - to measure critical engineering quantities in real time. SHM supplements the national bridge inspection program by providing performance data between inspections, measuring quantities that are invisible to the eye, such as strain, and reporting results from components that are obscured or difficult to reach.

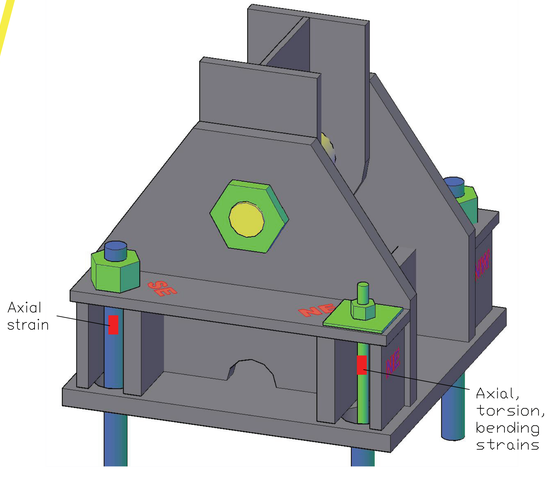



### SHM of the I-65 JFK Bridge Uplift Bearings

Sensors on uplift bearing components measure strain, movement, and temperature at key locations on both the original bearing assembly and retrofits. A computer-controlled data logger on the bridge records data and transmits it back to the lab.

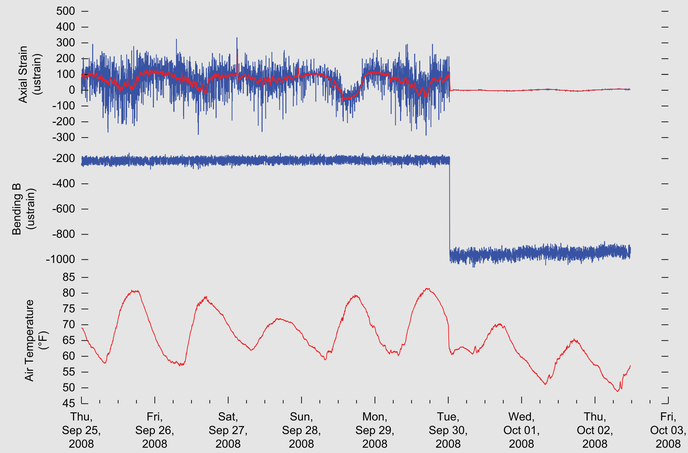







### Detecting A Component Failure From 300 Miles Away

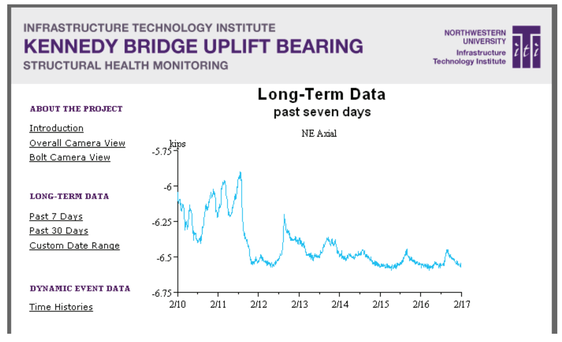
On the evening of September 29, 2008, the structural health monitoring system measured a large, sudden shift in strain measurements on an uplift bearing anchor rod, suggesting that the rod had fractured. Northwestern ITI researchers in the Chicago-area lab reviewed the data and promptly alerted the bridge owner. Upon inspection, the rod was found to be completely severed. Without monitoring, no one could have known about the fracture until the next routine inspection - even then, the fracture would have been nearly invisible, as the paint remained intact.



Structural health monitoring with sensors on the bridge components themselves provides an important supplement to regular visual inspections by recording otherwise invisible changes in time for corrective action. With wireless communication, bridges anywhere can report monitoring data directly to engineers down the street or across the nation.

### Reporting Data Over The Internet For Timely Management Decisions

- Data are automatically transmitted to the lab and displayed on a password-protected Web site.
- Accessible only to bridge owner and researchers
- Automatically updated with latest data
- Connected to relational database containing all sensor readings since beginning of project
- Easy comparison of current readings to historical trends helps engineers identify anomalies




### Technology Transfer

The goal of this research is to develop SHM systems that can be deployed readily by state DOTs and other transportation infrastructure owners.

Not every bridge needs SHM - but SHM can provide substantial benefits for management of aging, complex, non-redundant/fracture critical, or difficult-to-repair bridges.

Northwestern ITI's SHM technology - a product of University Transportation Center research - is already in use for management of in-service transportation infrastructure in several states. Northwestern ITI has deployed continuous remote SHM systems like the JFK Bridge system on in-service roads and bridges with the Kentucky Transportation Cabinet, Chicago Transit Authority, Wisconsin DOT, California DOT (Caltrans), Ohio DOT, Indiana DOT, and Florida DOT.

# San Francisco-Oakland Bay Bridge Congestion Pricing:

## Evaluation Findings to Date

## UC Berkeley & UC Transportation Center

The Bay Area Toll Authority implemented congestion pricing on the Bay Bridge to $6 in peak period and $4 in off peak on July 1 to:

- generate revenue for seismic retrofit program
- compensate for decline revenues due to the economy
- reduce congestion

**Focus Group Findings**

- Participants did not fully understand purpose of toll increase.
- General attitude: resigned acceptance.
- Few reported making changes in mode choice, but some reported changing the time of travel resulting in peak spreading.

***For Casual Carpoolers***

- Addition of toll has affected established behaviors – still being worked out.
- Some uncertainty over whether to offer or accept payment.
- Occasional conflicts if rider does not offer to pay or driver asks.

**Biggest changes:**

- Bay Bridge volumes down for carpool access lanes (from 18k to 13k in carpools; full fare before and after= 113k). BART increase of 4k
- Peak spreading occurring. Affects toll plaza operations and departure times for some drivers.
- Some delay reduction & additional analysis underway (27 minutes in May 2009 to 23 minutes in Sept/Nov 2010, 15% savings)

# USDOT-RITA Integrated Remote Sensing and Visualization for Bridge Monitoring

Edd Hauser, Shen-En Chen, William Ribarsky, Chuck Boyle
Eric Martin, Ben Smith

UNC CHARLOTTE

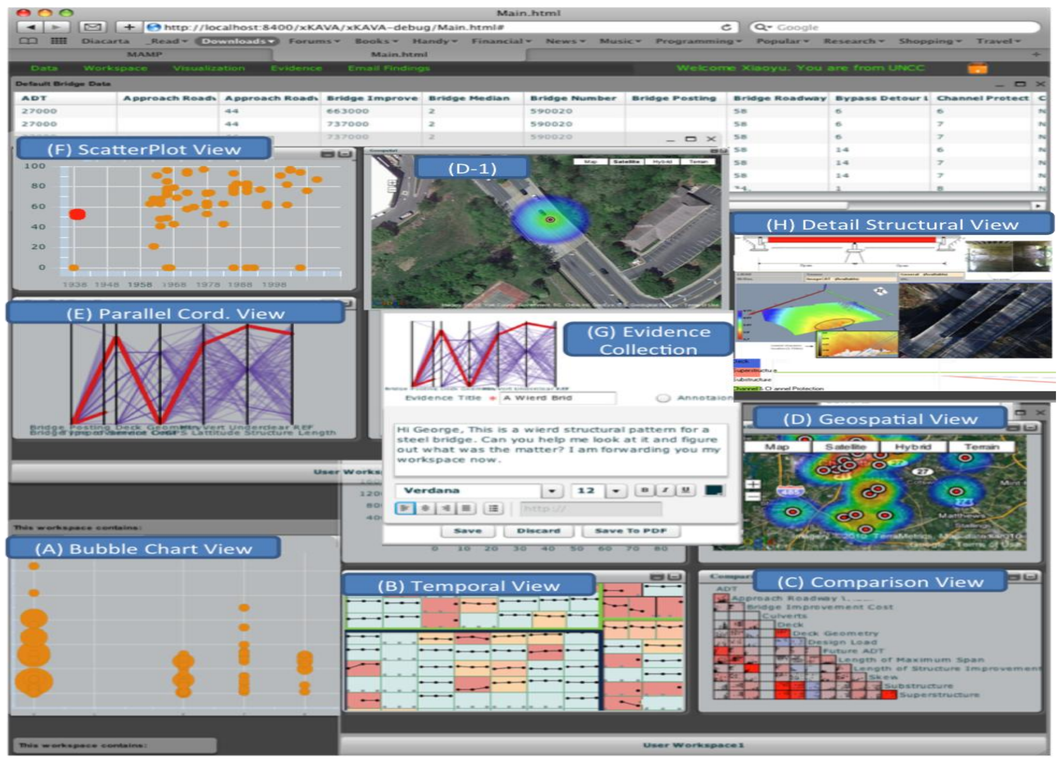
Center for
Transportation Policy Studies
Department of
Civil & Environmental Engineering

## Problem Description

US bridge inspection is a visual-based, labor intensive process. There is a need for safe, instrument-based technologies that can enhance bridge evaluation by accurately quantifying the "health state" of the bridge and better "preserve" the national highway bridge infrastructure.

**Research Goal:** The USDOT-RITA National Consortium for Remote Sensing for Transportation (NCRST) strives to introduce and promote the use of remote sensing (RS) technologies for bridge structure evaluation.

**RS Technologies:** Since 2007, the IRSV (Integrated Remote Sensing and Visualization) project has been developing RS technologies including: Spatial Integrated Small Format Aerial Photography (SI-SFAP) and the terrestrial 3D LiDAR scanning for Bridge Evaluation (LiBE). The IRSV system was established to help engineers better evaluate bridge data. Advanced Visual Analytics (AVA), IRSV allows bridge engineers to visualize bridge data in Geospatial, Multiple Parallel Axis and other views.




## LiBE (LiDaR) Bridge Evaluation

Scanning Light Detection and Ranging (LiDaR) utilizing infrared light for range finding and generates high density point clouds.

**Typical Bridge Applications**

- Defect quantification
  - -Concrete volume loss
  - -Crack length
  - -Structural Deflection under static loading
- Bridge Underclearance

### LiDaR Application Procedure

| Max Absolute Z=0.24676 | | Total Area=1.2891 | |
|---|---|---|---|
| Tolerance% | Tolerance Z | Area | Volume |
| 0% | 0 | 1.2891 | 0.022035 |
| 1% | 0.0024676 | 0.788369 | 0.019491 |
| 2% | 0.00493519 | 0.455761 | 0.017998 |
| 3% | 0.00740279 | 0.331487 | 0.017057 |
| 4% | 0.00987038 | 0.297846 | 0.016289 |
| 5% | 0.012338 | 0.283139 | 0.015572 |

1) LiDaR scan of defect 2) Data evaluation 3) Computer Calculation 4) Defect Analysis Results and Visualization

## SI-SFAP

Spatial Integrated Small Format Aerial Photography (SI-SFAP) technology uses geo-referenced, high-resolution (sub-inch) aerial photography and automated imaging to allow surface mapping of the bridge surface conditions. To achieve the high-resolution imagery, SI-SFAP technology adopted onboard GPS system and GIS data analysis to establish geo-referencing and geo-stamping of all imageries taken. The process:

- Fly over the bridge
- Imaging
- Image Assembly
- Georeference
- Crack Detection
- Image Quality Assessment
- Perform Bridge Deck Evaluation

Virtual Earth image

Our image

- Bridge deck crack profiling

**ACKNOWLEDGEMENTS**
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# Context Sensitive Solutions:
# Delivering Livable Communities and Sustainable Transportation Systems

*The Center for Transportation and the Environment at North Carolina State University*
*A US DOT University Transportation Center – Established 1991*

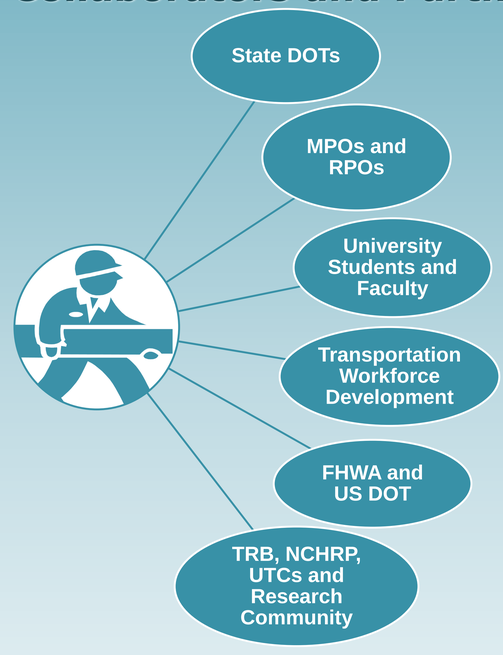
**Context Sensitive Solutions** >> ***Planning, designing, building and maintaining transportation infrastructure that enhances quality of life***

## What We Do:
### Connect Transportation with Quality of Life

CSS is an effective approach for addressing sustainability goals:

- Emphasizes an interdisciplinary approach needed to develop sustainable outcomes, which are inherently cross-disciplinary
- Supports and promotes methods for building consensus around complex issues
- Emphasizes the need to balance competing goals and arrive at an outcome focused on quality of life factors

## Who We Work With:
### Our Collaborators and Partners




- CSS Summer Academy for Undergraduates
- CSS: "A Better Way" Training
- Graduate Engineering CSS Course
- CSS National Dialog
- HUD-EPA-USDOT Partnership/Webcasts
- CSS Technical Assistance for State DOTs
- SHRP2-C08 Community Visioning

## How We Connect:
### With the Transportation Workforce of Today *and* Tomorrow

CSS offers tools and approaches to deliver transportation outcomes that enhance livability:

- Emphasizes the importance of partnering to link transportation with other community goals, including housing, jobs accessibility, and community stability and cohesion
- Requires careful attention to community context so transportation supports and enhances existing communities
- Underscores the need to balance mobility with quality of life factors
- Opens the transportation decision-making process to include all users and stakeholders

***Training, Teaching, Research, Technical Assistance, Outreach and Dissemination >> CTE Delivers What Works***

**James Martin, P.E. , Associate Director**
**Leigh Lane, Senior Research Associate**
**Ann Hartell, MRP, Research Associate**
**Eugene Murray, Distance Learning Specialist**

**www.cte.ncsu.edu** CTE

# THE *Fix This!* TOOL

*A Street Survey Tool for the Rest of Us*

***The development of "livable cities" requires shifting to transportation planning that is centered on appropriate travel modes and access to destinations. However, the spatial data to support this transition is lacking and ill-defined. Increasingly equipped with smartphones, the general public is uniquely positioned to help fill this data gap. While the use of public engagement techniques in GIS data collection is not new, the decentralized distribution and data collection model presented here by the Fix-This! tool demonstrates a novel means for addressing historic obstacles to wide-scale adoption.***

The Fix This! tool is designed for the iPhone but the concept is adaptable to any smartphone

Navigate the street map of the city using both built-in GPS and your finger

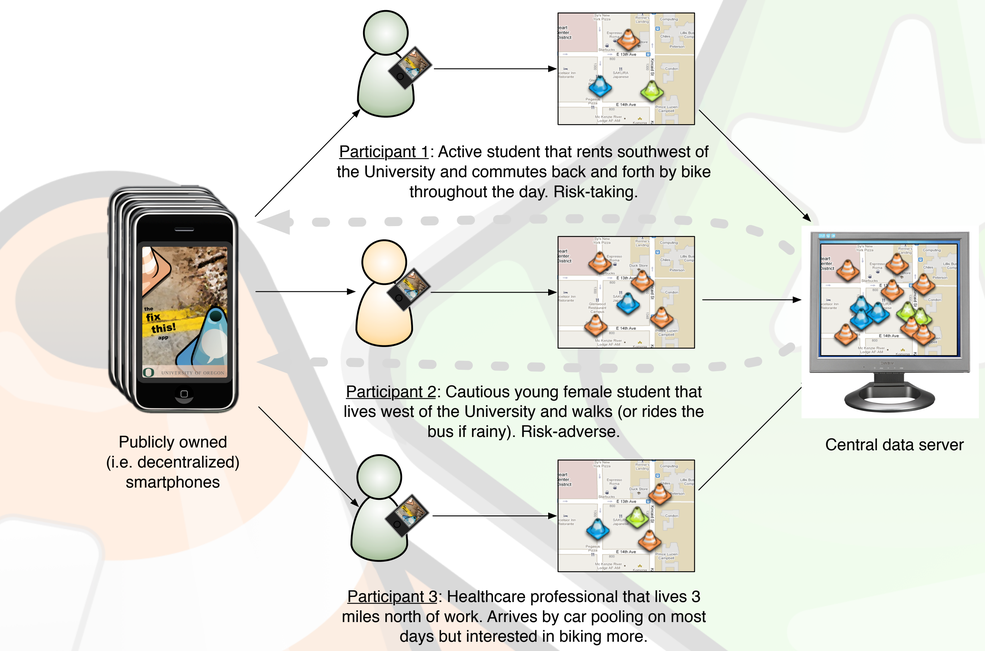
Double tapping anywhere on the screen marks a new observation

The survey focuses on affective qualities of the observation and descriptions later

The observation is wirelessly sent to the server. Data can be edited at a later point

Meanwhile, the user can scroll and add new observations to the surrounding area

These observations are quickly collected and synced with the central server




## ▲ Collection of data that is intuitive for the general public

*Public involvement is enhanced by removing technology-barriers to participation. Using gestures and Google-based maps, the Fix-This! tool better engages the public.*

## ◄ Audits that can be widely distributed and easily coordinated

*Distributing public transportation audit tools and coordinating subsequent data collection represents a key obstacle to the adoption of such tools at a national scale. The Fix-This! tool demonstrates how such tools can be remotely distributed to smartphones and how public data collection can be automatically synced to a central computer.*

## ▼ Data that supports mode-appropriate transportation planning

*The distributed data collection model differs from classic workshop formats because participants audit only those areas of interest, meaning that the data is spatially clumped and may overlap. The map below shows how the Fix This! tool can be applied to improving a heavily used bicycle corridor that passes west of the University.*

### For more information contact

Marc Schlossberg, PhD - Associate Professor
Planning, Public Policy, and Management
schlossb@uoregon.edu

Ken Kato - Assistant Director
InfoGraphics Lab
kkato@uoregon.edu



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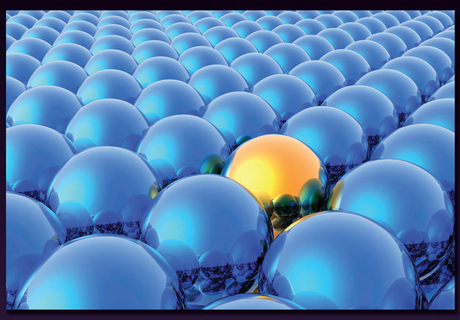
University of Oregon

GLOBALTRAK

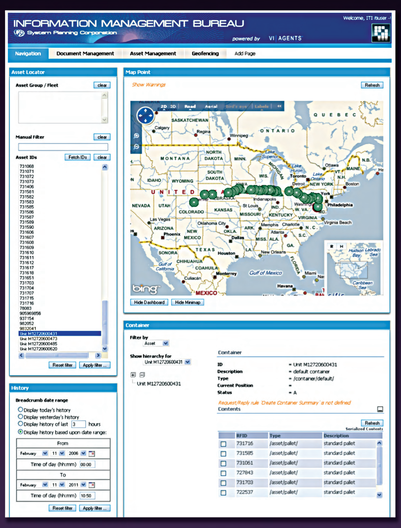
UNIVERSITY OF DENVER 1864

National Center for Intermodal Tranportation

# Virtual Warehousing



## Where's My Stuff?




## What Makes GlobalTrak Unique?

24 RFID tags read after device is installed and turned on

| Event Type | AtoS.ID | RFID Tag ID | Timestamp (GMT) | Latitude | Longitude | Door State | Light % Full Scale |
|---|---|---|---|---|---|---|---|
| TRCK LR DEF GPFL | M127206040433 | | 2010-11-03 21:00:26.0 | 40.11437183 | -76.89753392 | CLOSED | 8.5 |
| TRCK LR DEF GPFL | M127206040433 | | 2010-11-03 22:00:26.0 | 40.2617961 | -76.87514433 | CLOSED | 5.3 |
| TRCK LR DEF GPFL | M127206040433 | | 2010-11-03 23:00:09.0 | 39.91864179 | -76.96648883 | CLOSED | 3.9 |
| TRCK LR DEF GPFL | M127206040433 | | 2010-11-03 18:27:26.0 | 38.8786483 | -77.17478636 | CLOSED | 2.2 |
| INFO EPCIS.OU.ADD | M127206040433 | 32 | 2010-11-03 17:23:56.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
| INFO EPCIS.OU.ADD | M127206040433 | 30 | 2010-11-03 17:23:56.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
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| INFO EPCIS.OU.ADD | M127206040433 | 35 | 2010-11-03 17:23:55.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
| INFO EPCIS.OU.ADD | M127206040433 | 2 | 2010-11-03 17:23:55.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
| INFO EPCIS.OU.ADD | M127206040433 | 7 | 2010-11-03 17:23:55.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
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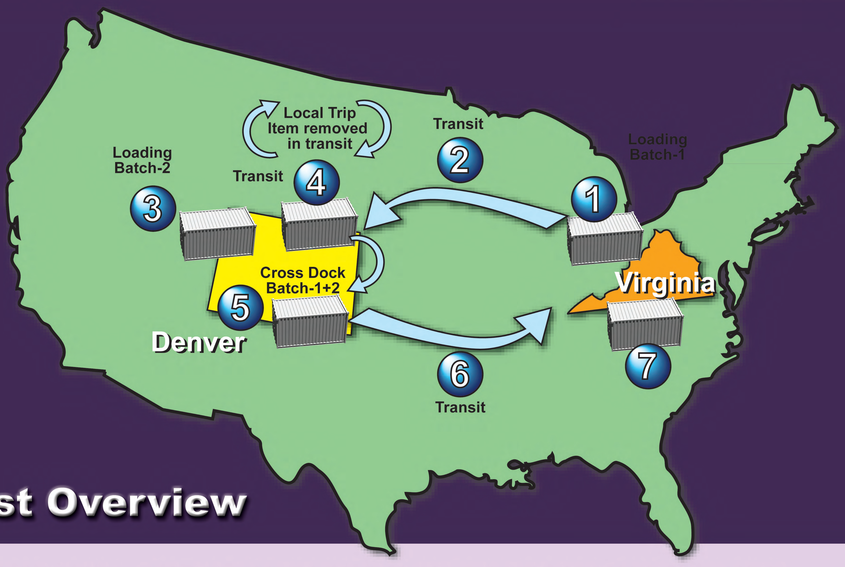
| INFO EPCIS.OU.ADD | M127206040433 | 35 | 2010-11-03 17:23:55.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
| INFO EPCIS.OU.ADD | M127206040433 | 733968 | 2010-11-03 17:23:55.0 | 38.87908569 | -77.17476547 | CLOSED | 3.8 |
| TRCK LR DOOR GPFL | M127206040433 | | 2010-11-03 17:21:39.0 | 38.8784922 | -77.17506122 | CLOSED | 3.8 |
| TRCK LR BOOT GPFL | M127206040433 | | 2010-11-03 17:20:04.0 | 38.8784922 | -77.17506122 | OPEN | 99.9 |

## Information Management Bureau




## Test Overview

1. Loading, Batch 1 – 8 pallet sized boxes with RFID tags each containing 2 carton sized boxes with RFID tags is loaded into Container 1 in Virginia. The loading events are captured in the IMB.

2. Transit – Container 1 is monitored while in transit to Denver.

3. Loading, Batch 2 – Container 2 arrives in Denver. 8 pallet sized boxes with RFID tags each containing 2 carton sized boxes with RFID tags are loaded. The loading events are captured in the IMB.

4. Local Trip, Item removed in transit – Container 2 goes on a local journey. During the trip, one box is removed from the load. The container returns to the origin where the container was loaded. The IMB will sense that an item was removed while in transit.

5. Cross dock, batch 1+2 – the contents of container 1 are loaded into container 2, the contents of container 2 are loaded into container 1. The doors on both containers are closed. A log of the load/unload events is in the IMB
   a. Trip/test for container 2 is completed.

6. Transit – Container 1 is monitored while in transit back to Virginia.

7. Unloading, batch 2 – Container 1 arrives in Virginia and is unloaded. A log of all load/unload events is available in the IMB.
   a. Trip/test for container1 is completed.

# Distracted Driving
# It's not only dangerous, but it adds to congestion

Peter T. Martin
Ivana Vladisavljevic, Ivana Tasic

## Abstract

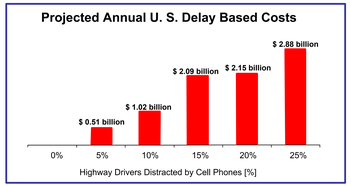
Previous research on wireless phones and driving has told us that cell phones are a safety problem. We know about the relationship between cell phones and safety. We know that there are plenty of cell phones and their widespread use while driving. Motorists who talk on cell phones drive slower on the freeway, pass sluggish vehicles less often and take longer to complete their trips. This means that the average person's commute is longer because of that person who is on the cell phone right in front of them. The study presented here shows that cell phones not only make driving dangerous, they cause delay too. The study used a driving simulator, to capture impaired driver behavior. Once identified, this behavior was then modeled in a mathematical representation of a real traffic stream, on a Freeway. When the research was presented to the Annual TRB Meeting in January 2008, the media response was substantial.

## Impact of Cell Phones on Traffic Flow

- ✓ We know that cell phones are dangerous
- ✓ We didn't know the effect of distraction on traffic efficiency

## What we already knew about Cell Phone Drivers and Traffic

- ✓ Drivers' perception/reaction time is increased
- ✓ Distracted drivers don't:
  - × Maintain speed
  - × Drive at appropriate following distance
  - × Maintain lane position
  - × Have awareness
  - × DRIVE SAFELY



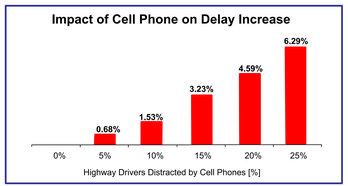

## Distracted Drivers' Behavior Modeling

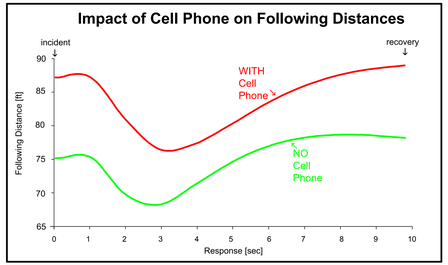
Driving Simulator

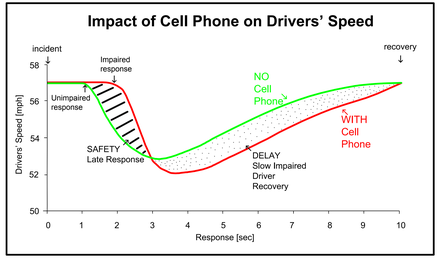
$ 2.8 billion
10 % drivers with cell phone
User cost $13.06/hr
VMT, US, 3 million (2004)
Highways

Two-Vehicle Traffic Microsimulation

Traffic Flow Microsimulation




## Some Key Numbers

| MEASURE | EFFECT |
|---|---|
| Drivers' reaction time | -18% |
| Time to Recover 50% of Speed Lost After Braking | +23% |
| Following Distances | +12% |
| Awarenes of Other Traffic | -40% |

A 20 year old driver on a cell phone has the perception/reaction time of a 70 year old (and doesn't know it)

## Research Questions

- ✓ Does cell phone distraction impact traffic flow?
- ✓ Does distraction have a measurable cost?
- ✓ How can we model distracted drivers' behavior?

## We found that Driving with Cell Phones:

- ✓ Decreases optimal flow speeds
- ✓ Increases traffic delays marginally
- ✓ Increases traffic congestion marginally
- ✓ Increases user costs dramatically

## The Next Steps

- ✓ Distraction by age, duration, call nature (angry, mundane, informative)
- ✓ Traffic conditions
- ✓ Road type (freeways to city streets)
- ✓ Enhanced simulation animation (military inspired)

# Electric Bike Sharing on UT-Knoxville Campus—Research and Education

**The University of Tennessee, Knoxville**

## Overview

Bike sharing is an exciting new model of public-private transportation provision that has quickly emerged in recent years. Shared electric bikes could provide an even higher level of service compared to regular bike share systems. Although there is little empirical evidence, electric bike sharing could be feasible, depending on demand and battery management. Pilot tests will be important and allow empirical evaluation of electric bike sharing system performance.

### Challenges Unique to Shared Electric Bikes:

- ❑ Electric-assisted range
- ❑ Recharging protocol
- ❑ Bike /battery check-out/check-in
- ❑ Securing components of the bike away from the station

### Expected Benefits of Electric Bike Sharing:

- ❑ Improve utility of existing bike sharing systems
- ❑ Electricity reduction through solar recharging
- ❑ Attract those who would normally not ride a bike
- ❑ Reduction in number of motor vehicle trips

### Research Questions and Objectives:

- ❑ Develop technology and operational concepts (battery recharging, solar)
- ❑ Investigate travel demand and displaced mode
- ❑ Investigate physical activity impacts
- ❑ Investigate environmental impacts and energy efficiency
- ❑ Investigate incidents of unsafe behavior between bike and e-bike
- ❑ Investigate willingness to pay as a function of trip length, terrain etc.

## Electric Bike Sharing Concept

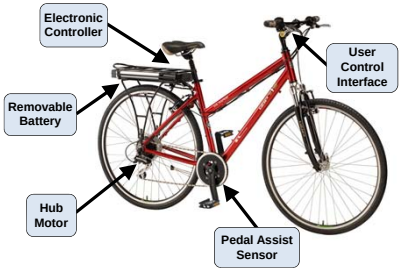



Figure 1. Typical Electric Bike

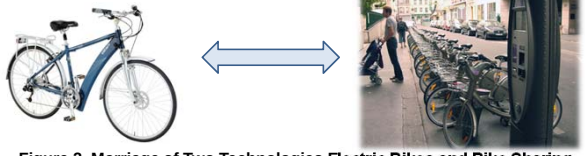


Figure 2. Marriage of Two Technologies Electric Bikes and Bike Sharing

### Electric Bike Sharing:

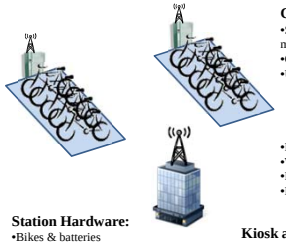
- ❑ Shared ownership and expense
- ❑ Provide urban short-distance transportation
- ❑ Improve sustainability of transportation system
- ❑ Pedal assist bikes increase the range of the bike
- ❑ Reduces fatigue barriers
- ❑ More attractive to casual riders

### Project Goals:

- ❑ Introduce the technology of electric bikes
- ❑ Improve utility of existing bike sharing systems
- ❑ Increase ridership by those not normally riding a bike
- ❑ Reduce the number of motor vehicle trips
- ❑ Evaluate willingness to pay
- ❑ Reduce the number of motor vehicle trips
- ❑ Reduce electricity through solar recharging

## Electric Bike Sharing Components

### System Components:



**Central Office:**

- •System administration & management
- •Communication with stations
- •User database
  - Local subscribers
  - Non-Local subscribers
  - Commercial subscribers
  - Casual users
- •Billing operations
- •WWW & smart phone interface
- •Reservation system
- •Maintenance facilities & personnel

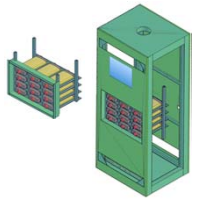
**Station Hardware:**

- •Bikes & batteries
- •Auto-locking racks
- •Battery charging and vending
- •Rental user interface
- •PV solar panels

**Station Software:**

- •User interface
- •Bike & battery vending
- •Battery management
- •Charging /solar power management
- •Communication with central office
- •Data logging

**Kiosk and Battery Vending**



### Operational Components:

- ❑ User enters credentials at bike station
- ❑ Bike is assigned to user and unlocked electronically
- ❑ User takes charged battery from vending area and places onto bike
- ❑ User obtains lock from vending area to secure bike while in use
- ❑ Bike is returned to an available station
- ❑ Credentials are entered and bike is identified
- ❑ Battery is placed into vending slot for recharging
- ❑ User enters any maintenance issues and bike use disabled if so
- ❑ Bike is locked into place and restored to service

### Electric Bike Demand/Battery Charge Management:

**Electric bike data:**

- ❑ Bike range depends on terrain, rider's weight, number of stops, level of assist
- ❑ On urban hilly terrain, 70-kg rider yielded a range of 20-25 km, or about 2 hours of riding

**Battery Management:**

- ❑ Recharge time can be up to 4-6 hours
- ❑ Range may be insufficient if there is significant demand
- ❑ Trip duration (time bike is away from station) needs to be short
- ❑ Maintain excess charged batteries
- ❑ Solar power use

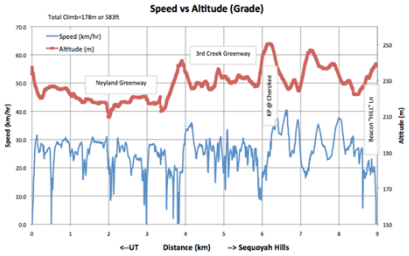



Figure 3. Typical Near-Campus Commute From GPS

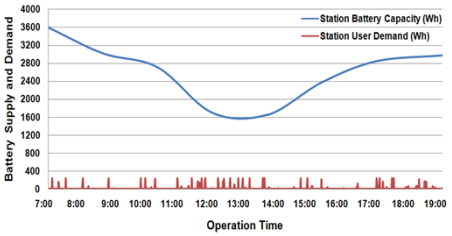



Figure 4. Simulation of Electric Bike Demand and Battery Capacity Components

## Outreach

Figure 5. EV Outreach to K-12 Students

- ❑ Electric bike used for community EV outreach.
  - ❑ High school electric camps
  - ❑ Middle school transportation academy
  - ❑ Elementary school alternative fuel module
  - ❑ Community outreach at environment-oriented festivals

## Conclusions and Next Steps

- ❑ Electric bike sharing combines two emerging technologies and attracts a new class of users by overcoming traditional barriers to cycling.
- ❑ This project will be the first of its kind and will provide valuable data on electric versus traditional bicycle use patterns and demand.
- ❑ The concepts here are being incorporated into a proof-of-concept pilot test to develop a joint bike sharing system on the UT campus-launching this year.
- ❑ A robust and replicable bike sharing model will be developed to be integrated with other bike sharing or multimodal systems.
- ❑ Shared electric bikes could find a significant role in our transportation system that reduces energy use and emissions while moving more individuals toward active transport modes.
- ❑ This initial infrastructure will serve as a test-bed for future research endeavors--providing a rich dataset of user-specific data.

## Project Team

**Dr. Christopher R. Cherry**
Assistant Professor, Civil and Environmental Engineering

**David Jordan**
Graduate Student, Civil and Environmental Engineering

**Brian Casey Langford**
Graduate Student, Civil and Environmental Engineering

**Kenric McCay**
Graduate Student, Geography

**Stacy K. Worley**
Senior Research Associate, Biosystems Engineering and Soil Science

**David R. Smith**
Research Associate II, Biosystems Engineering and Soil Science

**www.cycleushare.com**

**Email: cycleushare@utk.edu**

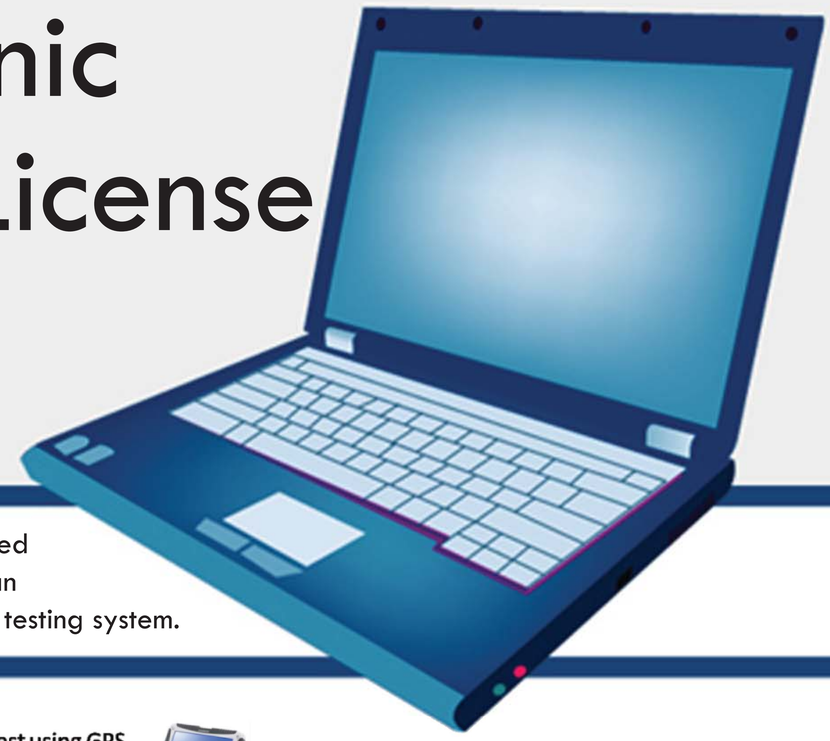
**cycleushare**

**@cycleushare**

RAHALL APPALACHIAN TRANSPORTATION INSTITUTE

# West Virginia Electronic Commercial Drivers' License (eCDL)

*Chandra Inglis-Smith, Project Manager* *cinglissmith@njrati.org*



## What is eCDL?

The West Virginia Electronic Commercial Driver's Licensing (eCDL) Program, created & developed by the West Virginia Division of Motor Vehicles (WVDMV) and the Nick J. Rahall, II Appalachian Transportation Institute (RTI), is a fully-automated, computer-based Commercial Drivers' License testing system.

## Product

The WV eCDL (electronic Commercial Drivers' License) project has converted a traditional, paper-based Commercial Drivers' License testing procedure into a fully-automated, computer-based, paperless system.

The eCDL project was undertaken with funding provided by the Federal Motor Carrier Safety Administration (FMCSA).

This software was born of a need to address:

- fraud and safety,
- an incomplete or nonexistent license testing process,
- the authentic identification of applicants and
- the monitoring process associated with the issuance of CDL.

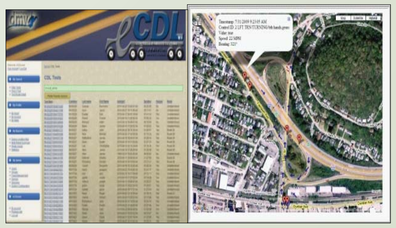
eCDL utilizes freeware/shareware computer applications to allow for free dissemination to other states. Many of those states, as well as Canada and Mexico, have expressed interest in obtaining eCDL as it becomes available.

Using Toughbook laptops with GPS capabilities, RTI developed a comprehensive integrated system that complies with federally-mandated CDL testing standards while increasing fraud detection capabilities for WVDMV.

eCDL not only utilizes the GPS system during the road test, but additionally records GPS data during the vehicle inspection and basic skills portion, to ensure the test is completed in regulated areas.

Examiners conduct CDL tests in the field throughout the State on the Toughbook, and upload results wirelessly. Information is then accessed, via a customized website by the WVDMV Administration, from anywhere in the state.

All tests are subjected to a rigorous statistical analysis of known parameters; any outliers are reported to the WVDMV Administration via email for closer inspection for possible fraud activity.



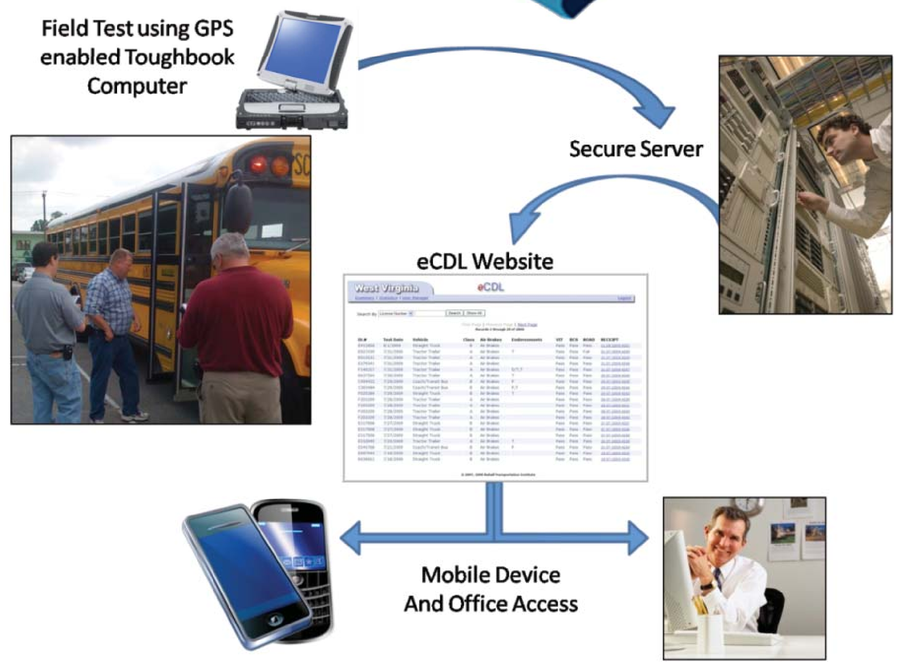
Further improvements include a notation screen, test scheduling calendar and encrypted email.

Fraud prevention capabilities include:

- *Examiner identication elements*
- *Time/date location stamp*
- *Test timer with email notication*
- *Randomized tests*
- *Test encryption*
- *Supervisory access to testing schedules*

## Financial Benefits

- State of West Virginia has received nearly $1,000,000 in Federal funds to develop the eCDL project
- Reduction through attrition: a savings of more than $400,000
- Decreased the DMV CDL state fleet by 60%
- Instant, paperless system results in 97% reduction in time for tracking, filing, auditing, archiving




## Awards and Recognition

- Harvard Ash Center Innovation in American Government, Fall 2010
- Finalist for NASCIO Awards for Outstanding Achievement in the Field of Information Technology, 2010
- West Virginia State Office of Technology Information Technology Award Winner, 2009
- Featured in the Council of State Governments' State News Magazine, November/ December 2009
- Council of State Governments' Innovations, Award Winner, September 2009
- Featured in AAMVA's MOVE Magazine, Fall 2009

USDOT Region V Regional
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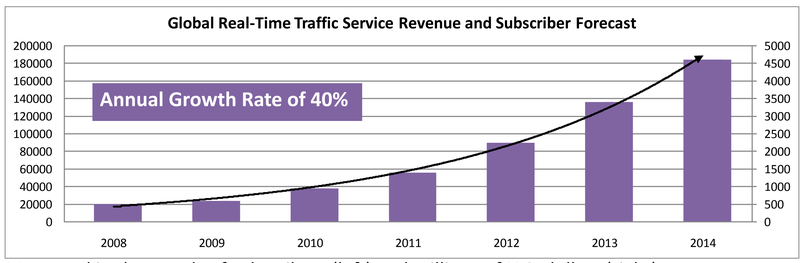
Martin University

# ENRICHING THE QUALITY OF TRAVEL EXPERIENCE: INNOVATIVE PARTNERSHIPS

## PROBLEM & SIGNIFICANCE

Real-time travel information enhances the quality and safety of travel experience by providing travelers with information on congestion, accidents, alternate routes, weather conditions, work zones, etc.

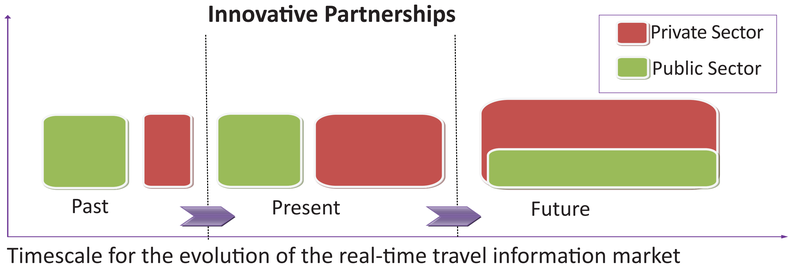



Measured in thousands of subscribers (left) and millions of U.S. dollars (right)
Source: Cellular News

- The evolving real-time travel information market represents a key win-win opportunity to generate revenue and resources through innovative partnerships
- The potential for new innovations and significant investments from the private sector in emerging technologies and applications related to real-time travel information can foster new businesses

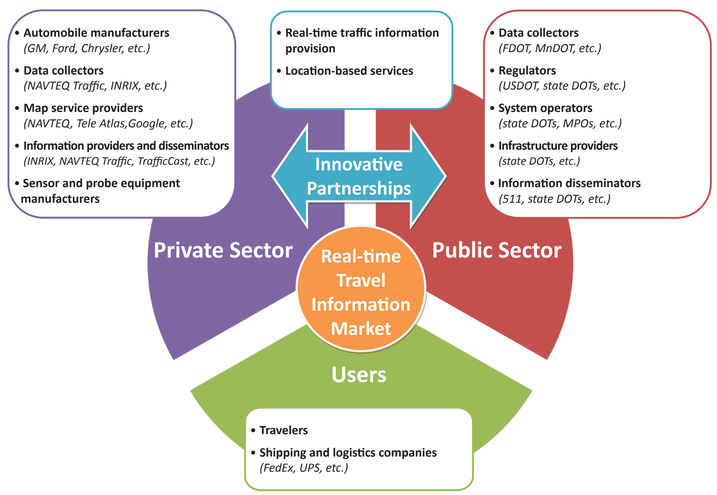
The evolution of these partnerships addresses multiple synergistic goals which:

- Supplement limited public sector resources with private sector funding to reduce congestion delays and improve safety
- Assure future U.S. economic competitiveness by significantly increasing the efficiency of the utilization of existing transportation facilities
- Meet multiple national objectives using a holistic approach
- Reinforce ongoing national programs that leverage technological advances (IntelliDrive/Connected Vehicle Research)



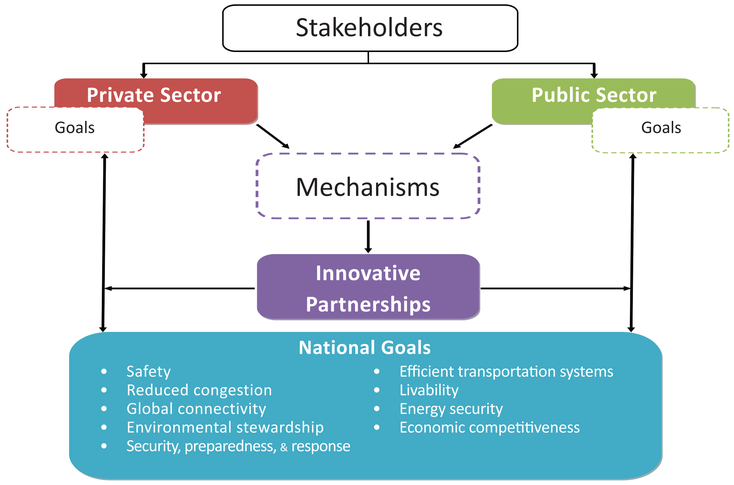

Timescale for the evolution of the real-time travel information market

## RESEARCH PRODUCT




The study identifies mechanisms to help foster innovative partnerships among various stakeholders.

The research product will help analyze how various stakeholders can participate beneficially and develop innovative partnerships in the evolving real-time travel information market.




## POTENTIAL IMPACTS

Innovative partnerships resulting from the evolution of the real-time travel information market aid critical national goals:

- Holistic Innovations: Ability to leverage market processes, technology-reinforced infrastructure renewal needs, and enhanced utilization of existing infrastructure to aid U.S. global economic competitiveness and generate new revenue streams
- Advanced Services: Ability to develop markets for location-based services and next-generation navigational services to enhance the quality of travel for transportation users and spawn a new generation of service businesses
- Holistic Policymaking: Foster collaborations between public and private sectors to develop standards and mechanisms to leverage investments from both sectors to achieve disproportionately favorable impacts
- Connected Infrastructure: Leverage technological advances to connect vehicles, transportation infrastructure, and users to seamlessly improve travel experience for users and enhance efficiency of U.S. freight services
- Auto Sector Rejuvenation: Leverage infrastructure enhancements due to the travel information market to seamlessly foster active safety capabilities, which can lead to a new generation of autos in the U.S. that are technologically savvy and energy efficient

# Estimation of Nonrecurring Incident Traffic Recovery Time for Different Flow Regimes

Mansoureh Jeihani, Ph.D., Petronella James (Doctoral Candidate) Anthony Saka, Ph.D. | School of Engineering/Transportation & Urban Infrastructure Studies

MORGAN STATE UNIVERSITY
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## Objective

- Apply Monte Carlo simulation to investigate the effect on TRT under varying levels of congestion, incident duration and lane closure scenarios.
- To develop an analytical model to estimate incident traffic recovery time (TRT ) along freeways.
- Analyze recovery factor per minute of incident time (INCRF) based on incident duration and incident severity.

## Introduction

- Freeway incidents have a dramatic impact on traffic operations.
- Inability to accurately predict full recovery time - estimate the effect of lane closures and increasing traffic intensity on congestion buildup.
- Incident TRT is defined as the time taken to return to pre-incident normal traffic state after clearance of an incident.
- Travel time uncertainty impacts users: route choice, mode choice & departure time.
- Congestion – ***impacts*** – reduction in capacity - *reduced speeds, delays and increased travel time.*
- Congestion – ***costs*** – *longer travel times, lost productivity, air/noise pollution, reduced freeway capacity, less efficient freeway operations.*

## Motivation

- Past studies estimate that traffic recovery time (TRT) increases by a factor of four up to eight for every minute of incident time along a freeway
- This rule (INCRF).does not distinguish for traffic intensity levels and lane closures at the time of incident.
- Traditional analytic and shockwave methods underestimates queue dissipation time (QDT).

## Procedure

- Determine matrix of scenarios to be tested across lane closure configurations, (3-3-lane, 3-2-lane and 3-1-lane).
- Generate base data using VISSIM to simulate traffic and incident conditions along a freeway for 2.5 hrs
- Evaluate measures of effectiveness (speed, volume, density, travel time, delay, queue) derived from simulation.
- Estimate TRT using Monte Carlo simulation.
- Create analytical model to establish relationship between incident TRT, incident duration and traffic intensity (*Rho*) for freeway systems.

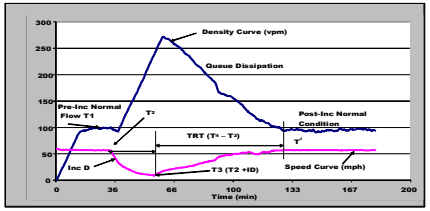


Figure 1: Typical Graph of Simulated Incidents and Traffic Recovery

- The graph shows 4-segments of the time-density graph - uncongested, congested, queue discharge & normal state

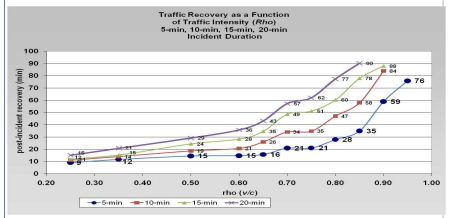


Figure 2: Traffic Recovery as a Function of Rho (v/c)

## Results

- A lognormal regression model proved to be the best fit for the data, for all variables and scenarios with an adjusted $R^2$ of 0.851.

$$Ln\ T_r = \beta T_{inc} + \gamma Rho + \theta L$$

*Where $T_r$ = recovery time (min), $T_{inc}$ = incident duration (min)*
*Rho = traffic intensity (v/c), L = ratio of lanes closed, β, γ, θ = coefficients*

Table 1: Regression Results from Simulation

| Regression Models | Rho | $T_i$ | L | $R^2$ | Adj. $R^2$ | N |
|---|---|---|---|---|---|---|
| All Scenarios Aggregated | 2.819 (0.000)* | 0.021 (0.000) | 1.475 (0.000) | 0.863 | 0.851 | 107 |
| **Traffic Intensity Levels** | | | | | | |
| Near Capacity | 2.858 | 0.043 | 1.285 | 0.999 | 0.907 | 14 |
| Moderate | 2.483 | 0.024 | 1.609 | 0.996 | 0.977 | 57 |
| Low | 2.855 | 0.020 | 1.506 | 0.999 | 0.968 | 36 |
| **Lane Scenario** | | | | | | |
| 3-Lane-Blocked | 4.437 | 0.039 | -- | 0.989 | 0.976 | 83 |
| 2-Lane-Blocked | 4.381 | 0.020 | -- | 1.000 | 0.900 | 12 |
| 1-Lane-Blocked | 3.393 | 0.019 | -- | 0.997 | 0.897 | 12 |

Table 2: Incident Recovery Time Analysis

| Scenario Matrix | | Inc Dur (min) | Orig RHO | Simulation SimQDT (min) | Shockwave ShkwQDT (min) | Shockwave Recovery Time (ShkwRT) (min) | Simulation Recovery Time (SimRT) (min) | Ratio of SimRT/ ShkwRT | Ratio of SimRT/ INC Dur |
|---|---|---|---|---|---|---|---|---|---|
| Moderate Capacity - Moderate Incident | MCMOD | 25 | 0.60 | 44 | 17 | 29 | 43 | 1.5 | 2 |
| | MCMOD | 25 | 0.75 | 55 | 30 | 51 | 73 | 1.4 | 3 |
| | MCMOD | 30 | 0.65 | 41 | 24 | 42 | 64 | 1.5 | 2 |
| | MCMOD | 30 | 0.75 | 56 | 36 | 61 | 74 | 1.2 | 2 |
| | MCMOD | 35 | 0.70 | 64 | 34 | 58 | 77 | 1.3 | 2 |
| | MCMOD | 35 | 0.80 | 64 | 53 | 88 | 97 | 1.1 | 3 |
| Moderate Capacity - Short Incident | MCSHT | 5 | 0.70 | 14 | 5 | 8 | 21 | 2.6 | 4 |
| | MCSHT | 5 | 0.80 | 15 | 8 | 13 | 28 | 2.2 | 6 |
| | MCSHT | 10 | 0.60 | 18 | 7 | 12 | 21 | 1.8 | 2 |
| | MCSHT | 15 | 0.70 | 35 | 15 | 25 | 49 | 1.9 | 3 |
| | MCSHT | 15 | 0.80 | 66 | 23 | 38 | 60 | 1.6 | 4 |
| | MCSHT | 20 | 0.65 | 28 | 16 | 28 | 43 | 1.6 | 2 |
| | MCSHT | 20 | 0.75 | 53 | 24 | 40 | 62 | 1.5 | 3 |
| Mod Cap - Long Inc | NCMOD | 25 | 0.85 | 79 | 49 | 80 | 93 | 1.2 | 4 |
| Near Capacity - Short Incident | NCSHT | 5 | 0.85 | 25 | 10 | 16 | 35 | 2.2 | 7 |
| | NCSHT | 5 | 0.90 | 37 | 13 | 22 | 59 | 2.7 | 12 |
| | NCSHT | 5 | 0.95 | 45 | 19 | 35 | 78 | 2.2 | 15 |
| | NCSHT | 15 | 0.90 | 81 | 39 | 66 | 88 | 1.3 | 6 |
| | NCSHT | 20 | 0.85 | 47 | 39 | 64 | 90 | 1.4 | 5 |

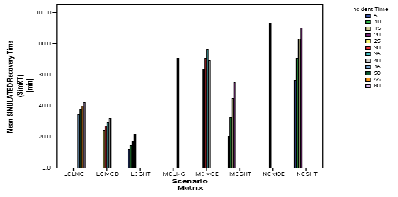


Figure 3: Scenario Matrix of Traffic Recovery Time

LC – v/c ≤ 0.50 (off-peak), LNG–long incident ≥ 40min
MC – 0.60 ≤v/c ≤ 0.80 (normal), MOD–moderate incident 20 ≤ inc ≤ 40min
NC – v/c ≥ 0.80 (peak), SHT–short incident – inc ≤ 20min

## Conclusions

- Congestion increases as incident duration increases at all *Rho* values but increases at faster rates for higher *Rho* values.
- As traffic intensity approaches capacity threshold (i.e. *Rho* = 1) TRT becomes indefinite.
- There is a non-linear relationship between TRT and the independent variables - traffic intensity, incident duration and lane closure.
- The regression models can estimate the effect of lane closures and increasing traffic intensity on congestion buildup.
- By utilizing this regression model TMCs have the benefit of determining the contribution of each variable - traffic intensity, incident duration, or lane closures - in the congestion equation.
- TRT "rule of thumb" must reflect traffic demand levels instead of being determined only by incident duration (INCRF).
- The scenario analyses in this research is useful to practitioners as a guide in estimating delays and available levels of capacity under varying incident scenarios.

## Future Work

- Evaluate shoulder incidents and rubbernecking effects on incident TRT.
- Comparative analysis of simulation and shockwave methodology for TRT estimation.

## Funding Source

***Special thanks to:***

**1.Morgan State National Transportation Center**
**2.Maryland State Highway Administration**
**3.FHWA Dwight Eisenhower Fellowship Program**

**USDOT Sponsored Research**
**Demonstration/Exhibition - April 06, 2011**

# Wireless Roadside Inspection


NTRCI
NATIONAL TRANSPORTATION RESEARCH CENTER, INCORPORATED
University Transportation Center
2360 Cherahala Blvd, Knoxville, TN 37932
www.ntrci.org

RITA Research and Innovative Technology Administration
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Battelle The Business of Innovation

THE UNIVERSITY of TENNESSEE KNOXVILLE

Battelle Memorial Institute
Project Principle Investigator
Denny R. Stephens, Ph.D., PMP

University of Tennessee
Project Principle Investigator
Christopher Cherry; Assistant Professor

Student Research Assistants
Daniel Alexander; BS-Civil Engineering
David Baldwin; BS-Computer Science
Lawson Bordley; PhD-Civil Engineering
Catherine Bryant; MS-Civil Engineering
Shuguang Ji; PhD-Civil Engineering
Jonathan Kelfer; MS-Information Science
Matt Burr; BS-Mechanical Engineering

APL The Johns Hopkins University Applied Physics Laboratory

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

OAK RIDGE NATIONAL LABORATORY
Managed by UT-Battelle for the Department of Energy

VOLVO

UNIVERSITY OF KENTUCKY

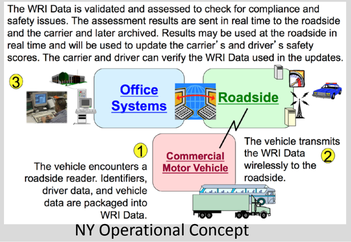
New York State Department of Transportation


## Introduction

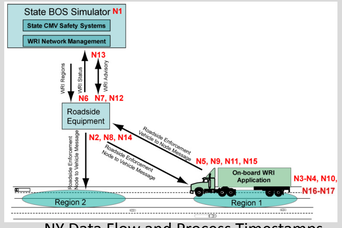
The Federal Motor Carrier Safety Administration (FMCSA) Wireless Roadside Inspection (WRI) Program is demonstrating the feasibility and value of electronically assessing truck and bus driver and vehicle safety 100 times more often than is possible using only roadside physical inspections. The WRI program is evaluating the potential benefits to both the motor carrier industry and to government. Potential benefits include reduction in accidents, fatalities and injuries on our highways and keeping safe and legal drivers and vehicles moving on the highways.

Wireless Roadside Inspection Pilot tests were conducted to prototype, test and demonstrate the feasibility and benefits of electronically collecting safety data message sets from in-service commercial vehicles and performing wireless roadside inspections using three different communication systems. The results of this phase of the effort demonstrate the capability to increase commercial vehicle inspections and to potentially realize significantly improvement commercial vehicle safety without increasing the burden on enforcement or compliant operators.

## New York Dedicated Short Range Communication (DSRC)



NY Operational Concept

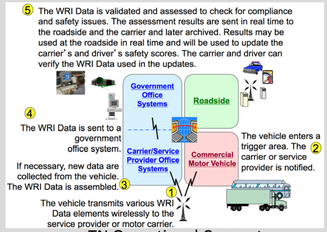


NY Data Flow and Process Timestamps

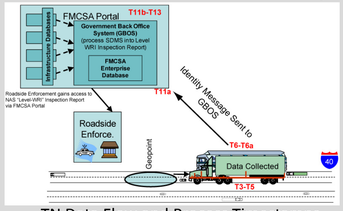
### New York System Performance

- The limited New York test produced two inspections from the state back office system to the truck
- The BOS simulator broadcast WRI regions to the roadside. This event took less than one second in both experiments. (N3-N1).
- The SDM was sent from the CMV to the BOS and the acknowledgement returned to the CMV. This event took less than one second in both experiments. (N9-N5).
- The WRI advisory message was requested from the CMV and inspection status returned from the BOS to the CMV. This event took less than one second in both experiments. (N15-N11).

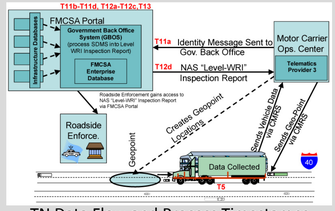
## Tennessee Commercial Mobile Radio Service (CMRS)



TN Operational Concept

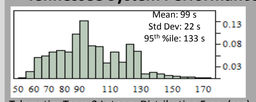


TN Data Flow and Process Timestamps (Telematics Team 2)

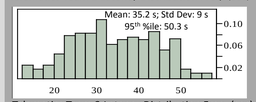


TN Data Flow and Process Timestamps (Telematics Team 3)

### Tennessee System Performance



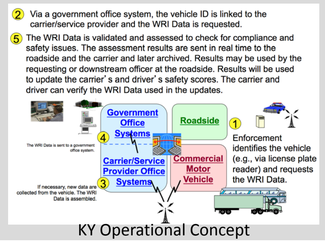
Telematics Team 2 Latency Distribution Freq. (sec)



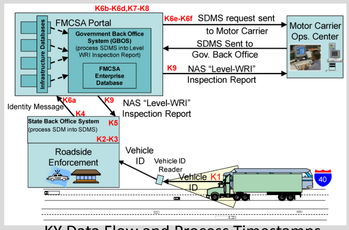
Telematics Team 3 Latency Distribution Freq. (sec)

Very low error rate and dropped inspection rate for both telematics teams

## Kentucky Universal Identification

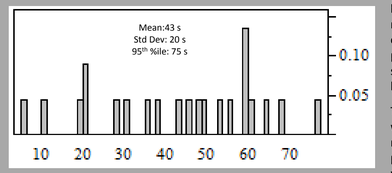


KY Operational Concept



KY Data Flow and Process Timestamps

### Kentucky System Performance



Kentucky License Plate Recognition Latency Distribution Freq. (sec)

The License Plate Recognition (LPR) system had a 87% successful read-rate under good operating conditions. In poor weather, the success rate was very low.

The latency (to the left) was relatively short. A manual data input process (not included) would require automation in a field test.

## Conclusions and Findings

### Quantitative Analysis of System Performance

**Data Delivery:**
- All platforms delivered full or partial data for a WRI transaction
- All platforms struggled with development of proper data formats and delivery
- All platforms simulated processes because of challenges with the technical environment.
- The pilot test had promising results for their ability to deliver WRI data to improve the inspection processes
- Problematic automation of sub-processes would need to be resolved in a full test

**Data Accuracy:**
- Data delivered through the WRI system were found to be relatively accurate.
- There were data anomalies in some of the data sets, including hours of service and other information
- Proper identification of vehicles will remain a challenge in the Universal Identification platform, in the absence of more robust identification technology.

**Data Timeliness:**
- Several of the operational scenarios (like real-time inspection report) require timely data delivery.
- Data latency ranges from a few seconds to over one minute, on average.
- System designs will need to take these latencies into consideration to support inspections, for instance placing the trigger upstream far enough to receive an inspection in time to interdict a vehicle.

### Qualitative Analysis of Stakeholder Perception

**TN Fleets:**
- Agree that in the context of a nationally-deployed system, WRI will likely improve the safety for all fleets and will help to level the playing field by forcing all companies to get CMVs up to required standards.
- Agree that WRI would improve the efficiency of their companies on a long-term basis.
- Strongly agree that company safety standards for their vehicles and driver attitudes towards safety will improve.

**KY Fleets:**
- Mixed results as to whether WRI is seen as a positive and/or necessary system.

**Law Enforcement:**
- Unanimous in their support of future WRI system deployment.
- Agree is would likely improve the safety of CMVs.
- Agree it would reduce violations in the long term.
- Think at-speed solutions are most realistic.

**Telematics Providers:**
- Some of the participating telematics providers think the WRI system should be implemented. Some do not (in it's current form).
- Provided valuable insight for improvements.

**Sensor Providers:**
- Express a strong desire to see the implementation of the WRI system.
- Had favorable impressions of the WRI technologies.

# Innovative System of FRP Bridge Deck Panels with Crash-Worthy Guardrail

**Authors:**
**Moni El Aasar, Ph.D., P.E., F. ASCE with BG Consultants, Inc. in Manhattan, Kansas**
**Hani Melhem, Ph.D., P.E. with Kansas State University**

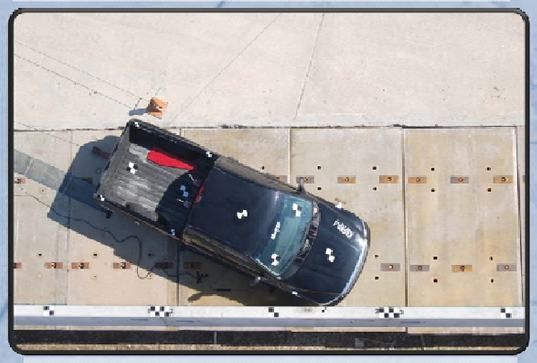
**For the first time a precast concrete vertical faced guardrail and its connection to a Fiber Reinforced Polymer (FRP) deck panels was designed. A full scale crash test showed the system can withstand the impact of a Quad cab pickup truck at an impact speed of over 60 mph and an impact angle of 26 degrees, and safely redirects the vehicle into the traffic lane.**

- **Innovative design that successfully met the *Manual for Assessing Safety Hardware* (MASH) evaluation criteria in a full scale crash test**
- **Fast installation (hours or few days) on a Temporary/Detour Bridge deck or a permanent deck replacement of an existing bridge**
- **More economical than total bridge replacement when bridge deck is deteriorated and concrete deck replacement is not an option due to limited substructure load carrying capacity**
- **Lighter weight (25% weight of Concrete) which allows for higher Live Loads and wider roadways on the same substructure**
- **Minimum road closure time and less inconvenience to the public.**
- **Less impact on channels and streams as exiting substructures can be used**
- **Less impact on the environment since the system is reusable and can be disassembled and used in different locations without affecting the integrity of the panels or the concrete barrier**

**Construction of Full Scale Bridge for Crash Testing**

**Innovative Bridge Rail and Connection to FRP Deck**

**Large Overhang (4.5'+) Tested to Allow for Wider Roadways on Rehab Projects**



**Test Setup for a Full Scale Crash at 26 Degrees**

**Impact at 60 mph Safely Re-directed the Pickup Truck into the Traffic Lane**

**Vehicle after Impact**

# INSTRUMENTATION AND METHODOLOGY FOR EVALUATING THE EFFECTIVENESS OF DUST CONTROL PALLIATIVES

## WHY IS DUST AN ISSUE?

Dust emissions from a roadway in Kotzebue, Alaska.

### Health Impacts:

- **$3 to $153.8B** in mortality and morbidity costs
- Respiratory health issues
- Quality of life is degraded

### Road Maintenance:

- **$260M** lost in material annually
- **7.9 tons** of dust emitted per mile per year

### Safety:

- Obscured vision
- Decreased handling and traction caused by weakening of road surface

## HOW IS DUST CONTROLLED?

Dust Palliative being applied to the gravel runway in the village of Nulato, Alaska. (Photo courtesy of Clark Milne, AKDOT&PF)

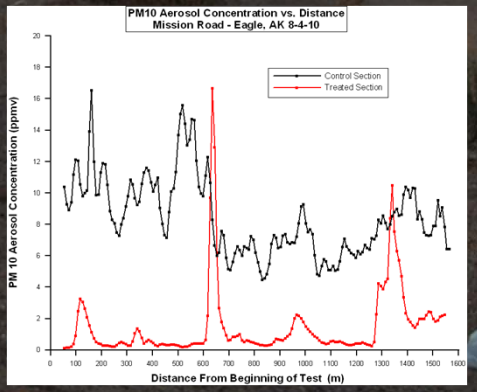
- Water
- Water Absorbing Products
- Organic Petroleum Products
- Organic Non Petroleum Products
- Electrochemical Products
- Synthetic Polymer Products
- Clay Additives

## HOW CAN WE MEASURE PALLIATIVE PERFORMANCE?

Dr. David Barnes operating the UAF-DUSTM on the infamous Taylor Highway in Alaska (Photo courtesy of Clark Milne, AKDOT&PF)

### UAF-DUSTM:

- Directly measures PM10 emissions for road surfaces every second
- Provides a non-destructive method to:
  - Quantify reduction of PM10 emissions from road surfaces
  - Monitor dust palliative performance
  - Ensure proper palliative application during construction
  - Determine the longevity of dust palliatives
- Simple, portable, and user friendly




### Results:

PM10 concentrations for a dust palliative treated (red series) and non-treated (black series) surface are shown versus distance. The palliative is providing a reduction in PM10 emissions. The large spikes in the red series indicate areas were the palliative has deteriorated or failed.

## INSERT CITAIONS

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# Integration of Variable Speed Control and Travel Time Information to Minimize Recurrent Highway Congestion

University of Maryland
Department of Civil & Environmental Engineering
By Gang-Len Chang, Sung Yoon Park, and Jawad Parach

## ABSTRACT

Contending with recurrent congestion on commuting corridors has long been a challenging and pressing issue for responsible highway agencies. However, effective strategies to mitigate the congestion level and the accompanied safety issues on those highway segments remain to be developed. In response to such needs, this study presents an innovative system that integrates variable speed control and travel time information for alleviating the day-to-day congestion at a highway corridor.

The entire system presented in this study includes a set of algorithms for setting variable speeds for different highway segments based on traffic conditions detected from roadway sensors, and a well-calibrated license-plate-recognition system for displaying the estimated travel time. Our field experiments of the proposed system on MD 100 over eight weeks have revealed that with a proper speed control in real time the congested highway segment indeed can achieve a higher throughput, stable traffic condition, and shorter travel time.

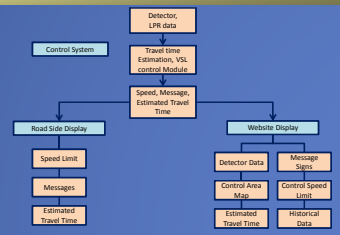
## INTRODUCTION

The core VSL logic is to dynamically adjust the set of speed limits properly located along a target roadway segment so as to smooth the speed transition between the upstream free-flow and downstream congested traffic states, and thereby preventing the formation of excessive queue due to the shockwave impacts. It is a common belief that proper implementation of VSL coupled with reliable traffic information messages can facilitate traffic flows to fully utilize the available capacity of the bottleneck segment, and thus result in an increase in the average traffic speed and throughput during the most congested period. With its dynamical adjustment capability, VSL control can also improve traffic safety on some hazardous highway segments that often experience poor weather conditions and justify the reduction in speed to prevent any potential accidents.

## Location Overview

## Control Design

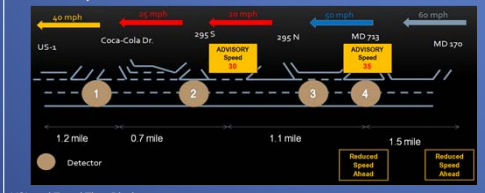
## Operational Flow Chart



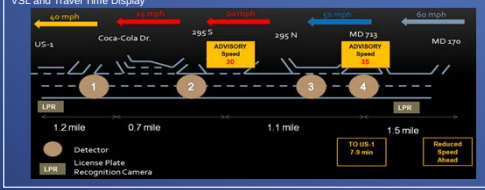

## Control Layouts

Travel Time Display Only

VSL Control Only

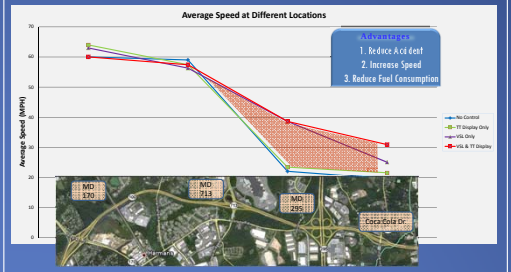



VSL and Travel Time Display

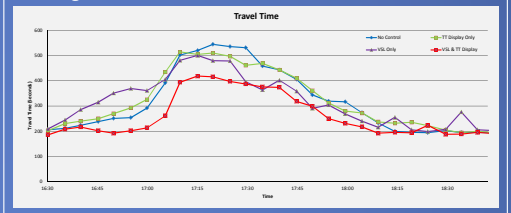



## Data Analysis

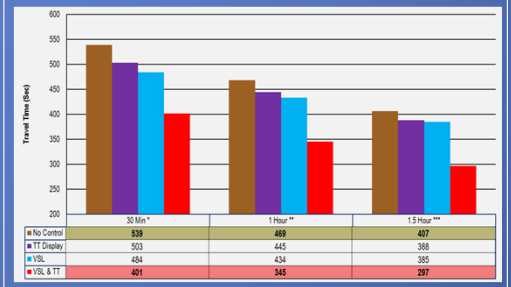
### Spatial distribution of average speed under different controls




### Average Travel Time Over Different Control Period

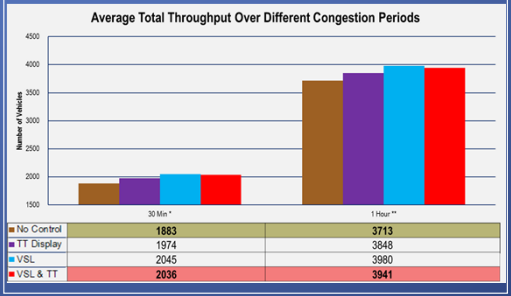



### Average Travel Time Over Different Control Periods



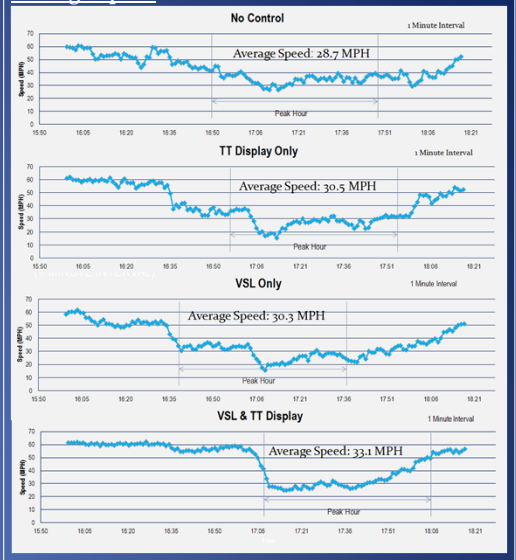

| | 30 Min * | 1 Hour ** | 1.5 Hour *** |
|---|---|---|---|
| No Control | 539 | 469 | 407 |
| TT Display | 503 | 445 | 388 |
| VSL | 494 | 434 | 385 |
| VSL & TT | 401 | 345 | 297 |

### Throughput




| | 30 Min * | 1 Hour ** |
|---|---|---|
| No Control | 1883 | 3713 |
| TT Display | 1974 | 3848 |
| VSL | 2045 | 3980 |
| VSL & TT | 2036 | 3941 |

### Average Speed




### Average Speed by selected interval during congestion period

| Control / selected interval | No control (MPH) | TT Display (MPH) | VSL (MPH) | VSL & TT (MPH) |
|---|---|---|---|---|
| First-5 Min | 27.8 | 25.2 | 24.2 | 26.6 |
| 15 Min | 19.7 | 19.6 | 22.2 | 20.0 |
| 30 Min | 18.1 | 19.3 | 20.8 | 24.8 |
| 1 Hour | 22.4 | 22.3 | 23.6 | 37.4 |

## System Products

| Control | System module | Control | System module |
|---|---|---|---|
| LPR camera | • Travel Time Estimation | VSL SPEED 45 | • Computation Algorithm |
| Detector | • Traffic Monitoring System | VMS 3-5 Min to US-1 | • Advanced Traveler Information System |

## Conclusions and Findings

VSL/Travel time control system can:

- ✓ Smooth the transition between the free-flow and stop-and-go traffic conditions;
- ✓ Increase the average speed;
- ✓ Reduce the overall travel time;
- ✓ Reduce potential incidents;
- ✓ Increase the total throughput during the peak commuting period.

Additional VSL/Travel time control system benefits:

- ✓ Reduce potential accidents and incidents;
- ✓ Reduce fuel consumptions;
- ✓ Reduce emissions.

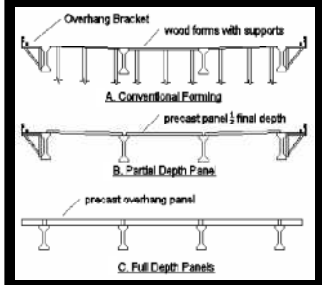
RITA Meeting: April 6, 2011

# Performance of Bridge Decks With Precast Overhangs and Welded Wire Mats

**Mostafa Ghashgesh, Sid Patil, Tyler Ley, Ph.D, P.E.**
**Department Civil and Environmental Engineering, Oklahoma State University**

**Abstract:**
Improved methods of bridge deck construction and repair are greatly needed. Bridge decks are often the first element to require repair or replacement because of its direct exposure to the elements and tire wear. This research presents a new precast overhang system that allows for significant improvements in construction speed, economy, and safety while meeting the AASHTO requirements and providing a serviceable structure. Deformed Wire mesh were also investigated to replace tied reinforcing bars with partial depth panels to improve the economy, constructability, and construction speed of bridge decks.

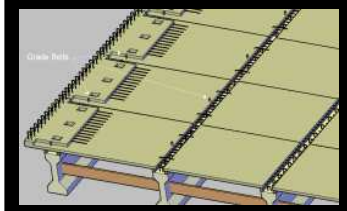
## Current Bridge Deck Design Practices:



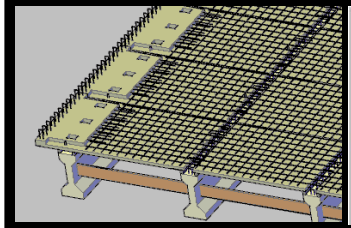
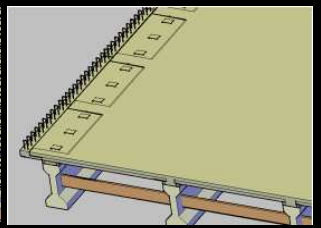

### Construction Steps
- Construct interior and exterior formwork
- Place reinforcing steel
- Make final grade adjustments to the steel and formwork with the screed in place
- Place concrete
- Remove formwork

### Challenges:
- Slow to construct
- Workers have to be harnessed
- Significant forming costs
- Formwork has to be placed and then removed

### New Precast Overhang System:
This bridge deck system uses precast panels as stay in place formwork and then cast in place concrete to provide the final riding surface. Adjustment bolts are used to adjust the geometry for construction tolerances. The precast panels in the interior spans are 4" deep (half of the bridge deck depth). The precast panels used for the overhangs are full depth in some sections (8") and partial depth in others.



### Construction Steps
- Place precast panels in the interior and exterior spans
- Make adjustments to the panel geometry with grade bolts
- Place pre – welded rebar mats
- Place concrete

**In Summer 2009, The Precast Overhang System was used in the construction of the Rock Creek Bridge in Parker County, Texas. The implementation was a success and is being planned on three more projects in Texas.**

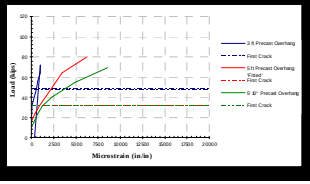
- **Improvements by the Precast Overhang System:**
  - Eliminates all formwork placement and removal
  - Reduces harnessed work by workers at edge of bridge
  - Simplifies construction and makes it easier to provide a satisfactory riding surface
  - Simplifies placement and location check of reinforcing steel
  - Reduces labor and material costs
  - Reduces deck construction time
  - Can reduce the numbers of beams required for construction

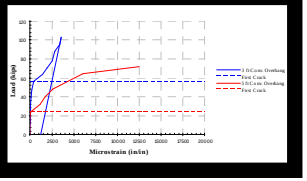
**Estimated to save over $100/ft and 7 days of construction time per 100 ft.**

## Research at OSU:

### i) Precast Overhang
The testing investigated the structural capacity and cracking of the precast overhang system. Conventional and Precast systems were investigated with 3′, 5′, and 5′-10″ overhang lengths. Specimens were tested with corner and midspan loads in the overhangs. Surface strains, deflections, and crack mapping was used to quantify the performance of the systems.

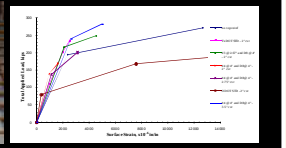
The practical limit of the overhang was found to be 5′-8″. Systems with spans less than this were found to be safe and serviceable.

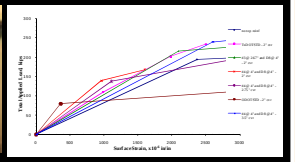





### ii) Welded Rebar Mats
Deformed wire mats provide a useful alternative to tied reinforcing bars.
- The mats can be created with bars that are much closer than could be economically placed by hand. This leads to improved crack control.
- Pre-connection of the needed reinforcing steel allows one to match the steel in the wire mats to the expected loads.

**Test results found that with deformed wire mats that the amount of reinforcing steel can be reduced by 30% and still provide 30% smaller crack control when compared to conventional reinforcing steel. This allows less steel to be used that produces bridge decks with smaller cracks.**





## Conclusions:
When comparisons were made between the performance of each specimen and the AASHTO 16 kip design load as a reference satisfactory performance was obtained:

- The precast overhang specimens showed the ability to allow a much greater dispersion of cracks when compared to the CIP overhangs. This was reflected in the reduction in surface strains by an average of 23% between the two systems for the same loading conditions. All specimens provided significant safety factors when comparing the service loading specified to AASHTO to the cracking and ultimate loads. A minimum factor of safety of 1.5 for cracking, and 3.0 at ultimate were both obtained for the 5′ overhang with corner loading.
- When deformed wire mats were used a significant improvement was observed in the resulting crack size. This could be used to significantly reduce the size of cracks in the resulting bridge decks while also reducing the amount of reinforcing steel used. This reduction in crack size would allow for significant improvement in concrete bridge deck durability and would be expected to extend the members service life.

## Technology Transfer
-www.precastoverhang.com
-Presentations:
- ASCE Texas Regional Meeting, Dallas, TX
- PCI/FIB International Bridge Conference, Washington D.C.
- ODOT Research Day, Oklahoma City, OK

## Ongoing Work
-Two journal Papers preparation.
-Preparation of a computer program to simulate the performance of bridge decks with different given dimensions and properties.

## Funding:
Texas Department of Transportation (TxDOT)
Austin Prestressed Incorporated
Oklahoma Wire and Steel
Insteel
Oklahoma Transportation Center - United States Department of Transportation

# MARKETING AND OUTREACH FOR THE SAFETY EDGE

Shauna Hallmark, Tom McDonald, Bob Sperry, Jerry Roche (FHWA), and Keith Knapp (LTAP)

MTC Midwest Transportation Consortium

Iowa State University
Institute for Transportation

ctre Center for Transportation Research and Education

Iowa LTAP Local Technical Assistance Program

## Overview

- FHWA estimates that 160 fatalities and 11,000 injuries annually are related to unsafe pavement edge
- Georgia study found edge drop-off present in 55% of crashes on rural 2-lane paved roadways
- Pavement edge drop-off crashes 2 times more likely to result in a fatal crash than other crashes on similar roadways
- FHWA encourages use of Safety Edge
  - Design feature creates a 30° fillet along the outside edge of the paved section of a roadway
  - Most commonly used on Hot Mix Asphalt (HMA) projects
  - Safety Edge device shapes and consolidates the asphalt material at the pavement edge
- Safety Edge developed based on research indicating that a sloped pavement edge surface could more easily be traversed by vehicles attempting to remount the pavement edge after leaving the paved roadway surface
- MRI estimated a crash reduction factor of 5.7% with use of Safety Edge

## The Project

- Safety Edge was fairly new to Iowa prior to 2010 construction season
- Center for Transportation Research and Education (CTRE) encouraged use of and assisted 17 Iowa counties and the Iowa DOT with application of Safety Edge
  - Answered questions at pre-letting and pre-construction meetings
  - Hosted open houses
  - Loaned Safety Edge equipment
  - Provided technical assistance
  - Made construction site visits
  - Measured Safety Edge slope for quality assurance
  - Evaluated density and drop-off formation
- Advisory panel included FHWA, the Iowa DOT, Iowa counties, the Asphalt Paving Association of Iowa, the Iowa Concrete Paving Association, and several construction companies
- Resulted in information and lessons learned that were ideal for outreach to state, county, and local agencies
- Working with Iowa Local Technical Assistance Program (LTAP) to disseminate information to local agencies

## Translation to Practice

- Topic was of significant interest to counties, cities, contractors
- Developed Outreach Material for LTAP
- Developed PCC design standard for Safety Edge
- Implemented into Iowa Lane Departure Strategic Guide

## Iowa Lane Departure Strategic Guide

- Besides final report, project resulted in a chapter in the "Lane Departure Guidance for Iowa"
- Proposed guidance to Iowa agencies for addressing roadway departures
- Supplements LTAP training material

## Developed Outreach Material for LTAP

- Worked with Iowa LTAP
- Developed tech brief and presentation geared towards local agencies
- Summarized
  - Scope of problem
  - Description of Safety Edge
  - Benefits of Safety Edge
  - Types of equipment available
  - Outreach activities for project which may be duplicated, such as Open Houses
  - Iowa DOT design standards
  - Guidelines for quality assurance including measuring slope and density
  - Guidelines for HMA projects
  - How PCC application came about
  - Guidelines for PCC projects
  - Study conclusions
  - Lessons learned
  - Information on determining additional costs or material
- Material can be adapted for short (< 1 hour) or ½ day training

## Development of PCC Application and Standards

- At commencement of project, no properly designed applications of the Safety Edge on Portland Cement Concrete, (PCC) paving projects existed nationally
- Worked with Iowa DOT and Iowa Counties to develop PCC Safety Edge design standards and specifications
- Resulted in first national demonstration of the Safety Edge with PCC on E-34 in Jones/Linn County in Iowa
- Used for 1 additional county project
- Iowa DOT now requires use of Safety Edge on all primary highways except when the roadway is an interchange ramp, is curbed or has paved shoulders >= 4 feet

## Project Impact

- Benefits for US DOT and Iowa DOT:
  - Efficient use of funds to translate research directly into practice
  - Quantifiable impact on safety to meet Iowa's "1 Death is 1 Too Many" and FHWA's "Every Day Counts" initiatives
- Benefits for local agencies
  - Readily available resources for outreach and training
  - Access to expertise of university
  - Potential savings on pavement maintenance
- Benefit for public
  - Safety Edge has potential to reduce roadway departure crash frequency and severity
  - Efficient use research dollars from tax payer funds
- Benefit for contractors
  - Savings if they do not have to pull shoulder up each night

Presented at: US DOT Sponsored Research Demonstration and Exhibit April 6, 2011

# Identification of Impact Conditions in Severe Cable Median Barrier Crashes


## Dr. Dean Sicking, Professor and Cody Stolle, Graduate Student

MID-AMERICA TRANSPORTATION CENTER

Improving safety and minimizing risk associated with increasing multi-modal freight movements.

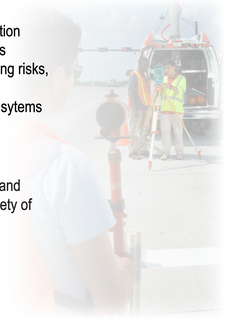
## About MATC:

The Mid-America Transportation Center is the Region VII University Transportation Center designated by the US Department of Transportation and a nationally recognized center of transportation excellence.

MATC's mission is to develop new knowledge, innovative solutions, and the next generation of transportation professionals necessary to maintain an increasingly safe, effective, efficient, sustainable and environmentally friendly transportation system.

## Research:

The overarching goals of MATC's research are:
- Improve linkages among all modes of transportation
- Improve livability of rural and urban environments
- Develop a systems-based approach for quantifying risks, to be utilized by all transportation agencies
- Increase the safety of the surface transportation sytems



## Tech Transfer:

MATC communicates research advances to public and private sector transportation workers through a variety of multi-media approaches, including:
- Webinars
- Electronic Publications and Websites
- Distance Learning Programs
- Short Courses, Workshops, and Presentations
- Press Releases and Press Conferences

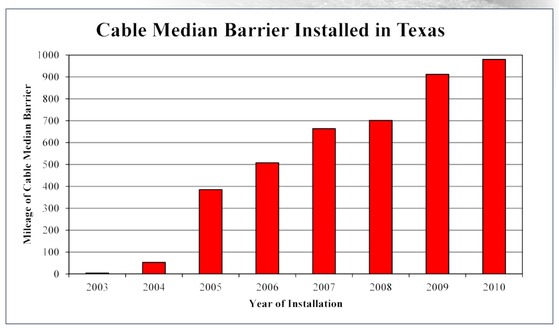
## Education:

Compenents of our education program include:
- MATC Intern Program: Provides research and professional experience for undergraduate students in the public and private sectors and academia
- MATC Scholars Program: Prepares students from under-represented groups for graduate study in science, engineering, technology and math
- Summer Professional Development Institute: Trains secondary teachers in the use of instructional materials that incorporate technology and transportation examples to facilitate student learning in science and math
- Engineering Excellence Experience Day: Secondary students spend a day on campus to experience what it is like to be an engineer
- After-school Program: Middle-school students are introduced to transportation careers and learn about science and math through hands-on transportation-based activities

## Introduction:

### Cable Median Barrier (CMB)
- Safe
- Economical
- Versatile

### Sometimes Deadly
- Currently 250 fatalities a year
- Estimated 500 fatalities a year by 2020
- Combined serious injury and fatality rate of 3.0%




## Goals and Objective:

***Objective*** – Improve Safety of CMB

### Goals
- Determine causes of CMB penetrations and rollovers
- Identify factors increased risk of serious injury or fatality

## Family of Research Studies:

1. Accurate, simple computer model of wire rope used in CMB
2. High-tension cable post base and anchor movement
3. High-tension, non-proprietary CMB end terminal
4. Computer simulation modeling of cable attachment hardware
5. Non-proprietary design for high-tension CMB
6. Impact condition-related increase in accident severity on CMB
7. CMB implementation guidelines
8. Retrofits and new designs for CMB to improve performance
9. Cost-effectiveness evaluation of retrofits and redesigns

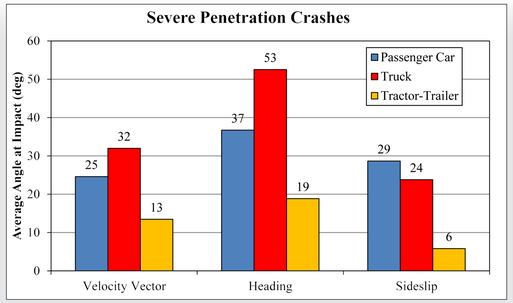
http://www.educationforthedrivingmasses.com/2010/11/cable-barrier-under-scrutiny-after-qe2.html

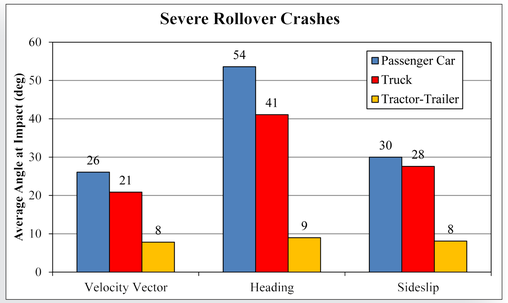
## Study Findings:

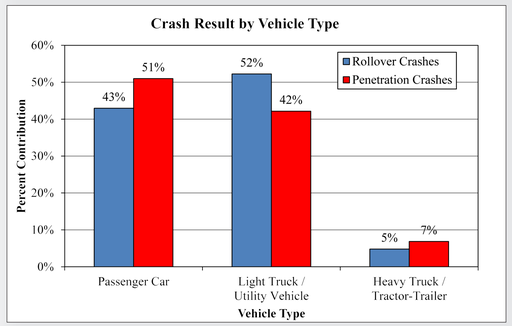
### Penetrations
- Occur in 5% of all CMB crashes
- Sedan / coupe vehicles

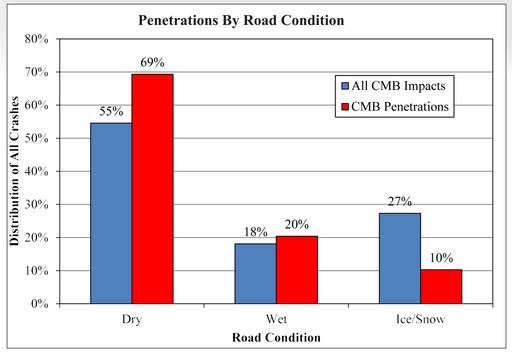
### Rollovers
- Occur in 7.5% of all CMB crashes
- Light trucks / utility vehicles

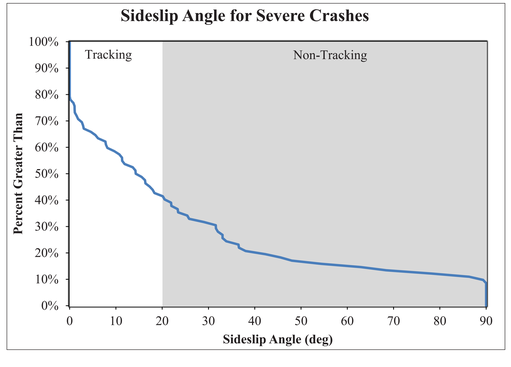
### All Severe Crashes
- High impact, sideslip angles
- Non-tracking impacts

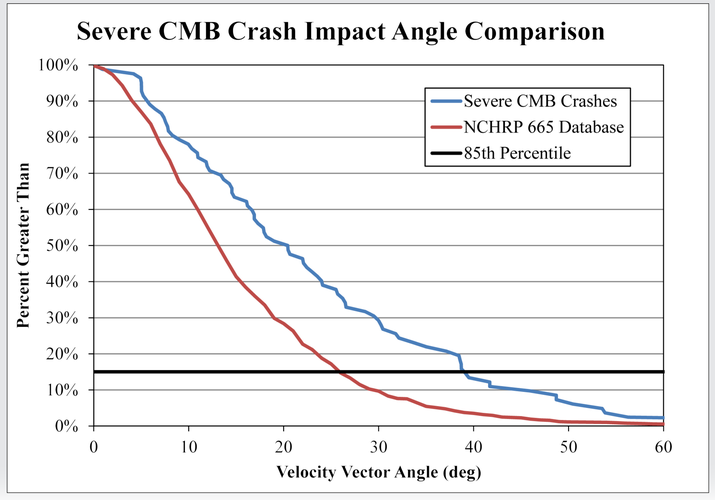



## Conclusions and Benefits:

### Conclusions
- Increase test impact angle
- More beneficial in snow country
- Low-profile vehicles penetrate, large vehicles rollover
- Projected prevention of 350 fatalities a year

### Benefits of Project
- Proactive approach
- Reduction in fatalities and serious injuries = reduction in societal cost
- Projected annual average savings of 30 million dollars per state

http://www.sanangelompo.org/projects_page/Cable%20Barrier.php

# NON-CONTACT STRAIN SENSOR FOR PRESTRESSED CONCRETE INSPECTION IN BRIDGE STRUCTURES AND HIGH-SPEED RAIL CROSS-TIES

*Dr. Robert Peterman (CE Department), Dr. John Wu (IMSE Department), Dr. Terry Beck (MNE Department)*
*Weixin Zhao (Ph.D. Student, MNE Department)*
***Kansas State University, Manhattan, KS***

***Sponsors:***

## IMPORTANCE TO THE TRANSPORTATION INDUSTRY

### Bridge Inspection

In order to evaluate structural performance of concrete members, it is often necessary to experimentally determine deformations in the member due to applied forces. The ability to accurately determine the stresses carried by in-situ bridge elements is extremely valuable when assessing the condition of an existing structure. This is especially important for rural bridges on county roads, where many existing bridges are structurally deficient and need repair.

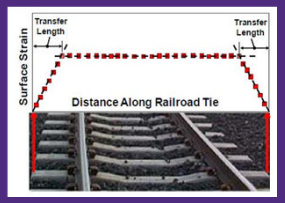
- Structural Performance of Concrete Members
- Structure Deformation Due to Applied Loads
- Transfer Length Diagnostics
- Crack Monitoring and Maintenance
- Determination of In-Situ Stresses

### Transfer Length Measurement

A parameter of particular importance to prestressed concrete bridge structures and beams is the “transfer length,” which is defined as the distance required to transfer the fully effective prestress force in the reinforcing-strand to the concrete (Naaman, 1982). Currently, transfer lengths are experimentally determined by measuring concrete surface strains near the ends of test specimens. This manual contact measurement involves the attachment of regularly spaced stainless-steel “points” to the specimen at 50 mm (2 in) spacing prior to de-tensioning the strands. Subsequent to de-tensioning of the strands by cutting, the displacement of the points is measured using a mechanical “Whittemore” gauge.

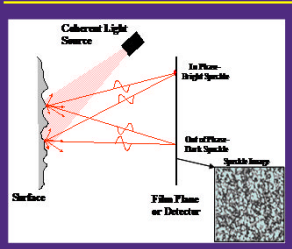
- Traditional Method Since 1950’s
- Time-Consuming Surface Preparation
- Tedious Manual Mechanical Measurement
- Special Operator Training Required

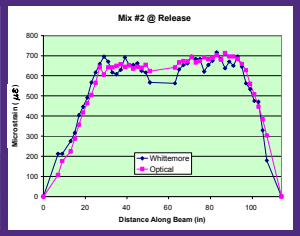
## High-Speed Rail Applications



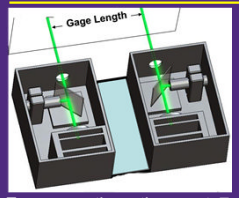

Apart from bridge structures utilizing prestressed concrete, prestressed concrete railroad cross-ties are becoming increasingly popular in the United States, and are an essential component for higher speed railway lines. In order for these prestressed concrete ties to function adequately over their expected service life, the prestressing force must be fully introduced into the railroad tie at a location well before the rail load is applied. Once again, the length required to transfer the prestress force into the concrete cross-tie member is the “Transfer Length.”

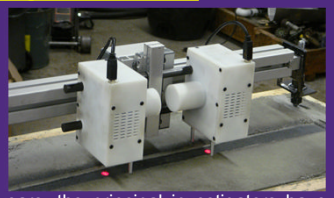
## NON-CONTACT STRAIN SENSOR TECHNOLOGY




### Non-Contact Transfer Length Measurement

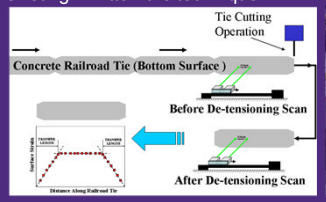


For more than the past 7 years, the principal investigators have been working as an interdisciplinary team to develop a practical non-contact optical strain measuring device based on a Laser Speckle Imaging (LSI) principle. The LSI device utilizes laser-speckle patterns that are generated and digitally recorded at various points along a prestressed concrete member. These patterns, which arise from the surface roughness of the concrete, generate an optical "tag" in the form of a random optical interference pattern known as "speckle." The displacement of this optical tag provides a measure of the surface strain, which can then be used to determine transfer length.

## IMPACT OF NON-CONTACT SENSOR TECHNOLOGY

The LSI technique has been verified against results obtained using the traditional method of adhering stainless-steel discs, and measuring surface strains with a mechanical strain gage (Demec or Whittemore type) and is considerably more accurate than the existing Whittemore technique.



The diagnostic testing of commercially manufactured prestressed concrete presents a critical sensor technology need (Russell and Burns, 1993). A survey of non-destructive inspection technologies related, in particular, to concrete bridge construction (Ciolko and Tabatabai, 1999) indicated that the methodology for this type of structure evaluation “could be revolutionized through the development of accurate, quantitative nondestructive test methods for strand in pretensioned and post tensioned structures.” Real-time prestressed concrete cross-tie inspection for high-speed railroad applications is now possible.

### Summary

- Innovative Non-Contact Surface Strain Technology
- Minimal Surface Preparation Required
- Verified Against Traditional Contact Methods (e.g., Whittemore)
- No Special Operator Training Required
- Adjustable Gauge Length
- Provides Real-Time Diagnostics & Field Testing Capability

### Acknowledgments

The University Transportation Center (UTC) at KSU, The Kansas Department of Transportation (KDOT), The Prestressed Concrete Institute (PCI), and The Advanced Manufacturing Institute (AMI) at KSU, are gratefully acknowledged for their support.

### References

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- Russell, B.W. and Burns, N. H., “Design Guidelines for Transfer, Development and Debonding of Large Diameter Seven Wire Strands in Pretensioned Concrete Girders,” Texas Dept. of Transportation, Research Proj. 3-5-89/2-1210, 286 pp., Jan. 1993.

UNIVERSITY of WASHINGTON

TRANS NOW

# OneBusAway: Behavioral and Satisfaction Changes Resulting from Providing Real-Time Arrival Information for Public Transit


Presenting:
Kari Edison Watkins, PE
kariwat@uw.edu


Public transit plays important role in providing mobility, combating congestion, reducing carbon emissions, and promoting sustainable communities.

BUT potential customers can be confused or intimidated by complexity of transit systems.

OneBusAway provides simple real-time information for Seattle-area bus riders.

Conducted a survey of OBA users that showed:

- Increased satisfaction with transit
- Decreased wait time
- Increased trips per week
- Increased feeling of safety
- Increased distance walked

http://onebusaway.org


Kari Edison Watkins, UW Civil & Envir. Eng.
Brian Ferris, UW Computer Science & Eng.
Dr. G. Scott Rutherford, UW Civil & Envir. Eng.
Dr. Alan Borning, UW Computer Science & Eng


## OBA TOOLS

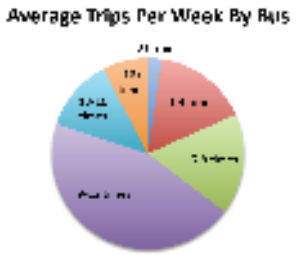
OneBusAway provides trip planning tools and real-time next bus countdown information for transit riders in greater Seattle via multiple interfaces. It serves 40,000 unique users per week.

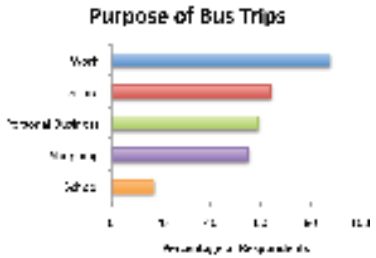
- Website: 15k users
- iPhone and Android apps: 25k users
- Standard telephone number: 2k users
- SMS interface for text-messaging: 1k users

Smart phone applications include automatic localization of information using phone's GPS capabilities. Other interfaces use stop ID or route / address search to access information.

## OBA EVALUATION

Two web-based surveys conducted in Aug 2009. First survey had 488 Respondents (10% of the daily OBA users at the time). A 139-respondent follow-up survey about walking was conducted based on the initial survey results. The majority of respondents were daily users who were commuting to work.

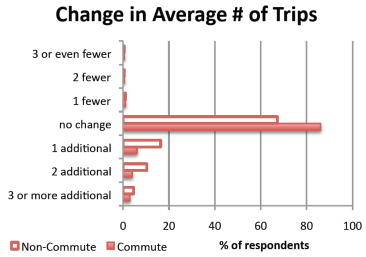


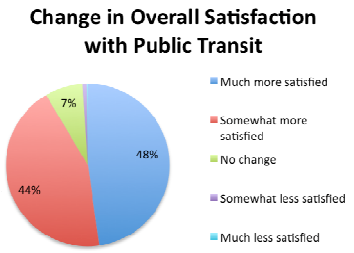




## SURVEY RESULTS

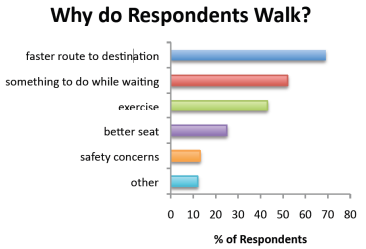
Respondents indicated that:

- 92% were more satisfied with transit
- 91% spent less time waiting
- 31% took additional transit trips
- 21% felt safer waiting




- 78% are more likely to walk to a different stop, either on a different route or further up or down the same route
- Average 6.9 additional blocks




## POLICY IMPLICATIONS

Survey shows promise of mobile real-time information, which is substantially cheaper to the agency than providing real-time signage. In addition, 73% of respondents indicated they use OneBusAway information exclusively to determine when to access the bus. The changing nature of information access could eventually allow transit agencies to operate more headway-based service saving the slack time required to maintain a schedule.

## OBA RESEARCH

The initial OBA survey was self-reported data with no control group of non-users. We are therefore conducting several additional studies:

1. To determine the influence of real-time information on people's perceived wait times and actual wait times
2. To determine if people actually take additional transit trips as a result of better rider information
3. To investigate the impact of information tools on bus drivers
4. To use crowd-sourcing correction of real-time and trip planning data

# Plan4Safety

Crash Data Analysis Tool

## *A picture is worth 1,000 lives*

Plan4Safety helps safety professionals make data-driven decisions

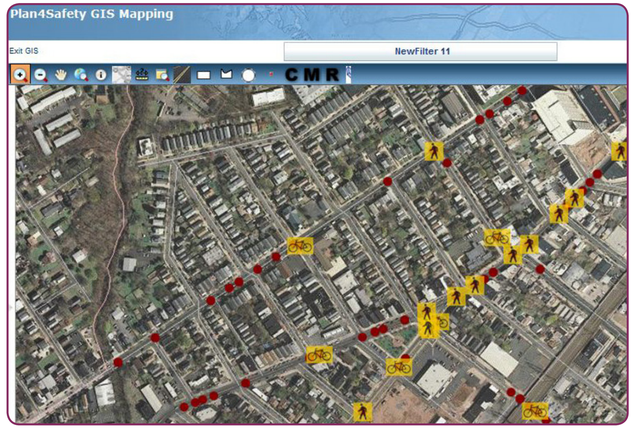
## Data Analysis Tools

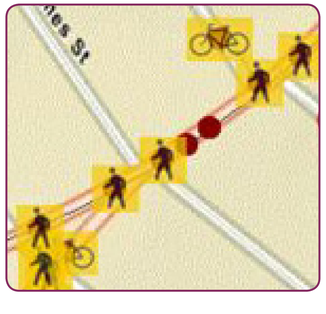
Easy to use software tools:

- **Filters through entire crash database in seconds**
- Creates computer-generated distributions, tables, and graphs
- Web-based; no special applications or computer processing power needed

## GIS Mapping

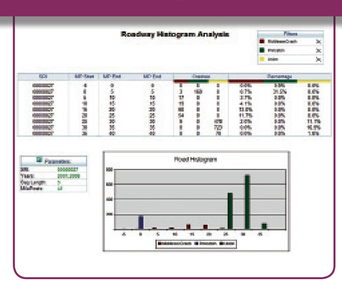
- Visual analytical tools
- Plots crash points on a street map or aerial image map
- Lets user examine physical characteristics of area surrounding a crash
- **Dynamically displays filtered crashes on GIS maps**
- Maps unique user-defined conditions

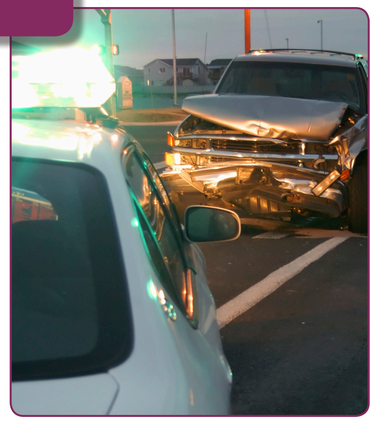


## Network Screening Tools

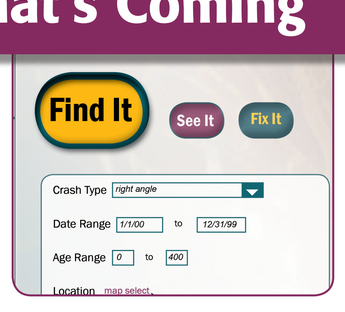
- **Ranks** crash locations using common methodologies
- Identifies potential areas for safety improvements



## Intuition: What's Coming

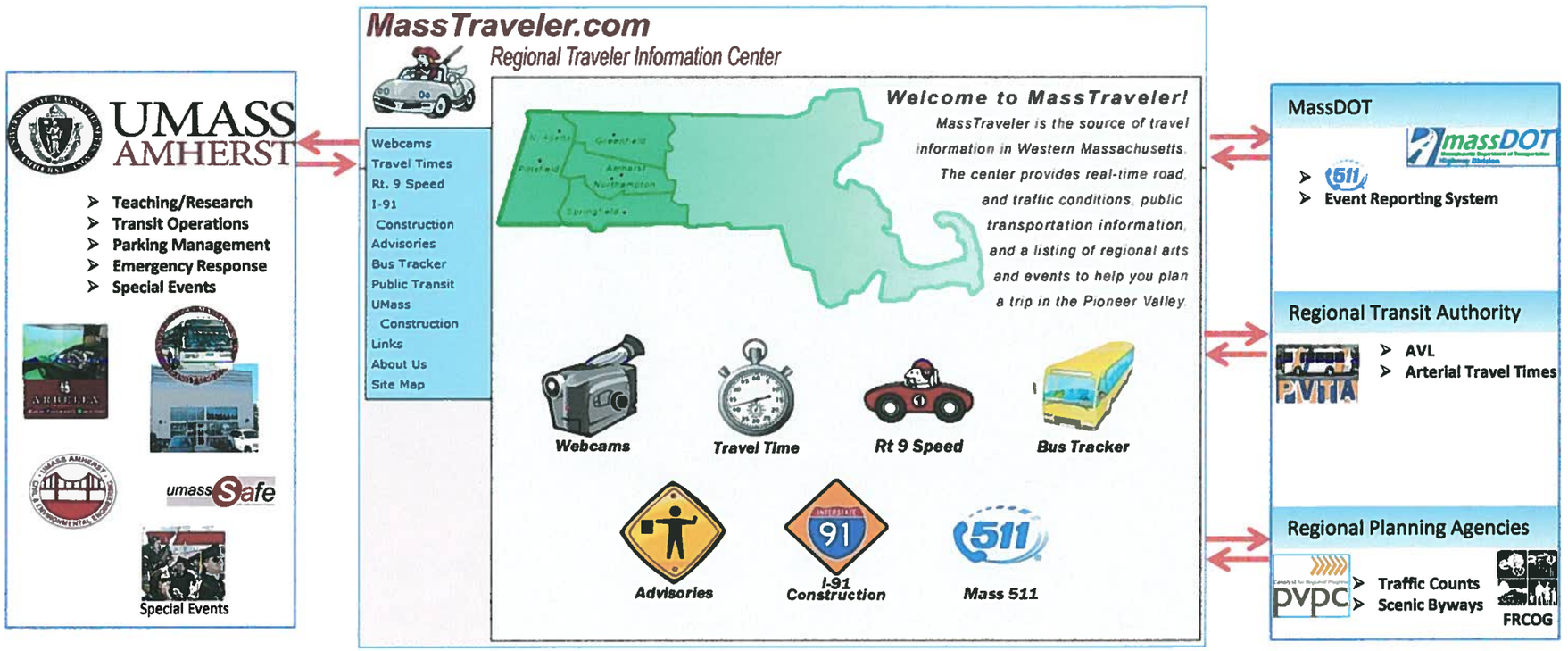
- Intuitively searches and finds trends within user data
- **Identifies grant eligible areas**
- Automatically guides user to each function



Developed by Mohsen Jafari, Ph.D., Dept. of Industrial and Systems Engineering, and the Transportation Safety Resource Center with funding provided by NJDOT

RUTGERS
Center for Advanced Infrastructure and Transportation

# UMASS TRANSPORTATION CENTER



CENTER FOR INTEGRATED TRANSPORTATION SYSTEMS MANAGEMENT

UNIVERSITY OF MARYLAND

# RoadSmart: A Low Cost Green Wireless Traffic Sensor

*Mehdi Kalantari Khandani, Masoud Hamedi, Farshad Ahdi*

Sponsored by CITSM, SHA, TEDCO

**Research objective:** To develop wireless, green, energy self sustained and scalable devices for vehicle detection, classification and anonymous reidentification

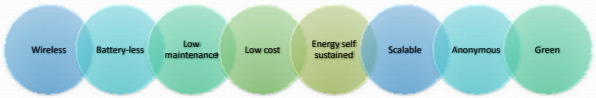
## Abstract

This project offers a novel and green device for traffic sensing devices based on magnetic detection and low power wireless communication. The technology offers a cost-effective, battery-free, and energy self sustained architecture for real-time traffic measurement over distributed points of a transportation system. This largely scalable technology will monitor traffic parameters such as flow, occupancy, point speed, vehicle type, and travel time on road systems in real-time. In addition to measuring traditional traffic parameters, the proposed sensor network will be capable of sampling the travel time of individual vehicles using an anonymous vehicle tracking scheme. The solution uses ultra low power, wireless and battery-free sensors that are capable of forming a sensor network over many points of the road pavement. The devices harvest their required energy from their surrounding environment, using ambient light and vibration, to power up the sensing transducer and telecommunication modules; thus, they do not need batteries.

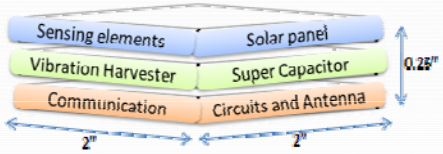
## Comparison with Existing Technologies

| Sensor Technology | Traffic Measures | | | | | | Lane by Lane Data | Power Source | Pavement Invasion | Weather Sensitivity |
|---|---|---|---|---|---|---|---|---|---|---|
| | Count | Presence | Speed | Occupancy | Travel Time | Classification | | | | |
| Inductive Loop | • | • | • | • | | • | • | External power supply | High | |
| Magnetometer | • | • | • | • | | | • | External power supply | High | |
| Magnetic Induction Coil | • | | • | • | | | • | External power supply | High | |
| Microwave Radar | • | • | • | • | | • | • | External power supply | None | |
| Active Infrared | • | • | • | • | | • | • | External power supply | None | • |
| Passive Infrared | • | • | • | • | | | | External power supply | None | • |
| Ultrasonic | • | • | | • | | | • | External power supply | None | • |
| Acoustic Array | • | • | • | • | | | • | External power supply | None | • |
| Video Image Processor | • | • | • | • | • | • | • | External power supply | None | • |
| Bluetooth | | | | | • | | | External power supply | None | |
| Wireless Magnetic | • | • | • | • | • | • | • | Battery | Low | |

## RoadSmart Features




## Architectural Components



➢**Sensing elements:** Anisotropic Magneto-Resistance (AMR) sensor which generates a digital signature of the passing vehicles

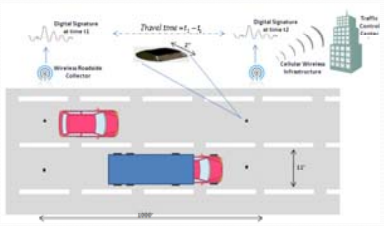
➢**Solar panel:** a small thin solar panel on the top section of the devices turns ambient light energy into electricity.

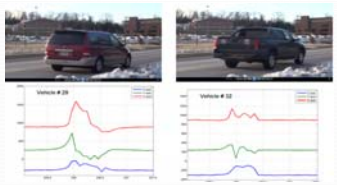
➢**Vibration harvester:** piezoelectric technology to harvest the vibration energy on the road pavement.

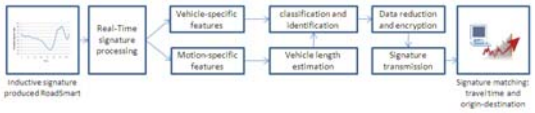
➢**Super capacitor:** a capacitive medium for storing harvested energy from solar and vibration sources.

➢**Circuit and antenna:** communication antenna and circuits for wakeup scheduling, instrumentation, amplification, and communication.

## Anonymous Vehicle Classification and Reidentification

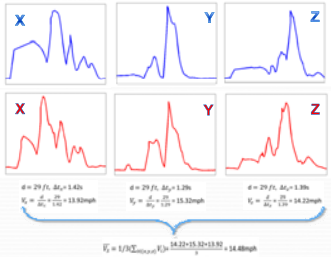







## Digital Signatures and Speed Measurement

**Ground Truth Speed: Image Processing**



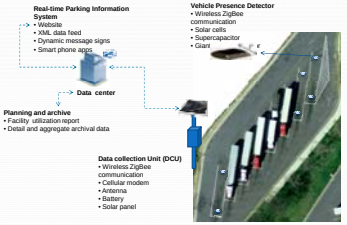

## Immediate Applications

**Wok zone safety**

- **Fast & disposable:** because of the low cost, the RoadSmart sensors can be treated as disposable devices for work zone data collection to improve the safety. Installation needs minimal effort.
- **Sensor networking:** RoadSmarts form a sensor network which acts as a medium in the absence or disruption of telecommunication services.

**Smart parking management**

- **Driver fatigue:** FHWA has estimated that driver fatigue is a primary factor in 4-5 percent of truck-involved fatal crashes and is a secondary factor in an additional 10-5 percent of such crashes.
- **Truck facility information:** Drivers do not have access to information on availability of spots in truck parking facilities.
- **Data collection** is the most critical component of smart parking management systems.
- **RoadSmart:** an easy and cost effective solution for real-time parking management.



# University Transportation Research Center

Region II
New York
New Jersey
Puerto Rico
U.S. Virgin Is.

12:17:15 P.M.

THURSDAY MAR.10, 2011 — TODAY 37 / 40

## American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## FLIGHT SCHEDULE INFORMATION

Select Language

| Airline | Flight | From | Scheduled | Terminal | Status |
|---|---|---|---|---|---|
| AA | AA699 | ORD - Chicago | 9:10 | T4 42B | Departed |
| UA | UA839 | SYD - Sydney | 10:15 | 7 77 | Departed |
| DL | DL1063 | MCO - Orlando | 10:30 | 5 56 | Scheduled |
| FL | FL58 | ATL - Atlanta | 10:40 | 3 33-A | Scheduled |
| QF | QF16 | BNE - Brisbane | 11:10 | T4 43 | Scheduled |
| NK | NK310 | MIA - Miami | 9:10 | 7 75A | Scheduled |
| UA | UA839 | SYD - Sydney | 10:15 | 7 77 | Departed |
| AA | AA699 | ORD - Chicago | 9:10 | T4 42B | Departed |
| FL | FL58 | ATL - Atlanta | 10:40 | 3 33-A | Scheduled |
| DL | DL1063 | MCO - Orlando | 10:30 | 5 56 | Scheduled |

FLIGHT SCHEDULE | NOTIFY ME | AIRPORT MAP | RESTAURANTS | SHOPPING

CISCO

# University Transportation Research Center

Region II
New York
New Jersey
Puerto Rico
U.S. Virgin Is.

12:17:15 P.M.

THURSDAY MAR.10, 2011 — TODAY 37 / 40

## American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

NOTIFY ME

Select Language

### Step 1: Choose a Flight
Track departing or arriving flights.

**Flight # or Record Locator :**

### Step 2: Enter a Device Address
Messages can be sent to any device
that receives e-mail or text message.

**Email or Phone Number:**

Q W E R T Y U I O P
A S D F G H J K L Notify Me
⇧ Z X C V B N M ! , ? . .COM
123 # + =

FLIGHT SCHEDULE | NOTIFY ME | AIRPORT MAP | RESTAURANTS | SHOPPING

CISCO

# University Transportation Research Center

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Puerto Rico
U.S. Virgin Is.

12:17:15 P.M.

THURSDAY MAR.10, 2011

TODAY 37 / 40

## American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## ABC INTERNATIONAL AIRPORT MAP

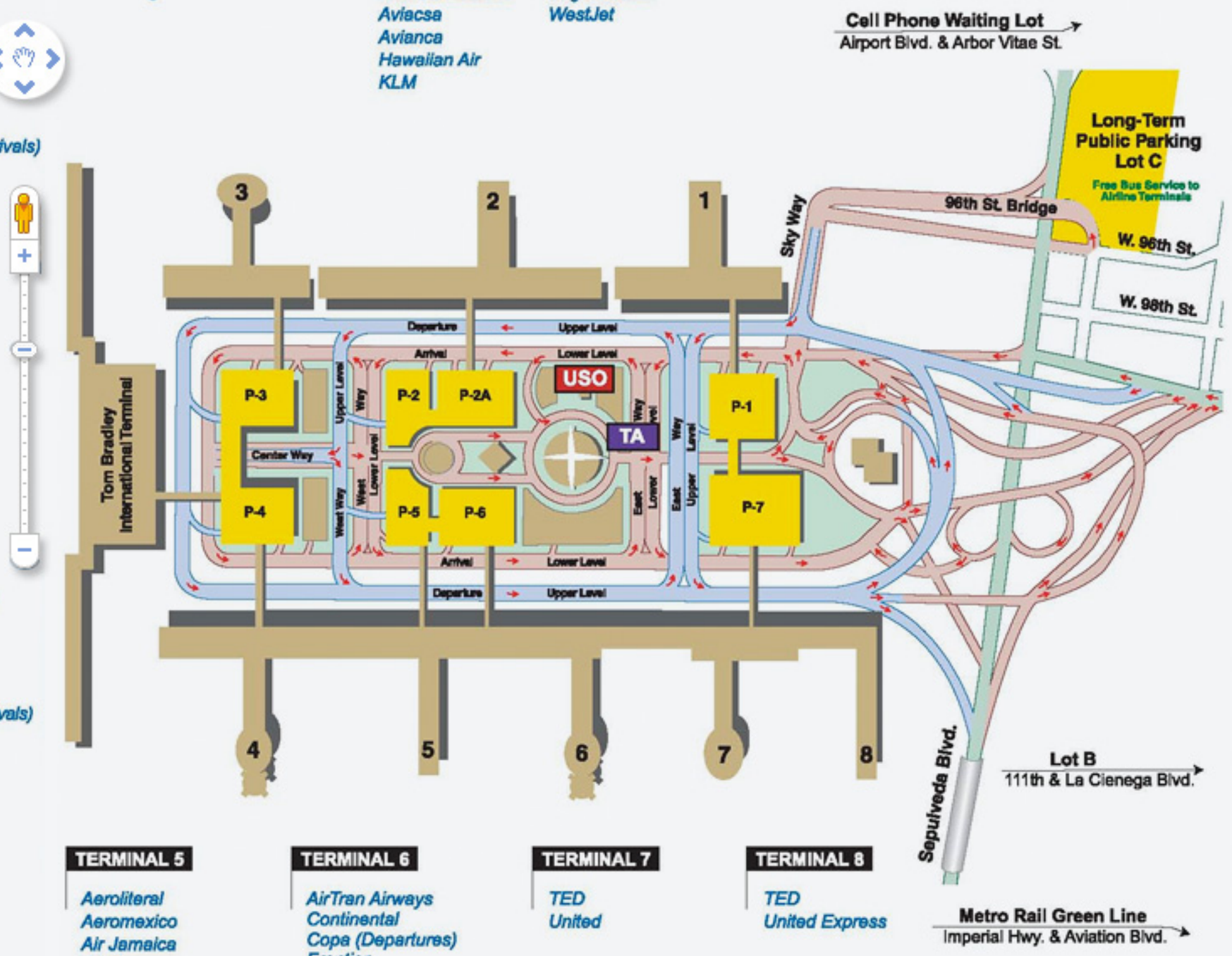
Select Language

**TERMINAL 3**
- Alaska Airlines
- Horizon
- V Australia
- Virgin America

**TERMINAL 2**
- Air Canada
- Air China
- Air France
- Air New Zealand
- Aviacsa
- Avianca
- Hawaiian Air
- KLM
- LACSA
- Northwest
- TACA
- Virgin Atlantic
- WestJet

**TERMINAL 1**
- Southwest
- US Airways

**TBIT**
- Aeroflot
- Air Pacific
- Air Tahiti Nui
- Alaska (Mexico Arrivals)
- All Nippon (ANA)
- Asiana
- British Airways
- Cathay Pacific
- China Airlines
- China Eastern
- China Southern
- Copa (Arrivals)
- El Al Israel
- Emirates Airline
- EVA Air
- Japan Airlines
- Korean Air
- LAN Airlines
- LAN Peru
- LTU
- Lufthansa
- Malaysia
- Mexicana
- Philippine Airlines
- QANTAS
- Singapore
- Spirit (Arrivals)
- Swiss Airlines
- TACA (Evening Arrivals)
- Thai




**TERMINAL 4**
- American
- American Eagle
- Midwest Airlines
- QANTAS

**TERMINAL 5**
- Aeroliteral
- Aeromexico
- Air Jamaica
- Delta

**TERMINAL 6**
- AirTran Airways
- Continental
- Copa (Departures)
- Frontier
- Spirit
- Sun Country
- United

**TERMINAL 7**
- TED
- United

**TERMINAL 8**
- TED
- United Express

**Free Shuttle Bus**

**A Route**
Airline Connection

**B Route**
Parking Lot B
(111th St. & La Cienega Blvd.)

**C Route**
Parking Lot C
(96th St. & Sepulveda Blvd.)

**G Route**
Metro Rail Green Line
(Imperial Hwy. & Aviation Blvd.)

**PARKING**

P-# Parking Structures (Example: P-1)

Departures Upper Level

Arrivals Level Lower Level

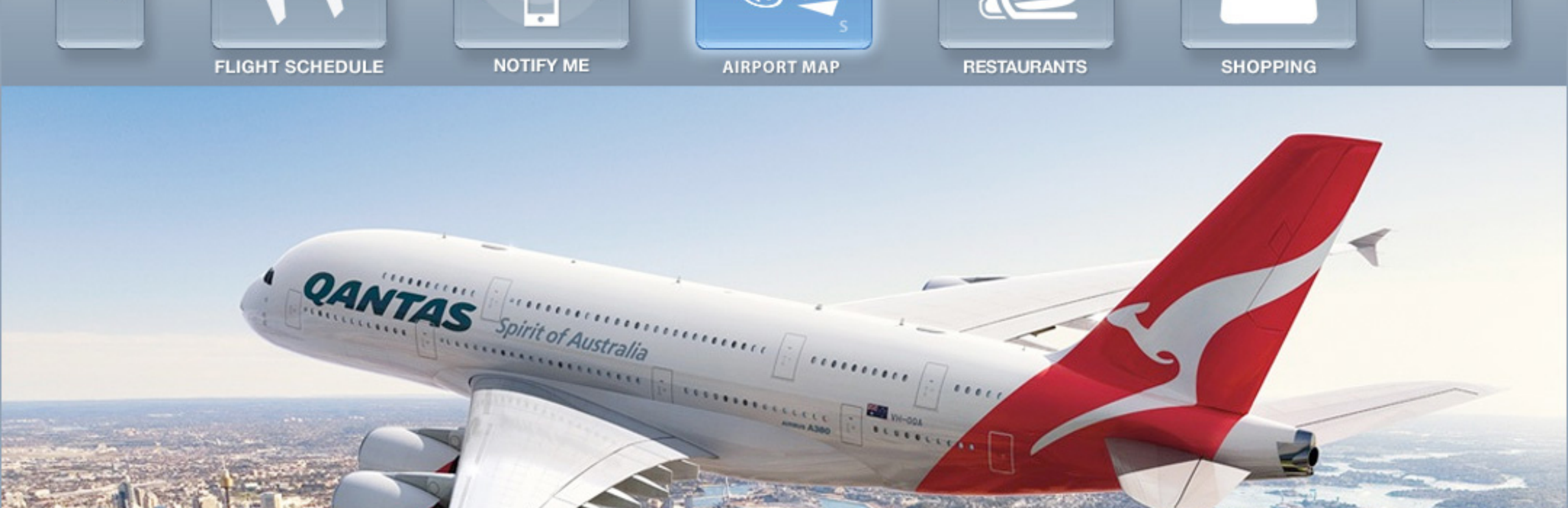
USO Bob Hope Hollywood USO

TA Travelers Aid Office

**AIRPORT INFOMATION**

For the most current information on airport traffic and parking conditions, and airline and charter locations, listen to 530 AM radio or call (310) 646-5252.

FLIGHT SCHEDULE | NOTIFY ME | AIRPORT MAP | RESTAURANTS | SHOPPING




CISCO

# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

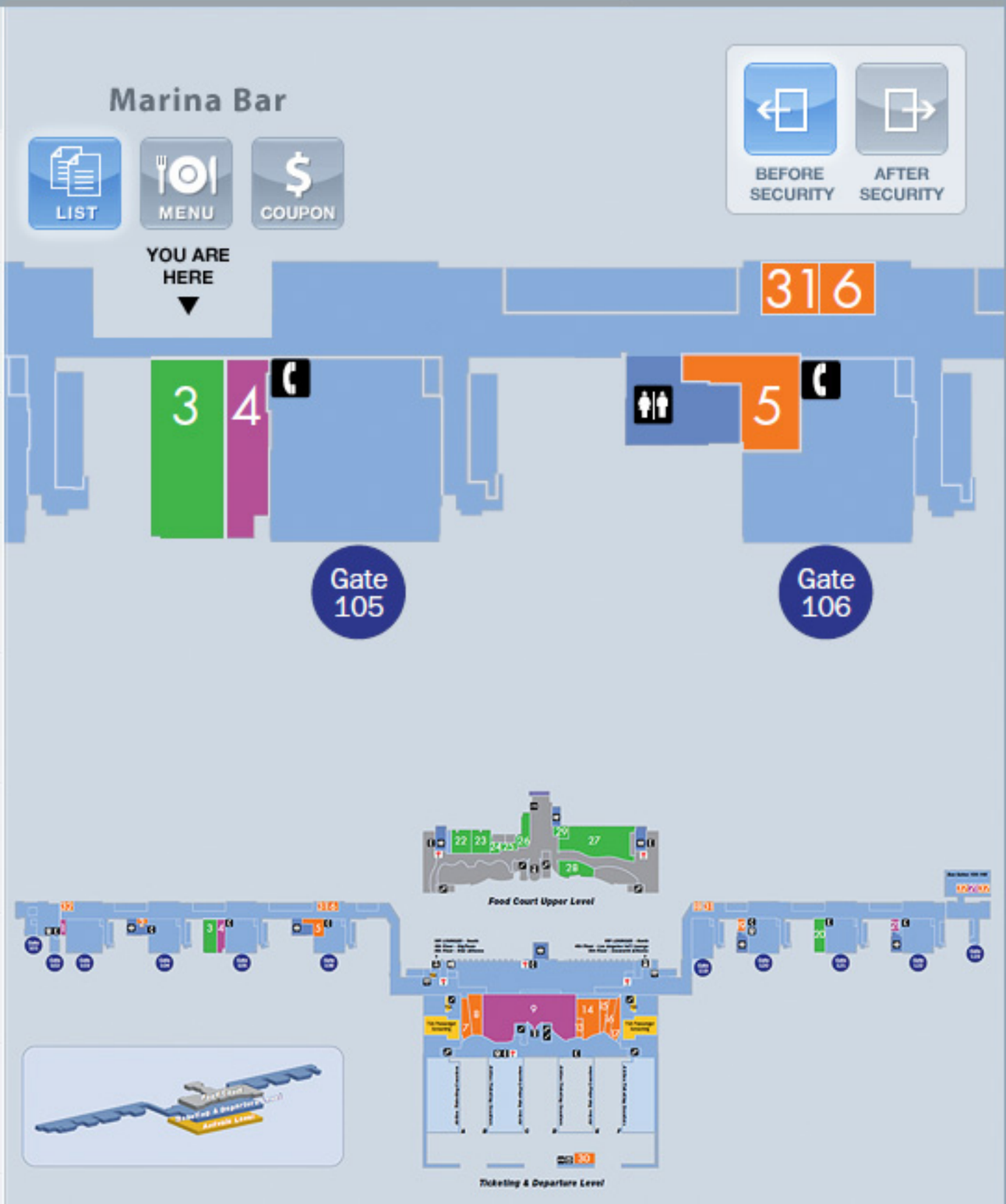
## RESTAURANTS

Select Language

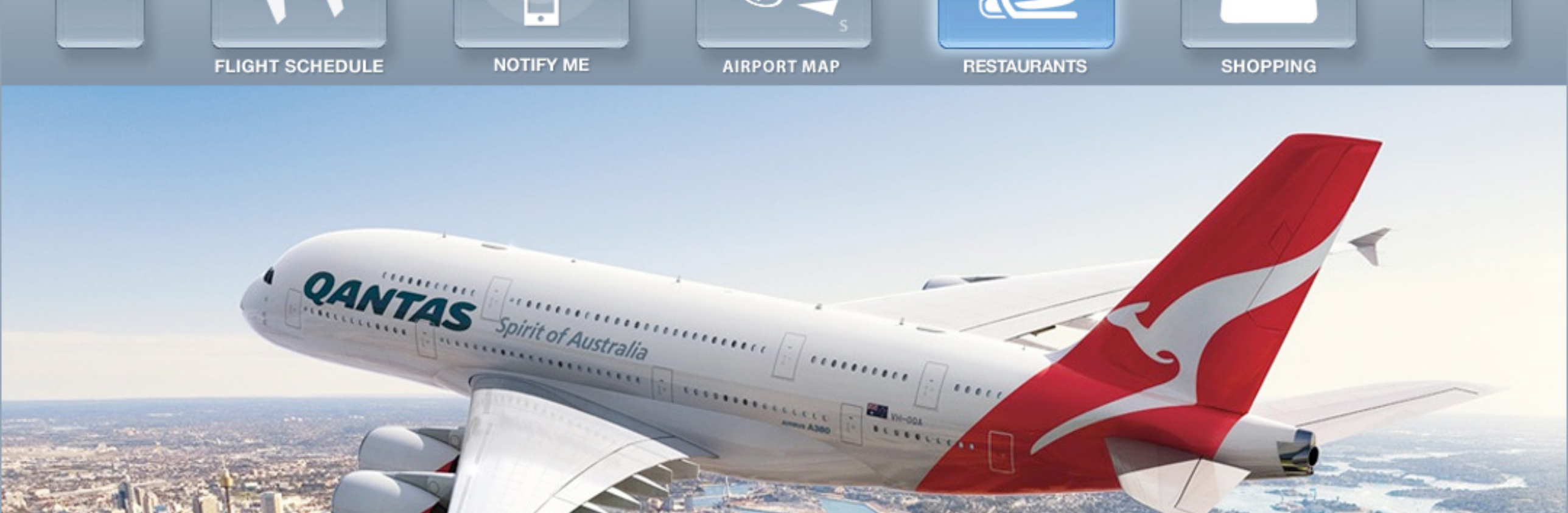
### Restaurants Index

- 03 - Marina Bar
- 20 - Sam Adams Bar
- 22 - McDonald's
- 23 - Marina Bar
- 24 - Camacho's Cafe
- 25 - Euro Coffee & Haagen Dazs
- 26 - Hamada Orient Express
- 27 - Daily Grill Restaurant
- 28 - Daily Grill Bar
- 29 - Pink's Hot Dogs

### Restaurants Map





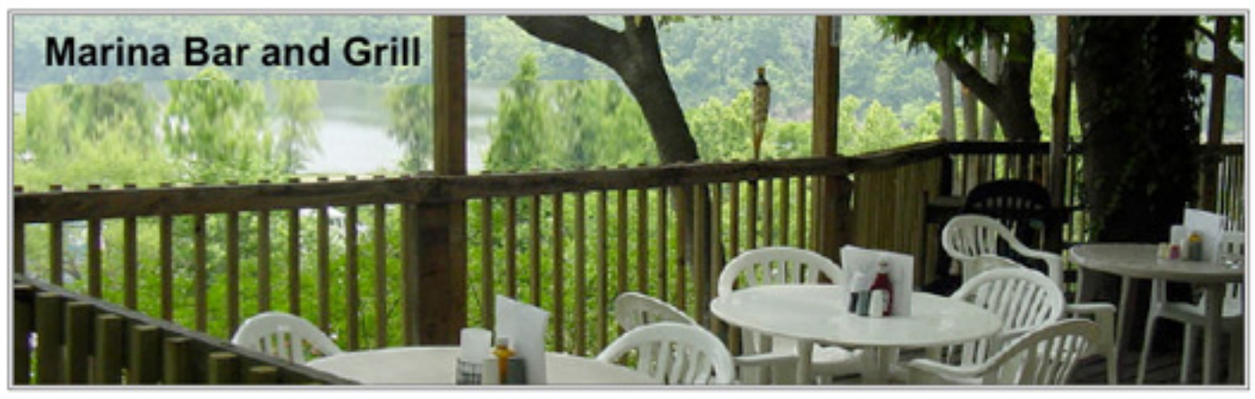



# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## RESTAURANTS

Select Language

### Marina Bar Menu




Marina Bar and Grill

Like 57 people like this. Be the first of your friends.

*Sunday Brunch 11-2pm*

*Happy Hour 4pm-6pm*

*Live Entertainment*

*Daily lunch special's*

*Carry outs welcome!*

*We do private parties! Call for details.*

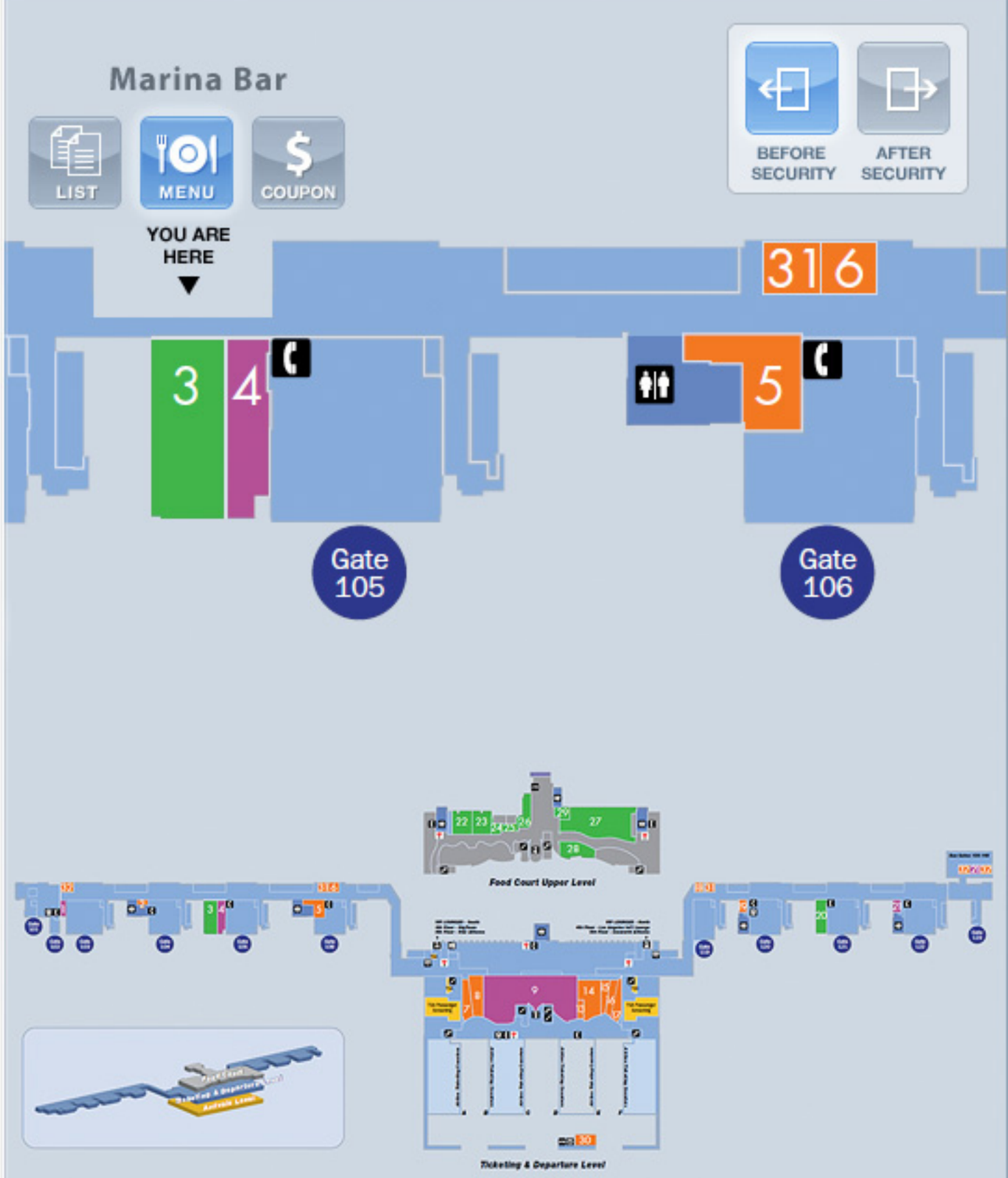
Sunday Brunch is back by popular demand!

Happy Hour
Wednesday-Saturday
4pm-6pm

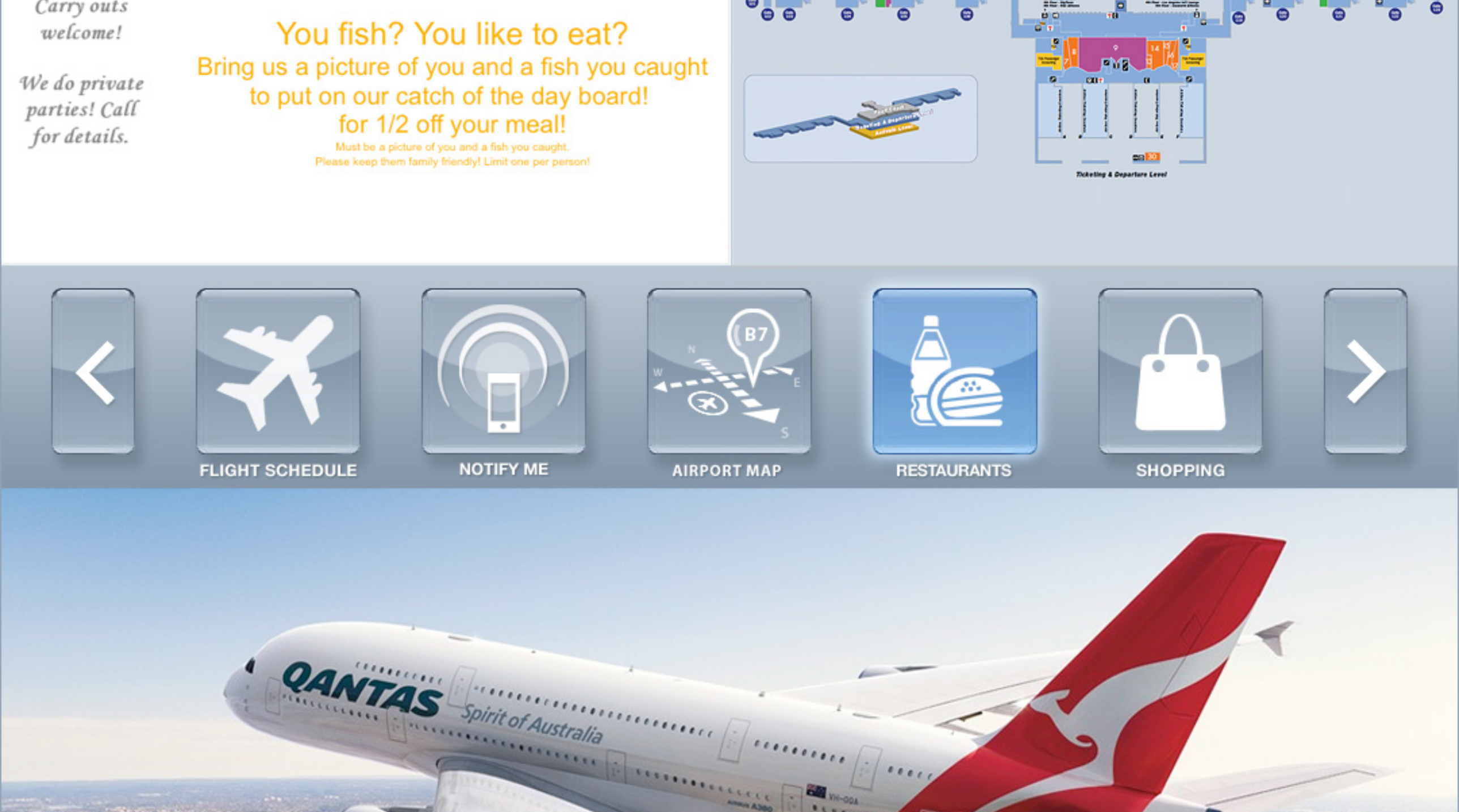
You fish? You like to eat?
Bring us a picture of you and a fish you caught
to put on our catch of the day board!
for 1/2 off your meal!

Must be a picture of you and a fish you caught.
Please keep them family friendly! Limit one per person!

### Restaurants Map



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University Transportation Research Center

Region II
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12:17:15 P.M.

THURSDAY MAR.10, 2011

TODAY 37 / 40

# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## RESTAURANTS

Select Language

McDonald's Daily Special

Restaurants Map

## $3 OFF Marina Bar Meal

Get a three dollar discount on any entree over $15

## Enter a Device Address

Restaurant coupons can be sent to any device that receives e-mail or text message

## Email or Phone Number:

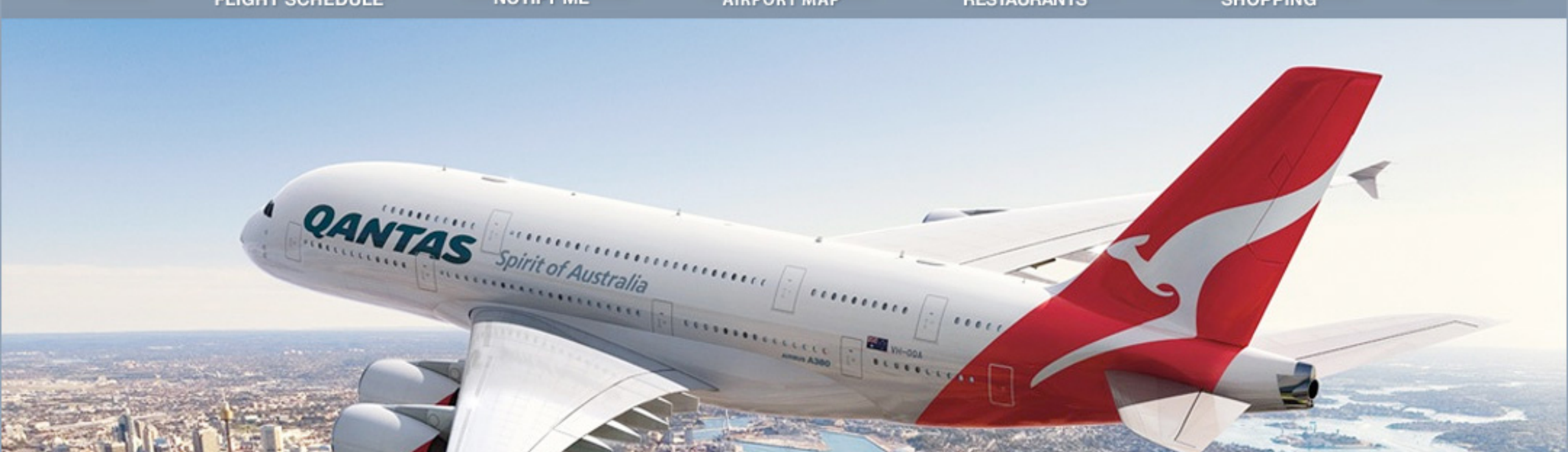
Q W E R T Y U I O P

A S D F G H J K L SEND

⇧ Z X C V B N M ! , ? . .COM

123 # + =

FLIGHT SCHEDULE | NOTIFY ME | AIRPORT MAP | RESTAURANTS | SHOPPING




CISCO

# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## RESTAURANTS

Select Language

### Restaurants Index

- 03 - Marina Bar
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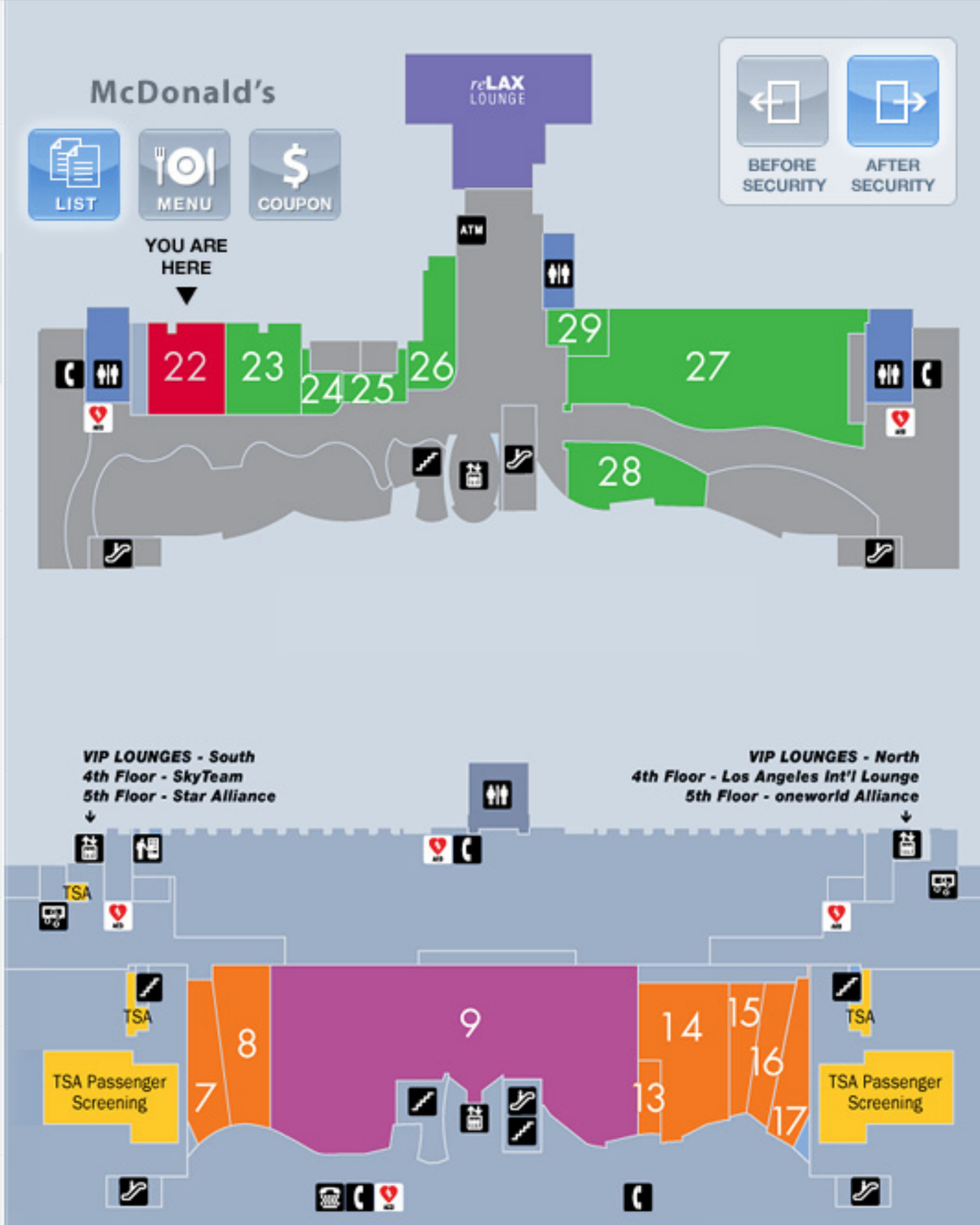
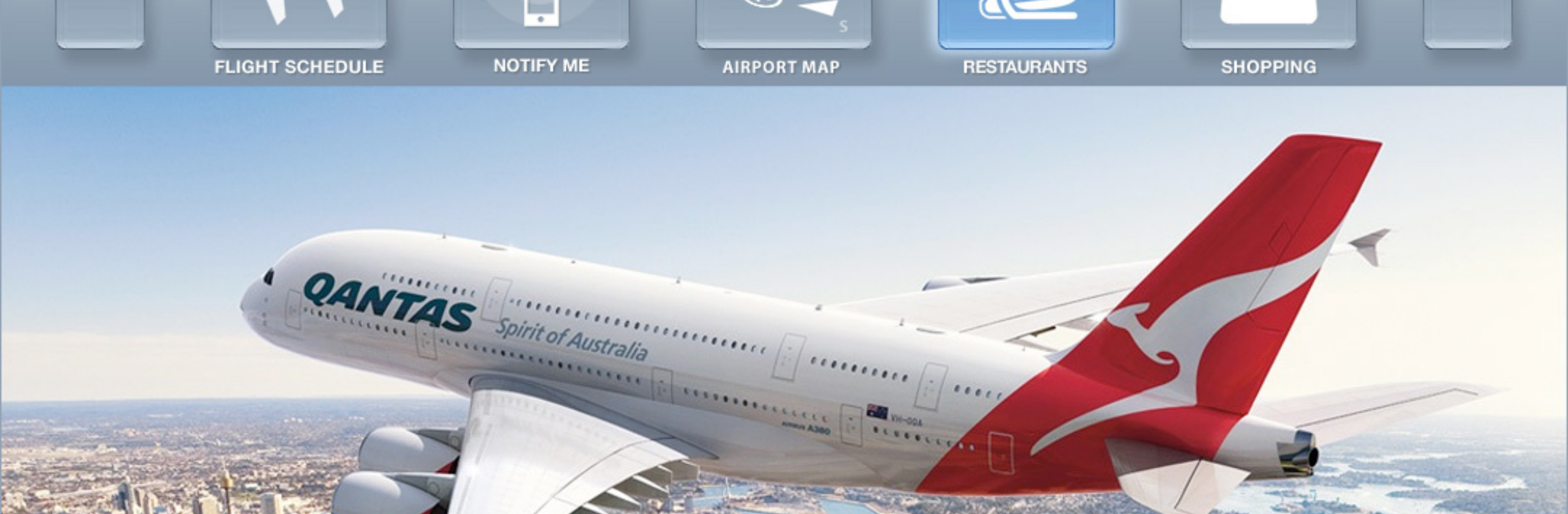
### Restaurants Map






CISCO

# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## RESTAURANTS

Select Language

### Marina Bar Menu

i'm lovin' it®
You so want one.

## Burgers & Sandwiches

View Full Menu

Delicious, freshly made, and oh-so-satisfying. From the Big Mac to our Premium Grilled Chicken Club to our classic Cheeseburger, McDonald's sandwiches make the meal.

Angus Chipotle BBQ Bacon

Angus Bacon & Cheese

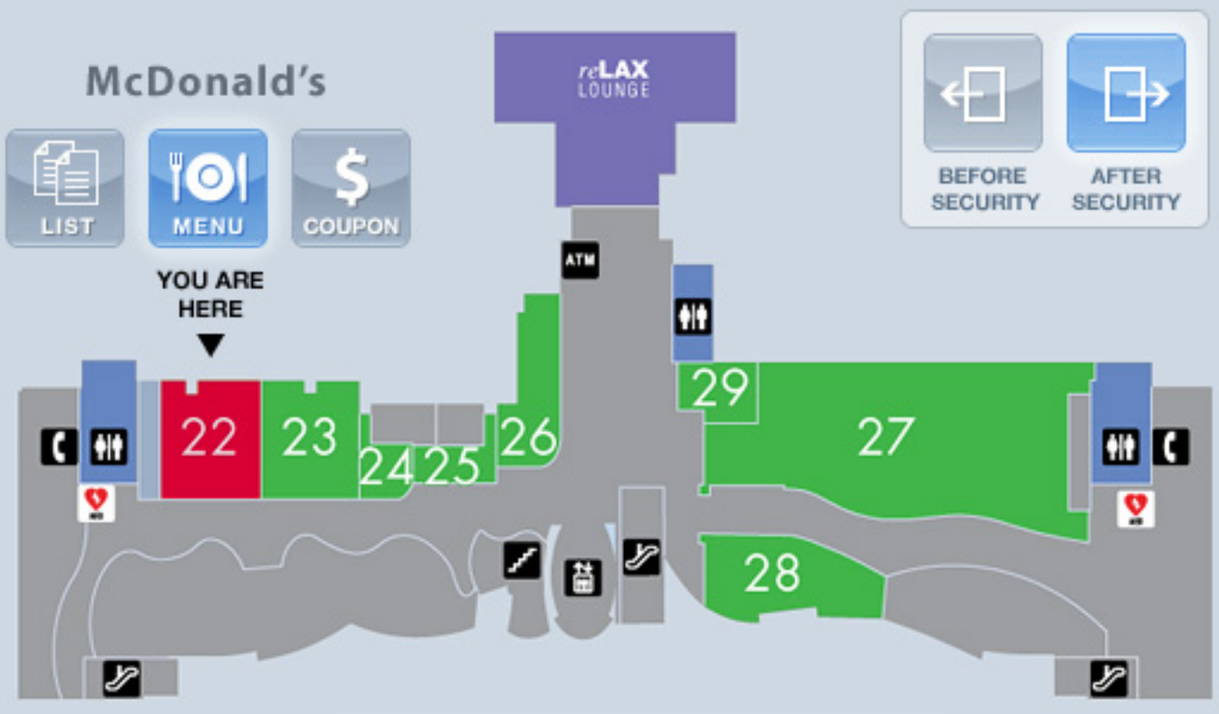
Angus Deluxe

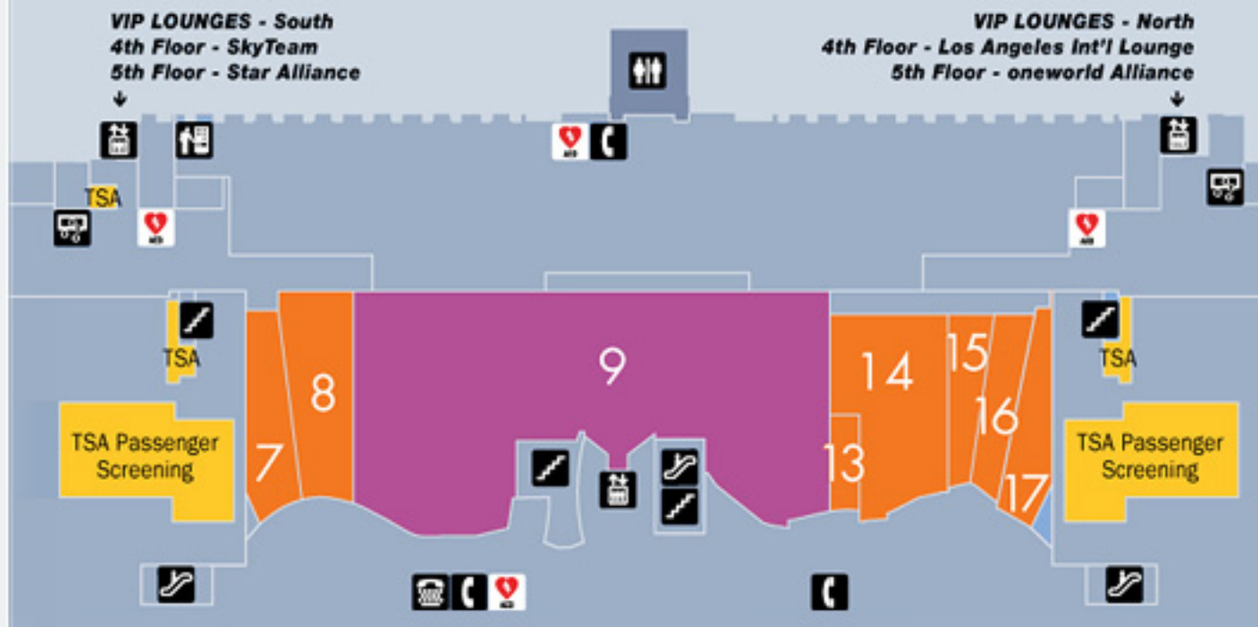
Big N' Tasty

Big N' Tasty with Cheese

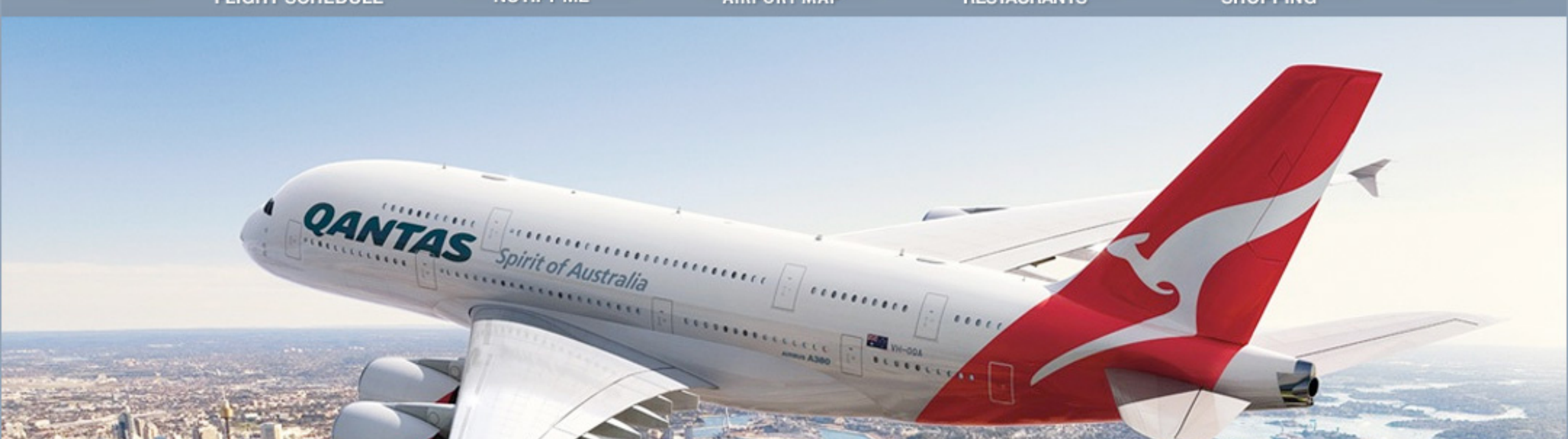
Premium Crispy Chicken Classic

### Restaurants Map






CISCO

# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## RESTAURANTS

Select Language

McDonald's Daily Special

Restaurants Map

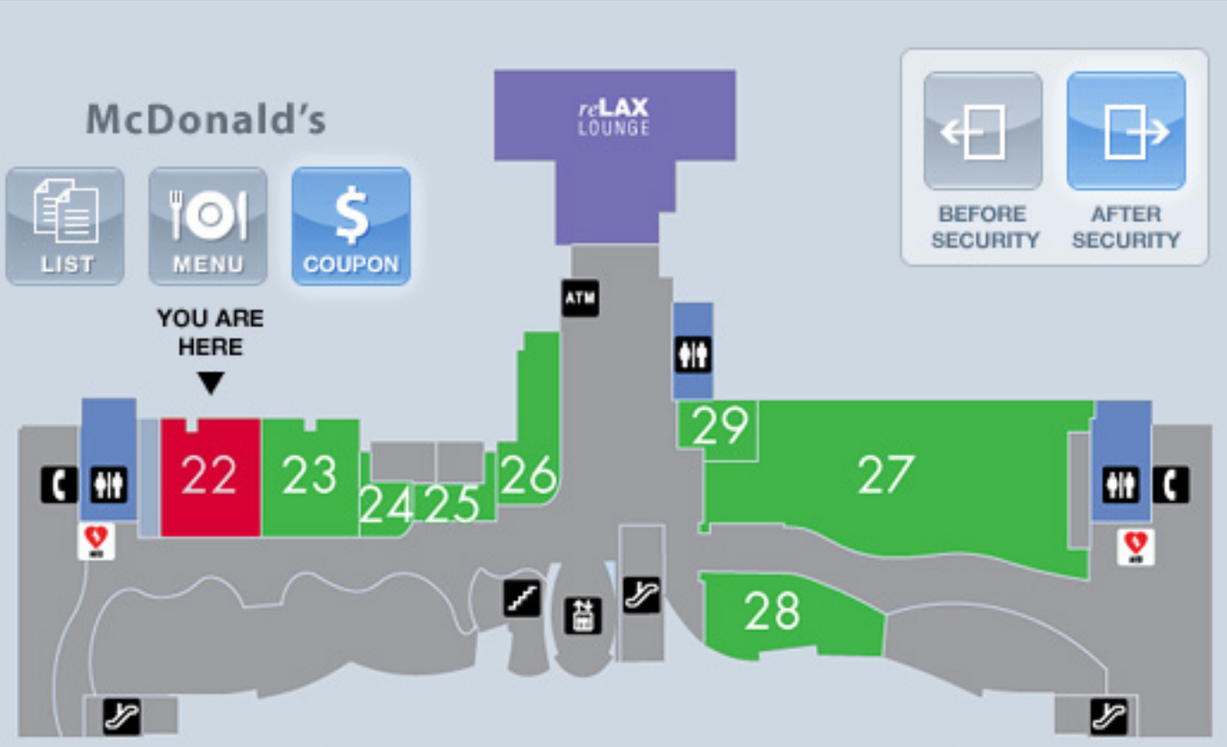
**$1 OFF Angus Third Pounder**

Any angus third pounder sandwich or extra value meal

**Enter a Device Address**

Restaurant coupons can be sent to any device that receives e-mail or text message

**Email or Phone Number:**



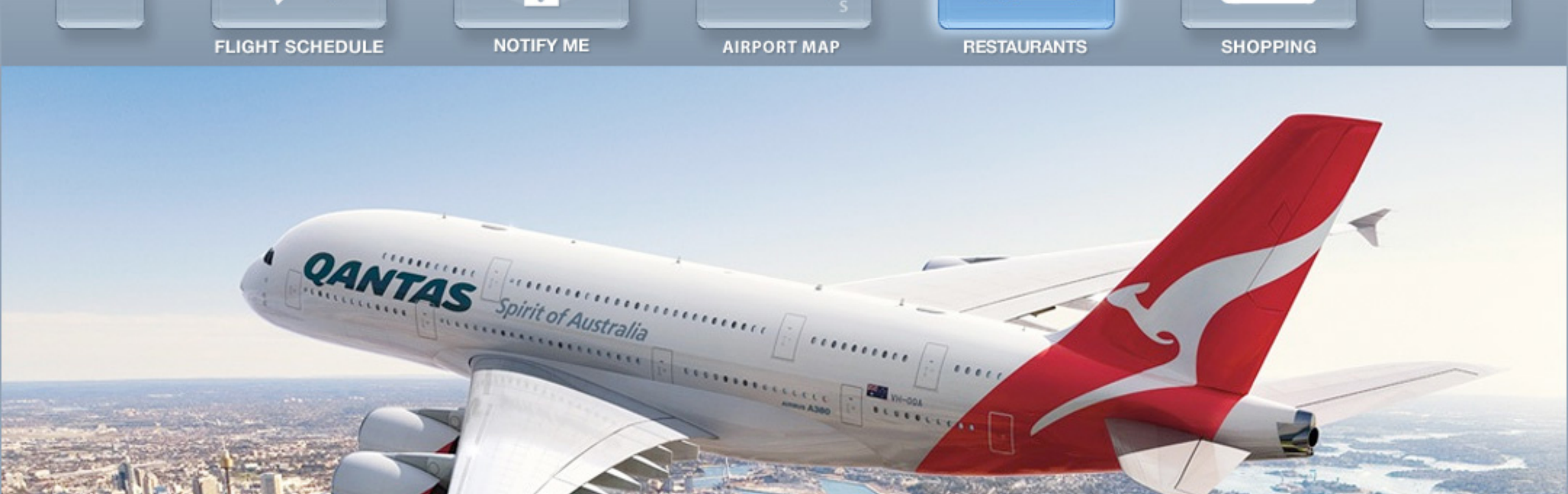

Q W E R T Y U I O P

A S D F G H J K L SEND

⇧ Z X C V B N M ! , ? . .COM

123 # + =






CISCO

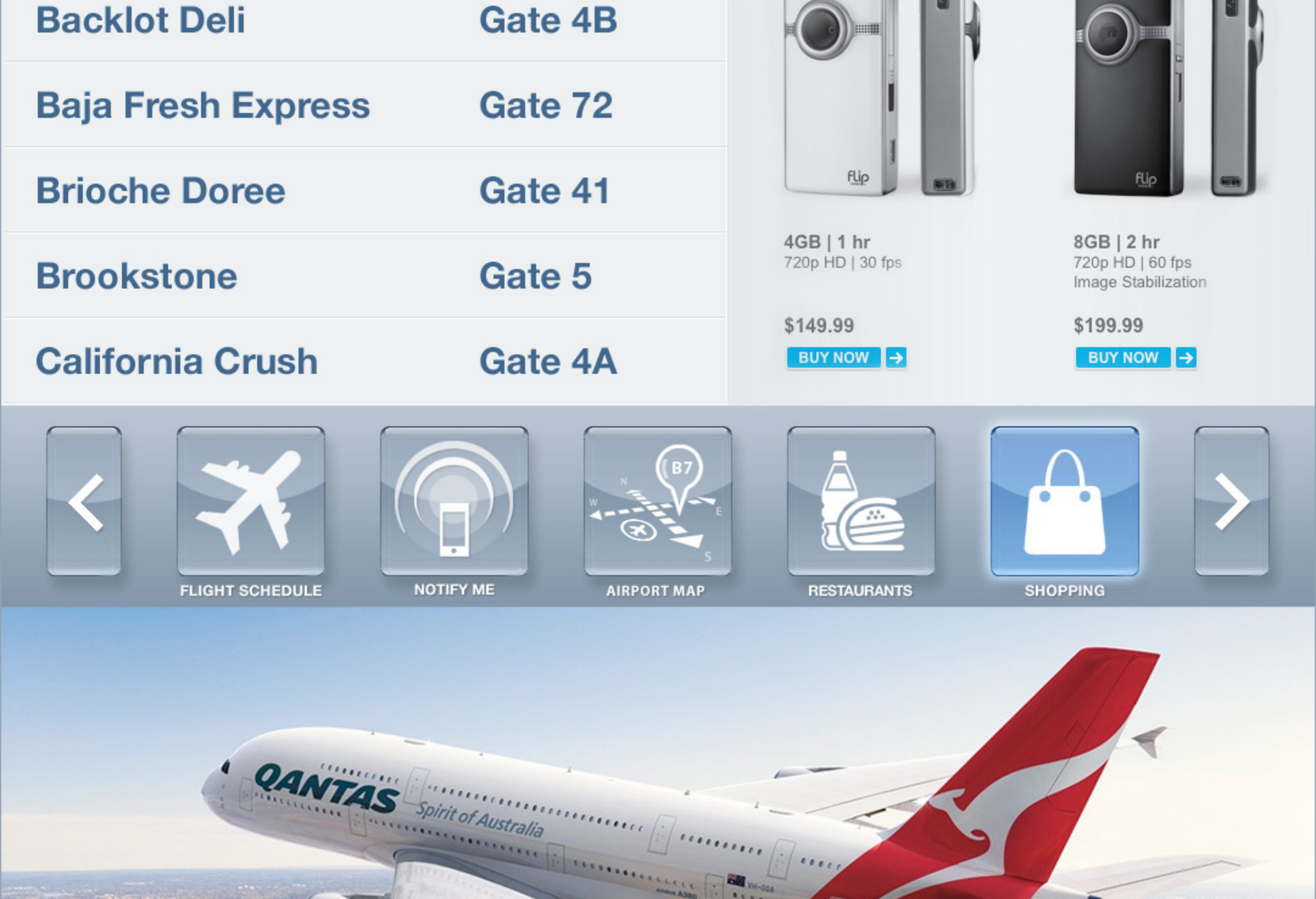
# American Airlines - Flight: AA699 - From: ORD - Chicaco to ATL - Atlanta

## SHOPPING

Select Language

| Restaurants & Stores | Gate / Area |
|---|---|
| ACI Gift Shop | T4 42B |
| Alaska Board Room | Gate 31 |
| Arrivals Café | Food Court |
| Backlot Deli Bar | Gate 4B |
| Backlot Deli | Gate 4B |
| Baja Fresh Express | Gate 72 |
| Brioche Doree | Gate 41 |
| Brookstone | Gate 5 |
| California Crush | Gate 4A |

Special Offers



# Smartphone-based Novice Teenage Driver Support System (TDSS)

Max Donath, Professor, Department of Mechanical Engineering; Janet Creaser, Research Fellow;
Alec Gorjestani, Research Fellow; Michael Manser, Director, HumanFIRST Program

## Problem: Unacceptably high crash rates among teen drivers

According to the Centers for Disease Control and Prevention, about 30 percent of teen deaths in the United States are caused by motor vehicle crashes, the leading cause of death for teens. Crash statistics indicate that teens frequently engage in a number of specific unsafe driving behaviors including speeding, failure to use seat belts, and distracted driving.

The adoption of Graduated Driver Licensing (GDL) laws in all 50 states has reduced the rates of crashes among teens by restricting new drivers' ability to operate vehicles in known high-risk situations. However, GDL provisions are difficult to enforce, relying largely on parents to monitor behavior and ensure compliance.

## Solution: the Teen Driver Support System

The urgent need to reduce risk-taking behavior among younger drivers and to improve the monitoring and compliance with GDL and other legal provisions motivated the development of an innovative, deployable Teen Driver Support System (TDSS).

The objective in developing the TDSS is to reduce the unacceptably high rate of vehicle crashes involving teenagers by providing critical assistance to inexperienced drivers and enabling parents to monitor their children's driving habits effectively.

The TDSS uses a suite of integrated technologies to address the specific behaviors linked to the high crash rate among teen drivers. The system integrates data on vehicle position, speed, speed limits, stop sign locations, curve locations, and excessive maneuvers, while also monitoring seat belt use by the driver and the presence of passengers in the vehicle.

## System architecture

The architecture of the TDSS was designed to implement as much functionality on a smartphone as possible. Only seat belt sensing, passenger sensing, and a gear shift interlock are implemented on a separate in-vehicle microprocessor that communicates with the smartphone using Bluetooth wireless protocols. The smartphone also hosts a digital map database of road features and speed limits. Designing the TDSS around smartphone technology reduces costs and increases deployability, as 75 percent of teens 15 to 17 years old carry a cell phone.

## Feedback and reporting functions

The TDSS incorporates driver alert functions to help inexperienced drivers avoid risky driving behaviors and reporting functions that allow parents to effectively monitor their teenagers' driving behavior. The current implementation of the TDSS:

- Provides visual and auditory information and alerts about seat belt usage, passengers, speeding, stop signs, upcoming curves, and excessive maneuvers to the driver
- Gives teens the opportunity to cancel alerts to parents for certain monitored behaviors (e.g., speeding) if they alter their behavior in a timely manner
- Prevents incoming and outgoing cell phone calls (other than 911) and text messaging while driving
- Logs any monitored risky behaviors and immediately communicates with parents via text message if the behavior continues

## Implementation and test results

The TDSS has been tested in a small-scale field study with teen drivers aged 18 to 19 and in a larger usability study with 16- to 17-year-old drivers and their parents.

In the field study:

- Teens were less likely to speed, less likely to exceed the speed limit by five miles per hour or more, and less likely to speed on curves when the TDSS was active.
- The average maximum speed of all subjects was lower when the TDSS was active.
- The majority of participants expressed neutral or positive attitudes about the TDSS auditory and visual feedback.
- More than 80 percent of participants felt the TDSS improved driving safety.
- No participants thought the TDSS was unreliable.

In the usability study:

- Teens and parents rated most functions of the TDSS favorably.
- The majority of teens felt the TDSS would help them reduce risky behavior and comply with legal driving requirements.
- More than 95 percent of parents said they would recommend the TDSS to other parents and teens.

## Future work

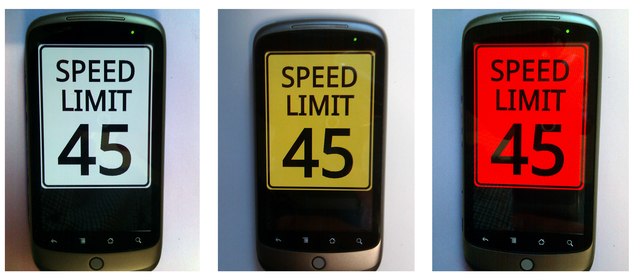
A large-scale field study of the TDSS has been proposed to examine the effectiveness of some TDSS functions in everyday driving. The study is expected to include the following monitored behaviors and situations:

- Sensing speeding events in relation to posted local speed limits
- Sensing aggressive driving events in relation to rates of deceleration and acceleration
- Sensing driving location and time-of-day
- Sensing the presence of passengers and seat belt compliance
- Restriction of all cell phone use other than 911, based on smartphone technology

Other options include:

- Geofencing to prohibit teens driving at times, locations, and on routes other than those approved by parents
- Monitoring system that automatically notifies parents that their teen has arrived at an approved destination

The visual feedback interface of the TDSS is designed around simple, easy-to-understand graphical elements. For example, information on speed limits and road features is presented in the form of iconic traffic signs.




Speed warning sequence. A) Driver at or below speed limit. B) Driver exceeding speed limit by less than 5 mph (8 km/h). C) Driver exceeding limit by more than 5 mph (8 km/h).

## Acknowledgements

ITS Institute (USDOT RITA), Minnesota Department of Transportation

# STATEWIDE TRANSPORTATION ENGINEERING WAREHOUSE FOR ARCHIVED REGIONAL DATA

**Kenneth G. Courage, Scott S. Washburn, Seokjoo Lee, and Vipul Modi**

Department of Civil and Coastal Engineering, University of Florida, Gainesville, FL 32611

## Introduction

What do traffic management centers (TMCs) in Florida do with the plethora of raw traffic data collected through the various intelligent transportation system (ITS) detectors installed on Florida's roadways? The answer: Statewide Transportation Engineering Warehouse for Archived Regional Data (STEWARD).

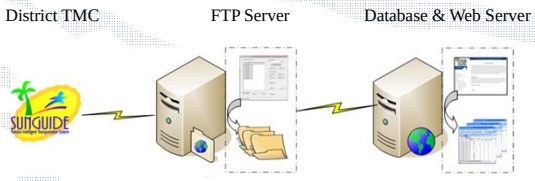
STEWARD has been developed to organize these raw traffic data that are gathered at the TMCs through the ITS detectors with the help of the SunGuide system. STEWARD processes these raw data and converts them into useful reports, which can then be used for various transportation projects by stakeholders such as ITS operators and engineers, state planners, transportation researchers, and private sector users.

STEWARD can be accessed from the following website:

http://cdwserver.ce.ufl.edu/steward/index.html

## Here is how it works

Raw traffic data are transferred daily from all TMC's to the STEWARD's FTP (File Transfer Protocol) server stationed at University of Florida through an FTP connection. These raw data files are processed and converted into useful formats/reports and stored in a database. This database is connected to a website that enables the users to retrieve the processed traffic data. The components involved in the daily operations are detailed below:




**STEWARD components**

**District TMC:** Transfers the daily speed, count, and occupancy raw data in 20- or 30-second intervals to the STEWARD's FTP server.

**FTP Server:** Raw data are extracted and converted into aggregated 5-, 15-, and 60-mins data intervals with the use of a computer program, SunETLUtility.exe.

**Database Server:** Aggregated data are uploaded onto the systems' database and customized reports are created within the database (Oracle 10.2g).

**Web Server:** Connects the database and hosts the STEWARDs' website for the users to retrieve the traffic data and other customized reports.

STEWARD runs through an automated procedure and requires minimal manual activity. The daily procedures are developed through multiple computer programming languages.

## STEWARD website and its reports

STEWARD is accessed via a user-friendly website which enables the stakeholders to view and download the daily traffic data along with several customized reports.

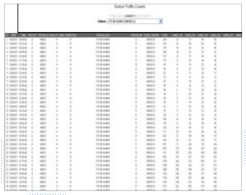
STEWARD home page

To download the traffic data and reports, the users are required to select a list of detector stations, the start/end dates of the data, and the aggregation level (5-, 15-, 60-mins) of the data from the "TSS Station-Level", "TSS Section-Level", and "TSS-Facility-Level" section of the website.

STEWARD's reports page

Here is an overview of reports created by STEWARD:

- ***All Data Fields:*** Aggregated speed, volume, and occupancy data and their statistics.
- ***Traffic Counts:*** Lane by lane volume data and their statistics.
- ***Max Flow Rates*:*** Maximum flow rate observed for a selected detector station.
- ***Effective Detector Length*:*** Effective vehicle length at a selected detector station.



An example of "Traffic Counts" Report

- ***Performance Measures*:*** Measures of a segment within a section of a roadway like, vehicle-miles, vehicle-hours, delay, speed, kinetic energy, etc.
- ***Travel Time Reliability*:*** Measures for travel time assessments like average travel time, travel time index, buffer index, on-time percent, etc.
- ***Volume Map and I/O Balance*:*** Tabular map of the entry, exit, and mainline volumes and the discrepancies in the balance of input/output from each segment.

*Not available temporarily

These reports can either be viewed on screen or downloaded in a .csv (comma separated value) file.

STEWARD provides the detector locations on a satellite photo map for all the regional areas that are covered within the state of Florida. Details of these detectors are also provided with the locations. An example of such a map is shown on right.

Jacksonville's detector coverage. (Source: Google Maps)

## STEWARD's coverage in Florida

| Regional Area | Roadways | No. of Detectors (Type) | Dates Available |
|---|---|---|---|
| Jacksonville | I-95, I-295, I-10 | 330 (RTMS) | Jul'07 – Present |
| Ft. Lauderdale | I-95, I-75, I-595 | 323 (Wavetronix) | Mar'08 – Present |
| Orlando | I-4, I-95, SR-528 | 533 (Wavetronix & Loop) | Oct'09 – Present |
| Miami | I-95, I-75, I-395, SR-826 | 387 (RTMS) | May'08 – Present |
| Tampa | I-75, I-275, I-4 | 274 (RTMS & Loop) | Jan'10 – Present |

*Tallahassee, Ft. Myers, FL Turnpike, Treasure Coast, and arterial data to be added soon over next few months.

## Projects that have benefited from STEWARD data

- **95-Express in Miami:** For analyzing the operations of newly built HOT (High Occupancy Toll) lanes.
- **Variable Speed Limits Assessment in Orlando:** For assessing the freeway operations on I-4 due to the dynamic speed limit sign-boards.
- **FDOT Central and Statistics Office:** Comparison of traffic counts from FDOT's (Florida Department of Transportation) permanent detector stations with traffic counts from SunGuide's ITS detectors.
- **Analysis of Breakdown at a Freeway Ramp:** For modeling the breakdown of traffic flow on a freeway in the vicinity of an entrance ramp for ramp-management strategies.
- **Simulation Support for SunGuide:** For developing micro-simulation methods and tools to support the SunGuide system implementation, operation, testing, and evaluation.
- **Investigation of Florida's Freeway Capacity:** For estimating/calculating freeway capacity for roadways in Florida (for five regional areas).

**Clients:** FDOT, University of Florida, Florida International University, Florida Highway Patrol, RS&H, Cambridge Systematics, HNTB, Xerox Corp., etc.

## STEWARD's future

- Archiving and integrating the daily crash data into/with the current database
- Archiving the Dynamic Message Sign (DMS) data to the database
- Provide real-time traffic data and reports to the stakeholders
- Guide other state DOT's for implementing a similar data warehouse

## Acknowledgements

We would like to thank the Florida Department of Transportation, the Center for Multimodal Solutions for Congestion Mitigation (CMS) at the University of Florida, and the stakeholders for providing the continuous support and resources in developing the STEWARD system.

ITS INSTITUTE

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# SMART-Signal (Systematic Monitoring of Arterial Road Traffic Signals)

Dr. Henry Liu, Wenteng Ma, Xinkai Wu, Heng Hu, Jie Sun, Saif Jabari, Jeff Zheng, Department of Civil Engineering, University of Minnesota

## Summary

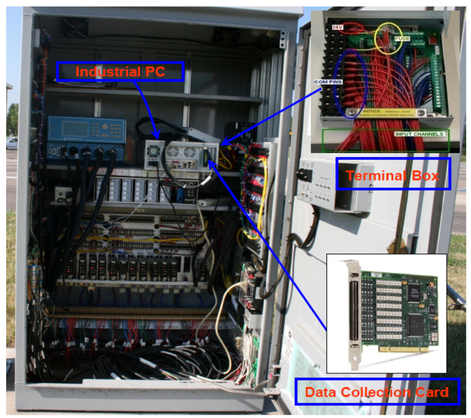
Although measuring and archiving freeway traffic performance using commonly available loop detector data has become a norm for many transportation agencies, similar approaches for monitoring the performance of urban arterials do not exist. In practice, operational data from traffic signal systems are neither stored nor analyzed, which prevents proactive management of arterial streets. The development of the SMART-Signal (Systematic Monitoring of Arterial Road Traffic Signals) system fills in this gap.

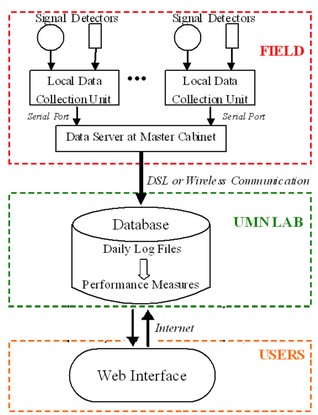
## The SMART-Signal system:

- Collects event-based high-resolution data from existing traffic signals at multiple intersections.
- Acts as a performance measurement system for intersection queue length and arterial travel time, especially under congested traffic conditions.
- Serves as a performance tuning system for the optimization of traffic signal parameters.
- Provides real-time traffic information to travelers.

## Data Collection

In the SMART-Signal system, a complete history of traffic signal control, including all vehicle actuation events and signal phase change events, are archived and stored. At each intersection, an industrial PC with a data acquisition card is installed inside the controller cabinet, and event data collected at each intersection are transmitted to the data server in real-time using an Ethernet connection.



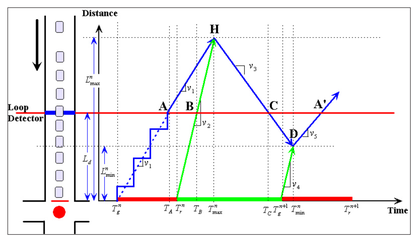



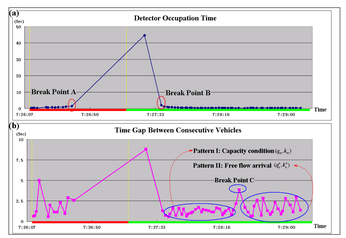

**Sample Data**

| | |
|---|---|
| 08:09:15.012, D8 on, 7.902s | **Detector #8 on at 08:09:15.012; Vacant time is 7.902s** |
| 08:09:15.481, D8 off, 0.468s | |
| 08:09:16.761, G3 off, 29.389s | **Green Phase #3 off at 08:09:16.761; Green duration time is 29.389s** |
| 08:09:16.761, Y3 on, 179.021s | |
| 08:09:17.620, D9 on, 2.686s | |
| 08:09:18.151, D10 on, 2.593s | |
| 08:09:18.307, D9 off, 0.687s | **Detector #9 off at 08:09:18.307; Occupy time is 0.687s** |
| 08:09:18.823, D10 off, 0.671s | |
| 08:09:20.244, Y3 off, 3.482s | **Yellow Phase #3 off at 08:09:20.244; Yellow duration time is 3.482s** |
| 08:09:21.649, D22 on, 80.953s | |
| 08:09:22.008, D22 off, 0.359s | |
| 08:09:23.242, G1 on, 172.806s | **Green Phase #1 on at 08:09:23.242; Red duration time is 172.806s** |

## Queue Length Estimation

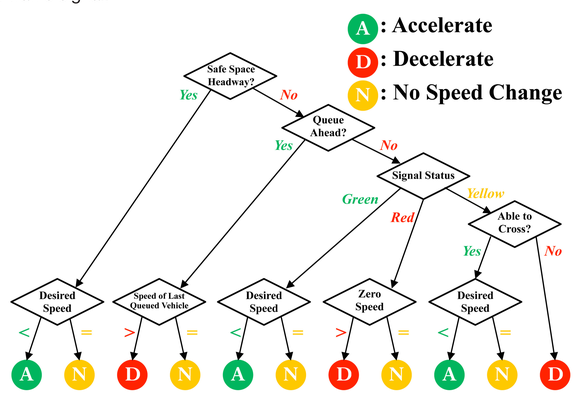
Queue length is the most important performance measure at a signalized intersection, since other performance measures such as average delay and level of services can be easily derived if queue length is known. A major shortcoming of traditional input-output models has been their inability to determine queue length when the queue of cars waiting to pass through an intersection extends beyond the upstream vehicle detector. SMART-Signal developers overcome this limitation by developing a new algorithmic approach to queue length estimation based on traffic shockwave theory. The changes in traffic states, i.e., the "break points," can be indentified using the event-based data, as shown in the figure below. The maximum intersection queue length and length of the residue queue (if existing) can then be derived from the constructed shockwave profile.



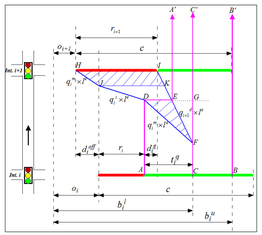

## Travel Time Estimation

Measuring travel time on signalized arterials is difficult because traffic flow on arterials is repeatedly interrupted by signal changes. SMART-Signal approaches this problem by simulating the movements of a virtual "probe vehicle" along the arterial road. As the virtual probe moves, it can modify its own state in response to the state of traffic around it by accelerating, decelerating, or maintaining a constant speed at each time step as it encounters queues, traffic signals, and changes in traffic density. This approach to travel-time estimation actually benefits from traffic flow interruptions caused by traffic signals, because differences between the trajectories of the virtual probe vehicle and a hypothetical real vehicle—for example, if the virtual probe moves slightly faster than real-world traffic—are corrected by stopping at a red traffic signal.




## Optimization of Signal Parameters

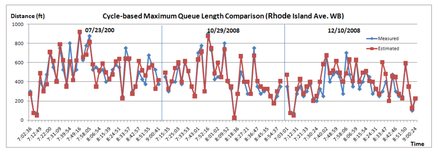
SMART-Signal can also optimize traffic signal parameters using the collected high-resolution data. The figure at right demonstrates how a stochastic optimization model can be formulated to fine-tune the signal offsets. Instead of relying on traditional offset optimization approaches, which are based on manually collected volume data on a typical day, SMART-Signal can account for traffic flow variations by using archived traffic signal data and the derived performance measures. Since queues formed by side-street traffic and residual queues from through traffic are critical to the determination of signal offset, they are considered explicitly in the optimization model. Different objective functions, including maximization of green bandwidth and minimization of total delay and number of stops, can be readily incorporated into the model.

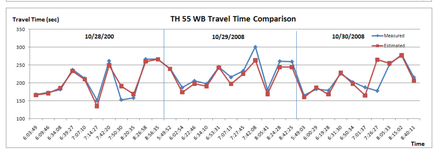


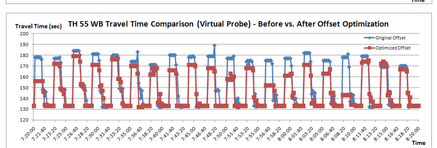
## Implementation

The SMART-Signal system has been field-tested on three major arterial corridors in Minnesota, including six intersections on Trunk Highway 55 in Golden Valley, eleven intersections on France Avenue in Bloomington, and three intersections on Prairie Center Drive in Eden Prairie. Technology transfer is currently being discussed and a demonstration project is being carried out on Orange Grove Boulevard in Pasadena, California.

In the current phase of research, the research team is developing next-generation SMART-Signal hardware that will be easier to deploy and maintain. A large-scale SMART-Signal system implementation project currently under discussion with the Minnesota Department of Transportation will monitor 100 intersections in the Twin Cities area.

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