Efficiency Matters for Mobility

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Presented at A3PS – ECO MOBILITY 2018
Vienna, Austria
November 12th and 13th, 2018
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

Automation

Ride-hailing

Car-sharing

New Powertrains

New Modes
DAILY HEADLINES – SURPRISING PARTNERS and ENTRANTS

GM and Lyft to Shape the Future of Mobility

Driving autonomously through Nevada Freightliner Inspiration Truck

Intel predicts a $7 trillion self-driving future

Uber’s Pittsburgh riders to try self-driving Volvos

Columbus nabs $50 million ‘smart city’ prize

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

Google, Fiat Chrysler Begin Work on Self-Driving Minivan

Waymo to Boost Self-Driving Operations in Detroit

Lyft Gets Approval for Ride-Sharing in Palo Alto

A Woman Needs a Ride to Cancer Treatment in Washington, D.C.
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
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 billion annually in truck operating costs and wasted fuel.

- **Coordinating data collection and analysis across systems and sectors**
  - 28 percent of all of the travel agencies in the United States have open data systems that merely provided travel times to the public.

- **Reducing inefficiency in parking systems and payment**
  - An estimated 30 percent of traffic in urban areas is created by users 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 for millions of people 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
DOE SMART MOBILITY LAB CONSORTIUM

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

* Based on anticipated funding
FUNDAMENTAL DISRUPTION, DRAMATIC ENERGY IMPACTS

Potential Increase in Energy Consumption

Potential Decrease in Energy Consumption

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

Distribution and Transmission Network

Individual Components

Individual Vehicles

New Mobility Services

Charging Network & Usage

Fuels

Metropolitan Area

Traveler Decision

Building Energy

Distribution and Transmission Network
AS MOBILITY AND TECHNOLOGY EVOLVES, SO MUST ANALYTICAL TOOLS FOR NEW KNOWLEDGE

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

RoadRunner
- Commercial Tools
- Microscopic traffic flow simulation
- Focus on detailed traffic flow, control
- Use Autonomie powertrain models

Corridor / Small Network
- Funded by US DOE
- Only system simulation of multi-vehicle and their environment focused on advanced control enabled by V2V, V2I...

PTV VISSIM

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

POLE•RIS
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

Simulation time: 1s
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

Eco-Signals (V2I...)
Knowledge of the environment (i.e. traffic light signal) enables vehicle speed control to minimize stops

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

Model Predictive Control (Indiv. Vehicles)
Knowledge of the environment enables simultaneous optimization of vehicle speed and powertrain control

Example scenario: 20 – 40% gear shift reductions

Example scenario: 5 -14% energy savings

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

Example scenario: 80% energy savings for Pre-transmission HEV
PROACTIVE PARTICIPATION WITH PRIVATE AND PUBLIC PARTNERSHIP– BEYOND IMAGING AN EFFICIENT MOBILITY FUTURE