

Infrastructure Impacts of SMART Technology: Data Analyses on Energy Use

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ENERGY EFFICIENT MOBILITY SYSTEMS PROGRAM
INVESTIGATES

MOBILITY ENERGY PRODUCTIVITY



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Projects



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THROUGH FIVE EEMS
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Smart Mobility
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HPC4Mobility &
Big Transportation Data Analytics



Core Evaluation &
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**Advanced
Fueling
Infrastructure**



**Connected &
Automated
Vehicles**



Urban Science



SMART MOBILITY LAB
CONSORTIUM

7 labs, 30+ projects, 65 researchers,
\$34M* over 3 years.

**Mobility Decision
Science**



**Multi-Modal
Transport**

*Based on anticipated
funding

Overview

Timeline

- Project start October 2017
- Project end September 2019
- 25% complete

Budget

- FY2018 – Requested: INL \$180K; NREL \$50K
- FY2019 – Proposed: INL \$180K; NREL \$50K

Barriers

- Accurately measuring the transportation system-wide energy impacts of connected and automated vehicles
- Determining the value and productivity derived from new mobility technologies
- Expansive community of relevant stakeholders

Partners

- National Renewable Energy Laboratory
- Data Partner: Carnegie Mellon University – Mobility Data Analytics (MAC)
- Data Partner: UCLA Smart Grid Energy Research Center (SMERC)
- Data Partner: Denver Regional Council of Governments (DRCOG)
- Data Partner: Smart Cities Challenge Finalists
Airports

Relevance and Objectives

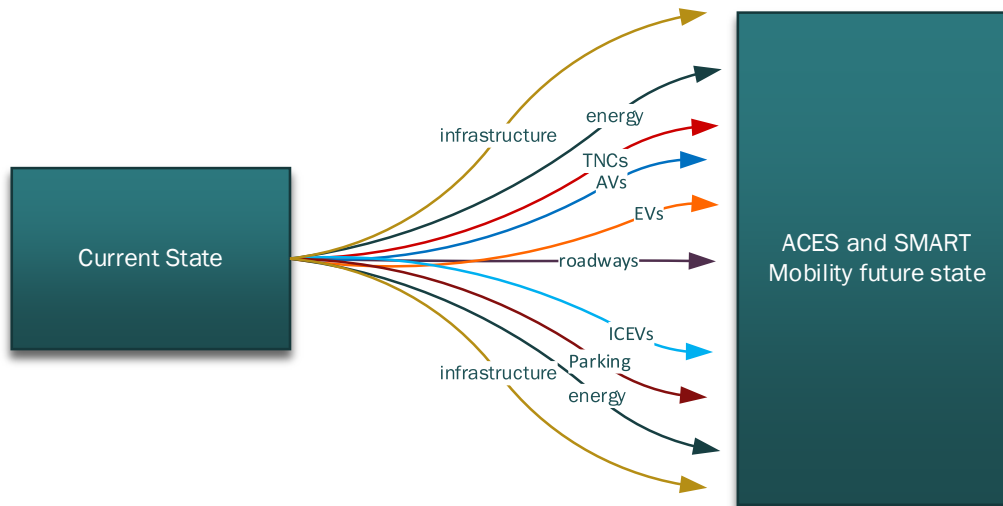
- Relevance:
 - New mobility technologies are persuading cities to change infrastructure to adapt
 - How will infrastructure changes happen? Mobility of the Future
- Objective:
 - Develop analysis model to estimate impacts of infrastructure changes (parking and land uses) with the implementations of TNCs, EVs/AVs, and other SMART technologies (e.g. automated-only roadways, auto-valet parking, AMDs, ICTs):
 - Energy consumption – reduction on vehicles and energy shift correlations
 - Productivity – ACES
 - Affordability – efficiency and convenient mobility options
 - Travel choices – transit over vehicle use and parking

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*, 2016, L. Isaac, 2016; US DOT/Census]

Relevance

- Methods for Initial Energy Analyses for Smart City Finalists
 - Informing TNC Design for/near Airports & Intermodal Transportation Facilities
 - Baseline metrics as estimates of existing surface level parking lots in downtowns
 - Utilize estimates for energy analyses of land use density/residential density
 - Forecast energy impacts from parking conversion to new land uses or new densities



Risks and Benefits:

- Increase or decrease congestion
- Land use and infrastructure reuse
- Measures and key indicators of parking
- Urban blight avoidance
- Encouragement of MaaS across urban-scapes for energy

“... per-capita daily energy demands decrease with increased resident and employment density.” Nichols & Kockelman, *Journal of Transportation and Land Use*, 8 (3): 1-15, 2015

Milestones

Date	Milestones	Status
January 2018	Milestone: Identify data opportunities for measuring parking demand, revenue, energy use, infrastructures	Complete
March 2018	Milestone: Preliminary analytics framework; strategic partners and stakeholders identified	On going
April 2018	Milestone: Begin acquire parking demand data (airports, surface parking, revenue, energy use, etc.)	On track
July 2018	Milestone: Baseline data for pre-smart technology	On track
August 2018	Milestone: Collect data from smart technology deployment data partners	On track
September 2018	Go/No-go: Finalize analytical framework; test data into analytic framework	On track
FY2019	Milestone: Analyze parking data in terms of energy impacts to cities infrastructure	On track
FY2019	Milestone: Document findings and develop strategic roadmap for mobility—infrastructure—energy forecasting	On track

Approach

- Formulate framework, model/analyses parameters from literature
 - trends, forecasts, scenarios etc.
 - data input criteria for use
- Define baseline analytics to perform & identify partner cities & stakeholders
 - San Francisco, Denver, Portland, Pittsburgh, Kansas City, parking app, university partner
- Secure appropriate data sets
 - Energy uses, land use, TNCs, and smart)and models parameters from cities, MPOs, and other agencies
- Perform data analytics on the validated (existing and newly created) parking, land use, and energy data sets
- Decision Point: October 2018 – baseline framework

Approach continued

- Highest energy benefit by changing urban-scape infrastructure
- Case studies perspectives
 - Parking management by employers
 - Chauffer services, TNC priority
 - Maas, not parking, is the new form of commuting
- Parking availability to drive mobility decision choices – energy shift
- Infrastructure:
 - Generation
 - Transmission
 - Distribution
 - Parking
 - Commuting
 - Land use
- Leverage data from various sources to measure possible for energy impacts

Accomplishments

• The Evolving Maturity of Transportation Data and Models Across Smart Cities

The Evolving Maturity of Transportation Data and

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Through the use of emerging data platforms, new mobility governance, research, industry, and communities maximizing the energy efficiency, equity, and safety of transportation may soon reach over 30% of U.S. energy cost an increasing proportion of U.S. population (~80% since exists to engage in urban data science-informed approaches how new approaches to transportation data and models an city mobility programs, projects, and policies. These approaches data exchange" in Columbus, "data utility" in Pittsburgh enterprise data management system in Denver, a "one data" winning "Xag" platform in Kansas City, to "DataSF" in San Francisco. These approaches continue to evolve travel demand and infrastructure investments by taking into account city initiatives in the United States are considering the many new technologies, with keen interests to leverage knowledge automated, connected, electric, and shared mobility, environmental, economic and societal impacts of these Department of Transportation (DOT) Smart City Challenge modeling environments of the seven cities selected as challenge winners. This effort includes stakeholder feedback loops whose initiatives track and emanate from their major objective of this challenge is to share lessons learned and early-stage research across diverse cities that are all More specifically, the major focus of this paper is shared and their evolution, as well as how these systems can help and energy. Key takeaways from data collection, modeling, and engagement includes an increased need to:

- Provide cross-city data platforms to visualize, explore, and analyze city mobility data and supporting model transformation, in response to disruptive changes in mobility and energy impacts while designing context-specific responses to emerging mobility and energy impacts
- Harmonize approaches in data and modeling by transitioning in mobility and energy impacts while designing context-specific responses to emerging mobility and energy impacts
- Address specific knowledge and data gaps as cities explore the impacts of, preparing for, and sharing strategies for smart cities, with increasing emphasis on shared, electric, connected, and automated mobility

Key Words: smart city; data visualization; automated, enhanced mobility; urban infrastructure modernization; data exchange

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ABSTRACT

SF: SFCTA 'SFChamp'- DTA Model

The SFCTA 'Chained Activity Modeling Process' (known as SFChamp) is a dynamic traffic assignment (DTA) travel demand model for the San Francisco Bay Area, calibrated using MTC's BATS 1999

Spatial Resolution of Model: TAZs

Model Architecture: 4-Step (Activity-Based) Input Data Static Assignment Dynamic Assignment Latest Version

Modes Covered: Auto Transit Walk

Special Generator: Airport Freight Internal Origin

Scenarios: Infrastructure Demographic Land Use

SUMMARY

The SF CHAMP activity-based model, is the longest running 2001 and based on data from a 1999 Stated Preferences Survey (when no onboard transit survey data was available new transit onboard survey in 2004 (with support from the FTA made with the MTC's BAYCAST model and SF-CHAMP model address inconsistencies in non-motorized trips and trip generation and recalibration efforts began in 2006/7, using the D survey. Based on Atlanta (ARC) methods, using 2000/20 update, with now over 981 zones in SF alone, and 350 new synthesis going from 110 classes to almost 600 classes. We modeling local SFCTA needs, the latest version of SF Champ transportation plan, fleet plans, waterfront transportation alternative action strategies and inventories, feasibility studies, alternative Champ model has a model consistency report released every Software used includes UrbanSim/OPUS (for land use), Citi mapping. When first created, the model ran on one PC in 26 hours, with modeling speeds now at 1-2 hours to 1 day. Model

INPUTS

Socio-Economic Data (2010 Census): Road Network (2010) Transit Network (2014) Land Use (2010)

MODEL KEY POINTS OF CONTACT & REVIEWERS

SF Travel Model: Joe Castiglione / Dan Tischler / Billy Charlton

Urban Sim: Paul Waddell / Mike Reilly

UrbanSim & SF-Champ synchronize every 5 years (since 2007)

RELATED PROJECTS

SF-Champ has been used to link with other Microsimulation tools (e.g. Synchro - for optimal signal timings based on road volumes) & VISSIM (for transit

<http://www.sfcta.org/sites/default/files/content/Planning/DataMart/trb%202007%20-%20sf-champ%20in%2015%20minutes.pdf>

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Cross-City Comparison and Summary of Model Details	Columbus	Portland	Pittsburgh	Austin	San Francisco	Denver	Kansas City
Model Name	MORPC	Metro	SPC	CAMPO	SF-CHAMP	FOCUS	MARC
4-Step (Yes) (Activity-Based (AB))	AB	AB	AS			AB	AS
Static Assignment (SA)	DA	DA	SA			SA	SA
Dynamic Assignment (DA)							
Last Upgrade	2004	2010	2015			2010	2015
Next Upgrade	2017	??	??			2017	??
TNC Model Included? (Y/N)	N	N	N			N	N
Special Generator	A - Airport, F - Freight, IE - Internal/External Trips, U - University, O - Other	F, IE	A, F, IE	A, IE		A, IE, U, O (Mountain/Casino)	A, IE
Scenarios Considered/Tested	I - Infrastructure, D - Demographic, L - Land Use, EN - Energy, EC - Economy, T - Technology	I, D, T	I, D, L, EN, EC, T	I, L, EN, EC		I, L, EN, EC	I, L, EN, EC
Model Capacity/Capability Level	A - Advanced, H - High, M - Medium, L - Low	H	H	L		M	L

The TDM models characterizations in Table 2 is for the most commonly used model in the city. It is not unusual for different models, or even model variants to be active within a city, particularly in cities where universities are active in urban modeling research. Austin, for example, with University of Texas at Austin (UT Austin) and Texas A&M Transportation Institute (TTI) in close proximity has been the subject of various research experiments with various aspects of the TDM developed by the local MPO (CAMPO). A 2017 research study by UT-Austin (Luo et al., 2017) leveraged the base CAMPO model and supporting data using open-source ABM software, MATSIM, to explore the anticipated effect of fully automated demand response service ("Automated Uber") based on socio-economic behavioral estimations derived from a literature review. Likewise, TTI augmented the CAMPO model with better traffic response (in essence a DTA) to assess the impact of consumers' change in vehicle route in response to external (smart phone app) stimuli.

The discussion of the Austin CAMPO model touches on another theme, and identified research gap, emerging from the data and model current task. Model capability is also correlated to model complexity. As TDM models progress from four-step to ABM, and from static to dynamic assignment, the data, computing, and personnel resources to build, maintain, calibrate, and exercise the model also escalate. As a result, the choice to advance the model from traditional to more modern framework and methodology is also a fiscal commitment that falls on the urban area. The gap or research question that emerged from the model capability assessment exercise is whether cities with a traditional framework (4-step and static assignment) can use or leverage emerging models to distill the impacts of ACES technologies, or is a more model development investment required? In order words, can more traditional (less-expensive) modeling tools be leveraged with less fiscal investment to estimate impacts of ACES, and plan appropriately for the urban area? These questions are being addressed in the SMLC research,

Accomplishments

- Literature searches



Accomplishments

- Data collection

Airport Data Reveal How Quickly We are Adapting to New Mobility

Recent studies have indicated that both air travel and ride-hailing (e.g., Uber, Lyft) services are on the rise across cities in the United States and globally. By 2035, global air travel demand is expected to double (within just a 20-year period), and tens of billions in new airport infrastructure investments and modernization upgrades are expected.

For U.S. cities with larger regional airports—such as Denver, San Francisco, Portland, and Kansas City—the number of recorded airport passengers has been rising steadily, from approximately 115M in 2011 to approximately 146M in 2017 (Figure 1). This represents an annualized growth rate of 3.8% for these airports, with a doubling time of approximately 18 years (even faster than global air travel demand projections). Today, air travel represents over 9% of total U.S. transportation energy use ([EIA 2016](#)), with a 567% increase (from 309 to 1,752 petajoules) in jet fuel and aviation-related gasoline consumption from 1960 to 2015 ([BTS 2016](#)).

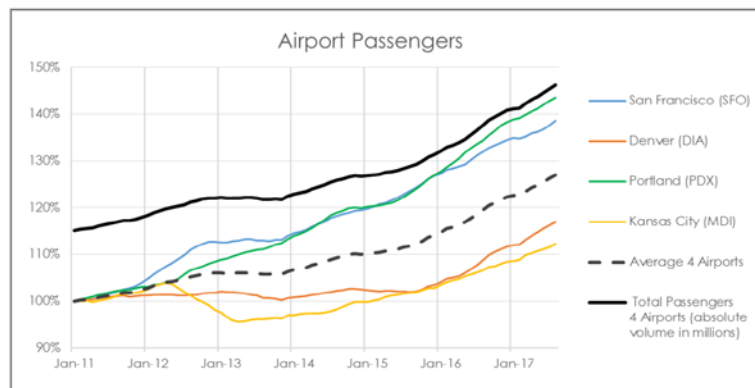
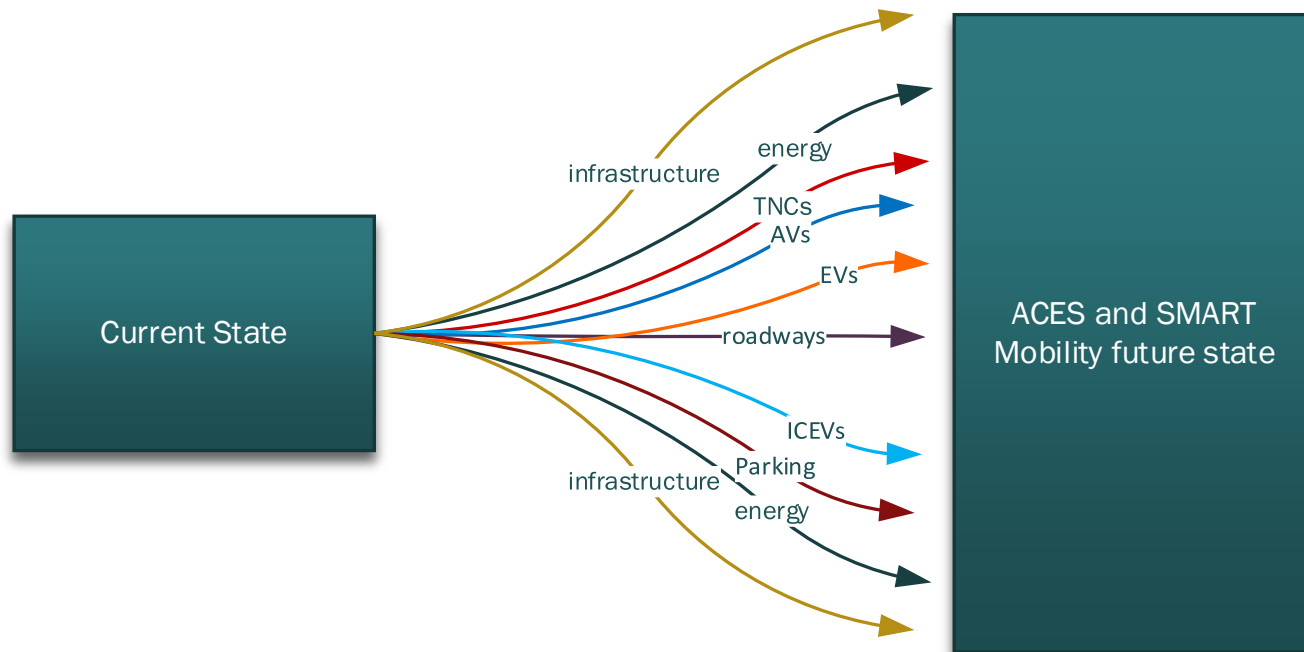


Figure 1. Airport passengers¹

¹Notes: Total airport passengers (enplaned + deplaned). All airports indexed to January 2011 as baseline (100%). Twelve-month running average, each month. Airports have mass transit service, except for Kansas City.

Accomplishments

- Framework



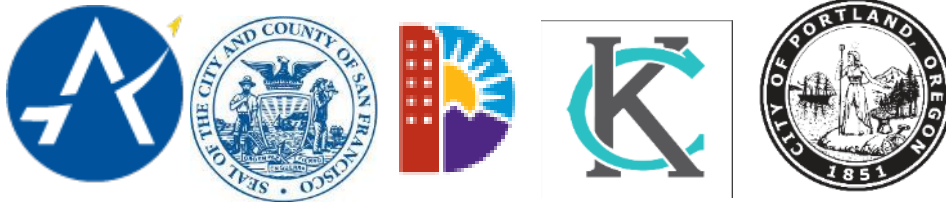
Responses to Previous Year

- In FY17 this task was included under Urban Science Task 2.1
- In FY18, split into two separate tasks, Urban Science Task 2.1.1 and Urban Science Task 2.2.1
- Responses from FY17 are address in Task 2.1.1 AMR presentation
- For FY2018, this task is considered new

Collaborations and Coordination



Co-Principal Investigator on Infrastructure
Energy Impacts of SMART Technology



Airport Data Partners

Carnegie Mellon University

Mobility Data Analytics Center –
Urban Infrastructure Interdependency



Aerial Imagery Infrastructure Datasets



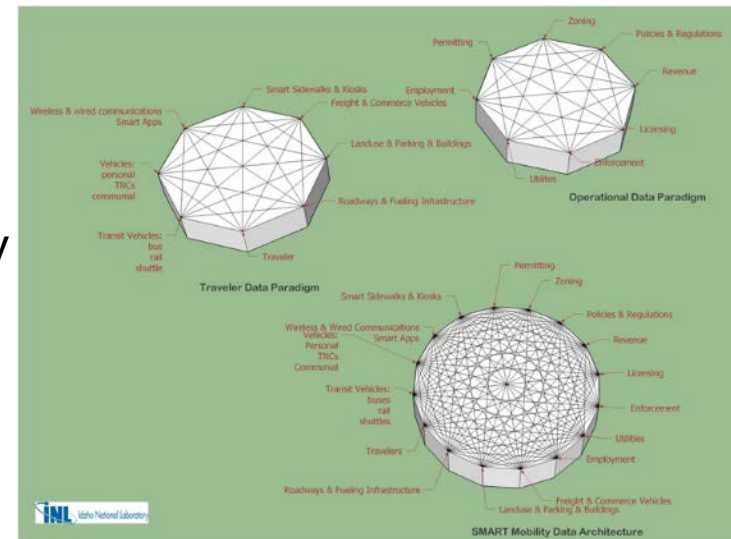
Campus Parking Infrastructure Data
Higher Education Commuting Trends

Remaining Challenges and Barriers

- Availability and uniformity of parking infrastructure data
- Need to define data parameters – future ties to SMART Mobility Data Architecture
- Accurately measuring the transportation system-wide energy impacts from infrastructures changes
 - Parking changes
 - Commuter options
 - ACES based MaaS
 - Energy Data as a Service (EDaaS) uniformity and availability

Proposed Future Research

- FY2018
 - Finish literature review
 - Solidify partners
 - DRCOG aerial imagery data
 - CMU Mobility Data AnalYTics Center
 - UCLA SMERC campus parking data
 - Energy data parameters for infrastructure impacts
- FY2019
 - Analytic framework and analyses
 - Energy changes
 - Congestion/VMT reduction and energy impacts
 - Mobility Metric integration
 - SMART Mobility Data Architecture



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

Summary

- Initial literature review
 - Parking infrastructure changes indicate opportunity reduce VMT and energy shift
 - ACES and TNCs are changing the urban-scape infrastructure
 - Energy shift from $E \rightarrow e^-$ is inconclusive on energy increase or decrease
- Strategic stakeholder partnerships can lead to better understanding of framework parameters
- Ties to other SMLC Tasks are beneficial in data sharing and value of understanding the complexity of the System of Systems nature of integrated transportation networks
- Clarity is needed in understanding the empirical real-world data available for infrastructure/energy analytics

