

# New England University Transportation Center



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## Final Report

*Project Title:*

# Disruptive Technologies for Massachusetts Bay Transportation Authority Business Strategy Exploration

**Project Number:**

MITR23-3

**Project End Date:**

12/31/12

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4/17/13

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## Tasks Accomplished

1. Methodology to extract Road Usage Patterns from Phone Data: We combined the most complete record of daily mobility, based on large-scale mobile phone data, with detailed Geographic Information System (GIS) data, uncovering previously hidden patterns in urban road usage. We found that the major usage of each road segment can be traced to its own - surprisingly few - driver sources. Based on this finding we proposed a network of road usage by defining a bipartite network framework, demonstrating that in contrast to traditional approaches, which define road importance solely by topological measures, the role of a road segment depends on both: its betweenness and its degree in the road usage network. Moreover, our ability to pinpoint the few driver sources contributing to the major traffic flow allows us to create a strategy that achieves a significant reduction of the travel time across the entire road system, compared to a benchmark approach.
2. Methodology to analyze GPS data for Control of Bus Performance: We investigated the potential of "low-frequency" bus localization data for the monitoring and control of bus system performance. We showed that data with a sampling rate as low as one minute, when processed appropriately, could provide ample information. In particular, we obtained accurate estimates of stop arrival and departure times, which in turn allowed the analysis of headways and travel times. A three-parameter gamma family of distributions is fitted for headways at the stops along a bus line. The evolution of the parameters demonstrates critical points on the line where bus bunching is significantly increased. This analysis allowed differentiating problems associated with varying passenger demand from uncertainties associated with traffic conditions. Furthermore, we showed that both expected travel time and travel time variability could be calculated from low-frequency localization data. Finally, we could present how our results can be used to calibrate a simulation model, which can test bus control strategies. We apply and validate the methods to data obtained from bus route number 1 in Boston.
3. Inferring Land Use from Mobile Phone Activity: The locations and communication patterns of millions of individuals are recorded alongside information about the function of the places they go. This work uses dynamic data to quantify the relationship between activity within an area (measured via mobile phones) and land use. First, we implement a machine-learning algorithm to assess the ability of mobile phone data to predict land uses as designated by municipal governments. Finding modest success, we perform a detailed analysis of errors that suggests official zoning may be insufficient to understand activity within a place. To test this further, we incorporate additional data on points of interest crawled from a large online database, boosting predictive accuracy and supporting our theory. This analysis suggests measured activity and points of interest areas are inconsistent with officially zoned uses. Results provide a temporal dimension to our understanding of land use and suggest new data sources that may give a more accurate description of activity in a place.

## Journal Publications

1. P Wang, T Hunter, AM Bayen, K Schechtner, MC González “*Understanding Road Usage Patterns in Urban Areas*” **Scientific Reports** 2: 1001 doi: 10.1038/srep01001 (December 2012).
2. Yang, Yingxiang, Bauer, Dietmar, Widhalm, Peter, Gerstle, David, and Gonzalez, Marta C. “*Potential of Low-Frequency Automated Vehicle Location Data for Monitoring and Control of Bus Performance*” **accepted** for publication in the **Transportation Research Record**.
3. Jameson L. Toole, Michael Ulm, Marta C. González, Dietmar Bauer “*Inferring land use from mobile phone activity*”, **submitted** to the **ACM Transactions on Intelligent Systems and Technology**.

## Conference Papers

4. Jameson L. Toole, Michael Ulm, Marta C. González, Dietmar Bauer “*Inferring land use from mobile phone activity*”, UrbComp '12: Proceedings of the **ACM SIGKDD International Workshop on Urban Computing** (August 2012).
5. Yang, Yingxiang, Bauer, Dietmar, Widhalm, Peter, Gerstle, David, and Gonzalez, Marta C. “*Potential of Low-Frequency Automated Vehicle Location Data for Monitoring and Control of Bus Performance*”

## Awards and Recognitions

1. “*Inferring land use from mobile phone activity*”: Winner of the “Best Paper Award”, in UrbComp'12 Technology.
2. “*Inferring land use from mobile phone activity*”: Best Poster Award, in NetSci 2012.
3. “*Practice ready*” paper, TRB Meeting 2013, accepted for Oral Presentation.

## Students and Postdocs Advised

- **Yingxiang Yang, MS Transp. (now PhD Cand. Transp/CEE)**  
Dissertation Proposal: “*Multi-Scale Multi-Cultural Study of Commuting Patterns Incorporating Digital Traces*”
- **Jameson Toole , MS in Eng. Sys. (now PhD Cand. ESD)** “*Analyzing the diffusion of innovations and human mobility patterns using massive spatiotemporal datasets*”
- **Pu Wang, Postdoc CEE**, now started a position as Professor in the School of Traffic and Transportation Engineering, in *Central South University*, in China.

## Webpages and Media Appearance

- About our Study to Mitigate Traffic Congestion based on Phone Usage

[MIT Webpage](#), [UC BERKELEY](#), [PHYS ORG](#), [SCIENCE DAILY](#), [R&D News](#), [News Track India](#), [TECHNEWS DAILY](#), [MSNBC](#), [LIVESCIENCE](#), [YahooNews](#), [TMCnet](#), [cellular-news](#), [EurakaAlert](#), [UPI](#), [TheAtlanticCities](#), [NBCnews](#), [REDORBIT](#), [FinancialTimes](#), [MercuryNews](#)

## [The Boston Globe \(“ideas”, Sunday printed edition\)](#)

- **In Austrian News: [ORF](#) , [WienerZeitung](#), [Krone](#)**. Also special interviews in the research sections of DerStandard & Die Presse printed editions.
- **About one of the students funded by this project: [Making sense of big data](#)**: PhD student Jameson Toole wants to harness data to improve human lives in the MIT Webpage.