Quantifying the Mobility and Energy Benefits of Automated Mobility Districts Using Microscopic Traffic Simulation

Lei Zhu, Venu Garikapati, Yi Hou, and Stanley Young, National Renewable Energy Laboratory

Yuche Chen, Vanderbilt University; H. M. Abdul Aziz, Oak Ridge National Laboratory

AUTOMATED MOBILITY DISTRICTS (AMDs)

- District-scale implementation of advanced vehicle (AV) technologies
  - Full benefits of an AV-shared-mobility service (SAE Level 5) within a confined geographic region or district
  - **Everything somewhere** vs. something everywhere
- AMD models serve as "special generators" in existing urban travel demand models (TDMs)—similar to how airports, university campuses, and central business districts (CBDs) are currently treated in TDMs
- AMD modeling and simulation toolkit informed by real-world deployments to quantify the mobility and energy impacts of an AMD.

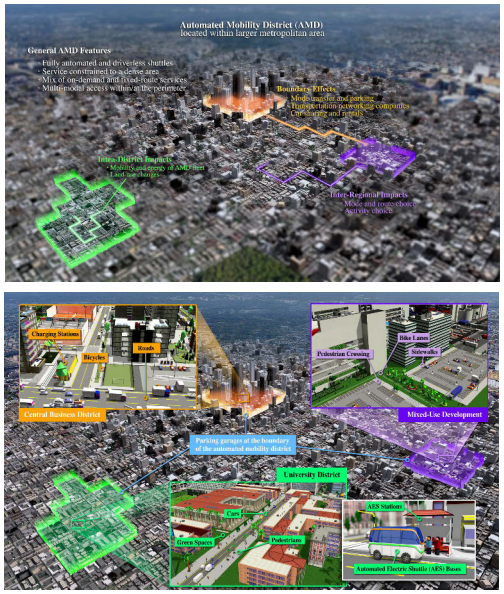


Figure 1. Conceptual depiction of AMDs

MODEL DESCRIPTION

- AMD toolkit
  - Builds on the Simulation of Urban Mobility (SUMO)—a leading open-source microscopic traffic simulation suite
  - Integrates the Future Automotive Systems Technology Simulator (FASTSim), a vehicle/powertrain simulation tool maintained by NREL.

- Origin-destination (O-D) data from TDM
- Local surveys or counts
- Induced travel demand.

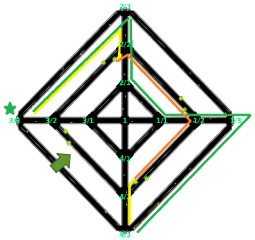
- Carries out network simulation of vehicles
- Outputs detailed travel trajectories.

- Outputs vehicle energy consumption.

Figure 2. AMD simulation toolkit: model flow

CASE STUDIES

A Hypothetical AMD Scenario



- Four AES vehicles operate "on-demand" inside the circuit.
- The simulation is carried out for a demand of 300 trips distributed across the 13 (O-D) pairs.
- Traffic demand is distributed as a bimodal distribution reflecting morning and afternoon peak hours during a typical day.
- The choice set of travel modes encompasses: 1) passenger car, 2) AES, and 3) walking.

Figure 3. A hypothetical AMD network in SUMO
Green lines ➔ Car mode
Yellow lines ➔ Pedestrian mode
Red lines ➔ AES mode

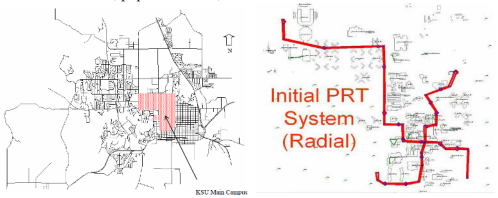
Scenario (Car: Walk: AES)	VMT (miles)	VATT (seconds)	VATD (miles)	FC (gal) [gasoline/ electric shuttle case]
Baseline (70:30:0)	128.8	86.5	0.6	5.9
Transitional (60:20:20)	153.8	124.3	0.8	7.0/5.3
Optimistic (50:10:40)	175.7	168.5	1.1	8.0/4.5

Vehicle miles traveled (VMT); vehicle average travel time (VATT); vehicle average travel distance (VATD); fuel consumption (FC) in gallons of gasoline

- Mobility impact: compared to the baseline scenario, the transitional and optimistic scenarios exhibit an increase in VMT, VATT, and VATD.
- Energy/fuel impact:
  - For the gasoline automated shuttle case, total gasoline consumption increases along with total VMT.
  - For the AES case, the transitional and optimistic scenarios see fuel consumption decrease by 10% and 26%, respectively.

Kansas State University Campus (Manhattan, KS)

- Kansas State University campus considered using a personal rapid transit (PRT) system to provide last mile mobility on campus
- Area: 664 acres; population: ~25,000.



(a) (b)

Figure 4. Kansas State University campus: (a) PRT system and (b) test region in satellite image

- Analyzed mobility metrics (personal miles traveled [PMT]/personal hours traveled [PHT]) with and without PRT system
- Mobility analysis
  - 10 AMD miles displaced ~ 4.5 ped & 4.5 vehicle miles
  - 4 AMD hours displaced ~3 ped & 1 vehicle hour
  - Total system VMT increased 2%–3%
  - Total system PHT decreased ~1% (people will travel further to go faster)
  - Total system energy (even with conservative assumptions) decreased.

Greenville AMDs

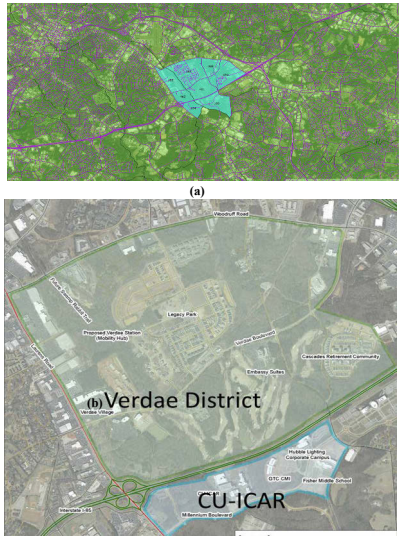


Figure 5. Greenville AMD automated taxi (a-taxi) shuttle service test region: (a) detailed road network and traffic analysis zone and (b) satellite image (zoomed in)

- On-demand fixed route automated shuttles (a-taxi shuttles) are operating inside Greenville field test region (AMD)
- Greenville AMD scenario toolkit is informed by the real-world traffic demand and network data (Figure 4(a)) from Greenville County
- A modeling and simulation scenario for the proposed Greenville AMD is developed for mobility and energy assessment
- Multi-modal traffic flow: 1) passenger car, 2) walking, 3) on-demand fixed-route shuttles, 4) on-demand door-to-door ride-sharing
- The Greenville AMD analysis is currently underway.

RESULTS AND DISCUSSION

- An AMD is a district-scale implementation of connected and automated vehicle technologies to realize the full benefits of an on-demand shared automated mobility service within a confined geographic region.
- A hypothetical AMD along with real-world AMD implementations, e.g., Greenville AMD and the Kansas State University campus, are introduced.
- This study develops an AMD modeling and simulation toolkit and reports on the preliminary analysis results for hypothetical AMD deployment, exercising the toolkit with three scenarios.
- Future research will focus on enhancing the toolkit to integrate different mobility operations of AMDs and define and quantify various performance metrics for AMDs.
- The model will also be extended to account for parking-related issues (availability and access times).

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