

Efficiency Matters for Mobility

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DOE'S NATIONAL LABORATORY COMPLEX

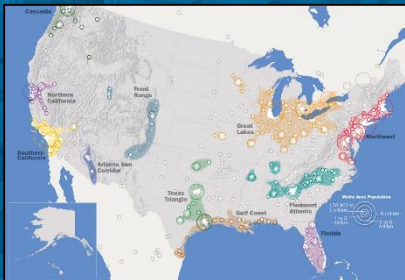


CONVERGING TRENDS ARE SHAPING MOBILITY

Population



Population expected to grow by **70 million** in next **30 years**



75% of population concentrated in **11 Megaregions**

Demographics

Americans are Living Longer

By 2045, the number of Americans over age 65 will increase by **77%**.



About **one-third** have a disability that limits mobility.

Millennials are Connected & Influential



There are **73 million** Americans aged 18 to 34.

They drove **20%** fewer miles in 2010 than at the start of the decade.

Technology



Integration of Connected & Automated Technologies



Introduction of Shared Service Platforms



Advancements in Energy Storage Technology



Deeper Application of Big Data



Faster Processing Speeds at Decreasing Cost

TRENDS ARE CAUSING A FUNDAMENTAL DISRUPTION



Connectivity



Ride-hailing



New Powertrains



Automation



Car-sharing



New Modes

DAILY HEADLINES – SURPRISING PARTNERS and ENTRANTS

GM CORPORATE NEWSROOM

Home News Company Plants & Facilities Images Videos Key Contacts

GM and Lyft to Shape the Future of Mobility

2016-07-04

DAIMLER

AUTONOMOUS DRIVING

Driving autonomously through Nevada
Freightliner Inspiration Truck



TECH TRANSPORTATION EVS

Intel predicts a \$7 trillion self-driving future

Over half a million lives will be part of the 'passenger economy'

by Kristin Kozlowski | Jun 1, 2017, 4:21pm EDT

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The New York Times

Lyft and Waymo Reach Deal to Collaborate on Self-Driving Cars

THE WALL STREET JOURNAL

Google, Fiat Chrysler Begin Work on Self-Driving Minivan

Alphabet Inc. unit also will establish self-driving engineering center in Detroit area



- RELATED COVERAGE
- Uber and Waymo Driverless
 - Waymo to Self-Drive
 - Lyft Gets Self-Driving Its Rival
 - A Lawsuit Rush to Court

Uber's Pittsburgh riders to try self-driving Volvos

Brett Molina and Marco della Cava, USA TODAY 6:19 p.m. EDT August 18, 2016

The Washington Post

Columbus nabs \$50 million 'smart city' prize

Transportation

Ford Go Further

The Local Motors Olli is a driverless EV minibus with IBM Watson inside

FORD

FORD TARGETS FULLY AUTONOMOUS VEHICLE FOR RIDE SHARING IN 2021; INVESTS IN NEW TECH COMPANIES, DOUBLES SILICON VALLEY TEAM

AUG 16, 2016 | PALO ALTO, CALIF.

- Ford announces intention to deliver high-volume, fully autonomous vehicle for ride

BEYOND CONGESTION IMPACTS: Air Quality, Climate, Quality of Life

Each Year, Traffic Congestion Costs Us:

Time



6.9 Billion Hours

Fuel



3.1 Billion Gallons

Money



\$160 Billion



EFFICIENCY...



- Household expenditures
- Use of natural resources
- Use of time
- Hassle-free movement
- Service expectation
- Technology speed to market
 - Improved product development cycle

EFFICIENCY MATTERS AT ALL LEVELS

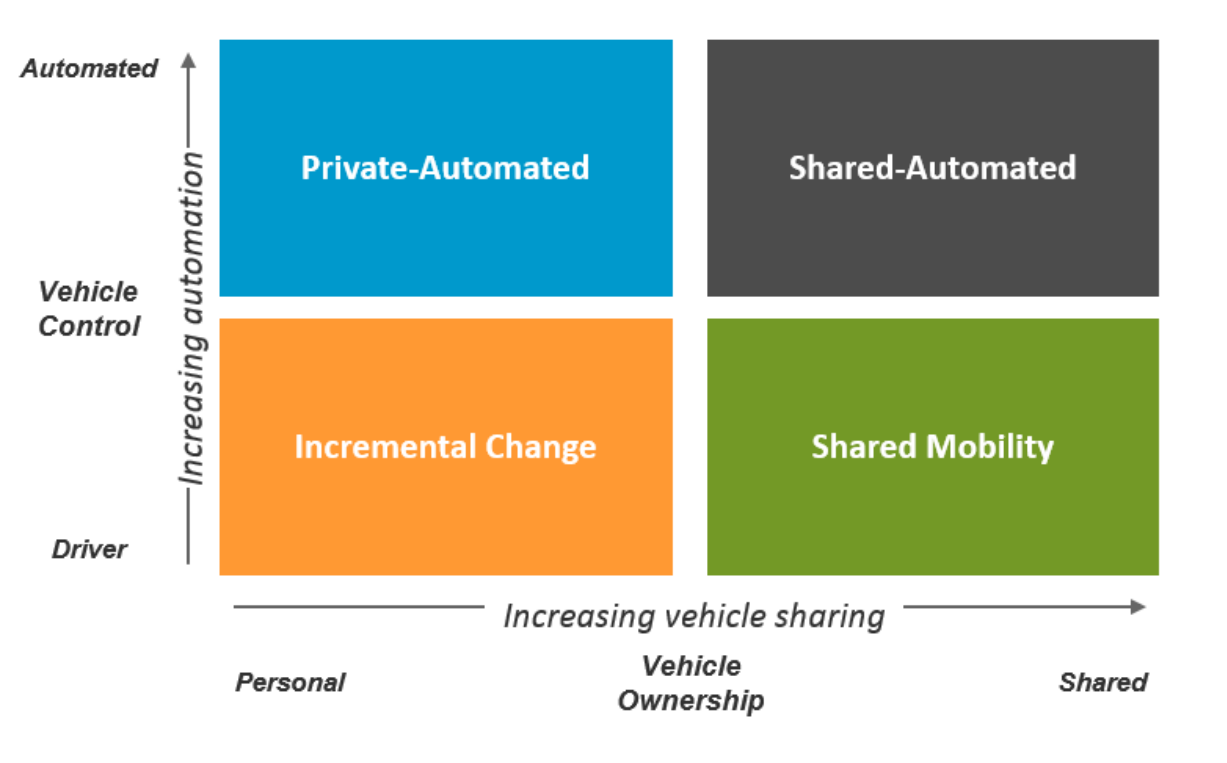


Component

Vehicle

Transportation System

FUTURE MOBILITY SCENARIOS – BREADTH OF OPTIONS



SYSTEM ENGINEERING AS URBAN AREAS FACING SIMILAR CHALLENGES



While the cities were diverse, many of the 78 applicants faced similar urban mobility challenges:

Providing first-mile and last-mile service for transit users to connect underserved communities to jobs



The typical job is accessible to only about **27 percent** of its metropolitan workforce by transit in **90 minutes** or less.

Facilitating the movement of goods into and within a city



Trucks stuck in stop-and-go traffic in metropolitan areas cost shippers an estimated **\$28 million annually** in truck operating costs and wasted fuel.

Coordinating data collection and analysis across systems and sectors



28 percent of all of the transit agencies in the United States have open data systems that freely provided transit times to the public.

Reducing inefficiency in parking systems and payment



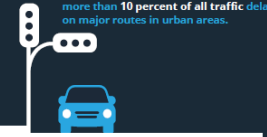
An estimated **30 percent** of traffic in urban areas is caused by cars looking for parking.

Limiting the impacts of climate change and reducing carbon emissions



The **78 applicant cities** represent over one billion metric tons of CO₂ emissions per year.

Optimizing traffic flow on congested freeways and arterial streets



Outdated traffic signal timing causes more than **10 percent** of all traffic delay on major routes in urban areas.

URBAN OPPORTUNITIES and CHALLENGES

- Transit ridership decrease with TNC
- Parking revenue decrease
- Curb space tension
- Zoning changes
- Congestion / VMT increase with added mobility
- E-commerce delivery frequency
- Infrastructure modifications, Signal Control, Lanes.....
- New business models and start-ups
- Expanded modes of travel
- CAVs testing and operation
- Policy ramifications
- Equity
- Vision Zero traffic fatalities

Advanced
Fueling
Infrastructure



Connected &
Automated
Vehicles



**DOE SMART
MOBILITY LAB**



Urban Science

CONSORTIUM

7 labs, 30+ projects, 65 researchers, \$34M*
over 3 years.

Mobility Decision
Science



Multi-Modal
Transport

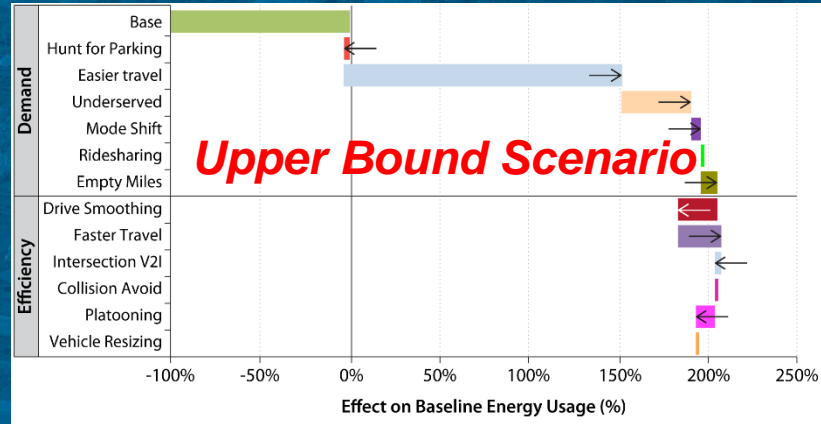
* Based on anticipated
funding

FUNDAMENTAL DISRUPTION, DRAMATIC ENERGY IMPACTS

+200%



Potential Increase
in Energy
Consumption



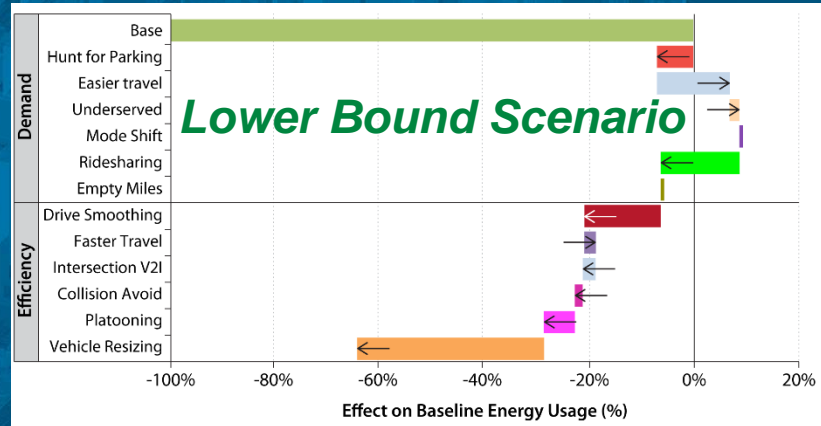
2050 Baseline Energy
Consumption



Potential
Decrease in
Energy
Consumption



-60%



QUESTIONS FOR FUTURE MOBILITY SCENARIOS

- National and Regional Level Energy Impacts
- Vehicle Level Energy Impacts, Coordination and Communication
- Vehicle Ownership Models for Private vs Shared
- Freight Movement, Delivery of goods, E-commerce trends
- Interactions with Infrastructure Systems and Urban Environment
- Behavior, Motivations, Values
- Non-Car Modes
- Ride Sharing
- Value of Travel Time
- Mobility Energy Productivity
 - Energy, GDP, Access to Opportunity, Quality of Life

BUILDING BLOCKS FOR EFFICIENT MOBILITY



AS MOBILITY AND TECHNOLOGY EVOLVES, SO MUST ANALYTICAL TOOLS FOR NEW KNOWLEDGE

Single Vehicle



Corridor / Small Network



Entire Urban Area



- Funded by US DOE
- Vehicle energy consumption and cost
- VTO requirements & benefits
- Only commercial tool with vehicle level control
- Licensed to >250 companies



RoadRunner

- Funded by US DOE
- Only system simulation of multi-vehicle and their environment focused on advanced control enabled by V2V, V2I...
- Use Autonomie powertrain models



- Commercial Tools
- Microscopic traffic flow simulation
- Focus on detailed traffic flow, control



- Funded by US DOT/FHWA
- Agent-based mesoscopic traffic flow simulation
- Focus on traveler behavior, system...
- Use outputs from micro-simulation, Autonomie, GREET & MA3T

HIGH EFFICIENCY and HIGH THROUGHPUT ENABLED BY HPC



Clusters



Super-Computer



First Exascale Machine in
2021 @ ANL

Leverage BIG Data with Machine Learning – Component, Vehicle and Transportation System Level

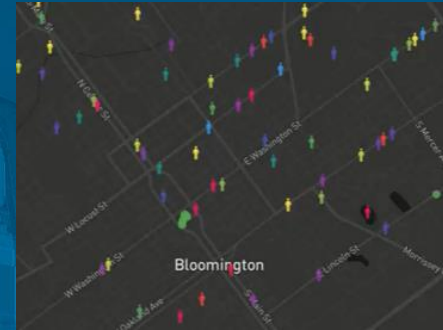
- Capture Efficiency throughout the value chain

FUTURE MOBILITY SCENARIOS STUDIED

Impact of coordinated platooning and CACC on energy

Impact of multi-modal travel

CAV impacts on value of time and network performance

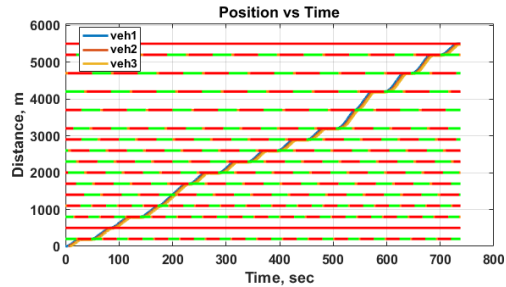


ENERGY IMPACT OF V2V, I2V

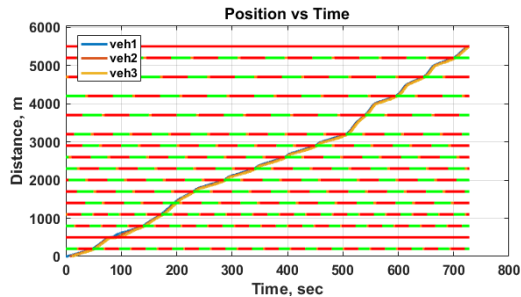


EcoSignal

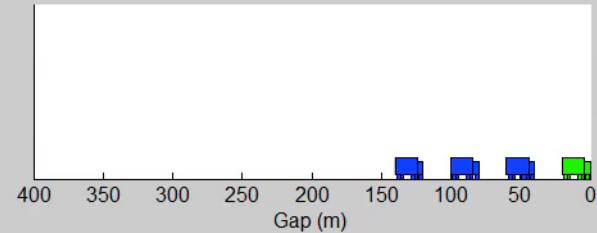
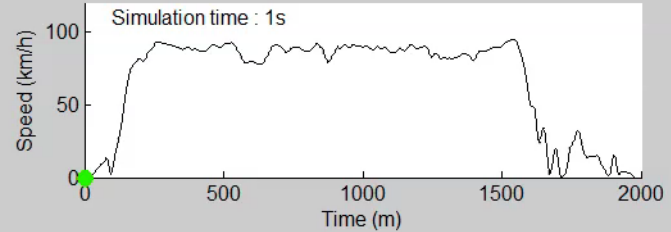
(1) Reference Vehicle



(2) Connected Vehicle



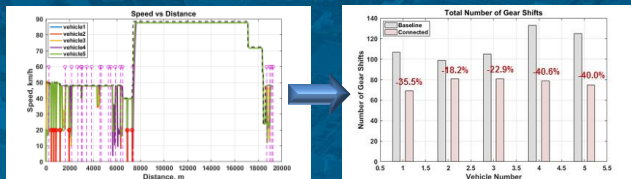
Platooning



Energy Consumption Improvements – V2V, I2V, V2I, but the Traveler Behavior Can Increase the Overall Energy Used

Component Optimization

Connectivity reduces the number of shifting events, leading to potential transmission redesign and increase reliability



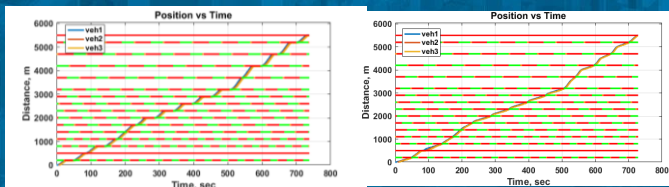
Example scenario: 20 – 40% gear shift reductions

Eco-Signals (V2I...)

Knowledge of the environment (i.e. traffic light signal) enables vehicle speed control to minimize stops

Human/Baseline

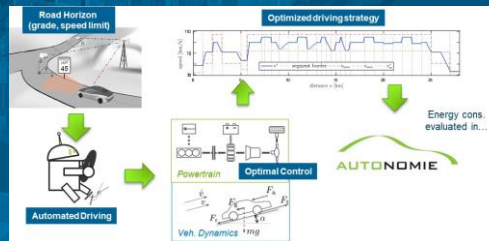
CAVs



Example scenario: 5 -14% energy savings

Model Predictive Control (Indiv. Vehicles)

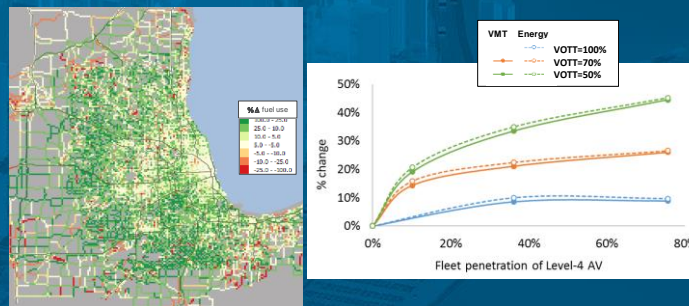
Knowledge of the environment enables simultaneous optimization of vehicle speed and powertrain control



Example scenario: 6% energy savings for Pre-transmission HEV

Traveler Behavior

Low value of time (VOT) increases VMT and energy (up to 45% for high AV penetration and low VOT!)



PROACTIVE PARTICIPATION WITH PRIVATE AND PUBLIC PARTNERSHIP– BEYOND IMAGING AN EFFICIENT MOBILITY FUTURE

