SMART Mobility – Urban Science Pillar

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Project ID # EEMS006

NREL/PR-5400-68291

Overview

Timeline

- Project start date: 10/01/2016
- Project end date: 9/30/2019
- Percent complete: 45% FY17

Budget

- Total project funding
  - DOE share: $2M FY17
- Funding received in FY 2016: 0
- Funding for FY 2017: $2M

Barriers

- Computational models, design and simulation methodologies
- Constant advances in technology

Partners

- DOE Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Consortium

  NREL: National Renewable Energy Lab

  ANL: Argonne National Lab

  INL: Idaho National Lab

  LBNL: Lawrence Berkeley National Lab

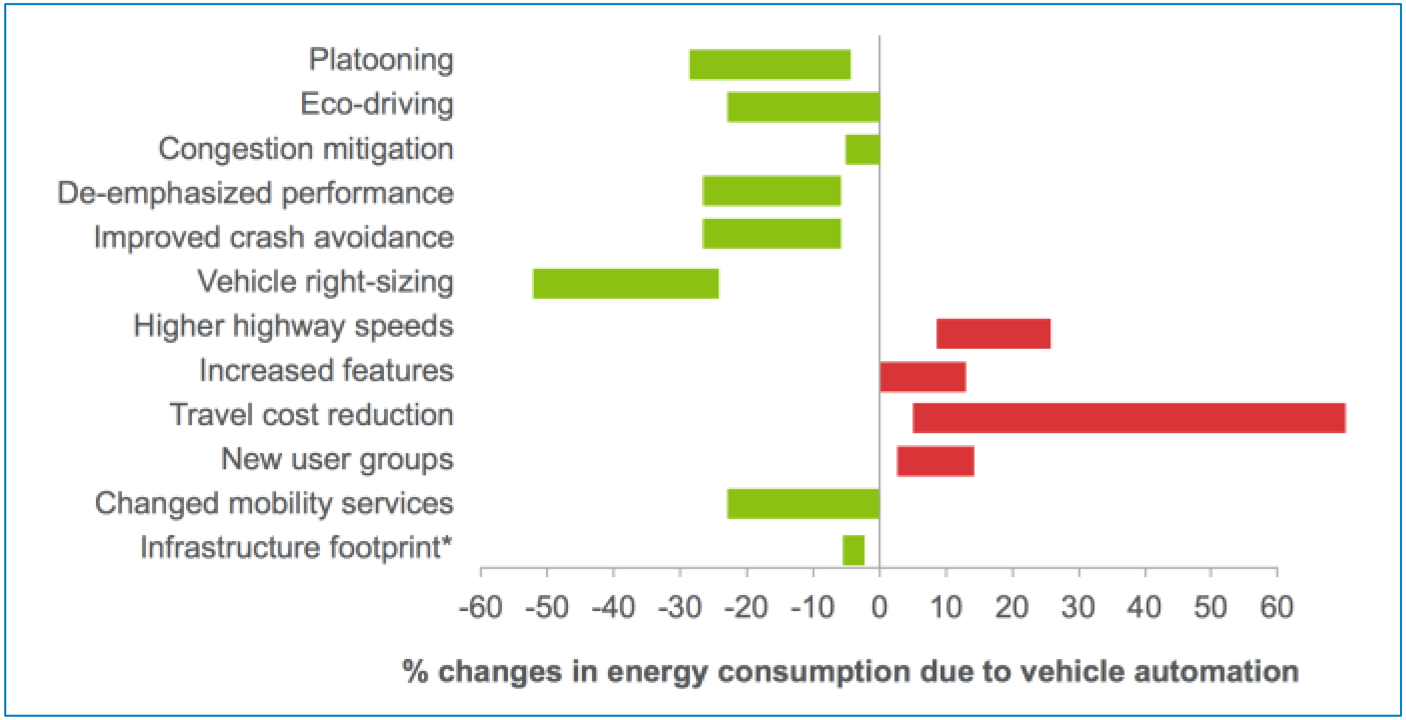
  ORNL: Oak Ridge National Lab
- Associated Labs

  LANL: Los Alamos National Lab

  PNNL: Pacific Northwest National Lab
- Subs
  - Texas Transportation Institute
  - Metropia Inc.
  - George Mason University

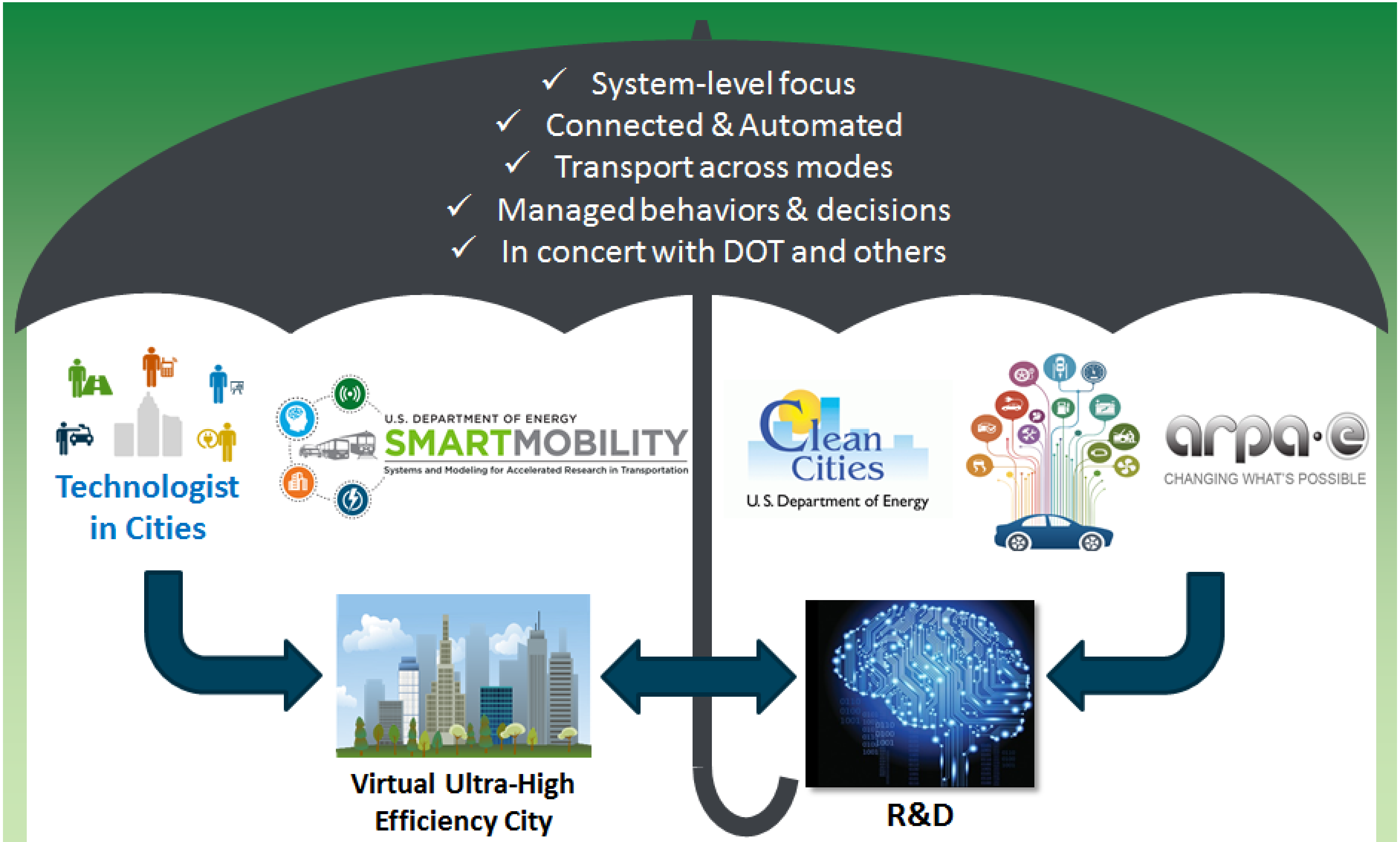
Relevance

- **VTO Concerns**
  - **Increased connectivity, automation, and mobility may lead to -90% to +200% energy use and emissions impact**
- **EEMS Initiative towards a "Maximum Mobility, Minimum Energy Future"**



EEMS: Energy Efficient Mobility Systems

Relevance – Continued



Relevance – Continued

- **SMART Urban Science Objectives**:
  - Harmonize methods, models, and data on the impacts and implications of SMART Mobility
  - Provide multiple urban case studies that yield insights by leveraging complementary expertise and tools across labs in the consortium
  - Support the development of effective policies and best practices
  - Identify key leverage points to increase sustainability
  - Create a layered tool kit and modular tools to support Smart Cities.

Milestones

Month / Year	Description of Milestone or Go/No-Go Decision	Status
December 2016	Assess the state of urban mobility modeling maturity and capability to reflect SMART mobility mega-trends. Engage practitioners, industry, academia, and DOE researchers through a hosted workshop to benchmark existing practice and prioritize future investment in DOE transportation model development. Host workshop in FY17, summary report of findings FY17 Q1.	Complete
March 2017	Synthesis study on existing signal infrastructure and control schemes. Documenting existing state of practice is the initial step in developing robust control infrastructure to be co-deployed for heterogeneous traffic (mix of connected and automated vehicles [CAVs] with human drivers) while leveraging safety, congestion, and energy gains.	Complete
June 2017	Curate Smart City partners' transportation models and supporting data, establishing a managed repository for urban science mobility modeling/research. The repository will serve as the basis to exercise and extend established urban transportation models in collaboration with partners to reflect the impacts of SMART technologies on the urban traveler.	On Track
September 2017	Computational framework for rapid transportation system model calibration. Develop methodological framework for transferability of detailed agent/activity-based models from one city to another, leveraging newly available data sets.	On Track

Approach – the Overarching SMART Structure

U.S. DEPARTMENT OF ENERGY
SMARTMOBILITY
Systems and Modeling for Accelerated Research in Transportation

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

Approach – the Urban Science Pillar

- **Urban Science – one of five SMART Mobility pillars**
  - How automation, connectivity, electrification, and shared use might impact the urban network/traveler
  - A city-centric view to modeling, data, and impact
- **Stakeholder engagement** with multiple urban areas to understand the problem space, then support and collaborate on targeted transportation energy opportunities
- Organized around five key Urban Science pillar tasks

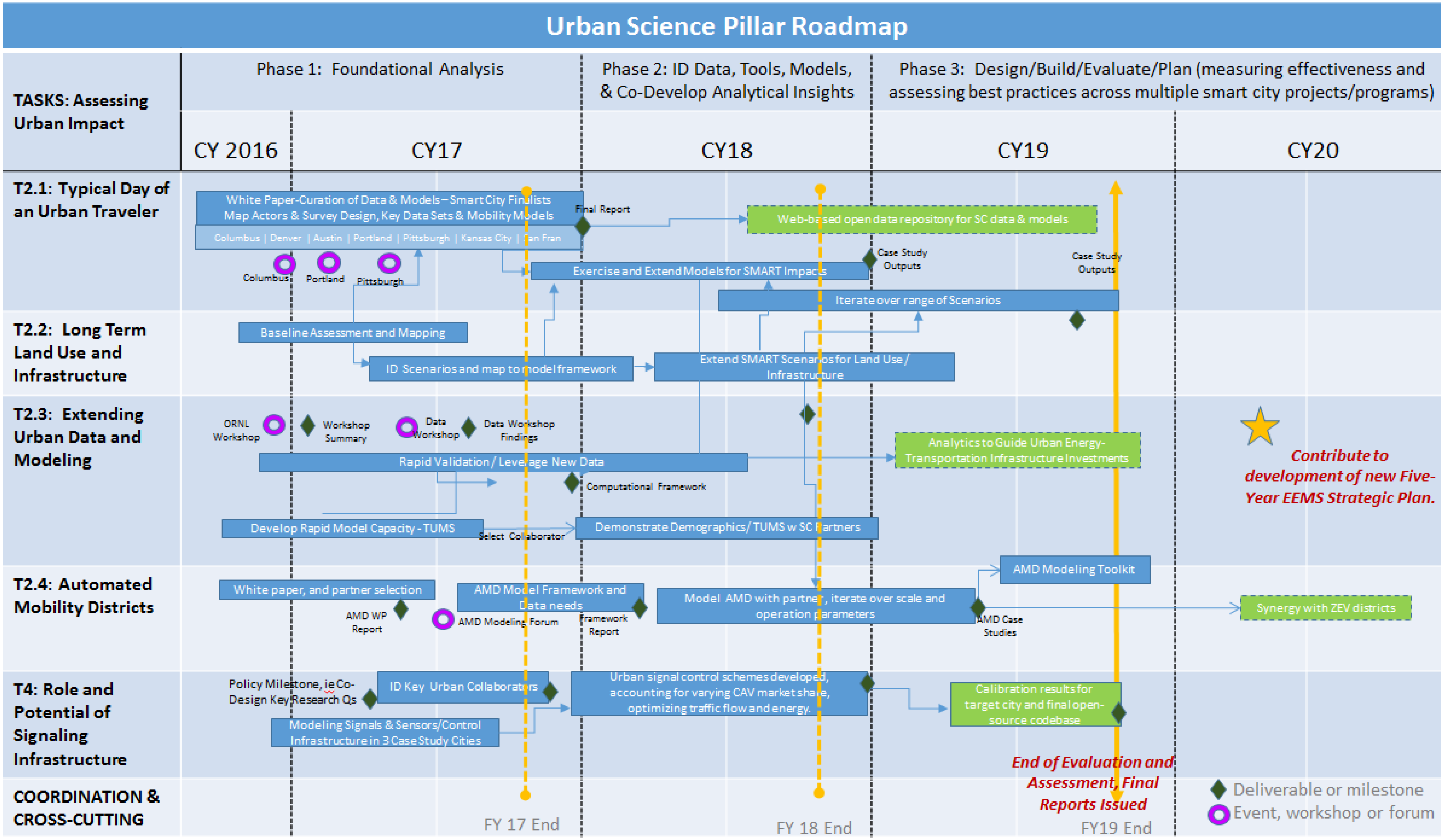
Approach – Tasks

- How will SMART tech impact cities
  - The Traveler – vehicle miles travelled (VMT), congestion, ownership, MaaS (2.1)
  - Evolution of urban built environment (2.2)
- Extending urban data and models (2.3)
  - Enable the efficient transfer of analysis and case studies developed within SMART to interested cities.
- Analyze impact of AMDs (2.4)
- Role of signal system in smart-enabled city (4.0)
  - Consider robust control infrastructure (signals and sensors) be co-deployed for heterogeneous traffic

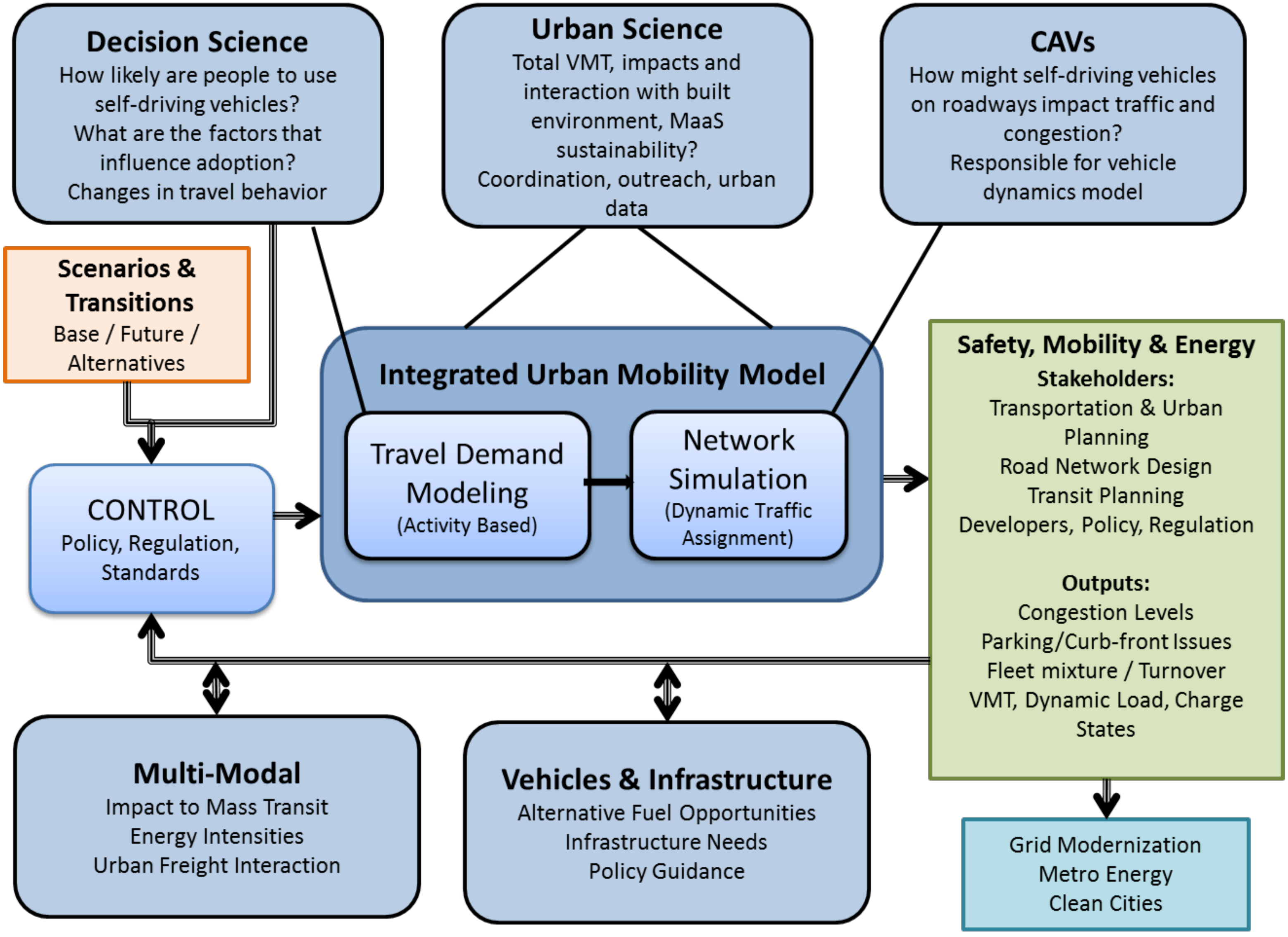
MaaS: Mobility as a Service

Approach – Continued

Multi-Year Urban Science Roadmap



Approach – How all the pieces fit together



Technical Accomplishments and Progress

- How will SMART Mobility technologies impact cities (2.1 & 2.2)
  - Curate data and models from Smart City finalists
  - Denver, Columbus, Portland and Pittsburgh – engaged
  - Initial draft – Q3 FY17
  - Provides basis for other tasks/ pillars
  - Identifies issues & opportunities for collaborative work
- AMR Presentation
  - Josh Sperling

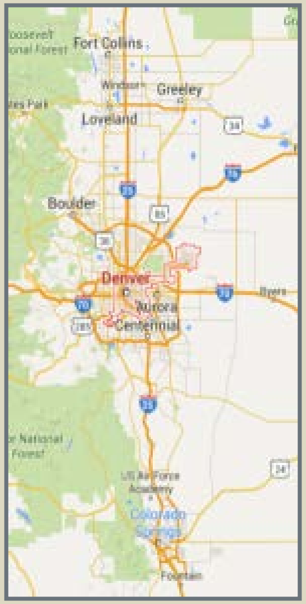
Pittsburgh, Pennsylvania

Portland, Oregon

Columbus, Ohio - MORPC

Denver, Colorado / Front Range / Colorado

- Players / Actors
  - City of Denver, DRCOG
  - RTD, CDOT Planning
- Data Sets / Inventory
  - Denver Regional Aerial Photography Project (DRAPP)
  - Capability & gap analysis
- Model Parameters/Status
  - Focus / Compass Transportation Models
- Concerns
  - Technology Scenarios



CDOT: Colorado Department of Transportation
DRCOG: Denver Regional Council of Governments
RTD: Regional Transportation District

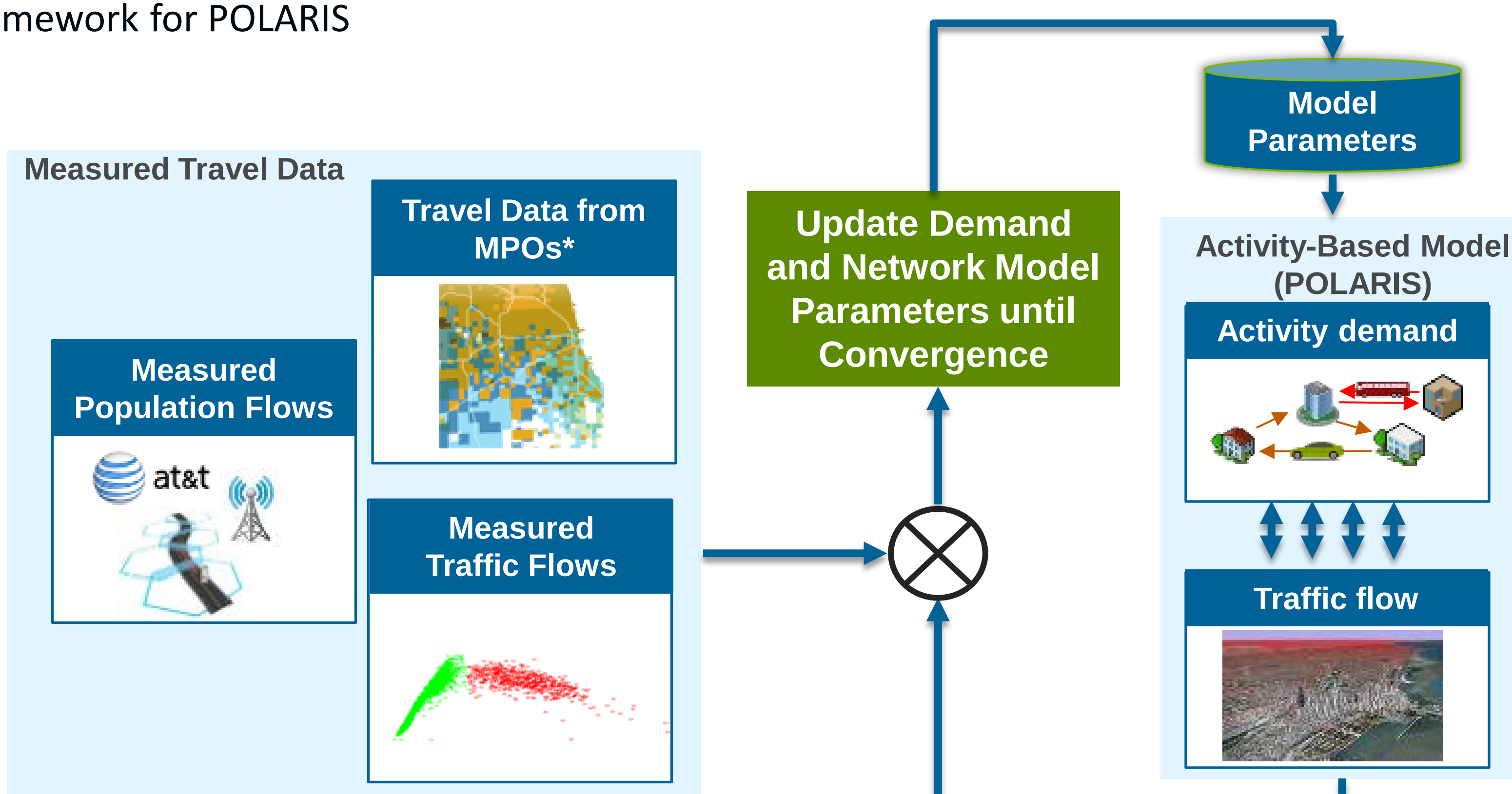
Technical Accomplishments and Progress

- Extending Urban Data and Modeling (2.3x)
  - *SMART Mobility Modeling & Simulation Tools Workshop*, November 2017 at ORNL, summary of workshop published
  - *SMART Mobility Transportation Data Workshop,* May 9–10, UC Berkeley
  - Develop and extend rapid modeling capacity of TUMs (2.3.3)
    - Established a collaborative arrangement with Mid Ohio Regional Planning Commission to use Columbus modeling datasets in TUMS
    - See Poster by Budhendra L. Bhaduri , Project ID: EEMS018

TUMS: Toolbox for Urban Mobility Simulations

Photo courtesy of ORNL

- Calibration of Activity-Based Transportation System Simulation Tools using High-Performance Computing (2.3.2)
  - Approach: develop an HPC framework to automatically calibrate activity-based transportation system models – usually a manual and expensive process
  - Defined mathematical formulation of the problem (Bayesian optimization) and developing HPC framework for POLARIS

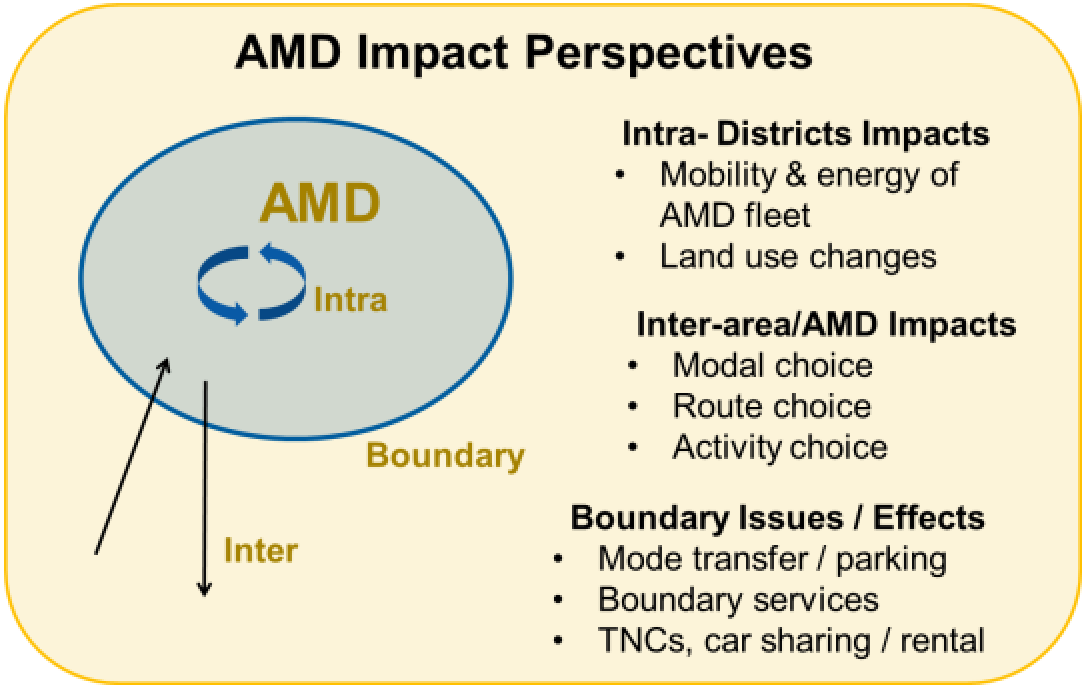


Argonne NATIONAL LABORATORY
GEORGE MASON UNIVERSITY
BERKELEY LAB

See EEMS015 for further details

Technical Accomplishments and Progress

- Automated Mobility Districts (2.4)
  - o Initial white paper draft – *"Initial Assessment and Modeling Framework Development for Automated Mobility Districts,"* submitted to ITS World Congress
  - o Identified potential collaborators
    - – Greenfield residential development
    - – University district
    - – Military base
  - o Exploratory modeling exercise using MATSim
  - o Yuche Chen – AMR Pres.



TNCs: Transportation Network Companies
MATSim: Multi-Agent Transport Simulation Toolkit

Technical Accomplishments and Progress

- Role & Potential of Signal Infrastructure in SMART (4.0)
  - White paper – *"Synthesis Study on Transitions in Signal Infrastructure and Control Algorithms for Connected and Automated Transportation,"* March 31, 2017
  - ITE abstract accepted – "*Opportunities and Challenges in Traffic Signal Operations and Infrastructure Deployment in the Era of Connected and Automated Vehicles*"
  - Ongoing – identification of collaboration partners for case studies

— See poster Presentation EEMS019 by Abdul Aziz, Ph.D. —

Table excerpt showing Smart City signal infrastructure elements in proposals

City	State	Challenge	Vision Element	Strategy
Austin	TX	Pedestrian / Bicyclist Safety	Intelligent, Sensor-based Infrastructure	Pedestrian Detectors (intersections)
Austin	TX	Freight Delays / Congestion	Urban Delivery and Logistics	Freight Signal Priority
Austin	TX	Accessibility for People with Disabilities and the Elderly	User-Focused Mobility Services and Choices	Apps for People with Disabilities
Austin	TX	Vehicle / Vehicle Collisions (intersections)	Connected Vehicles	Intersection Movement Assist (IMA)
Austin	TX	Delays at Intersections	Connected Vehicles	MMITSS / I-Sig
Austin	TX	Freight Delays / Congestion	Connected Vehicles	Freight Signal Priority
Austin	TX	Unpredictable / Unreliable Transit Service	Connected Vehicles	Transit Signal Priority

Response to Previous Year Reviewers' Comments

- This is a new project under the Energy Efficient Mobility Systems initiative. This project was not reviewed last year.

Collaboration and Coordination with Other Institutions

- DOE National Laboratories
  - NREL, INL, ANL, ORNL, LBNL – SMART Mobility Laboratory Consortium
  - PNNL, LANL – Associated Laboratories
- Other Institutions – Subcontractors
  - Texas A&M Transportation Institute
  - Metropia Incorporated
  - George Mason University
- U.S. DOT and U.S. DOT Smart City Finalists
  - Enabled through MOU with U.S. DOT – Technologist in City at Columbus, OH
  - Columbus, OH; Portland, OR; Denver, CO; Pittsburg, PA
  - Austin, TX; San Francisco, CA; Kansas City, MO
  - Collaboration with U.S. DOT personnel and offices
- Other Institutions
  - Universities: Texas Southern, Georgia Tech, Arizona State, U of Arizona, U of Maryland, U of Tennessee, U of Illinois Chicago, Northwestern, UCLA
  - Companies: RSG, Cambridge Systematics, ARUP, MRIGlobal
  - Transportation Authorities and MPOs: Atlanta Regional Council, CDOT

Remaining Challenges and Barriers

- **Rapid Adoption of Technology**
  Many of the changes in transportation are anticipated in a five-year horizon, while existing urban modeling cycles are 10 years or greater.
- **Data access and sharing**
  Access to city-specific data provides modeling opportunity. Industry data sets are becoming the norm, not the exception.
- **Efficiency in Urban Modeling**
  Transportation system modeling is extremely resource-intense (primary takeaway of workshop). Case studies, increased efficiencies, and standardized methods & tools are needed to extend limited resources.

Proposed Future Research

- FY17 – Remaining
  - Complete curation of key models and mobility models (2.1 & 2.2)
  - Engagement with remaining Smart City finalists: San Francisco, Kansas, and Pittsburgh (2.1 & 2.2)
  - Identify scenarios for SMART Mobility impacts (2.1 & 2.2)
  - Rapid Calibration Computational framework (2.3)
  - TUMS collaborators finalized and data/model integration requirements (2.3)
  - AMD model frameworks (2.4)
  - Key signal infrastructure urban collaborators (4.0)

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

Proposed Future Research

- Impact of SMART Technology on Urban Areas (2.1 & 2.2)
  - FY18
    - Expand/exercise partner transportation models for SMART tech
    - Develop web-based SMART Mobility open data repository
    - Expand SMART Mobility scenarios for land use and infrastructure
  - FY19
    - Expand/exercise models for land-use/built-environment scenarios
- Extending Urban Data and Modeling (2.3)
  - FY18/19
    - Demonstrate rapid tools (i.e., TUMS, Polaris calibration/validation) with partners
    - Continued industry-focused forums
    - Consideration of national-scale data plays
    - Toward rapid deployment framework/tools

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

Proposed Future Research – Continued

- Automated Mobility Districts (2.4)
  - FY18 Model and demonstrate AMD deployments with partners
    - Case study/ies of planned or deployed AMDs
  - FY19 Synthesize AMD Toolbox for wider application
    - Synergy with Zero Energy/Emission Vehicle (ZEV) districts

- Role and Potential of Signal Infrastructure (4.0)
  - FY18 Data preparation, simulation tool selection (adaptation), scenario development through collaboration with other pillars
    - Scenarios relevant to the future SMART signal infrastructure and CAV deployment; data ready for simulation studies
  - FY19 Development and execution of signal control schemes accounting for the progress path of signal infrastructure and potential CAV market share
    - Algorithm implementation and quantification of energy minimization benefits along with travel delays and greenhouse gas emissions

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

Summary

- SMART Mobility: Urban Science
  - o Urban/City-center perspective for impact of SMART technologies
  - o Emphasizes collaborative stakeholder engagement
  - o System-level modeling/assessment
    - – Exercise existing city transportation models on travelers and built environment (2.1&2.2)
    - – Extend/enhance urban data set and modeling methodology (2.3)
    - – Capture impacts of Automated Mobility Districts (2.4)
    - – Examine signal system role and optimal control strategies (4.0)