SEPTEMBER 24, 2020

U.S. DEPARTMENT OF ENERGY SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

# SYSTEMS-LEVEL TRANSPORTATION SIMULATION: CREATING THE SMART MOBILITY MODELING WORKFLOW

**DAVID ANDERSON**
Program Manager
Energy Efficient Mobility Systems (EEMS)
Vehicle Technologies Office
U.S. Department of Energy

For more information, contact:
eems@ee.doe.gov

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Argonne NATIONAL LABORATORY · BERKELEY LAB · INL Idaho National Laboratory · NREL NATIONAL RENEWABLE ENERGY LABORATORY · OAK RIDGE National Laboratory

# MOBILITY: CONNECTING PEOPLE TO OPPORTUNITY

The solutions we are developing will power the next transportation revolution, ushering in a new era of

**SMART Mobility.**

# TRANSPORTATION IS FUNDAMENTAL TO OUR WAY OF LIFE

**Population density** is increasing — 75% of the population lives in urban mega-regions.

More **congestion** leads to increased **greenhouse gases** and **pollution**.

**Transportation costs** are high — second only to housing expenses.

# SMART MOBILITY CONSORTIUM

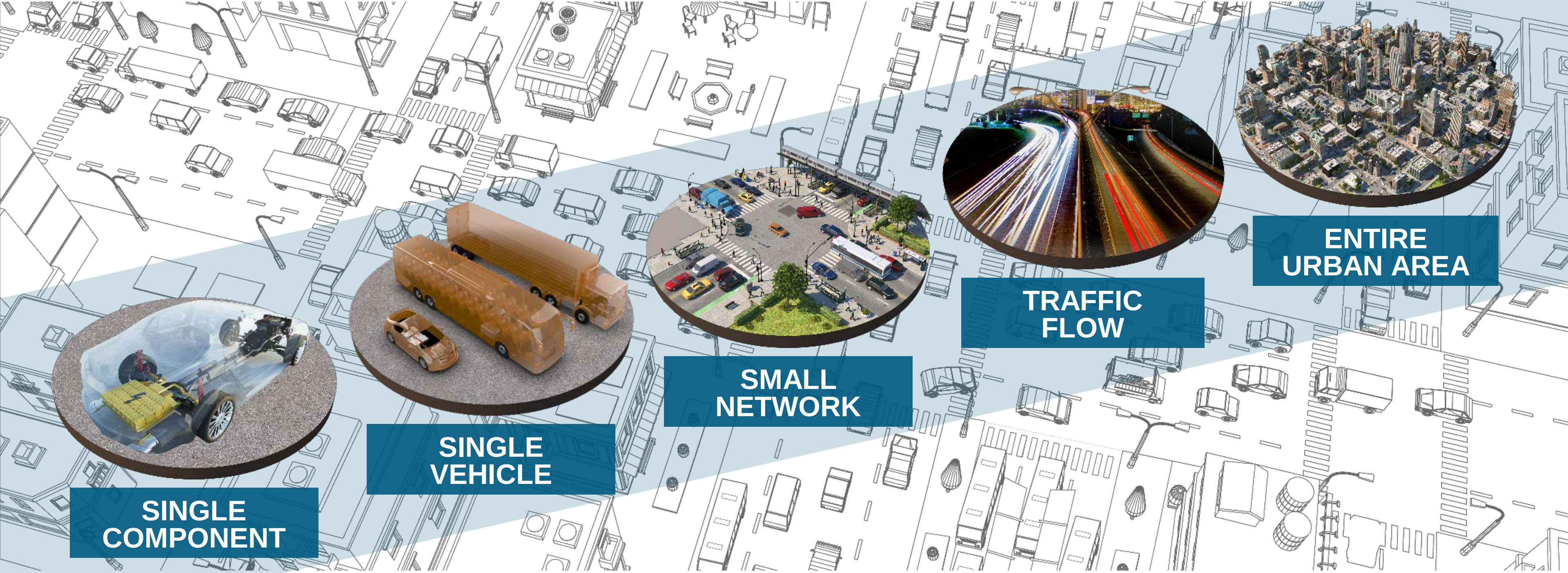
**The SMART Mobility Consortium is a multi-year, multi-laboratory collaborative dedicated to further understanding the energy implications and opportunities of advanced mobility solutions.**

Argonne NATIONAL LABORATORY
BERKELEY LAB
INL Idaho National Laboratory
NREL NATIONAL RENEWABLE ENERGY LABORATORY
OAK RIDGE National Laboratory

# Mobility

The quality of a network or system to connect people to goods, services, and employment that define a high quality of life.

# VTO SYSTEMS-LEVEL R&D



# FIVE RESEARCH FOCUS AREAS

### CONNECTED AND AUTOMATED VEHICLES

Identifying the energy, technology, and usage implications of connectivity and automation and identifying efficient CAV solutions.

### MOBILITY DECISION SCIENCE

Understanding the human role in the mobility system including travel decision-making and technology adoption in the context of future mobility.

### MULTI-MODAL FREIGHT

Evaluating the evolution of freight movement and understanding the impacts of new modes for long-distance goods transport and last-mile package delivery.

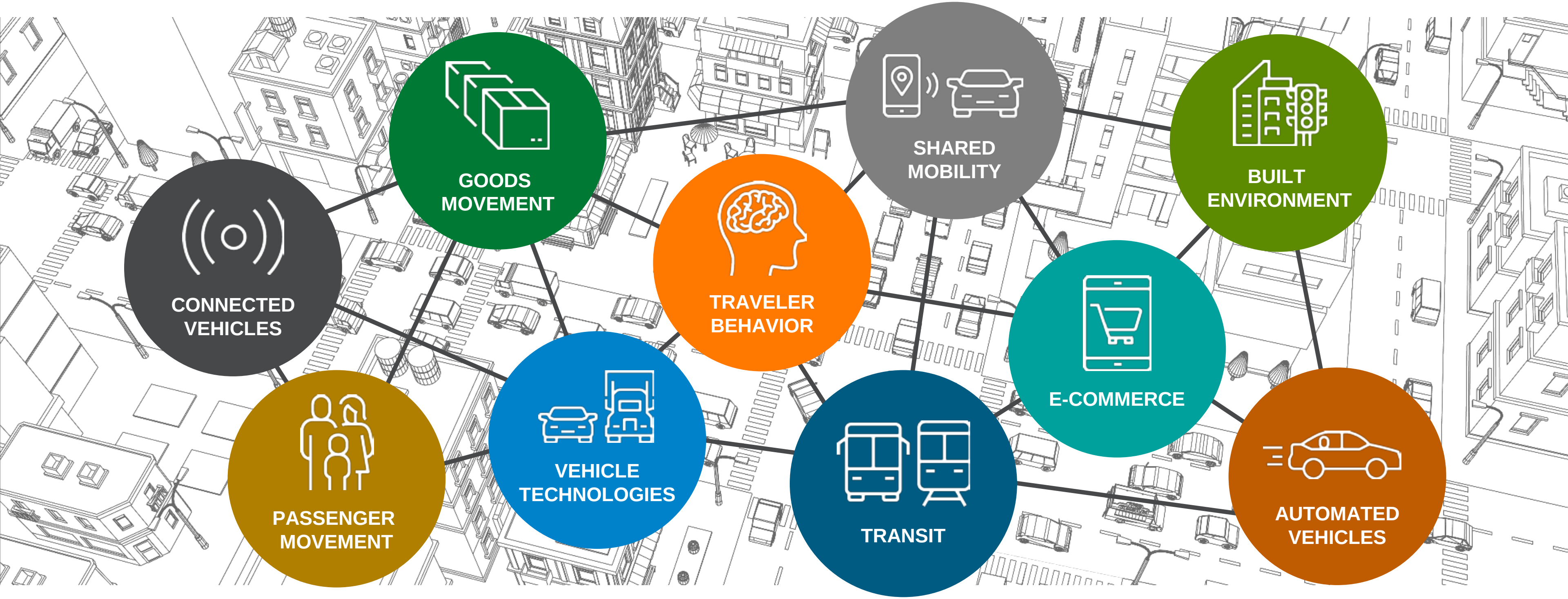
### URBAN SCIENCE

Understanding the linkages between transportation networks and the built environment and identifying the potential to enhance access to economic opportunity.

### ADVANCED FUELING INFRASTRUCTURE

Understanding the costs, benefits, and requirements for fueling/charging infrastructure to support energy efficient future mobility systems.

# TRANSPORTATION IS A SYSTEM OF SYSTEMS





Source: Ford Motor Company



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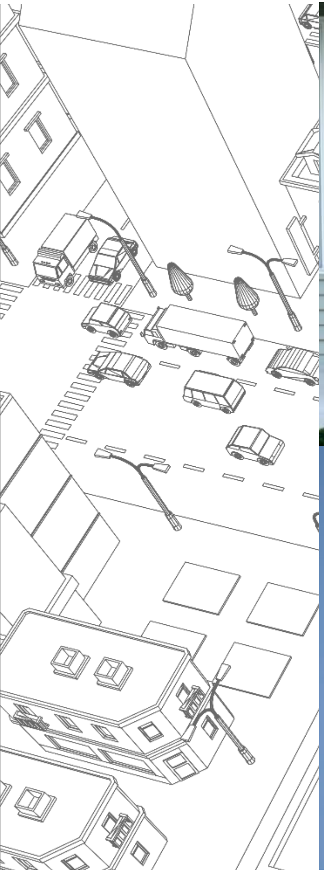

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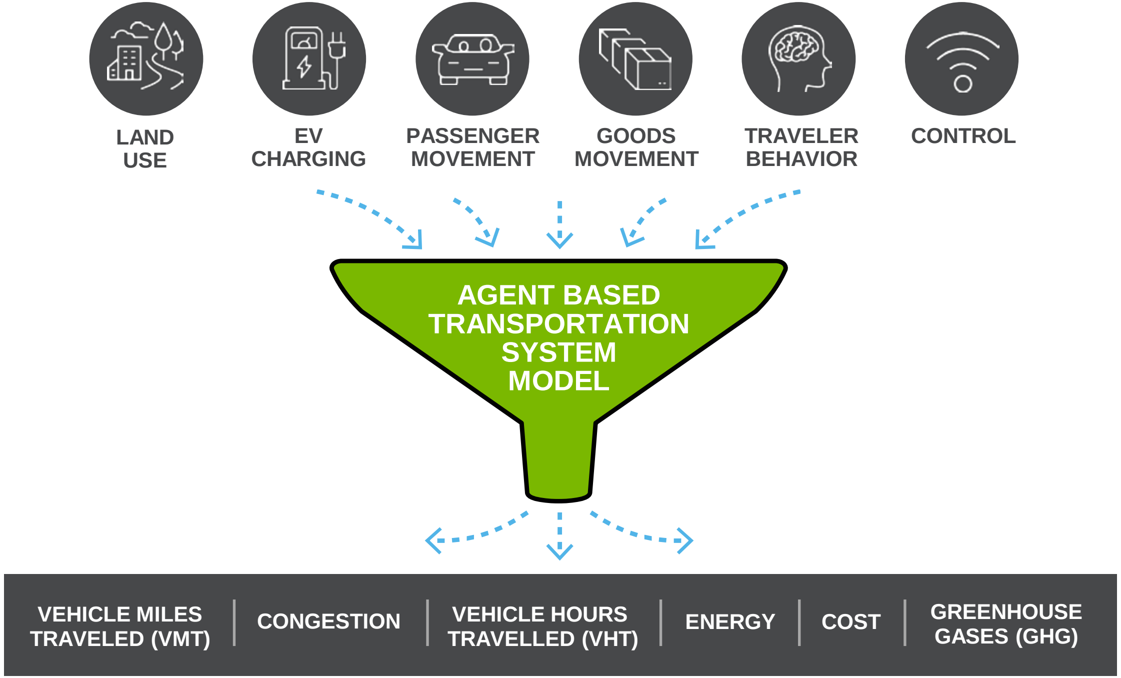
# SMART MOBILITY MODELING WORKFLOW

**By creating a multi-fidelity end-to-end modeling workflow, SMART Mobility researchers advanced the state-of-the-art in transportation system modeling and simulation.**



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# SYSTEMS-LEVEL TRANSPORTATION SIMULATION: CREATING THE SMART MOBILITY MODELING WORKFLOW

**AYMERIC ROUSSEAU**

Group Manager
Vehicle and Mobility Systems
Argonne National Laboratory

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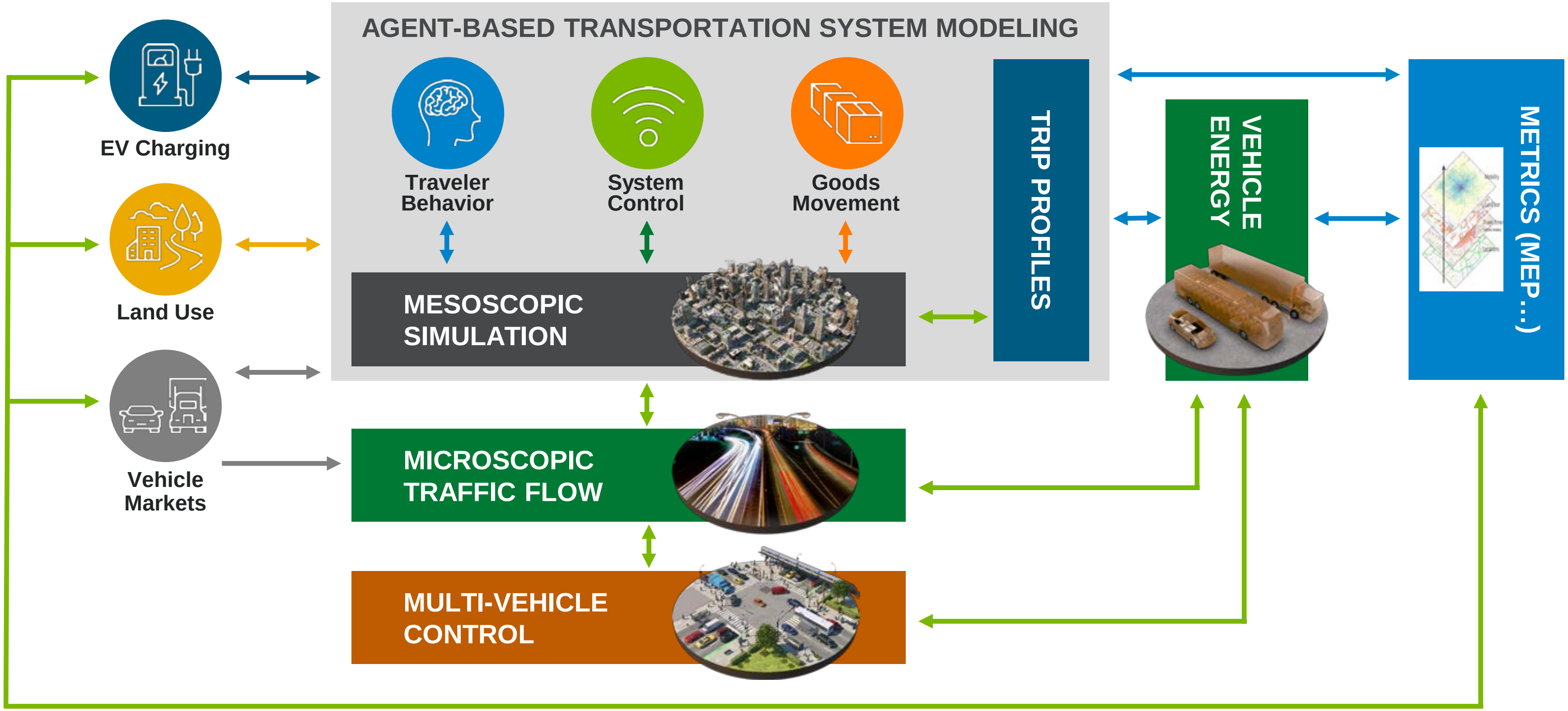
# RESEARCH QUESTIONS ARE NUMEROUS AND DIVERSE

- Will new technologies and services promote or inhibit shift of travelers to lower energy travel modes? What is the impact on VMT, energy…?
- Will these technologies encourage development further from urban areas, and thus decrease urban density?
- What changes in charging and fueling infrastructure are needed to support these technologies and services in various scenarios?
- How can traffic control infrastructure leverage the new technologies for better management of traffic and thus less energy?
- What is the energy impact and sensitivities on freight delivery vehicles?
- Will these technologies and services promote a shift from private ownership?
- What will be the impact on powertrain, vehicle design, and attribute mix? …

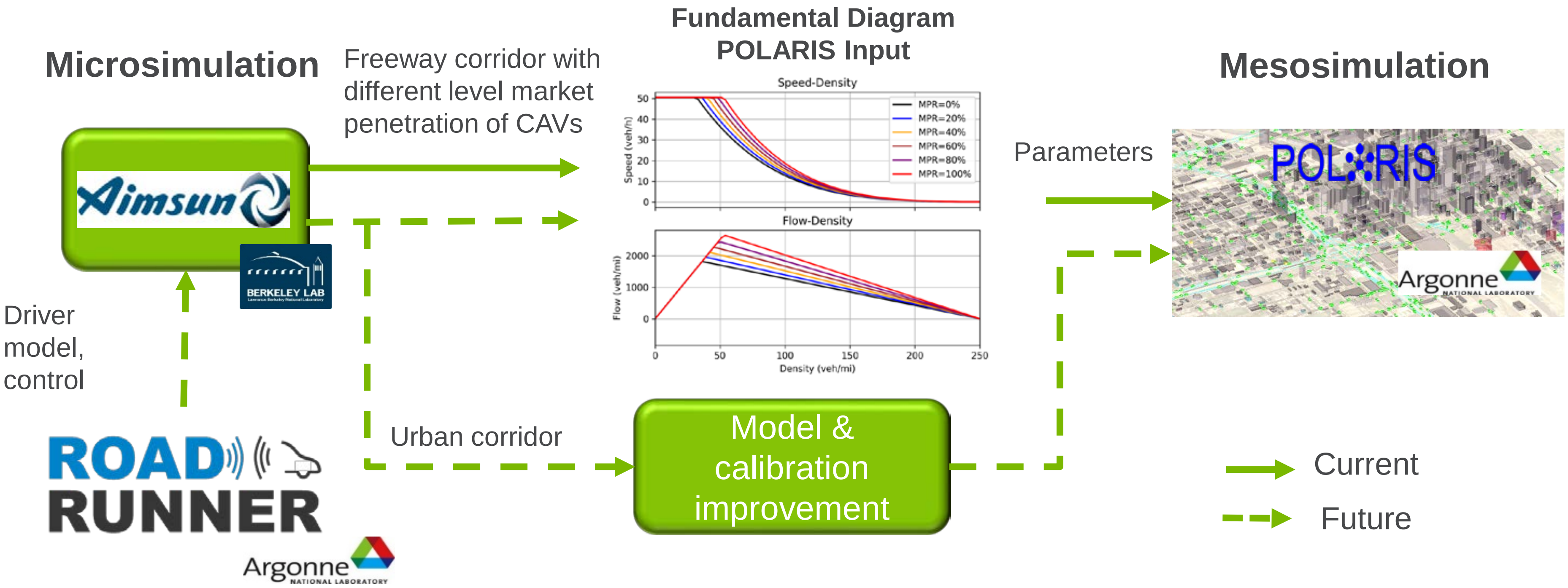
# END-TO-END MODELING WORKFLOW



# WORKFLOW DEVELOPMENT PROCESS

- 18Q3 — Model Workshop
- 18Q4 — SMART Workflow Proof-of Concept
- 19Q1 — SMART Gantt Chart developed across consortium developed scenarios
- 19Q2 — Develop & Implement processes for model I/O
- 19Q3 — Quantify energy, mobility and MEP impact of new transportation technologies
- 19Q4 — Seamless workflow leveraging expertise across multiple national research organizations

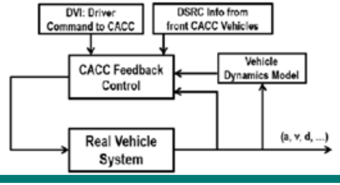
# LEARNING FROM DETAILED MODELS TO SCALE TO LARGER ONES



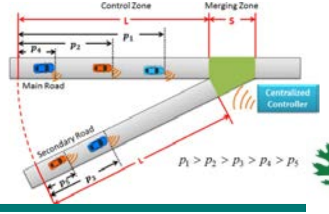

Note: Any proposed future work is subject to change based on funding levels.

# SAME MODELS USED ACROSS MULTIPLE PROJECTS

### ACC / CACC Control




### CAVs Coordination




### Travel Behavior


Individual vehicles speed

AUTONOMIE

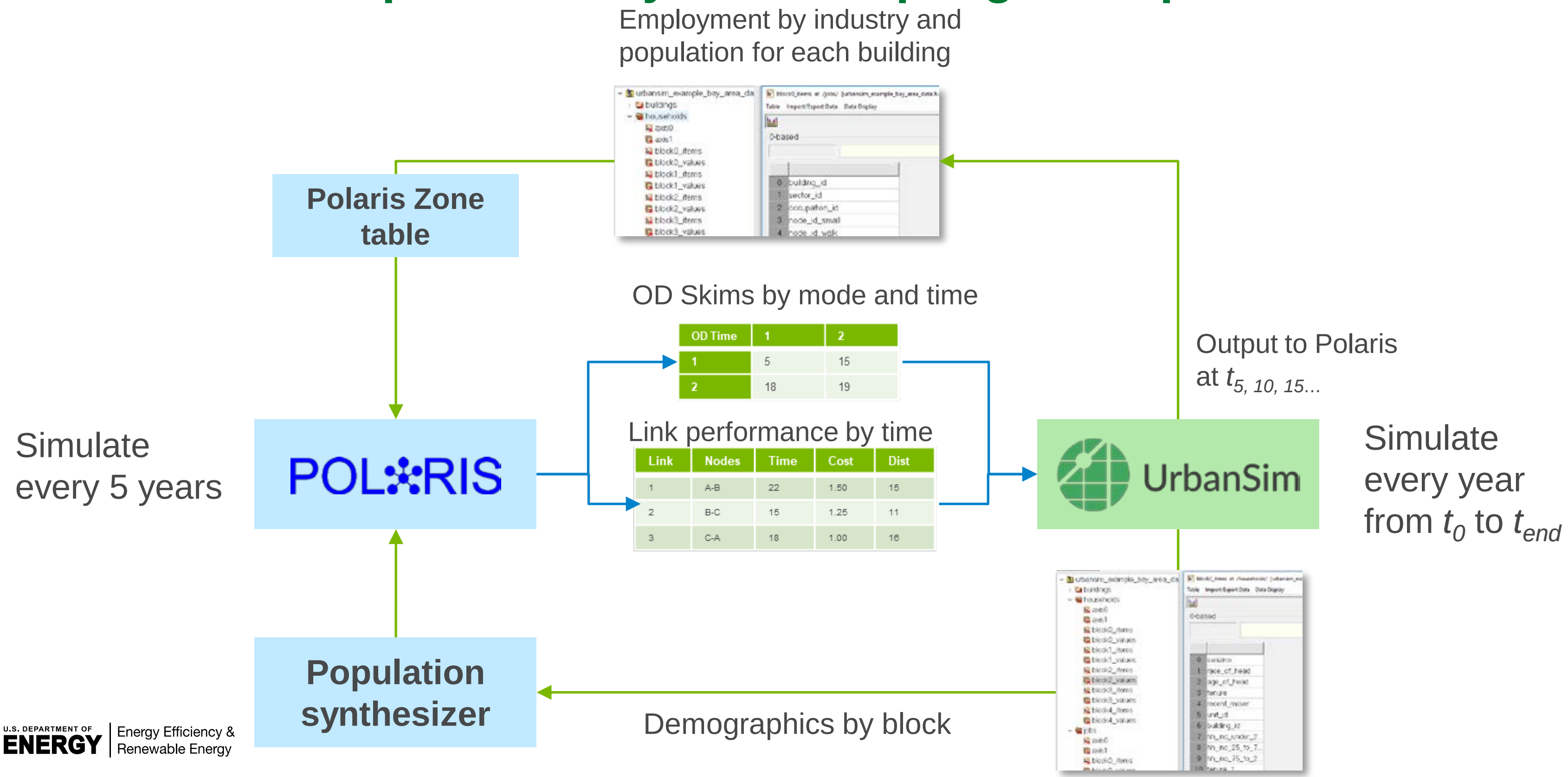
**Vehicle Models**

Vehicle energy consumption, cost…

Microscopic & Mesoscopic Simulations -> Autonomie for Energy
=> Provides consistent and comparable results

# MULTIPLE TOOLS REQUIRE ITERATIVE PROCESS

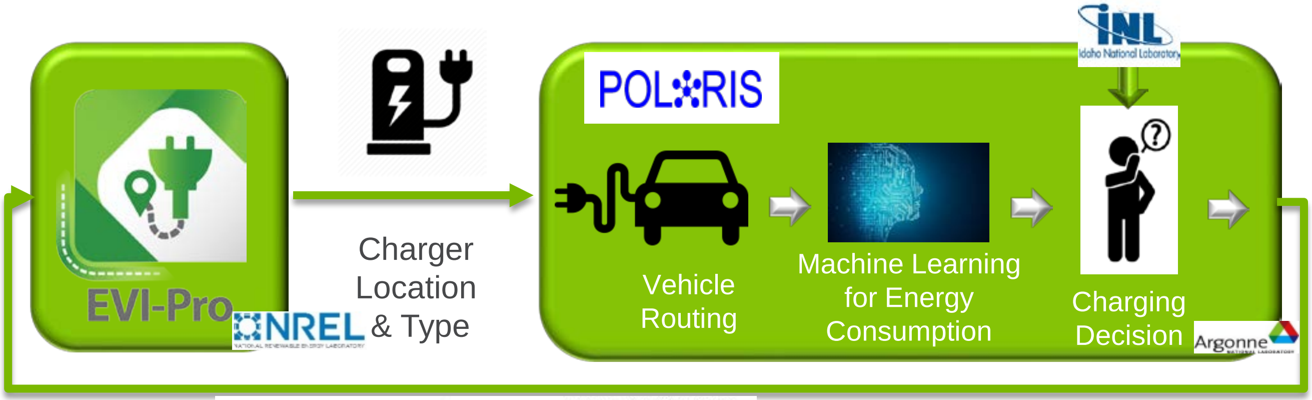
## Land Use / Transportation System Coupling Example

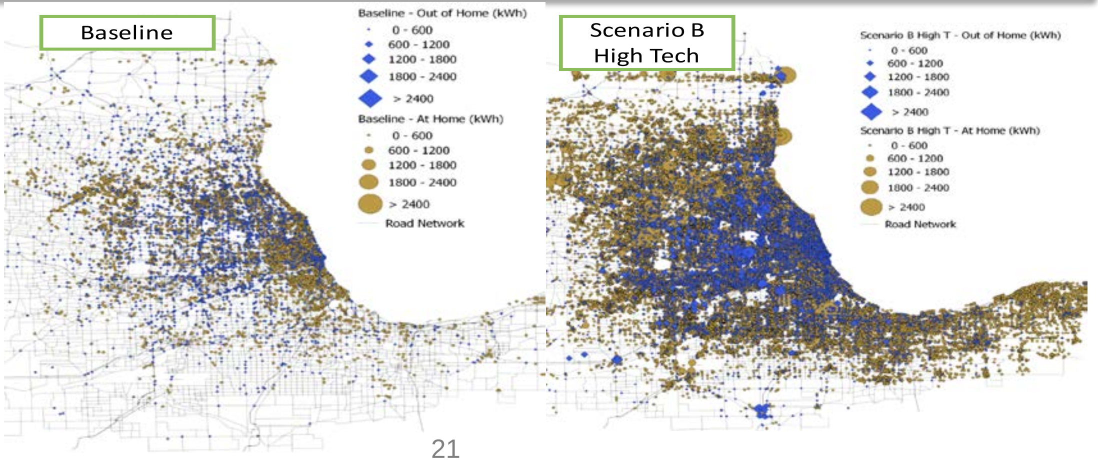



| OD Time | 1 | 2 |
|---|---|---|
| 1 | 5 | 15 |
| 2 | 18 | 19 |

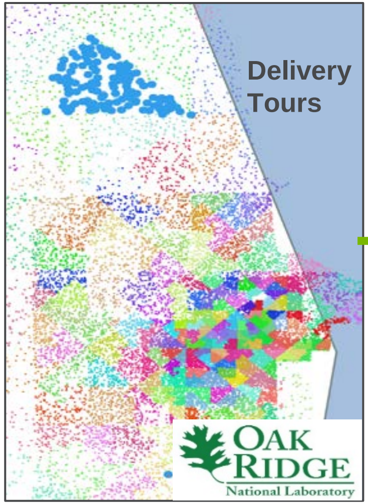
| Link | Nodes | Time | Cost | Dist |
|---|---|---|---|---|
| 1 | A-B | 22 | 1.50 | 15 |
| 2 | B-C | 15 | 1.25 | 11 |
| 3 | C-A | 18 | 1.00 | 16 |

# PEV CHARGING LOCATION AND BEHAVIOR



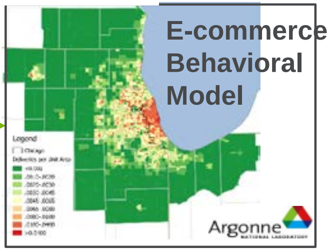



# IMPROVED SCENARIOS – FREIGHT EXAMPLE




**Base year:**
Traffic Analysis Zone - Level: Total Parcel Deliveries
Stop-Level: Random Delivery Locations
Medium Duty Delivery Tours


POLARIS




SVTRIP

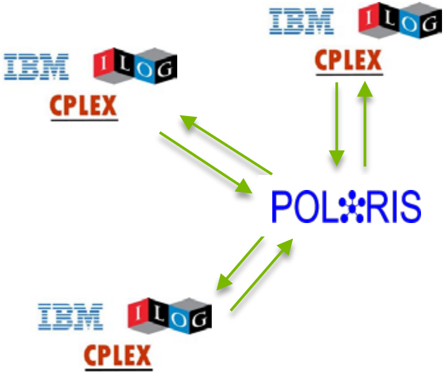
AUTONOMIE

WholeTraveler

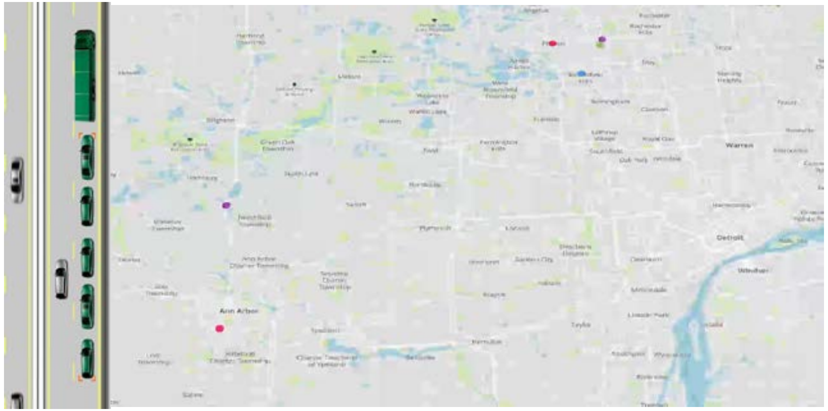
Survey Data

# HPC ENABLES OPTIMIZATION & CONTROL

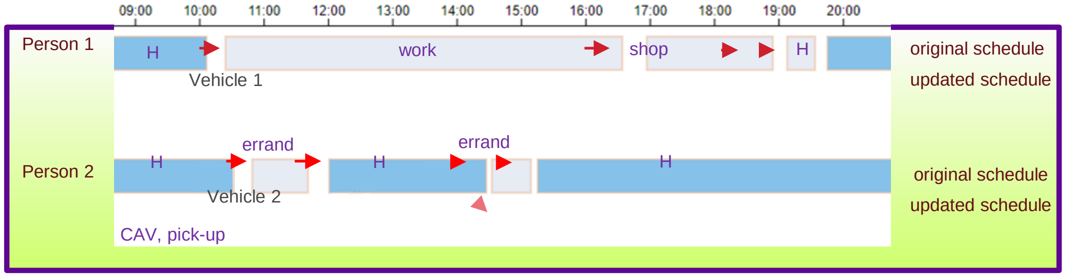
Implemented processes to efficiently link to external optimization tools




## Example: Platoon Formation Decision



## Example: Personally Owned AVs



# MAIN WORKFLOW OUTPUTS

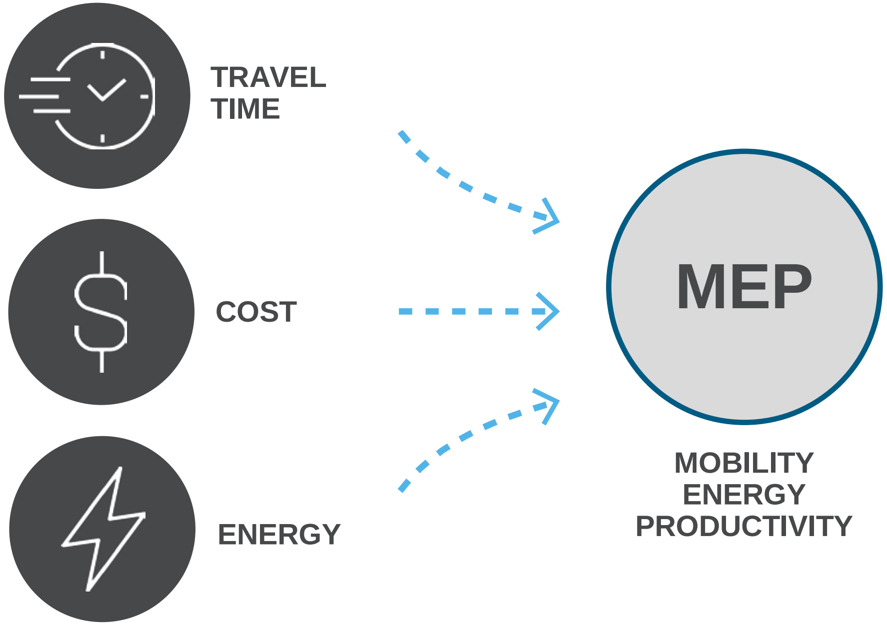
- **Vehicle miles traveled (VMT)**
  The total amount of miles traveled by all vehicles in the system for each scenario, representing a measure of the load on the system from the transportation network perspective.
- **Productive miles traveled (PMT)**
  The total amount of person-miles traveled by all travelers in any mode (i.e., cars, ride-hailing/taxi vehicles, transit vehicles, walking, and biking), plus all freight delivery miles, unloaded miles (e.g., taxi, ride-hailing vehicles, or fully automated vehicles without a passenger, freight delivery vehicles without a load).
  - *PMT represents a measure of the load on the system from a user perspective (i.e. how much mobility is the system providing). A higher ratio of PMT to VMT indicates better system performance.*
- **Vehicle hours traveled (VHT)**
  The total travel time for all vehicles in the system, representing another measure of the transportation system load. VHT increasing faster than VMT indicates growing congestion and delay in the system.
- **Productive hours traveled (PHT)**
  The total travel time for all users in the system, with users defined the same as for PMT.
- **Average vehicle travel/network speed**
  The ratio of VMT / VHT.
- **Average trip/travel speed**
  The ratio of PMT / PHT.
- **Travel efficiency**
  The average energy required to move a person or a good one mile (PMT / total energy).

# MOBILITY ENERGY PRODUCTIVITY (MEP)

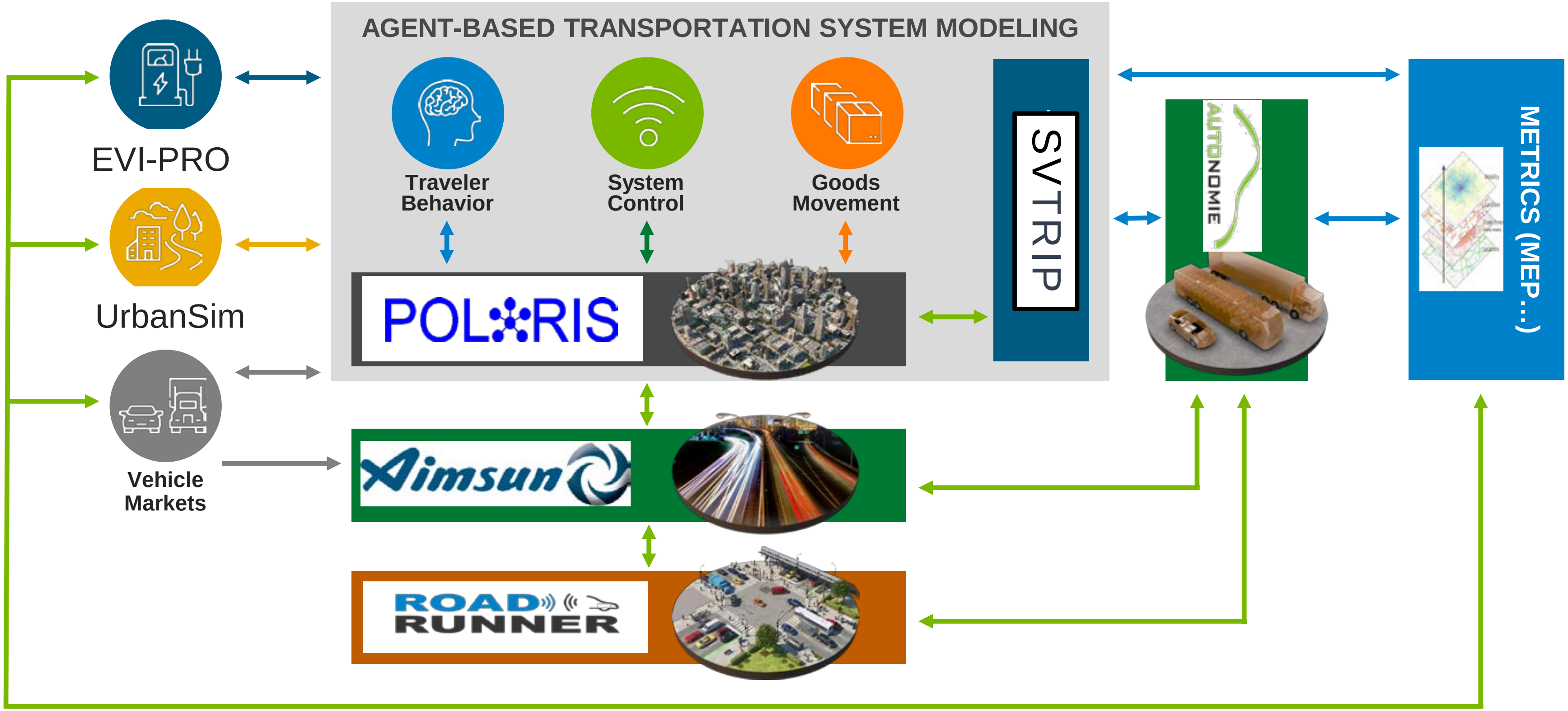
## A comprehensive mobility metric

### WHAT

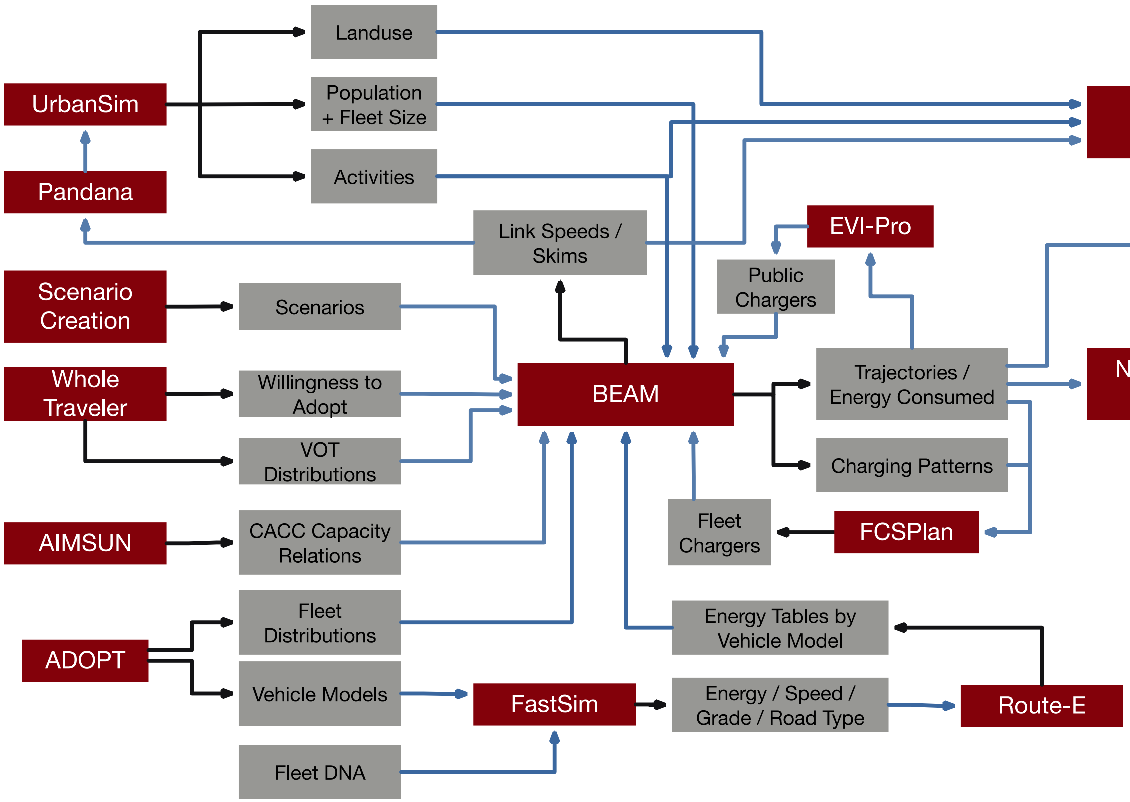
**Mobility Energy Productivity (MEP) methodology quantifies the energy, cost, and time-weighted opportunity space within a reachable area.**



# WORKFLOW IMPLEMENTATION CENTERED AROUND POLARIS



# WORKFLOW IMPLEMENTATION CENTERED AROUND BEAM

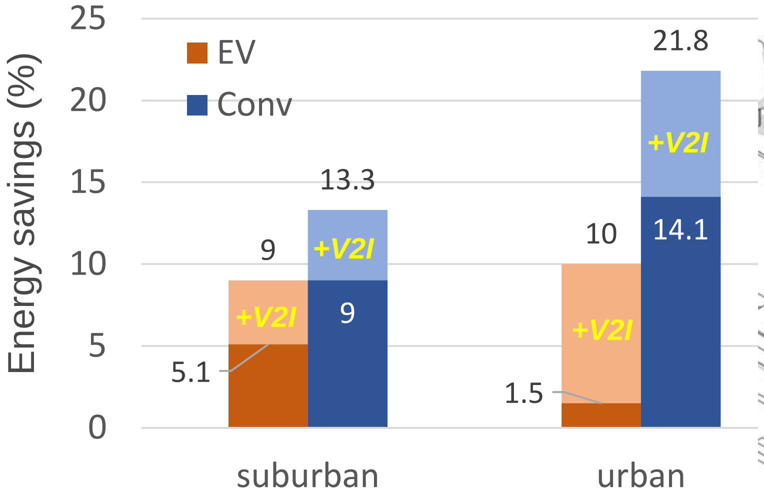


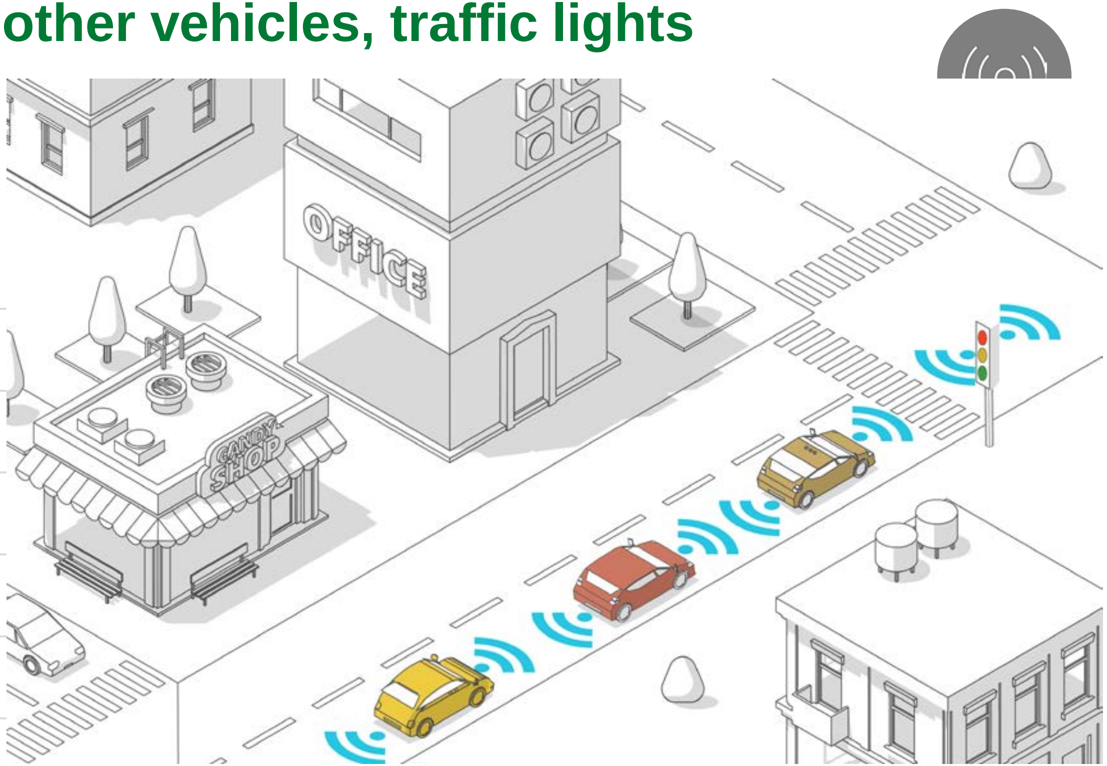
# RESULTS EXAMPLES

# VEHICLE AND POWERTRAIN CONTROL OFFER SIZABLE BENEFITS

## Adaptation to conditions, other vehicles, traffic lights

**UP TO 20% INDIVIDUAL VEHICLE FUEL CONSUMPTION REDUCTION**



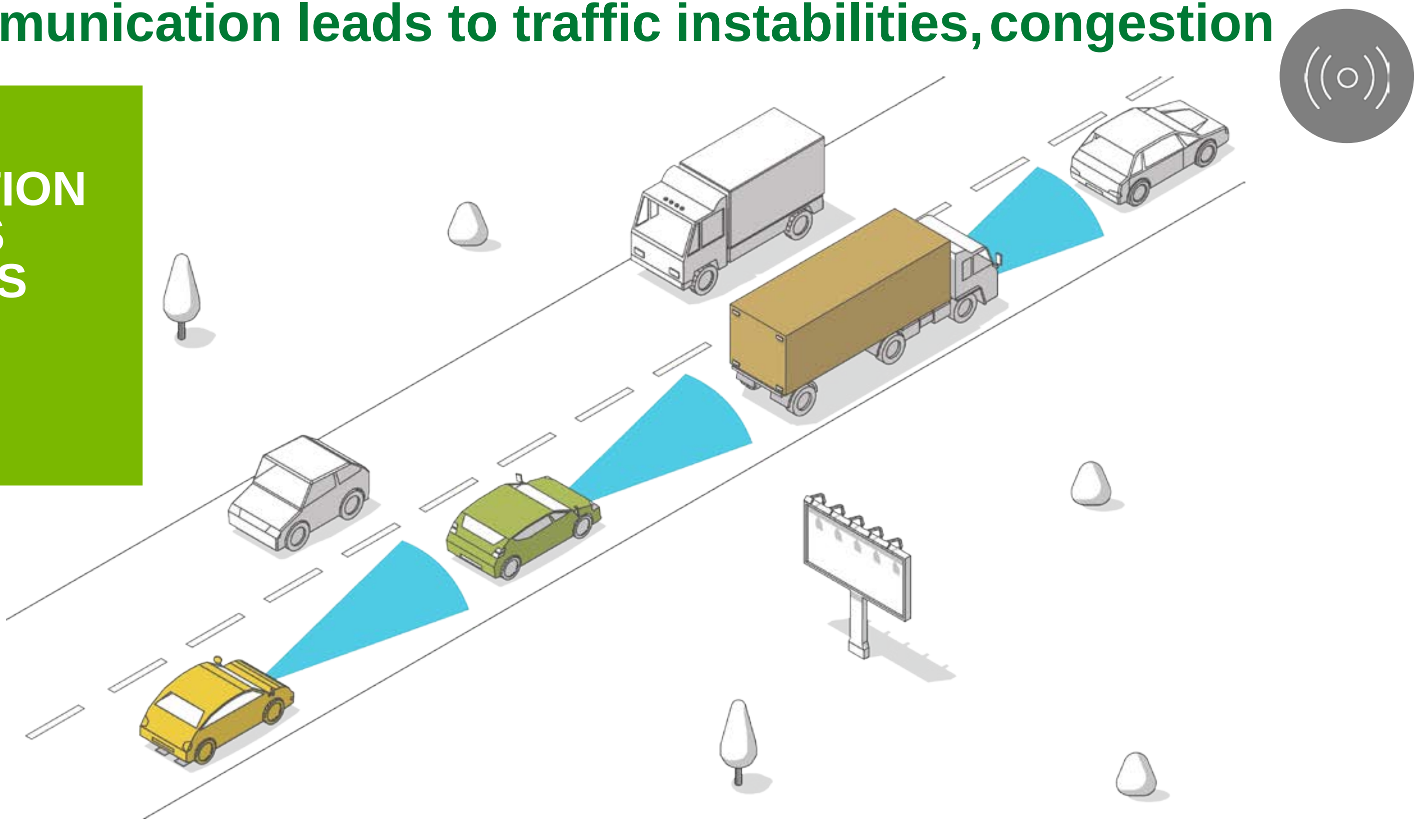



# HIGH ACC PENETRATION MAY NEGATIVELY IMPACT TRAFFIC

## Lack of communication leads to traffic instabilities, congestion

**FUEL CONSUMPTION INCREASES AS MUCH AS**

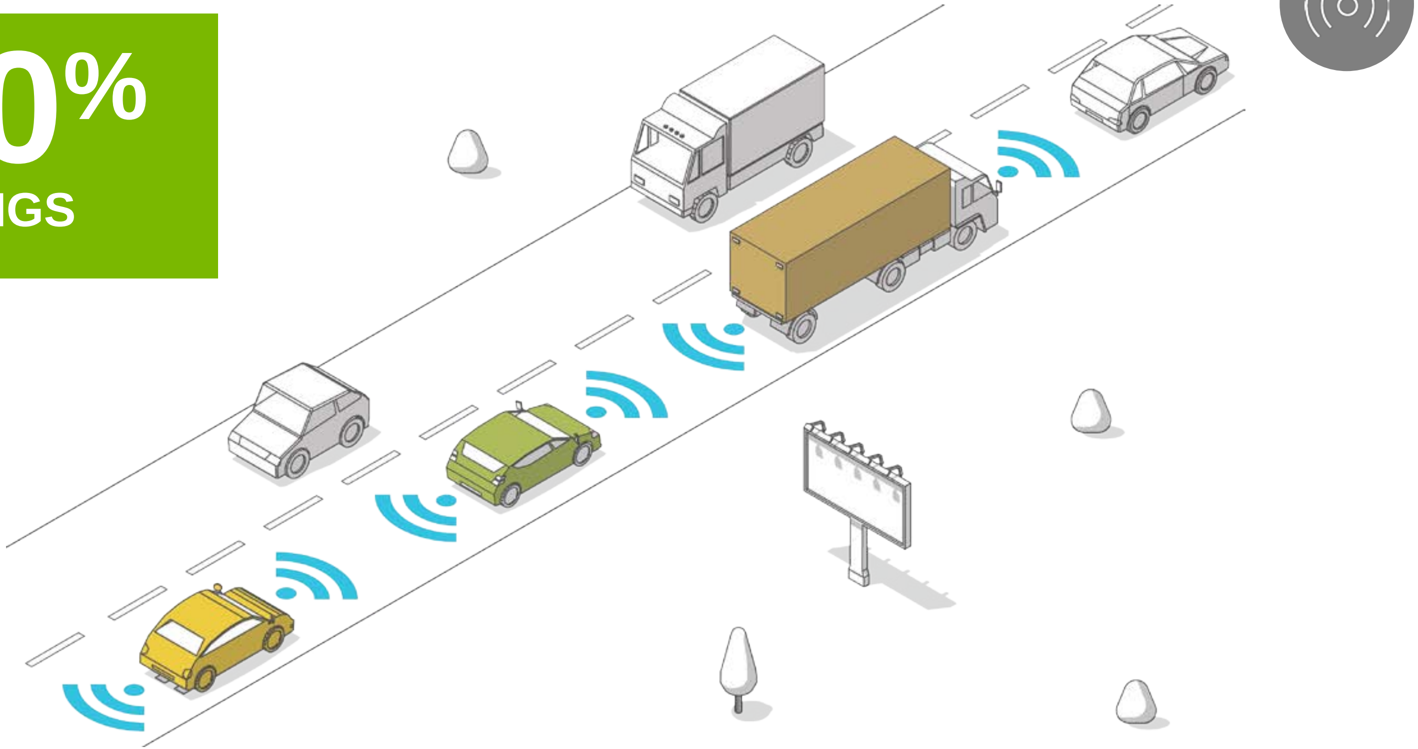
# 60%



# CACC HELPS TRAFFIC FLOW, LOWERS ENERGY USE

## Vehicle communication + automation improves traffic flow

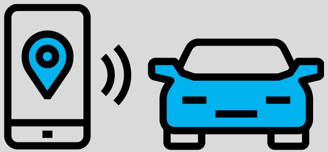
**UP TO 20% FUEL SAVINGS**



# MOBILITY SCENARIOS CONSIDERED

## A world of

### HIGH SHARING, PARTIAL AUTOMATION (A)

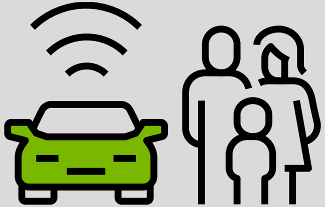


New technology enables people to significantly increase the use of **transit, ride-hailing** and **multi-modal travel. Partial automation** is introduced and is primarily used on the highway.

### HIGH SHARING, HIGH AUTOMATION (B)

Technology has taken over our lives, enabling **high usage of fully automated driverless vehicles, ride-hailing and multi-modal trips**, which are convenient and inexpensive. As a result, **private ownership has decreased**
and **e-commerce has increased**.

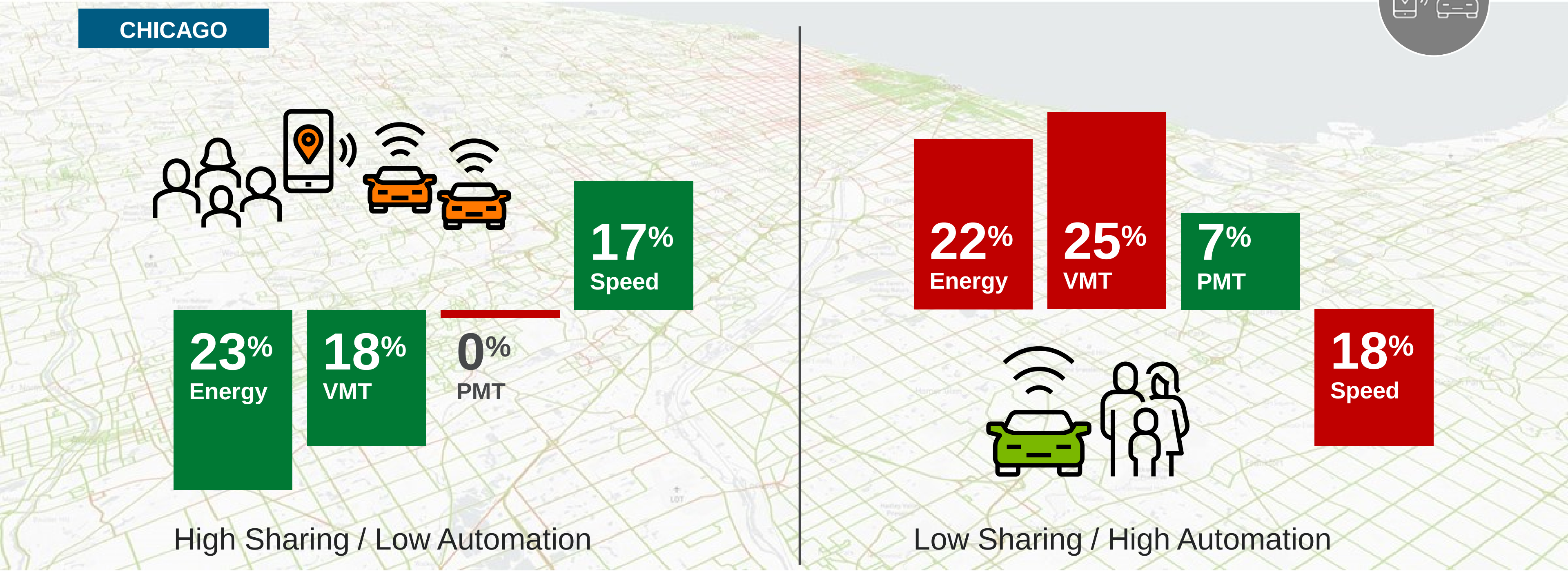
### LOW SHARING, HIGH AUTOMATION (C)



**Fully automated privately owned driverless vehicles** dominate the market. The ability to own AVs leads to **low ride-sharing** and an expansion of urban/sub-urban boundaries, while **e-commerce has increased.**

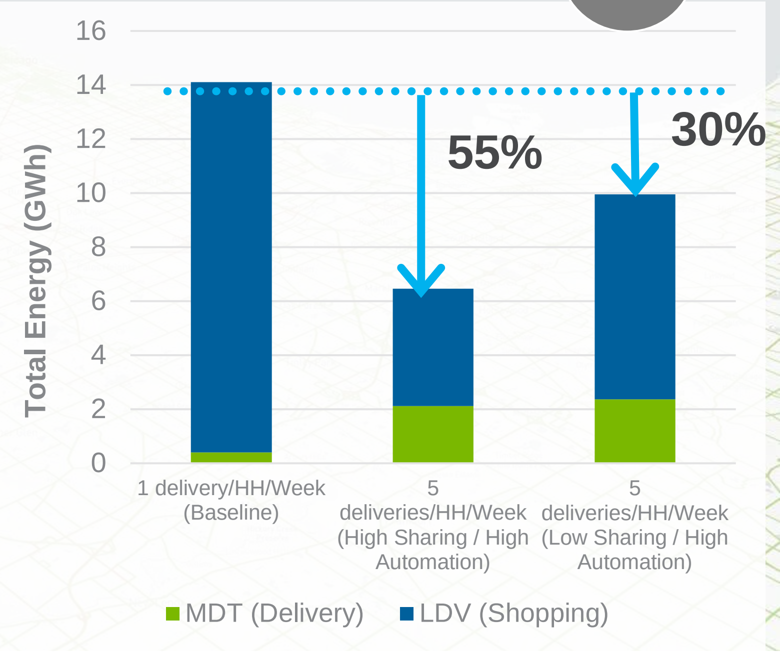
# SHARED CAVS ENABLE HIGH SYSTEM EFFICIENCY

## Compared to personally owned CAVs



# INCREASE IN E-COMMERCE LOWERS OVERALL SYSTEM VMT AND ENERGY

## Fewer shopping trips, more deliveries make the difference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SIGNAL CONTROL

**8%** REDUCTION IN TRAVEL TIME AND ENERGY

CACC

**15–25%** FUEL SAVINGS

SHARED CAVs

**18%** VMT DECREASE

PLATOONING

**7–13%** FUEL SAVINGS

VEHICLE AND POWERTRAIN CONTROL

**20%** FUEL CONSUMPTION REDUCTION

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# MOBILITY FOR OPPORTUNITY


FOR MORE INFORMATION

**David Anderson**
Program Manager
Energy Efficient Mobility Systems (EEMS)
Vehicle Technologies Office
U.S. Department of Energy
**eems@ee.doe.gov**


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