VS186

Evaluation of Dynamic Wireless Charging Demand

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OVERVIEW

Timeline	Barriers
• Project start date: Oct. 2015 • Project end date: Sept. 2016	• Lack of effective decision support tool for investment of charging infrastructure • Lack of knowledge about en route EV performance regimes • Lack of efficient models representing vehicular interaction at scale
Budget (DOE share)	**Partners**
• FY16 funding: • DOE VS - $180k	• Argonne National Laboratory • National Renewable Energy Laboratory • Oak Ridge National Laboratory

OBJECTIVE: Accelerate future deployment of EV and needed infrastructure through a better understanding of demand

"WHY"

- **Electrification of the nation's vehicle fleet offers large potential reductions in energy consumption, criteria emissions, and greenhouse gases.**
- **Dynamic wireless charging is a promising technology to reduce electric car drivers' range anxiety and size of battery by providing capability of en route charging.**
- **Demand of dynamic wireless charging is critical to the deployment not only because the cost of infrastructure but also because the demand can depend on traffic**

"HOW"

- **Develop and validate representing traffic models for simulating vehicle interaction with road topology, surrounding vehicles, and traffic control.**
  - Horizontal and vertical road alignment
  - Travel demand
  - Vehicle characteristics
  - Traffic control models
- **Estimate EV power demand based on simulated vehicle dynamic considering traffic factors**
  - Baseline battery models
  - Baseline EV load models
- **Evaluate dynamic wireless charging demand based on the estimated power demand**

RELEVANCE*

- **Supports 2 major VTO Mission Critical Goals:**
  - Reduce the cost of electric-drive technologies (EV Everywhere Initiative).
  - Determine impact on electricity grid and consumer charging behavior.
- **Directly supports 2 VS cross-cutting activities:**
  - Modeling and simulation; vehicle systems efficiency improvements.
- **Indirectly supports VS Grid Modernization efforts.**
- **Addresses the following VS Barriers:**
  - **Risk aversion**: Integrates model-based simulation and analysis with experimental measurements.
  - **Cost**: Utilizes data and models from other VTO projects.
  - **Constant advances in technology**: Emphasizes latest advanced high power wireless charging technologies.
  - **Computational models, design, and simulation methodologies:** Combines EV load model and traffic condition with best available laboratory and real-world data to maximize accuracy.

***Reference: Vehicle Technologies Multi-Year Program Plan 2011-2015:**
http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/vt_mypp_2011-2015.pdf

FY2016 MILESTONES

Month /Year	Milestone or Go/No-Go Decision	Description	Status
Dec 2015	Milestone	Identify a route-choice-behavior dynamic traffic assignment model that allows travelers to regularly receive updated traffic information and reroute as needed.	COMPLETE
Mar 2016	Milestone	Develop a baseline microscopic traffic network model with travel demand, composition of traffic, and traffic controls for power demand analysis.	COMPLETE
Jun 2016	Milestone	Perform Monte Carlo simulations to estimate EV power demand under different control scenarios	ON TRACK
Oct 2016	Milestone	Evaluate dynamic wireless charging demand based on the estimated power demand	ON TRACK

APPROACH: Bring vehicular interaction into formula

- How vehicles are operated in real world
  - ✓ Road alignment
  - ✓ Speed limit
  - ✓ Fleet composition
  - ✓ Car following
  - ✓ Lane changing
  - ✓ Traffic control
  - ✓ Routing, etc.

- How a vehicle is actually controlled
  - ✓ cruise,
  - ✓ acceleration,
  - ✓ deceleration.
- Four data sources
  - ✓ Standard
  - ✓ Selected in lab
  - ✓ Selected on-road
  - ✓ Traffic

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- EV Loads
- Battery size
- State of Charge
- Charging preference
- Economical factors, Not included here.

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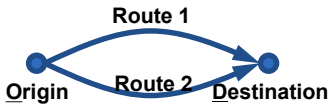
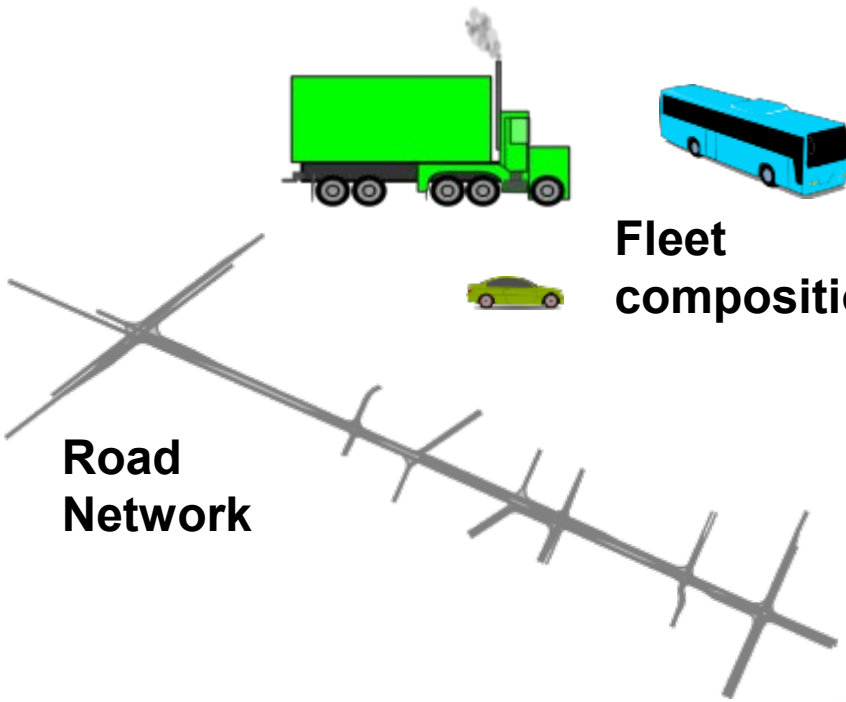
APPROACH: Model Based Controls to Demand Simulation



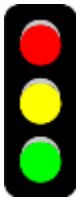
- Travel Demand
- Traffic Assignment



Road Network

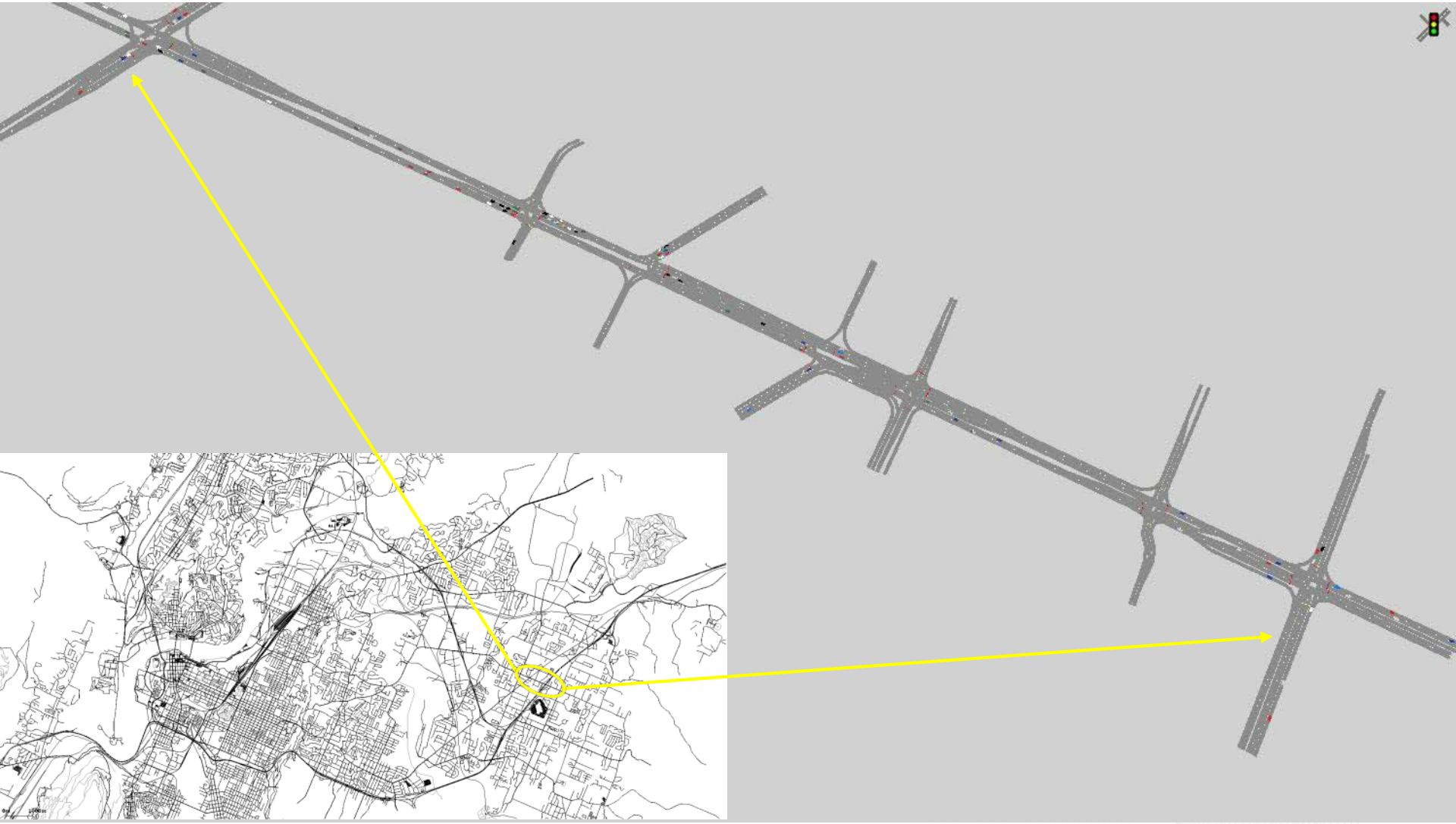
Fleet composition

Power Demand



- Traffic control types
- Timing

APPROACH: Visualization Example of Traffic Simulation



ACCOMPLISHMENT (1): Traffic Assignment

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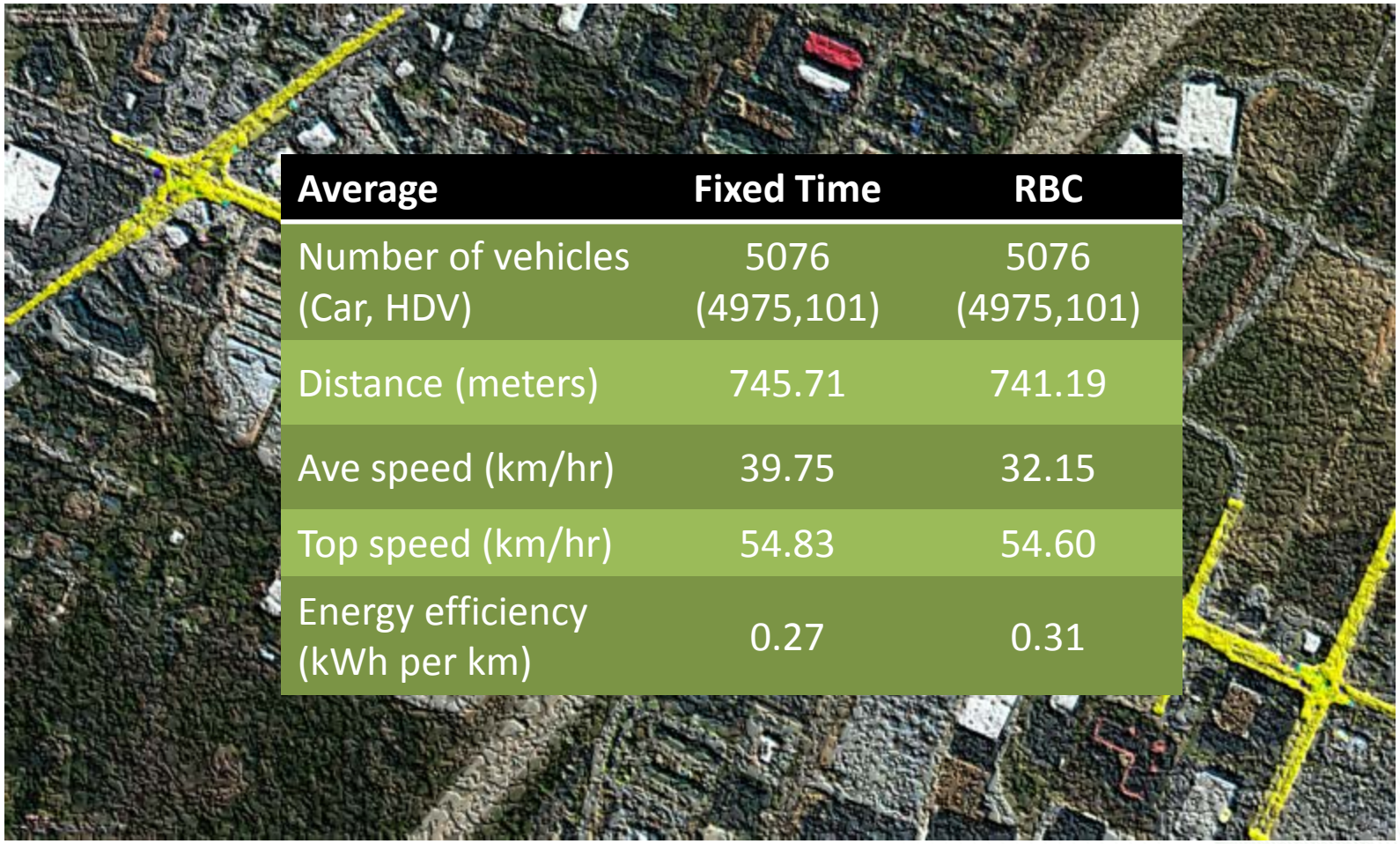
ACCOMPLISHMENT (2): Baseline microscopic traffic network

ACCOMPLISHMENT (3): Energy Estimation under Traffic Controls



Average	Fixed Time	RBC
Number of vehicles (Car, HDV)	5076 (4975,101)	5076 (4975,101)
Distance (meters)	745.71	741.19
Ave speed (km/hr)	39.75	32.15
Top speed (km/hr)	54.83	54.60
Energy efficiency (kWh per km)	0.27	0.31

COLLABORATION AND COORDINATION

- **Argonne National Laboratory**
  - Building upon previous work at ANL for light duty, plug-in hybrid electric vehicles
  - Consulting for baseline approaches for vehicle system simulation
- **National Renewable Energy Laboratory**
  - Collaboration with and use of duty cycle information from Fleet DNA database
- **Related ORNL Activities**
  - ORNL Medium and Heavy Truck Duty Cycle “real world” database (including grade).
  - Research in National Household Travel Survey and Traffic Operation

PROPOSED FUTURE WORK

- **FY16**
  - **Monte Carlo simulations to estimate vehicle power demand under different control scenarios**
    - Specific efforts will be made on integrating baseline battery and EV load models into the simulation
  - **Evaluation of dynamic wireless charging demand based on the estimated power demand**
    - Specific efforts will be made on creating an aggregate power demand matrix
- **FY17 and beyond**
  - **Upscale to larger metropolitan or regional scale**
  - **Refinement of the simulation model with additional traffic control strategies**
  - **Preliminary optimization for charging infrastructure siting**
  - **Exploration on strategies to conduct the simulation at scale**
  - **Integration of baseline climate control strategies into overall supervisory controls**
  - **Preliminary supervisory controls optimization for minimal on-road energy consumption**
  - **Validation of the optimization with hardware-in-the-loop testing of system in ORNL VSI Laboratory**
  - **Support the vehicle and infrastructure pillar of SMART Mobility to better understand the benefits of dynamic wireless charging**

SUMMARY:

- **Relevance**
  - Research is focused on advanced **dynamic wireless charging** systems that will **reduce energy consumption, criteria emissions, and greenhouse gases.**.
- **Approach**
  - **Multi-faceted approach** to evaluation of dynamic wireless charging demand utilizing travel demand, vehicle dynamic, and traffic control strategies.
- **Technical accomplishments and progress**
  - Identified a route-choice-behavior dynamic traffic assignment model that allows travelers to regularly receive updated traffic information and reroute as needed**.**
  - Develop a baseline microscopic traffic network model with travel demand, composition of traffic, and traffic controls for power demand analysis.
  - Estimation of EV power demand and evaluation of dynamic wireless charging demand is on track
- **Collaborations**
  - **Government**: Argonne National Laboratory, and National Renewable Energy Laboratory
- **Proposed Future Work**
  - **Optimization for charging infrastructure siting based on the evaluation**
  - **Strategies to conduct the evaluation at scale**
  - **Support the SMART Mobility consortium**

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