Next Generation Integrated Mobility:

Driving Smart Cities

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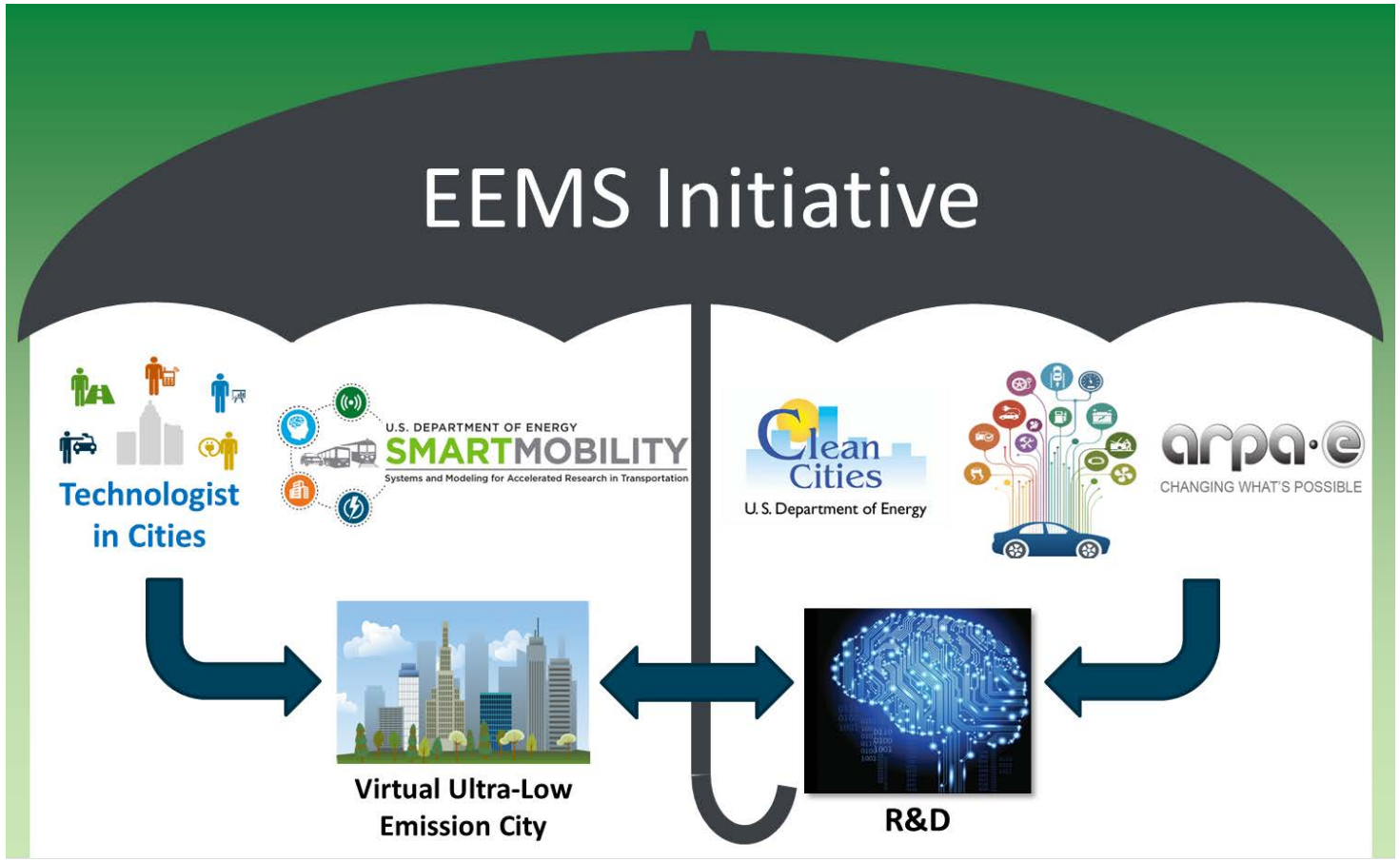
National Renewable Energy Laboratory (NREL)

Initial Assessment and Modeling Framework Development for Automated Mobility Districts

Energy Efficient Mobility Systems



SMART Mobility Consortium: Five National Laboratories

Multi-Year, Multi-Lab Effort (3 years, 5 labs)

- Energy implications of connectivity & automation
- Multi-modal transport of people and goods
- **City-scale urban mobility models for planning**
- Informed fueling infrastructure investments
- Understanding consumer mobility decisions

What is an Automated Mobility District (AMD)

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

Characteristics of an AMD

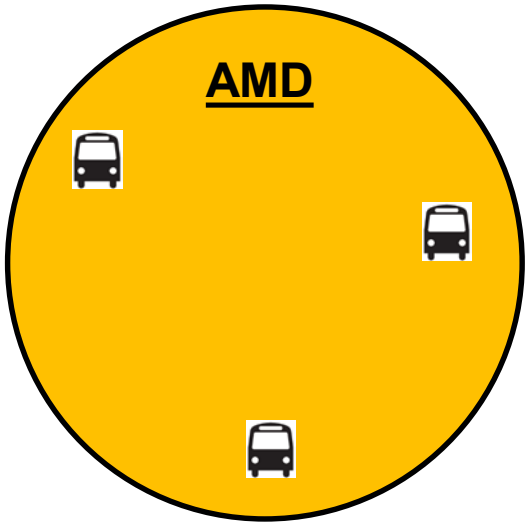
Fully automated and driverless cars

- Mix of on-demand and fixed route services

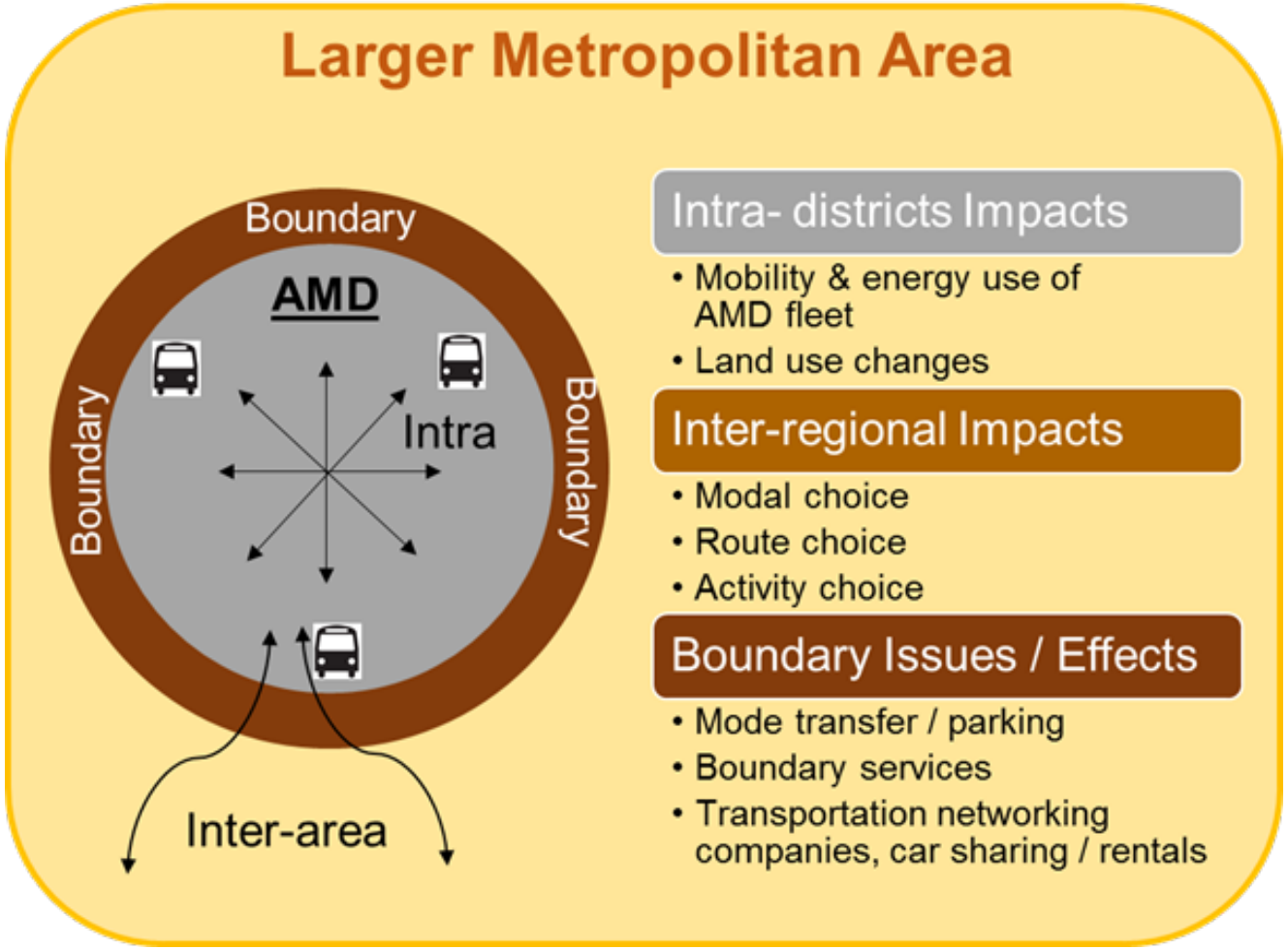
Service constrained to a dense area

Multi-modal access within/at the perimeter

Personal vehicle use not prohibited, but discouraged



AMD Impact Perspectives



AMD – Operational and Application Contexts

Operational Context

On a captive guideway (traditional airport APM – restricted to guideway)

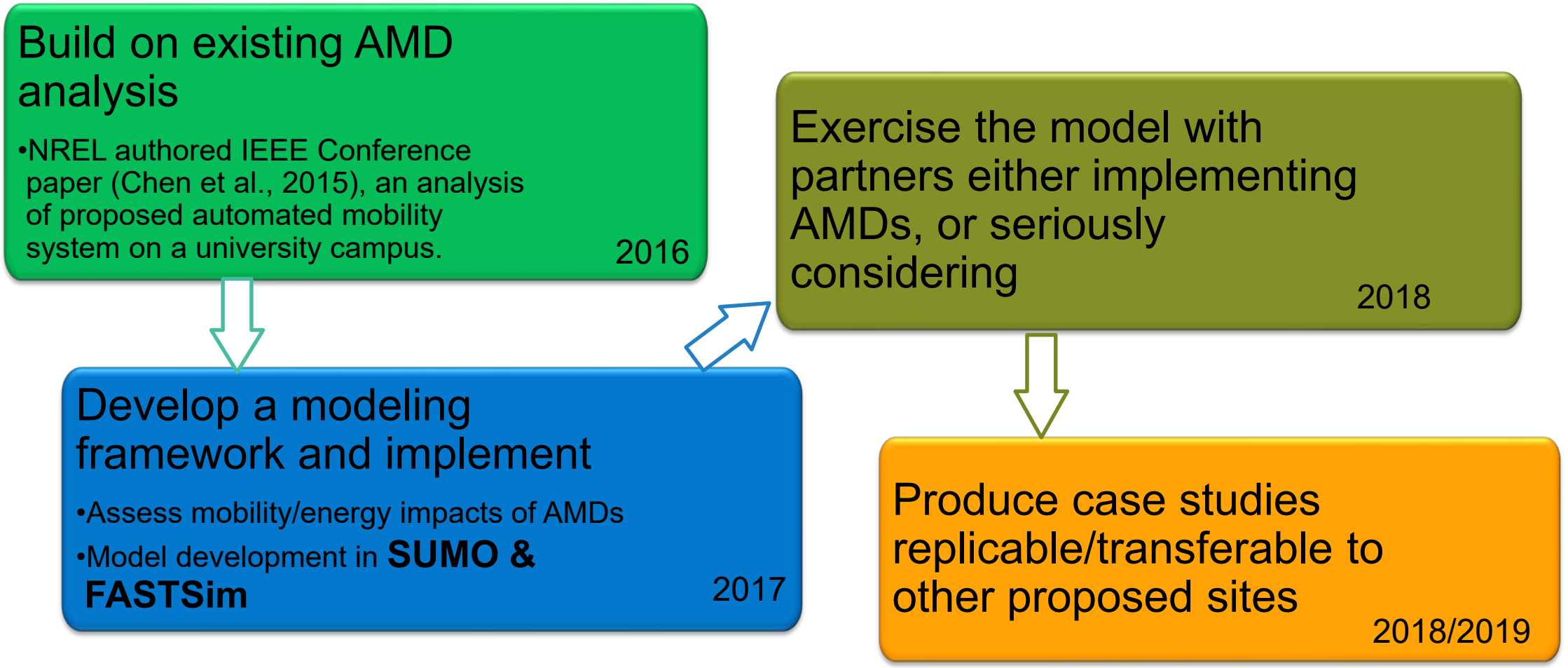
Continuum of service / area / flexibility emerging.

On existing road network (Full automation everywhere)

Application Context

Collaboration	Potential AMD Deployments	Location: Military Base	Location: Residential Community	Location: University Campus	Location: Neighborhood
	Miramar Military Base (California)	✓			
	Babcock Ranch (Florida)		✓		
	Houston University (Texas)			✓	
	Greenville (South Carolina)		✓	✓	✓
	Jacksonville (Florida)				✓
	Pena Next Station (Denver)				✓

AMD Modeling Approach



AMD Modeling

Where we are

Existing tools primarily emphasize on

- Limited capabilities to model AMDs
- The road network, with minimal to no consideration for ped/bike/transit
- Privately owned vehicles, but do not model shared economies
- Models built from traditional travel surveys
- Any others…

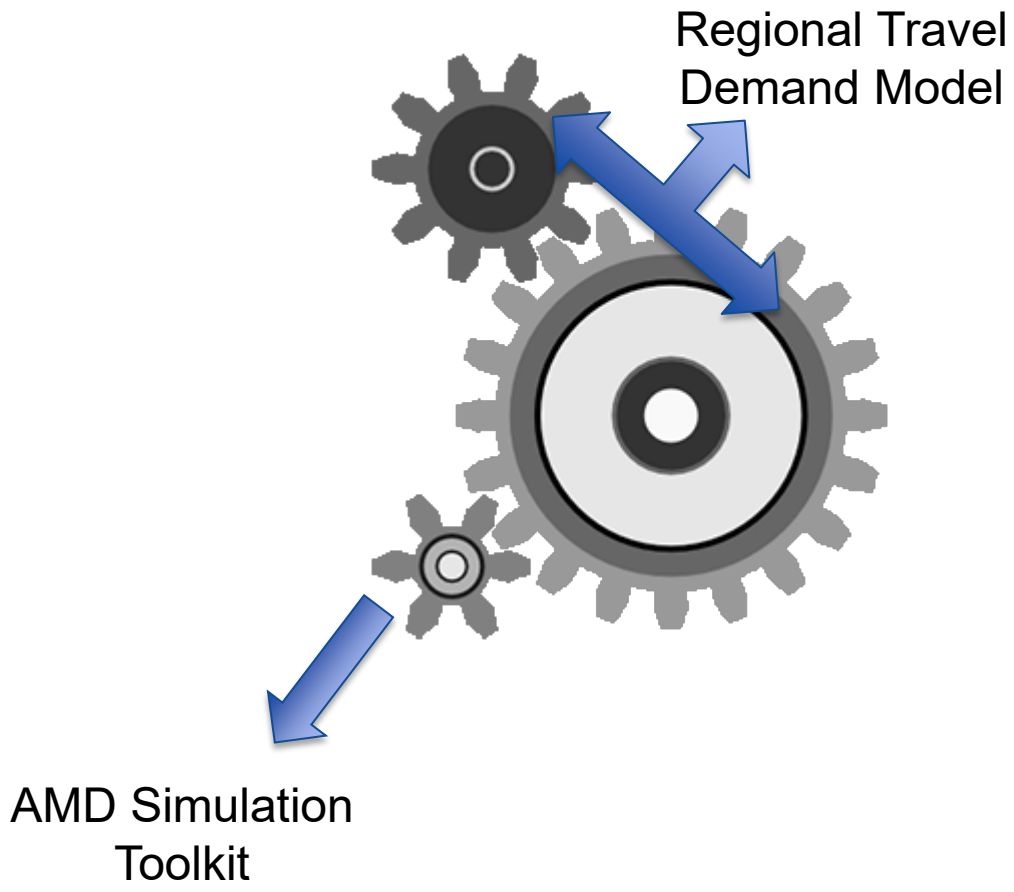
Where we want to be

The AMD modeling toolkit will

- Model the impact of AMDs on travel behavior
- Consider the interaction between different modal alternatives
- Capture private as well as shared economies in vehicles
- Are built from data based on field deployments
- Can quantify the energy and emission benefits
- Any others…

What is the AMD Modeling and Simulation Toolkit?

- A special generator submodel that plugs into an existing travel demand model for the region
- ***Simulates*** the 'micro' movements of various modes with the district
- ***Considers*** travel interactions between the district and the rest of the region
- ***Quantifies*** mobility and energy benefits of automated electric mobility service within the district



AMD Simulation Toolkit: Model Flow

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

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

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

SUMO – Inputs and Outputs

- SUMO is an open source, microscopic and continuous road traffic simulation package

Inputs

- Regional traffic demand (transportation agencies)
- Road network and configurations (OSM, agency GIS, etc.)
- Automated and connected vehicle service configurations (number of automated vehicles, vehicle capacity)
- CAV Vehicle operational characteristics (average speed, acceleration, headways, etc.)

Outputs

- Network mobility metrics: average travel time (deadheading time), average travel distance, PMT, etc.
- Other scenario related metrics (best number of shuttles, best shuttle capacity, etc.)
- Detailed vehicle trajectories.

FASTSim – Inputs and Outputs

- Output from the SUMO model will be fed into the FASTSim Model

Inputs

- 1Hz vehicle travel trajectories under different vehicle operational characteristics
- Attributes of vehicles, e.g. length, vehicle type, powertrain type, etc.
- Battery & Charging characteristics, e.g. min / max SOC, roadway charging, etc. (if applicable)
- Vehicle passenger and cargo loads

Outputs

- 1Hz energy consumption of vehicles
- Temporal or spatial aggregated vehicle energy consumption
- Comparison of energy consumption based on different vehicle type and powertrain mix
- Other scenario related metrics (best mix of powertrain and vehicle type, best vehicle range for EVs etc.)

AMD Simulation Toolkit: Array of Uses

- Test various operational configurations of AMDs (Fixed route, on-demand, mixed)
- Quantify performance metrics
- Energy analysis (e.g., best mix of powertrain and vehicle type)
- AMD impacts on travel to / from the district?
- Analysis of interconnected AMDs (intra-district, inter-district, and boundary travel)
- Minimum number of vehicles needed to satisfy demand

AMD – Preliminary Simulation

Future Work

- Develop a proof of concept AMD Simulation Toolkit
- Collect travel survey and vehicle operational data from a real-world AMD deployment
- Augment the modeling components of the toolkit with data from real work AMD deployments
- Integrate the AMD toolkit into a regional traffic model
- Quantify the mobility and energy benefits of AMDs

Questions/Comments