Project ID # eems009

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Modeling and Simulation of Automated Mobility Districts

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DOE Vehicle Technologies Office

2018 Annual Merit Review and Peer Evaluation Meeting

June 20, 2018

Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

BERKELEY LAB

OAK RIDGE National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

ENERGY EFFICIENT MOBILITY SYSTEMS PROGRAM INVESTIGATES

MOBILITY ENERGY PRODUCTIVITY

THROUGH FIVE EEMS ACTIVITY AREAS

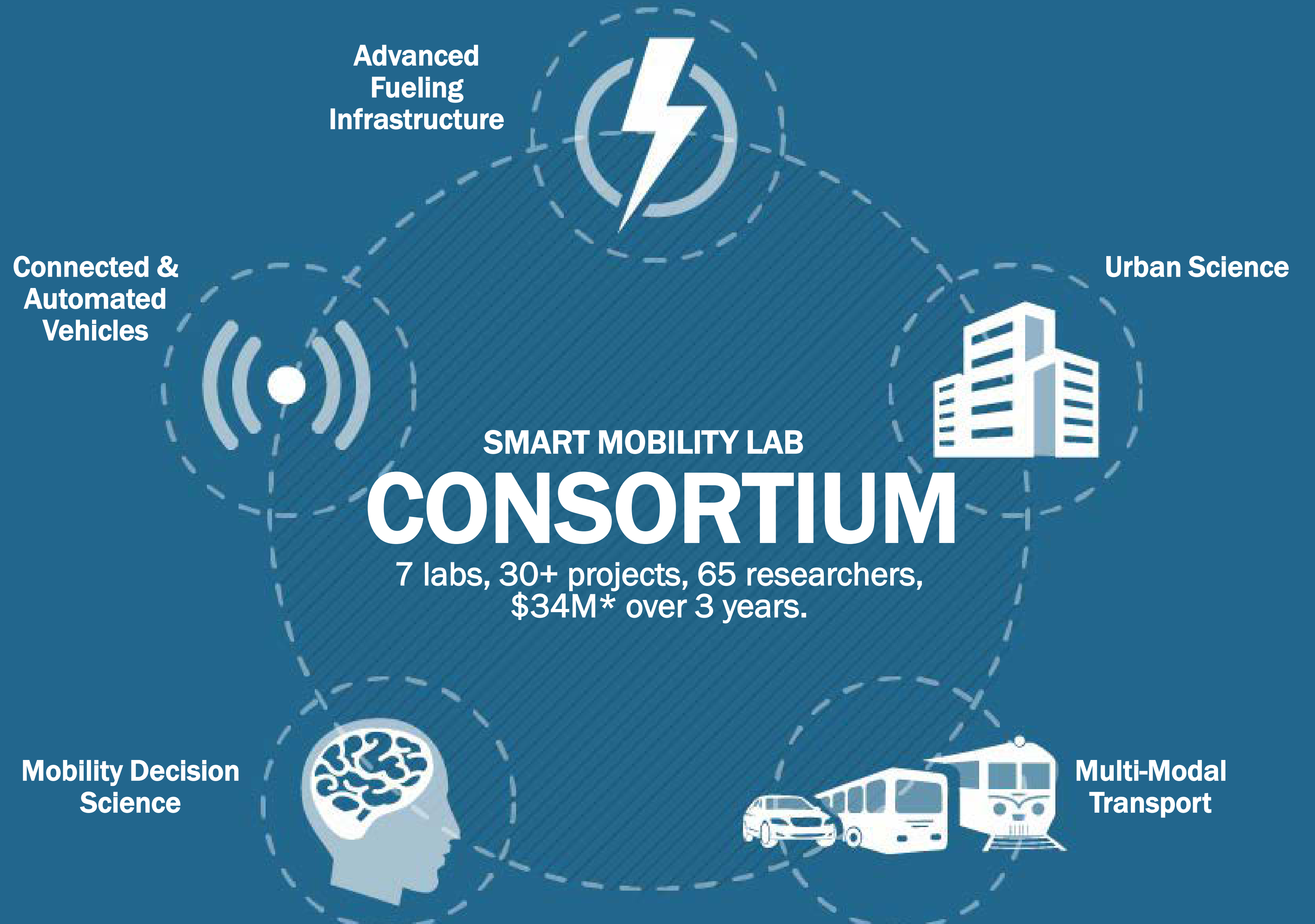
Advanced R&D Projects

Living Labs

Smart Mobility Lab Consortium

Core Evaluation & Simulation Tools

HPC4Mobility & Big Transportation Data Analytics



*Based on anticipated funding

OVERVIEW

Timeline

- Project start date: 10/1/2016
- Project end date: 9/30/2019
- Percent complete: 60% (FY18)

Barriers

- Computational models for CAVs, design, and simulation methodologies for AMDs
- Lack of real-world data to support AMD modeling efforts

Budget

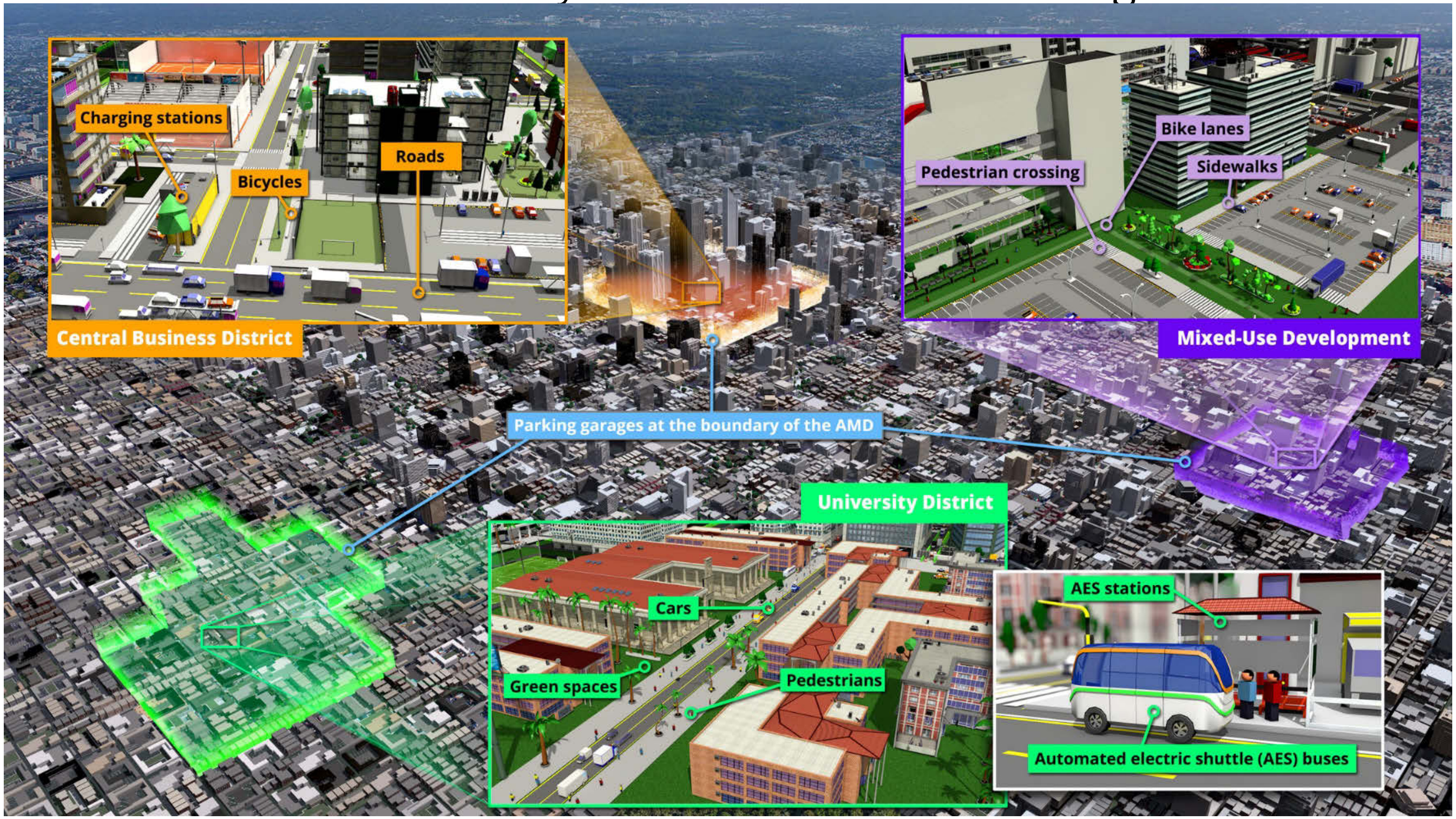
- Total project funding
  - DOE share: $930K
  - Contractor share: $0
- Funding for FY 2017: $290K
- Funding for FY 2018: $320K

Partners

- SMART Mobility Laboratory Consortium:
  - National Renewable Energy Lab (NREL)
  - Oak Ridge National Laboratory (ORNL)
  - Idaho National Laboratory (INL)
- Greenville County [Primary Collaborator], South Carolina
- Jacksonville Transit Authority
- Vanderbilt University

WHAT IS AN AMD?

An automated mobility district (AMD) is a campus-sized implementation of connected/automated vehicle (CAV) technology to realize the full benefits of a fully electric automated mobility service within a confined region or district.



RELEVANCE

Source: https://www.energy.gov/eere/articles/energy-and-transportation-departments-commit-supporting-cities-future

The Energy Efficient Mobility Systems (EEMS) Program envisions an ***affordable, efficient, safe, and accessible*** transportation future in which mobility is decoupled from energy consumption. The program will conduct ***early-stage R&D*** at the vehicle, traveler, and system levels.

- **Project Objectives**
  - Quantify the net mobility gains and energy impacts of automated, connected, electric and/or shared (ACES) vehicles deployed in dense urban districts
  - Develop modeling capabilities for VTO to estimate the energy and environmental effects of AMDs

Intra-District Impacts	Inter-Regional Impacts	Boundary Issues/ Effects
• Mobility and energy of AMD fleet • Land use changes.	• Modal choice • Route choice • Activity choice.	• Mode transfer/ parking • Boundary services • TNCs, car sharing/rental.

  - Integrate AMD model into existing regional travel models to simulate AMDs as a "special generator" in the region to quantify energy and mobility impacts.

MILESTONES

Month/Year	Description of Milestone or Go/No-Go Decision	Status
March 2017	White paper, “Initial Assessment and Modeling Framework Development for Automated Mobility Districts,” presented at 2017 ITS World Congress	Complete
September 2017	Identify early adopter stakeholders: • Non-disclosure agreement (NDA) with Robotic Research • Memorandum of understanding (MOU)/Partnership with Greenville, SC	Complete Final Stages of Approval
February 2018	Conference paper, “Quantifying the Mobility and Energy Benefits of Automated Mobility Districts Using Microscopic Traffic Simulation,” selected for presentation at the ASCE-ICTD conference to be held in Pittsburgh, PA	Complete
September 2018	Exercise the AMD modeling toolkit for a real-world deployment	On Schedule

APPROACH

AMD Simulation Toolkit: Model Flow

Travel Demand

- Origin-Destination data from regional travel demand model
- Local surveys or counts
- Induced travel demand.

SUMO
(Mobility Analysis)

- SUMO – Simulator of Urban Mobility
- Carries out the network simulation of vehicles
- SUMO will output travel trajectories.

FASTSim
(Energy Analysis)

- FASTSim – Future Automotive Systems Technology Simulator
- FASTSim will output vehicle energy consumption.

APPROACH

District-scale implementations of automated mobility systems are getting off the ground in multiple deployment locations in the United States.

2016

- Build on existing AMD analysis
  - NREL authored Institute of Electrical and Electronics Engineers (IEEE) Conference paper (Chen et al., 2015), an analysis of a proposed automated mobility system on a university campus.

2017

- Develop and implement a modeling framework
  - Assess mobility/energy impacts of AMDs
  - Model development in **SUMO**

2018

- Exercise the model with partners either implementing AMDs, or seriously considering them.

2018/19

- Integrate into a regional travel demand model (Austin → Task 2.1.3)
- Produce case studies replicable/transferable to other proposed sights.

		Location			
Collaboration	Potential AMD Deployments	Military Base	Residential Community	University Campus	Neighborhood
	Greenville (SC)		✓	✓	✓
	Miramar Base (CA)	✓			
	Houston University (TX)			✓	
	Jacksonville (FL)				✓

APPROACH

End of March

Version 1

→ Bare bones simulation setup

→ Hypothetical demand and network data

→ Dedicated guideways and fixed schedules for automated electric shuttles (AES).

End of July

Version 2

→ Real network and fixed demand

→ Location of application: Greenville

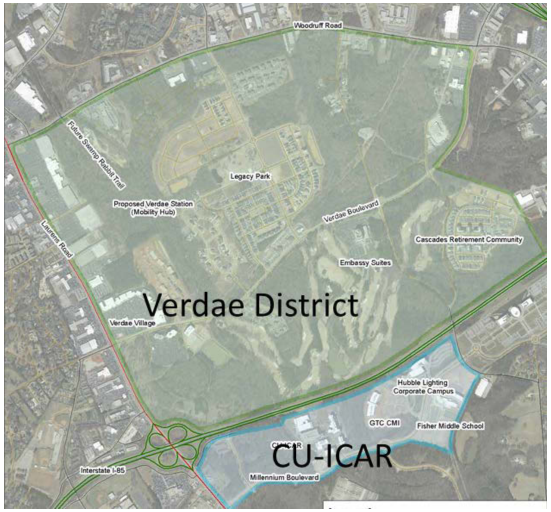
→ On-demand services for AES

→ AES simulation in conditions.

End of September

Version 3

→ Real network and dynamic (induced) demand.



Source: Presentation from Greenville County

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

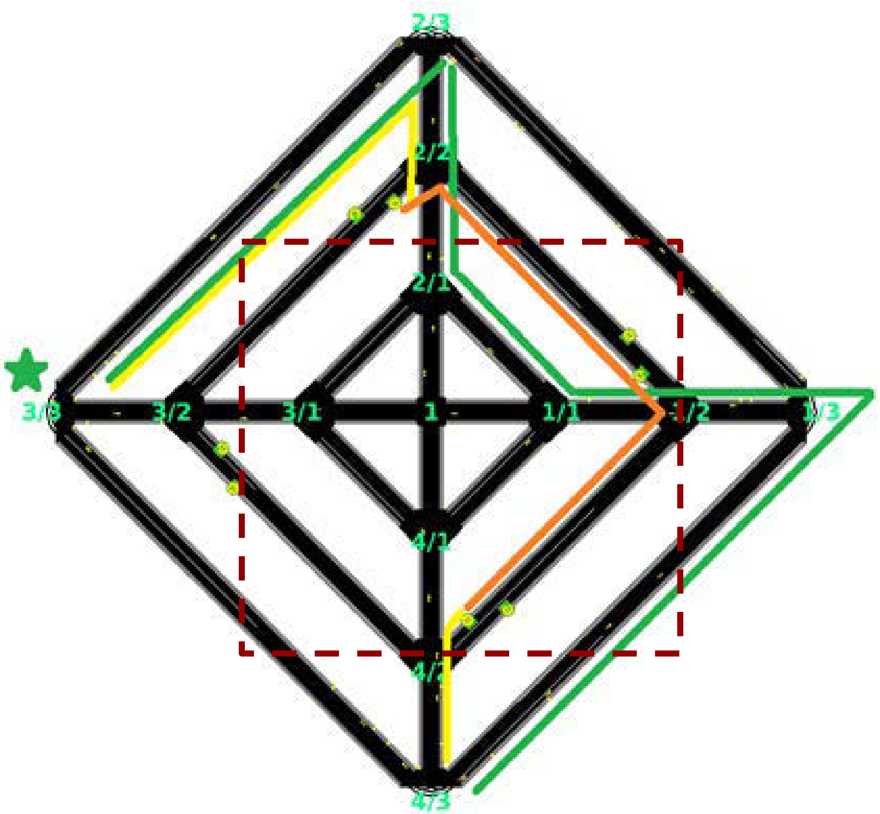
FY 2017 (Previous Accomplishments)

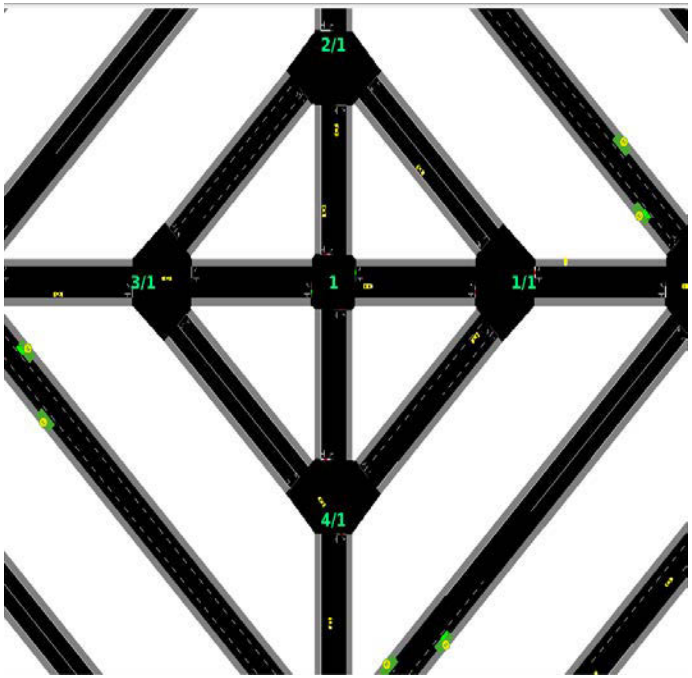
- Conducted extensive literature and practice search on mobility and energy impact analysis of automated transit systems
- Applied framework to existing Personal Rapid Transit (PRT) / Automated Transit Network (ATN) study in Manhattan, Kansas
- Developed initial framework for assessing mobility/energy impacts of AMDs
- Explored tools available for modeling AMDs and select tools to be used
- Hosted an AMD workshop at the Princeton Smart Driving Car Summit.

FY 2018

- Coded a hypothetical network in the chosen network model in SUMO
- Coded an on-demand automated electric shuttle mode in SUMO
- Ran a few preliminary scenarios with assumed demand and modal distribution on the hypothetical network
- MOU underway with Greenville, SC. Greenville won a $4M U.S. Department of Transportation (DOT) grant to deploy automated taxi (A-taxi) shuttle systems in three neighborhoods
- Received travel demand and traffic network data from Greenville, currently being coded into SUMO
- Hosted two AMD sessions at the American Society of Civil Engineers (ASCE) — Automated People Movers Conference.

Preliminary AMD Simulation

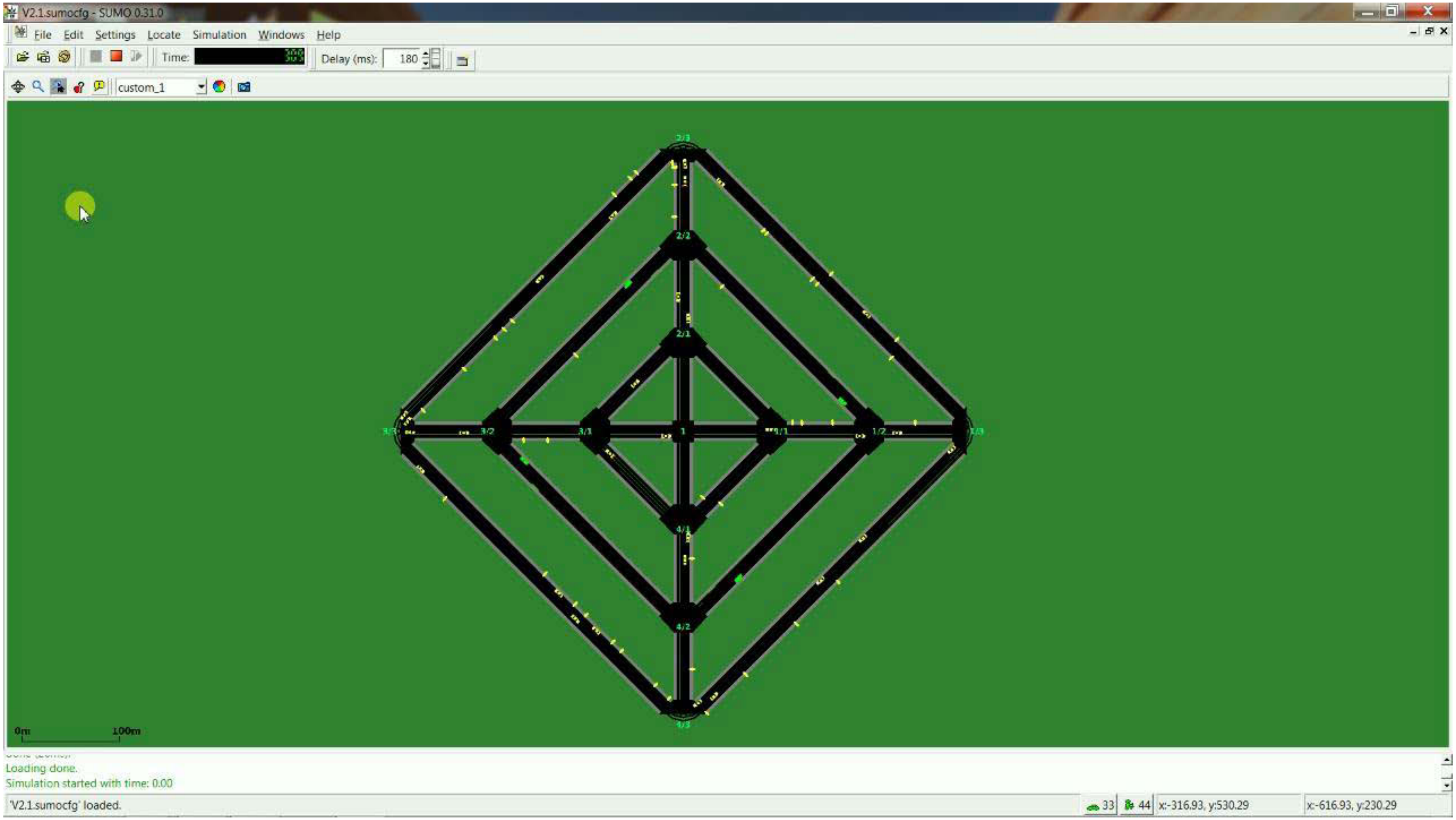




Car
Walk
AES

Sample of hypothetical AMDs using mixed modes (car, walking, automated electric shuttles) coded in SUMO to simulate intra-district mobility and energy impacts

Preliminary AMD Simulation



TECHNICAL ACCOMPLISHMENTS AND PROGRESS

Preliminary AMD Simulation — Assumptions

Network	• A hypothetical trapezoidal network is generated in SUMO.
Travel Demand	• For the preliminary analysis, hypothetical traffic demand is generated and distributed across the 13 origin-destination (O-D) pairs in the network.
Mode Share	• This initial study intends to understand the mobility and energy impacts of an AMD, so the mode shares are "assumed" for various scenarios.
AES Fleet and Operation	• A total of four AES serve the designated demand in the AMD. • AES pick up only one passenger at a time. They stop after dropping a passenger and wait for the next trip request.
Vehicles	• Cars → 2016 Toyota Camry • AES → 2016 Nissan Leaf

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

Scenario Development

Scenarios	Car mode	Walk mode	Automated Shuttle mode
Baseline	70%	30%	0%
Transitional	60%	20%	20%
Optimistic	50%	10%	40%

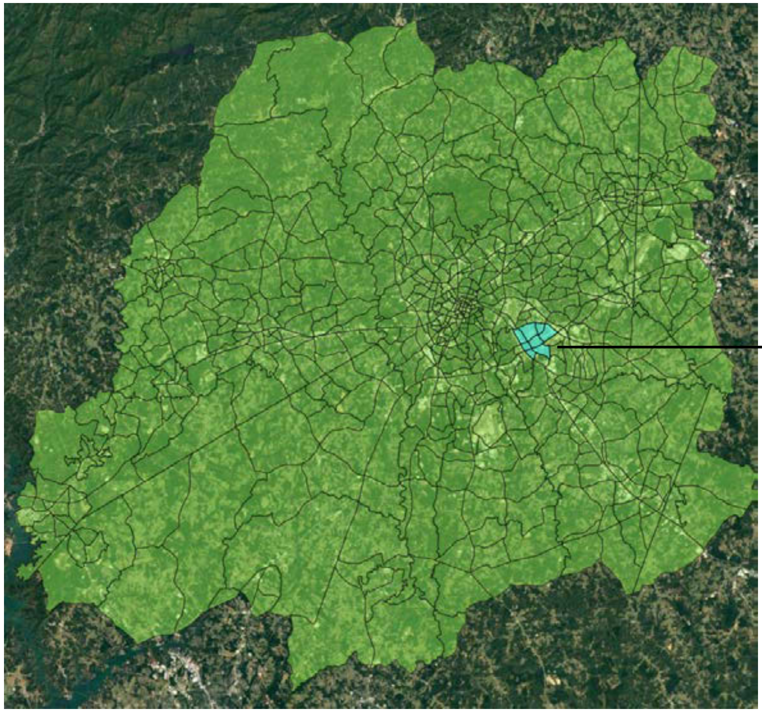
Results

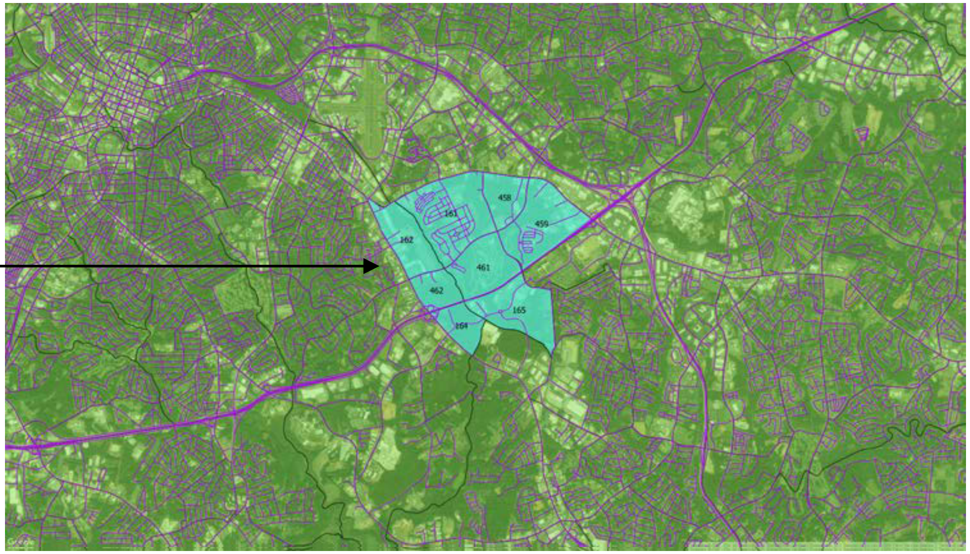
Scenario	VMT (miles)	VATT (seconds)	VATD (miles)	FC (gal) [gasoline/ electric shuttle case]
Baseline	128.8	86.5	0.6	5.9
Transitional	153.8	124.3	0.8	7.0/5.3
Optimistic	175.7	168.5	1.1	8.0/4.5

- Vehicle Miles Traveled (VMT) — the sum of all private vehicle and automated shuttle mileage for the scenario
- Vehicle Average Travel Time (VATT) — the average time of travel in vehicle (does not include walking), averaged across private vehicles and automated shuttle trips
- Vehicle Average Travel Distance (VATD) — the average travel distance (excluding any pedestrian links), averaged across private vehicle and automated shuttle trips
- Fuel Consumption (FC) — in gallons of gasoline across the entire system

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

Greenville AMDs: Phase 0 and Phase 1





- Phase 0: Two electric automated vehicles (EAVs) will be repurposed as A-Taxis in Greenville at ***CU-ICAR***, connecting with nearby academic and business collaborators [Already Underway]
- Phase 1: A-Taxi service will expand across I-85 (4-6 A-Taxis) to serve the nearby ***Verdae development*** with its housing, office, retail, and commercial centers [3–6 months following the ATCMTD Grant]

RESPONSES TO PREVIOUS YEAR REVIEWERS' COMMENTS

1. The reviewer commented that two DOE laboratories and two universities are project partners, but no city partner that is planning to implement AMDs has been identified. [Two other reviewers emphasized the need for an AMD deployment partner].
Response: The project team has partnered with Greenville, SC which is currently testing A-Taxi shuttle systems in three locations in Greenville. Greenville has already provided the project team with travel demand and network information. Data from a-taxi operations will be collected in this fiscal year. The team continues communications with other leading deployments/demos.

2. The reviewer stated the project may need many bounds or a scenario-based approach to understand the uncertainty of AMD energy impact, similar to how general Automated Vehicle (AV) energy impacts have been bounded, but hopefully with much less uncertainty.
Response: The authors are indeed considering a scenario-based approach for testing AV energy impacts. Some preliminary work has been published and included as a part of this presentation.

3. The reviewer said that military base collaboration is promising, and stated that there is a program underway with Major Brandon Newell that should be considered.
Response: The authors are in active discussions with Major Brandon Newell to seek data from AES deployment in Miramar Military base for AMD model tool kit development.

COLLABORATION AND COORDINATION

Within VTO

- SMART Mobility Consortium Laboratories: NREL, ORNL, and INL
- SMART Mobility Pillars: Advanced Fueling Infrastructure, CAVs, Mobility and Decision Science

Outside VTO

Collaborators	Type	Extent
Greenville	County/City	AMD deployment partner, providing travel demand and network supply data
Robotic Research	Industry	Automated shuttle operations data from Greenville deployment
Texas Southern	University	Potential AMD deployment partner
Miramar Military Base	Government	Potential AMD deployment partner
Vanderbilt	University	Energy consumption modeling (Sub)

REMAINING CHALLENGES AND BARRIERS

- No existing modeling and simulation tools exist for AMD impact analysis
  - Requires multi-modal simulation (road, pedestrian, transit, parking, and AMD)
  - Most tools focus on single mode, simplifying others – though some previous art in automated people movers and airport modeling may apply
- Virtually none of the studies that focus on shared automated mobility is based on data from actual field implementation of automated vehicles
- Connecting the “special generator” AMD toolkit into a region’s travel demand model is going to be a key challenge, once the AMD toolkit is fully developed
  - Collaborating with Task 2.1.3 [SMART Mobility Modeling for Typical Mid-Size City] in the Urban Science pillar to address this.

PROPOSED FUTURE RESEARCH

- FY18 – Remaining
  - Complete the intra-district micro-simulation (SUMO) component of the AMD modeling toolkit
  - Exercise the AMD toolkit based for Greenville, SC
- FY19
  - Integrate the AMD toolkit into a regional travel demand model
  - Model inter-district and boundary impacts of AMDs in conjunction with the regional travel demand model
  - Produce case studies transferable to other sites

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

SUMMARY

- AMD research, under SMART Mobility Urban Science, anticipates early deployment of fully automated vehicles in geographically constrained areas as a public mobility service – increasingly supported by early deployment announcements
- Objective is to develop modeling capabilities for VTO to estimate energy, emission, and mobility impacts of AMDs
- FY18 efforts to date include preliminary modeling and simulation efforts using hypothetical network and demand data
  - Preliminary results published in a conference paper
- Remaining efforts in FY18 will be focused on further refining the AMD modeling and simulation process using data from a real-world deployment (Greenville)
- FY19 efforts will focus on:
  - Integrating the model toolkit into a regional travel demand model
  - Produce case studies transferable to other sites.

Thank You

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