January 26, 2023

Clean Cities Coffee with a Researcher Webinar

U.S. DEPARTMENT OF ENERGY SMARTMOBILITY
Systems and Modeling for Accelerated Research in Transportation

BEAM CORE
Comprehensive Regional Evaluator

Agent-Based Model to Simulate Transportation Behaviors on a Regional Scale

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

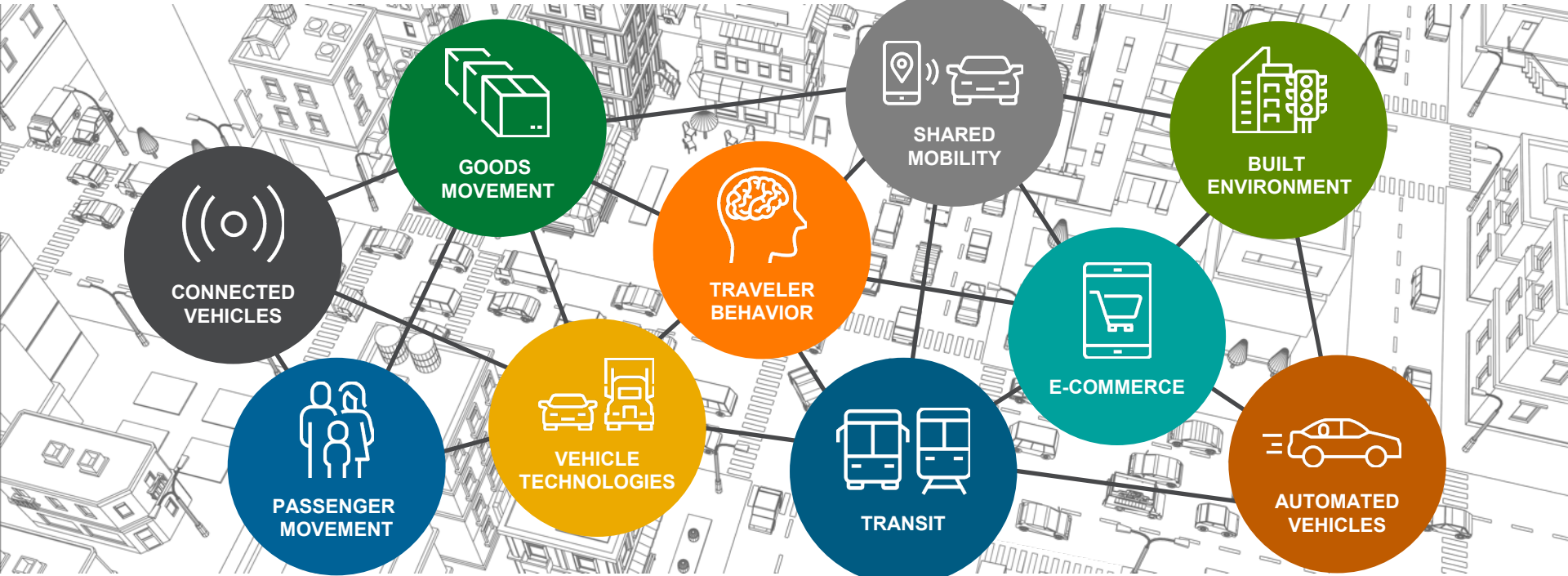
BERKELEY LAB

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

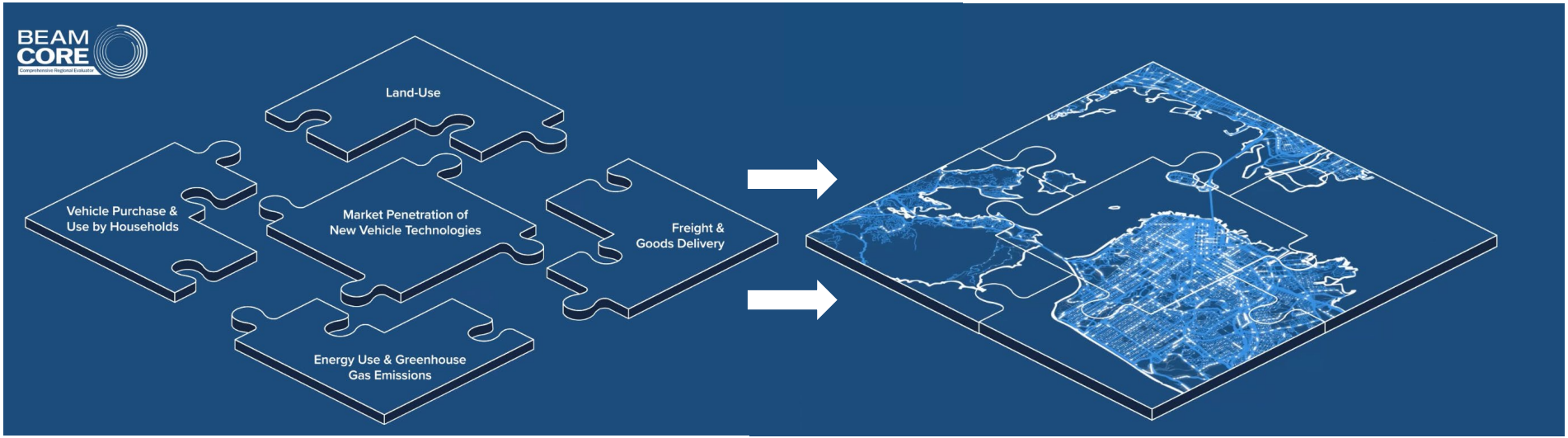
DOE Energy Efficient Mobility Systems Program

SMART Mobility Consortium

Transportation is a System of Systems

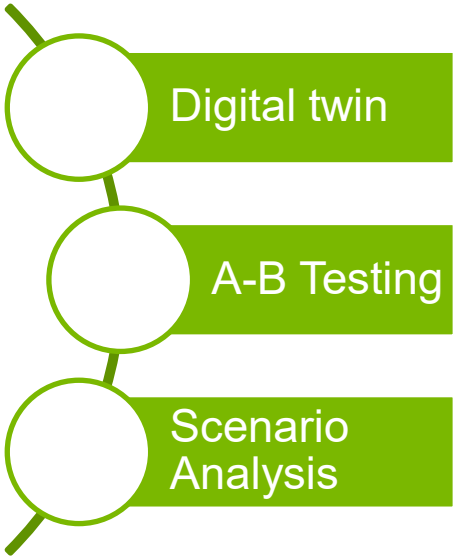


What is BEAM CORE?

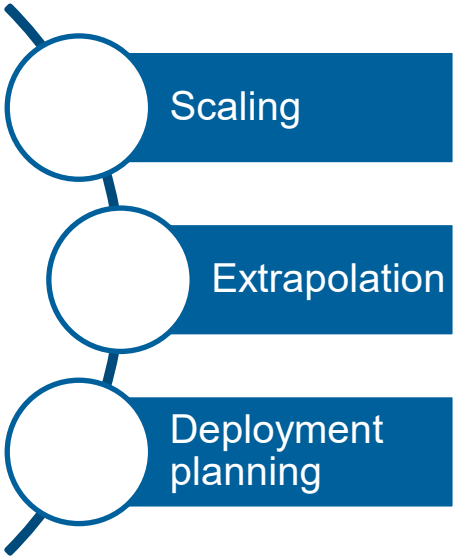


Use cases

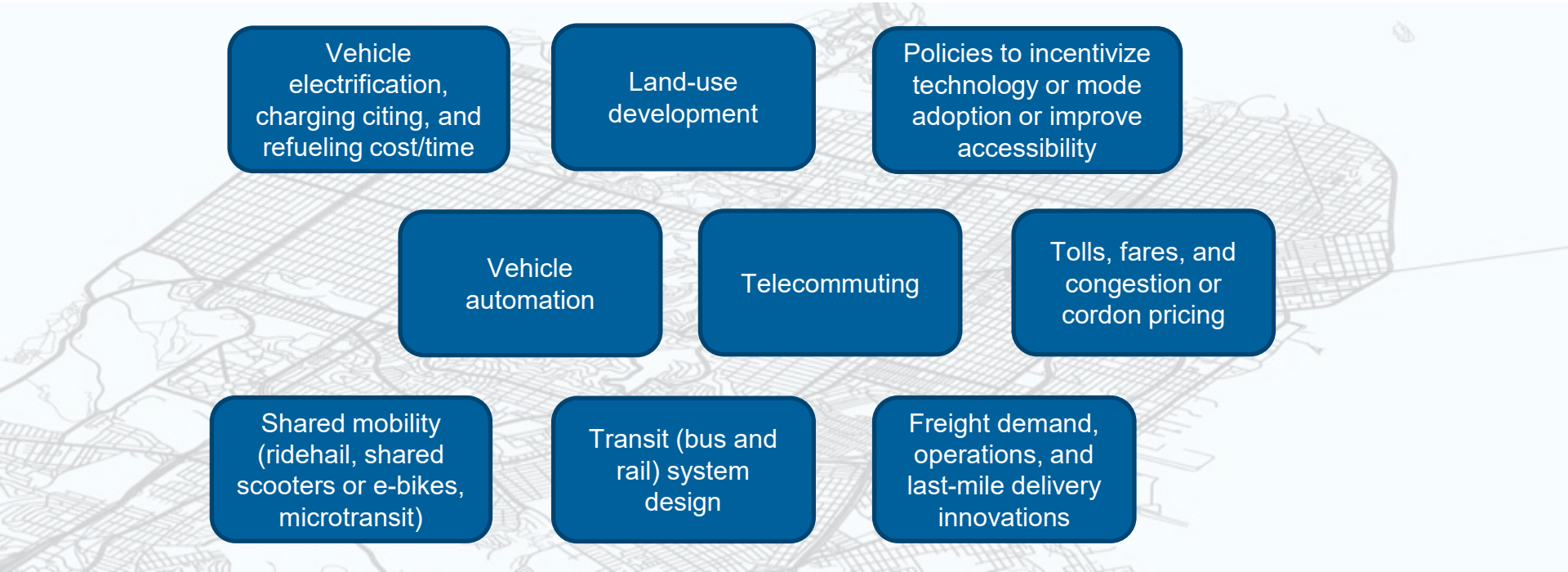
Understand what to expected from alternative policies or implementation strategies ahead of deployment



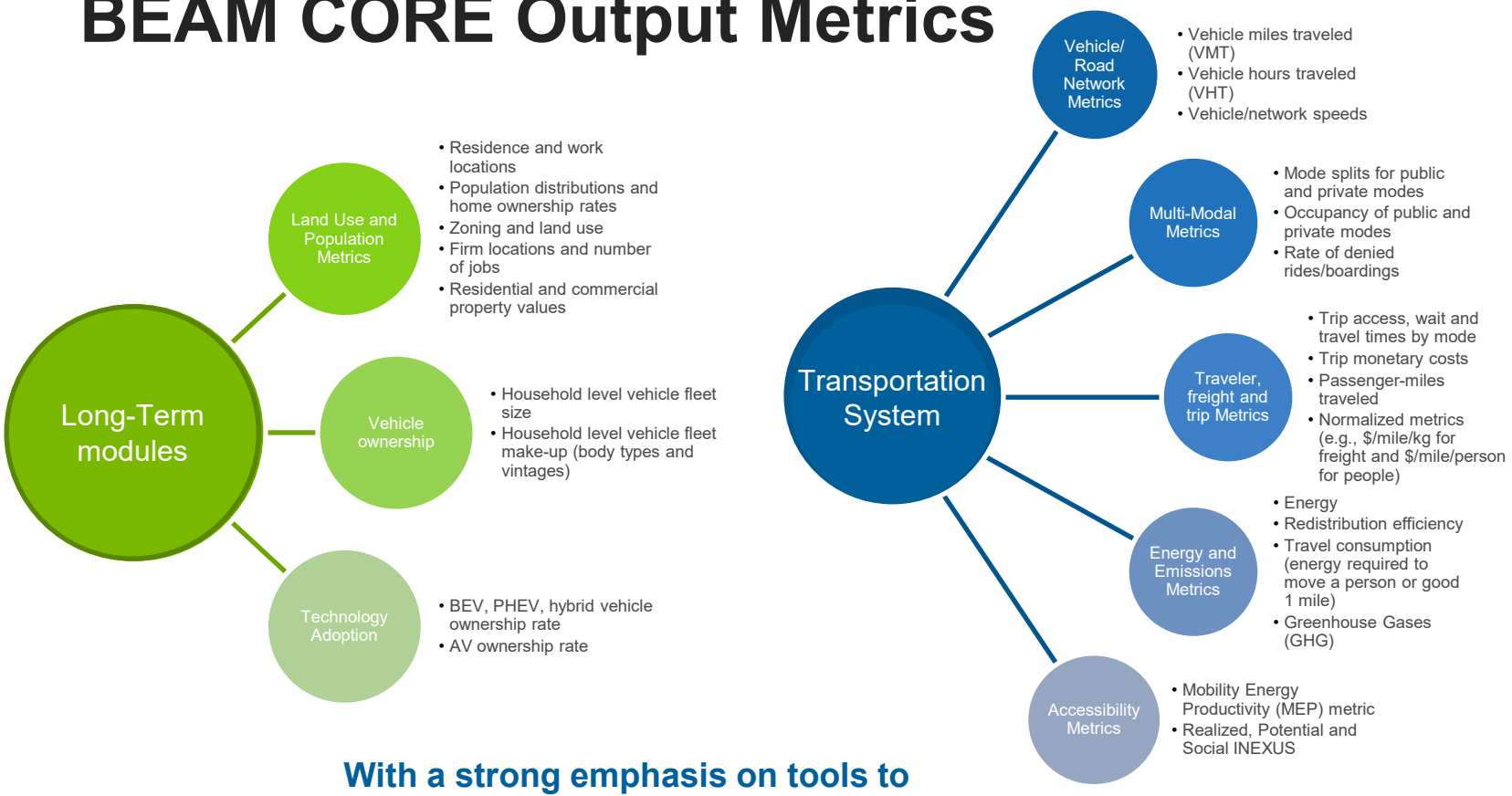
Take results from a limited pilot and understand how that program will scale to a broader implementation and under what conditions



Example Types of Scenario Levers



BEAM CORE Output Metrics



With a strong emphasis on tools to enable equity and distributional analysis

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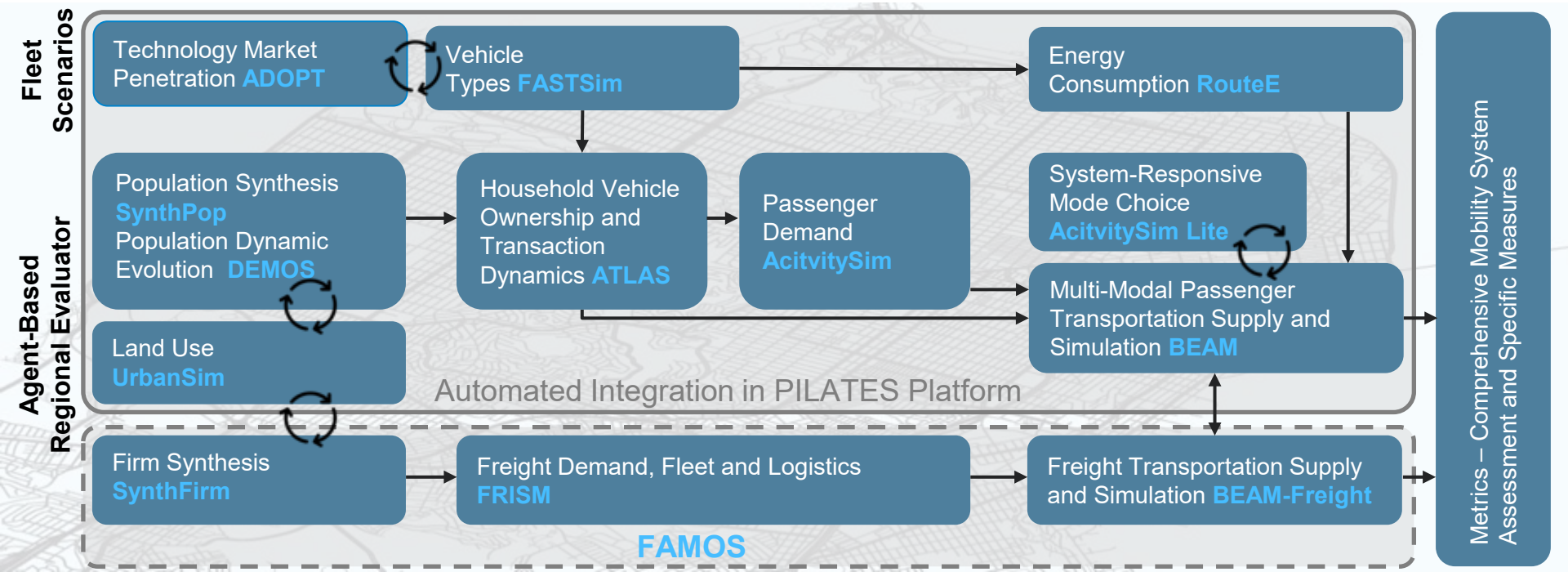
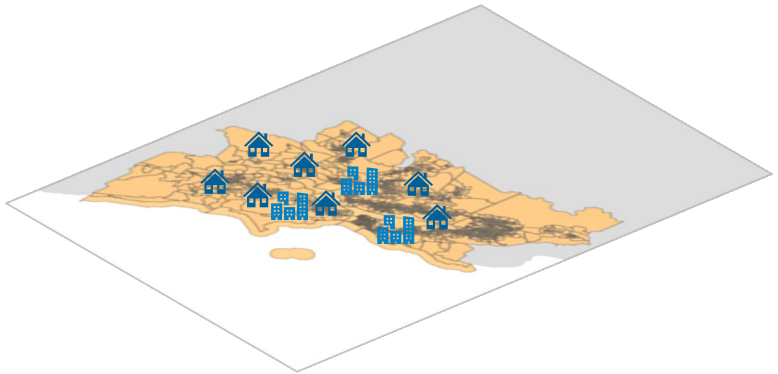


UrbanSim

- **UrbanSim is a suite of microsimulation models that run iteratively from year to year over long-term forecasting horizons**
- **The model system runs a series of models sequentially, updating:**
  - household and employment,
  - real estate supply, and
  - real estate prices and
  - rents

  at each step.

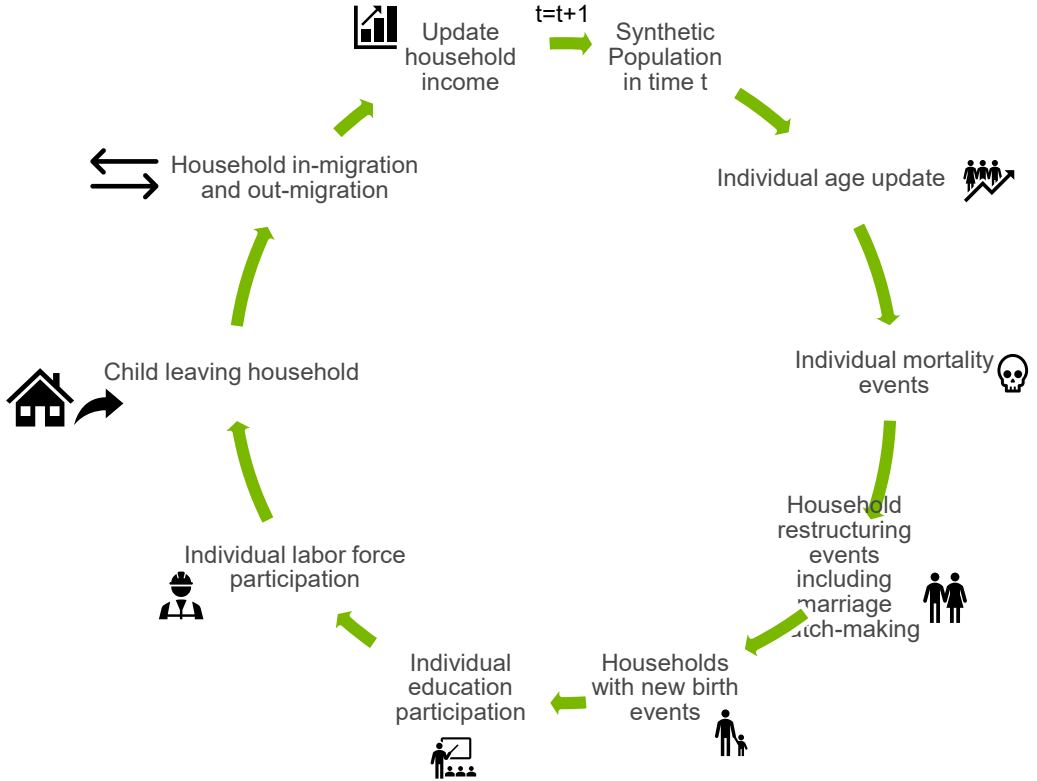


https://www.urbansim.com/

DEMOS

Demographic Microsimulation

- **DEMOS is a dynamic synthetic population micro-simulation.**
- **Individuals and households in the synthetic population evolve through different life events and household lifecycle phases from year to year.**

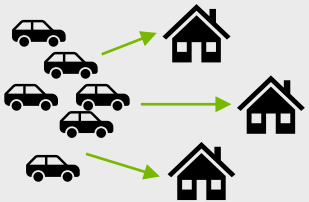


ATLAS

Automobile and Technology Lifecycle-Based Assignment

- ATLAS is a dynamic vehicle transaction and technology adoption model.
- Enabled by DEMOS, vehicle transaction decisions are sensitive to lifecycle phase transitions in the household.
- Enables dynamic analysis of impact of policies and technology scenarios over time, such as how long it takes for the personal vehicle fleet to transition to a new technology.

Distribute initial population of vehicles across households and assign household vehicle fleet when new household moves into region



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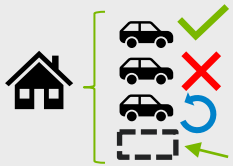
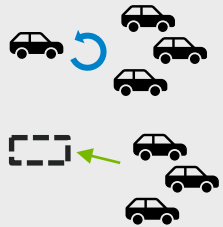
Each timestep household makes vehicle fleet transaction decisions (keep, dispose, replace, acquire). Decisions based on dynamic lifecycle events.



If disposing or replacing, specifies which vehicle to dispose.

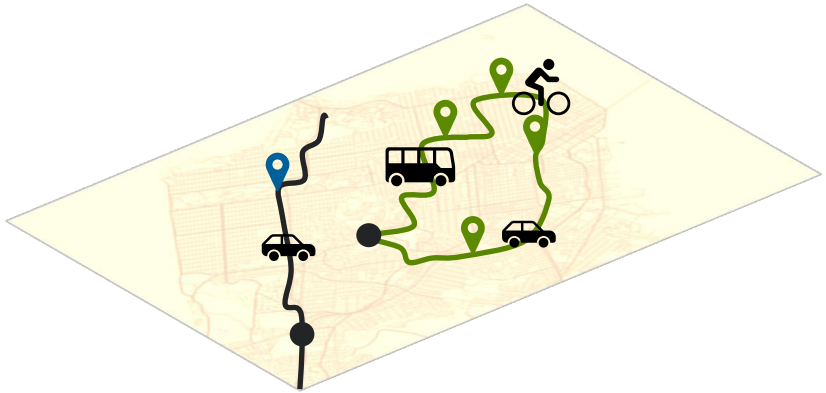
If acquiring or replacing, specifies which vehicle to obtain, including consideration of new technologies (e.g., vehicle power train)



ActivitySim

Open Source Transportation Demand Simulation

- Led by a consortium of Metropolitan Planning Organizations (MPOs), ActivitySim provides a comprehensive transportation demand simulation package with modules governing a range of transportation behaviors. The modules leveraged by BEAM CORE include:
  - **Activity planning** – the set of activities each agent will undertake in a simulation day and at what times.
  - **Activity location choice** – where specifically will each activity take place.
  - **Tour mode choice** – for activities linked together in a multi-trip tour, what is the primary mode type used for the tour.
  - **Trip mode choice** – for each trip leg in the tour, what is the specific mode chosen.

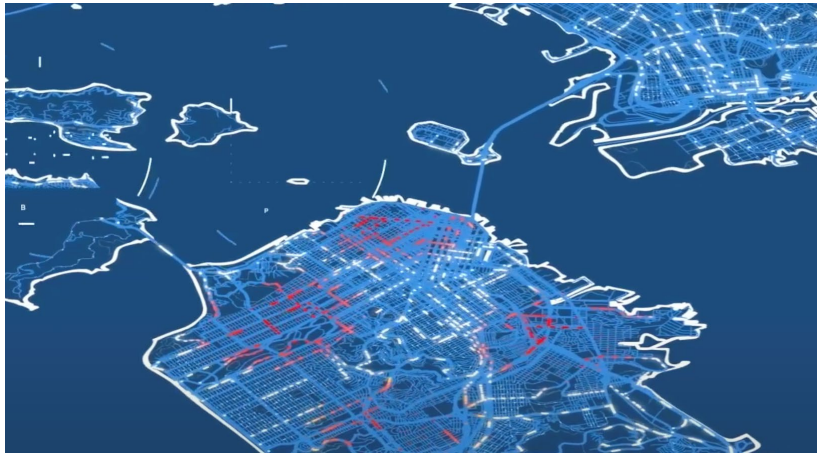


BEAM
Behavior Energy Autonomy Mobility

U.S. DEPARTMENT OF ENERGY SMARTMOBILITY
Systems and Modeling for Accelerated Research in Transportation

Open-source agent-based transportation system model

- Traditional and emerging modes and technologies
- Resolution of limited resource markets: road capacity, parking, transit capacity, etc.
- Travel behavior
- Traffic flow simulation
- Replanning within a day
- Energy
- EV Charging
- Ride-hail operations
- And more!



Watch video about BEAM at beam.lbl.gov

FAMOS

Freight Activity Mobility Simulator

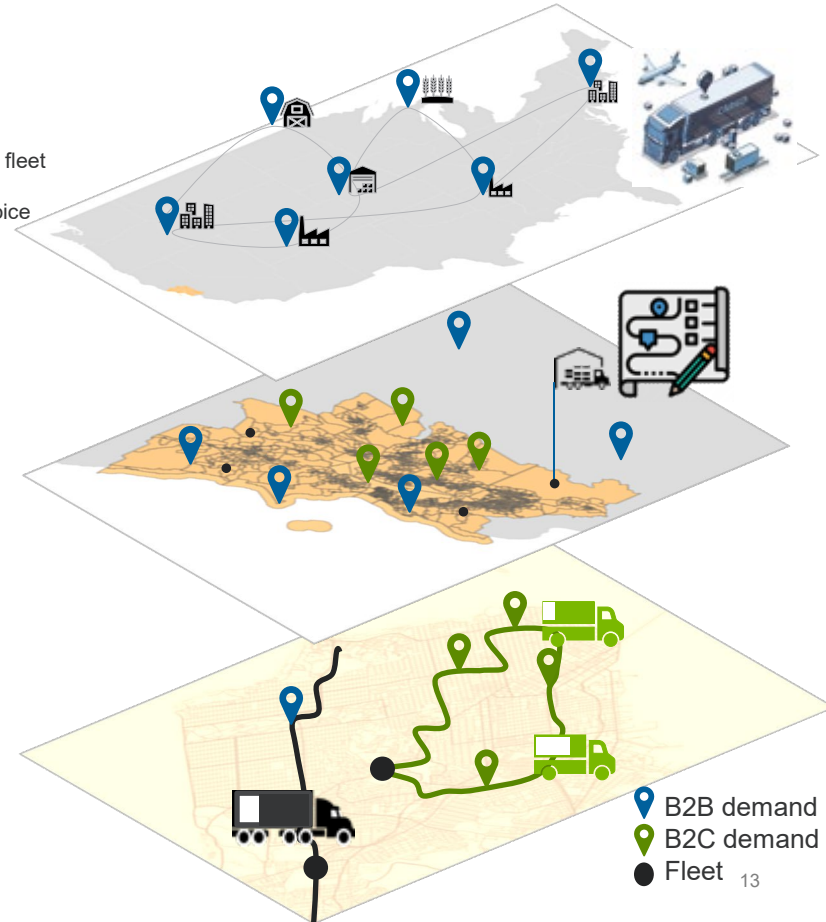
- Agent-level modeling of entire chain of freight activities and interactions from shippers, receivers, households and carriers, to vehicles, and infrastructure impact
- National-scale Business-to-Business (B2B) shipment simulation → synthesize all firms in entire U.S.
- Business-to-Consumer (B2C) shipment simulation focused on household online-shopping demand
- Sequential models of decisions on shipment-to-vehicle flow conversion
- Simulating tour-based vehicle movements and vehicle load profiles along tours, enabling better energy estimation

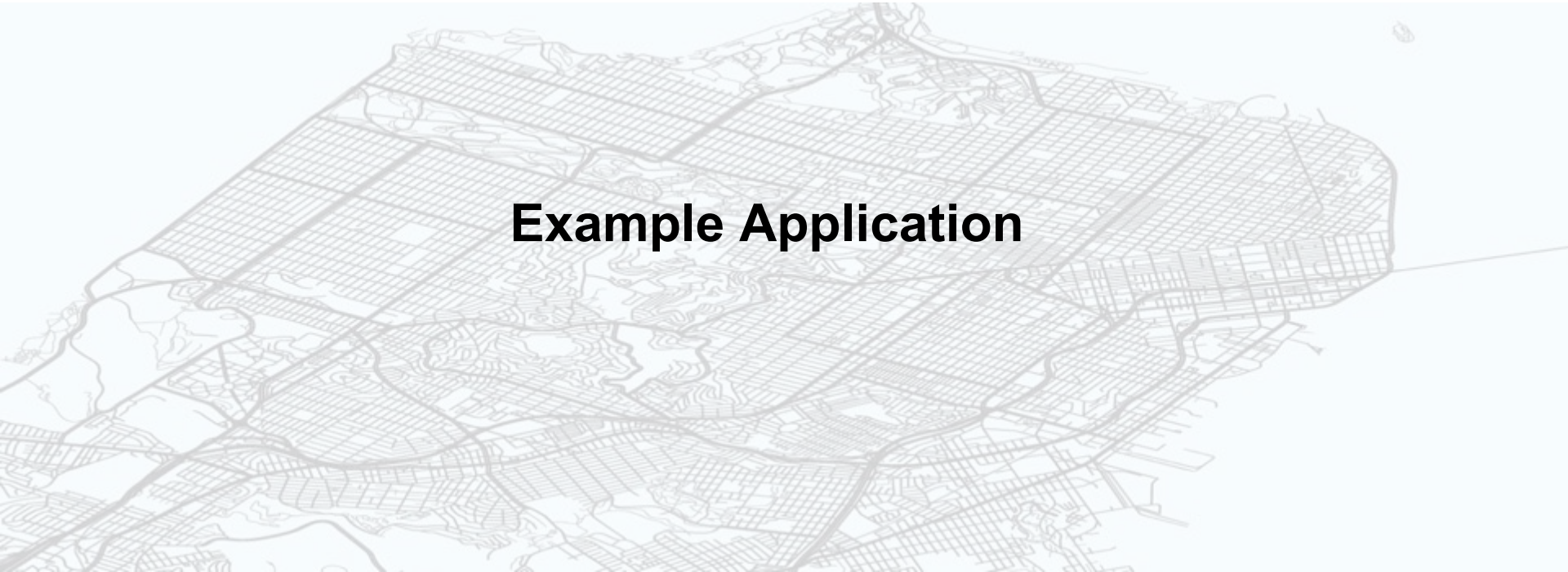
Freight Activity MObility Simulator

SynthFirm
Synthesis of firm & vehicle fleet
Supply-chain logistics
Shipment size & mode choice

FRISM
Online-shopping demand
Daily shipments
Fleet operation plan

BEAM-Freight
Vehicle routing
Traffic assignment
Infrastructure use



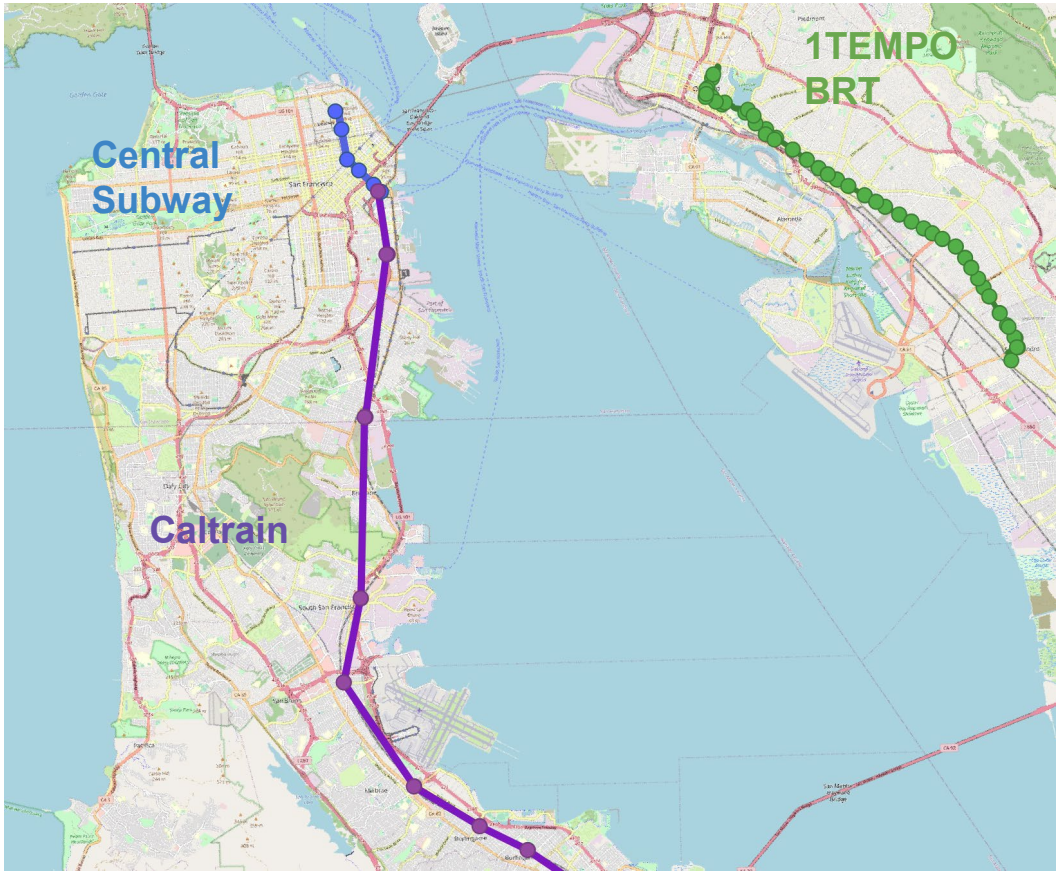


Example Application

Map of three projects simulated

1. SF Muni Central Subway Project
   - Underground from Caltrain 4th Street station to Chinatown
   - 4 stations, 1.7 miles
   - Construction 2011 to Spring 2021
   - Revenue service planned to start Fall 2022

2. Electrify Caltrain (from downtown SF to San Jose) by 2024

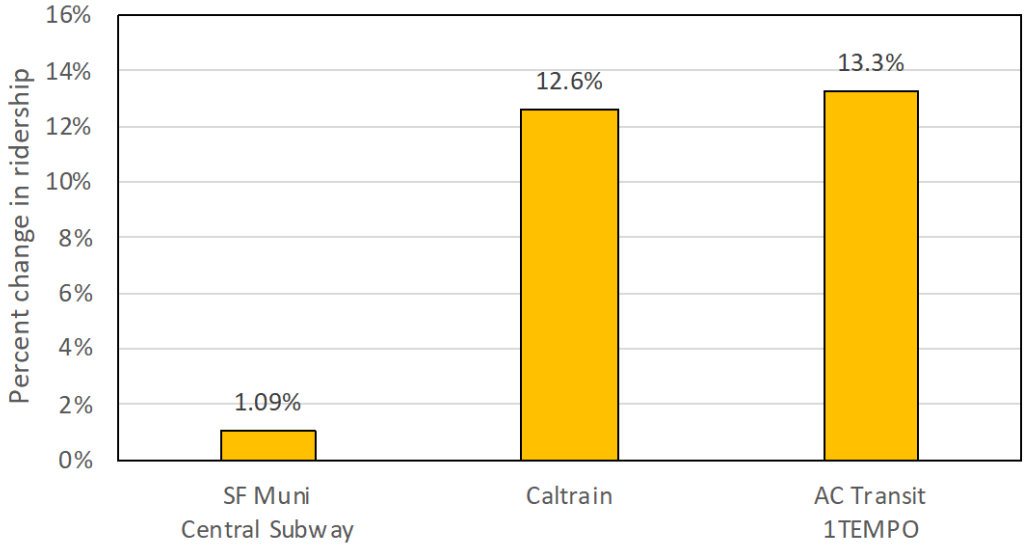


3. 1TEMPO Bus Rapid Transit "light" line in East Bay

Preliminary results

Change in SF Bay Area transit ridership

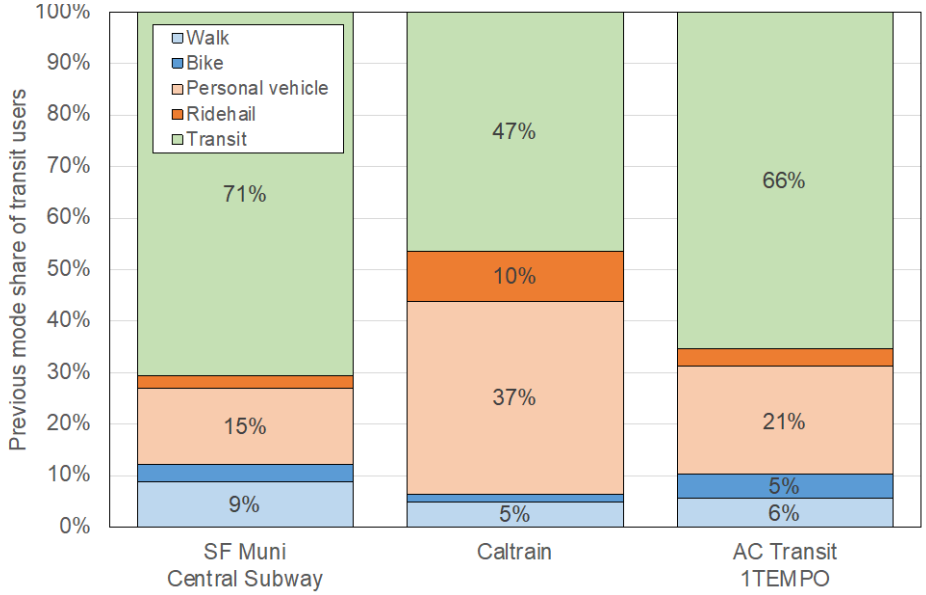
- Central Subway increased ridership across all Muni 1.1%, and on Muni light rail 9.5%
- Central Subway is 8% of all Muni light rail
- Caltrain electrification increased ridership 13%
- ACTransit 1TEMPO, with planned frequency, increased ridership 13%



Preliminary results

Previous mode of new transit riders

- 47% (Caltrain) to 71% (Central Subway) used transit
- 15% (Central Subway) to 37% (Caltrain) used personal vehicle
- 10% (Caltrain) used ridehail
- 5% (Caltrain) to 9% (Central Subway) walked
- 5% (1TEMPO) biked



Innovative Metrics

INNOVATIVE METRICS CAN PROVIDE MEANINGFUL NEW INSIGHTS FROM AGENT-BASED MODELING

- High-resolution agent-based modeling frameworks are powerful tools for exploring alternative transportation system policy, design, and technology deployment scenarios.
- Gaining multi-faceted insights from these scenario outcomes requires a range of innovative ways of processing the results, including development of informative metrics.
- We demonstrate an example of this using a sensitivity analysis in the BEAM CORE integrated agent-based modeling framework in which the price of ridehail is varied from 800% to 0% of the baseline.
- This makes a flexible backup option more or less affordable and accessible.

INEXUS Suite of Metrics

Individual **ex**perienced **u**tility-based **s**ynthesis

Potential INEXUS

Captures the full utility of modal options available to the individual

Realized INEXUS

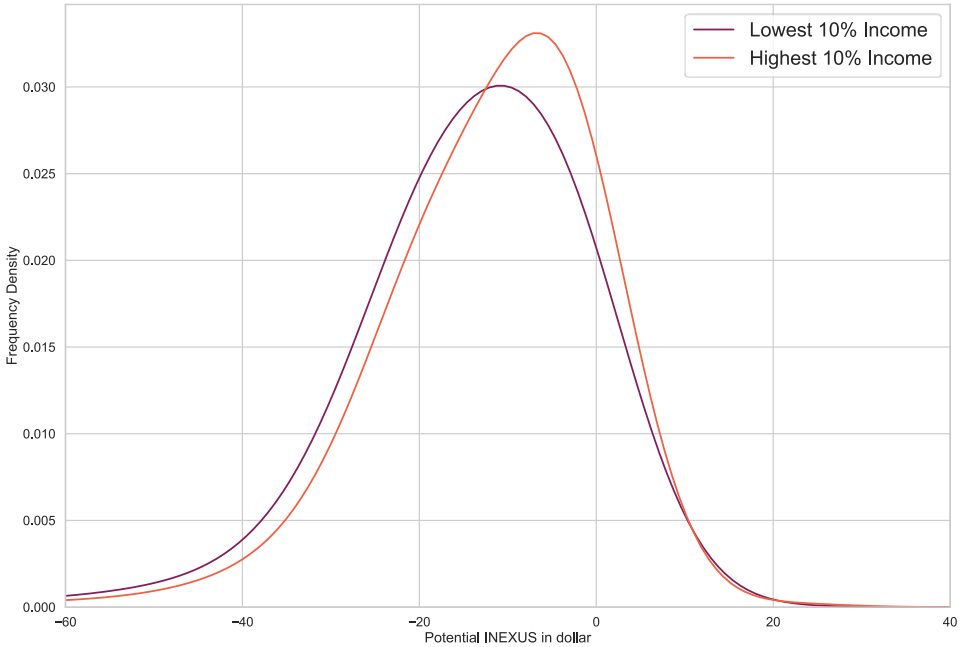
Measures the utility experienced by the agent for the mode they actually chose

Social INEXUS

Measures the utility experienced by and the externalities associated with the agent for the mode chosen

THE POTENTIAL INEXUS CAN HIGHLIGHT INEQUITIES IN THE TRANSPORTATION SYSTEM

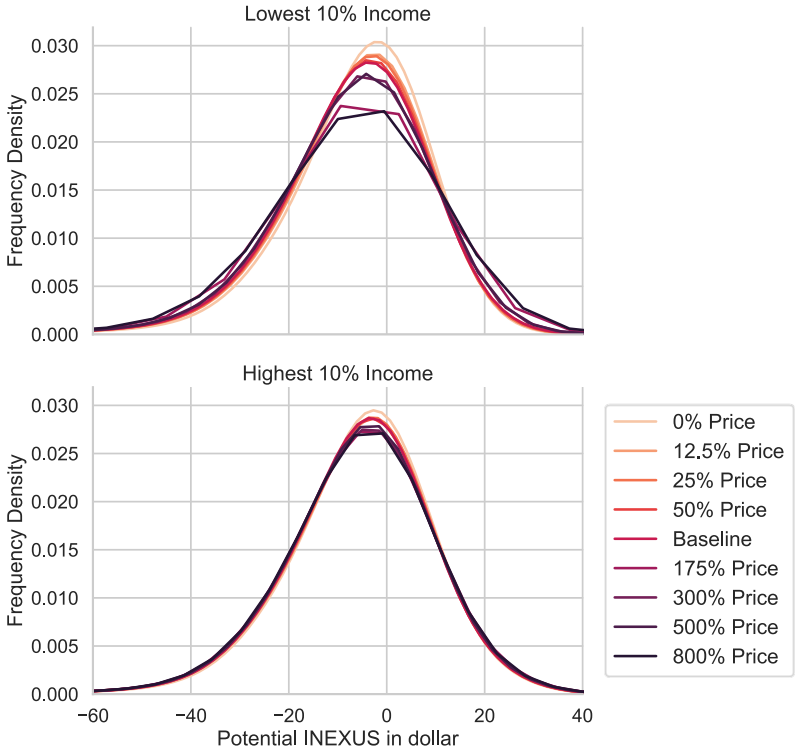
- In the baseline, the median Potential INEXUS for mandatory trips for the highest income decile is 16% higher than for the lowest income decile.
- This demonstrates the extent to which a multitude of factors (residence location, mode availability, budget constraints, vehicle ownership, etc.) contribute to systematic inequities in the current transportation system.

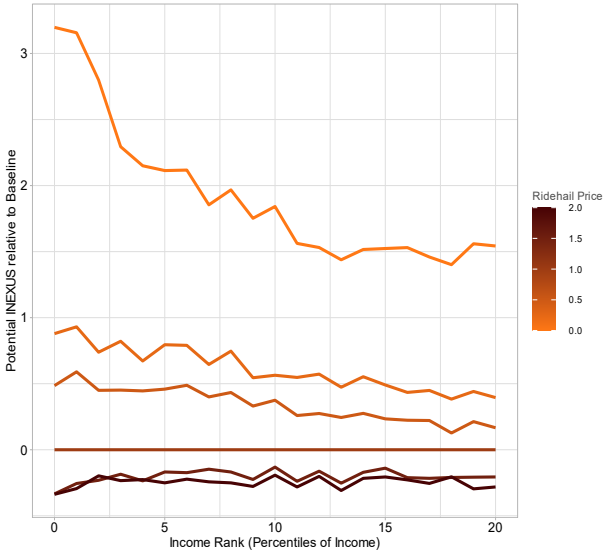


Distribution of Potential INEXUS values for mandatory trips in the baseline scenario across income groups

THE POTENTIAL INEXUS HIGHLIGHTS HOW MAKING A BACKUP MODAL OPTION MORE AFFORDABLE DISPROPORTIONATELY BENEFITS THE LOWEST INCOME SUBPOPULATION

- Moving from baseline price to no-cost ridehail results in a 44% improvement in the median Potential INEXUS for the lowest income decile compared to a 13% improvement for the highest income decile.



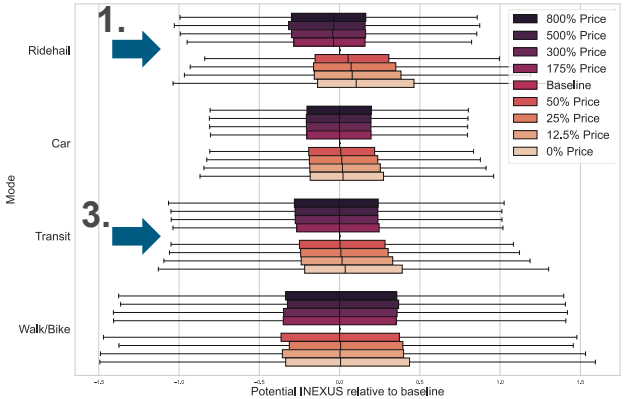


Distribution of Potential INEXUS across ridehail price scenarios by the income of travelers

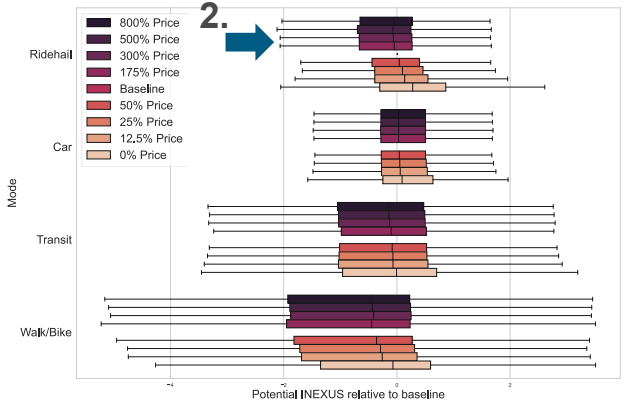
THE POTENTIAL INEXUS CAN CAPTURE HOW IMPROVEMENTS IN AFFORDABILITY OF A GIVEN MODAL ALTERNATIVE CAN BENEFIT PEOPLE IN A RANGE OF WAYS

1. **Freeride direct benefit**: travelers that use ridehail in both the baseline and the lower ridehail price scenario receive benefits without any induced behavior change
2. **Re-optimization direct benefit:** some travelers reoptimize their mode choice and switch to a mode that makes them better off
3. **Backup option indirect benefit:** some travelers that don't reoptimize are still better off because they have a more appealing backup option available

Potential INEXUS for travelers who **do not change** their mode from the baseline

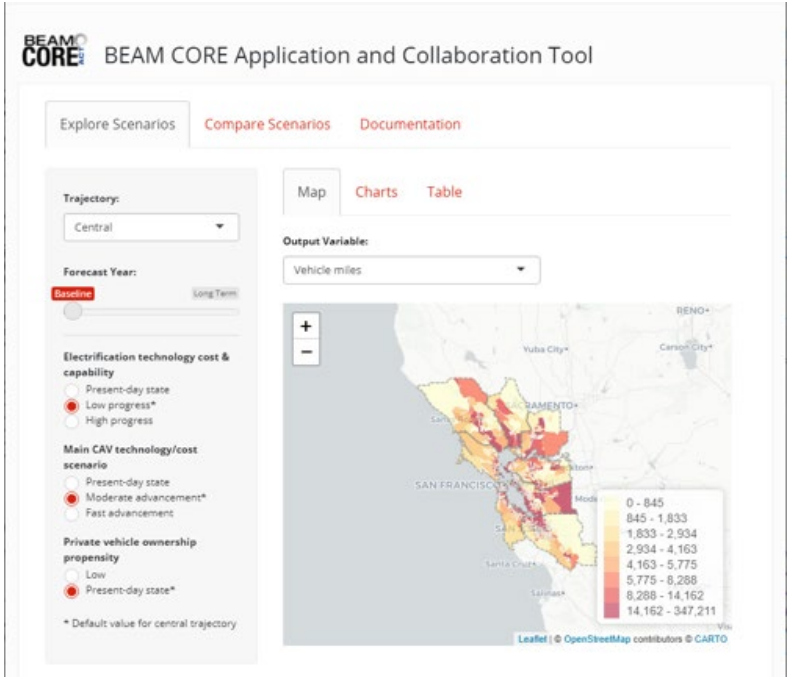


Potential INEXUS for travelers who **do change** their mode from the baseline



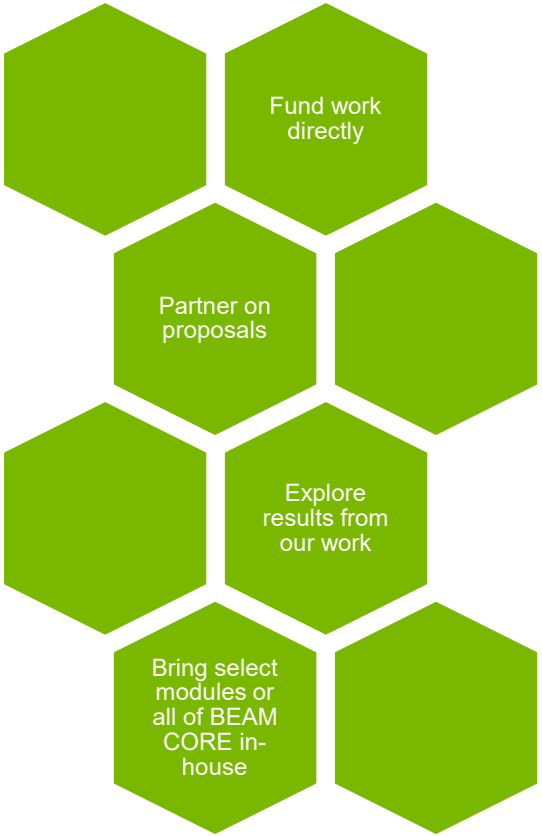
BEAM CORE APPLICATION AND COLLABORATION TOOL (ACT)

- Visualization tool for stakeholders developed by NREL
- Users will be able to select one of three overall trajectories (conservative, central, or aggressive) and an accompanying forecast year/timeframe
- Users will be able to explore marginal effects of individual input parameters by selecting varying levels from the central trajectory
- Results will be viewed for a range of output variables, including different categories of vehicle and passenger miles travelled
- Results can be visualized as a map, chart, or table
- Charts and tables include additional breakdowns by powertrain or mode



HOW TO ENGAGE

- **Current partners and collaborators**
  - Collaborators/advisors on DOE-funded work
    - San Francisco County Transportation Authority (SFCTA)
    - San Francisco Municipal Transportation Agency (SFMTA)
    - Bay Area Rapid Transit (BART)\
    - New York Metropolitan Transportation Authority (NYMTA)
  - Funders for contracted work
    - US Department of Energy
    - US Environmental Protection Agency
    - Cruise
    - California Air Resource Board (CARB) [coming soon]
  - Other users of the model
    - T-SCORE: Transit – Serving Communities Optimally, Responsively, and Efficiently (UKentucky, Georgia Tech, BYU)



ACKNOWLEDGEMENTS

Large Interdisciplinary Team

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  - Rob Fitzgerald
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  - Mingyi He
  - Dylan Hettinger
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  - Jake Holden
  - Josh Hoshiko
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  - Nick Reinicke
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  - Bingrong Sun
  - Juliette Ugirumurera
  - Aaron Young
  - Stan Young

Thank You!

For more information and to learn how to partner:

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2023 SMART MOBILITY WEBINAR SERIES

Initiated in 2019 by the US DOE Vehicle Technologies Office (VTO) Energy Efficient Mobility Systems (EEMS) program, the SMART (Systems and Modeling for Accelerated Research in Transportation) Mobility Laboratory Consortium is a multi-year, multi-laboratory collaborative dedicated to further understanding the energy implications and potential opportunities from advanced mobility solutions.

The SMART Consortium is launching a webinar series to summarize insights and recommendations addressing the following topics:

- Multi-modal travel (including transit, ride hailing, and micromobility)
- Connectivity and automation (including vehicles and infrastructure)
- Freight
- Transportation electrification

The first webinar, to be held on Tuesday, February 14th at 2pm EST, will provide an overview of DOE's SMART Consortium addressing the overall project questions, metrics (such as energy, emissions, and the composite mobility energy productivity (MEP) metric), and example insights across multiple technologies.

DOE SMART Program Objectives and Metrics

SMART Mobility Webinar #1

Tuesday, February 14
2 p.m. EST

To receive registration details and additional information on the webinar series, please visit **survey.alchemer.com/s3/7151527/2023-SMART-Mobility-Webinar-Series**

Questions?

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QUESTION 1

What are the most pressing challenges and questions that are proving most difficult or relevant to address future mobility and emerging services and technologies?

QUESTION 2

What immediate policy and planning questions, needs, and challenges are key priorities?

QUESTION 3

With all the uncertainty now, what are some of the key questions pertaining to long-term sustainable (and resilient) mobility investments?

QUESTION 4

What are the most critical metrics for performance for your organization or your stakeholders? Do you feel like you're in a good position to measure those now?