TRANSPORTATION-AS-A-SYSTEM (TAAS)

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IMAGINE…

BIG IDEA

Radically reshape the transportation energy footprint of the nation

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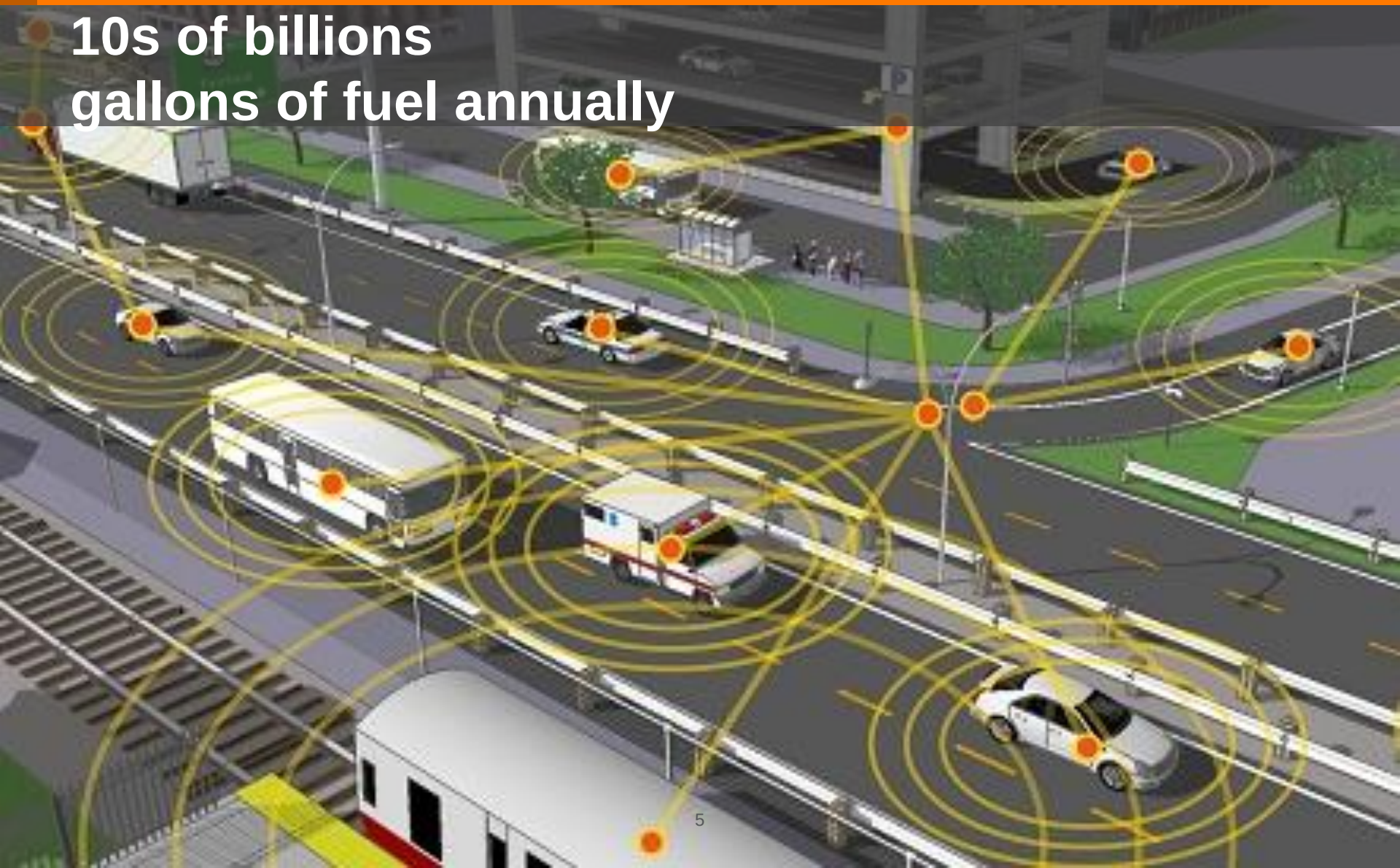
Radically reshape the transportation energy footprint of the nation:

- **Develop policy decision support systems for emerging energy mobility paradigms**
- **Leverage existing and establish new and necessary expertise at DOE in transportation energy systems**

THE IMPACT?

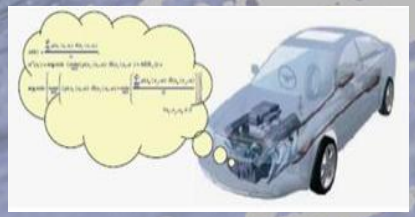
10s of billions gallons of fuel annually



THE OPPORTUNITY AND PROBLEM….

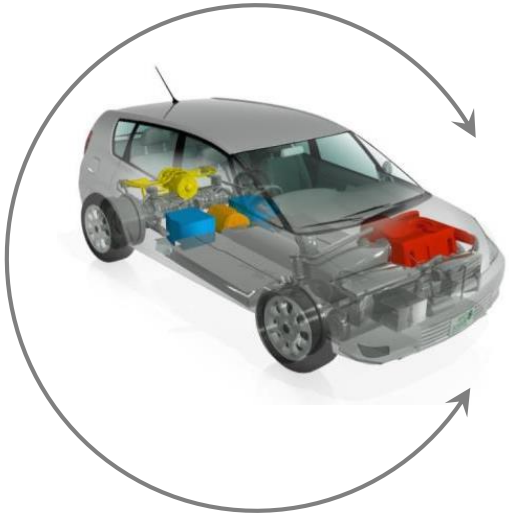
Massive wave of changes hitting our transportation system

Megatrends
Shared Mobility
MaaS
GPS/Map Services
E-Retailing

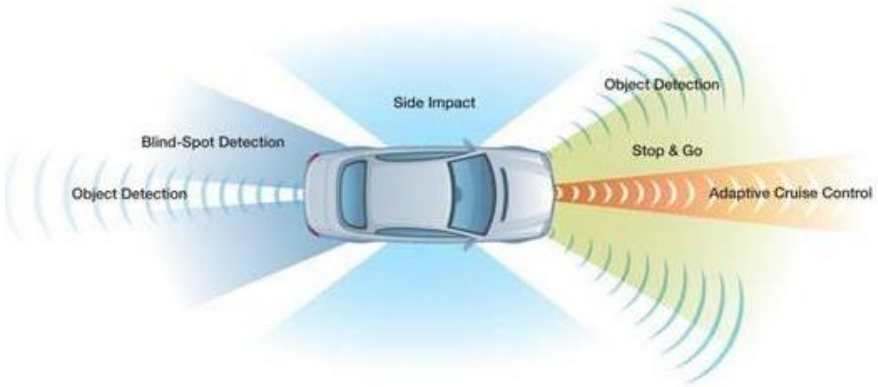


Master the wave or get washed out on GHG emissions

TODAY….ADVANCED VEHICLES IN A "SUB-ADVANCED" SYSTEM



Efficient vehicles enter an inefficient system – potentially negating efficiency gains



CAVs technology targeting safety is hitting the market.

Leveraging advances in safety to hit energy and emissions goals while improving overall mobility

INTRODUCING TRANSPORTATION-AS-A-SYSTEM

Our Proposal:
Explore untapped system-level efficiencies at planning and operations timescales

- Today:
  - Vehicle-level focus
  - Independent
  - Unconnected
  - Subject to behaviors & decisions
- Tomorrow:
  - System-level focus
  - Connected
  - Automated
  - In concert
  - Across modes
  - Managed behaviors & decisions
  - Agencies working together (energy, safety, mobility)

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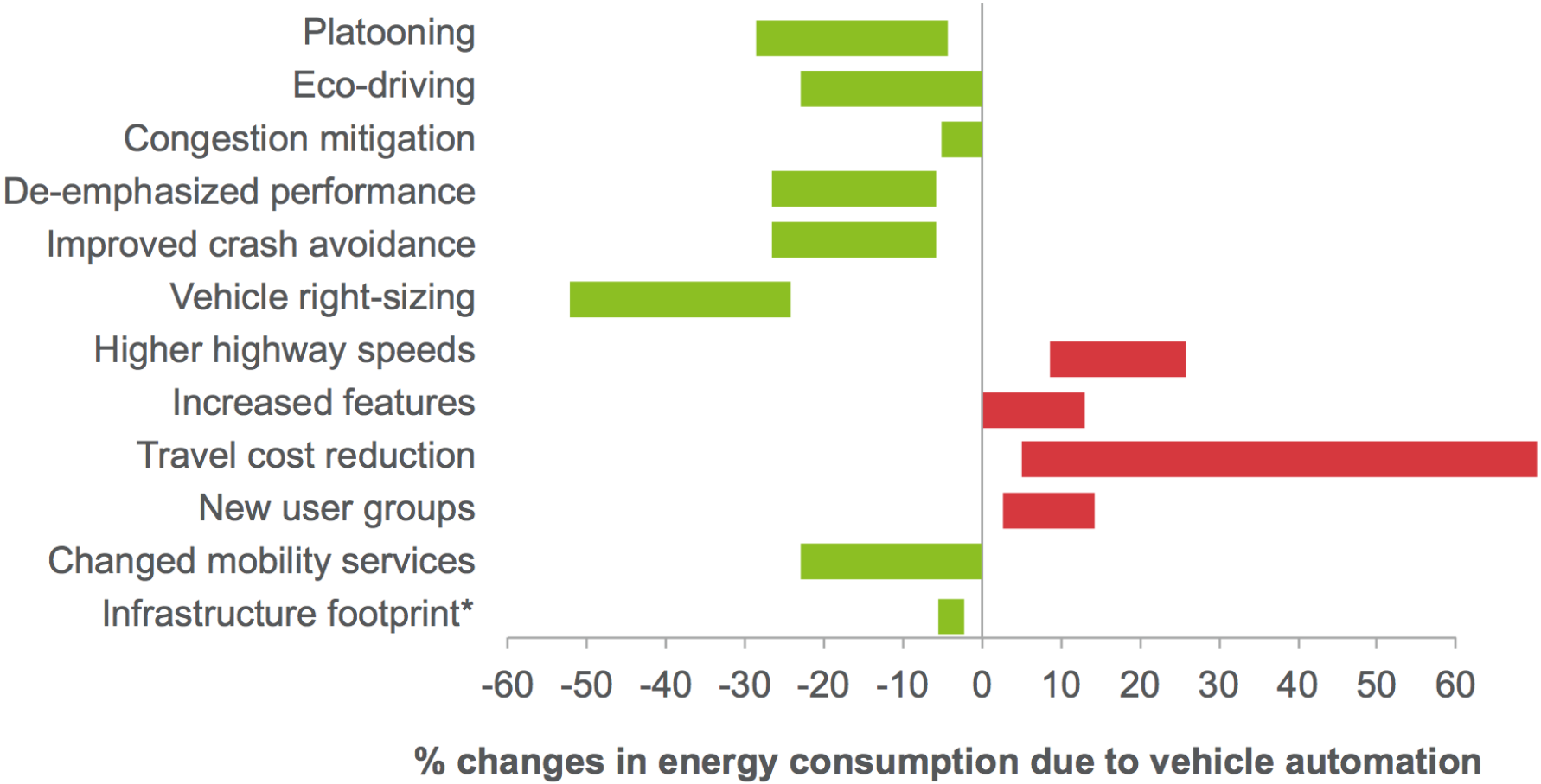
THE WAVE….CAVs AND MAAS, BETTER OR WORSE GHG?

- Maturation of Alt-Vehicles and MAAS (Mobility as a Service)
- Maturation of CAVs

Combination → Substantial reduction or increase of GHG?



LARGE ENERGY AND GHG EMISSIONS IMPLICATIONS

+200%

Potential Increase in Energy Consumption

2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

-90%

Vast range of energy implications … more research required

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UNLOCKING VALUE MAY UNLEASH CONSUMPTION

Travel More
Travel Faster
Modal Shifting*
Ship More Goods*

* Not included in preliminary projections

+200%

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2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

-90%

Reduce Congestion
Smooth Traffic Flow
Operate More Efficiently
Adopt More ZEVs

Will new value creation drive unbridled consumption?

INCREASINGLY COMPLEX DECISION ENVIRONMENT

Decisions
Technology
Policy
Market

+200%

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2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

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Decouple Energy from GHG Emissions

How do we transform increasing complexity into clarity for decision makers?

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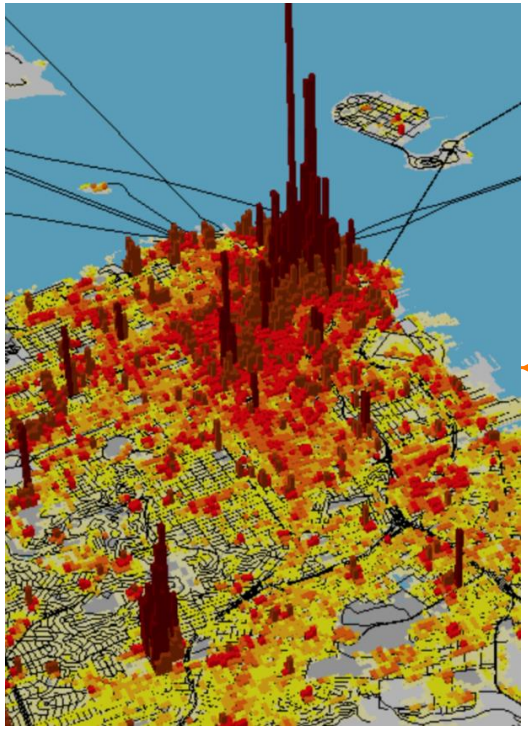
TECHNICAL APPROACH – BEGINS WITH THE END IN MIND

Cities and Regions



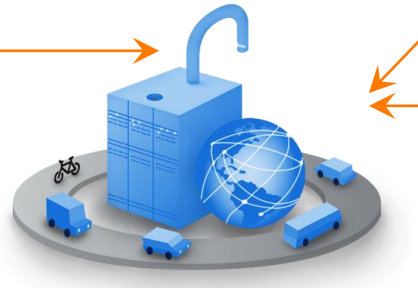
Decisions

Charging/Fueling Infrastructure

Connected Travelers

Image by NREL

Data Management



CAVs

Energy Infrastructure

More Decisions

TARGETED RESEARCH PORTFOLIO

Vehicle & Fuel Technology

Multi-modal
Transportation choices for people and freight

Automation & Connectivity
Exploiting data to reduce congestion & vehicle miles traveled, increase safety

Vehicles & Infrastructure
Fuels, roadway, and building support for new technologies

Urban Systems
Data, models and controls to manage urban systems

Behavior & Decision Science
Understanding and influencing consumer choice and travel behavior

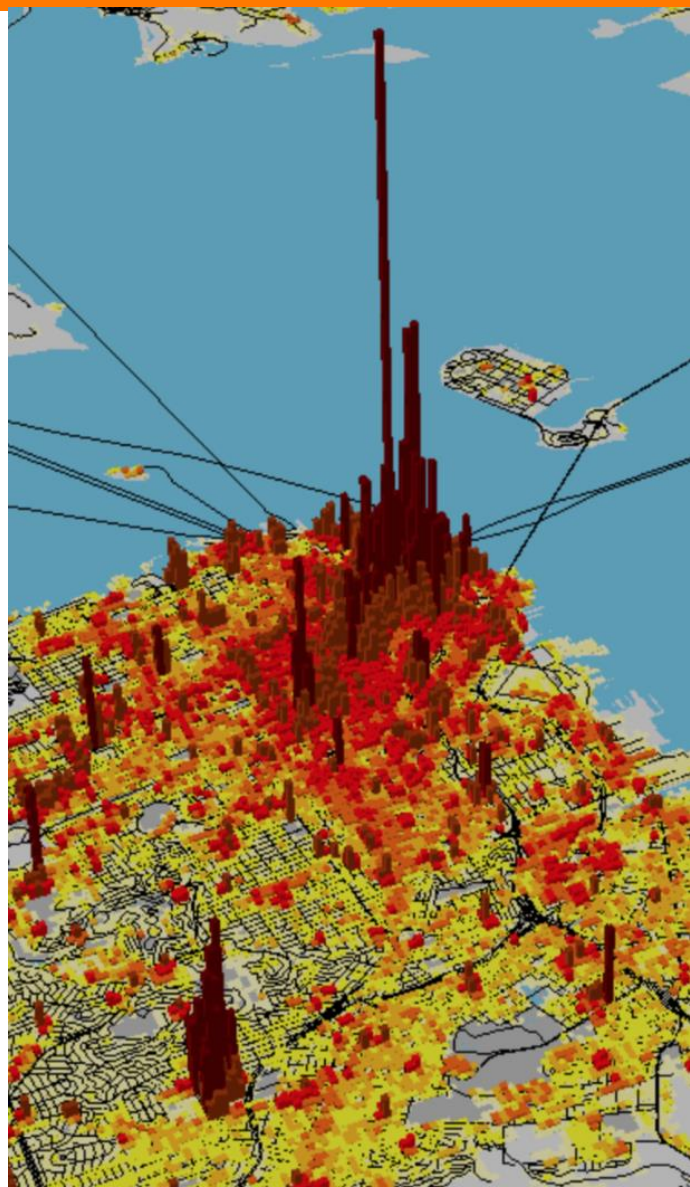
- **Market uptake of new technology**
- **Efficient traffic flow**
- **Broad selection of low-carbon fuels**
- **Reduced VMT and increased parking**
- **Healthy MaaS ecosystem**

URBAN MOBILITY SCIENCE

Expected Outcomes:

- Revealing the previously unknown: a new class of data science: urban data science
  - New city-scale computational mobility models
  - Calibrated and validated by large transportation data sets: estimation, inference, system identification
- Frameworks and analytical tools
  - Learn, create, run, optimize composite models of urban components for sustainable transportation
  - Can inform local decisions (policy making)
- **Example:** does MaaS increase or decrease VMT, volatility of travel time, energy efficiency?

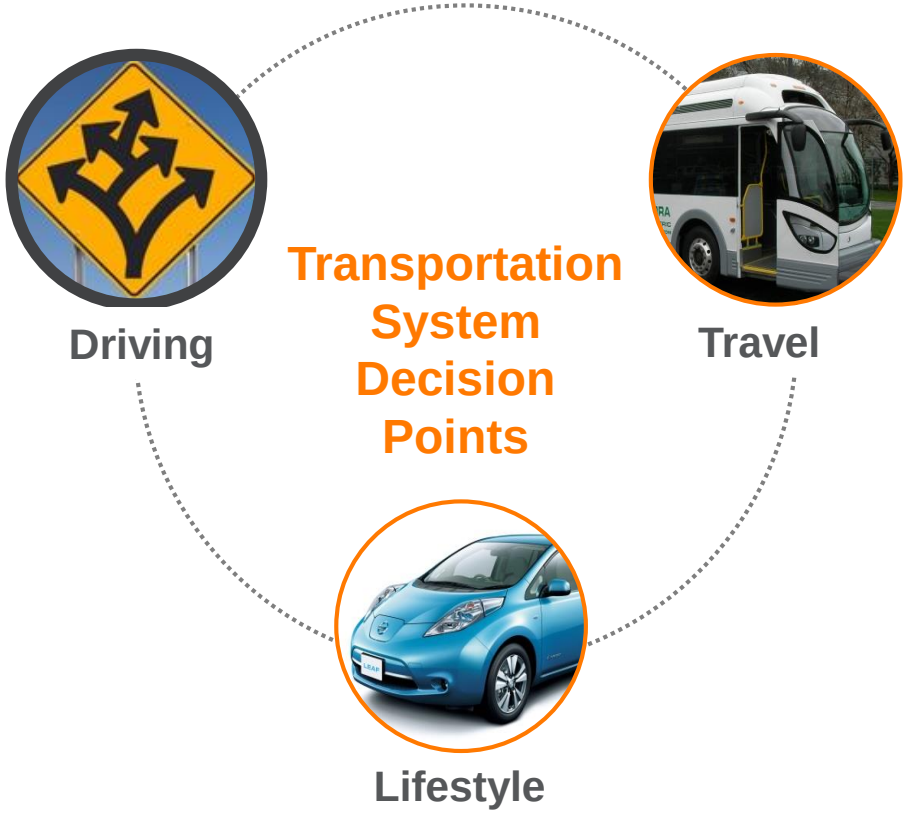
Providing scientific support to decision makers



MOBILITY DECISION SCIENCE

Expected Outcomes:

- A science of decision making:
  - Understanding of individual and market behavior: behavioral economics
  - Understanding of future technologies, policies, and transportation systems
  - Understanding of enhanced vehicle adoption and choice models
  - Information of holistic policy decisions, vehicle R&D, and infrastructure investments
- **Example:** delivery of goods to the store with the customer driving or delivery to the home



Technology and policy that anticipate how decisions are made

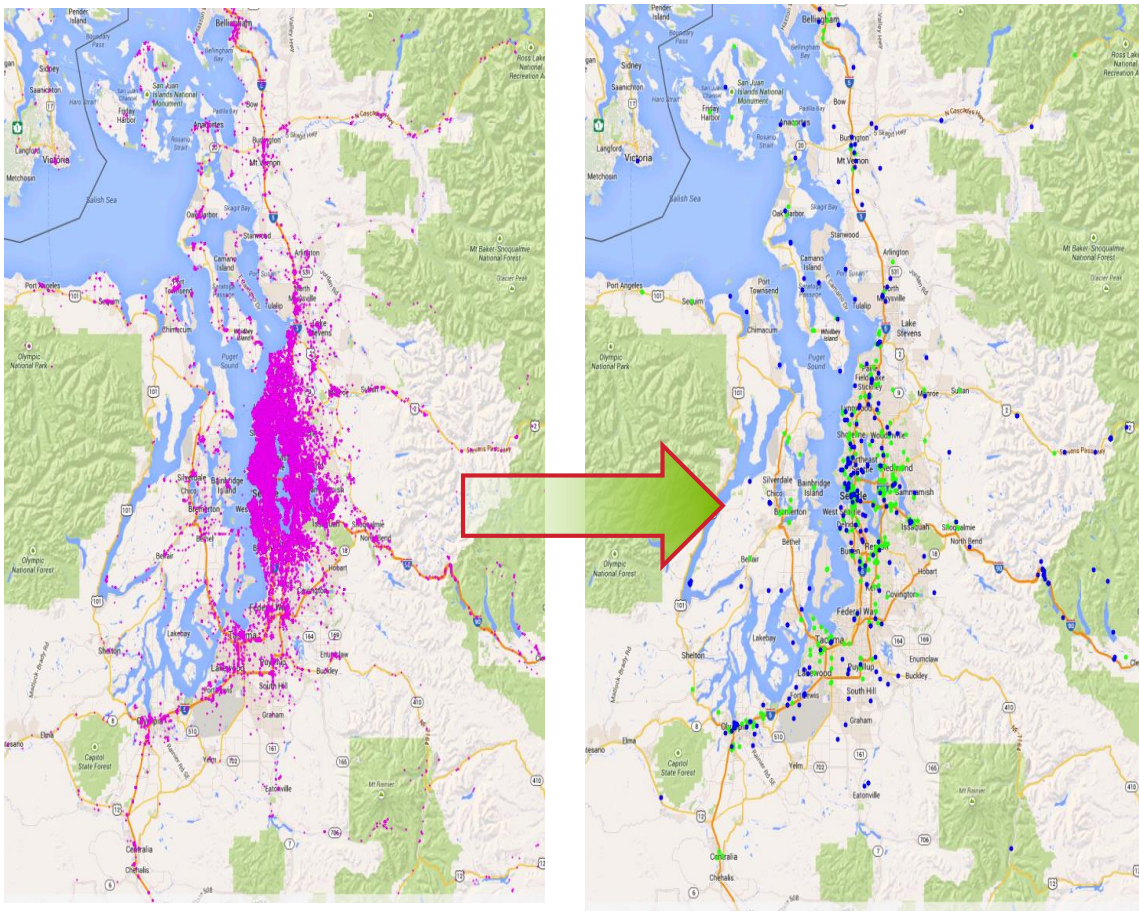
VEHICLES AND INFRASTRUCTURE

Expected Outcomes:

- Integrated modeling of vehicle and fuel technologies with consumer preferences
- Best leverage public and private resources for EV/AFV fueling infrastructure
- **Example:** charging station placement with dynamic usage

Informed infrastructure investments that drive consumer adoption

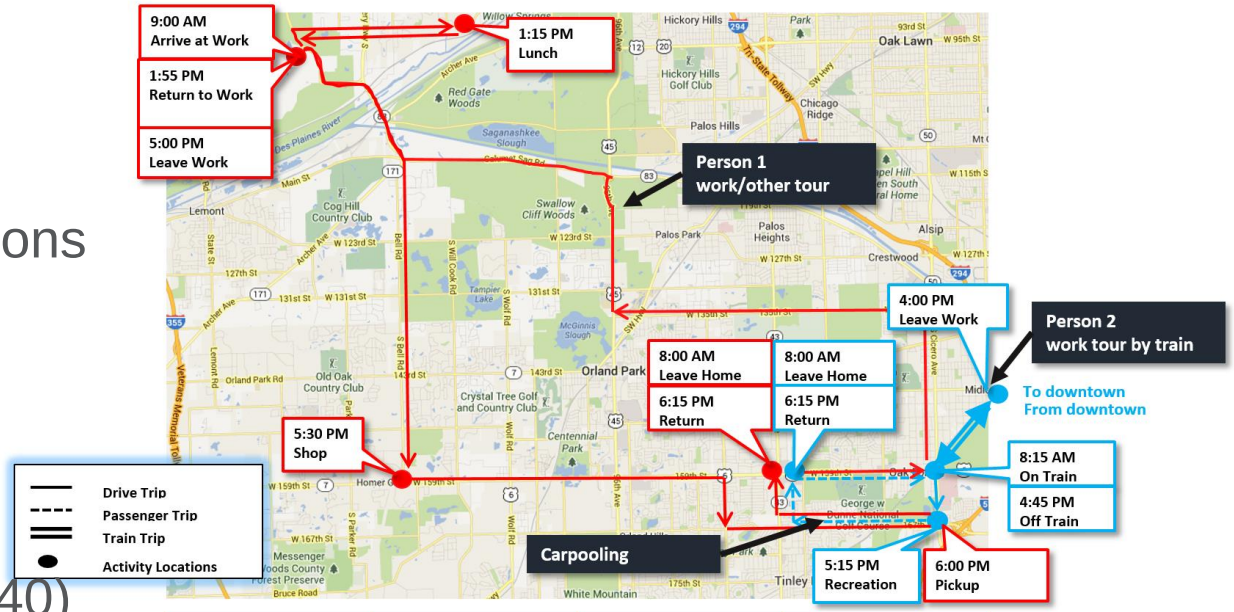
Mapping EV Technology with Travel Patterns Reduced EVSE Locations from 18,000+ to 281 in Seattle



MULTI-MODAL

Expected Outcomes:

- Quantify potential energy savings and GHG reductions
  - Diminished modality barriers
  - Passenger and freight scope
- Counteract projected growth of freight energy consumption (through 2040)
  - Leveraging of disparate modal energy intensities
  - Multiscale approach (rural, intercity, etc.)
- **Example:** Contributions of MaaS to congestion



Person	Auto VMT	Passenger MT	Transit PMT
1 (Red)	51	-	-
2 (Blue)		6	51

51 auto vehicle miles traveled

Energy-efficient, seamless multi-modal transport of people and goods

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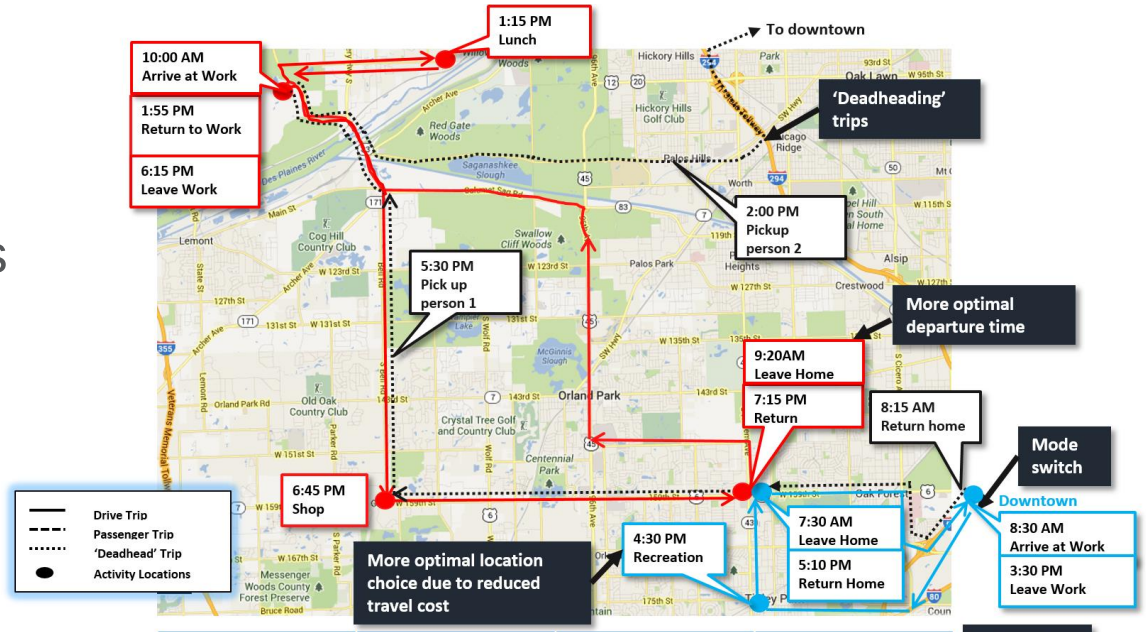

Person	Auto VMT	Passenger VMT	Transit VMT
1 (Red)	44	-	-
2 (Blue)	60	-	-
Empty (Black)	70	-	-

174 auto vehicle miles traveled, increase of ~200%

Reduced carpooling

Energy-efficient, seamless multi-modal transport of people and goods

CONNECTED & AUTOMATED VEHICLES (CAVs)

Expected Outcomes:

- Quantify the energy impact of CAVs
  - Multi-scale
  - Multiple scenarios
  - Different technologies
- Identify CAV-enabled opportunities
  - Vehicle electrification
  - Lightweighting
  - Powertrain optimization
  - Vehicle utilization
- Inform policy/research on CAVs
  - Maximize sustainability impacts
- Address the barriers to CAVs
  - Cost, cyber security, bandwidth
- **Example:** platooning and traffic flow smoothing

Designing for the nexus of safety, energy, and mobility

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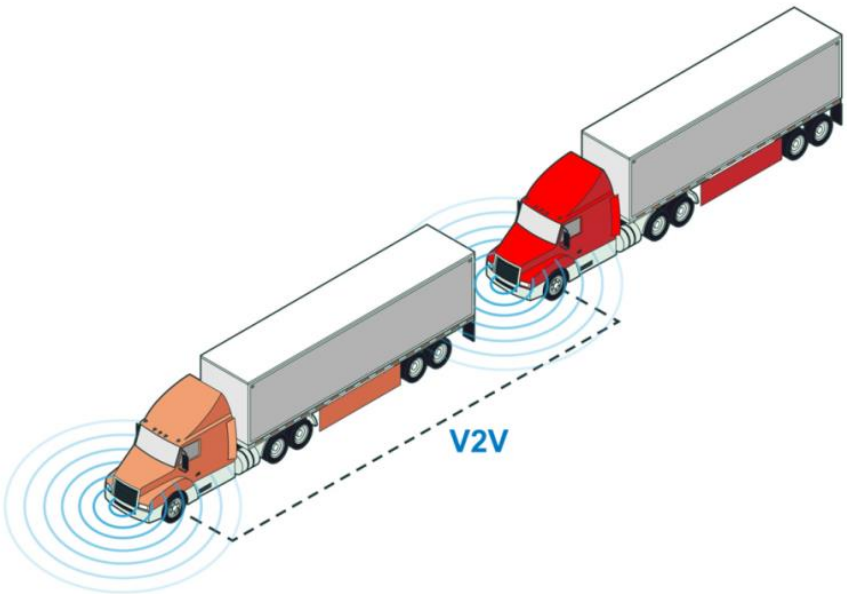
CAVs - PILOT AND DEMONSTRATIONS

Semi-Automated Platooning (NREL, Peloton, Paccar, Intertek)

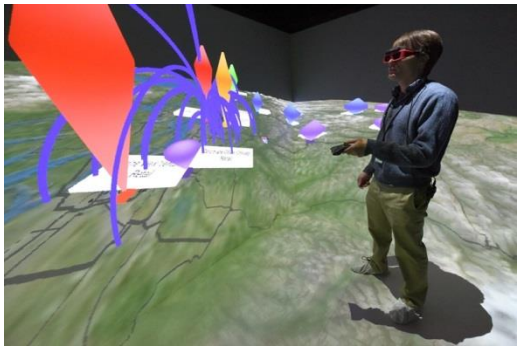
3.7 – 6.4% Team Savings



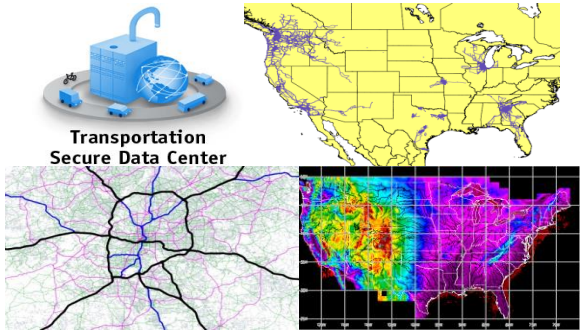
EERE Incubator Award (U of M, ANL, INL) 500 Vehicle Fleet

Improving our ability to predict the energy impact of CAV's

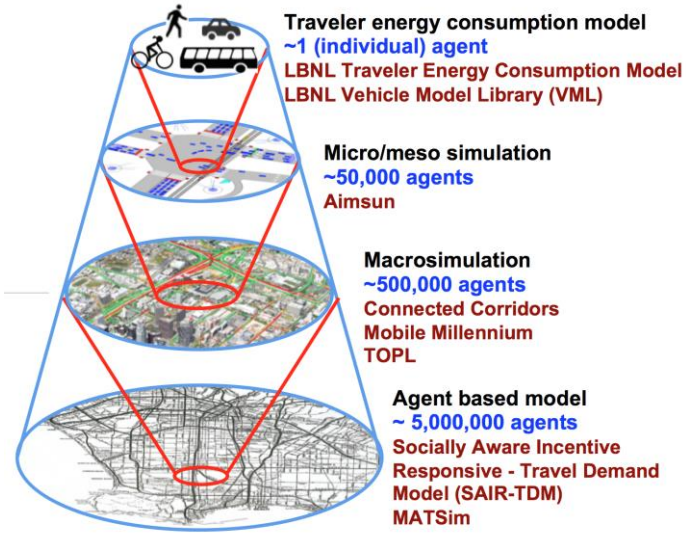
LABORATORY RESOURCES - COMPLEMENTARITY



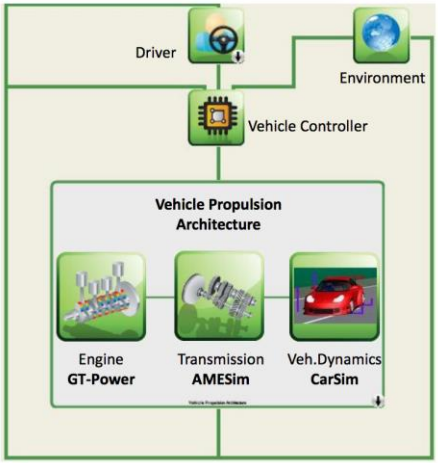
Automation tools



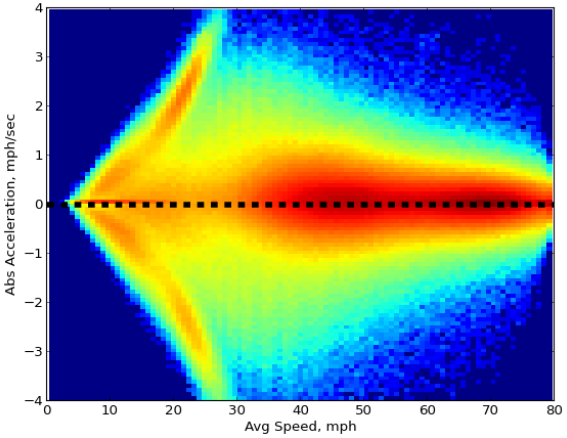
Massive data feeds



Multiscale mobility models



Propulsion / powertrain
Modeling systems



HPC architecture and systems

Landuse models and regional models

DOE SMART MOBILITY

U.S. DEPARTMENT OF ENERGY

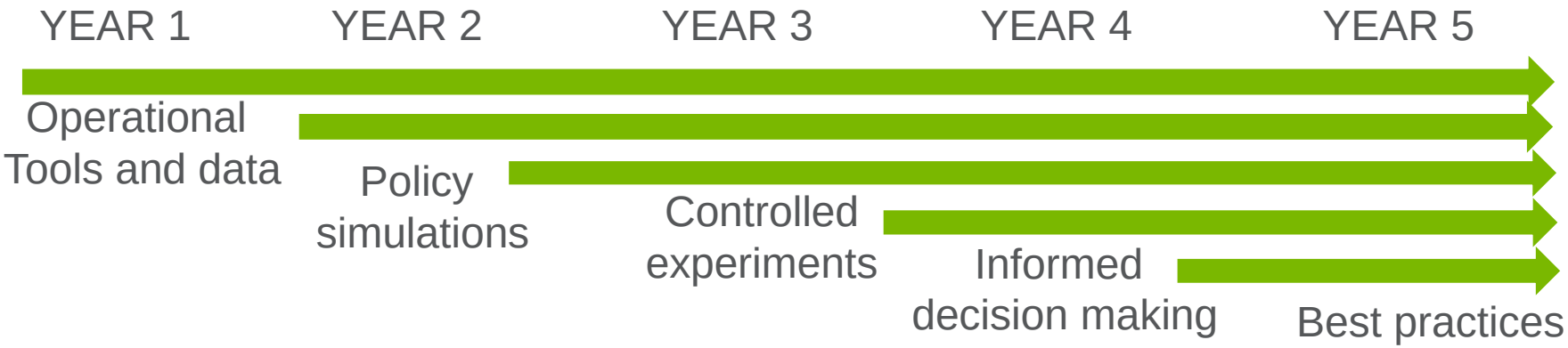
SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Multi-lab consortia exploring the nexus of energy and future mobility paradigms

WHAT DEFINES SUCCESS?

- New science, data, calibrated models and tools exist for planning and operations, to include energy and support policy decisions
- Consumers, regulators, industry, and policy developers understand the energy impacts of new approaches
- DOE receives vital feedback for its technology portfolio
- Nation is poised to adopt new technologies and policies
- Later benefits (beyond successes): drivers embrace the opportunity of unburdened travel



PARTNERSHIPS ARE KEY

ALIGNMENT WITH SMART CITIES

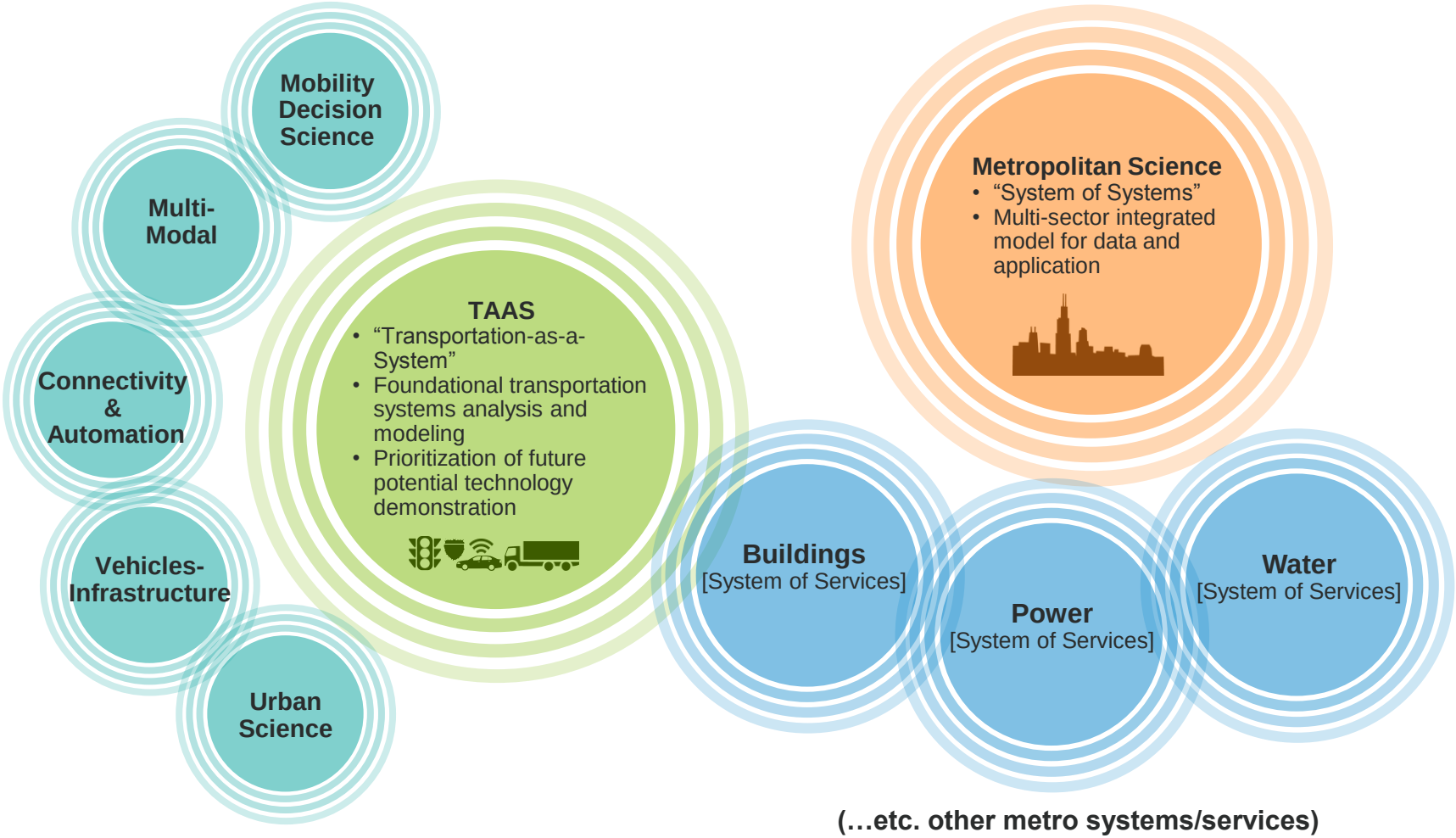
TAAS examines the nexus of energy and mobility for future transportation systems (in collaboration with and support of Smart Cities, where appropriate)

"Smart Cities" harnesses data to continuously improve the collection, aggregation, and use of data to improve the life of their residents

TAAS Consortium	Smart Cities Key Strategies[1]
▪ Combination of existing applications into and development of entirely new systems-based collaborative models ▪ Focused technology demonstrations	▪ Test beds for "Internet of Things" applications and developing new multi-sector collaborative models
▪ Collaboration with broader stakeholder network, including state and municipal governments, planners, and data scientists	▪ Collaborating with the civic tech movement and forging intercity collaborations
▪ Building on and unifying existing foundational efforts exploring transportation as a system	▪ Leveraging existing Federal activity
▪ Planning coordination with the International Energy Agency's Connected and Automated Vehicles (CAVs) Task	▪ Pursuing international collaboration

[1]https://www.whitehouse.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help

TAAS AND METROPOLITAN SCIENCE: COMPLEMENTARY BUT DISTINCT



(…etc. other metro systems/services)

Transportation-as-a-System offers a unique opportunity to analyze challenges/opportunities for energy-efficient mobility systems for people and goods.

OUR GREATEST RESOURCE

LAB	STEERING COMMITTEE MEMBERS		
ANL	Ann Schlenker	aschlenker@anl.gov	630 252 5542
INL	Kev Adjemian	kev.adjemian@inl.gov	208 526 0121
LBNL	Alexandre Bayen	bayen@lbl.gov	510 642 3585
NREL	Chris Gearhart	Chris.Gearhart@nrel.gov	303 275 3830
ORNL	Ron Graves	gravesrl@ornl.gov	865 946 1226

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