Efficiency Matters for Mobility

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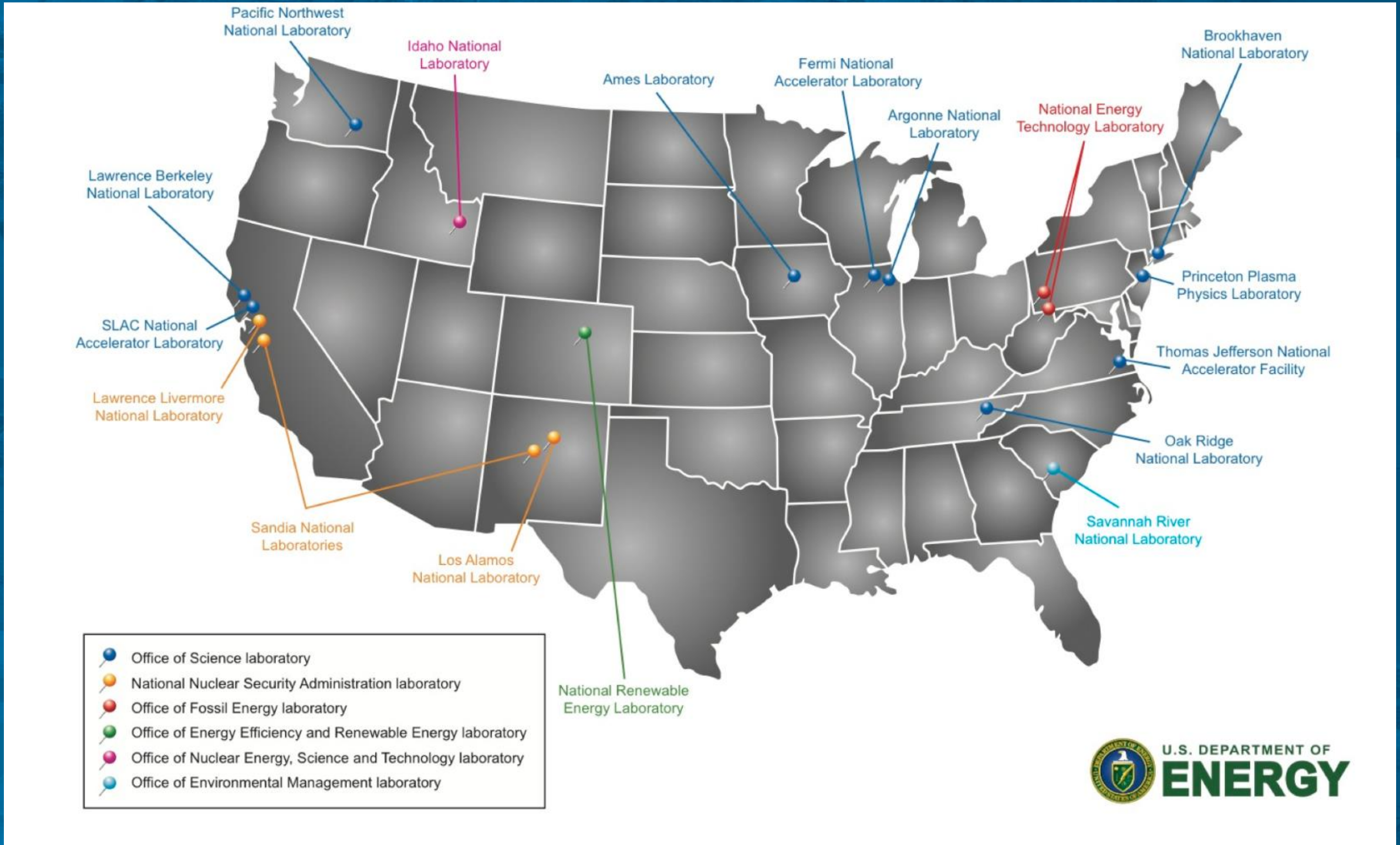
DOE'S NATIONAL LABORATORY COMPLEX



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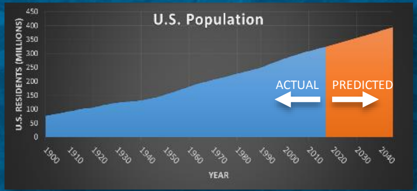
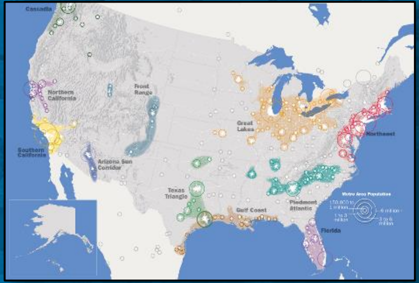
CONVERGING TRENDS ARE SHAPING MOBILITY

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**

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TRENDS ARE CAUSING A FUNDAMENTAL DISRUPTION

Connectivity

Ride-hailing

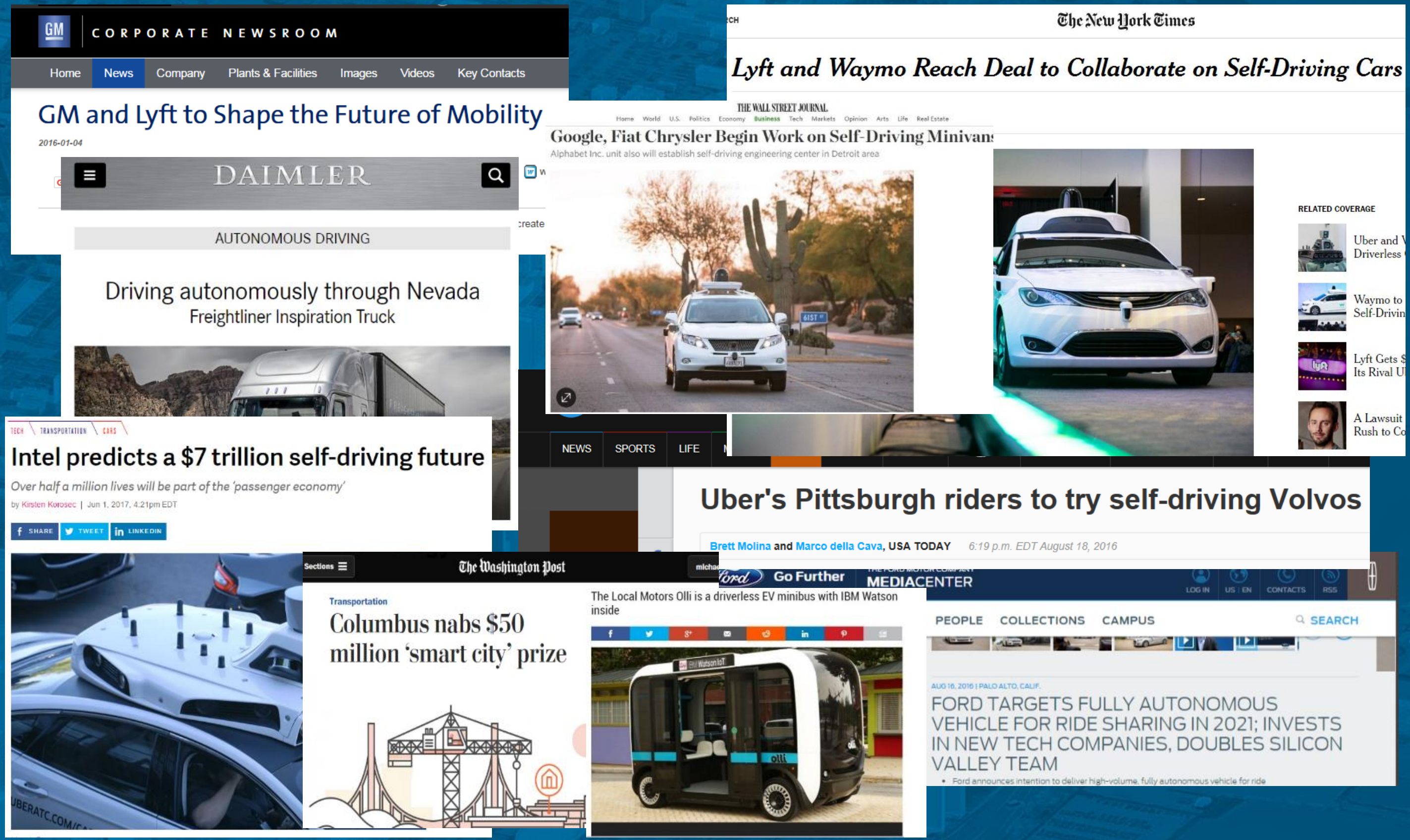
New Powertrains

Automation

Car-sharing

New Modes

DAILY HEADLINES – SURPRISING PARTNERS and ENTRANTS



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

Each Year, Traffic Congestion Costs Us:

Time

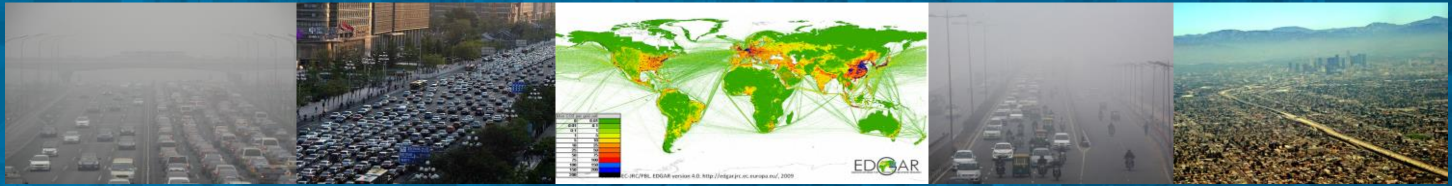
6.9 Billion Hours

Fuel

3.1 Billion Gallons

Money

$160 Billion



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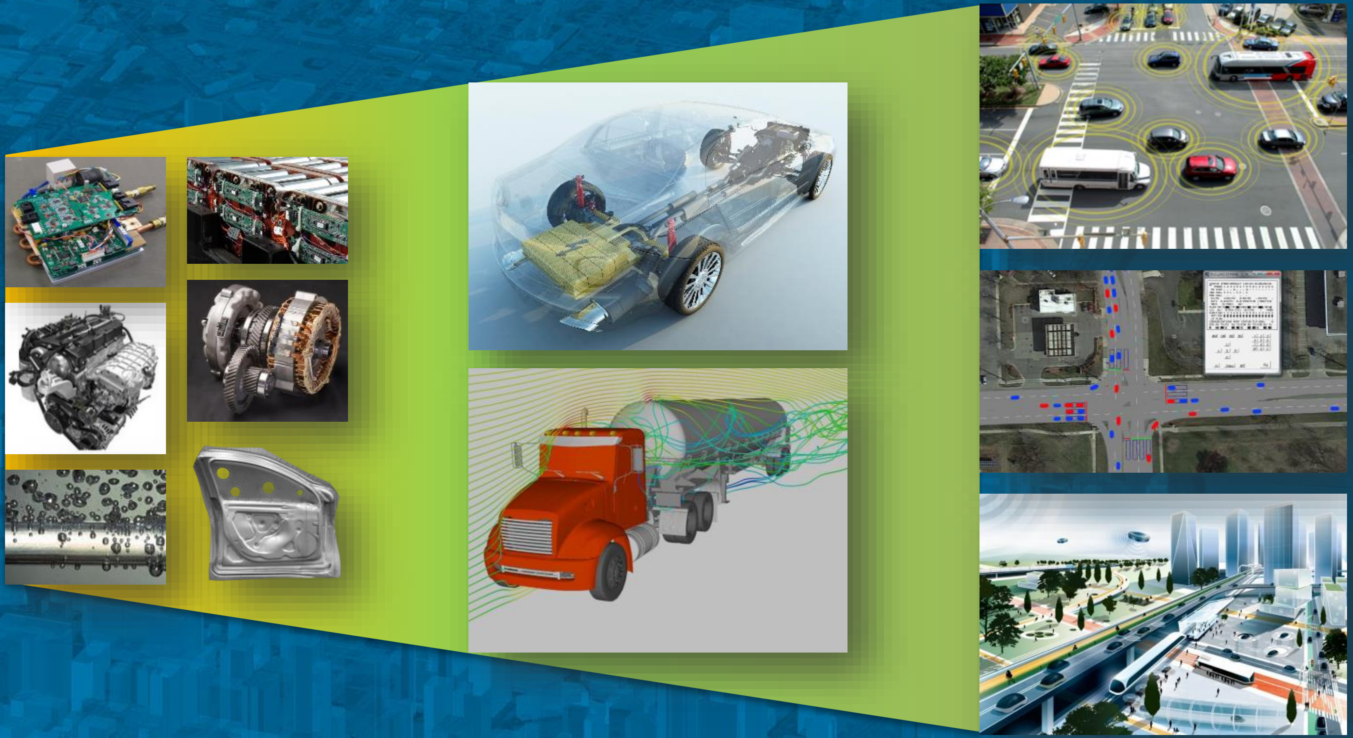
Data from Schrank, B., Eisele, B., Lomax, T., and Bak, J. (2015). 2015 Urban Mobility Scorecard. Technical report, Texas A& M Transportation Institute..

EFFICIENCY…

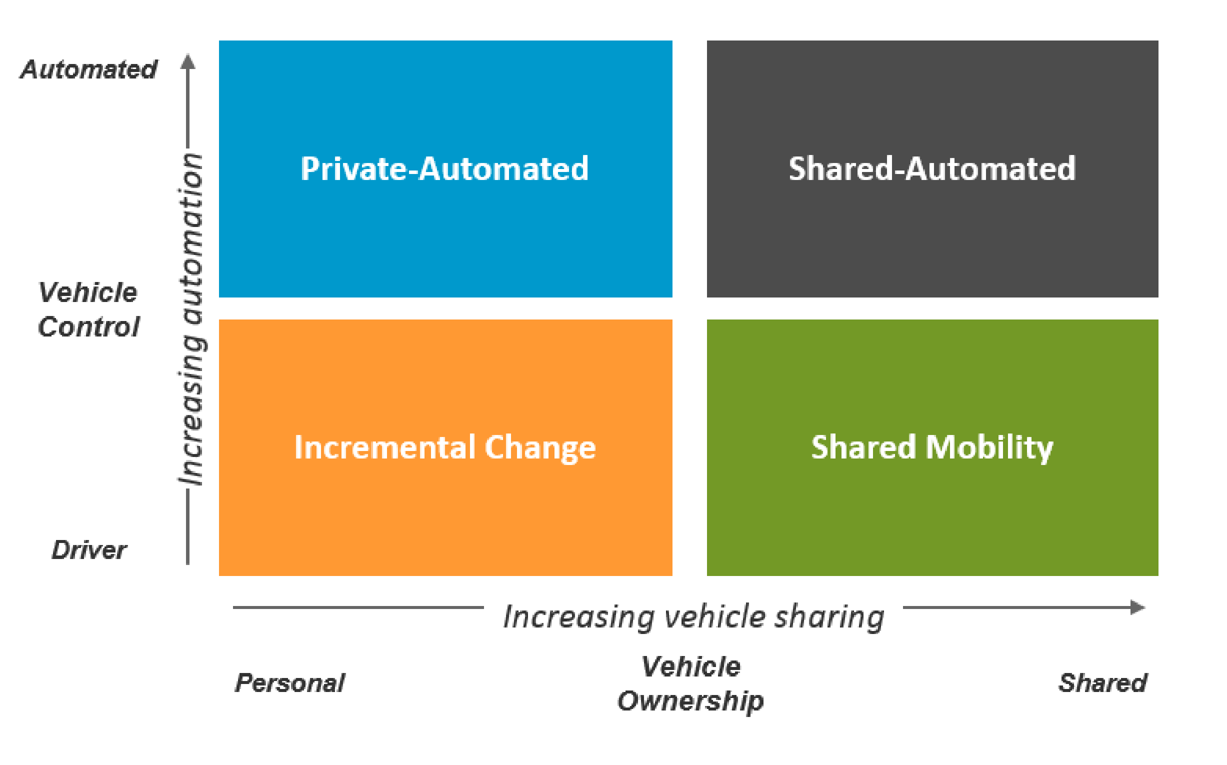
- Household expenditures
- Use of natural resources
- Use of time
- Hassle-free movement
- Service expectation
- Technology speed to market
  - Improved product development cycle

EFFICIENCY MATTERS AT ALL LEVELS



Component Vehicle Transportation System

FUTURE MOBILITY SCENARIOS – BREADTH OF OPTIONS



SYSTEM ENGINEERING AS URBAN AREAS FACING SIMILAR CHALLENGES

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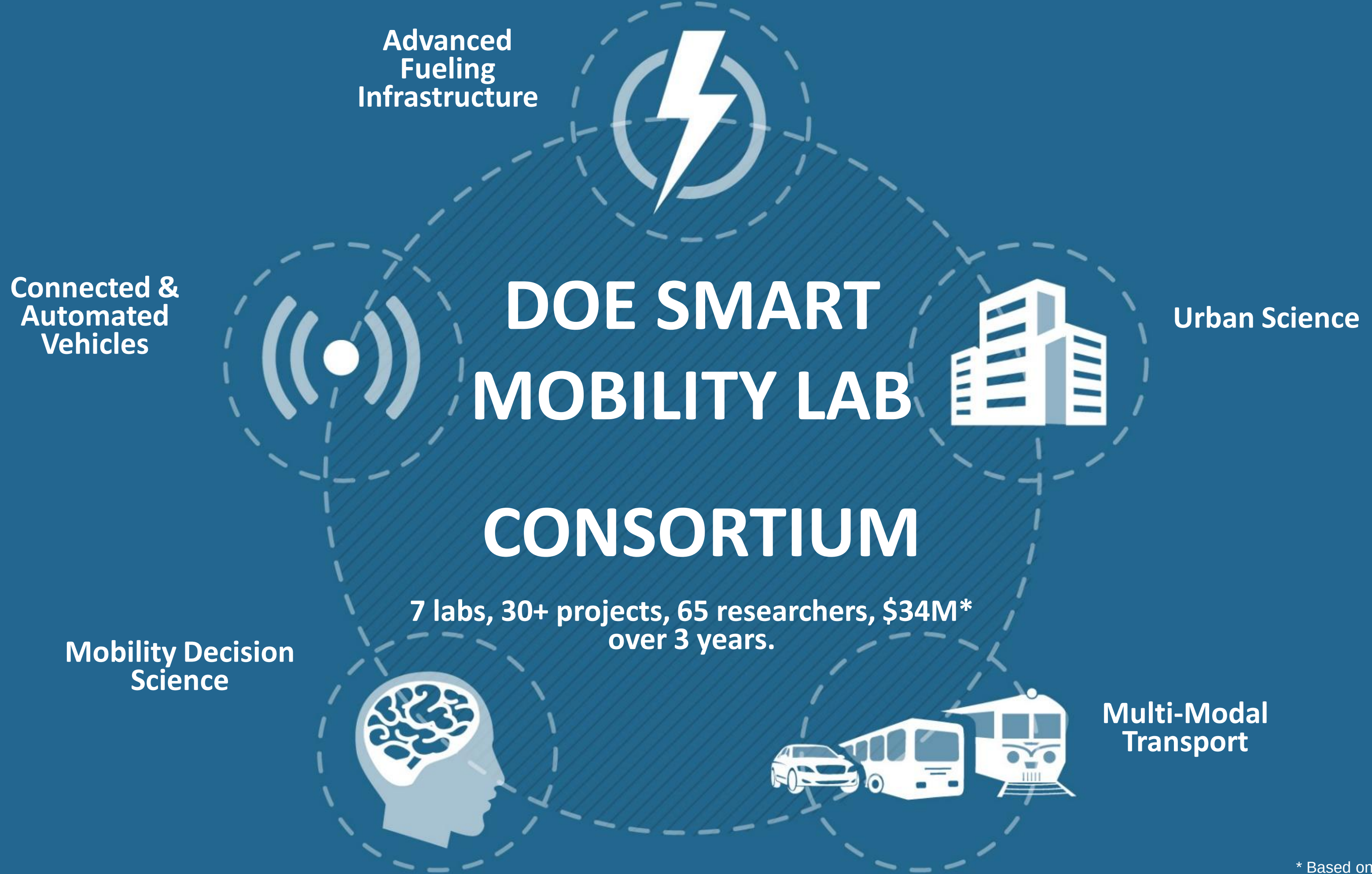
URBAN OPPORTUNITIES and CHALLENGES

- 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

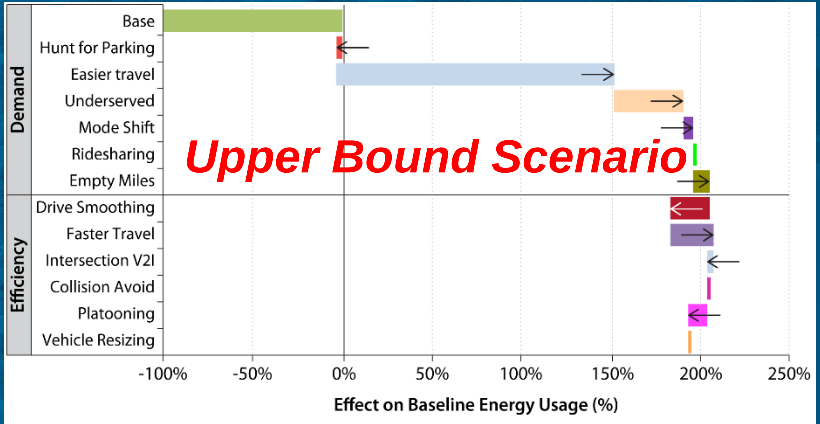


* Based on anticipated funding

FUNDAMENTAL DISRUPTION, DRAMATIC ENERGY IMPACTS

+200%

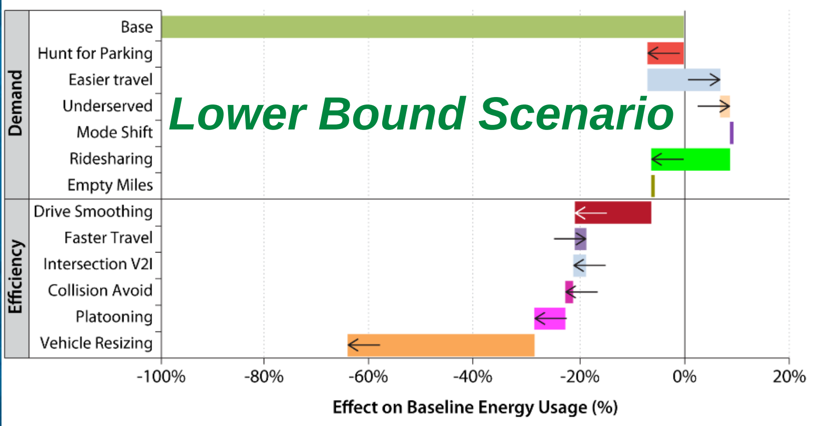
Potential Increase in Energy Consumption



2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

-60%



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Source: Joint study by NREL, ANL, and ORN

http://www.nrel.gov/docs/fy17osti/67216.pdf

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**

AUTONOMIE → RoadRunner → PTV VISSIM / Aimsun → POLARIS

AUTONOMIE
- 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

PTV VISSIM / Aimsun
- Commercial Tools
- Microscopic traffic flow simulation
- Focus on detailed traffic flow, control

POLARIS
- 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

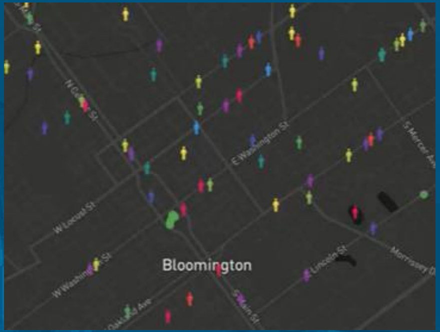
Leverage BIG Data with Machine Learning – Component, Vehicle and Transportation System Level

- Capture Efficiency throughout the value chain

FUTURE MOBILITY SCENARIOS STUDIED

Impact of coordinated platooning and CACC on energy

Impact of multi-modal travel

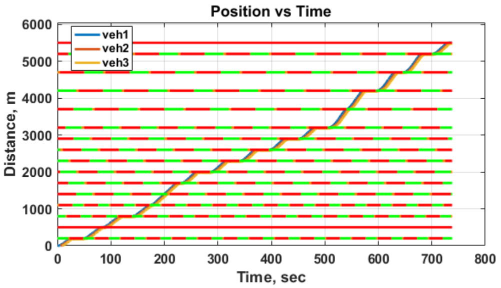


CAV impacts on value of time and network performance

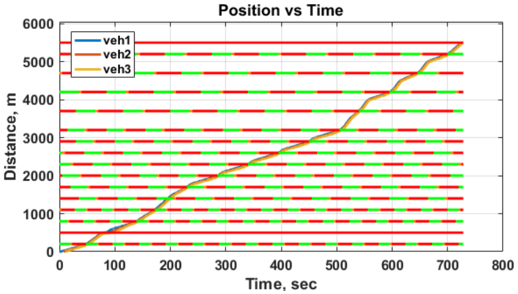
ENERGY IMPACT OF V2V, I2V

EcoSignal

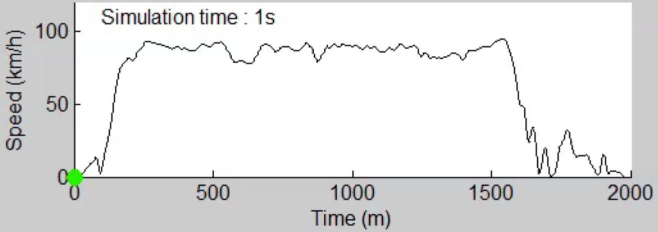
(1) Reference Vehicle

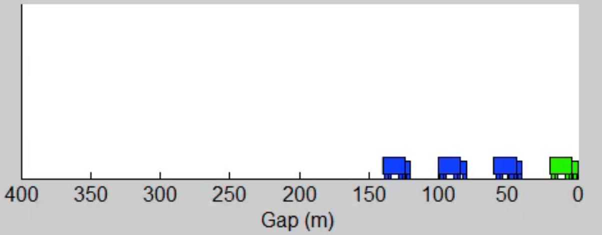


(2) Connected Vehicle



Platooning

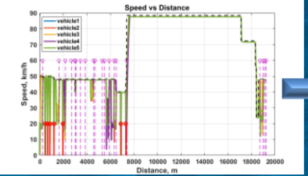


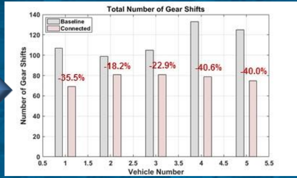


Energy Consumption Improvements – V2V, I2V, V2I, but the Traveler Behavior Can Increase the Overall Energy Used

Component Optimization

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

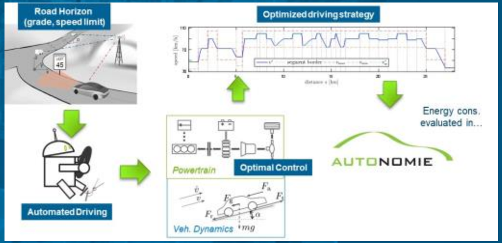




Example scenario: 20 – 40% gear shift reductions

Model Predictive Control (Indiv. Vehicles)

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

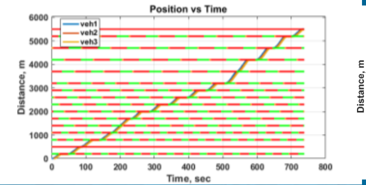


Example scenario: 6% energy savings for Pre-transmission HEV

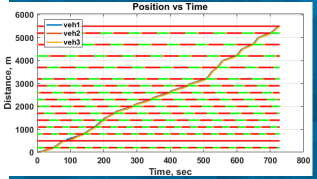
Eco-Signals (V2I…)

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

Human/Baseline



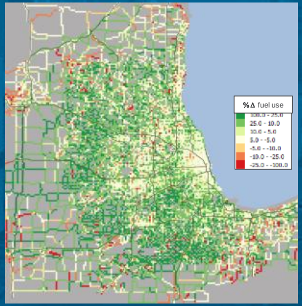
CAVs

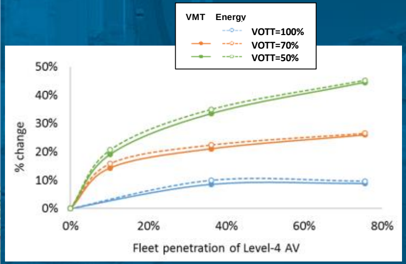


Example scenario: 5 -14% energy savings

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