U.S.Department of Transportation
Federal Highway Administration

Office of Operations Research and Development

RESEARCH PROJECTS AND BENEFITS

AMERICA'S MOBILITY CHALLENGE

Congestion is one of the greatest transportation challenges currently facing the United States, and it continues to increase each year. Congestion negatively impacts the Nation's economy, productivity, and environment. It also makes it more difficult for citizens to get where they need to be on time, from work and school to soccer games and family dinners. Decreasing congestion requires addressing the various sources that cause it. These sources can be recurring, such as bottlenecks on the roadway where capacity is decreased, or nonrecurring, such as bad weather and traffic incidents.

The Federal Highway Administration (FHWA) Office of Operations Research and Development (R&D) addresses the congestion problem by partnering with industry and academia to conduct forward-thinking research into technologies and applications that can improve mobility on our Nation's roadways.

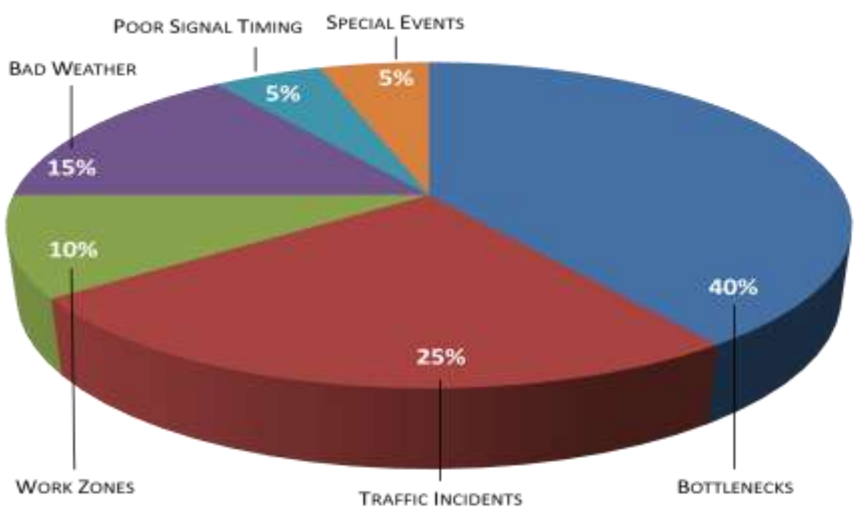
The Congestion Problem[1]

National Impact

- $121 billion in delays and fuel costs.
    - $27 billion lost by freight industry.
- 5.5 billion hours of extra time on the road.
- 2.9 billion gallons of wasted fuel.
- 56 billion pounds of additional carbon dioxide emissions.

Impact on Average Commuter

- Roughly $820 additional annual cost per commuter.
- 38 extra hours per person on the road.

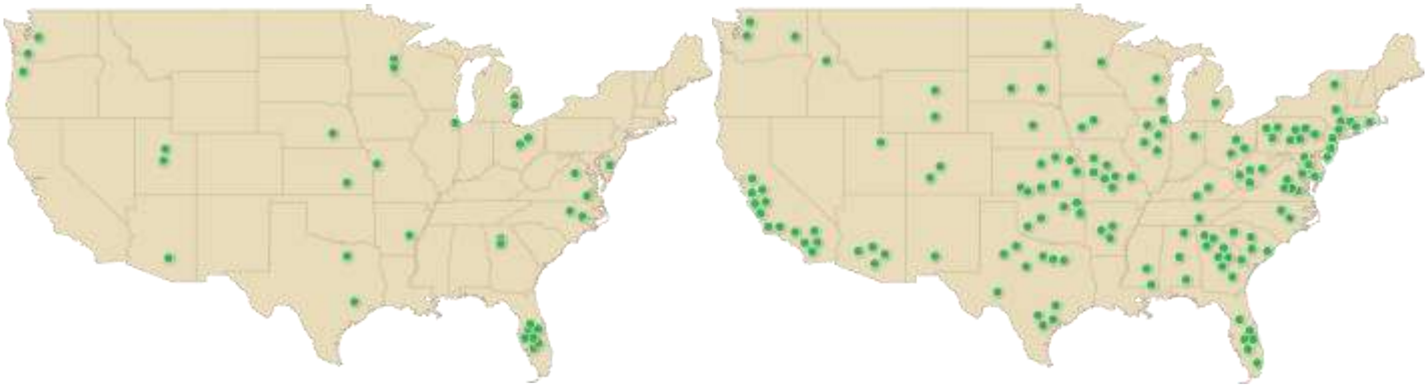


***Sources of Congestion**: Over 50 percent of congestion is directly attributable to large fluctuations in demand (such as special events), poor signal timing, traffic incidents, inclement weather, and work zones.*

[1] Texas A&M Transportation Institute, *2012 Urban Mobility Report*, Dec 2012. Available at: http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-report-2012.pdf.

ADAPTIVE SIGNAL CONTROL TECHNOLOGY

Static signal timing may induce congestion when traffic demand exceeds the capacity of an intersection design, resulting in increased fuel consumption, delays, harmful emissions, and reduced safety. Recognizing the need for a more dynamic approach to signal timing, the FHWA Office of Operations R&D began a research effort more than 20 years ago to develop adaptive signal control technologies (ASCT). These technologies use sensors to interpret characteristics of traffic approaching a signal and adapt signal timings accordingly in order to optimize performance. From 1991 to 2004, FHWA developed and demonstrated four ASCT approaches for dynamically updating signal timing. Due in part to these initial research efforts and to FHWA's Every Day Counts program, there has been a 192 percent increase in the deployment of ASCT from 2006 to 2014, and multiple ASCT products are now available in the marketplace.



Growth in Nationwide deployments of ASCT from 1991–2005[2] (left) versus 2006–2014[3] (right).

TRUCK PLATOONING

Truck platooning involves using vehicle automation, vehicle-mounted sensors, and wireless communication technology to allow trucks to drive closer together. Truck platooning may offer significant benefits to both the trucking industry and the public, including lower emissions and fuel consumption, lower operating costs, increased highway capacity, and improved safety.

Past FHWA-sponsored field tests of automated truck platooning.

In prior FHWA-funded research, the University of California, Berkeley - Partners for Advanced Transportation Technology (California PATH) equipped two tractor trailer trucks with platooning equipment, which demonstrated benefits of 10 to 15 percent in fuel savings and the potential to double the number of trucks able to use truck-only lanes. In a second study, California PATH added a third truck to the platoon with the vehicles spaced at 4 to 6 meter distances. Based on these results, the research team estimated that tractor trailer trucks driving under typical highway conditions could save up to 20 percent in fuel consumption with truck platooning.

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[2] National Cooperative Highway Research Program (NCHRP), *Synthesis 403: Adaptive Traffic Control Systems: Domestic and Freight State of Practice*, 2010. Available at: http://www.nap.edu/catalog.php?record_id=14364.

[3] Stevanovic, Aleksandar, Florida Atlantic University, "Map of Adaptive Traffic Control Systems in US." Available at: https://www.google.com/maps/d/viewer?dg=feature&ll=43.644026,-98.4375&msa=0&spn=26.898865,67.631836&mid=z1vKKpwJWHk0.kIwxhy_e4uU4

ECO-APPROACH AND DEPARTURE AT SIGNALIZED INTERSECTIONS

Eco-Approach and Departure (EAD) at Signalized Intersections is an application that uses wireless communications to give drivers recommendations that encourage "green" approaches to signalized intersections, increasing the fuel economy and reducing emissions of vehicles traveling through an intersection. The application, located in the vehicle, receives signal phase and timing (SPaT) data via wireless communications from a roadside unit. It uses these data to determine the best speed to reach the next traffic signal on a green light, or to come to a stop in the most eco-friendly manner.

Reduced Fuel Consumption

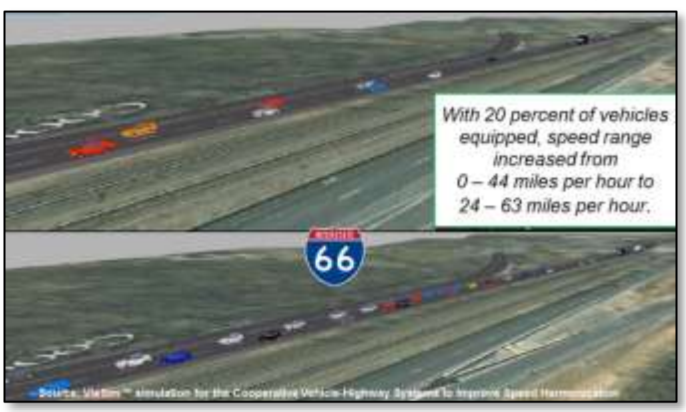
Speed (mph)	Average % Improvement
25	18.1%
30	11.2%
35	6.3%
40	9.5%

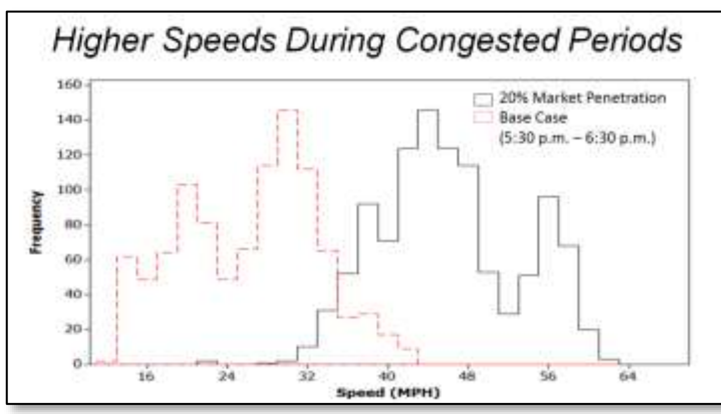
Image and results of eco-approach and departure application demonstration.

Initial testing for EAD was done in fall 2012 as part of the U.S. Department of Transportation's Applications for the Environment: Real-Time Information Synthesis (AERIS) program. The University of California, Riverside (UCR) developed and tested an EAD algorithm that showed up to 18 percent fuel savings at the Connected Vehicle-Highway Testbed located at the FHWA Turner-Fairbank Highway Research Center in McLean, VA.[4]

SPEED HARMONIZATION

Speed Harmonization is a method to reduce congestion and improve traffic performance where lanes merge and form bottlenecks which are the greatest cause of congestion nationwide. This strategy involves gradually lowering speeds before a heavily congested area in order to reduce stop-and-go traffic. FHWA funded a project that used computer modeling to evaluate the effects of a large-scale deployment of speed harmonization. The computer modeled vehicles and roads in a way that replicated conditions on I-66 in Northern Virginia during evening rush hour. Modeling results showed that speeds ranged from 0–44 miles per hour (mph) approaching a congested location during a normal day. The same model showed speeds of 28–63 mph with only 20 percent of the vehicles equipped with speed harmonization.





Screenshot of speed harmonization simulation (left) and results (right).

[4] University of California Riverside, *AERIS Field Study Application: Eco-Approach to Signalized Intersections, Task 3 of the Identification and Evaluation Transformative Environmental (AERIA) Applications,* U.S. Department of Transportation, Federal Highway Administration, Sep 2012.

SAXTON TRANSPORTATION OPERATIONS LABORATORY

FHWA's Saxton Transportation Operations Laboratory, located at TFHRC, is a state-of-the-art facility for conducting transportation operations research, including research on automation and connected vehicles and infrastructure.

SAXTON LABORATORY Driving Future Highways

Research Vehicle Fleet

- Communications
  - 5.9 GHz Dedicated Short-range Communications (DSRC)
  - Fourth Generation (4G) Cellular/Long-Term Evolution (LTE)
  - Wireless Fidelity (Wi-Fi)
- Positioning
  - Localization system that provides continuous positioning
- Vehicle Control
  - Software Control Module consisting of two electronic control units (ECU):
    - Throttle ECU
    - Brake ECU

Three FHWA research vehicles in the Saxton Laboratory Test Vehicle Garage.

FHWA's Taylor Lochrane shows U.S. President Barack H. Obama the research vehicle fleet.

Connected Infrastructure

- Connected Traffic Signal
  - Roadside Communications (Roadside Equipment and Black Box)
  - Information Processing
- Connected Road
  - 5.9 GHz DSRC
  - Cellular Communication and Worldwide Interoperability for Microwave Access (WiMAX)
  - Wireless Pavement Sensors
  - Weather and GPS Base Station
  - High-Speed Cameras
- Connected Mobile Traffic Sensing System
  - Microwave Vehicle Detection
  - Outdoor Pan/Tilt/Zoom Dome Cameras
  - Solar Powered

Intelligent intersection and signal controller cabinet at TFHRC

Connected Laboratory

- Connected Vehicle PlugFest
- State-of-the-Art Simulation and Analysis Tools
- High-Bandwidth Internet2 Connectivity
- High-Capacity Data Servers

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