DOE Technical Assistance Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy


The Parker Ranch installation in Hawaii

Traffic Signal Synchronization for Energy Savings

May 18, 2011

12:00-1:00 EDT

What is TAP?

DOE's Technical Assistance Program (TAP) supports the Energy Efficiency and Conservation Block Grant Program (EECBG) and the State Energy Program (SEP) by providing state, local, and tribal officials the tools and resources needed to implement successful and sustainable clean energy programs.

How Can TAP Help You?

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TAP offers:

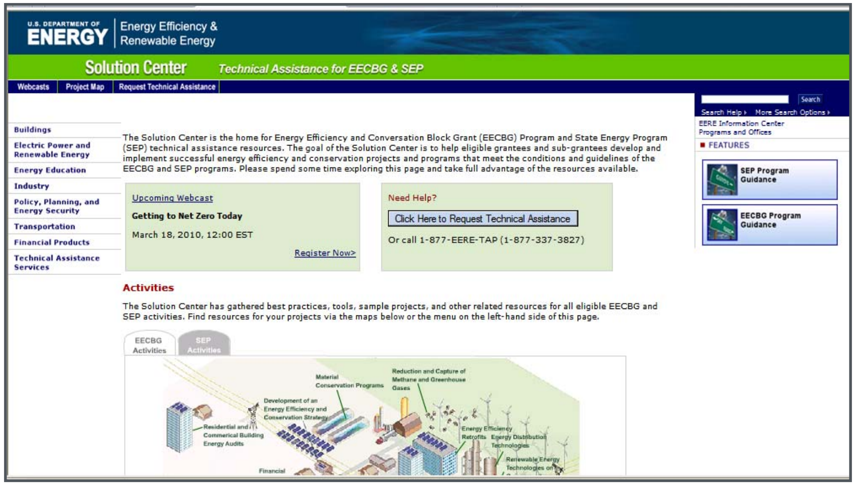
- One-on-one assistance
- Extensive online resource library, including:
  - Webinars
  - Events calendar
  - TAP Blog
  - Best practices and project resources
- Facilitation of peer exchange

On topics including:

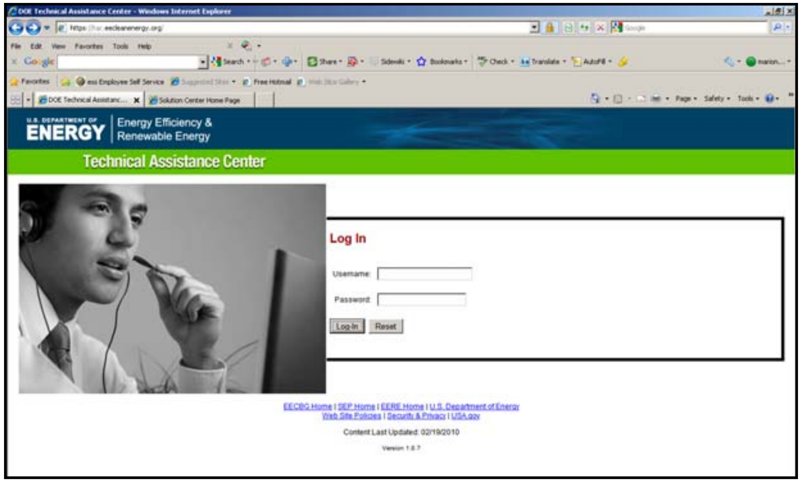
- Energy efficiency and renewable energy technologies
- Program design and implementation
- Financing
- Performance contracting
- State and local capacity building

We encourage you to:

1) Explore our online resources via the [Solution Center]



2) Submit a request via the [Technical Assistance Center]



3) Ask questions via our call center at 1-877-337-3827 or email us at [solutioncenter@ee.doe.gov]

Please join us again:

Title: **Using Social Media to Engage the Community in Energy Efficiency Projects**

Host: ICF International

Date: May 26, 2011

Time: 1:00 – 2:30 EDT

Title: **Policies and Procedures for Enhancing Code Compliance**

Host: MEEA

Date: May 31, 2011

Time: 2:00 – 3:00 EDT

For the most up-to-date information and registration links, please visit the Solution Center webcast page at www.wip.energy.gov/solutioncenter/webcasts

Webinar Outline

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- What is Traffic Signal Synchronization?
- When and Where is it Appropriate?
- How is it Implemented?
- What Benefits can be Expected?
- How Much does it Cost?
- How do we Measure Success?
- What can we Learn from Case Studies?

Webinar Goals

- To provide a general overview of signal synchronization principles
- To present strategies for implementation in order to maximize benefits
- To describe tools and techniques to evaluate benefits
- To present real-life implementation projects funded through DOE's Energy Efficiency and Conservation Block Grant (EECBG)

What is Traffic Signal Synchronization?

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- Facilitates smooth vehicle progression along a series of adjacent signals along an arterial street
- Recognized as one of the most cost effective and successful strategies to reduce congestion

Signal Synchronization fits within the ITS Toolbox

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- Arterial Management
- Freeway Management
- Crash Prevention & Safety
- Road Weather Management
- Roadway Operations & Maintenance
- Transit Management
- Transportation Management Centers
- Traffic Incident Management
- Emergency Management
- Electronic Payment and Pricing
- Traveler Information
- Information Management
- Commercial Vehicle Operations
- Intermodal Freight

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Arterial Management

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- Manage traffic along arterial roadways, using:
  - Vehicle detectors
  - Traffic signals
  - Traveler information systems
- Traffic signals primarily address traffic flow and safety
- Adaptive signal control systems
- Advanced signal control systems (centralized)

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Transportation Management Centers

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- Integrates a variety of ITS applications to facilitate the coordination of information and services
- TMCs typically includes:
  - Incident management
  - Network surveillance and data collection
  - Dissemination of data to travelers and other agencies
  - Traffic management for special events and evacuations

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

What Benefits can be Expected from Signal Synchronization?

- Increases efficiency of the transportation system
- Enhances mobility
- Improves safety
- Reduces the impact of automobile travel on energy consumption and air quality
- Improves customer satisfaction
- Eliminates/delays need for street widening

Key Principles of Signal Synchronization

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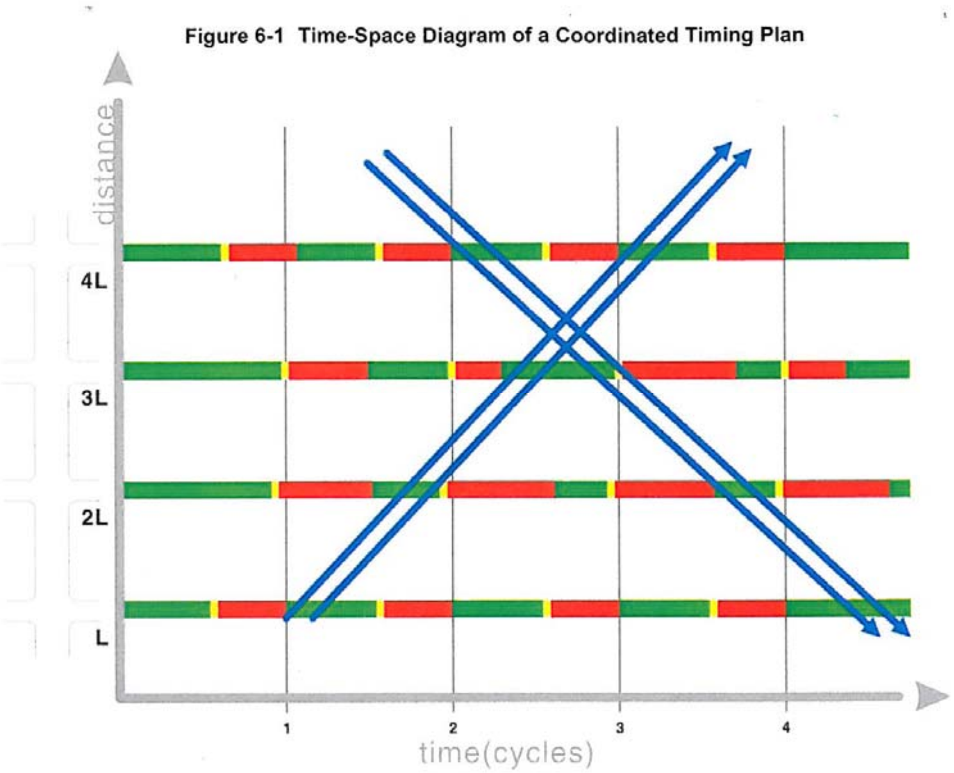
- Close proximity of intersections
- Large amount of traffic on coordinated street
- Arriving traffic includes vehicle platoons from upstream intersection
- Reduce travel times, stops and delays – which in turn reduces fuel consumption and improves air quality
- Concept best illustrated using a time-space diagram

Source: FHWA – Traffic Signal Timing Manual. June 2008

Time Space Diagram



- Signal timings along the time axis
- Intersection locations on the distance axis
- Vehicles travel in both directions
- Potential trajectories for vehicles within the progression bands

Source: FHWA – Traffic Signal Timing Manual. June 2008

Many Factors Can Affect or Limit Synchronization

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- Intersection Spacing
- Cycle Length
- Vehicle Speeds
- Two-Way Traffic Flow
- Cross Street Traffic
- Congestion
- Left Turn Phases
- Pedestrian Crossing
- Safety Considerations
- Emergency Vehicle Pre-emption
- Construction

Some Potential Disadvantages

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- May increase travel speeds
- May attract additional traffic
- Higher capital and maintenance costs
- Requires qualified staff for maintenance and monitoring

Range of Reported Benefits from Signal Synchronization

Criteria	Range	Source
STOPS	Decrease 6-77%	6 cities
	Decrease 12-14%	California, Texas
DELAYS	Decrease 14-19%	Syracuse, NY
	Decrease 25%	Texas
EMISSIONS	Decrease 0-22%	5 cities
FUEL CONSUMPTION	Decrease 0-13%	5 cities

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Range of Reported Benefits from Signal Systems Improvements

Criteria	Range
Travel Time	Decrease 8-15%
Travel Speed	Increase 14-22%
Vehicle Stops	Decrease 0-35%
Delay	Decrease 17-37%
Fuel Consumption	Decrease 6-12%
Emissions (CO)	Decrease 5-13%
Emissions (HC)	Decrease 4-10%

Source: FHWA, Intelligent Transportation Infrastructure Benefits, 1996

Factors Affecting Impact Range

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- Existing timing plans
- Degree of network congestion
- Peak vs. off peak conditions

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Costs

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- Optimizing signal timing is considered a low-cost approach
- From $2,500 to $3,100 per signal per update
- Well-trained technicians are needed to maintain traffic signal
- One technician can typically maintain 30-40 signals

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Benefit-Cost Studies

- The Traffic Light Synchronization program in Texas showed a benefit-to-cost ratio of 62:1
  (delay reduced by 25% - fuel consumption by 9% - stops by 14%)

- A 2005 Oakland Metropolitan Transportation Commission analysis of its traffic signal coordination program yielded a benefit-to-cost ratio of 39:1

Source: USDOT/RITA – ITS Benefits, Costs, Deployment, and Lessons Learned; 2008 Update

Evaluation Techniques

Measure	Primary Evaluation Technique	Supplemental Technique
Delays	Deterministic traffic analysis tool	Floating car runs (through movement or intersection observation)
Stops	Field data collection using manual observers or floating car runs	Floating car runs or simulation
Travel Time	Floating car runs	Microscopic traffic simulation
Emissions	Microscopic traffic simulation	Environmental or planning models
Fuel Efficiency	Microscopic traffic simulation	Environmental or planning models

Source: FHWA – Traffic Signal Timing Manual. June 2008

Microscopic Traffic Simulation

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- Simulate the flow of traffic at the vehicular level
- Examples: Vissim, Paramics, TransModeler, Corsim…
- May include vehicle maneuverings such as acceleration, deceleration, weaving, start, and stop

- Outputs: vehicle speeds, moving delay, intersection delay, progression effectiveness, signal effectiveness, volume to capacity ratios, level of service, emissions, and fuel consumption.

Microsimulation Model Example

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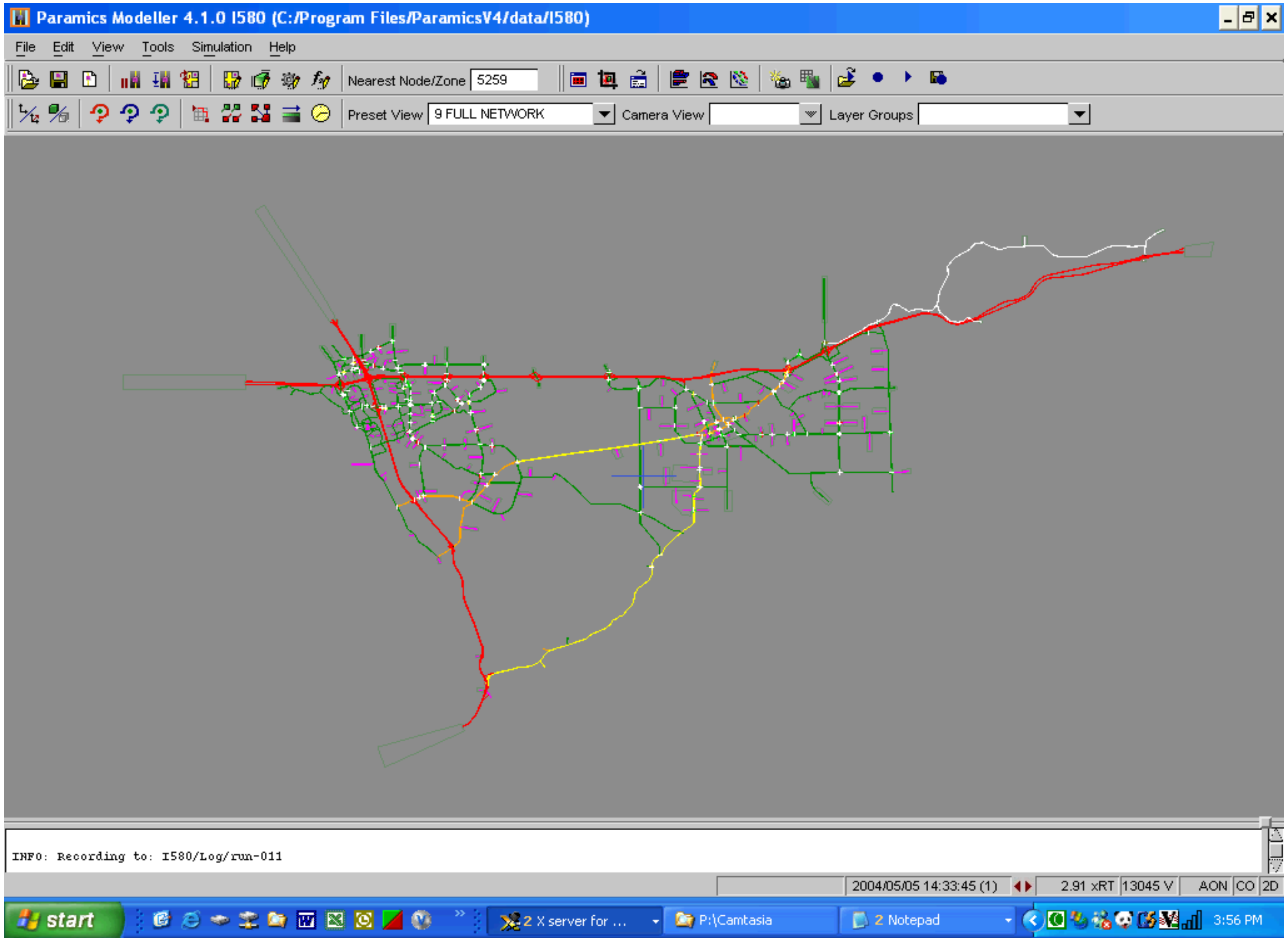

I-580 Project; Caltrans District 4

Fuel Consumption Models

- Typically based on the number of stops, delay, travel distance, free-flow speed (or design speed), and through volume
- Two examples
  - University of Florida model
  - Penic & Upchurch model

Emission Model: MOVES

- MOVES2010: EPA's current official model for estimating air pollution emissions from cars, trucks, motorcycles, and buses
- Developed by EPA's Office of Transportation and Air Quality (OTAQ)
- Based on millions of emission test results
- Replaces the previous model for estimating on-road mobile source emissions, MOBILE6.2
- Best available tool for quantifying pollutant and precursor emissions, air toxics, and greenhouse gas.

Two Case Studies

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- City of Lee's Summit, MO

  Real-Time Adaptive Traffic Control on Chipman Road

- St. Johns County, FL

  Traffic Signal Timing Optimization and Coordination

Case Study#1: Lee's Summit, MO

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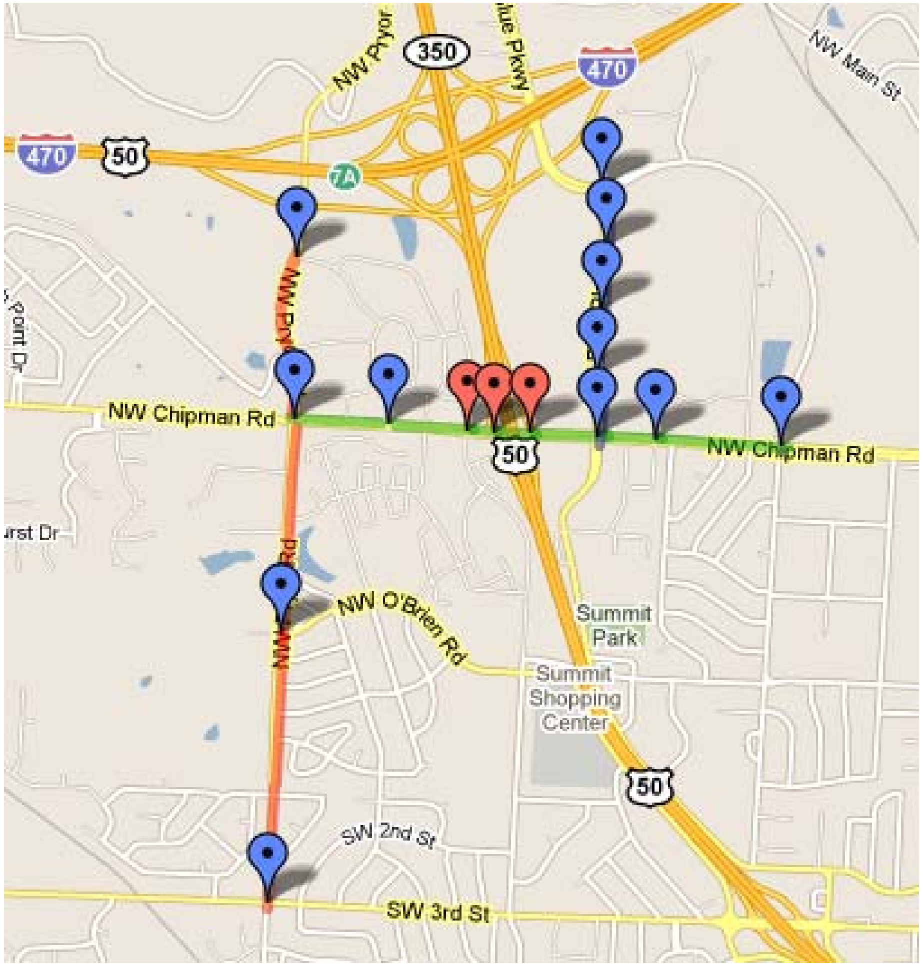
- Real-Time Adaptive Traffic Control on Chipman Road in Lee's Summit, MO
- Contact: Michael Park, City Traffic Engineer
- $400,000-$500,000 project cost
- 100% funded through DOE's Energy Efficiency and Conservation Block Grant (EECBG)
- 15 intersections along multiple corridors crossing City and MoDOT jurisdictions
- Applied InSync adaptive traffic control system using video detection and built-in artificial intelligence

Source: Real-Time Adaptive Traffic Control on Chipman Road. City of Lee's Summit. March 2011.

Lee's Summit – Setting



- 15 intersections along 3 major corridors
- High traffic volumes on Chipman Rd (27,000 ADT), crossing arterials and highway access ramps
- Area includes 2 large retail centers, a large employment center, and retirement centers; high pedestrian volumes

Lee's Summit – Top Goals

1. Minimize travel time for motorists along Chipman Road by synchronizing traffic signals
2. Minimize the number of vehicle stops along Chipman Road
3. Maintain north/south progression along Pryor Road
4. Maintain north/south progression along Blue Parkway
5. Provide a reliable and accessible communications network to all intersections

Lee's Summit View1

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A mast arm on Chipman Rd. with mounted Internet Protocol video camera for vehicle detection.

Lee’s Summit View2

Westbound Chipman Rd. progressing under U.S. Highway 50. Drivers are now typically experiencing all green lights as they move through 7-8 traffic signals.

Lee's Summit View3

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The InSync system installed on these traffic signals allows motorists to move through busy corridors without stopping. This saves time, fuel and frustration.

Lee’s Summit – Evaluation

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- Team collected “Before” data on travel times and average speeds on Chipman Road through multiple floating car runs for each 3 time periods
- During final configuration:
  - Chipman Road, the focal point of this project, and Blue Parkway were coordinated using real-time adaptive control.
  - The Pryor Road corridor was found to operate best without coordination, in a locally optimized mode.
- Team collected “After” data on travel time and average speed on Chipman Road.

Source: Real-Time Adaptive Traffic Control on Chipman Road. City of Lee’s Summit. March 2011.

Lee's Summit – Results

	AM Peak	Midday	PM Peak
Travel Time	Decrease 43-55%	Decrease 35-42%	Decrease 28-45%
Average Speed	Increase 39-50%	Increase 43-47%	Increase 17-33%

Other key benefits

- Less fuel consumption
- Less harmful emissions
- Overall safety improvement

Source: Real-Time Adaptive Traffic Control on Chipman Road. City of Lee's Summit. March 2011.

Lee's Summit – Fuel Savings Estimate

- Annual fuel savings due to the project were estimated at at least 165,160 gallons (i.e. 5,541,118 kWh)
- Estimation based on reduced idling time at red lights – reduced delay converted in fuel savings using EPA average of 0.070452 gallons of fuel spent per minute of idle time
- Estimate is conservative because:
  - Only accounts for reduced idle time but not higher travel speed, reduced braking and acceleration
  - It only accounts for 3 hours of the day, and only weekdays

Source: Real-Time Adaptive Traffic Control on Chipman Road. City of Lee's Summit. March 2011.

Case Study#2: St. Johns County, FL

- Traffic Signal Timing Optimization and Coordination in St. Johns County, FL
- Contact: Greg Kennedy, County Traffic Operations Manager
- $370,000 project cost
- Partly funded through DOE's Energy Efficiency and Conservation Block Grant (EECBG)
- 23 intersections along 4 highway sections
- Project still in the planning phase

Source: EECBG Grant Application. St. Johns County, FL. October 2010.

St. Johns County – Stated Goals

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- Synchronize signals so that platoons of vehicles can travel through a series of signals with minimum delay or no stopping
- Optimize signal timing and coordination of traffic flow to reduce fuel consumption and harmful emissions.
- Postpone or eliminate the need for costly reconstruction by providing improved traffic flow using existing resources in a more cost effective manner.

Source: EECBG Grant Application. St. Johns County, FL. October 2010.

St. Johns County – Signalized Arterials

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Highway	Project Limits	Length (miles)	AADT	# Signalized Intersections
SR- A1A-South	SR 312 To Dondanville Road	3.2	11,624	7
SR-207	SR-312 to Wildwood Drive	4.0	29,492	5
SR-13	Roberts Road to Race Track Road	2.0	21,760	4
US-1-South	S. Shores Boulevard to Walmart Entrance	4.6	38,686	7

St. Johns County – Operational Analysis

- "Before-After" travel time and delay study
- Multiple travel time runs in each direction for each corridor during AM, midday and PM peak periods including peak weekend periods
- Retiming and synchronization of traffic signals based on Synchro program
- Delay, fuel and dollar savings computed with Tru-Traffic TS/PP computer program

St. Johns County – Anticipated Benefits

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- 728,894 gallons of gasoline saved
- 2,247 metric tons of carbon emissions prevented
- Estimates based on State Energy Program (SEP) Metrics Calculator
- Developed by the National Renewable Energy Laboratory
- Used by the States in estimating the energy savings, cost savings and carbon emission reductions
- Provides estimates based on lane-mile of synchronization

Sources: EECBG Grant Application. St. Johns County, FL. October 2010.
US DOE. Outcome Estimator for State Energy Program.

Any Questions?

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Thank You

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- Thanks for Attending
- If you have any additional questions, please contact me:

Yonnel Gardes

YGardes@icfi.com

(206) 801-2844