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BEAM CORE Core Tools

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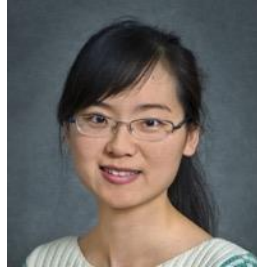
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Overview



Timeline

Project start date: October 1, 2024

Project end date: September 30, 2025

Percent complete: 50%

Budget

Total project funding: **\$1,475,000**
(DOE Share: 100%)

FY25 project funding: **\$1,475,000**

Barriers and Technical Targets

Contributes to targets from VMSATT 2024 Roadmap: (1) existing models and tools have been developed to focus on individual vehicles over pre-defined driving cycles. The technologies considered require a new focus to be placed on specific models (e.g., human driver) and capabilities (e.g., multi-vehicle system simulation within an environment). EEMS-supported models (such as BEAM CORE, POLARIS, RoadRunner, and UrbanSim) are highlighted. There is prioritization of partnerships as a mechanism for technical information exchange, feedback, and suggestions for model application.

Partners

Technical project teams

- Berkeley Lab
- National Renewable Energy Laboratory
- Argonne National Laboratory

Relevance



Objective

Directly contribute to EEMS Strategic Goal #1: Develop new tools, techniques, and core capabilities to understand and identify the most important levers to improve the energy productivity...of future integrated mobility systems.

- Modular set of transparent, open-source capabilities with flexible deployment pathways.
- Simplified capabilities and standardized data inputs developed to support any ABM TDM anywhere in the country.
- Complete outward-facing documentation and public software access to the full BEAM CORE integrated modeling platform.

Impacts

- Significant progress towards a comprehensive public resource: an à la carte menu of deployment options any agency or researcher can access and use to stand up, expand, or support any ABM anywhere in the country.
- A streamlined and generalized pipeline for BEAM CORE module calibration in any U.S. region.
- Reduced barriers to adoption of VTO investments, enabling local transit and planning agencies to improve their ability to identify strategies to increase mobility, reduce congestion, realize cost savings for local governments and residents, and increase efficiency and health for their local population.

Milestones

OT=On Track

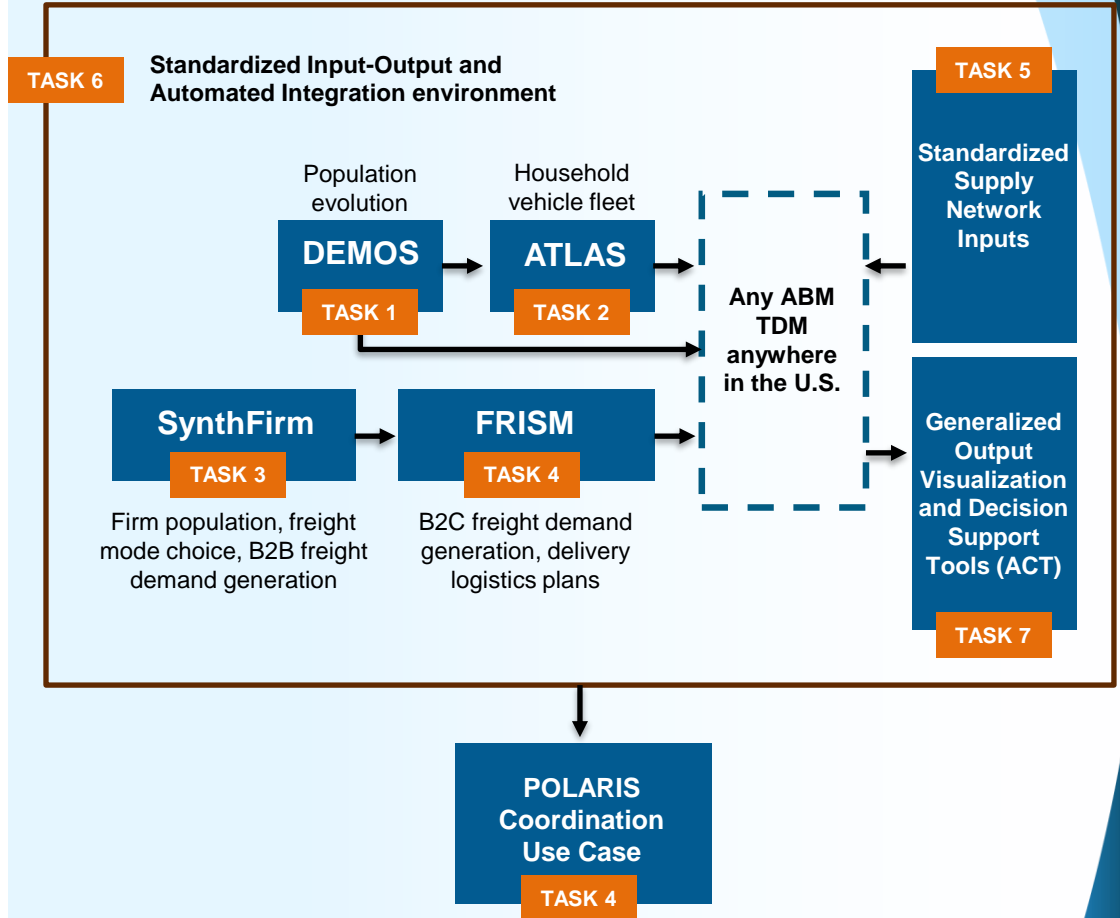
✓ = Done

Task 1: DEMOS	Demonstration of a fully decoupled DEMOS module including comparison of results from past version.	Q2	✓
	Dockerized version of decoupled DEMOS with public release of (version 1) code through GitHub.	Q4	OT
Task 2: ATLAS	Estimation and validation data collection, harmonization, and variable standardization for generalized ATLAS.	Q2	✓
	Standardized, automated & flexible estimation code ready for generalized ATLAS deployment nation-wide.	Q4	OT
Task 3: SynthFirm	National-scale baseline fleet generation complete. Baseline fleet validation performed for CA and WA.	Q2	✓
	Comprehensive SynthFirm enhancement with updated fleet generation & automated calibration/validation.	Q4	OT
Task 4: FRISM	Initial module for automated input data processing complete	Q1	✓
	Generalized e-commerce demand model demonstrated for a test region (Seattle).	Q3	OT
Task 5: Supply & Network input development	Technical documentation defining what network attributes will be stored and used to generate network inputs for simulation and validation. Initial script to download these data and store them in a structured way.	Q1	✓
	Automated pipeline to translate stored network data into the appropriate formats for traffic simulation and validation in any region in the U.S.	Q3	OT
	Demonstration use of this pipeline to generate a road network for BEAM and then using that road network in BEAM to generate peak hour skims in a new region.	Q4	OT
Task 6: Input-Output Schema	Draft relational database schema containing all relevant inputs and outputs for all BEAM CORE models.	Q2	✓
	Working database storing the input data required to run any individual BEAM CORE model independently or to launch a full integrated BEAM CORE run. Have working inputs for multiple scenarios in multiple regions.	Q4	OT
Task 7: ACT	Generalized inputs identified & documented for integrating results from BEAM, POLARIS, or other ABMs	Q3	OT
Task 8: POLARIS Coordination	Share identified potential future pathways for BEAM CORE and POLARIS with DOE.	Q3	OT

Approach

Organized over a set of eight tasks, this project takes a large step towards the vision of a comprehensive library of accessible open-source resources to support agent-based transportation system modeling anywhere in the U.S. Each Task focuses on:

- Refined functionality
- Streamlined/automated generalizable calibration processes
- Reliance on nationally available data
- Standardization
- Documentation



Technical Accomplishments and Progress

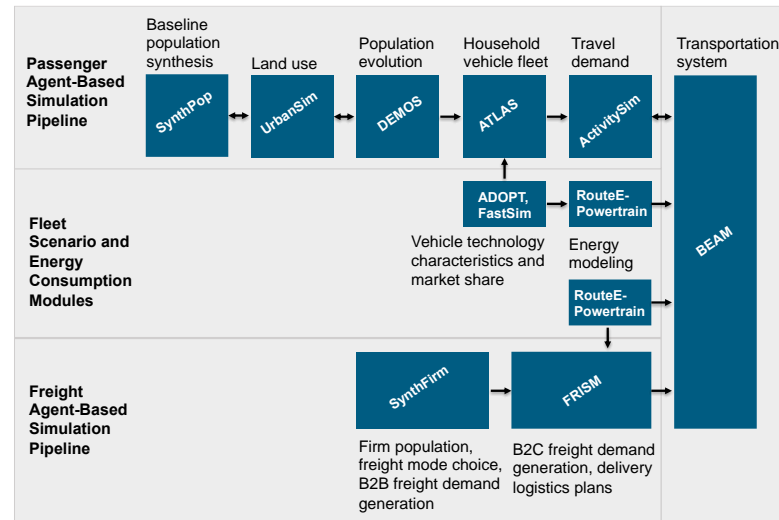
- **Task 1: DEMOS** Developed standalone version of DEMOS to remove dependencies on a third-party tool, enabling broader adoption and easier integration into diverse transportation and urban planning workflows.
- **Task 2: ATLAS** National coverage data collected and San Francisco Bay Area ATLAS implementation expanded to the state of California, relying on nationally available data.
- **Task 3: SynthFirm** Updated national-scale baseline truck fleet at firm level using latest data sources. Projected future fleet by fuel and powertrains from Truck Integrated Techno-economic Analysis (TITAN) and local regulations.
- **Task 4: FRISM** Developed approach to automate the input data processing for e-commerce demand generation to address variation in reporting standards and formats in regional survey data. Created a pipeline to identify locations of e-commerce service providers for any region across the nation.
- **Task 5: Standardized Supply Network Extraction and Calibration** Completed automatic transport network generation and enhancement for any location worldwide from Open Street Map data. Partially completed systematic pipeline to calibrate traffic flows using isolated traffic counts matched to the transport network.
- **Task 6: Standardized Input-Output Schema** Developed flexible structure for storing inputs and outputs across scenarios for multiple use cases. Synchronized definitions across multiple modeling workflows.
- **Task 7: ACT Results Visualization Tool** Integrated person-level trip characteristics in ACT. Developing standardized input format for more generalized input accommodation.
- **Task 8: BEAM CORE-POLARIS Coordination** Developing a shared vision for potential collaborative workflow leveraging elements of both BEAM CORE and POLARIS. Had a full teams in-person workshop with multiple breakout groups to explore opportunities.



Collaboration and Coordination



- Berkeley Lab is the prime lab, develops the BEAM, SynthFirm and ATLAS modules, leads the system simulation input development tasks, develops the PILATES platform, and leads the coordination with the POLARIS team.
- NREL develops DEMOS, FRISM and ACT and provides inputs from other supporting modules (ADOPT, FastSim and RouteE-Powertrain) for energy estimation in BEAM CORE. They also support on the coordination with the POLARIS team.
- All three lab teams (Berkeley Lab, NREL and Argonne) are collaborating on developing potential pathways and visions for future collaboration and a new workflow leveraging integrated components of POLARIS and BEAM CORE.



Remaining Challenges and Barriers

There are no outstanding challenges or barriers to completing the promised scope. All work is proceeding as planned and on schedule.



Proposed Future Research



In the last half of this fiscal year the focus will be on completing the generalized deployable versions of the upstream BEAM CORE modules, finalizing development of automated supply network extraction and calibration pipelines, and upstream module automated calibration pipelines, and initiating public software releases of new module versions.

This work will underpin the future of BEAM CORE deployment, application, and integration with a growing range of new partners, regions, agencies, and use cases.

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

Summary

Objectives

This project moves the BEAM CORE modular set of transparent, open-source capabilities to the next phase of streamlined, accessible and flexible deployment pathways. Through this work we lean into simplified capabilities and standardized data inputs developed to support any ABM TDM anywhere in the country.

Progress

All tasks are on-track and all modules are moving towards more efficient, automated, standardized deployment anywhere in the U.S.

Impact

The impact of this work will be a streamlined and generalized pipeline for BEAM CORE module calibration in any U.S. region. This will reduced barriers to adoption of VTO investments, enabling local transit and planning agencies to improve their ability to identify strategies to increase mobility, reduce congestion, realize cost savings for local governments and residents, and increase efficiency and health for their local population.



Technical Backup Slides

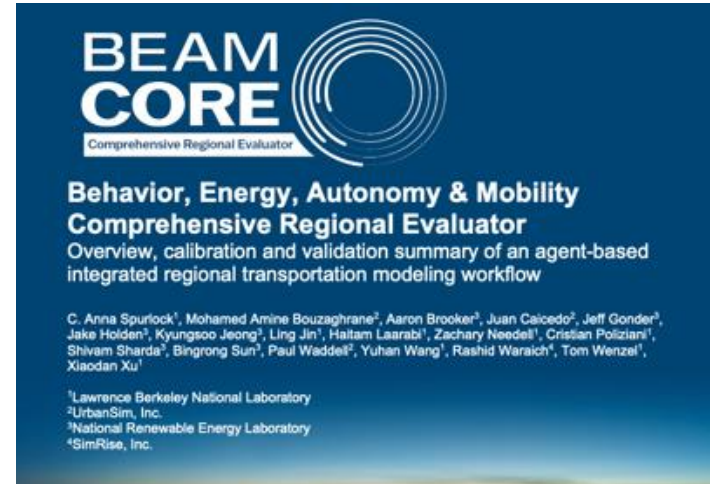
Where to learn more about BEAM CORE

Video Animations on BEAM and BEAM CORE



<https://transportation.lbl.gov/beam/>

Overview Report on BEAM CORE



<https://transportation.lbl.gov/publications/behavior-energy-autonomy-mobility>

Where to learn more about BEAM CORE

ATLAS - Automobile and Technology Lifecycle-Based Assignment

- Software citation: <https://doi.org/10.11578/dc.20240618.2>
- Primary technical documentation: Jin, et al. (2024). Technology progress and clean vehicle policies on fleet turnover and equity: insights from household vehicle fleet micro-simulations with ATLAS. *Transportation Planning and Technology*, 1–24. <https://doi.org/10.1080/03081060.2024.2353784>

SynthFirm

- Software citation: <https://doi.org/10.11578/dc.20240621.2>
- Recent technical documentation: Xu, et al. (2024). Teaching freight mode choice models new tricks using interpretable machine learning methods. *Frontiers in Future Transportation*, 5, 1339273. <https://doi.org/10.3389/ffutr.2024.1339273>

BEAM – Behavior Energy Autonomy Mobility

- Software citation: <https://doi.org/10.11578/dc.20241024.2>
- Primary technical documentation: Laarabi, et al. (2024). A Modeling Framework for Behavior, Energy, Autonomy and Mobility (BEAM). *Lawrence Berkeley National Laboratory Report*. <https://transportation.lbl.gov/publications/modeling-framework-behavior-energy>

PILATES - Platform for Integrated Land use And Transportation Experiments and Simulation

- Software citation: <https://doi.org/10.11578/dc.20240613.2>

FRISM – Freight Integrated Simulation Model

- Software citation: <https://doi.org/10.11578/dc.20240910.28>

DEMOS – Demographic Microsimulation

- Software citation: [Forthcoming]
- Primary technical documentation: Sun, et al. (forthcoming). Demographic Microstimulator for Integrated Urban Systems: Adapting Panel Survey of Income Dynamics to Capture the Continuum of Life. *Transportation Research Record*

Where to learn more about BEAM CORE



Other Integrated Software

- ADOPT – Automotive Deployment Options Projection Tool. Learn more at: <https://www.nrel.gov/transportation/adopt.html>
- FASTSim – Future Automotive Systems Technology Simulator. Learn more at: <https://www.nrel.gov/transportation/fastsim.html>
- RouteE-Powertrain – Route Energy Prediction Model. Learn more at: <https://www.nrel.gov/transportation/route-energy-prediction-model.html>
- SynthPop – Learn more at: <https://github.com/UDST/synthpop/tree/development>
- UrbanSim – Learn more at: <https://www.urbansim.com/>
- ActivitySim – Learn more at: <https://activitysim.github.io/>

Additional Publications

- Jin, L. et al. (2022). What makes you hold on to that old car? Joint insights from machine learning and multinomial logit on vehicle-level transaction decisions. *Frontiers in Future Transportation*, 3, 894654. <https://doi.org/10.3389/ffutr.2022.894654>
- Lazar, A. et al. (2021, December). Performance of the gold standard and machine learning in predicting vehicle transactions. In 2021 IEEE International Conference on Big Data (Big Data) (pp. 3700-3704). IEEE. <https://doi.org/10.1109/BigData52589.2021.9671286>
- Poliziani, C. et al. (2024). “Simulating Impacts from Transit Service Enhancements in the San Francisco Bay Area.” *Transportation Research Record*. <https://doi.org/10.1177/03611981241292338>
- Rezaei, N. et al. (in press). “Zooming in on virtual commutes: telecommuting impacts on mobility and sustainability.” *Transportation Research Part D*.

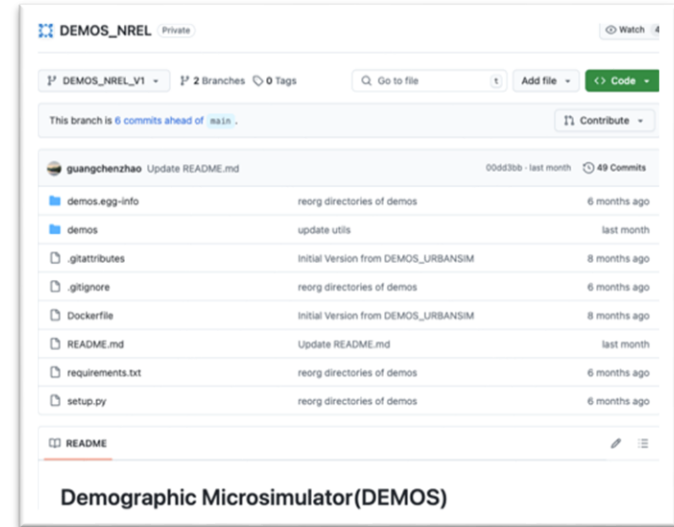
Reviewer Only Backup Slides

Technical Accomplishments and Progress

Additional Details for Task 1: DEMOS

- The NREL team has finished the decoupling of DEMOS modules from the integrated UrbanSim version.
- The outputs of the decoupled and UrbanSim integrated versions were compared to verify that the tool's functionality was preserved.
- The decoupled version has all the demographic components (aging, mortality, household restructuring etc.) but does not have any destination choice components (work/school location choice etc.)

Decoupled DEMOS is hosted on NREL github page.



Technical Accomplishments and Progress

Additional Details for Task 2: ATLAS



Goal

- Develop a flexible household fleet initialization module that can be readily deployed in any region nationally.
- This will significantly reduce the overhead of deploying ATLAS to a new region and immediately enable subsequent energy, emissions and air quality analysis from transportation scenarios.

Technical Accomplishments

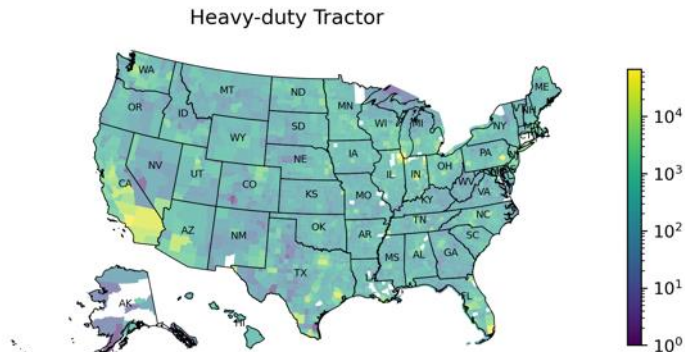
- This project leveraged complementary work funded by California Air Resource Board (CARB) in which a version of ATLAS was implemented CA-wide.
- To facilitate national deployment, modeling data with national coverage has been collected and harmonized. This includes surveys, location attributes, and vehicle registration from different sources and resolutions for model estimation, calibration, and validation.
- The ATLAS team has expanded the SF Bay Area implementation to the state of California, relying on nationally available data, and determined required model parameterization to ensure performance and fidelity in extended regions.

Technical Accomplishments and Progress

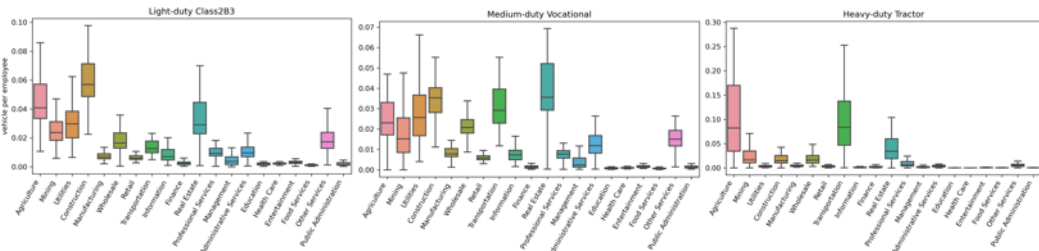
Additional Details for Task 3: SynthFirm

Baseline fleet from national truck registration data (2022 Experian)

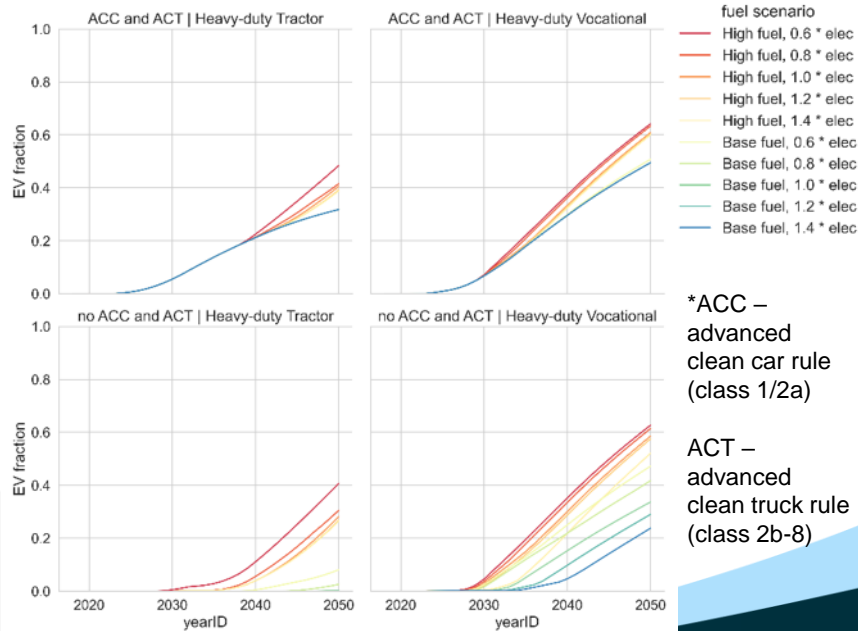
Truck count by county



Truck count per employee



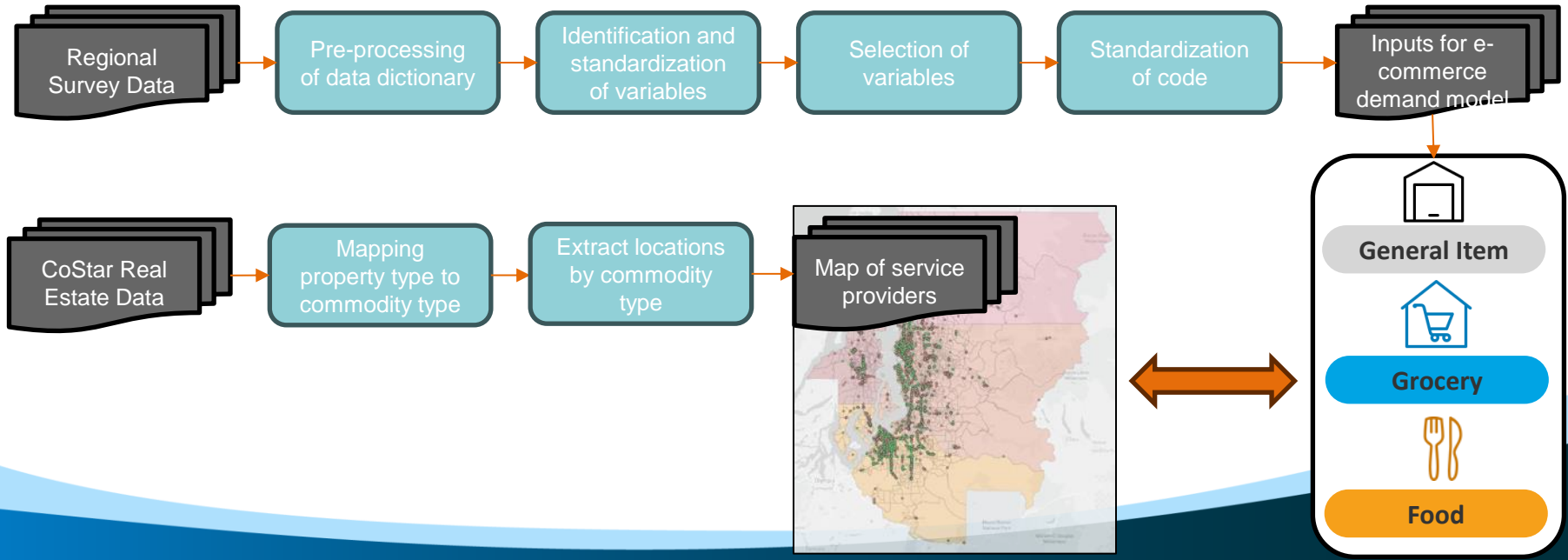
Fleet projection under fuel price variation and local policies



Technical Accomplishments and Progress

Additional Details for Task 4: FRISM

- Developed an approach to automate the input data processing for the e-commerce demand generation to address variation in reporting standards and formats in regional survey data
- Created a pipeline to identify locations of e-commerce service providers (e.g., home delivery distribution centers, grocery, food) for a region across the nation



Technical Accomplishments and Progress

Additional Details for Task 5: Standardized Supply Network Extraction and Calibration

Completed automatic transport network generation and enhancement for any location worldwide from OSM data

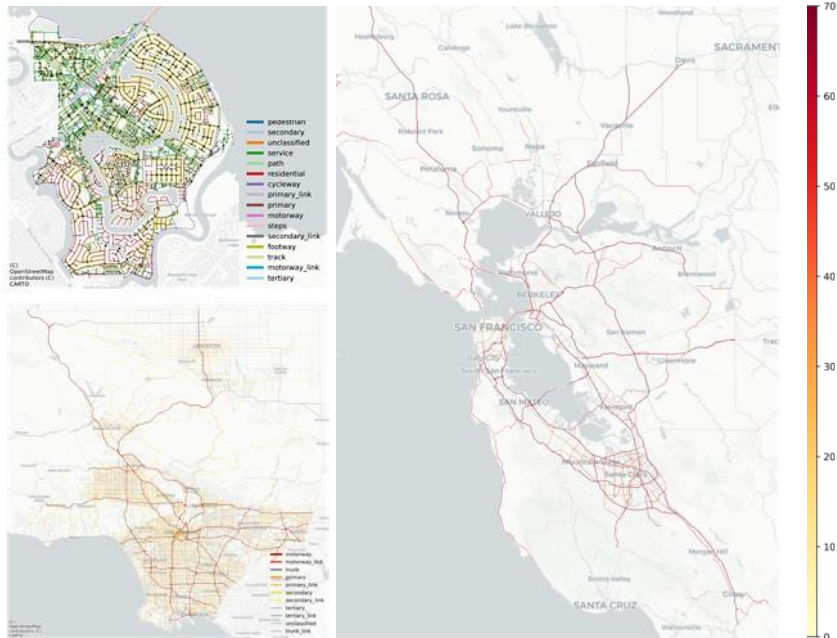


Fig.1 Transportation networks downloaded for Foster City, Los Angeles and the San Francisco Bay Area, California

Partially completed - Calibrating traffic flows using isolated traffic counts matched to the transport network



Fig.2 San Francisco's network: links matched to Caltrans traffic counts

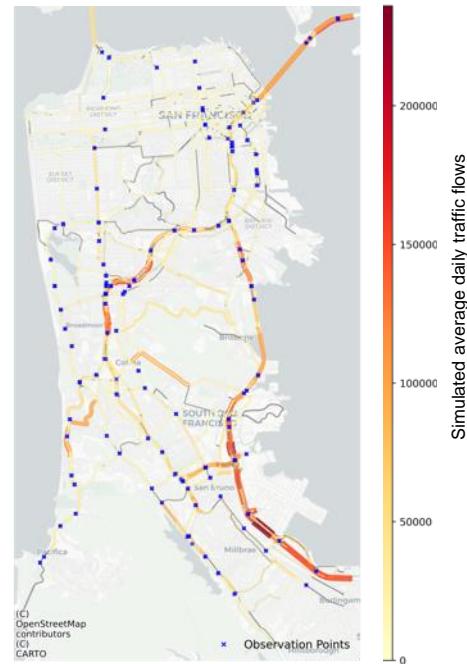
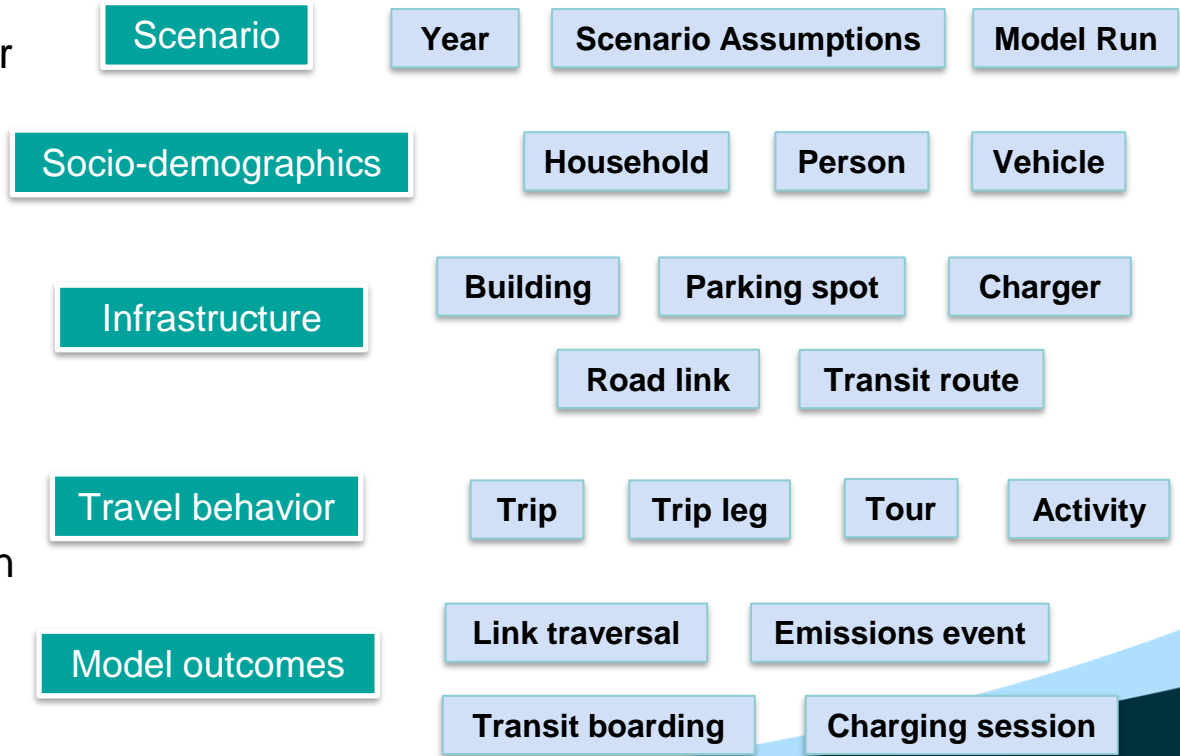


Fig.3 Inferred traffic flows from isolated traffic counts

Technical Accomplishments and Progress

Additional Details for Task 6: Standardized Input-Output Schema

- Developed flexible structure for storing inputs and outputs across scenarios.
- Synchronized definitions between BEAM CORE and POLARIS workflows.
- Will allow for sharing scenario assumptions and comparing results between workflows.
- Will enable easier collaboration across labs and between disciplines.

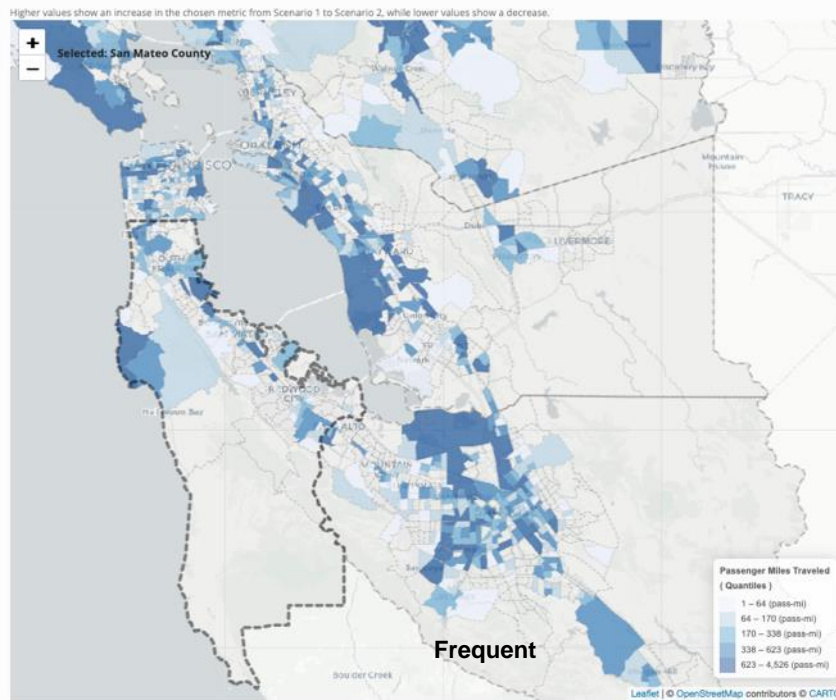
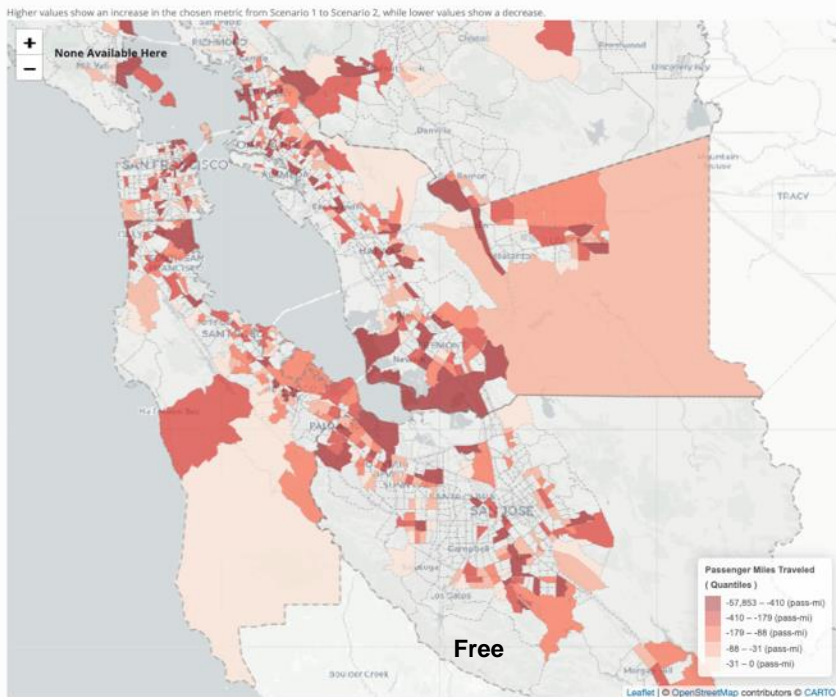


Technical Accomplishments and Progress

Additional Details for Task 7: ACT Results Visualization Tool

- Integrated person-level trip characteristics and metrics for scenarios in San Francisco and Austin
- Working with POLARIS team to integrate outputs from POLARIS model runs and develop standardized input format

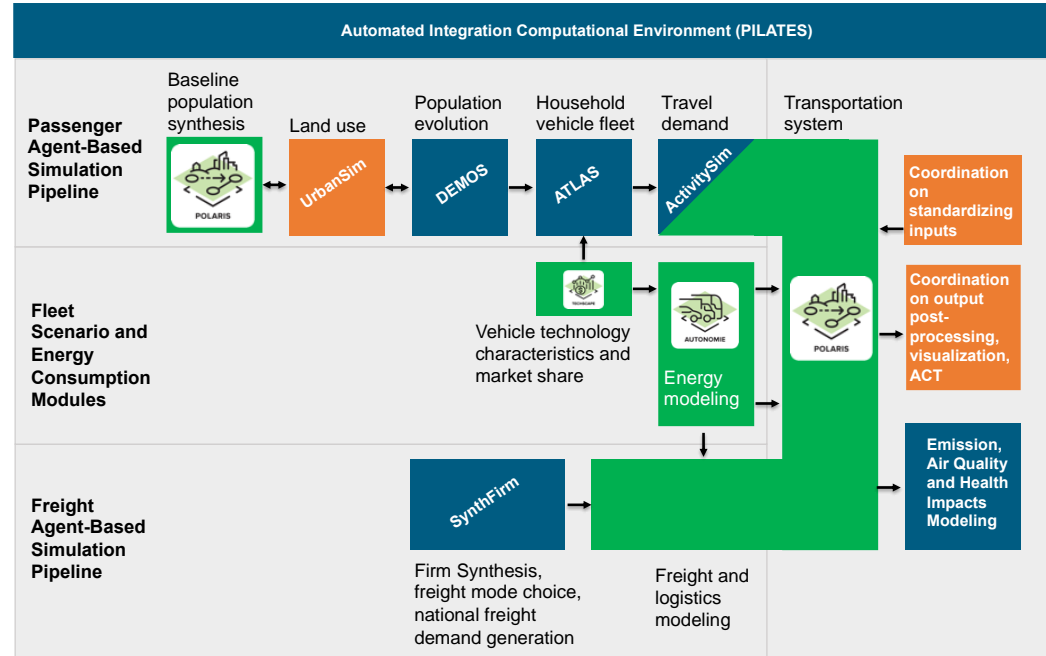
Example Comparison: Geographic Variation of Benefits for Free vs. More Frequent Transit Service



Technical Accomplishments and Progress

Additional Details for Task 8: BEAM CORE - POLARIS Coordination

- Working on developing a shared vision for potential collaborative workflow leveraging elements of both BEAM CORE and POLARIS.
- Had a full teams in-person workshop with multiple breakout groups to explore opportunities.
- Working on formulating a potential proposed framework for an integrated workflow (example on right... not final)



Coordinated
 BEAM CORE
 POLARIS

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