U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

SMART Mobility Stakeholders – Curating Urban Data & Models

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Argonne NATIONAL LABORATORY | INL Idaho National Laboratory | BERKELEY LAB | OAK RIDGE National Laboratory | NREL NATIONAL RENEWABLE ENERGY LABORATORY

Overview

Timeline

- Project start date: 10/01/2016
- Project end date: 9/30/2019
- Percent complete: 15%

Budget

- Total project funding
  - DOE share: $1.655 M FY17–FY19
- Funding received in FY 2016: 0
- Funding for FY 2017: $555 K

Barriers

- High-quality data for integration, visualization, and analytics/modeling
- Constant advances in technology

Partners

- DOE Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Lab Consortium
  - NREL: National Renewable Energy 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 A&M Transportation Institute
  - Metropia Inc.

A Race the U.S. Cannot Afford to Lose: Technology/Infrastructure Services for Shaping Sustainable/Smart Cities and Energy-mobility Nexus Innovation

On the Cusp of Many Changes:

→ **Transportation transformations & integrated mobility transitions** at different speeds, in diverse cities:

- **How** much will urban mobility change in the next 3, 10, 30 years? **What** will be the energy impacts?
- **Why** and **where** will cities/districts individually and collectively shape energy-efficient mobility in the age of shared, electric, automated, and connected vehicles?
- **When** are transitions/rates of change accelerated?

February 2016 Report on Technology and the Future of Cities:
This field is expected by 2030 "to connect thousands of researchers and represent **more than $2.5 billion in annual research and development investment to advance sustainable, resilient, and smart urbanization** and transfer that knowledge to the public sector." (PCAST, 2016).

Utopia? Nightmare?

→ A **context** for data/model curation

- Advancing objective analytics-tools-models for **mobility blueprints** and **rapid testing/experimentation**
- **Who are the change-makers that shape urban futures?** Informed by and informing planning with key cross-scale actors/institutions for cities.

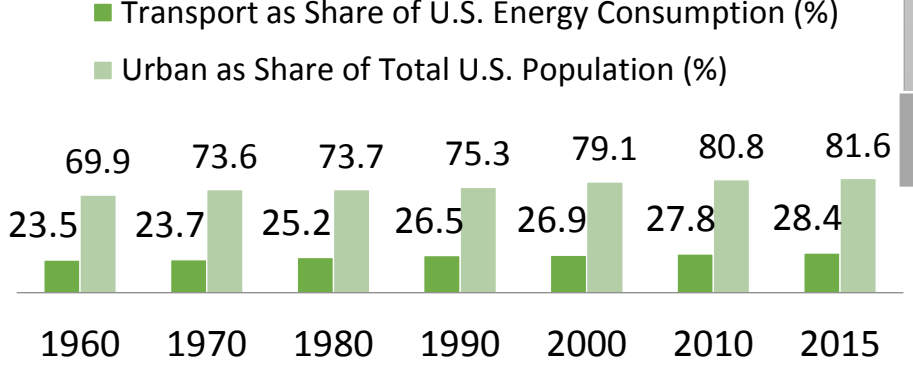
Sun Valley EcoDistrict (SVED) Draft Master Plan

(graphic used with permission from the Sun Valley EcoDistrict) | Denver, Colorado, USA

Relevance – Alternative Urban Futures: Nightmare? Utopia?

- **Rationale:** Transportation may soon reach over **30% of U.S. energy consumption**, with **urban >80% of U.S. population**
- **Objective:** Engage stakeholders to **curate urban data/models** and **accelerate research and innovation at the nexus of mobility and energy**
- **Methods:** Co-designed research & analytical approaches/questions to shaping mobility ecosystems with smart city stakeholders:

  >Top-Down; Bottom-Up; Inside-Out; Outside-In



Multi-Criteria Performance (Adapted from Isaac, 2016)	(-)	(+)
Energy/Vehicle Miles Traveled	↑	↑↓
Urban Sprawl / Congestion	↑	↓
Parking Requirements	No change	↓
Low-Income Mobility	↓	↑
Safety	↑	↑
Roadway Maintenance	↓	↓
City Revenues (e.g., parking)	↓	↑

[Sources: Adapted from *Driving Towards Driverless: A Guide For Government Agencies*, Isaac, 2016; US DOT/Census]

Relevance – Supporting Maximum Mobility, Minimum Energy…Urban Futures

Technology convergence *could* revolutionize transportation, dramatically improve safety and mobility while reducing costs and environmental impacts (e.g., via electrification)

- Connected Vehicles
- Vehicle Automation
- Internet of Things
- Machine Learning
- Big Data
- Mobility on Demand

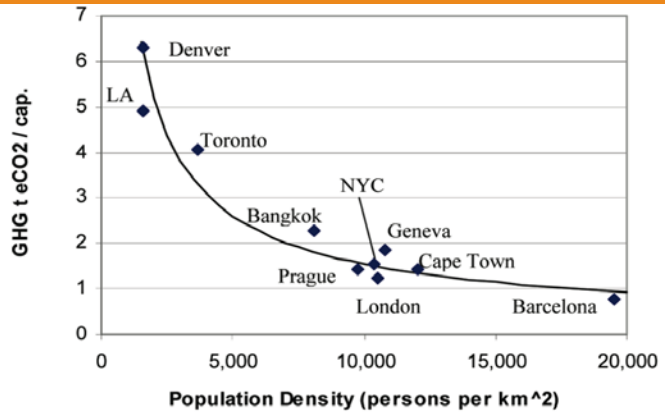


FIGURE 3. GHG emissions from ground transportation fuels are inversely related to population density.

US Petroleum, million barrels /day (EIA, 2016)

Gross Import	Export	Net Imports
10.06	5.19	4.87

Impacts of Integrated Mobility for Smarter Cities?

Will Marchetti's constant for cities hold true? Imagine 9 out of 10 cars and parking spaces disappearing from city centers **versus** auto-oriented sprawl for hundreds of miles…

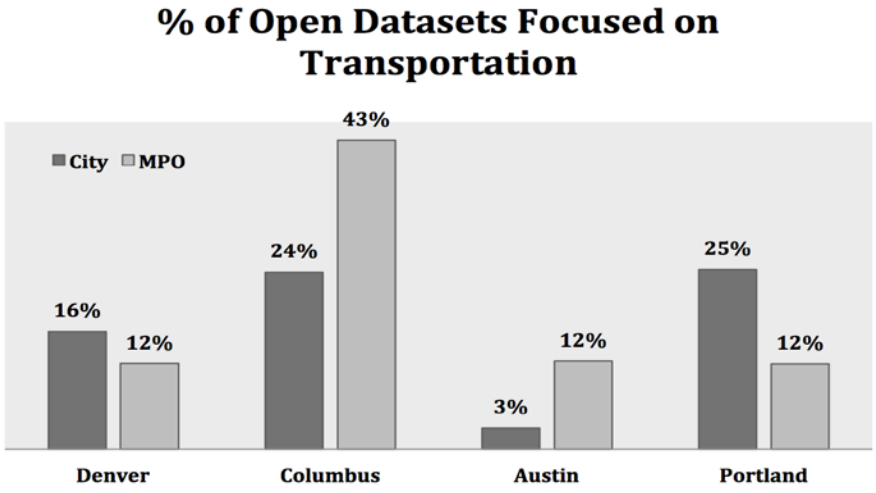
Risks and Benefits:

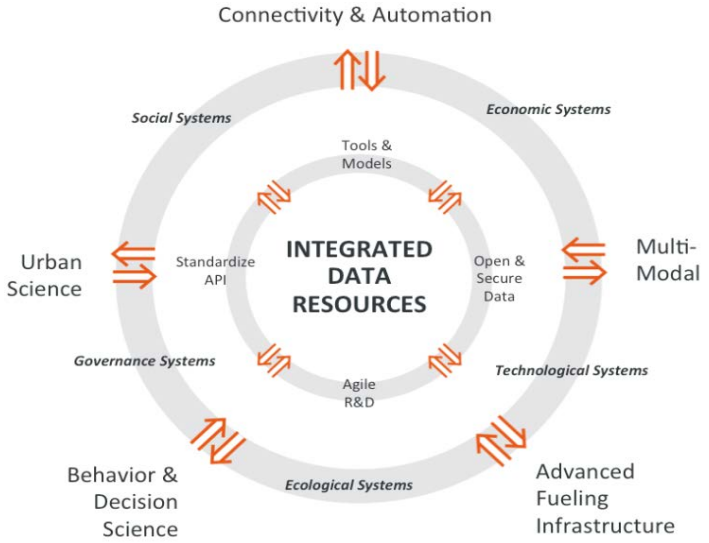
- Order of magnitude energy savings/increases and safety upgrades/risks
- Increasingly vulnerable or resilient transport energy system (e.g. cyber)
- Reduced or increased congestion?
- Improved access to jobs and services or increased accessibility anxiety?
- Reduced costs for gov't and users vs. big $ for infrastructure modernization
- Access & mobility synergies/tradeoffs

Does increasingly automated, connected, electric, & shared (ACES) mobility lead to energy efficiency gains? Quantitative impacts on urban travel, infrastructure, & energy consumption/supply/demand?

Urban Science for Exploring Advanced Mobility Systems, Technologies and Smart Cities for People : Task 2.1/2.2 Objectives

- **Harmonize** city-regional data, analysis methods, models on impacts/implications of “smart” mobility for people
- **Provide** new data, case studies, expertise, and leverage advanced tools
- **Support** data-driven development of city technology, plans, and policies
- **Identify** key leverage points/best practices to increase sustainability
- **Create** a suite of data integration techniques, analysis visualizations, and modular analytic tools to support DOT Smart Cities & beyond.
- **Explore** enablers/barriers to SMART Mobility technologies; tools to make sense of “big” data and multiple criteria
- **Analyze** city-relevant research questions; extend data integration, viz. tools/scenario models to augment decision-making & system performance





Critical Research Questions

- **PEOPLE: How** does SMART-enabled mobility impact urban travelers? **Why** energy use, vehicle miles traveled, congestion, vehicle ownership, mobility-as-a-service (MaaS), safety may shift and transform in the near to mid-term?

- **INFRASTRUCTURE: What** are long-term impacts of SMART mobility on city infrastructures? **Where** are combined infrastructures/social structures enabling SMART Mobility adoption?

- **IMPACTS**: What will SMART mobility system impacts be on energy, traffic congestion, **parking**, and land use in cities? **When** are transitions/rates of change accelerated to automated-connected-electric-shared mobility in cities?

Integration of Data, Advanced Tools, and Visualization to Accelerate Planning & Decision-Making

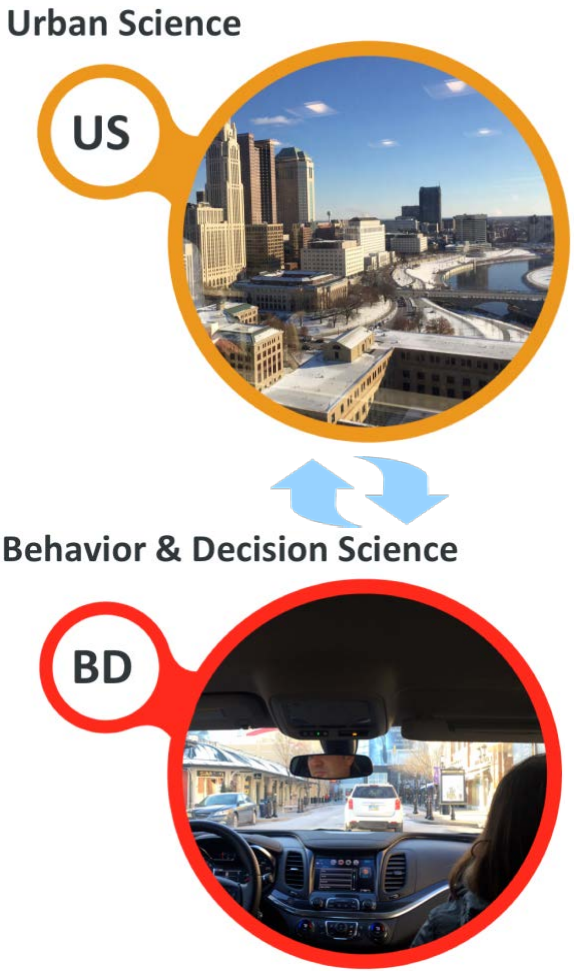


Photo Credit: Josh Sperling (in Columbus)

Milestones

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 researchers through a hosted workshop to benchmark existing practice • Convene workshops and develop key report for FY17 Q1. • Prioritize future investments in mobility model development	Complete
June 2017	• Curate Smart City partners transport models and data to include in repository for urban mobility science and research • Extend data as basis to exercise/advance urban models Identify impacts of SMART technologies on urban travelers	On Track
FY18/19	• **Advance** computational framework/open web-**Diffuse** data/model innovation with open transfer/up-scaling of best practices/analyses on advanced urban mobility • **Leverage** data integration, visualization, and analytical tools to accelerate planning and decision-making on urban futures.	On Track

Technical Accomplishments: Initial Progress Towards a Smart City Data, Resources & Solutions Library for Energy-Efficient Mobility Systems w/ Events, Key Findings, & More…

- NIST Global Smart City Transport Event
- DOE SMART Mobility city engagements as foundation for RD&D:
  - City of Denver
  - City of Portland
  - City of Columbus
  - City of Pittsburgh

type	city-scale metric	national bench-mark	Denver, CO	Portland, OR	Austin, TX
Transport	Road (VMT/ capita/day)	(27)	24 *[28]*	22 *[26]*	26 *[28]*
	Airline (enplaned passenger/ capita)	(2.3)	8	4	3
	Jet fuel (gallons/enplaned passenger)	(22)	19	26	17
	Long distance freight truck ($-1997/cap)	($288)	$295	$424	$94

Developing Integrated Urban Data-Modeling Resources to Advance and Accelerate Decision-Support Systems for Technology-Planning-Policy-Behavioral-Finance Transitions in Cities

Cross-Scale Actors & Institutions | Open Data Platforms | Key Smart City Indicators | Tools & Model Development | City-Based Lit. Review & Reports

Approach – Urban Science Pillar Tasks on Curating Data & Models

BEYOND TRAFFIC: DENVER THE SMART CITY CHALLENGE

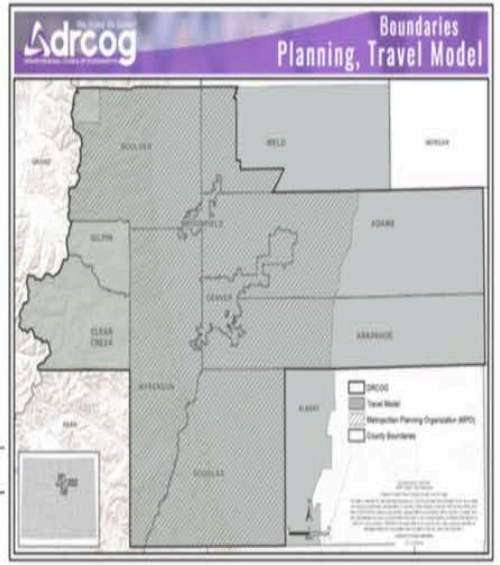
Denver FOCUS Travel Model

April 2017

MPO: drcog DENVER REGIONAL COUNCIL OF GOVERNMENTS

The current DRCOG activity-based model for the Denver metropolitan region was built using the 1997 Travel Behavior Inventory (TBI) Survey and calibrated using 2005 input datasets.

Spatial Resolution of Model	Counties	TAZs ✔	MAZs			
Model Architecture	4-Step	Activity-Based ✔	**Input Data from Surveys**	1997 TBI	2008 Transit Survey	2010 HHTS
	Static Assignment ✔	Dynamic Assignment	**Latest Upgrade Year**	2010	**Next Upgrade**	2017
Modes Covered	Auto ✔	Transit ✔	Walk ✔	Bike ✔	Freight ✔	Taxi	TNCs
Special Generator	Airport ✔	Freight	Internal/External Trip Generator ✔	University ✔	Other: Mountain / Casino ✔		
Scenarios	Infrastructure	Demographic	Land Use	Energy	Economy	Technology	Other



Level of Detail by Mode: Freight

None/Not covered — Advanced/Extensive

Level of Detail by Mode: Non-Motorized

None/Not covered — Advanced/Extensive

Level of Detail by Mode: TNCs

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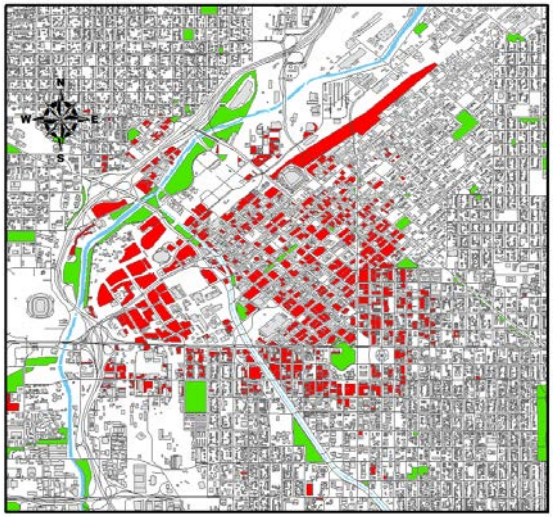
drcog Boundaries Planning, Travel Model



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Approach – Curation of Modeling Template (Text Box Headings) to Inform Pillar Interdependencies & Engagement with Stakeholders

MODEL SUMMARY

MODEL PROCESS FLOW CHART

INPUTS

OUTPUTS

BENEFITS

LIMITATIONS

RELATED PROJECTS

RELATED MODELS

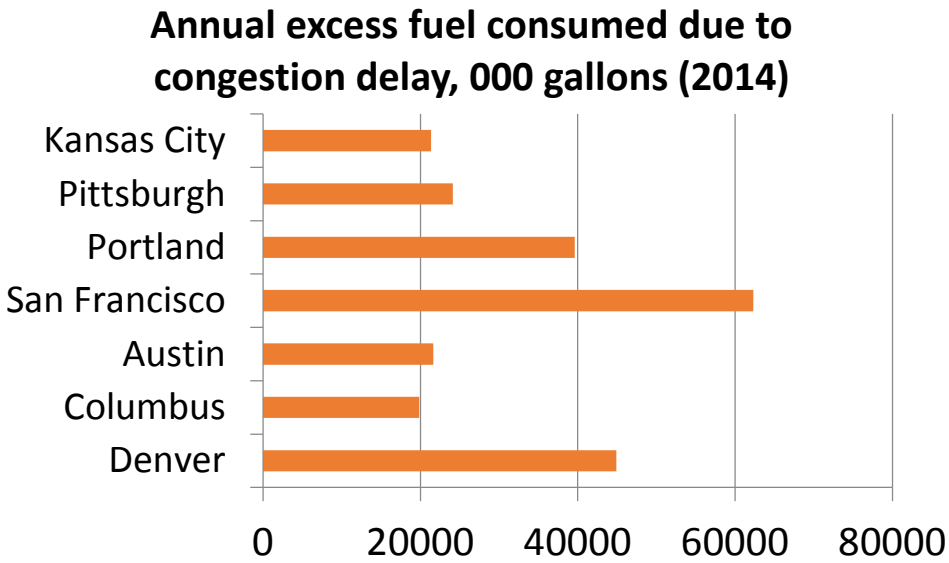
OPEN DATA RESOURCES

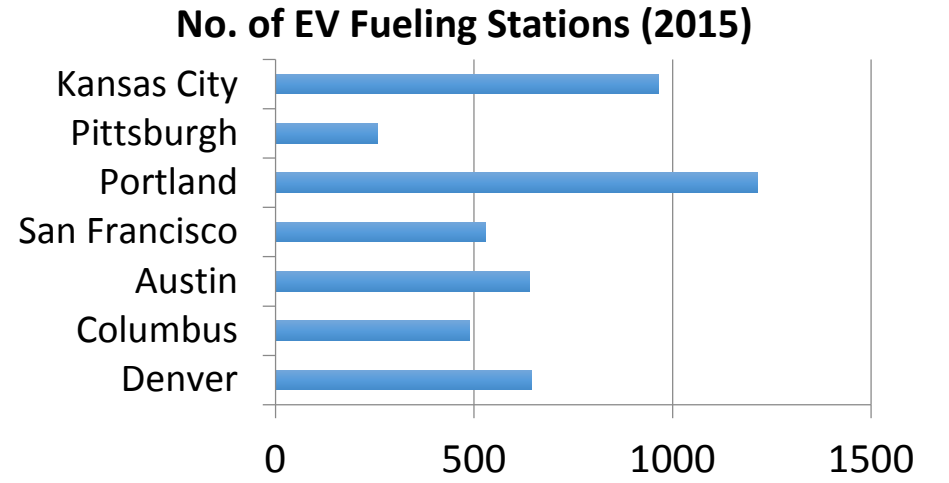
PRIORITIES FOR MODEL IMPROVEMENT

NEW MODEL SCENARIOS

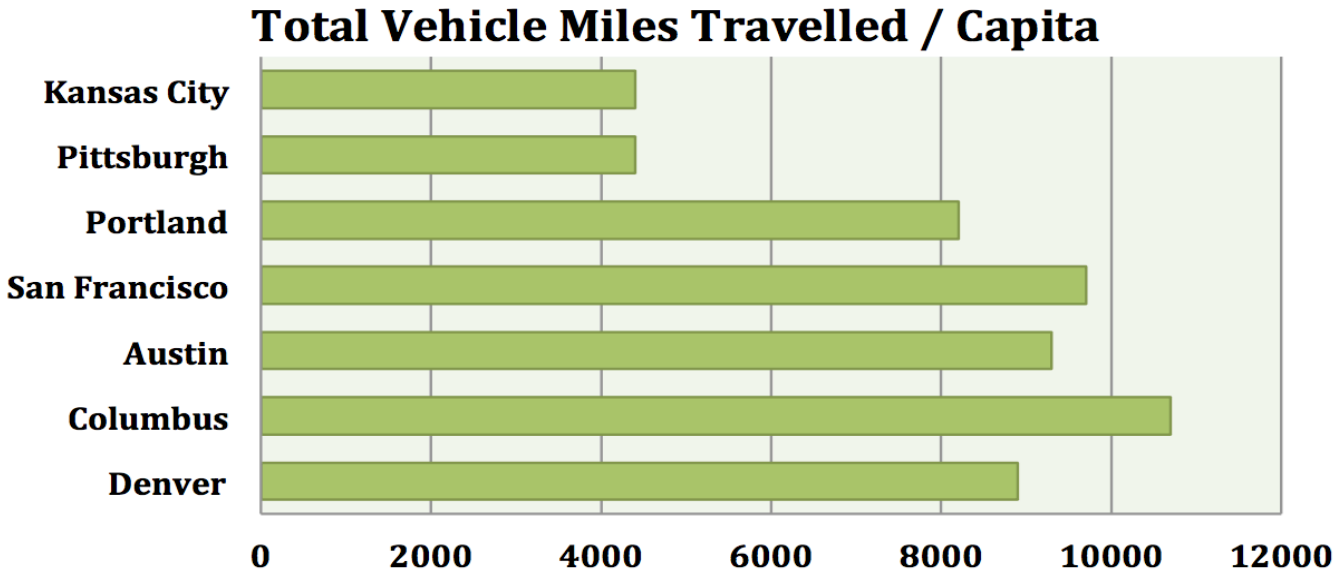
KEY MODEL CONTACTS & REVIEWERS

- **Participation in Major Forums:** "Decision Science & Changing Mobility Landscape" at BECC 2016; Smart Cities-Energy-Mobility Panel at ACEEE Intelligent Efficiency
- **Curating Baseline Data:** on models, open data sources, model output maps/GIS data
- **Convening and Peer-to-Peer Sharing:** Talks, urban data/technology workshops, posters, exchange and on-going surveys/interviews.





- **Collaborative discussion /annual data collection** with cities for Automated Mobility/Zero Energy District deployments as test beds; **presentations/paper submissions**:
  - A Convergence of Public-Private Benefits in Denver, USA: Surveys and Analysis to Inform Energy-Efficient Urban Mobility Systems and Urban Infrastructure Planning & Operations
  - Exploring an Energy-Mobility Nexus: A Framework for Curating and Comparing Data, Key Performance Indicators, and Models Using Case Studies of Four DOT "Smart City" Finalists

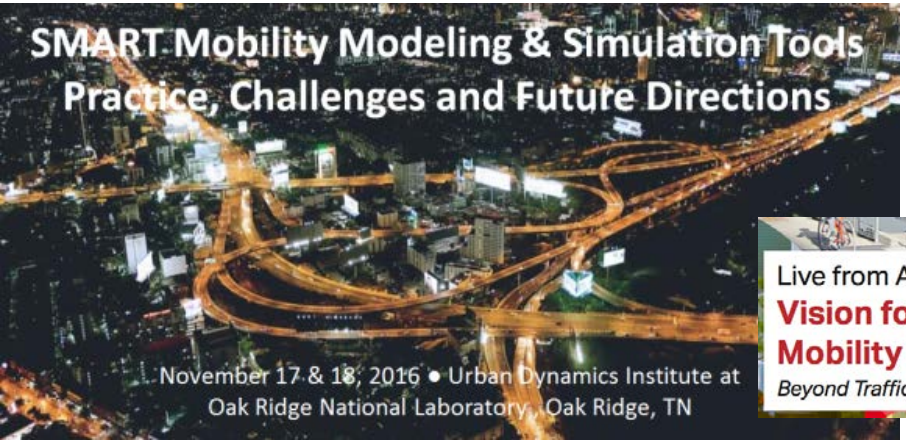


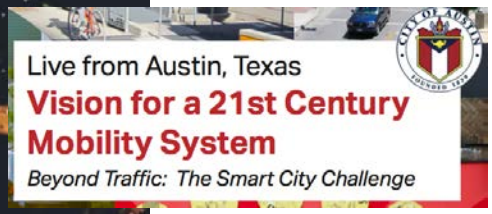
Project not reviewed last year

Collaboration & Coordination with Cities and Other Institutions – With Learning from Regular 'TIC' & City of Denver Engagements

- DOE National Laboratories
- Smart City Finalists, their cities/MPOs, universities, transit agencies, and MaaS providers
- Emerging Collaborations via invites to DOE SMART Mobility Data and Modeling Workshops

Table 1. City Populations of Smart City Challenge Finalists		
Columbus	800,000	Total pop. in the cohort of Smart Cities finalists = ~ 4.4 M
Denver	600,158	
Austin	790,390	
Portland	583,776	
San Francisco	805,235	
Pittsburgh	305,704	
Kansas City	459,787	





Technologist in Cities (TiC)

SMARTCOLUMBUS

Remaining Challenges and Barriers - The Urban Trans-boundary Challenge for Energy Assessment using Data & Models

- **Data / models keeping up with reality and** model integration/urban energy assessments

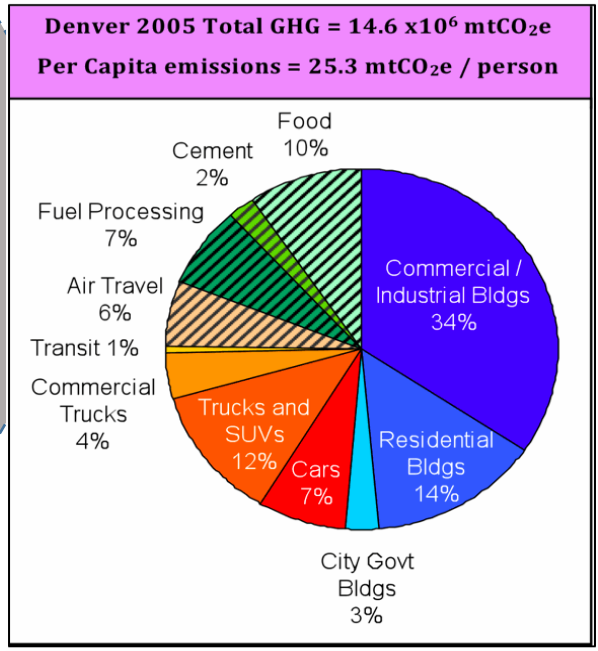
Freight & Goods

Airline Travel

Commuter

Feedback loops of applied urban science, technology, and policy in real-world settings

City or Urban Region w/ Buildings, Vehicles, Industries (Scope 1)



Ramaswami et al., 2008.

Remaining Challenges and Barriers -
The Urban Trans-boundary Challenge for Energy Assessment using Data & Models

- **Data / models keeping up with reality and** model integration/urban energy assessments

Key Urban Flows

-Food

- Water

- Energy
  Electricity
  (Scope 2)
  Transp Fuel

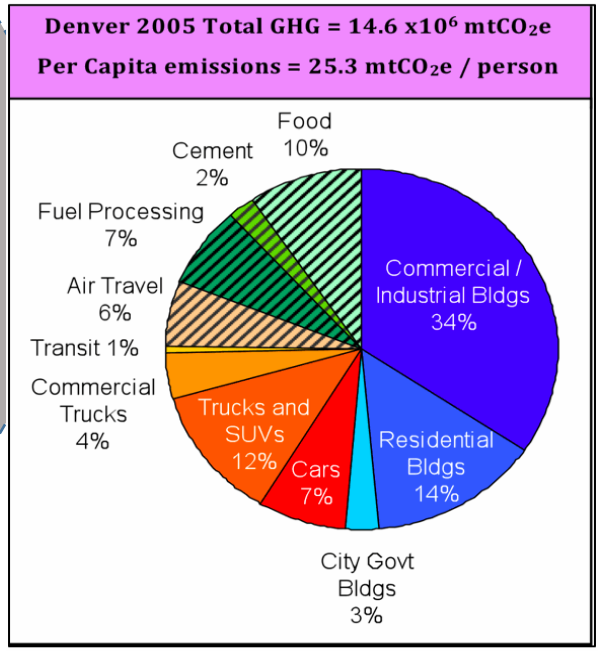
- Shelter
  Cement

…

Feedback loops of applied urban science, technology, and policy in settings

Commuter

City or Urban Region w/ Buildings, Vehicles, Industries (Scope 1)



Ramaswami et al., 2008.

Proposed Future Research – FY17

- Curation/synthesis of city models and related DOE urban tools
- Further curate data/models with remaining finalists: San Francisco, Kansas City, Pittsburgh
- Advance data, analytics, models on energy-efficient mobility, land use, parking, and infrastructure/ information/institutional systems
- Scenarios of SMART Mobility and energy impacts of changing cities.

EXAMPLE OF 3 SCENARIOS IN A REGIONAL-TO-STATEWIDE TRANSPORT MODEL

1. **Quick and Full Adoption:** of CAVs with both shared and private ownership
2. **Strategic Uses:** of CAVs by transit agencies, car share companies, and freight
3. **Market Quagmire:** some high-profile crashes and other hiccups lead to consumer skepticism

[Note: any proposed future work is subject to change based on funding levels.]

.

Proposed Future Research

- **FY18/19**
  - Iterate on SMART Mobility with harmonized approaches to urban data-models co-designed research with cities and DOE SMART Mobility
  - Develop web-based data repository and platform with other lab consortium pillars and offer city-to-city exchange on research and innovation
  - Analytics on urban energy-mobility infrastructure investments, AMD deployments, and tools to accelerate city experimentation/learning.

BROAD IMPACTS:

- Enabling efficient transfer of SMART analyses and case studies to interested cities
- Engaging Cities/MPOs/Industry/Academia/DOE-DOT to accelerate innovation.

PROPOSED NEXT STEPS:

→ Advancing spatial/temporal resolution of data, models, and visualization tools to accelerate planning and decision-making (with usability) across diverse city contexts

→ E.g., residential, downtown, freight, commercial; growing / shrinking; sprawled / compact

[Note: any proposed future work is subject to change based on funding levels.]

Summary

- DOE SMART Mobility Urban Science Efforts are helping:
  - Expose key data sets, models, roles for DOE in engaging across the seven Smart City Finalists+ for ensuring useful/useable insights
  - Assess opportunity (model and data maturity) for analyses
  - Feed/support other Urban Science/broader SMART initiatives

ADVANCING THE OF FUTURE ENERGY-EFFICIENT MOBILITY SYSTEMS AND SERVICES FOR PEOPLE IN CITIES

An Opportunity?

An Urban Energy-Mobility Challenge:

Info/Incentives/Social Norms for New Sustainable Behaviors shaped by Automated, Connected, Electric & Shared Mobility?

THANK YOU! QUESTIONS?

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